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Shaw, Byron H.; Turyk, Nancy
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A COMPARATIVE STUDY ON NITRATE-N LOADING TO GROUNDWATER FROM MOUND, IN GROUND PRESSURE AND AT GRADE SEPTIC SYSTEMS

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A Comparative Study of Nitrate-N Loading to Groundwater from Mound, In Ground Pressure and At Grade Septic Systems

Byron Shaw
Nancy Turyk

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Project Final Report to Wisconsin DNR
Groundwater Management Section

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ABSTRACT

Fifteen pressure dosed septic drainfields in sandy soil areas of Wisconsin were studied to evaluate their impact on groundwater quality. They included; two single family at grade systems, two single family and four multiple family in ground pressure systems, and four single family and three multiple family mound systems. Dosing chamber effluent was sampled ten times during the 18 month study, and the total volume of effluent pumped to the drainfield was measured. Groundwater sampling was conducted quarterly from two multiport well nests of four wells each. These well nests were located downgradient of each drainfield. Analyses preformed on the groundwater samples included; nitrate+nitrite-N, NH_4-N, Kjeldahl-N, chloride, pH, conductivity, total phosphorous, total hardness, and alkalinity. BOD and COD were run on some sample sets.

All 15 systems resulted in groundwater nitrate-N exceeding the drinking water standard of 10 mg/l. Values ranged from 21 to 108 mg/l in the contaminant plumes, and averaged 34 mg/l for single family systems and 31 mg/l for multiple family systems.

Nitrogen to chloride ratios for dosing chambers and groundwater were used to evaluate nitrogen loss from drainfields. These ratios indicate there was no significant nitrogen loss occurring from the drainfields by denitrification or volatilization. The ratio of nitrogen and chloride in groundwater contamination plume and dosing chambers was used as an index of dilution of wastewater by upgradient groundwater or recharge in the vicinity of the drainfield. This indicates a significant degree of dilution is occurring between the outlet pipe from the dosing chamber, and the contaminant plume, within about 20 feet of the drainfield. The average ratio of nitrogen concentrations in effluent to nitrogen concentrations in groundwater was 2.4 and ranged from 1.3 to 3.8. Hydraulic loading, drainfield orientation to groundwater flow, and groundwater flow characteristics all influence the amount of dilution that occurs as effluent enters and mixes with groundwater. These systems evaluated all treated wastewater as designed for bacterial removal, but did little for removal of nitrate-N from wastewater.

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INTRODUCTION

The groundwater below the Central Sands of Wisconsin are particularly susceptible to contamination from various land use practices, one being on site septic systems. This is due to the sandy soil types and the shallow depth to the groundwater. This project was designed to evaluate the chemical treatment efficiency of "alternative" septic systems.

Private sewage systems, typically consisting of a septic tank with gravity flow to a drainfield or dry well, have been used since the advent of interior plumbing. The primary purpose of current private sewage systems is for the disposal of wastewater and the removal of bacteria. Only recently has consideration been given to the level of chemical treatment which can be expected from private sewage systems and their potential for groundwater pollution.

Soil absorption systems are designed to allow wastewater to percolate into the soil, hopefully being treated in the process. Recognition in the early 1970's that sewage eventually recharges groundwater, resulted in a change in research on private sewage systems from an emphasis on sewage disposal to an emphasis on sewage treatment (Walker, et al, 1973). It is generally recognized that 0.9 meters of unsaturated soil is required to properly treat sewage effluent to allow adequate removal of disease causing bacteria, viruses (pathogens), suspended solids and the breakdown of some organic materials (WDILHR, 1992). Less than 0.9 meters of soil may be adequate if the soil has a substantial silt and clay content and does not have a high degree of structure. More than 0.9 meters of soil may be required in coarse, sandy or gravelly soils or additional finer soil may need to be above the very coarse soils.

Conventional septic systems have been used on the sites with the highest permeability and the greatest depth to groundwater and bedrock. When used on sandy soils these systems have been shown to result in significant addition of nitrate-N concentrations to groundwater (Walker, et. al., 1973; Ritter, et. al., 1988; Robertson, et. al., 1991). There are an increasing number of alternative septic systems installed on less suitable or more sensitive sites, where the 0.9 meter separation does not exist between the bottom of the drainfield and groundwater or bedrock. This project focuses on three types of alternative pressurized septic systems; mound, in ground, and at grade systems. The primary difference between these systems is the location of the drainfield distribution pipes in relation to the ground's surface. In ground systems have the distribution pipes below grade; at grade systems have distribution pipes located at grade, with soil piled above grade to prevent freezing; and mound systems have their distribution pipes above grade for increased distance between the drainfield and the groundwater. Soil is brought in to place below the distribution lines of mound systems to obtain the needed 0.9 meter of soil. These systems all use pumps to distribute effluent to the drainfield, which should result in more uniform waste distribution compared to conventional systems.

Treatment efficiency in on site sewage systems for many chemical constituents varies considerably, depending on the nature of the chemical and the soil. Because nitrate-N, a breakdown of organic nitrogen compounds, is very soluble and does not adsorb to soil, it often reaches groundwater from what are considered well functioning septic systems. Other mobile, inorganic compounds, such as chlorides, will also pass directly to the groundwater (Reneau, 1989). The number and complexity of materials discharged to private sewage systems has greatly increased over time. Many common household products contain potentially harmful substances that may be passed to groundwater (Yates, et. al., 1989).

Monitoring the impact of septic systems on groundwater quality is desirable in areas where groundwater protection is important due to high use, where it is desirable to maintain groundwater quality concentrations at or below drinking water standards, and when planning new land use developments. US EPA (1984) points out the lack of simplistic, cost effective methodologies for monitoring the impact to groundwater from on site septic systems. Monitoring the groundwater for sewage system impacts is difficult because of contaminant plume migration, plume characteristics, seasonal fluctuations of infiltration and groundwater elevation, the orientation of the drainfield to the groundwater flow direction, and the dosing frequency and the amount of dose to the soil adsorption bed (US EPA, 1987; Kerfoot, 1989; Mote, et.al.1990; Robertson, et.al., 1991). Proper location of monitoring wells relative to the drainfield is essential for consistent monitoring of the contaminant plume. Dilution of the contaminant plume must be considered when determining the location of the well. The amount of dilution can be affected by the factors mentioned above, as well as being related to the distance between the monitoring well and the drainfield. Pruel (1966) indicated that average concentrations of nitrate-N (originating from on site septic systems) were below 10 mg/l within 12 m of the study systems. However, in a study done in the sandy soils of Wisconsin, Walker, et. al. (1973) observed that a distance of approximately 30 m from the drainfield was needed to achieve 10 mg/l nitrate-N in the top 30 cm. Robertson (1990) observed only a 50% reduction of effluent concentrations in sandy soil aquifers at a distance of 130 m from the drainfield. The contaminant plume in their study was 10 m wide and 2.5 m thick. The plume thickness was monitored using piezometer bundles to obtain samples from the same location at various depths. A similar technique was used in this study, and we believe the use of multilevel wells with four sample ports (sampling from the water table to a depth of 3.3 m) will result in a series of samples which should include much of the contaminant plume, and can be used to indicate the vertical thickness of the plume.

SITE DESCRIPTION

Portage County is located in central Wisconsin (Figure 1). It is approximately 2120 square kilometers in size. Winters are cold and snowy and summers are hot and humid. The average date of the first hard freeze is October 1, and the average date of the last hard freeze is May 11. The average annual precipitation is 80 cm, with about 60 percent (48 cm) occurring between May through September. Fifteen to 25 cm of the precipitation occurring in the period between May and September becomes runoff and infiltration. It is estimated that 90 percent of the runoff/infiltration becomes groundwater recharge.

The project study sites are all located in the north central section of the county, in the Town of Hull (Figure 2). Geologically, this area is considered part of the sand plain province, which consists primarily of glacially deposited sand and gravel. These deposits average 30 m in depth, with crystalline rock below.

The sand-gravel deposits make up most of the aquifer, and have the capacity to accommodate large quantities of groundwater. The flow of the groundwater is generally in a south-westerly direction, towards the Wisconsin River, but this direction can be locally variable, which was apparent at several of our study sites.

Study sites were chosen from single and multiple family housing sites which had alternative septic systems in place, and homeowners who were willing to cooperate with the study. The age of the systems at the beginning of the study ranged between 2 and 10 years. Three alternative septic system designs were represented; pressurized mound, at grade pressure, and in ground pressure. Other physical variables of the

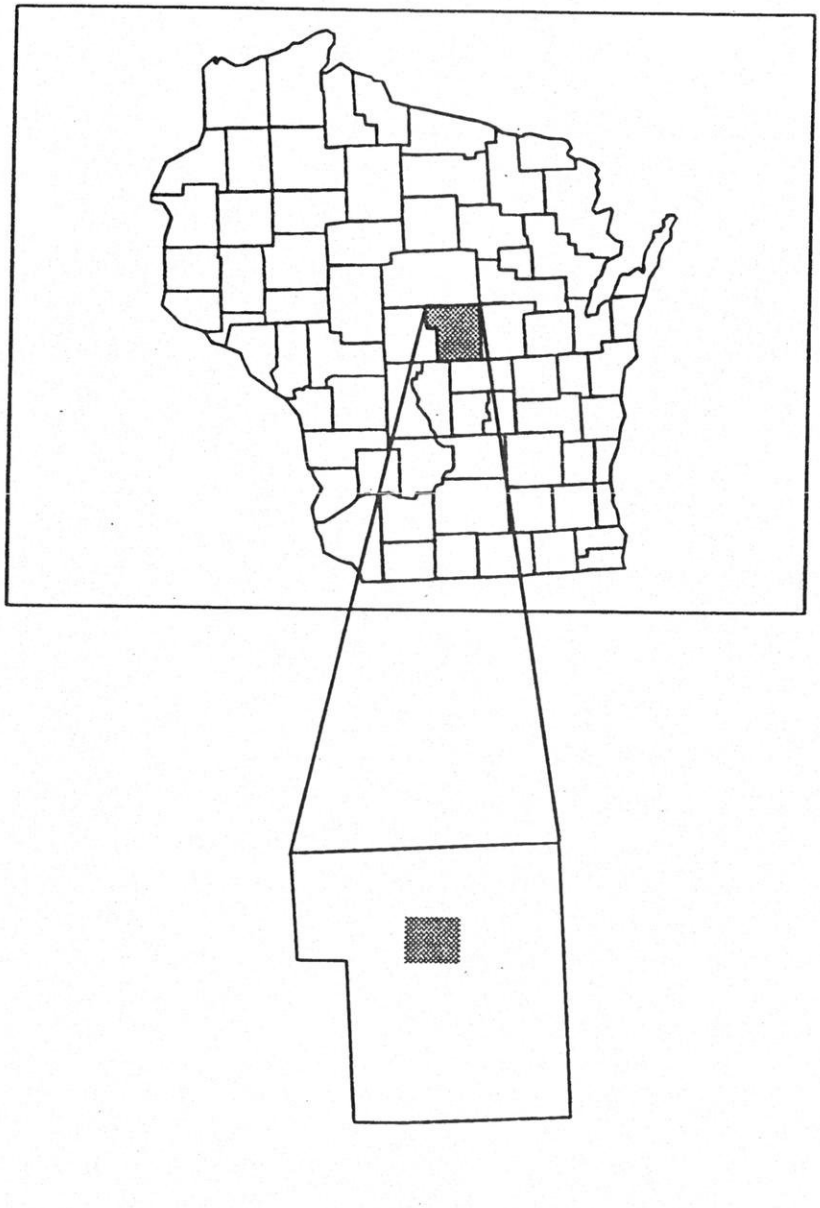


Figure 1. The location of the alternative septic system study sites situated in the central sands of Portage County, Wisconsin.

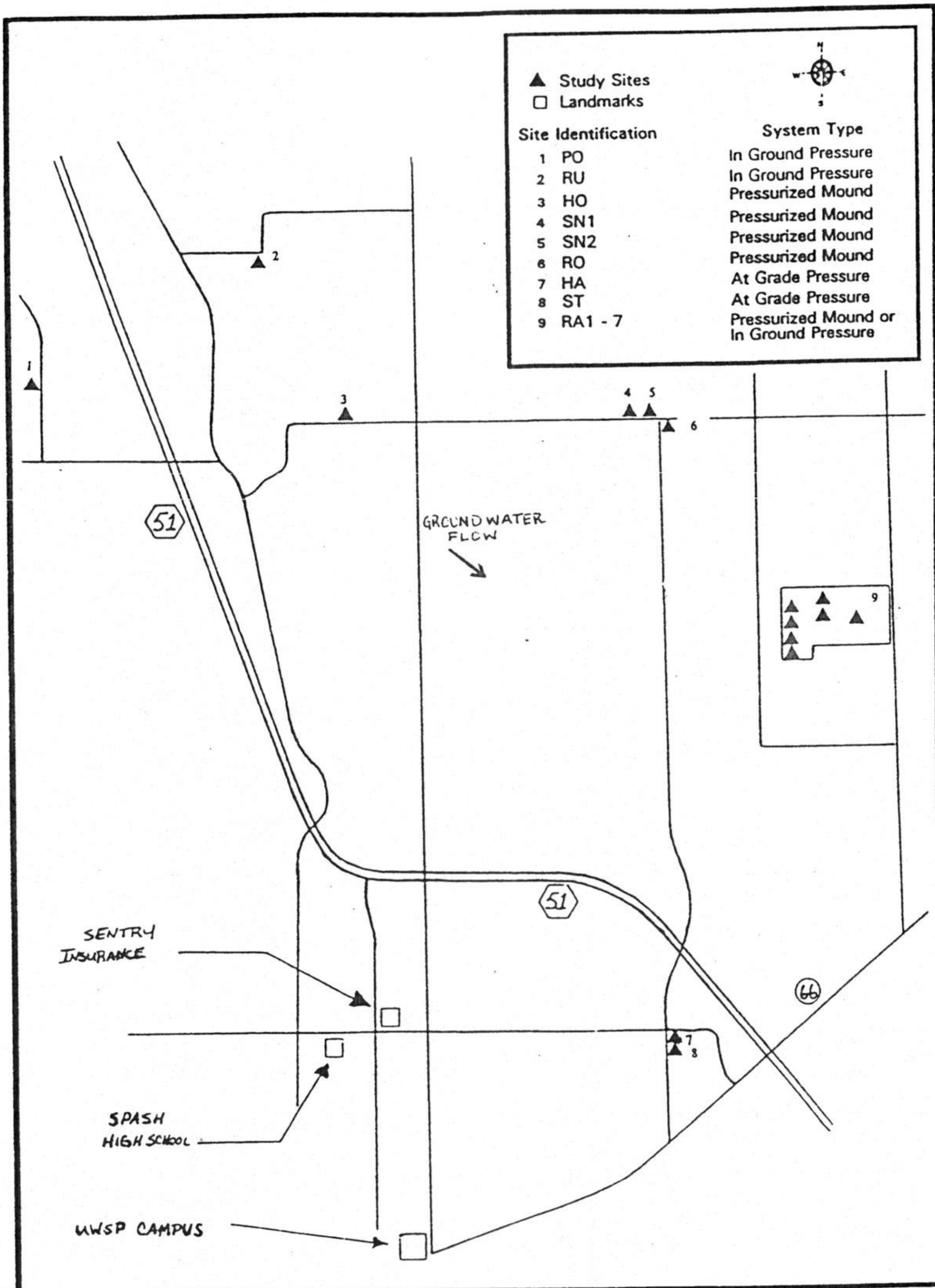


Figure 2. Location map of the alternative septic system study sites with general groundwater flow direction.

alternative septic systems which are pertinent to the study include the number and size of the septic tanks, the dosing chamber dose volume and frequency, and the seepage bed area and its orientation to the groundwater flow direction. This specific system information can be found in Table 1. The site descriptions will be organized by single and multiple family housing types, with further internal divisions by septic system type.

SINGLE FAMILY SEPTIC SYSTEMS

Pressure Mound Systems

Four single family pressure mound septic systems were included in this study. Three of these sites were located within a quarter mile of each other (RO, SN1, and SN2).

The oldest of the mound systems is RO (Figure 3), which was installed in November 1980. A 3780 liter (1000 gallon) septic tank and dosing chamber were added to the existing 2835 liter (750 gallon) septic tank for this three bedroom house. The gray water from this house is routed onto the lawn, just north of our upgradient well (ROUG). The septic tanks were last pumped in October 1990.

SN2 (Figure 4) is located on the north side of the street, across from site RO. Although these systems are almost adjacent to one another, they appear to be on opposite sides of a groundwater divide. The groundwater at this site (SN2) flows in a northwest direction, while the groundwater at site RO flows in a southeast direction. The mound system at this site was installed in October 1984. The septic tank at this location was last pumped in the fall of 1991.

Site ID	System Type *	Septic Tank Number	Septic Tank Total Vol. (l)	Dosing Chamber Dose Volume (l)	Dosing Chamber Ave. Number Doses/Day	Dosing Chamber Ave. Total Dose Vol./Day (l)	Seepage Bed Orientation ~	Seepage Bed Area (sq. meters)
Single Family								
HA	AG	2	7560	648	0.6	389	Perpendicular	46
ST	AG	2	7560	631	0.4	252	Diagonal	46
PO	IG	1	3785	438	0.5	219	Parallel	46
RU	IG	2	7560	679	0.6	407	Perpendicular	84
HO	M	1	3785	518	0.9	466	Perpendicular	35
RO	M	2	6615	611	0.4	244 ^	Parallel	35
SN1	M	1	3785	614	1.6	982	Parallel	35
SN2	M	1	3785	577	0.3	173	Perpendicular	35
Multiple Family								
RA2	M	2	9450	1512	1.2	1814	Perpendicular	117
RA3	M	2	7560	1172	1.4	1641	Perpendicular	93
RA4	M	2	7560	1230	1.1	1352	Perpendicular	93
RA1	IG	2	9450	1652	1.3	2148	Perpendicular	418
RA5	IG	3	15120	1890	1.4	2646	Parallel	502
RA6	IG	2	9450	1996	0.7	1397	Perpendicular	334
RA7	IG	3	15120	2272	1.0	2272	Diagonal	670

* System Types: AG = At Grade Pressurized System
IG = In Ground Pressurized System
M = Mound System

~ Orientation refers to the seepage bed orientation relative to the groundwater flow direction.

^ Does not include gray water.

Table 1. Alternative septic system design for single and multiple family systems.

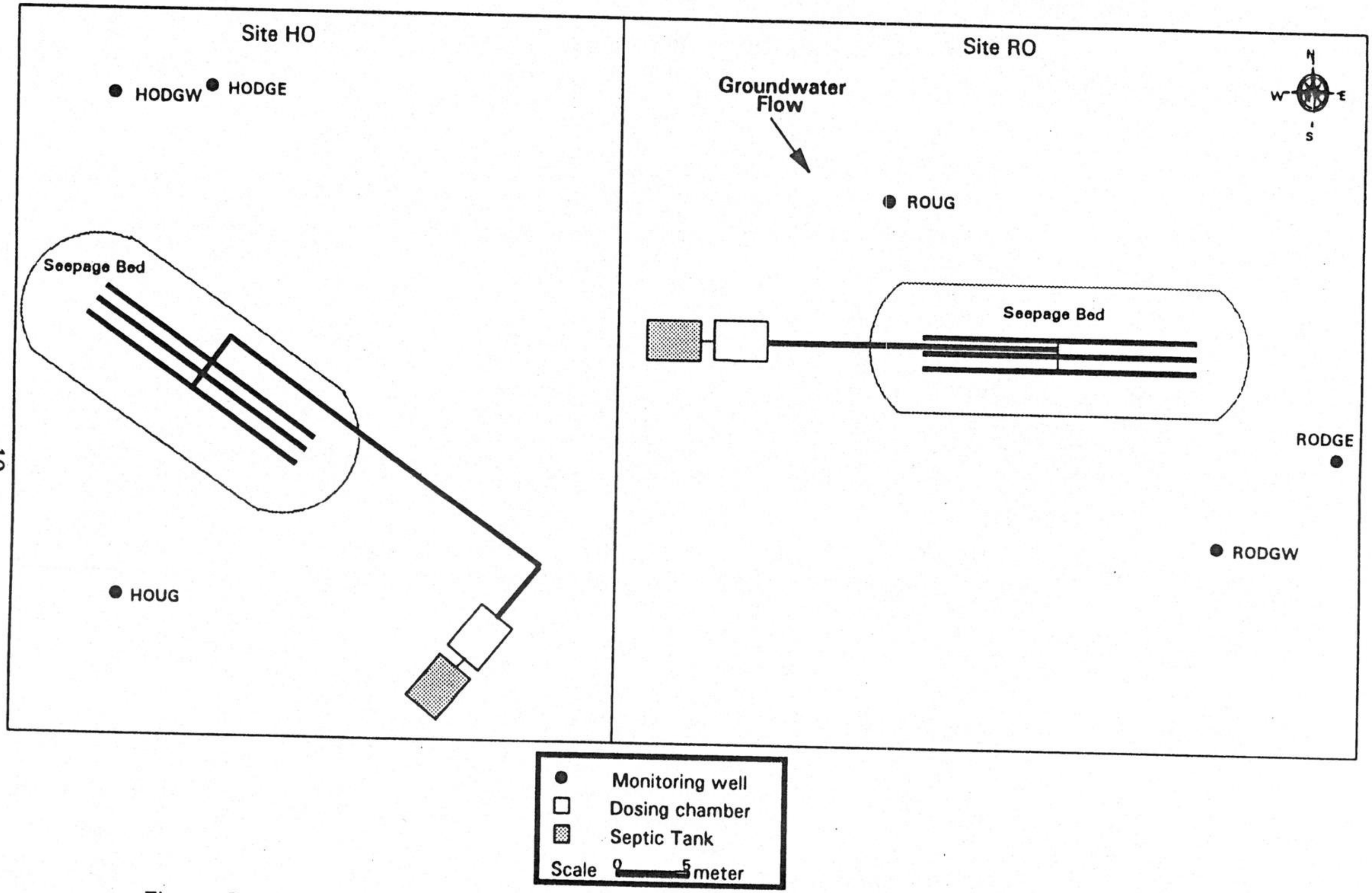


Figure 3. Plan view maps of single family pressurized mound systems, sites HO and RO.

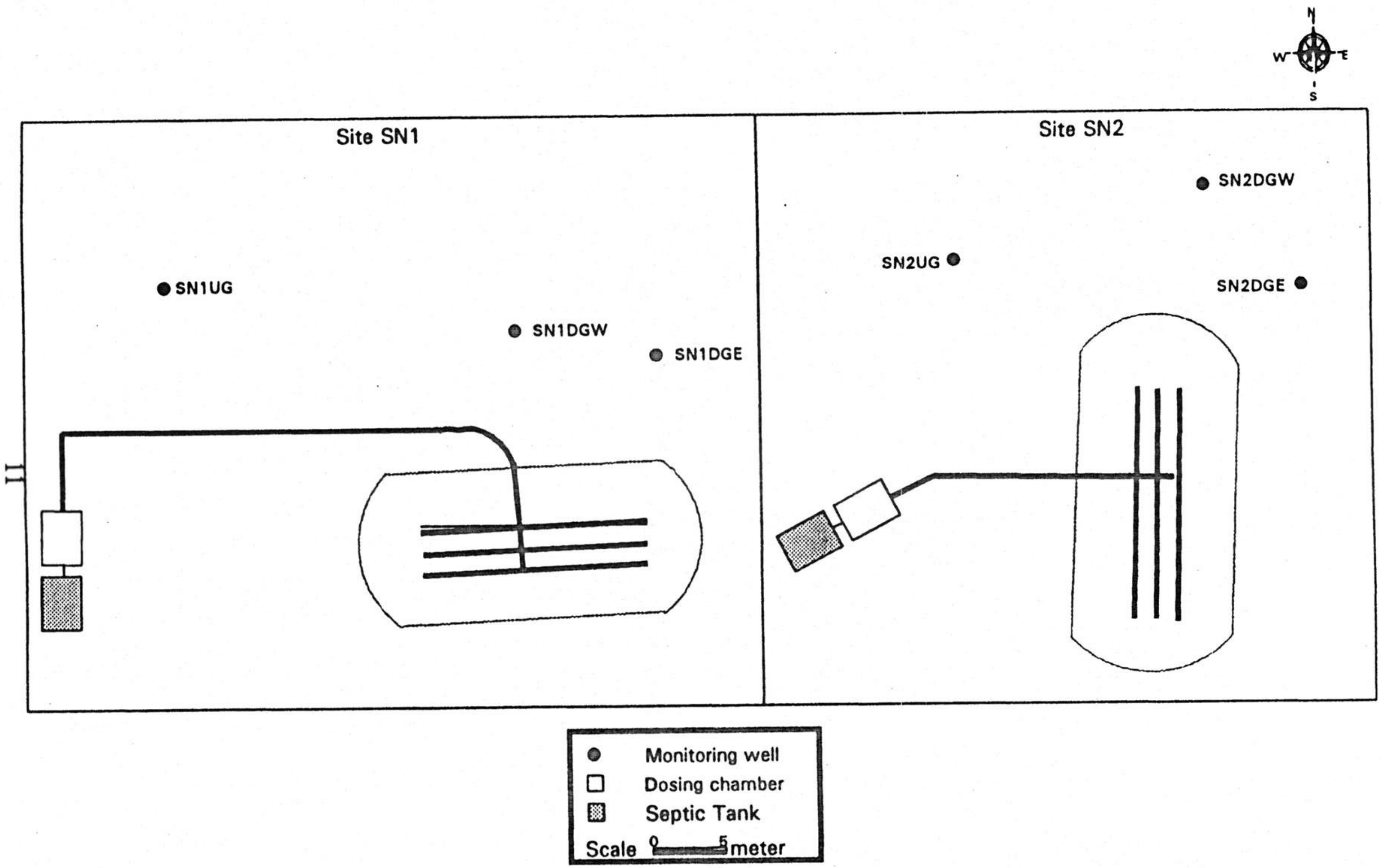


Figure 4. Plan view maps of single family pressurized mound systems, sites SN1 and SN2.

Site SN1 is located just west of site SN2 (Figure 4). The two lots are separated by a small forested area. This system was installed in August 1983, and was last pumped out in October 1991. Site HO (Figure 3) is located several miles west of site SN1. Hay fields are located in the north and west parts of this lot. The mound system was installed in June 1984, and the septic tank was last pumped out in the fall of 1990. We were unable to obtain dosing chamber effluent samples from this site, as the dosing chamber cover was inaccessible.

At Grade Pressure Systems

There were two sites in the study representing at grade pressure systems. These sites, HA and ST (Figure 5), are located adjacent to one another, but the seepage beds are oriented in different directions. This demonstrates different orientations with relation to the direction of the groundwater flow. HA is perpendicular to the flow and ST is diagonal to the groundwater flow. The background groundwater upgradient of both sites is quite high in chloride, sodium and fluorescence. The background average groundwater chemical concentrations at site HA are as follows; 112.9 mg/l chloride, 64.3 mg/l sodium, and a fluorescence of 57.7. The background groundwater chemical concentrations at site ST are 92.5 mg/l, 50.5 mg/l and 43.7, respectively. Both systems were installed in November 1987. The system designs both include two 3780 liter septic tanks placed in series before the dosing chamber.

Site HA is a rental unit, so the number of occupants and water use details varied during the study. Although site ST is a year round three bedroom home, the residents spend all winter and much of summer away from this home.

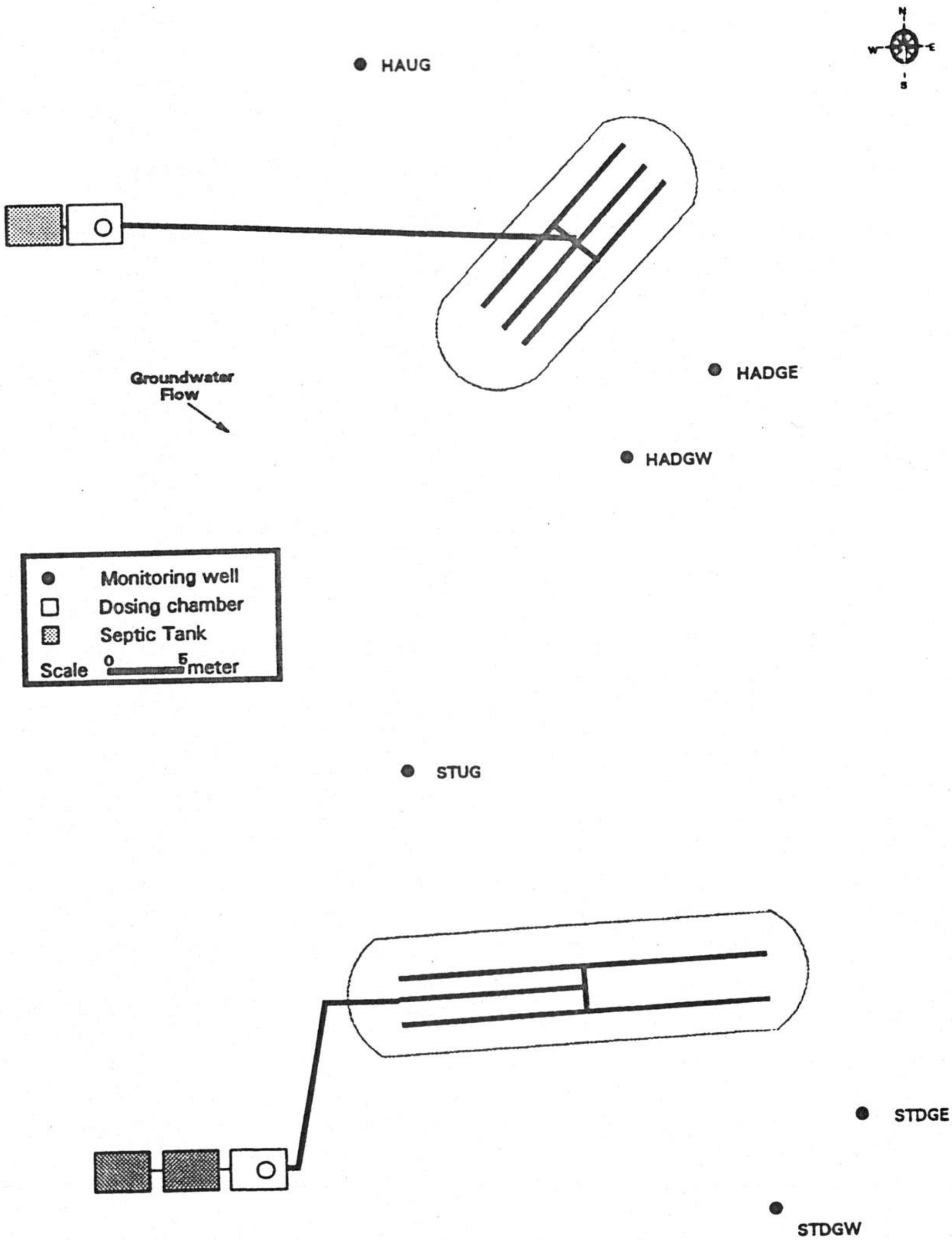


Figure 5. Plan view maps of single family at grade pressure systems, sites HA and ST.

In Ground Pressure Systems

Single family in ground pressure systems were represented at two sites, PO and RU (Figure 6). Site RU is on a large lot surrounded by a small pine plantation. The septic system was installed in July 1988. The dual 3780 liter septic tanks are in a series configuration, prior to the dosing chamber. The septic tanks were pumped for the first time in the fall of 1991.

Site PO is also located on a large lot, with a corn field adjacent to the west. The system was constructed in December 1986. The septic tank was last pumped in August 1991.

MULTIPLE FAMILY SEPTIC SYSTEMS

The multiple family septic systems in this study are all located in the same 233 unit, 80 acre mobile home community. Each septic system services four to eight mobile homes, with the average number of occupants ranging from 10 to 21 individuals. The septic tanks and dosing chambers are pumped out annually in June. Laundry washing machines are not permitted in any of the mobile homes, although there is a laundromat located on the grounds. This laundry gray water is disposed of on the land in a wooded area located on the west end of the park. The groundwater gradient in the park averages 0.1667 ft/100 feet, and generally flows in a southeastern direction.

General layout of the mobile home community and the septic systems included in this study can be seen in Figure 7, followed by detailed maps of each septic system with the monitoring well locations (Figures 8 to 11). The three pressurized mound

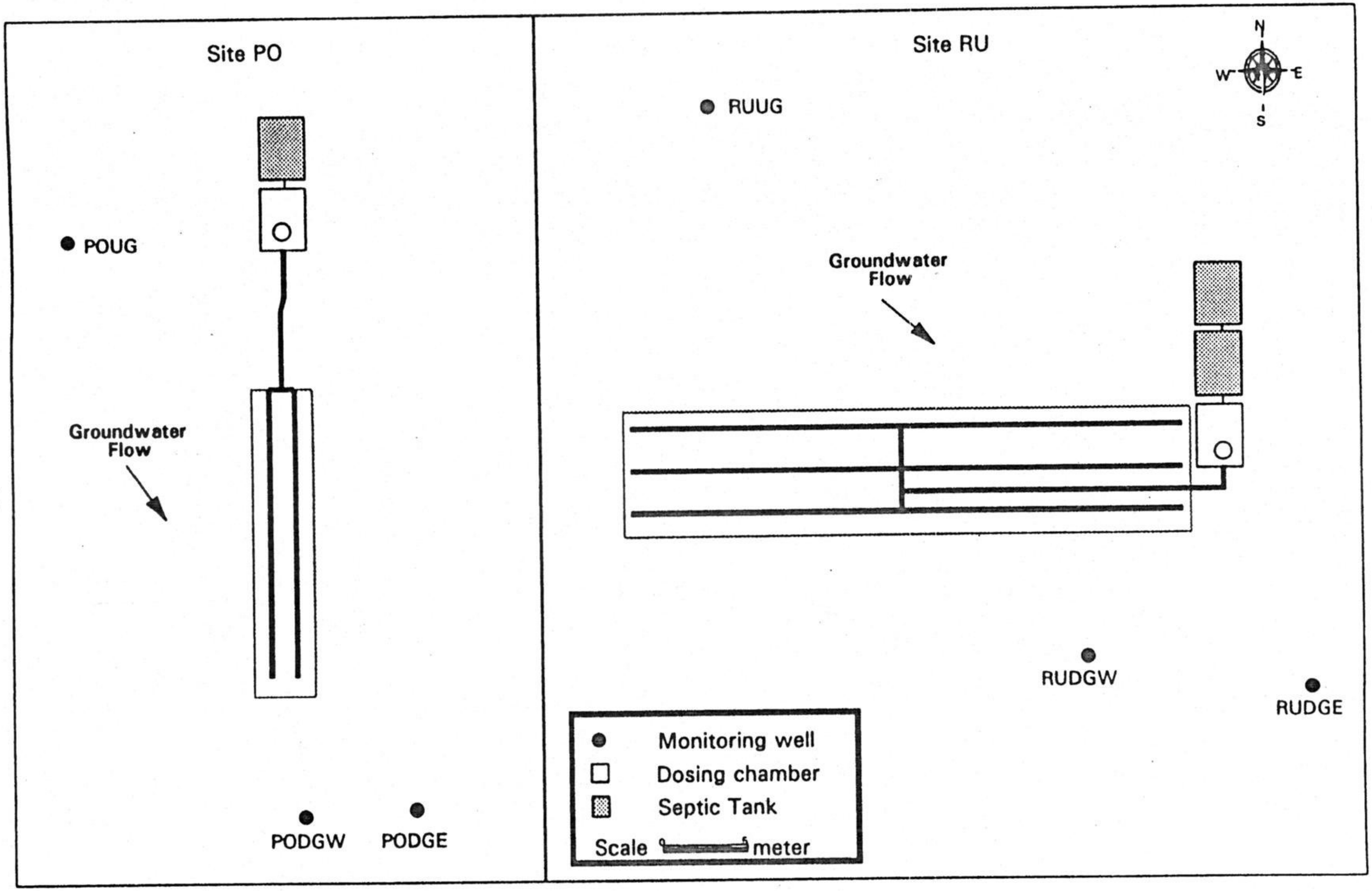


Figure 6. Plan view maps of single family in ground pressure systems, sites PO and RU.

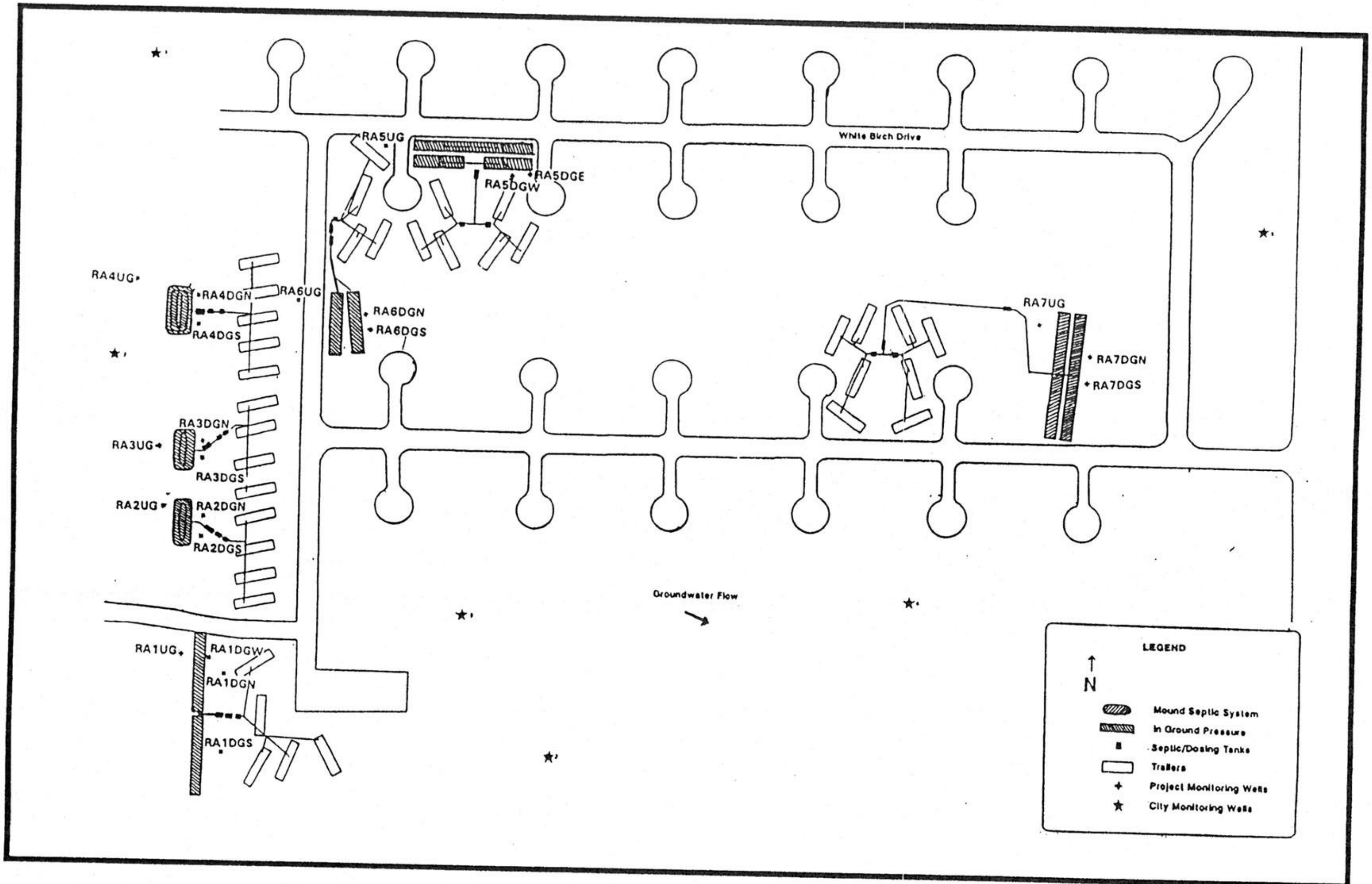


Figure 7. Plan view map of the multiple family septic system study sites.

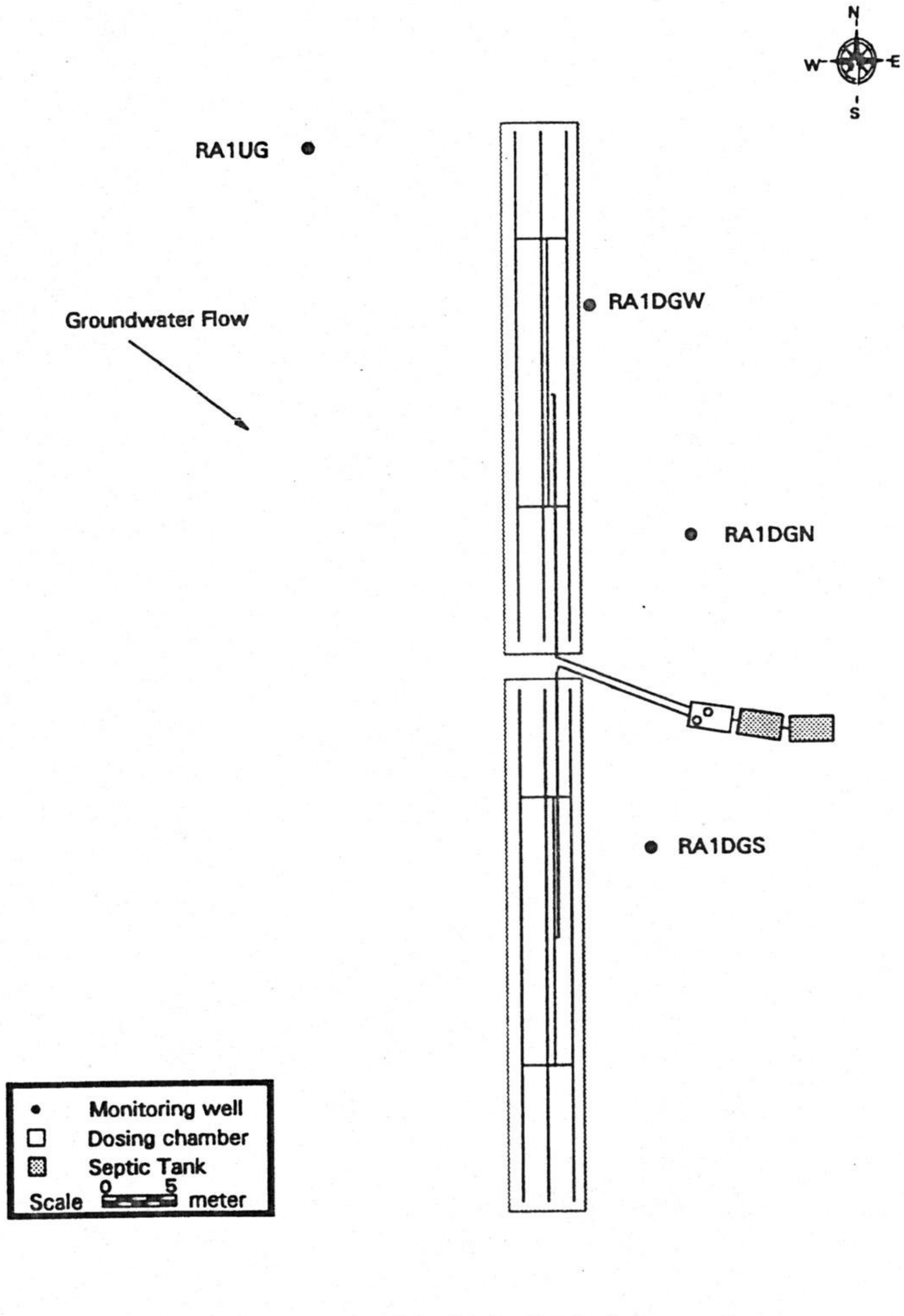


Figure 8. Plan view map of multiple family in-ground pressure system, site RA1.

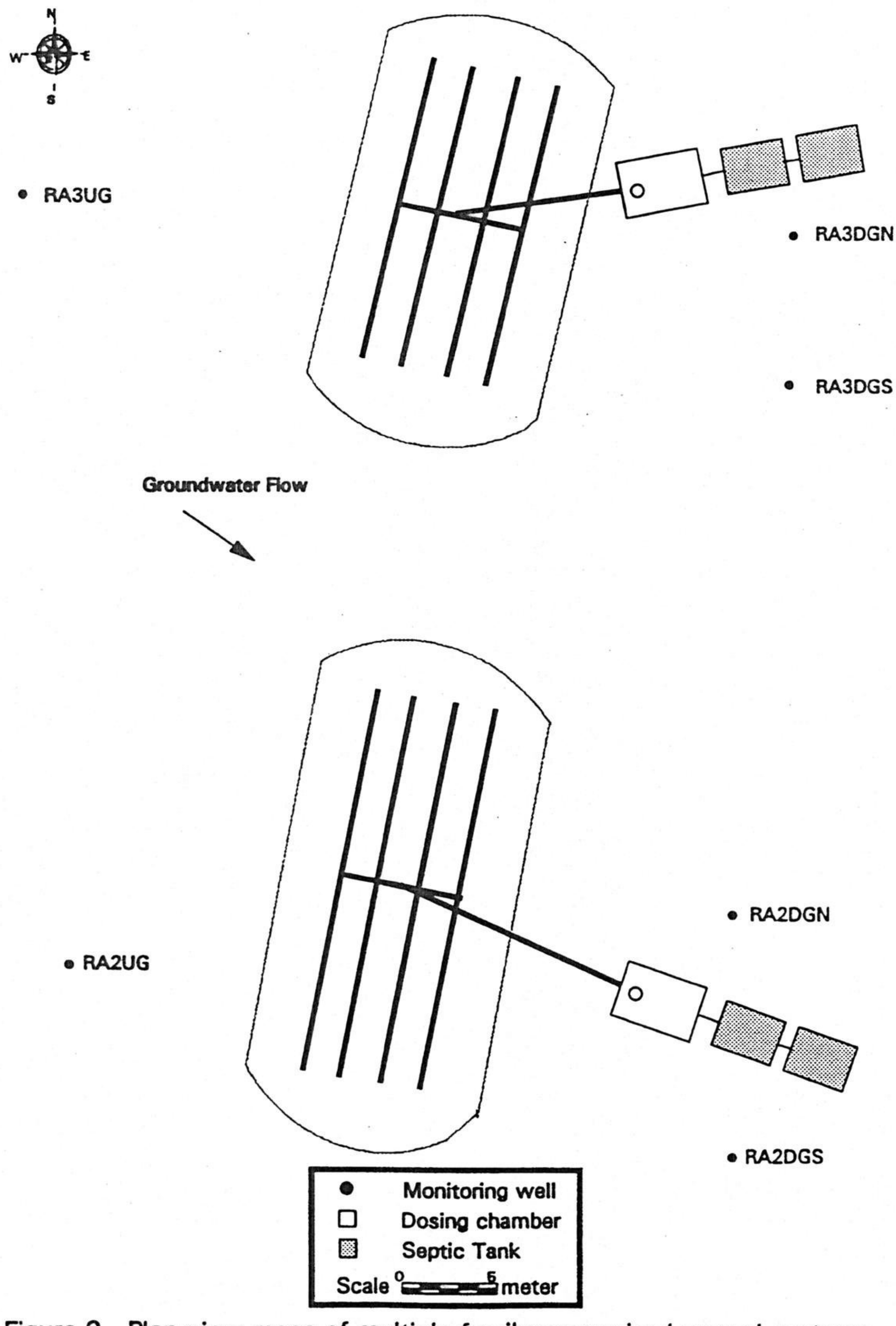


Figure 9. Plan view maps of multiple family pressurized mound systems, sites RA2 and RA3.

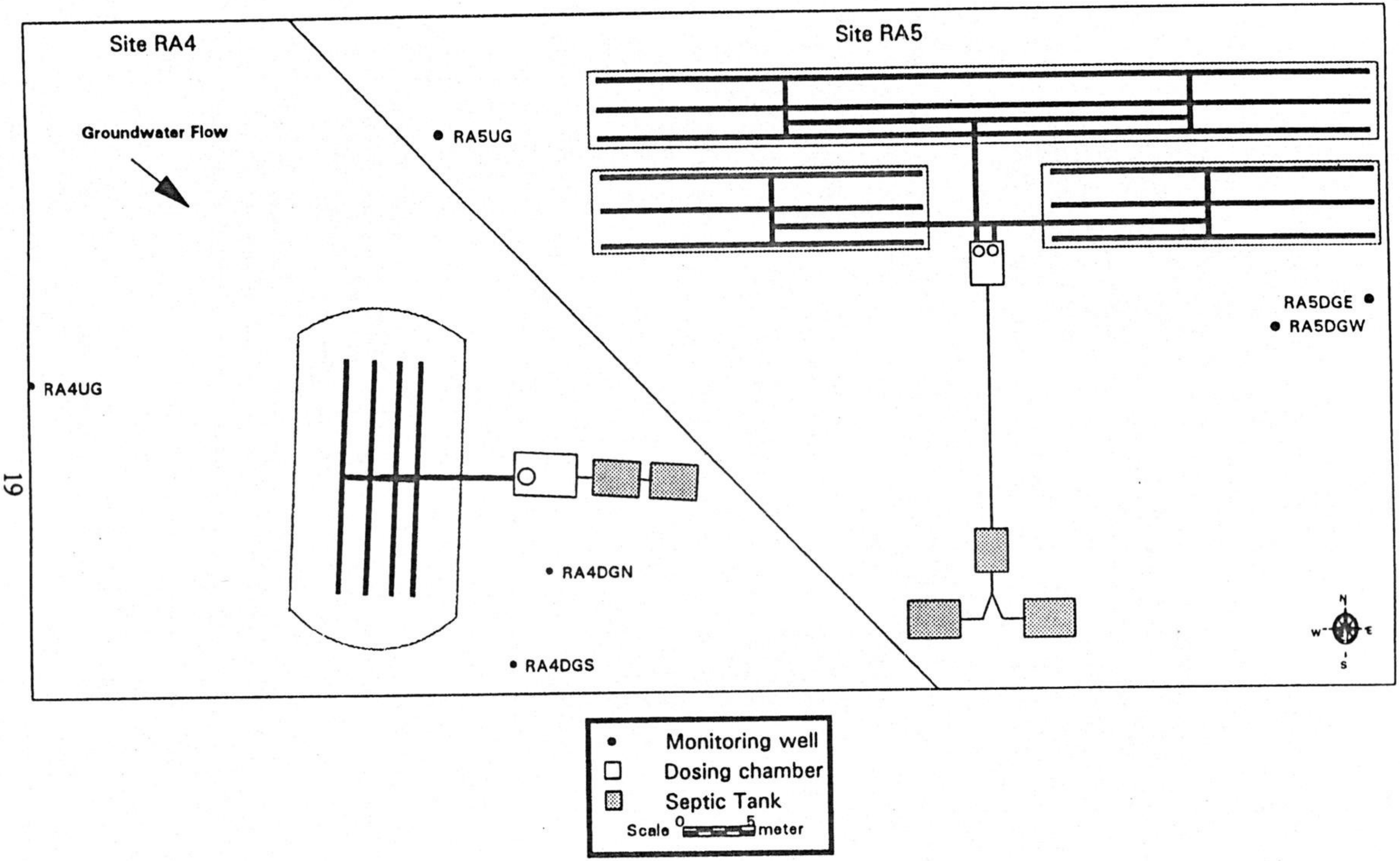


Figure 10. Plan view map of multiple family pressurized mound system at site RA4, and in ground pressure system at site RA5.

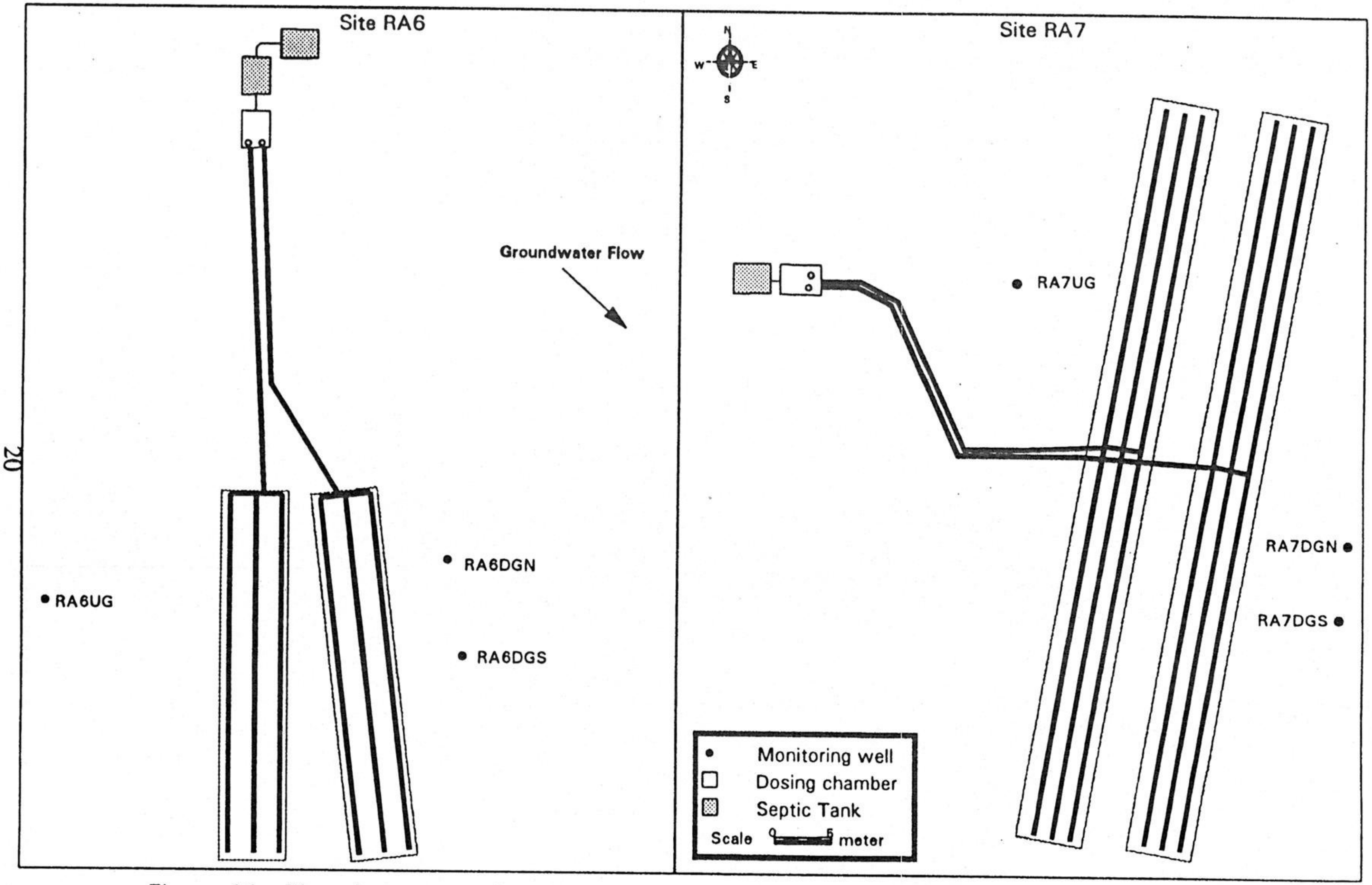


Figure 11. Plan view maps of multiple family in ground pressure systems-sites RA6 and RA7.

systems in the study which are located in the park (Sites RA2, RA3, and RA4) are all parallel to one other, and adjacent to the far west side of the park. RA1, one of the in ground pressurized systems is located due south of these systems, also adjacent to the wooded area. RA6, another in ground pressurized system is located east of the mound systems, with another in ground pressurized system (RA5) study site north east of RA6. The final in ground pressurized system in the study is located on the far east end of the park, site RA7. The multiple bed in ground and at grade systems have two different effluent distribution schemes; at sites RA1, 6 and 7 the effluent is pumped alternately to one of the drainfields, whereas at site RA5, the effluent is distributed to all drainfields at each pump cycle.

MATERIALS AND METHODS

Initial Contaminant Plume Investigation

Water table elevation maps by the Wisconsin Geological and Natural History Survey (1981) were reviewed to determine general groundwater flow direction in the area. Piezometers were installed at each study site to determine the actual local groundwater flow direction. Groups of the study sites were surveyed to a common reference point. Groundwater levels were determined using an audible popper and tape measure. These data were translated into groundwater elevations, which were triangulated to ascertain the local groundwater flow direction.

The locations of the contaminant plumes resulting from the seepage beds were originally determined by boring into the saturated zone of the aquifer with a bucket auger and sampling the groundwater. Two to 11 borings were done around the downgradient perimeter of each seepage bed. Preliminary groundwater samples were obtained by placing PVC test wells into the boreholes and extracting the sample with a peristaltic pump. Electrical conductivity was determined using a field conductivity meter. A high conductivity reading compared to upgradient wells was used to indicate the presence of the contaminant plume generated by the seepage bed. Downgradient multilevel wells were then installed in/near the boreholes which revealed high field conductivities.

Installation of Monitoring Wells

The upgradient monitoring wells consisted of a nest of the piezometer, a 3.2 cm (1.25 inch) inside diameter (I.D.) PVC well with a 0.91 m (3 feet) long slotted screen, and a 1.9 cm (0.75 inch) I.D. PVC well with a 0.46 m (1.5 feet) long slotted screen. The piezometers were constructed from a 3.2 cm I.D. PVC well and a 0.91 m slotted screen. The piezometer was placed 1.8 m into the aquifer, while the smaller well was placed with half of its screen above the water table.

The downgradient monitoring wells were multilevel well nests consisting of four 1.9 cm I.D. PVC wells with 0.46 m slotted screens. Sites HO, RA5, RA6, and RA7 were constructed with 0.61 m intervals between the tops of the screens on each well in the series. The remaining sites (HA, PO, RO, RU, SN1, SN2, ST, and RA1 to RA4) all had 0.46 m screen intervals. The shallowest well in each well nest was placed with half of the screen above the water table. This was to allow for fluctuation of the groundwater level, maintaining the ability to skim the upper layer of groundwater, where the seepage bed contamination frequently occurs.

Most well bore holes were excavated with a 7.6 cm bucket auger as deep into the aquifer as possible, usually 0.7 m. The wells were then driven to the desired depth and back filled with native subsoil to within 0.5 m of the surface. To prevent vertical channeling down the borehole, bentonite clay was used from 0.2 to 0.5 m below grade. The upper 0.2 m was filled with native soil.

Groundwater Sampling Techniques

Monitoring wells were sampled on a quarterly basis between September 1990 and June 1992. Samples were obtained using a peristaltic pump and polypropylene silicone tubing. Each well was purged with approximately three well volumes prior to the acquisition of the sample. Field filtering was accomplished by using in line

0.45 um membrane filters. In the laboratory the 250 ml polyethylene sample bottles were acid washed, then triple rinsed and filled with distilled water. In the field, the distilled water in the sample bottles was used to rinse sample equipment. The bottles were then double rinsed with the filtered sample water prior to filling, to insure a non diluted, representative sample. The samples were stored on ice during transport to the laboratory, where they were refrigerated.

Water table depth was measured using an audible popper attached to a measuring tape. The measuring tape was accurate to the hundredth of a foot.

In July 1991, eight wells were sampled for the presence of fecal coliform, total coliform, fecal streptococcus, and coliphage bacteriophages. The following describes the sterile methods and techniques utilized for this sampling. Individual rigid sampling tubes with silicone attachments were put into separate bags and autoclaved for 30 minutes. A disinfecting solution (100 mg/l chlorine bleach) was used to sterilize the monitoring wells (Norenberg, Standridge, 1990). This was done in the field two days prior to sampling, allowing for sufficient contact time with the solution. On the day of sampling, the remaining chlorine solution was removed by pumping a minimum of three well volumes with a peristaltic pump. The Idometric Method II (APHA, et. al., 1985) was used to check for any residual free available chlorine. Sterile sampling techniques were administered while extracting the groundwater samples with a peristaltic pump and pre-sterilized tubing. The samples were put into sterilized 250 ml polypropylene bottles that were prepared with the addition of 0.2 ml 0.25N sodium thiosulfate. The samples were transported on ice and set up for bacterial analysis at the Environmental Task Force. Coliphage analysis was done at the Food Research Institute at the University of Wisconsin-Madison.

Dosing Chamber Investigation

The volume and chemical properties of the effluent entering the seepage beds played an important role in determining the drainfield's ability to remove contaminants.

The volume of effluent entering the drainfield was determined in several steps. The volume of each dose was calculated by determining the high effluent level and the post pumping effluent level. The dose volume was then calculated using known dosing tank dimensions. This technique was utilized at sites HA, PO, RO, RU, SN1, SN2 and ST. When we were not able to determine the effluent levels, estimated dose volumes from the Portage County site inspection reports were utilized. At each site, a counter was connected to the pump switch to obtain the pumping frequency over a given time period.

Dosing Chamber Effluent Sampling Techniques

Effluent samples were collected by lowering a weighted 200 ml polyethylene sample cup into the dosing chamber. The sample was transferred into two, 125 ml polyethylene bottles, one was preserved with 1 ml concentrated sulfuric acid (H_2SO_4), and the other was not preserved. The preserved sample was used for analysis of the following; NO_2+NO_3-N, NH_4-N and Cl^-. Precautions were always taken when handling, transporting and analyzing this biohazardous material.

Water and Effluent Chemical Analysis

Water and effluent analyses were performed by the Environmental Task Force at the University of Wisconsin-Stevens Point.

Nitrate-N and chloride were analyzed on the Lachat Auto-Analyzer. Nitrate-N analysis used a sulfanilamide complex read at 520 nm (QuikChem Method No. 10-107-04-1-A). Chloride analysis used a ferricyanide ion read at 480 nm (QuikChem Method No. 10-117-07-1-A).

Ammonium-N, total Kjeldahl nitrogen (TKN), total phosphorous (TP), reactive phosphorous and sulfate were all accomplished with the Technicon Auto-Analyzer. TKN and ammonium-N were determined using an ammonium-salicylate reagent read at 60 nm (Industrial Method No. 329-74 W/B). Total and reactive phosphorous both used a phosphomolybdenum complex read at 880 nm (Industrial Method No. 329-74 W/B). The sulfate analyses used a methylthymol blue color reagent read at 460 nm (Sulfate Industrial Method No. 118-71 W/B).

Analytical techniques found in Standard Methods for the Examination of Water and Wastewater (APHA et al, 1985) were followed in the analyses for alkalinity, total hardness, fecal coliform, total coliform, fecal streptococcus, chemical oxygen demand and biochemical oxygen demand (BOD). The BOD analysis used the five day method with a YSI dissolved oxygen meter.

Sodium and potassium analyses were done with a Varian AA475 Atomic Absorption spectrophotometer. Sodium was read at 589.0 nm and potassium was read at 766.5 nm. Fluorescence was analyzed with a Baird-Atomic Flouripoint, with the excitation scan beginning at 355 nm and emission at 425 nm. The pH was determined using a Corning electrode meter. An YSI conductivity cell was used in the determination of electrical conductivity of the samples.

RESULTS AND DISCUSSION

The data from the 15 sites is presented to focus on the following relationships which are related to wastewater produced by families and the impact on groundwater from disposal through (what are referred to as) alternative septic systems.

1. Average and maximum concentrations of nitrate-N and chloride in dosing chambers and groundwater.

2. Relationship between nitrogen loading and concentration found in dosing chambers to those found in groundwater.

3. Treatment differences between different system designs.

4. Variability and location of contaminant plume over time.

5. Water use and wastewater characteristics.

6. Factors influencing wastewater concentrations and plume dilution.

7. Variability of nitrate-N concentrations over time and depth in groundwater.

8. Loss of alkalinity and decrease in pH due to the formation of nitrate-N.

9. Recommendations for future research and monitoring well designs for drainfields to evaluate septic system input to groundwater.

Nitrate-N in Groundwater

Table 2 presents average and maximum concentrations of nitrogen in dosing chambers and the downgradient well ports determined to be in the contaminant plume. It is obvious from this data that all 15 systems studied resulted in nitrate-N concentrations in groundwater exceeding the 10 mg/l standard. There was however, a wide range of concentrations observed between systems, and over time and depth in groundwater for the individual systems.

Site Number	Average Nitrogen (mg/l) Effluent	Average Nitrogen (mg/l) Groundwater	Average N:N Ratio	Maximum Nitrogen (mg/l) Effluent	Maximum Nitrogen (mg/l) Groundwater	Maximum N:N Ratio	Average Chloride (mg/l) Effluent	Average Chloride (mg/l) Groundwater	Average Cl:Cl Ratio	Maximum Chloride (mg/l) Effluent	Maximum Chloride (mg/l) Groundwater	Maximum Cl:Cl Ratio
ST	76.1	35.9	2.1	92.0	108.0	0.9	141	47	3.0	168	105	1.6
PO	80.3	39.7	2.0	92.5	70.8	1.3	34	26	1.3	50	48	1.0
RU	79.7	21.2	3.8	174.0	44.2	3.9	139	44	3.1	139	50	2.8
RO	84.9	48.8	1.7	108.0	82.7	1.3	105	53	2.0	123	70	1.8
SN1	46.5	37.1	1.3	77.0	49.3	1.6	41	29	1.4	78	42	1.9
SN2	85.6	22.9	3.7	110.0	37.5	2.9	51	31	1.7	60	45	1.3
SF Average	**75.5**	**34.3**	**2.2**	**108.9**	**65.4**	**1.7**	**85.2**	**38.2**	**2.2**	**103.0**	**60.0**	**1.7**
SF Std. Dev.	**14.6**	**10.5**	**1.1**	**34.1**	**26.9**	**1.2**	**49.3**	**11.1**	**0.8**	**47.3**	**24.2**	**0.6**
RA1	105.0	33.3	3.2	142.0	70.0	2.0	76	33	2.3	100	65	1.5
RA2	69.2	30.9	2.2	90.0	77.4	1.2	40	25	1.6	50	37	1.4
RA3	76.0	37.7	2.0	90.0	57.0	1.6	44	30	1.5	58	46	1.3
RA4	71.4	33.5	2.1	88.0	55.0	1.6	45	23	1.9	50	38	1.3
RA5	57.4	26.9	2.1	78.0	39.1	2.0	38	23	1.7	59	54	1.1
RA6	51.2	27.8	1.8	65.0	53.3	1.2	37	22	1.7	52	33	1.6
RA7	68.3	26.4	2.6	85.5	50.2	1.7	48	21	2.3	61	50	1.2
MF Average	**71.2**	**30.9**	**2.3**	**91.2**	**57.4**	**1.6**	**46.9**	**25.3**	**1.9**	**61.4**	**46.1**	**1.3**
MF Std. Dev.	**17.2**	**4.2**	**0.4**	**24.1**	**12.7**	**1.9**	**13.4**	**4.3**	**0.3**	**17.6**	**11.2**	**0.2**
All-Average	**73.2**	**32.5**	**2.4**	**99.4**	**61.1**	**1.8**	**64.5**	**31.2**	**2.0**	**80.6**	**52.5**	**1.5**
All-Std. Dev.	**15.5**	**7.6**	**0.8**	**29.3**	**20.0**	**0.8**	**38.7**	**10.3**	**0.6**	**39.4**	**18.9**	**0.5**

SF = Single Family MF = Multiple Family
* Sites HA and HO concentrations were omitted from all averages.

Table 2. Comparison of average and maximum concentrations (mg/l) of Nitrogen and Chloride obtained from the dosing chamber and the contaminant plume in the groundwater monitoring wells.

Effluent Dilution by Groundwater

One means of estimating the extent of effluent dilution in groundwater is to compare chemical concentrations in dosing chambers to the values found in the contaminant plume. Chloride is an excellent chemical to use for this purpose, as it is not effected by chemical or biological reactions. Comparing average and maximum chloride in the groundwater contaminant plumes to the average and maximum chloride in dosing chambers gives some insight to the extent of mixing and dilution occurring in groundwater for each site (Table 2). Background chloride data had minimal effect except at sites HA and ST. Sites ST and RO had water softeners, which accounts for the much higher average chloride values in their dosing chambers. The average maximum chloride in dosing chambers (80.6 mg/l) divided by the average maximum values in contaminant plumes (52.5 mg/l) results in an estimated dilution factor of 1.5. Dividing the dosing chamber average chloride of 64.5 mg/l by the contaminant plume average value of 31.2 mg/l gives a dilution factor of 2.0. Dilution from rainfall induced recharge in the drainfield, and mixing with upgradient groundwater in the shallow aquifer apparently results in an initial dilution of septic system effluent of 1.5 to 2.0 based on this data. It can be assumed that other chemicals would be diluted similarly to chloride, as chloride is a very conservative chemical.

The ratios of total nitrogen in dosing chambers to nitrate-N in contaminant plumes are also presented in Table 2. While there is a considerable range of ratios observed for different sites, the average ratios for the project showed no statistical difference between nitrogen and chloride ratios, indicating the two chemicals behaved very similarly as they moved from the dosing chamber to groundwater. This is especially true for single family systems where the average ratios are identical. The multiple family system did show a slightly higher ratio for nitrogen than chloride, however this was not found to be statistically significant.

Treatment Differences Between Different System Designs

Table 3 presents the average nitrogen and chloride ratios for the different types of systems studied. There was no statistical difference found for the different systems when comparing the change in chloride and nitrogen concentrations between dosing chamber and contaminant plumes. This indicates that the different types of pressurized systems are accomplishing similar treatment, and result in similar concentrations of nitrogen and chloride reaching groundwater. As there was only one at grade system with usable groundwater data, we would hesitate to draw too many conclusions relating to at grade systems.

Denitrification

The question often arises as to the extent to which denitrification may occur in various septic system drainfields. We have attempted to evaluate the extent to which this may have occurred in this study by comparing the nitrogen to chloride ratios found in the dosing chambers to those found in the contaminant plume in the groundwater. If there was any significant loss of nitrogen by denitrification or volatilization from the drainfield, there should be an increase in the chloride to nitrogen ratio for groundwater, compared to that found in the dosing chamber. Table 4 presents these results with averages by system type. Table 5 presents the same data

Site Number	Average Nitrogen (mg/l) Effluent	Average Nitrogen (mg/l) Groundwater	Average N:N Ratio	Maximum Nitrogen (mg/l) Effluent	Maximum Nitrogen (mg/l) Groundwater	Maximum N:N Ratio	Average Chloride (mg/l) Effluent	Average Chloride (mg/l) Groundwater	Average Cl:Cl Ratio	Maximum Chloride (mg/l) Effluent	Maximum Chloride (mg/l) Groundwater	Maximum Cl:Cl Ratio
SF Average	75.5	34.3	2.2	108.9	65.4	1.7	85.2	38.2	2.2	103.0	60.0	1.7
SF Std. Dev.	14.6	10.5	1.1	34.1	26.9	1.2	49.3	11.1	0.8	47.3	24.2	0.6
MF Average	71.2	30.9	2.3	91.2	57.4	1.6	46.9	25.3	1.9	61.4	46.1	1.3
MF Std. Dev.	17.2	4.2	0.4	24.1	12.7	1.9	13.4	4.3	0.3	17.6	11.2	0.2
IG Average	73.7	29.2	2.5	106.2	54.6	1.9	62.0	28.2	2.2	76.8	50.0	1.5
IG Std. Dev.	19.3	6.4	3.0	42.4	13.2	3.2	40.8	8.8	4.6	35.5	10.3	3.4
M Average	72.3	35.2	2.2	93.8	59.8	1.7	54.3	31.7	1.7	69.8	46.3	1.5
M Std. Dev.	14.3	8.6	0.8	12.7	17.2	1.8	25.1	10.7	2.4	28.0	12.1	2.3
AG *	76.1	35.9	2.1	92.0	108.0	0.9	141.0	47.0	3.0	168.0	105.0	1.6
All-Average	73.2	32.5	2.3	99.4	61.1	1.8	64.5	31.2	2.0	80.6	52.5	1.5
All-Std. Dev.	15.5	7.6	2.0	29.3	20.0	0.8	38.7	10.3	0.6	39.4	18.9	0.5

System Types: AG = At Grade Pressurized System IG = In Ground Pressurized System M = Pressurized Mound System
SF = Single Family System MF = Multiple Family System
Sites HA and HO concentrations were omitted from all averages.
* AG is represented by 1 site.

Table 3. Summary of average and maximum concentrations (mg/l) of Nitrogen and Chloride obtained from dosing chamber effluent and the contaminant plume in the groundwater monitoring wells, by type of system, for single and multiple family units.

Site Number	System Type *	Dosing Chamber Effluent: Average Total-N	Average Chloride	Average Cl:N Ratio	Maximum Total-N	Maximum Chloride	Maximum Cl:N Ratio	Concentrations in Downgradient Monitoring Wells: Average NO3-N	Average Chloride	Average Cl:N Ratio	Maximum NO3-N	Maximum Chloride	Maximum Cl:N Ratio
ST	AG SF	76.1	141	1.9	92.0	168	1.8	35.9	47.0	1.3	108.0	105	1.0
PO	IG SF	80.3	34	0.4	92.5	50	0.5	39.7	25.7	0.6	70.8	48	0.7
RU	IG SF	79.7	139	1.7	174.0	139	0.8	21.2	44.2	2.1	44.2	50	1.1
RA1	IG MF	105.0	76	0.7	142.0	100	0.7	33.3	32.5	1.0	70.0	65	0.9
RA5	IG MF	57.4	38	0.7	78.0	59	0.8	26.9	22.9	0.9	39.1	54	1.4
RA6	IG MF	51.2	37	0.7	65.0	52	0.8	27.8	22.4	0.8	53.3	33	0.6
RA7	IG MF	68.3	48	0.7	85.5	61	0.7	26.4	21.2	0.8	50.2	50	1.0
IG Average		**73.7**	**62.0**	**0.8**	**106.2**	**76.8**	**0.7**	**29.2**	**28.2**	**1.0**	**54.6**	**50.0**	**1.0**
IG Std. Dev.		**19.3**	**40.8**	**0.5**	**42.4**	**35.5**	**0.1**	**6.4**	**8.8**	**0.5**	**13.2**	**10.3**	**0.3**
HO	M SF	N/A	N/A	N/A	N/A	N/A	N/A	16.6	14.1	0.8	28.5	33	1.2
RO	M SF	84.9	105	1.2	108.0	123	1.1	48.8	52.6	1.1	82.7	70	0.8
SN1	M SF	46.5	41	0.9	77.0	78	1.0	37.1	28.9	0.8	49.3	42	0.9
SN2	M SF	85.6	51	0.6	110.0	60	0.5	22.9	30.7	1.3	37.5	45	1.2
RA2	M MF	69.2	40	0.6	90.0	50	0.6	30.9	24.9	0.8	77.4	37	0.5
RA3	M MF	76.0	44	0.6	90.0	58	0.6	37.7	30.1	0.8	57.0	46	0.8
RA4	M MF	71.4	45	0.6	88.0	50	0.6	33.5	23.1	0.7	55.0	38	0.7
Mound Average		**72.3**	**54.3**	**0.8**	**93.8**	**69.8**	**0.7**	**35.2**	**31.2**	**0.9**	**61.1**	**52.5**	**0.9**
Mound Std. Dev.		**14.3**	**25.1**	**0.3**	**12.7**	**28.0**	**0.3**	**7.6**	**10.3**	**1.4**	**20.0**	**18.9**	**0.9**
Average All Sites		**73.2**	**64.5**	**0.9**	**99.4**	**80.6**	**0.8**	**32.5**	**31.2**	**0.9**	**61.1**	**52.5**	**0.9**
Std. Dev. All Sites		**15.5**	**38.7**	**2.5**	**29.3**	**39.4**	**1.3**	**7.6**	**10.3**	**1.4**	**20.0**	**18.9**	**0.9**

* System Types: AG = At Grade Pressure System IG = In Ground Pressure System M = Pressurized Mound System
SF = Single Family System MF = Multiple Family System

Averages may include well ports not in the contaminant plume.

Site HO was omitted from all averages.

Table 4. Summary of Nitrogen and Chloride concentrations (mg/l) and Nitrogen:Chloride ratios in dosing chamber effluent and the contaminant plume in the groundwater monitoring wells. Data organized and averaged by system type.

Site Number	System Type *	Dosing Chamber Effluent: Average Total-N	Average Chloride	Average Cl:N Ratio	Maximum Total-N	Maximum Chloride	Maximum Cl:N Ratio	Concentrations in Downgradient Monitoring Wells: Average NO3-N	Average Chloride	Average Cl:N Ratio	Maximum NO3-N	Maximum Chloride	Maximum Cl:N Ratio
ST	AG SF	76.1	141	1.9	92.0	168	1.8	35.9	47.0	1.3	108.0	105	1.0
PO	IG SF	80.3	34	0.4	92.5	50	0.5	39.7	25.7	0.6	70.8	48	0.7
RU	IG SF	79.7	139	1.7	174.0	139	0.8	21.2	44.2	2.1	44.2	50	1.1
RO	M SF	84.9	105	1.2	108.0	123	1.1	48.8	52.6	1.1	82.7	70	0.8
SN1	M SF	46.5	41	0.9	77.0	78	1.0	37.1	28.9	0.8	49.3	42	0.9
SN2	M SF	97.1	51	0.5	200.0	60	0.3	22.9	30.7	1.3	37.5	45	1.2
SF Average		**77.4**	**85.2**	**1.1**	**123.9**	**103.0**	**0.9**	**34.3**	**38.2**	**1.2**	**65.4**	**60.0**	**0.9**
SF Std. Dev.		**16.8**	**49.3**	**0.6**	**50.5**	**47.3**	**0.5**	**10.5**	**11.1**	**0.5**	**26.9**	**24.2**	**0.2**
RA1	IG MF	105.0	76	0.7	142.0	100	0.7	33.3	32.5	1.0	70.0	65	0.9
RA2	M MF	69.2	40	0.6	90.0	50	0.6	30.9	24.9	0.8	77.4	37	0.5
RA3	M MF	76.0	44	0.6	90.0	58	0.6	37.7	30.1	0.8	57.0	46	0.8
RA4	M MF	71.4	45	0.6	88.0	50	0.6	33.5	23.1	0.7	55.0	38	0.7
RA5	IG MF	57.4	38	0.7	78.0	59	0.8	26.9	22.9	0.9	39.1	54	1.4
RA6	IG MF	51.2	37	0.7	65.0	52	0.8	27.8	22.4	0.8	53.3	33	0.6
RA7	IG MF	68.3	48	0.7	85.5	61	0.7	26.4	21.2	0.8	50.2	50	1.0
MF Average		**71.2**	**46.9**	**0.7**	**91.2**	**61.4**	**0.7**	**30.9**	**25.3**	**0.8**	**57.4**	**46.1**	**0.8**
MF Std. Dev.		**17.2**	**13.4**	**0.1**	**24.1**	**17.6**	**0.1**	**4.2**	**4.3**	**0.1**	**12.7**	**11.2**	**0.3**
Ave.-all sites		**74.1**	**64.5**	**0.9**	**99.4**	**80.6**	**0.8**	**32.5**	**31.2**	**1.0**	**61.1**	**52.5**	**0.9**
Std. dev.-all sites		**15.5**	**38.7**	2.5	**29.3**	**39.4**	1.3	**7.6**	**10.3**	1.4	**20.0**	**18.9**	0.9

* System Types: AG = At Grade Pressurized System IG = In Ground Pressurized System M = Pressurized Mound System
SF = Single Family System MF = Multiple Family System

Averages may include well ports not in the contaminant plume.

Sites HA and HO were omitted from all averages.

Table 5. Summary of Nitrogen and Chloride concentrations (mg/l) and Nitrogen:Chloride ratios in dosing chamber effluent and the contaminant plume in the groundwater monitoring wells.
Data presented and averaged by single and multiple family systems.

grouped by single and multiple families.

There was not any statistically significant difference between the nitrogen to chloride ratios for any of the system groupings evaluated, which indicates little or no loss of nitrogen as wastewater passes through the drainfields studied. The multiple family systems did show a more consistent decline in nitrogen relative to chloride between the dosing chamber and groundwater (Table 5). This may suggest some nitrogen loss associated with the higher hydraulic loading to multiple family systems.

Water Use and Wastewater Characteristics

Results from dosing chamber samples show a fairly wide range of water use and chemical loading to the septic systems studied (Tables 6 and 7). Per capita water use ranged from 97 to 327 liters (26 to 86 gallons) per day for single families. This range excludes site RO where gray water did not enter the septic system. Their water use averaged only 61 liters (16 gallons) per person per day. Multiple family water use averaged 133 liters (35 gallons) per person per day, compared to 155 liters (41 gallons) for the single family residences studied. Lower volumes may reflect the fact that clothes washers are not used in the homes of the multiple family systems.

Nitrogen loading from single families averaged 5.6 kg (12.4 pounds) per person per year compared to 4.5 kg (9.9 pounds) for individuals served by the multiple family systems. Site RO, with the elimination of gray water, showed only 2.5 kg (5.5 pounds) per person per year of nitrogen loading to the dosing chamber.

Average chemical concentrations for nitrogen and chloride from the dosing chambers are presented in Table 8. Other chemical analyses for the dosing chambers

Site ID	System Type *	Seepage Bed Orientation ~	Seepage Bed Area (sq. meters)	Dosing Chamber Ave. Total Dose Vol.(l)/Day	Water Use Number of Adults	Water Use Number of Children	Water Use Volume (l)/ Person/Day	Ave Total-N (mg/l) In Wastewater	Nitrogen g N/Person per Day	Nitrogen # N/Person per Year
Single Family										
HA	AG	Perpendicular	46	389	2	2	97	85.1	8.3	8.9
ST	AG	Diagonal	46	252	2	0	126	76.1	9.6	10.3
PO	IG	Parallel	46	219	2	0	110	80.3	8.8	9.4
RU	IG	Perpendicular	84	407	2	1	136	79.7	10.8	11.6
HO	M	Perpendicular	35	466	2	2	117	N/A	N/A	N/A
RO	M	Parallel	35	244	2	2	61++	84.9++	5.2++	5.5++
SN1	M	Parallel	35	982	2	1	327	46.5	15.2	16.3
SN2	M	Perpendicular	35	173	1	0	173	85.6	14.8	15.8
Average							**155**			**12.4**
Multiple Family										
RA2	M	Perpendicular	117	1,814	8	4	151	69.2	10.5	11.2
RA3	M	Perpendicular	93	1,641	7	6	126	76.0	9.6	10.3
RA4	M	Perpendicular	93	1,352	10	6	85	71.4	6.0	6.5
RA1	IG	Perpendicular	418	2,148	8	7	143	105.0	15.0	16.1
RA5	IG	Parallel	502	2,646	9	6	176	57.4	10.1	10.8
RA6	IG	Perpendicular	334	1,397	7	3	140	51.2	7.2	7.7
RA7	IG	Diagonal	670	2,272	14	7	108	68.3	7.4	7.9
Average							**133**			**9.9**
Overall Average							**144**			**10.3**

~ Orientation refers to the seepage bed orientation relative to the groundwater flow direction

* System Types: AG = At Grade Pressure System IG = In Ground Pressure System M = Pressurized Mound System

++Ommitted from average due to lack of grey water into the system.

Table 6. Septic system design, water use, and nitrogen loading data for single and multiple family alternative septic systems.

Site ID	System Type *	Septic Tank Number	Septic Tank Total Vol.(l)	Dosing Chamber Dose Volume (l)	Dosing Chamber Ave. Number Doses/Day	Dosing Chamber Ave. Total Dose Vol./Day(l)	Seepage Bed Orientation ~	Seepage Bed Area (sq. meters)	Number of Occupants	Water Use Vol./Person per Day (l)	Vol./Person per Day (gal)	Hydraulic Loading (l/m2)
HA	AG	2	7560	648	0.6	389	Perpendicular	46	4	97	26	8.5
ST	AG	2	7560	631	0.4	252	Diagonal	46	2	126	33	5.5
PO	IG	1	3785	438	0.5	219	Parallel	46	2	110	29	4.8
RU	IG	2	7560	679	0.6	407	Perpendicular	84	3	136	36	4.8
HO	M	1	3785	518	0.9	466	Perpendicular	35	4	117	31	13.3
RO	M	2	6615	611	0.4	244 ^	Parallel	35	4	61	16	7.0
SN1	M	1	3785	614	1.6	982	Parallel	35	3	327	87	28.1
SN2	M	1	3785	577	0.3	173	Perpendicular	35	1	173	46	5.0
RA2	M	2	9450	1512	1.2	1814	Perpendicular	117	12	151	40	15.5
RA3	M	2	7560	1172	1.4	1641	Perpendicular	93	13	126	33	17.6
RA4	M	2	7560	1230	1.1	1352	Perpendicular	93	16	85	22	14.5
RA1	IG	2	9450	1652	1.3	2148	Perpendicular	418	15	143	38	5.1
RA5	IG	3	15120	1890	1.4	2646	Parallel	502	15	176	47	5.2
RA6	IG	2	9450	1996	0.7	1397	Perpendicular	334	10	140	37	4.2
RA7	IG	3	15120	2272	1.0	2272	Diagonal	670	21	108	29	3.4

* System Types: AG = At Grade Pressurized System
IG = In Ground Pressurized System
M = Mound System

~ Orientation refers to the seepage bed orientation relative to the groundwater flow direction.

^ Does not include gray water.

Table 7. Alternative septic system design and water use data for single and multiple family systems.

Site Number	System Type *	Doseing Chamber Effluent: Average Total-N	Average Chloride	Average Cl:N Ratio	Maximum Total-N	Maximum Chloride	Maximum Cl:N Ratio	Concentrations in Downgradient Monitoring Wells: Average NO3-N	Average Chloride	Average Cl:N Ratio	Maximum NO3-N	Maximum Chloride	Maximum Cl:N Ratio
ST	AG SF	76.1	141	1.9	92.0	168	1.8	35.9	47.0	1.3	108.0	105	1.0
PO	IG SF	80.3	34	0.4	92.5	50	0.5	35.6	22.8	0.6	70.8	48	0.7
RU	IG SF	79.7	139	1.7	174.0	139	0.8	15.3	24.9	1.6	44.2	50	1.1
RA1	IG MF	105.0	76	0.7	142.0	100	0.7	33.3	32.5	1.0	70.0	65	0.9
RA5	IG MF	57.4	38	0.7	78.0	59	0.8	22.6	21.1	0.9	39.1	54	1.4
RA6	IG MF	51.2	37	0.7	65.0	52	0.8	21.9	18.3	0.8	53.3	33	0.6
RA7	IG MF	68.3	48	0.7	85.5	61	0.7	19.4	16.3	0.8	50.2	50	1.0
HO	M SF	N/A	N/A	N/A	N/A	N/A	N/A	28.9	13.5	0.5	28.5	33	1.2
RO	M SF	84.9	105	1.2	108.0	123	1.1	46.7	50.4	1.1	82.7	70	0.8
SN1	M SF	46.5	41	0.9	77.0	78	1.0	36.6	28.4	0.8	49.3	42	0.9
SN2	M SF	85.6	51	0.6	110.0	60	0.5	18.4	25.0	1.4	37.5	45	1.2
RA2	M MF	69.2	40	0.6	90.0	50	0.6	26.5	21.4	0.8	77.4	37	0.5
RA3	M MF	76.0	44	0.6	90.0	58	0.6	34.5	27.4	0.8	57.0	46	0.8
RA4	M MF	71.4	45	0.6	88.0	50	0.6	30.7	21.0	0.7	55.0	38	0.7
Average	**ALL**	**73.2**	**64.5**	**0.9**	**99.4**	**80.6**	**0.8**	**29.0**	**27.4**	**0.9**	**61.1**	**52.5**	**0.9**
Std. Dev.	**ALL**	**15.5**	**38.7**	**2.5**	**29.3**	**39.4**	**1.3**	**9.1**	**10.4**	**1.1**	**20.0**	**18.9**	**0.9**

* System Types: AG = At Grade Pressurized System IG = In Ground Pressurized System M = Pressurized Mound System
SF = Single Family System MF = Multiple Family System

Averages may include well ports not in the contaminant plume.

Site HA was omitted from all averages due to high background concentrations of Chloride.

Site HO was omitted from all averages.

Table 8. Summary of nitrogen and chloride concentrations (mg/l) and nitrogen:chloride ratios in dosing chamber effluent and the upper 2 m of the groundwater monitoring wells.

are presented in the Appendix, and include pH, specific conductivity, alkalinity, total hardness, total phosphorous, and for some samples total suspended solids, COD, BOD_5, reactive phosphorous and sodium.

Factors Effecting Wastewater Concentration and Plume Dilution

Factors that may account for the difference in dosing chamber concentrations and those found in the contaminant plume are presented in Table 9. Sites RU, SN2 and RA1 had the highest ratio of effluent to plume nitrogen concentrations. These sites all had drainfields laid out perpendicular to groundwater flow and all had relatively low hydraulic loading to the soils. These conditions appear to allow for the greatest reduction in nitrogen concentrations by allowing for mixing with upgradient groundwater and producing a larger but more dilute contaminant plume. By contrast, the system at site SN1 had an orientation parallel to the groundwater flow direction and very high hydraulic loading that allowed for minimal dilution of the effluent as it entered groundwater.

High hydraulic loading rates are likely to produce a plume that has less opportunity to mix with upgradient groundwater. This is especially true if the drainfield is oriented parallel to the direction of groundwater flow. Figures 3 to 11 show the drainfield, groundwater flow direction and monitoring well layout for each study site.

Site ID	System Type *	Drainfield Orientation	Hydraulic Loading (l/m2)	Effluent Average N (mg/l)	Contam. Plume Average N (mg/l)	N Ratio ^
HA	AG	Perpendicular	8.5	85.1	16.1	5.3
ST	AG	Diagonal	5.5	76.1	35.9	2.1
PO	IG	Parallel	4.8	80.3	39.7	2.0
RU	IG	Perpendicular	4.9	79.7	21.2	3.8
HO	M	Perpendicular	13.0	N/A	16.6	N/A
RO	M	Parallel	7.0	84.9	48.8	1.7
SN1	M	Parallel	28.0	46.5	37.1	1.3
SN2	M	Perpendicular	4.9	85.6	22.9	3.7
RA2	M	Perpendicular	15.5	69.2	30.9	2.2
RA3	M	Perpendicular	17.6	76.0	37.7	2.0
RA4	M	Perpendicular	14.5	71.4	33.5	2.1
RA1	IG	Perpendicular	5.1	105.0	33.3	3.2
RA5	IG	Parallel	5.2	57.4	26.9	2.1
RA6	IG	Perpendicular	4.2	51.2	27.8	1.8
RA7	IG	Diagonal	3.4	68.3	26.4	2.6

* System Types: AG = At Grade Pressure IG = In Ground Pressure M = Mound

~ Orientation refers to the seepage bed orientation in relation to the groundwater flow direction

^ Dosing chamber effluent average N : Groundwater contaminant plume average N

Table 9. Average Nitrogen concentrations by site and site factors relating to dilution of effluent in groundwater.

Variability of Nitrate-N Concentrations Over Time and Depth in Groundwater

Figure 12 presents the mean and range of nitrate-N concentrations found over time in the groundwater plumes for all 15 sites and the groundwater table fluctuation over the same time period.

The larger decrease in mean nitrogen concentrations, observed in the May 1991 sampling, corresponds to a 0.7 meter rise in groundwater elevations from the spring recharge. The highest nitrate-N concentrations were observed in the fall and winter of 1990 following a dry period with minimal recharge.

These data suggest that the time of year when shallow monitoring wells are sampled can result in widely different groundwater chemical concentrations. Figures 13-27 present data over time for each site, showing the nitrate-N concentrations with depth for each nested downgradient well in addition to the upgradient well.

The wide variability of groundwater chemistry that occurs with depth and between two nearby nested wells that were initially located in the contaminant plume is demonstrated by these data. In addition, these data show clearly that these plumes are often vertically fairly thin, and are not uniform in their chemistry over the entire width of the drainfield. Plumes often occurred in only one or two well ports of the nested downgradient wells, while in other cases they extended over the entire 2 meter monitored depth, and may have extended a meter or more deeper than our monitoring network. The depth of the center of the plume into groundwater for each site is presented in Table 10. Well distance from the drainfield, drainfield orientation and hydraulic loading are also presented in Table 10. These data did not show a

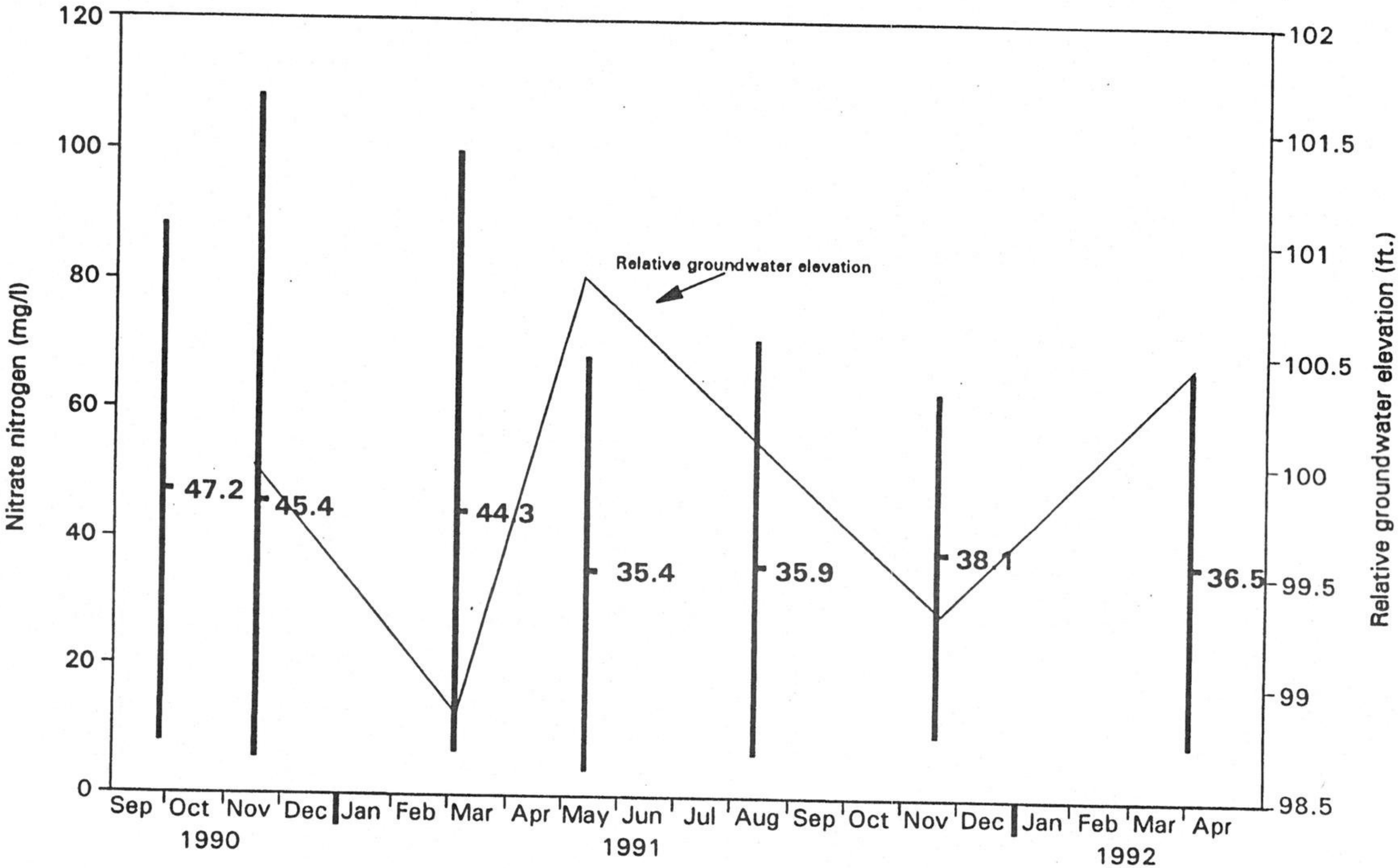


Figure 12. Mean and Range of maximum groundwater nitrate-N concentrations for all 15 sites for 7 sampling dates compared to standardized relative groundwater elevations representative of most study sites.

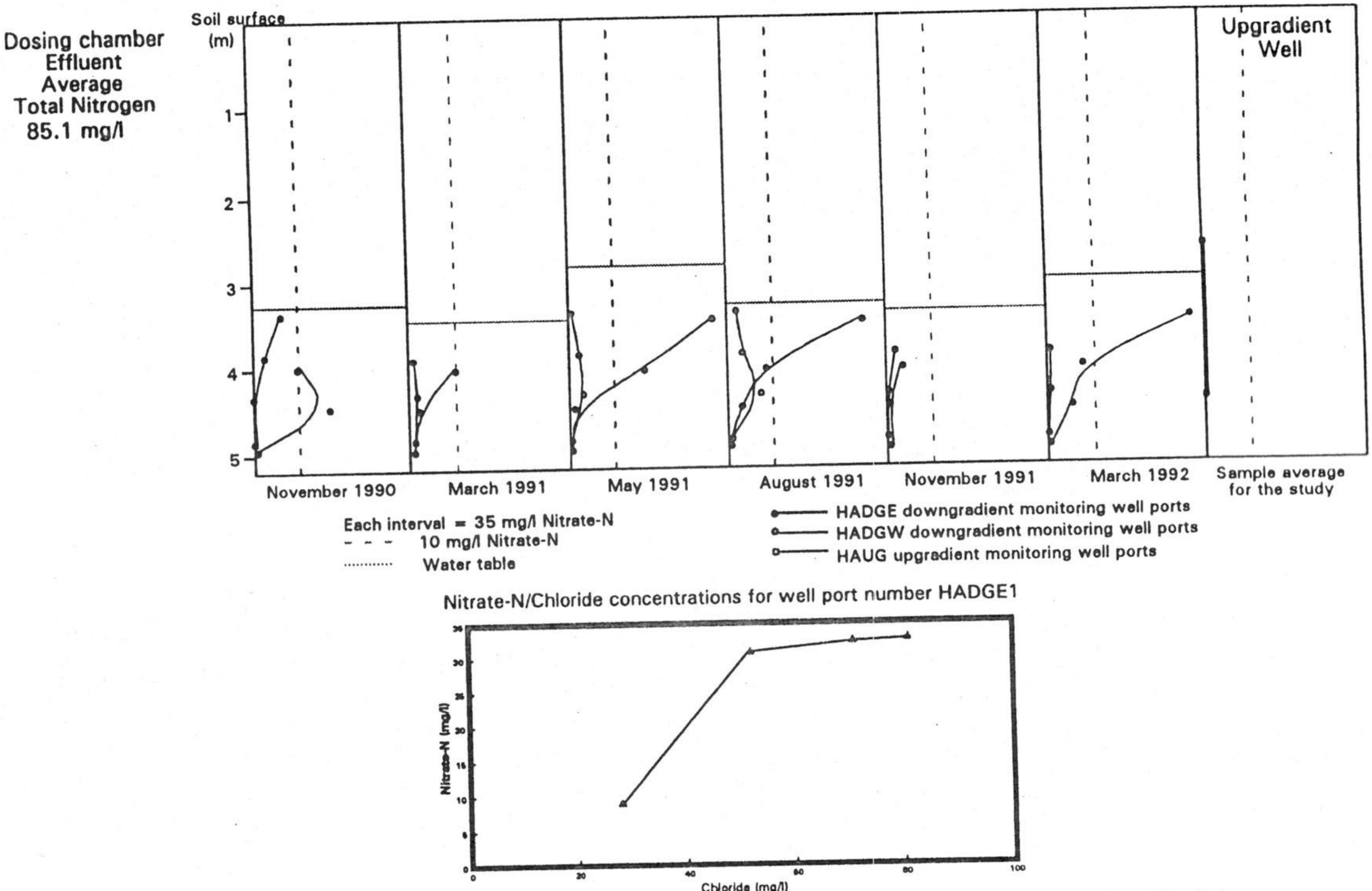


Figure 13. Profile of Nitrate-N concentrations (mg/l) for the At Grade Pressure System at Site HA for each downgradient well port,and the average for all samples from the upgradient well.

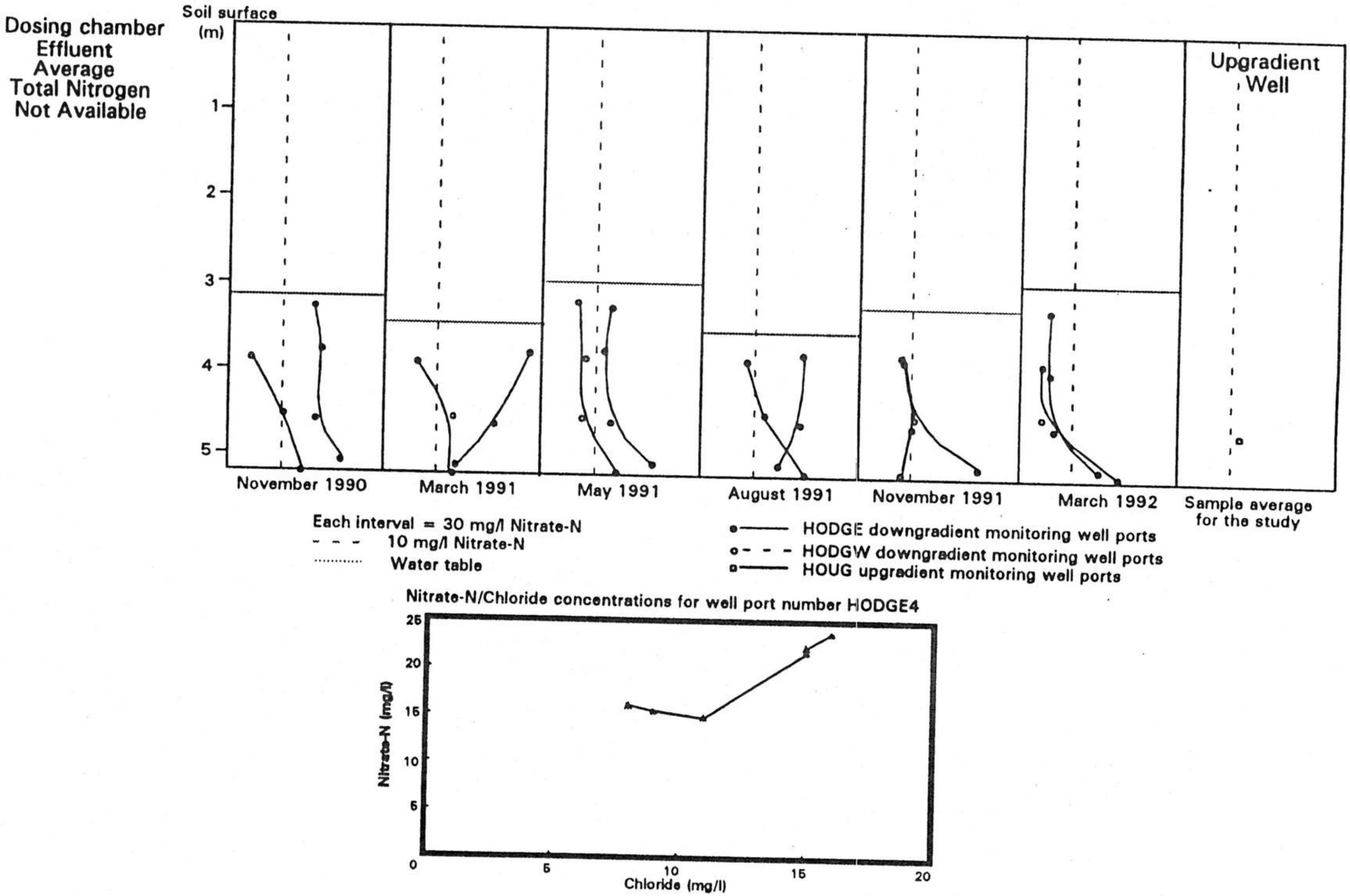


Figure 14. Profile of Nitrate-N concentrations (mg/l) for the Mound System at Site HO for each downgradient well port and the average for all samples from the upgradient well.

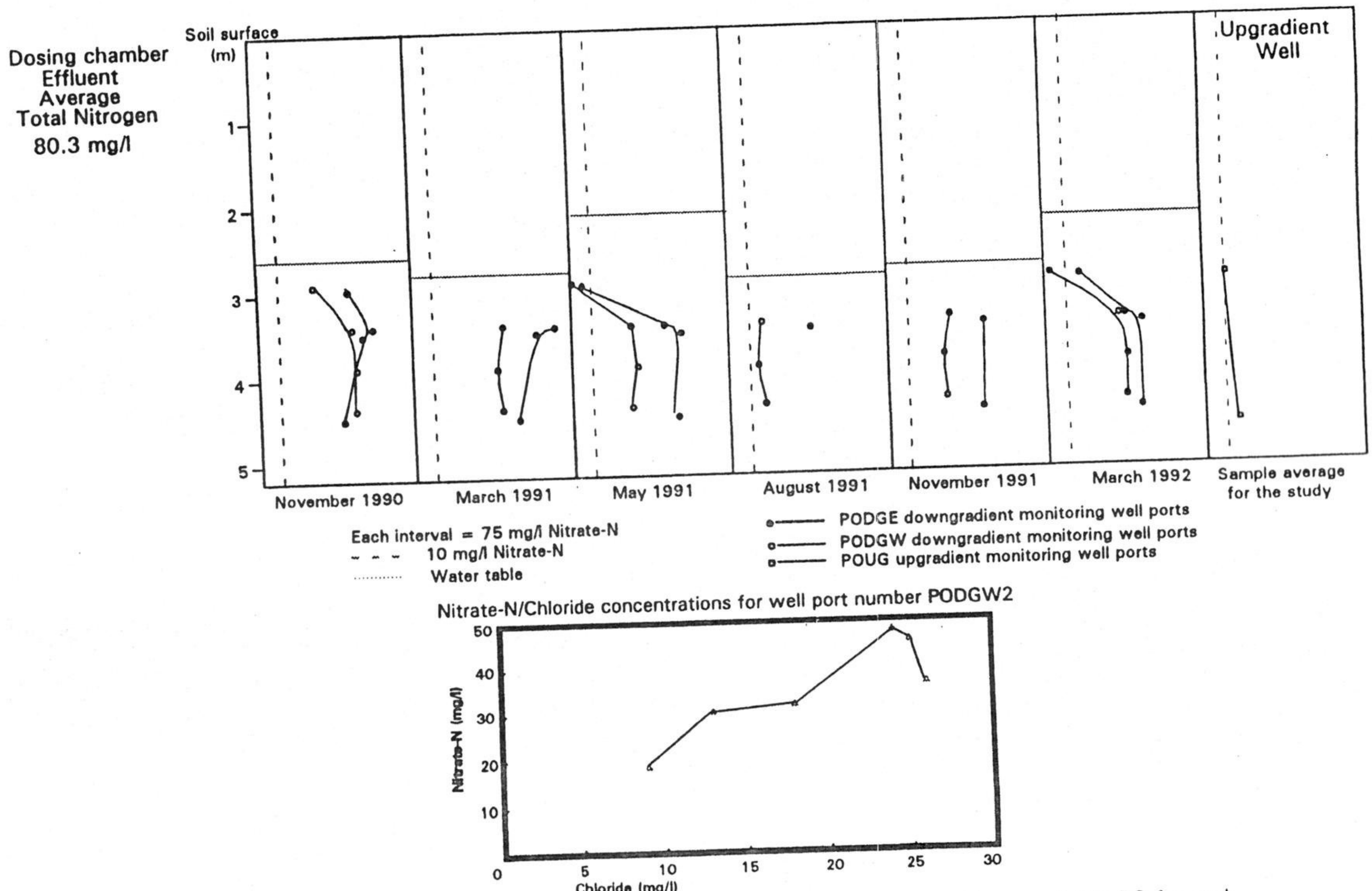


Figure 15. Profile of Nitrate-N concentrations (mg/l) for the In Ground Pressure System at Site PO for each well port in the downgradient wells, and the average for all samples for the upgradient well.

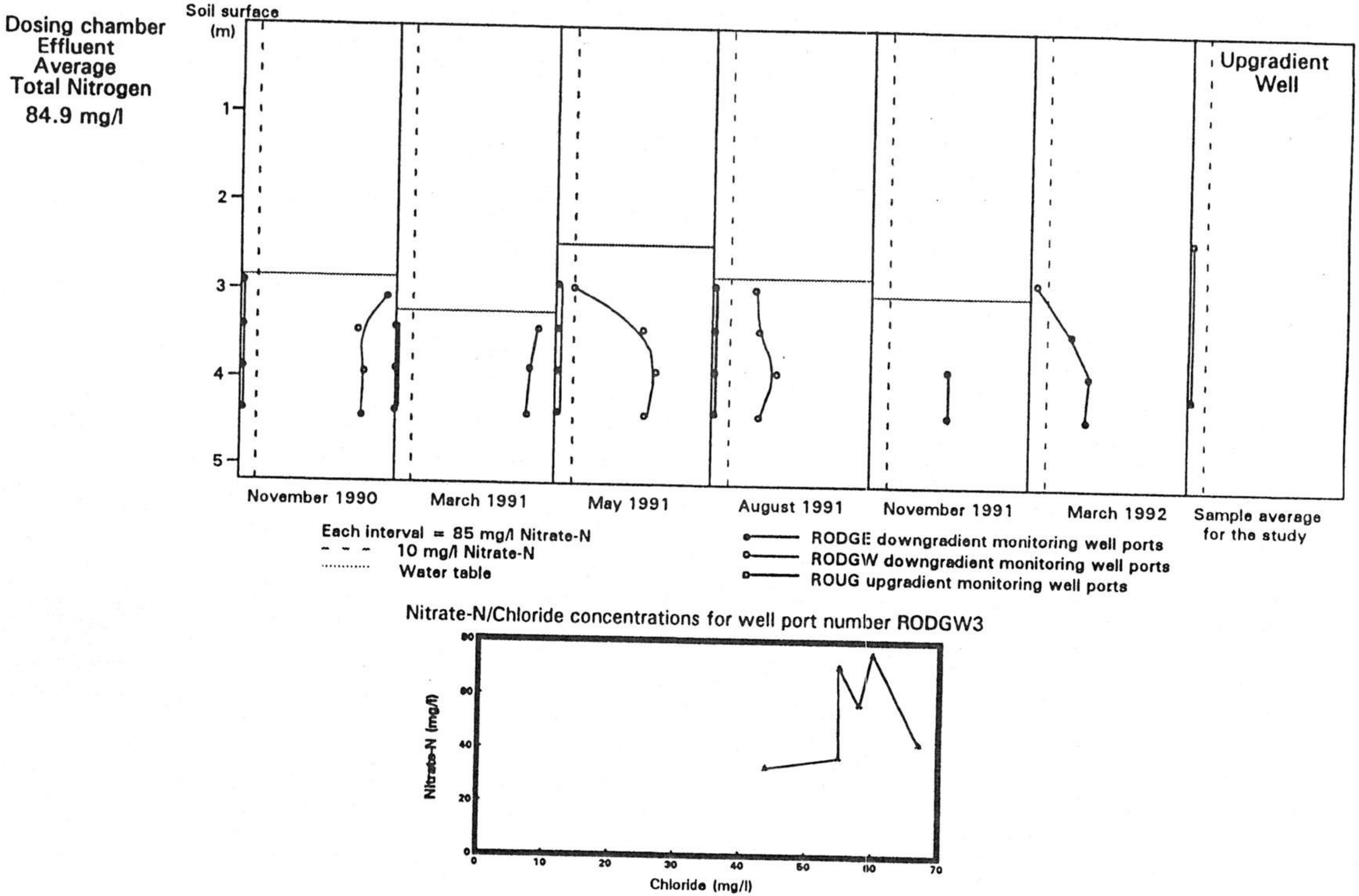
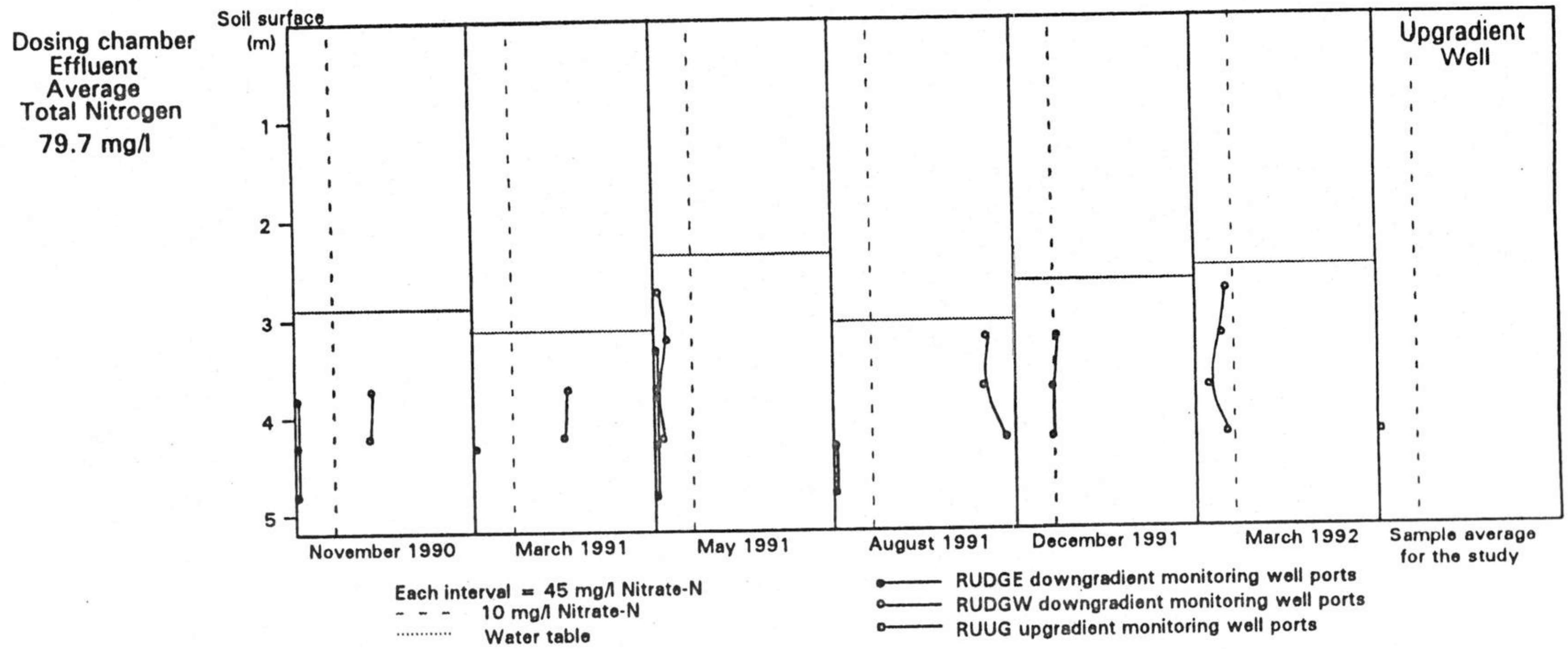


Figure 16. Profile of Nitrate-N concentrations (mg/l) for the Mound System at Site RO for each downgradient well port, and the average for all samples from the upgradient well.



Nitrate-N/Chloride concentrations for well port number RUDGW4

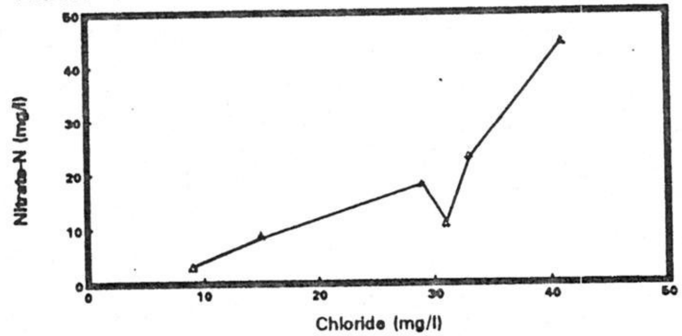


Figure 17. Profile of Nitrate-N concentrations (mg/l) for the In Ground Pressure System at Site RU for each downgradient well port, and the average for all samples from the upgradient well.

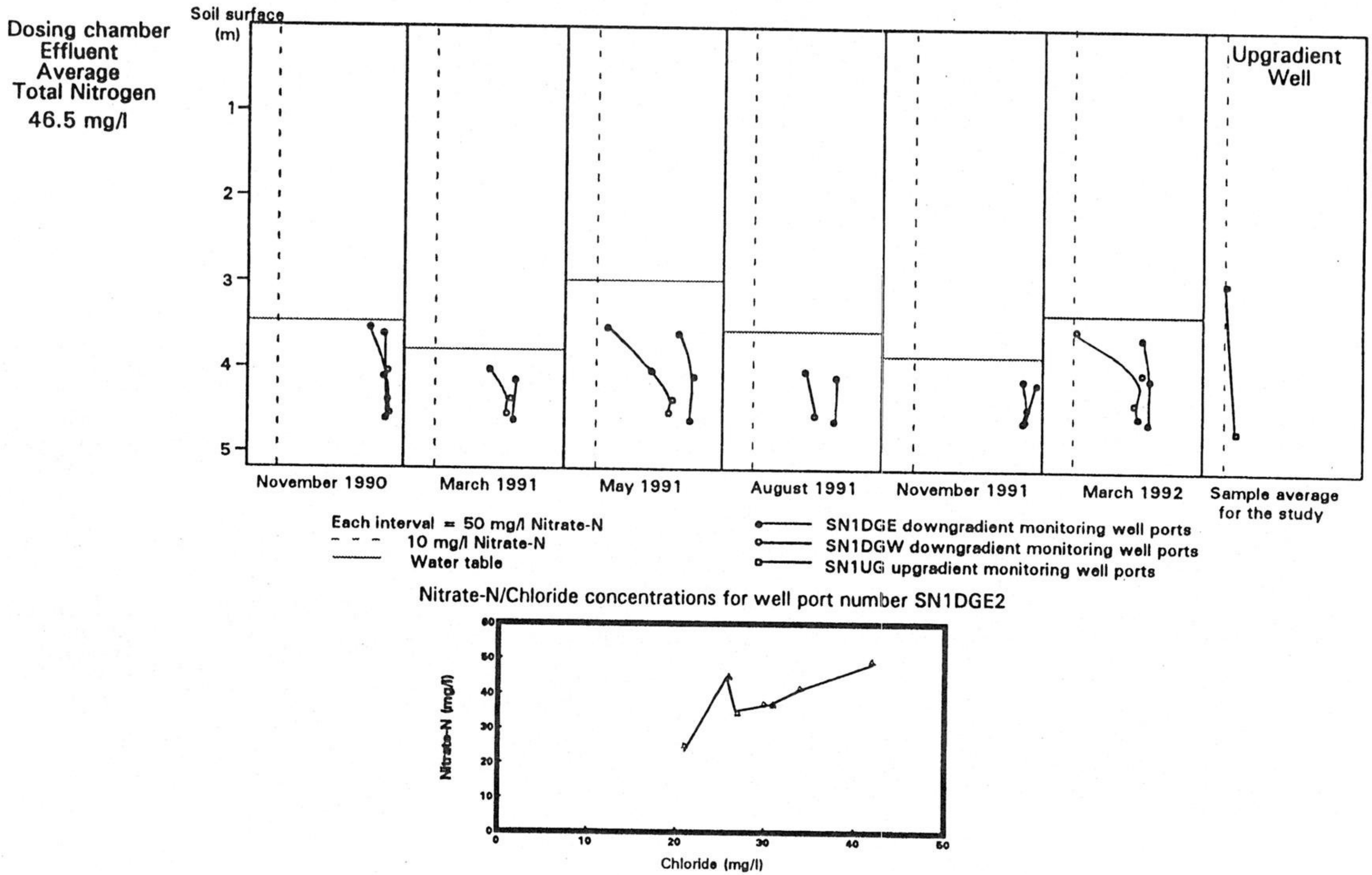
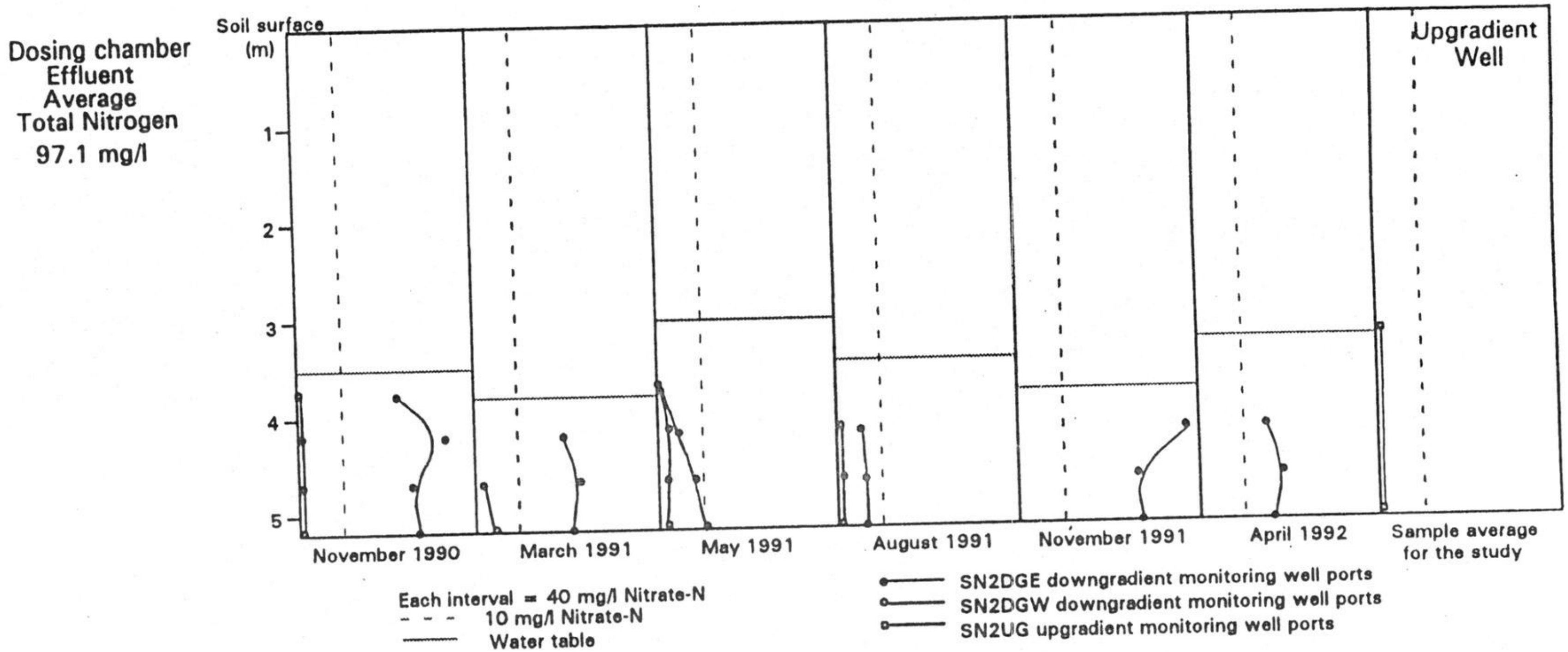


Figure 18. Profile of Nitrate-N concentrations (mg/l) for the Mound System at Site SN1 for each downgradient well port, and the average for all samples from the upgradient well.



Nitrate-N/Chloride concentrations for well port number SN2DGE3

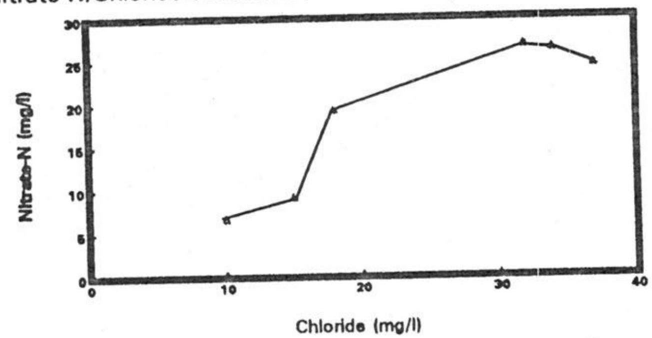


Figure 19. Profile of Nitrate-N concentrations (mg/l) for the Mound System at Site SN2 for each downgradient well port, and the average for all samples from the upgradient well.

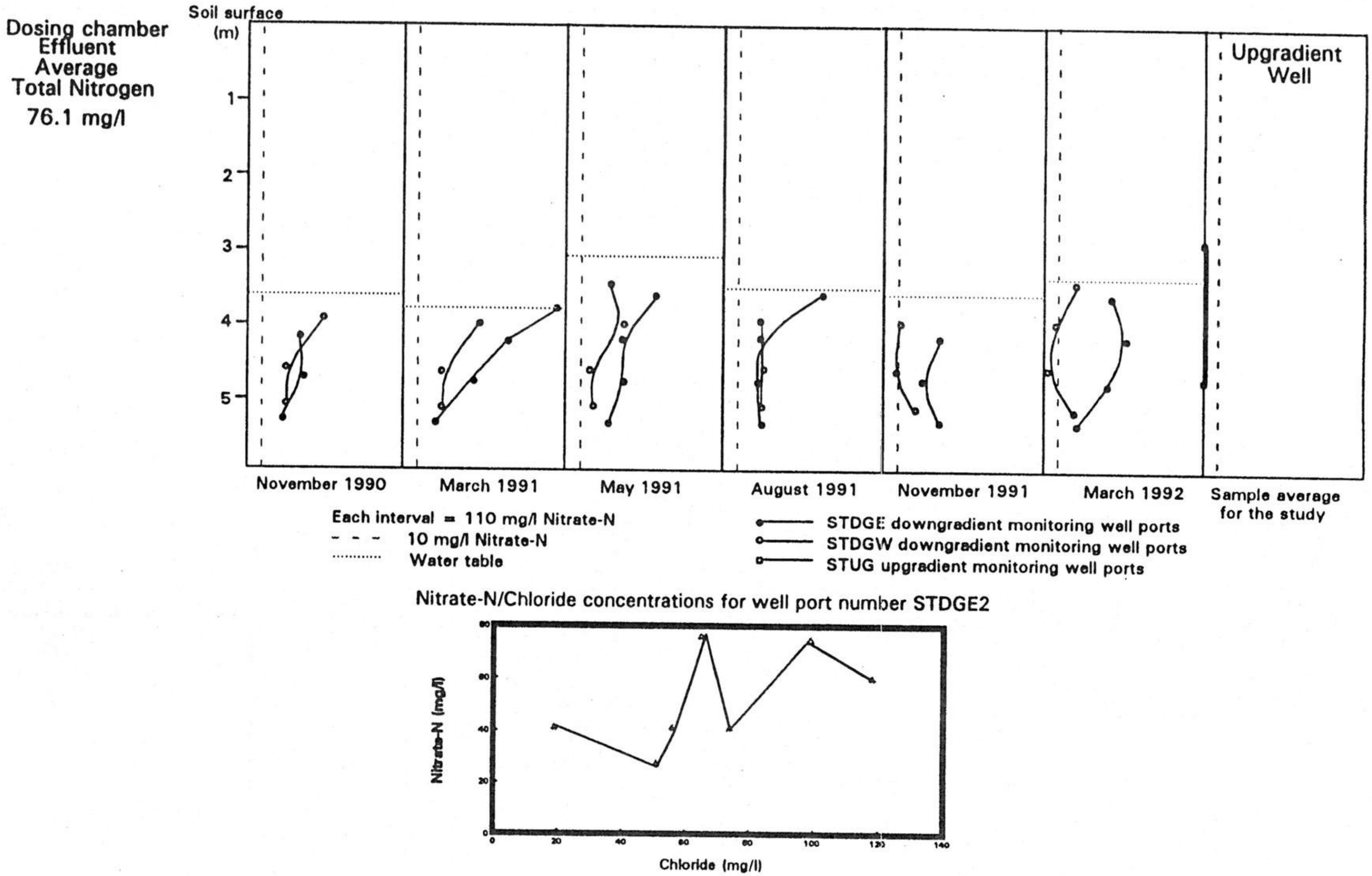
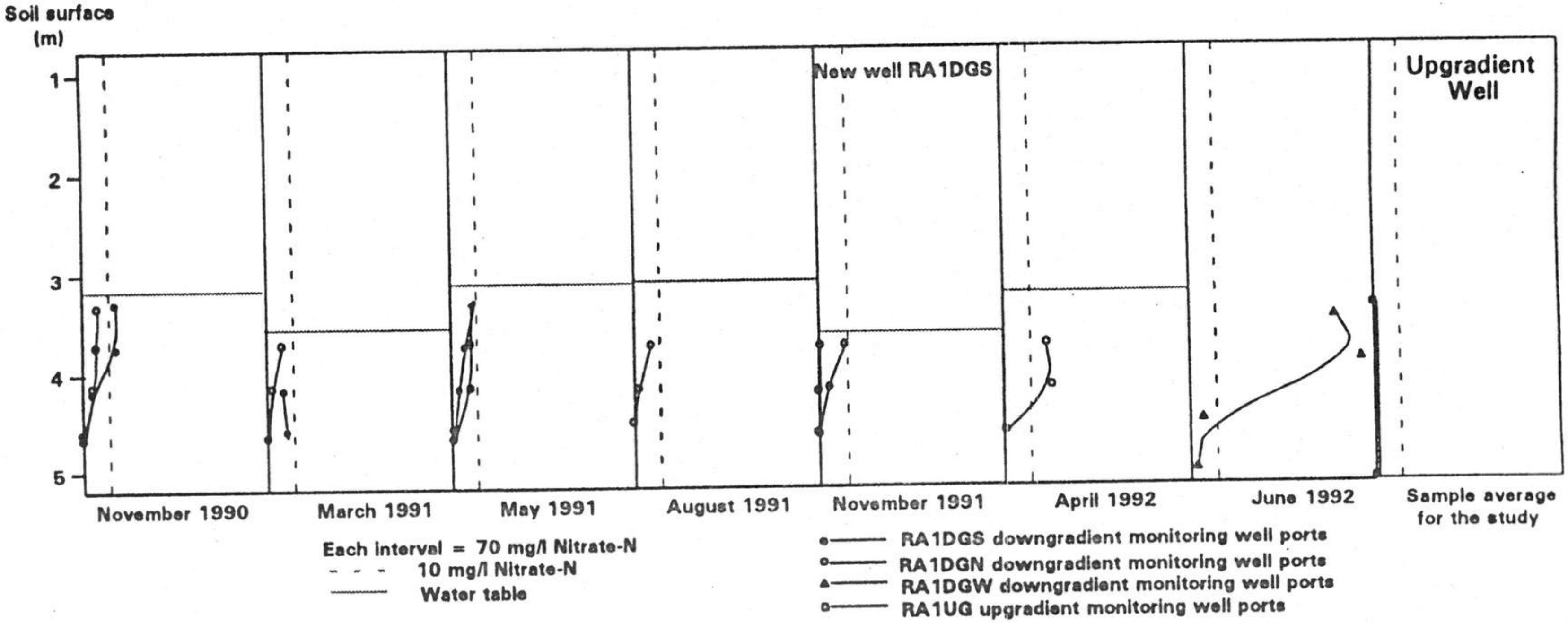
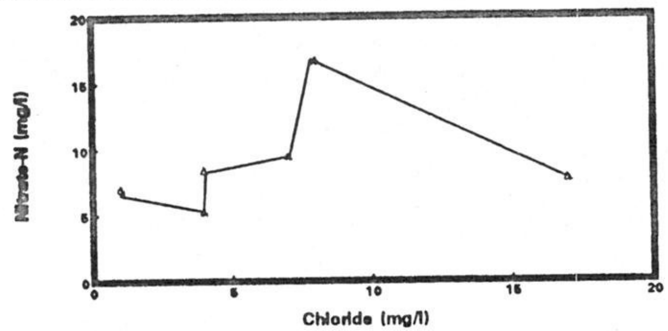


Figure 20. Profile of Nitrate-N concentrations (mg/l) for the At Grade Pressure System at Site ST for each downgradient well port, and the average for all samples from the upgradient well.



Nitrate-N/Chloride concentrations for well port number RA1DGN2



Dosing chamber
Effluent
Average
Total Nitrogen
105.0 mg/l

Figure 21. Profile of Nitrate-N concentrations (mg/l) for the In Ground PressureSystem at Site RA1 for each downgradient well port and the average for all samples from the upgradient well.

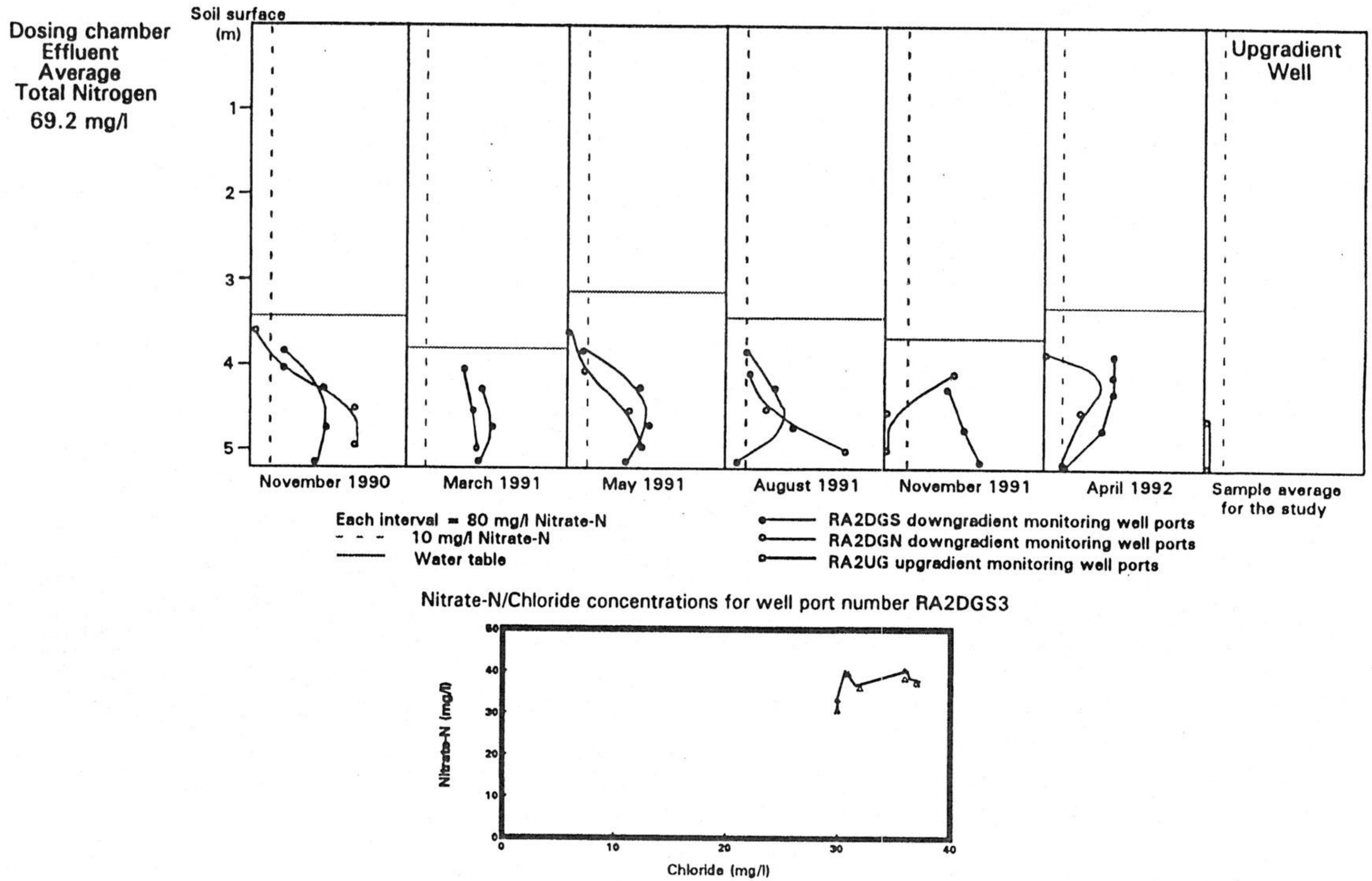


Figure 22. Profile of Nitrate-N concentrations (mg/l) for the Mound System at Site RA2 for each downgradient well port, and the average for all samples from the upgradient well.

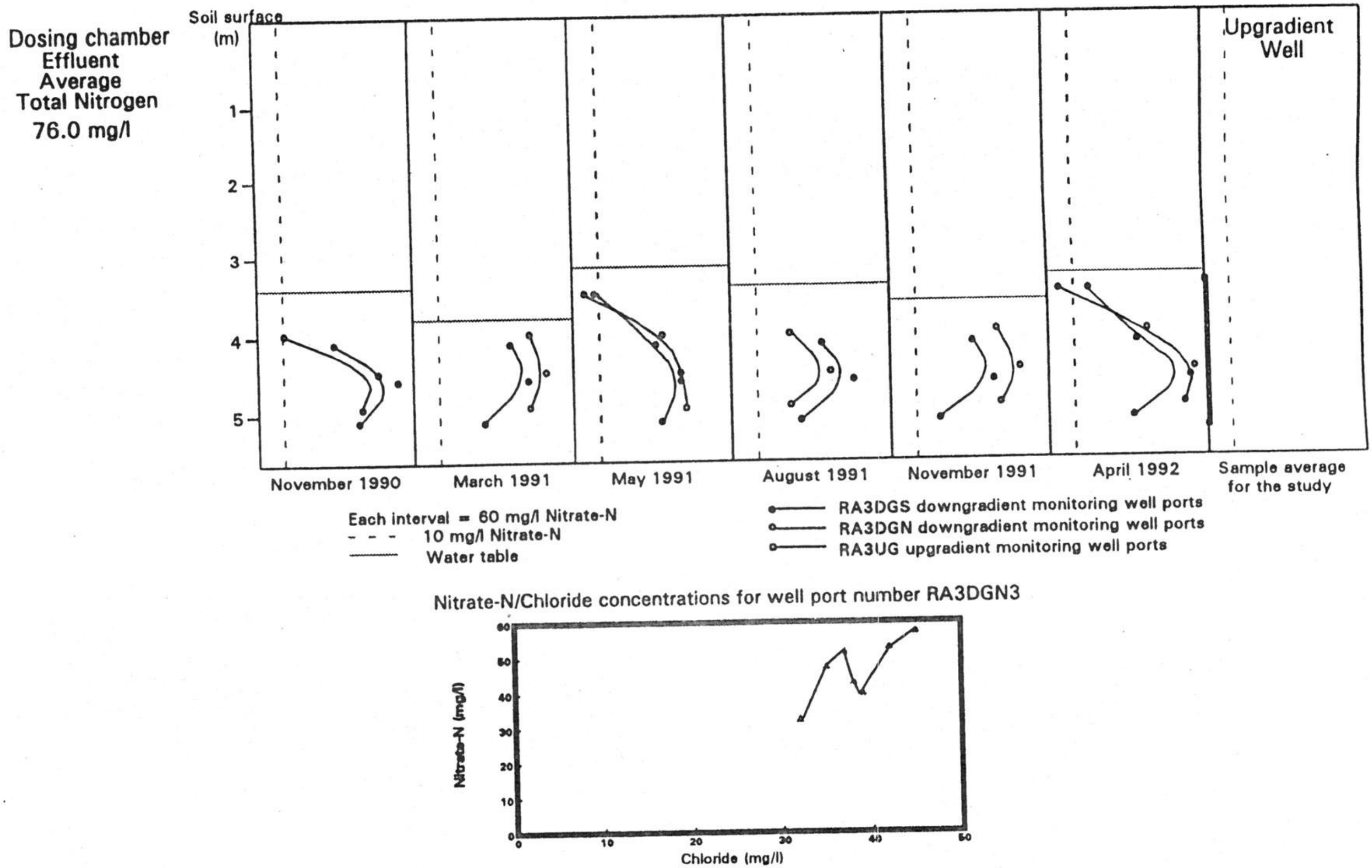


Figure 23. Profile of Nitrate-N concentrations (mg/l) for the Mound System at Site RA3 for each downgradient well port, and the average for all samples from the upgradient well.

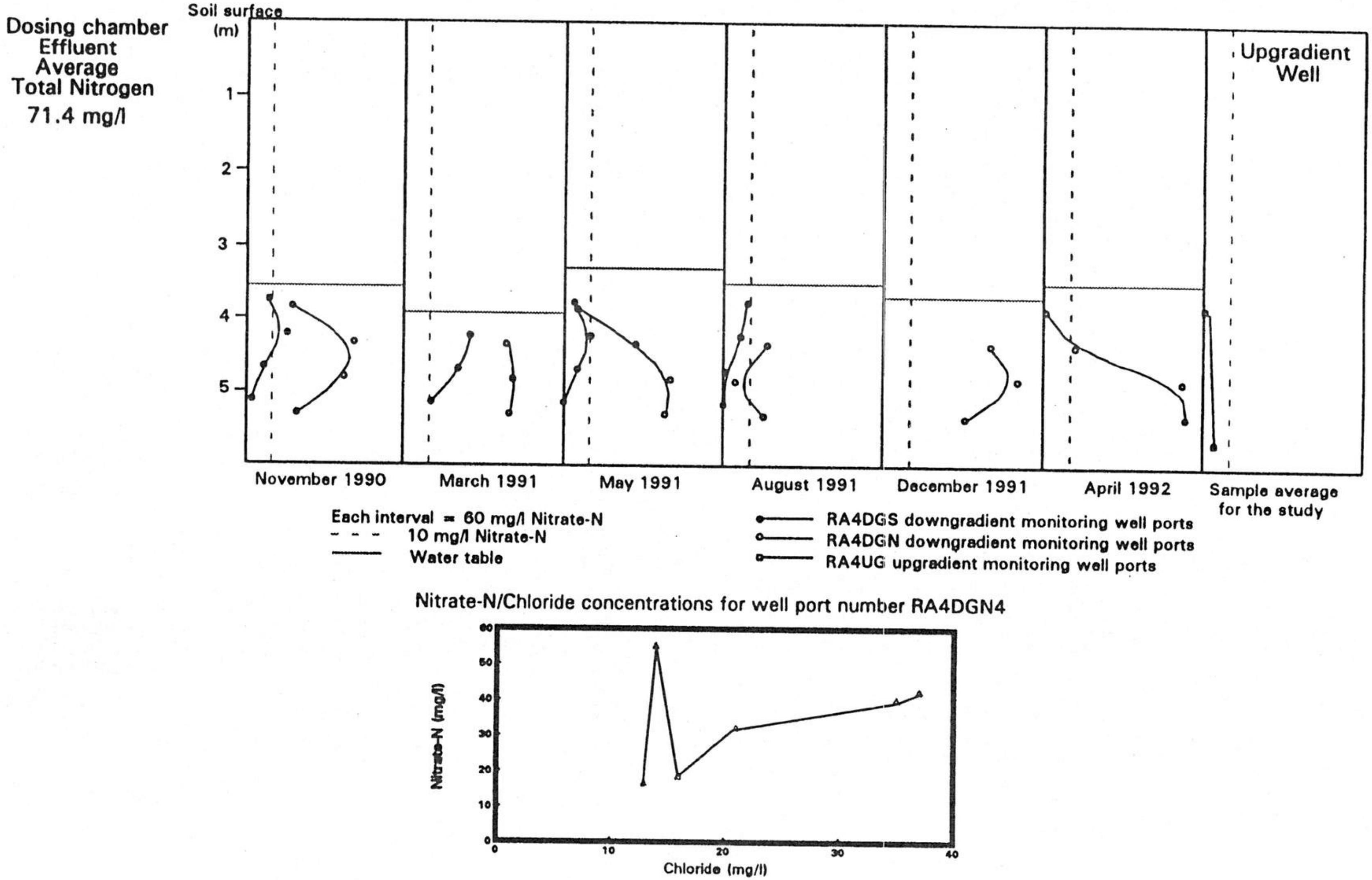
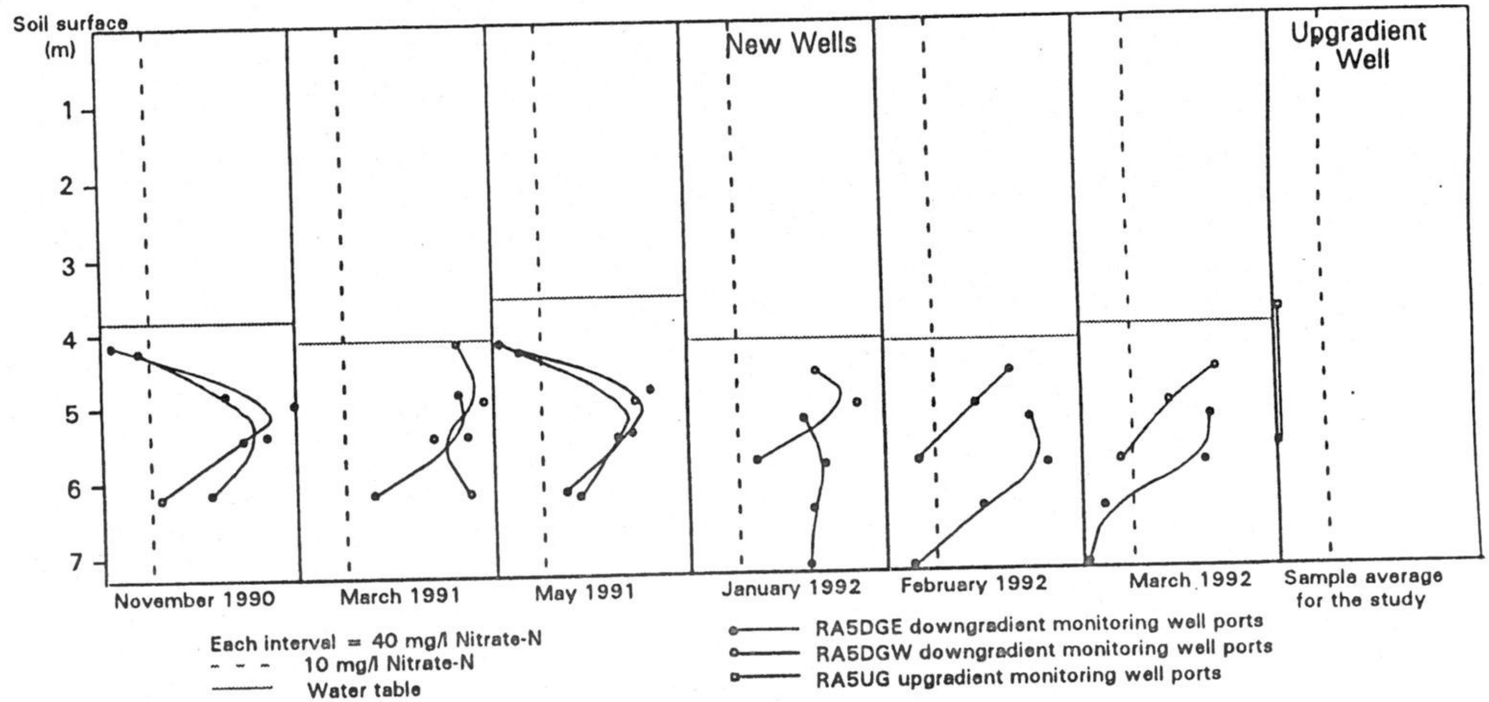


Figure 24. Profile of Nitrate-N concentrations (mg/l) for the Mound System at Site RA4 for each downgradient well port,and the average for all samples from the upgradient well.

Dosing chamber Effluent Average Total Nitrogen 57.4 mg/l



Nitrate-N/Chloride concentrations for well port number RA5DGW2

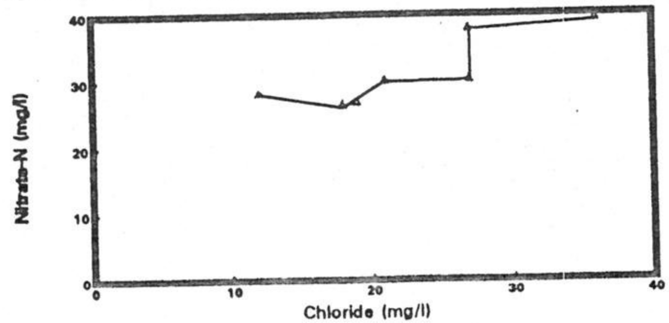


Figure 25. Profile of Nitrate-N concentrations (mg/l) for the In Ground Pressure System at Site RA5 for each downgradient well port, and the average for all samples from the upgradient well.

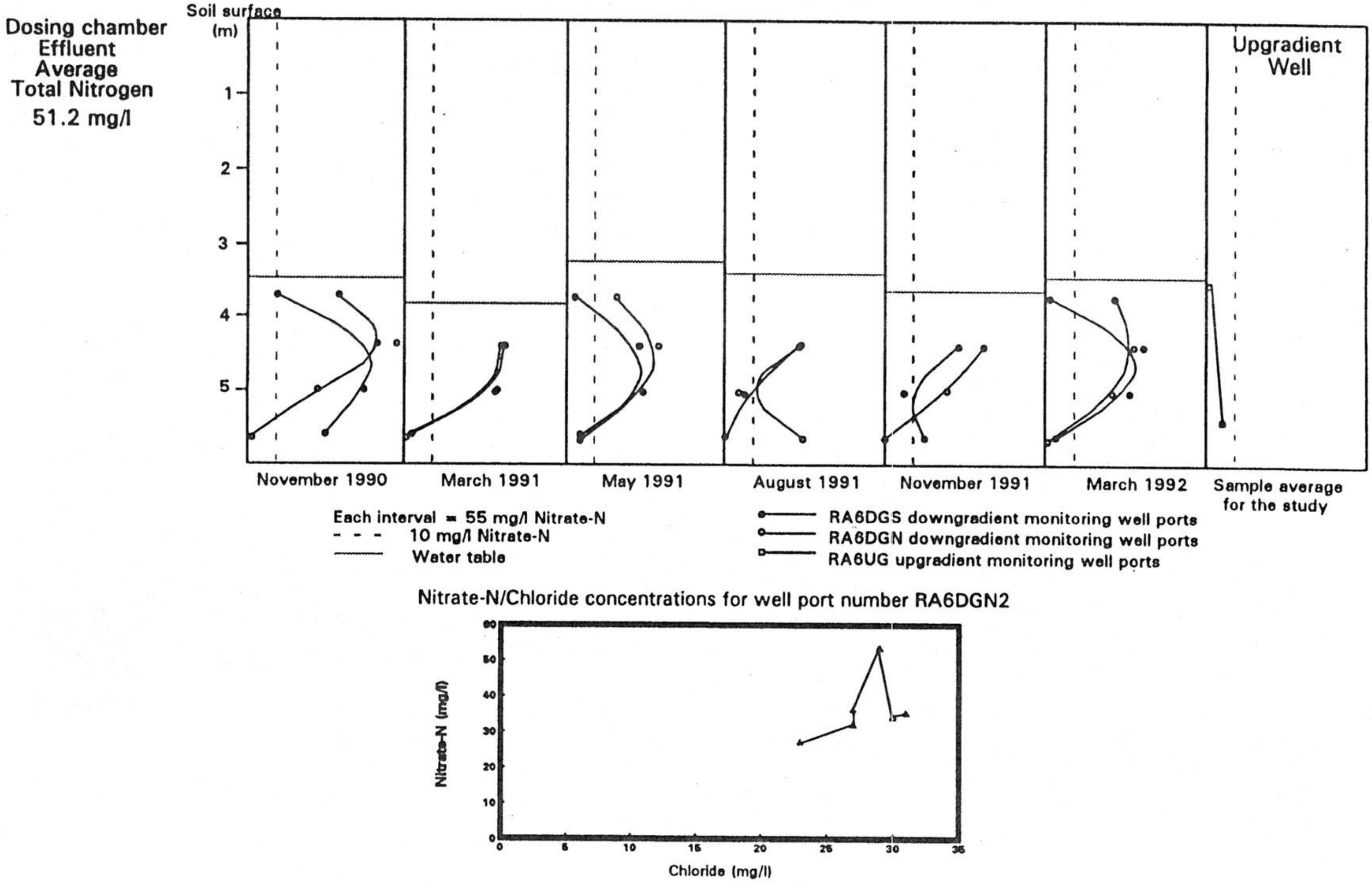
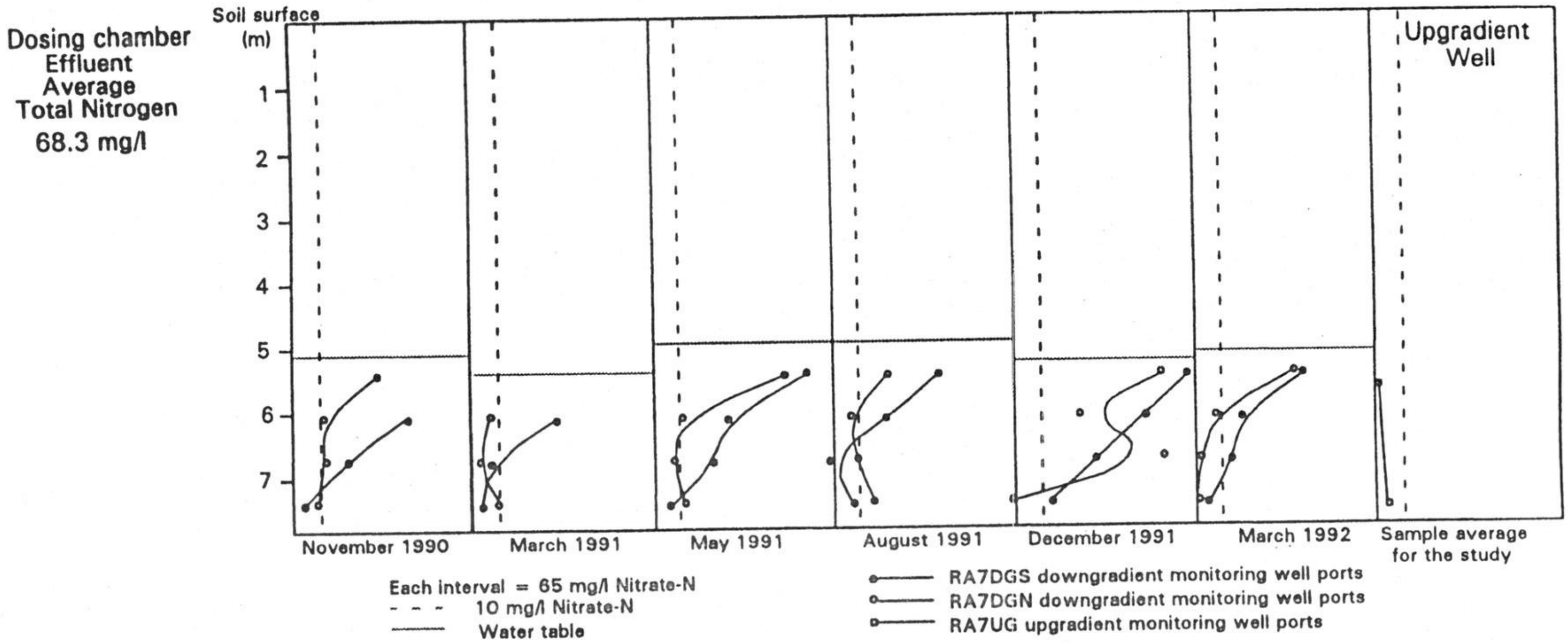


Figure 26. Profile of Nitrate-N concentrations (mg/l) for the In Ground Pressure System at Site RA6 for each downgradient well port, and the average for all samples from the upgradient well.



Nitrate-N/Chloride concentrations for well port number RA7DGN1

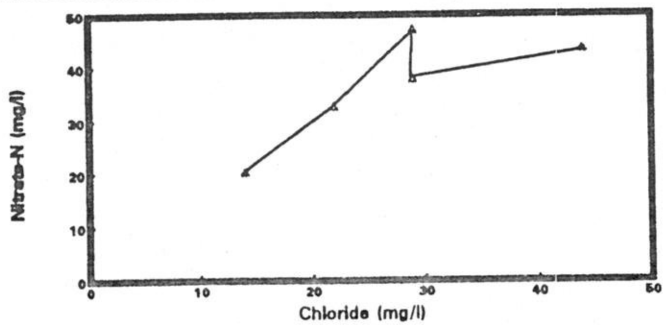


Figure 27. Profile of Nitrate-N concentrations (mg/l) for the In Ground Pressure System at Site RA7 for eachdowngradient well port,and the average for all samples from the upgradient well.

Site ID	System Type *	Seepage Bed Orientation ~	Seepage Bed Area (m2)	Well ID	Well Distance from the seepage bed (m)	Well port depth into aquifer of Ave. Highest N (m)	Site Max Nitrate-N in Groundwater (mg/l)	Site Hydraulic Loading (l/m2)
HA	AG	Perpendicular	46	HADGE '	8.2	0.62	32.6	8.5
				HADGW	7.5			
ST	AG	Diagonal	46	STDGE '	6.9	0.58	108.0	5.5
				STDGW	9.2			
PO	IG	Parallel	46	PODGE '	10.5	1.55	70.8	4.8
				PODGW	9.2			
RU	IG	Perpendicular	84	RUDGE	11.5	1.02	44.2	4.9
				RUDGW '	6.9			
HO	M	Perpendicular	35	HODGE '	11.8	1.55	28.5	13.0
				HODGW	12.5			
RO	M	Parallel	35	RODGE	7.2	1.48	82.7	7.0
				RODGW '	7.9			
SN1	M	Parallel	35	SN1DGE '	10.5	0.71	49.3	28.0
				SN1DGW	13.5			
SN2	M	Perpendicular	35	SN2DGE '	9.2	1.19	37.5	4.9
				SN2DGW	9.8			
RA2	M	Perpendicular	117	RA2DGN '	7.5	1.15	77.4	15.5
				RA2DGS '	8.2			
RA3	M	Perpendicular	93	RA3DGN '	10.5	1.23	57.0	17.6
				RA3DGS	11.2			
RA4	M	Perpendicular	93	RA4DGN '	9.5	1.10	55.0	14.5
				RA4DGS	8.5			
RA1	IG	Perpendicular	209	RA1DGN '	10.2	0.45	70.0	5.1
			209	RA1DGS	9.8			
				RA1DGW '	0.3			
RA5	IG	Parallel	251	RA5DGE	4.9	0.65	39.1	5.2
			251	RA5DGW '	6.9			
RA6	IG	Perpendicular	167	RA6DGN '	5.9	1.26	53.3	4.2
			167	RA6DGS '	6.9			
RA7	IG	Diagonal	335	RA7DGN	9.5	0.61	50.2	3.4
			335	RA7DGS '	10.2			

~ Orientation refers to the seepage bed orientation in relation to the groundwater flow direction
* System Types: AG = At Grade Pressure System IG = In Ground Pressure System M = Pressurized Mound System
' Well from which the highest Nitrogen concentrations were obtained.

Table 10. Groundwater nitrate-N concentrations relative to distance from drainfield, well depth, and system characteristics.

significant relationship between the depth of the contaminant plume and the distance from the drainfield or the hydraulic loading. The major variables which were not adequately evaluated that would effect groundwater flow and plume characteristics (depth and thickness), are hydraulic conductivity and hydraulic gradients at each site. Hydraulic gradients were very difficult to evaluate at most of the study sites, as the water table was relatively flat and some groundwater mounding was observed (at least seasonally) at most sites.

Loss of Alkalinity due to Nitrate-N

The effect of oxidation of reduced forms of nitrate-N in the septic system drainfield was evaluated by comparing the difference between hardness and alkalinity to the amount of nitrate-N in the contaminant plumes. Figure 28 presents this data graphically for all sites. It is obvious from these data that increasing nitrate-N levels result in a decrease in alkalinity relative to hardness in wastewater plumes. The R value for the relationship is 0.877, with line of best fit showing a decrease of 3.39 mg/l alkalinity from each mg/l nitrate-N present in the plume. The theoretical decrease in alkalinity is 3.5 mg/l for each mg/l nitrogen oxidized from ammonia to nitrate-N. The effect of reduced alkalinity is to lower the pH of the impacted groundwater. This can effect the rates of various biological processes. In addition, the resulting lower pH/low alkalinity water would be more corrosive to plumbing systems if withdrawn for domestic use.

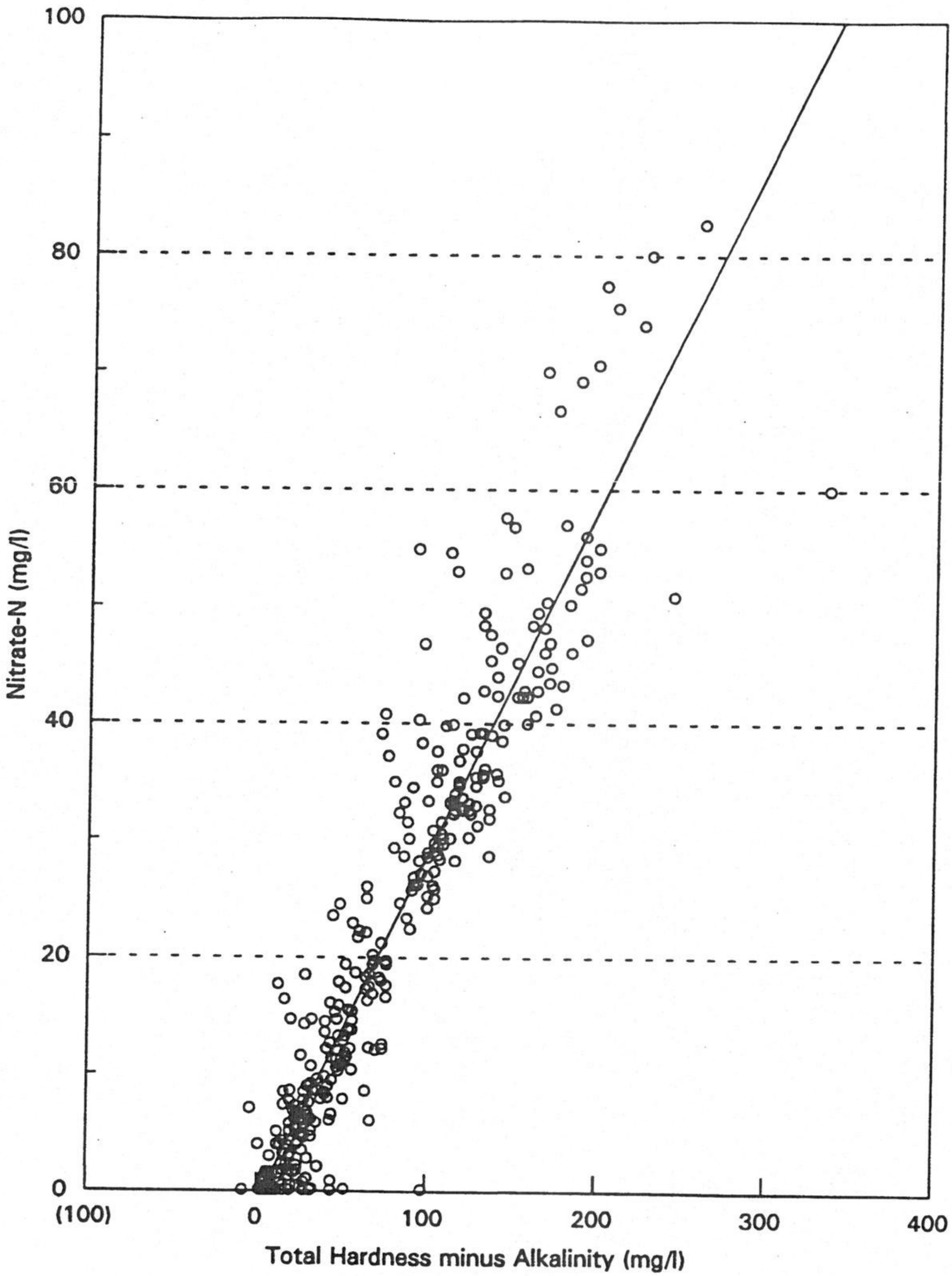


Figure 28. Graph of total hardness minus alkalinity against nitrate-N for samples from the contaminant plume at all study sites. (Slope = 3.39:1, R squared = 0.877)

Monitoring Well Design for Septic Systems

The monitoring data, while quite variable, does indicate that the well network did a fairly good job of evaluating groundwater impacts from the septic systems. Due to the variability of the plumes both horizontally and vertically, obtaining a quantitative evaluation of plumes would require many more monitoring wells than was feasible in this study. We feel a suitable monitoring system could be produced by sampling the upper 3.3 meters of the aquifer within 9.8 meters from the drainfield, using 3 well nests that consist of 4 wells each. Seasonal variability does exist downgradient of the septic systems, suggesting that at least seasonal sampling is required. Worst case conditions can be anticipated in late winter or late summer, and the greatest plume dilution can be expected following both spring and fall groundwater recharge.

CONCLUSIONS

The following conclusions can be drawn from this research:

1. There was no significant difference between the treatment efficiency of mound, in ground pressure or at grade pressure systems.

2. Pressurized systems on sandy soils do not remove any significant amount of nitrogen from wastewater. Concentrations of nitrate-N in the contaminant plumes ranged from 21 to 108 mg/l, averaging 34 mg/l in the single family systems and 31 mg/l for the multiple family systems.

3. Developing monitoring well networks for septic systems is difficult, and should consist of at least three multi level well nests located downgradient of the drainfield. The two nested wells used in this study were not always adequate to characterize the plume. Four ports sampling to a depth of 3.3 m into the groundwater should be adequate for wells located within 9.8 m of the drainfield.

4. There was no significant loss of nitrogen as water moved from dosing chamber, to drainfield, to groundwater based on chloride to nitrogen ratios.

5. The amount of dilution of wastewater by groundwater was estimated by comparing effluent nitrogen values to those found in the contaminant plume. This ratio averaged 2.4 and ranged from 1.3 to 3.8.

6. There is a wide range in the amount of waste produced and water used by homeowners. Water use ranged from 100 to 307 liters per person per day. The amount of nitrogen discharged through the dosing chambers to drainfields ranged from 2.9 to 8.2 kg per person per year, and averaged 4.5 kg per person per year for the mobile home community and 5.6 kg per person per year for the single family sites. Similar amounts are believed to be entering groundwater as chloride to nitrogen ratios do not change between dosing chambers and groundwater.

7. The presence of nitrate-N from septic systems in groundwater decreases the amount of alkalinity by 3.4 mg/l for each mg/l of nitrate-N.

8. Seasonal data showed increased nitrate-N concentrations during the winter of 1990-91, with apparent dilution of the plume from groundwater recharge in the spring and fall of 1991.

9. Average phosphate concentrations in wastewater were 10.8 mg/l for single family residences and 8.7 mg/l for multiple family systems. The difference may be due to the presence of clothes washers and associated cleaning products in the single family residences. Phosphorous did not show up in groundwater downgradient of these systems as they are fairly new, and the adsorption sites of the soil are not yet saturated with phosphorous.

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APPENDIX 1

Dosing Chamber Chemistry

ALTERNATIVE SEPTIC SYSTEM DOSING CHAMBER DATA

SITE ID	DATE	NO2+NO3-N (mg/l)	NH4-N (mg/l)	TKN (mg/l)	CL (mg/l)	pH	COND (mhos)	ALK (mg/l)	T HARD (mg/l)	TSS (mg/l)	FLUOR (mg/l)	COD (mg/l)	BOD (mg/l)	REACT P (mg/l)	TOTAL P (mg/l)	NA (mg/l)
HA	28-Apr-92	0.2	65.0	65.0	86		1188	472	188						9.2	
HA	05-Mar-92	<0.2	76.0	82.0	95		1280	464	180						10.5	
HA	27-Feb-92	<0.2	89.5	95.0	103		1275	468	208						11.0	
HA	18-Feb-92	0.2	78.0	85.0	87		1210	460	212						11.0	
HA	17-Feb-92	0.2	72.0	125.0	86		1188	440	216							
HA	13-Feb-92	<0.2	71.2	75.0	110		1187	444	216						10.8	
HA	06-Feb-92	<0.2	68.8	72.0	103		1128	416	216							
HA	14-Jan-92	<0.2	62.0	87.5	84											
HA	07-Jan-92	<0.2	58.8	79.0	101								167			
HA	08-Nov-91	<0.2	51.0	85.0	100	6.72	939	312	160		330	725	312	9.5	13.0	
average		0.1	69.2	85.1	96		1174	435	200						10.9	
std.deviation		0.1	10.8	16.4	9		107	53	21						1.2	
PO	02-Apr-92	0.3	54.0	70.0	29		755	256	44						6.5	
PO	05-Mar-92	<0.2	69.0	80.0	46		808	312	40						7.8	
PO	27-Feb-92	<0.2	73.0	85.0	41		711	292	36						7.2	
PO	24-Feb-92	0.2	70.5	75.0	2		732	332	44						7.0	
PO	18-Feb-92	0.2	69.5	75.0	36		736	276	40						8.0	
PO	04-Feb-92	<0.2	62.5	82.0	48		740	268	120							
PO	14-Jan-92	<0.2	68.8	92.5	14											
PO	07-Jan-92	<0.2	71.2	84.0	50								155			
PO	08-Nov-91	<0.2	64.0	72.0	40	7.17	751	284	56		230	527	153	5.8	8.5	34.5
PO	21-Aug-91	<0.2	37.5	87.0	29	6.93	552	252	80	232	350	421	347	4.3	9.7	25.0
average		0.1	64.0	80.3	34		723	284	58						7.8	
std. deviation		0.1	10.8	7.2	15		75	27	29						1.1	
RA1	05-May-92	<0.2	82.0	136.0	73		1207	420	120						11.0	
RA1	02-Apr-92	0.4	74.0	105.0	63		1114	364	120						10.8	
RA1	27-Feb-92	<0.2	76.2	90.0	85		1017	348	116						10.2	
RA1	24-Feb-92	0.2	77.5	98.0	55		995	376	116						11.8	
RA1	17-Feb-92	0.3	81.2	85.0	74		1071	364	124							
RA1	13-Feb-92	2.1	81.2	88.0	100		1141	400	116						12.0	
RA1	06-Feb-92	0.2	80.5	95.0	85		1062	356	120							
RA1	30-Jan-92	<0.2	78.0	105.0	73											
RA1	07-Jan-92	<0.2	83.0	142.0	81								497			
RA1	05-Nov-91	<0.2	70.0	106.0	71	6.93	1008	384	132		222	563	390	7.6	13.8	48.9
average		0.3	78.4	105.0	76		1077	377	121						11.6	
std. deviation		0.6	4.1	19.4	13		73	24	5						1.3	

SITE ID	DATE	NO2+NO3-N (mg/l)	NH4-N (mg/l)	TKN (mg/l)	CL (mg/l)	pH	COND (mhos)	ALK (mg/l)	T HARD (mg/l)	TSS (mg/l)	FLUOR (mg/l)	COD (mg/l)	BOD (mg/l)	REACT P (mg/l)	TOTAL P (mg/l)	NA (mg/l)
RA2	28-Apr-92	<0.2	51.0	51.0	42		820	281	120						7.0	
RA2	07-Apr-92	<0.2	62.0	72.0	37		942	336	136						8.8	
RA2	02-Apr-92	0.2	59.0	90.0	37		970	328	128						8.2	
RA2	27-Feb-92	<0.2	41.2	58.0	38		616	266	112						7.2	
RA2	24-Feb-92	0.3	44.5	52.0	28		613	264	116						5.8	
RA2	17-Feb-92	0.2	52.0	55.0	35		771	296	116							
RA2	13-Feb-92	<0.2	55.0	68.0	50		801	352	112						9.0	
RA2	06-Feb-92	<0.2	57.0	88.0	50		819	328	136							
RA2	30-Jan-92	0.4	47.0	75.0	36											
RA2	07-Jan-92	<0.2	57.0	82.5	44								387			
average		**0.1**	**52.6**	**69.2**	**40**		**794**	**306**	**122**						**7.7**	
std. deviation		**0.2**	**6.7**	**14.8**	**7**		**130**	**34**	**10**						**1.2**	
RA3	05-May-92	0.2	72.0	76.0	58		983	360	130						9.0	
RA3	28-Apr-92	0.5	64.0	64.0	49		989	340	124						9.5	
RA3	07-Apr-92	<0.2	44.0	65.0	31		759	268	116						7.2	
RA3	02-Apr-92	0.3	39.0	70.0	8		680	248	116						6.0	
RA3	27-Feb-92	<0.2	70.0	90.0	56		861	350	106						12.2	
RA3	30-Jan-92	0.2	65.5	75.0	43											
RA3	07-Jan-92	<0.2	62.5	87.0	56								183			
RA3	05-Nov-91	<0.2	58.0	81.0	47	7.00	809	304	124		153	449	273	7.5	11.6	25.1
average		**0.2**	**59.4**	**76.0**	**44**		**847**	**312**	**119**						**9**	
std. deviation		**0.2**	**11.9**	**9.6**	**17**		**123**	**46**	**8**						**2.4**	
RA4	05-May-92	<0.2	52.0	58.0	49		829	310	110						8.5	
RA4	07-Apr-92	<0.2	48.0	88.0	50		792	284	124						10.2	
RA4	02-Apr-92	0.3	47.0	75.0	43		817	288	124						9.0	
RA4	27-Feb-92	<0.2	55.5	75.0	50		780	310	118						10.5	
RA4	24-Feb-92	0.2	53.8	70.0	39		732	292	120						10.0	
RA4	17-Feb-92	0.3	52.0	68.0	39		773	300	120							
RA4	13-Feb-92	<0.2	53.0	65.5	46		812	280	124						10.0	
RA4	06-Feb-92	<0.2	52.5	75.0	43		776	300	116							
RA4	30-Jan-92	0.4	57.5	70.0	42											
RA4	07-Jan-92	<0.2	36.2	69.0	48								143			
average		**0.1**	**50.8**	**71.4**	**45**		**789**	**296**	**120**						**9.7**	
std. deviation		**0.2**	**6.0**	**7.8**	**4**		**31**	**11**	**5**						**0.8**	

SITE ID	DATE	NO2+NO3-N (mg/l)	NH4-N (mg/l)	TKN (mg/l)	CL (mg/l)	pH	COND (mhos)	ALK (mg/l)	T HARD (mg/l)	TSS (mg/l)	FLUOR (mg/l)	COD (mg/l)	BOD (mg/l)	REACT P (mg/l)	TOTAL P (mg/l)	NA (mg/l)
RA5	05-May-92	<0.2	41.0	51.0	42		731	260	130						5.8	
RA5	02-Apr-92	0.4	42.0	60.0	24		739	280	132						6.0	
RA5	27-Feb-92	<0.2	50.0	78.0	44		697	280	114						7.5	
RA5	24-Feb-92	0.2	52.5	55.0	31		680	272	124						11.0	
RA5	17-Feb-92	0.3	45.5	60.0	29		682	264	112							
RA5	13-Feb-92	<0.2	58.8	66.2	59		852	296	124						8.5	
RA5	06-Feb-92	<0.2	39.5	48.0	43		646	248	112							
RA5	30-Jan-92	<0.2	35.5	45.0	30											
RA5	07-Jan-92	<0.2	41.2	55.0	40								118			
RA5	05-Nov-91	<0.2	35.0	56.0	36	7.14	607	244	120		141	316	180	3.2	7.0	22.0
average		**0.1**	**44.1**	**57.4**	**38**		**704**	**268**	**121**						**7.6**	
std. deviation		**0.2**	**7.6**	**9.5**	**10**		**73**	**18**	**8**						**1.9**	
RA6	05-May-92	<0.2	32.0	36.0	39		639	230	120						5.0	
RA6	02-Apr-92	0.4	36.0	60.0	29		689	264	132						7.5	
RA6	27-Feb-92	<0.2	50.5	60.0	49		750	308	124						8.0	
RA6	24-Feb-92	0.2	49.5	62.0	36		784	280	132						7.2	
RA6	17-Feb-92	0.2	48.0	65.0	38		769	288	124							
RA6	13-Feb-92	<0.2	49.5	55.0	52		824	316	128						10.8	
RA6	06-Feb-92	<0.2	45.0	58.0	49		730	280	132							
RA6	30-Jan-92	0.5	39.5	55.0	32											
RA6	07-Jan-92	<0.2	11.4	19.0	19								50			
RA6	05-Nov-91	<0.2	22.0	42.0	30	7.30	494	232	120		138	184	50	3.1	6.0	18.7
average		**0.1**	**38.3**	**51.2**	**37**		**710**	**275**	**127**						**7.4**	
std. deviation		**0.2**	**13.2**	**14.5**	**10**		**104**	**32**	**5**						**2.0**	
RA7	05-May-92	<0.2	46.0	54.0	47		755	280	120						6.8	
RA7	02-Apr-92	0.4	59.0	75.0	34		927	332	120						8.0	
RA7	27-Feb-92	<0.2	58.8	62.0	53		793	320	108						7.8	
RA7	24-Feb-92	0.3	67.0	78.0	36										8.0	
RA7	17-Feb-92	0.2	58.0	68.0	39		823	320	116							
RA7	13-Feb-92	<0.2	40.0	48.0	45		652	236	112						6.5	
RA7	06-Feb-92	<0.2	62.0	68.0	60		854	320	116							
RA7	30-Jan-92	0.2	62.0	65.0	50											
RA7	07-Jan-92	<0.2	70.5	85.5	61								192			
RA7	05-Nov-91	<0.2	54.0	79.0	55	7.25	823	316	116		174	475	160	4.9	10.2	35.3
average		**0.1**	**57.7**	**68.3**	**48**		**804**	**303**	**115**						**7.9**	
std. deviation		**0.2**	**9.2**	**11.6**	**10**		**86**	**34**	**4**						**1.3**	

SITE ID	DATE	NO2+NO3-N (mg/l)	NH4-N (mg/l)	TKN (mg/l)	CL (mg/l)	pH	COND (mhos)	ALK (mg/l)	T HARD (mg/l)	TSS (mg/l)	FLUOR (mg/l)	COD (mg/l)	BOD (mg/l)	REACT P (mg/l)	TOTAL P (mg/l)	NA (mg/l)
RO	07-Apr-92	<0.2	56.0	70.0	97		1058	312	152						8.5	
RO	02-Apr-92	0.3	55.0	72.0	86		1001									
RO	06-Feb-92	<0.2	54.5	65.0	110		954	316	140							
RO	04-Feb-92	<0.2	46.2	65.0	107		960	300	124							
RO	14-Jan-92	<0.2	70.5	97.5	114											
RO	07-Jan-92	<0.2	75.0	94.0	123								215			
RO	08-Nov-91	<0.2	80.0	108.0	100	7.18	1051	372	152		230	725	170	11.1	15.2	51.0
RO	21-Aug-91	<0.2	78.8	108.0	102	7.26	1176	408	160	110	231	1665	405	10.9	14.5	53.0
average		**0.0**	**64.5**	**84.9**	**105**		**1033**	**342**	**146**						**12.7**	
std. deviation		**0.1**	**13.0**	**18.9**	**11**		**82**	**46**	**14**						**3.7**	
RU	02-Apr-92	0.3	45.0	80.0	39		865	296	100						14.0	
RU	05-Mar-92	<0.2	50.0	60.0	56		926	332	82						15.2	
RU	27-Feb-92	<0.2	53.8	60.0	54		856	332	106						15.5	
RU	18-Feb-92	0.2	52.0	60.0	49		844	308	92						18.2	
RU	04-Feb-92	<0.2	47.0	70.0	57		924	316	92							
RU	14-Jan-92	<0.2	47.0	67.5	40											
RU	07-Jan-92	<0.2	50.5	73.0	56								205			
RU	08-Nov-91	<0.2	55.0	98.0	51	6.92	866	336	96			969		17.1	24.0	78.0
RU	22-Aug-91	<0.2	40.0	54.0	139	7.40	1304	432	100	72	177	178	114	11.4	13.9	192.0
RU	21-Aug-91	<0.2	42.0	174.0	131	7.07	1264	384	220	1924	390	3950	1450	10.9	42.7	161.0
average		**0.1**	**48.2**	**79.7**	**67**		**981**	**342**	**111**						**20.5**	
std. deviation		**0.1**	**4.9**	**35.5**	**36**		**190**	**45**	**45**						**10.4**	
SN1	21-May-92	<0.2	25.2	22.0	78	6.89		136	56		189	482.5	237		7.5	
SN1	22-Apr-92	<0.2	25.6	40.0	37	6.59		159	84		153	383.5	292		6.5	25.9
SN1	05-Mar-92	<0.2	24.0	35.0	35		481	162	52						6.5	
SN1	27-Feb-92	<0.2	29.5	35.0	34		453	148	52						7.8	
SN1	08-Jan-92	<0.2	36.2	61.2	36	6.92		280	80		130	543	278		8.7	28.4
SN1	06-Dec-91	<0.2	30.0	42.0	32	6.75		212	56		190	745	225		5.8	25.6
SN1	09-Oct-91	<0.2	38.8	52.0	29	7.08	1005	208	60		160	144	145		6.0	39.9
SN1	06-Sep-91	<0.2	33.2	54.0	41	6.94		192	70		195	187	150		5.9	30.4
SN1	21-Aug-91	<0.2	38.0	77.0	48	6.73	590	168	90	196	183	26	288	4.5	9.3	24.0
average		**<0.2**	**31.2**	**46.5**	**41**		**632**	**185**	**67**						**7.1**	
std. deviation		**<0.2**	**5.7**	**16.4**	**15**		**255**	**44**	**15**						**1.3**	

SITE ID	DATE	NO2+NO3-N (mg/l)	NH4-N (mg/l)	TKN (mg/l)	CL (mg/l)	pH	COND (mhos)	ALK (mg/l)	T HARD (mg/l)	TSS (mg/l)	FLUOR (mg/l)	COD (mg/l)	BOD (mg/l)	REACT P (mg/l)	TOTAL P (mg/l)	NA (mg/l)
SN2	08-Nov-91	<0.2	37.0	200.0	52	7.59	860	344	268			2280	1200	0.9	94.9	43.3
SN2	02-Apr-92	0.3	57.0	85.0	38		1003	368	120						7.5	
SN2	05-Mar-92	<0.2	52.0	70.0	60		980	354	114						6.5	
SN2	27-Feb-92	<0.2	65.0	110.0	56		910	348	120						14.2	
SN2	18-Feb-92	0.2	60.5	78.0	42		884	336	116						8.8	
SN2	06-Feb-92	<0.2	63.8	90.0	57		954	360	116							
SN2	04-Feb-92	<0.2	62.5	102.0	54		983	348								
SN2	14-Jan-92	<0.2	65.5	85.0	46											
SN2	07-Jan-92	<0.2	66.2	75.5	56								65			
SN2	21-Aug-91	<0.2	53.0	75.0	50	7.32	942	380	150	87	201	360	183	4.1	7.3	48.0
average		**0.1**	**60.6**	**85.6**	**51**		**951**	**356**	**123**						**8.9**	
std. deviation		**0.1**	**5.4**	**13.2**	**8**		**42**	**15**	**14**						**3.1**	
ST	02-Apr-92	0.8	54.0	68.0	117		1475	420	232						6.0	
ST	05-Mar-92	0.2	50.0	70.0	167		1379	416	180						6.0	
ST	27-Feb-92	<0.2	59.5	70.0	168		1360	404	224						6.2	
ST	18-Feb-92	0.3	60.0	68.0	120		1390	392	216						6.0	
ST	17-Feb-92	0.3	58.8	68.0	126		1416	392	216							
ST	06-Feb-92	<0.2	59.5	78.0	160		1400	388	216							
ST	14-Jan-92	<0.2	65.5	81.0	129											
ST	07-Jan-92	<0.2	68.0	84.0	161								125			
ST	08-Nov-91	<0.2	65.0	92.0	140	7.12	1174	376	212		390	687	248	9.1	13.5	78.0
ST	21-Aug-91	<0.2	61.2	82.0	117	7.33	1227	412	180	159	480	3319	197	6.4	8.9	75.0
average		**0.2**	**60.2**	**76.1**	**141**		**1353**	**400**	**210**						**7.8**	
std. deviation		**0.3**	**5.4**	**8.5**	**21**		**101**	**15**	**19**						**3.0**	

Groundwater Chemistry

Well ID	Date	pH	Cond. mhos	Alk. mg/l	T. Hard mg/l	React P mg/l	NH4-N mg/l	NO2+NO3-N mg/l	Cl mg/l	Na mg/l	Fluor. mg/l	COD	GW Elev.
HADGE1	20-Mar-92	4.77	641	8	144			32.6	81	51.1	48.0		92.29
HADGE1	13-Aug-91	5.17	461			0.005	<0.02	30.7	52		6.0		91.47
HADGE1	13-May-91	4.89	555	3	128			32.2	71				92.96
HADGE1	15-Nov-90	5.99	206	6	36			9.0	28			8.6	91.56
HADGE2	20-Mar-92	5.77	274	8	48			8.5	45	27.9	36.0		92.29
HADGE2	15-Nov-91	5.68	229				<0.02	4.5	44	20.6	41.0	10.4	91.24
HADGE2	13-Aug-91	5.80	147			0.002	0.02	9.5	13		45.0		91.47
HADGE2	13-May-91	5.75	364	10	76			17.5	47				92.96
HADGE2	05-Mar-91	5.80	289	12	60	0.005	0.45	10.3	54	27.4	27.0		90.94
HADGE2	15-Nov-90	4.79	264	1	44			16.1	29			13.4	91.56
HADGE3	20-Mar-92	5.69	341	8	40			6.2	62	45.2	38.0		92.29
HADGE3	15-Nov-91	5.35	624				<0.02	<0.2	181	64.0	28.0	28.4	91.24
HADGE3	13-Aug-91	5.77	259			0.002	0.02	3.5	51		45.0		91.47
HADGE3	13-May-91	5.77	214	16	24			1.6	38				92.96
HADGE3	05-Mar-91	5.89	326	16	40	<0.002	0.05	2.2	81	46.6	32.0		90.94
HADGE3	15-Nov-90	6.02	338	12	48			2.1	86				91.56
HADGE4	20-Mar-92	5.64	325	20	40			1.3	207	29.4	44.0		92.29
HADGE4	15-Nov-91	5.43	437				<0.02	<0.2	112	50.3	5.0	28.8	91.24
HADGE4	13-Aug-91	5.60	326			<0.002	<0.02	0.7	76		49.0		91.47
HADGE4	13-May-91	5.54	291	16	44			<0.2	65				92.96
HADGE4	05-Mar-91	5.54	357	12	56	<0.002	<0.02	<0.2	99	43.5	34.0		90.94
HADGE4	15-Nov-90	5.70	302	15	48			0.2	85			6.7	91.56
HADGW1	20-Mar-92	5.25	76	8	14			1.6	6	4.9	24.0		92.39
HADGW1	13-Aug-91	5.22	78			<0.002	<0.02	2.8	4		3.0		91.49
HADGW1	13-May-91	5.30	59	3	16			1.5	4				93.00
HADGW1	15-Nov-90	6.52	130	8	32			6.8	9			7.7	91.60
HADGW2	20-Mar-92	5.98	248	24	46			1.6	48	24.5	36.0		92.39
HADGW2	15-Nov-91	6.09	154				<0.02	2.7	15	11.5	5.0	11.3	91.33
HADGW2	13-Aug-91	6.05	109			0.005	0.10	3.9	4		61.0		91.49
HADGW2	13-May-91	6.06	196	20	40			3.1	25				93.00
HADGW2	05-Mar-91	6.27	247	24	40	<0.002	0.50	0.5	53	31.2	38.0		91.03
HADGW2	15-Nov-90	6.48	213	22	52			2.8	30			12.0	91.60
HADGW3	20-Mar-92	5.77	402	24	68			0.9	94	47.8	4.0		92.39
HADGW3	15-Nov-91	5.95	335				<0.02	0.4	76	40.6	52.0	16.7	91.33
HADGW3	13-Aug-91	5.87	194			<0.002	<0.02	7.9	16		54.0		91.49
HADGW3	13-May-91	6.12	242	24	36			4.0	32				93.00
HADGW3	05-Mar-91	5.90	317	14	44	<0.002	0.05	1.1	84	38.6	25.0		91.03
HADGW3	15-Nov-90	6.39	319	28	52			0.5	70			13.4	91.60
HADGW4	20-Mar-92	6.11	427	56	72			<0.2	92	54.3	111.0		92.39
HADGW4	15-Nov-91	5.90	442				<0.02	<0.2	110	56.0	81.0	30.2	91.33
HADGW4	13-Aug-91	5.84	276			<0.002	<0.02	1.2	62		67.0		91.49
HADGW4	13-May-91	6.03	356	32	64			<0.2	76				93.00
HADGW4	05-Mar-91	6.03	562	26	124	<0.002	0.05	0.2	159	57.0	58.0		91.03
HADGW4	15-Nov-90	6.43	416	28	80			0.2	105			16.3	91.60
HAP	20-Mar-92	5.77	425	40	44			0.5	108	64.0	37.0		93.10
HAP	15-Nov-91	5.78	489				<0.02	0.1	129	78.0	65.0	18.2	91.99
HAP	16-Oct-91	5.90	565	16	56	<0.002	<0.02	0.8	168		51.0		91.69
HAUG1	13-May-91	6.48	359	48	72			0.7	71				93.26
HAUG2	20-Mar-92	6.70	510	90	76			1.0	90	118.0	76.0		92.68
HAUG2	15-Nov-91	6.54	562				<0.02	0.3	131	53.5	74.0	17.5	91.53
HAUG2	13-Aug-91	6.59	447			0.215	0.02	0.2	92		69.0		91.72
HAUG2	13-May-91	6.26	365	42	56			0.4	77				93.26
HAUG2	05-Mar-91	6.68	614	68	112	0.245	<0.02	1.1	153	8.0	32.0		91.31
HAUG2	15-Nov-90	6.73	501	38	100			0.4	110			17.8	91.84

Well ID	Date	pH	Cond. mhos	Alk. mg/l	T. Hard mg/l	React P mg/l	NH4-N mg/l	NO2+NO3-N mg/l	Cl mg/l	Na mg/l	Fluor. mg/l	COD	GW Elev.
HODGE1	24-Mar-92	7.00	139	24	52			6.1	5	6.8	36.0		92.07
HODGE1	13-May-91	6.81	237	36	92			13.8	16				92.52
HODGE1	15-Nov-90	7.15	290	44	112			16.9	14			9.6	91.36
HODGE2	24-Mar-92	7.29	151	32	60			6.2	4	6.7	38.0		92.07
HODGE2	19-Nov-91	6.69	164				<0.02	8.8	10	8.3	24.0	14.4	90.98
HODGE2	13-Aug-91	7.51	411					20.2	22		67.0		90.25
HODGE2	13-May-91	7.13	237	26	100			12.2	14				92.05
HODGE2	05-Mar-91	7.54	456	64	164	0.005	<0.02	28.9	33	26.0			90.41
HODGE2	15-Nov-90	7.44	349	68	140			18.3	15			11.1	91.12
HODGE3	24-Mar-92	7.40	162	34	64			6.5	5	7.2	36.0		92.07
HODGE3	19-Nov-91	7.29	239				<0.02	11.3	10	11.6	52.0	16.3	90.98
HODGE3	13-Aug-91	7.22	415					19.9	22		63.0		90.25
HODGE3	13-May-91	7.07	257	50	104			13.8	15				91.84
HODGE3	05-Mar-91	6.95	337	40	104	0.002	<0.02	22.1	20	23.8			90.41
HODGE3	15-Nov-90	7.05	314	60	112			17.4	14			9.6	91.01
HODGE4	24-Mar-92	5.98	180	8	56			15.9	8	4.5	5.0		92.07
HODGE4	19-Nov-91	5.80	271				3.00	23.7	16	8.2	9.0	<3.0	90.98
HODGE4	13-Aug-91	6.29	194					15.3	9		15.0		90.25
HODGE4	13-May-91	5.84	249	5	64			21.7	15				91.82
HODGE4	05-Mar-91	5.93	166	8	40	<0.002	2.90	14.7	11	4.4			90.41
HODGE4	15-Nov-90	5.94	242	20	80			22.2	15			<3.0	91.01
HODGW1	13-May-91	6.73	139	13	44			7.6	15				92.25
HODGW2	24-Mar-92	6.68	95	8	36			4.9	4	4.0	16.0		92.00
HODGW2	19-Nov-91	7.28	232				0.05	9.5	8	9.7	53.0	19.2	90.90
HODGW2	13-Aug-91	6.72	181					9.0	11		32.0		91.00
HODGW2	13-May-91	6.71	162	23	56			8.6	8				91.97
HODGW2	05-Mar-91	7.25	158	32	60	<0.002	0.02	7.2	8	5.8			90.31
HODGW2	15-Nov-90	7.33	143	32	64			4.7	5			<3.0	91.04
HODGW3	24-Mar-92	6.49	93	8	36			4.9	4	4.0	17.0		92.00
HODGW3	19-Nov-91	6.61	209				<0.02	11.2	12	13.1	23.0	4.8	90.90
HODGW3	13-Aug-91	6.64	221					12.5	12		25.0		91.00
HODGW3	13-May-91	6.62	156	14	56			8.0	8				91.80
HODGW3	05-Mar-91	6.73	239	36	64	<0.002	<0.02	14.3	12	19.8			90.31
HODGW3	15-Nov-90	6.96	207	48	80			10.7	8			8.6	90.96
HODGW4	24-Mar-92	6.37	258	20	72			19.4	14	2.0	17.0		92.00
HODGW4	19-Nov-91	6.20	154				<0.02	9.2	6	10.9	2.0	7.8	90.90
HODGW4	13-Aug-91	6.27	320					20.4	20		32.0		91.00
HODGW4	13-May-91	6.07	219	14	60			15.3	11				91.78
HODGW4	05-Mar-91	6.06	176	16	56	<0.002	<0.02	13.6	8	1.0			90.31
HODGW4	15-Nov-90	6.13	207	20	60			14.5	8			40.3	90.96
HOT	17-Sep-90	6.13	166	12	52			7.3	20				
HOUG2	24-Mar-92	6.29	198	14	96			12.9	9	9.7	64.0		91.95
HOUG2	19-Nov-91	6.37	153				<0.02	10.1	8	7.8	83.0	13.7	90.87
HOUG2	13-Aug-91	6.24	151					8.0	5		45.0		89.92
HOUG2	05-Mar-91	6.11	196	12	76	<0.002	<0.02	14.3	8	1.0			90.34
HOUG2	15-Nov-90	7.45	215	16	72			15.7	10			9.1	91.02

Well ID	Date	pH	Cond. mhos	Alk. mg/l	T. Hard mg/l	React P mg/l	NH4-N mg/l	NO2+NO3-N mg/l	Cl mg/l	Na mg/l	Fluor. mg/l	COD	GW Elev.
PODGE1	24-Mar-92	5.17	212	8	56			17.9	14	11.4	21.0		90.03
PODGE1	13-May-91	6.10	132	13	36			7.3	6				90.38
PODGE1	15-Nov-90	6.35	522	12	176			44.5	34			7.1	88.99
PODGE2	24-Mar-92	4.78	457	4	76			39.1	29	24.9	27.0		90.03
PODGE2	13-May-91	5.11	512	3	100			46.8	38				90.38
PODGE2	05-Mar-91	5.65	638	8	40	<0.002	4.12	70.8	42	36.5			88.38
PODGE2	15-Nov-90	5.44	584	28	172			57.6	37			3.6	88.99
PODGE3	24-Mar-92	5.23	486	6	80			40.8	31	27.5	24.0		90.03
PODGE3	19-Nov-91	5.56	533				14.60	47.3	37	32.5	32.0	32.6	88.33
PODGE3	13-Aug-91	5.48	508				16.40	41.3	38		28.0		88.17
PODGE3	13-May-91	5.40	605	4	116			54.6	48				90.34
PODGE3	05-Mar-91	5.60	589	4	40	<0.002	3.98	61.4	39	33.4			88.38
PODGE3	15-Nov-90	5.95	542	20	164			52.9	32			6.1	88.99
PODGE4	19-Nov-91	5.40	523				13.10	46.2	35	31.5	35.0	45.5	88.33
PODGE4	13-May-91	5.73	595	4	120			53.0	44				90.25
PODGE4	05-Mar-91	6.06	559	8	40	<0.002	2.40	52.6	35	32.0			88.38
PODGE4	15-Nov-90	5.99	448	8	148			42.4	26			17.8	88.94
PODGW1	24-Mar-92	5.97	89	8	32			4.0	3	3.4	22.0		90.01
PODGW1	13-May-91	6.06	49	12	20			0.4	1				90.42
PODGW1	15-Nov-90	5.34	314	8	88			29.3	15			<3.0	89.03
PODGW2	24-Mar-92	5.51	409	4	112			36.0	26	24.7	22.0		90.01
PODGW2	19-Nov-91	5.70	358				0.08	31.5	18	19.7	27.0	3.0	88.38
PODGW2	13-Aug-91	5.58	235				0.02	18.4	9		18.0		88.17
PODGW2	13-May-91	5.49	312	15	104			30.1	13				90.42
PODGW2	05-Mar-91	5.90	459	4	140	<0.002	0.52	45.4	25	18.4			88.41
PODGW2	15-Nov-90	5.69	493	20	156			47.6	24			<3.0	89.03
PODGW3	24-Mar-92	5.54	434	6	120			39.9	28	25.8	22.0		90.01
PODGW3	19-Nov-91	6.04	332				0.05	28.9	16	16.3	25.0	<3.0	88.38
PODGW3	13-Aug-91	5.75	218				0.02	16.4	8		2.0		88.17
PODGW3	13-May-91	5.62	336	5	120			33.3	16				90.39
PODGW3	05-Mar-91	5.75	429	4	136	<0.002	0.02	42.8	22	16.8			88.41
PODGW3	15-Nov-90	5.79	512	20	152			49.5	27			<3.0	89.01
PODGW4	24-Mar-92	5.71	444	6	116			39.8	28	26.2	21.0		90.01
PODGW4	19-Nov-91	6.08	338				0.02	29.6	16	17.3	24.0	20.3	88.38
PODGW4	13-Aug-91	5.80	242				<0.02	19.0	9		17.0		88.17
PODGW4	13-May-91	5.98	329	5	108			30.8	15				90.32
PODGW4	05-Mar-91	5.94	425	4	144	<0.002	0.05	44.0	23	17.6	5.0		
PODGW4	15-Nov-90	6.10	502	20	152			48.4	26			<3.0	88.96
POUG1	24-Mar-92	5.45	135	8	52			9.0	4	2.6	13.0		90.07
POUG1	13-May-91	5.87	169	4	52			13.6	3				90.66
POUG1	15-Nov-90	6.09	152	12	52			12.3	3			<3.0	89.18
POUG2	24-Mar-92	5.49	180	4	68			13.5	5	4.4	24.0		90.07
POUG2	19-Nov-91	5.67	150				<0.02	10.2	3	4.5	28.0	11.1	88.44
POUG2	13-Aug-91	5.69	154				<0.02	8.9	3		23.0		88.27
POUG2	13-May-91	5.58	236	6	80			19.5	7				90.50
POUG2	05-Mar-91	5.55	251	8	100	<0.002	<0.02	25.0	7	6.5			88.49
POUG2	15-Nov-90	5.60	284	12	140			26.5	10			<3.0	89.10

Well ID	Date	pH	Cond. mhos	Alk. mg/l	T. Hard mg/l	React P mg/l	NH4-N mg/l	NO2+NO3-N mg/l	Cl mg/l	Na mg/l	Fluor. mg/l	COD	GW Elev.
RA1DGN1	13-May-91	5.88	195	16	80			8.6	1				87.89
RA1DGN1	15-Nov-90	6.31	139	24	52			5.4	<1			5.7	87.00
RA1DGN1	29-Sep-90	6.60	202	5	72	<0.002		6.1	2	24.0			
RA1DGN2	07-Apr-92	6.08	263	20	96	<0.002		16.6	8	8.3	19.0		
RA1DGN2	19-Nov-91	6.17	177				0.05	9.4	7	10.9	16.0	6.4	86.34
RA1DGN2	13-Aug-91	6.30	196					7.6	17		11.0		87.09
RA1DGN2	13-May-91	6.43	154	16	56			8.3	4				87.89
RA1DGN2	05-Mar-91	6.42	139	22	44	<0.002	<0.02	6.9	1	7.5	8.5		85.86
RA1DGN2	15-Nov-90	6.20	131	20	40			5.2	4			10.4	87.00
RA1DGN2	29-Sep-90	6.18	187	5	56	<0.002		7.9	6	37.0			
RA1DGN3	07-Apr-92	6.13	235	16	84	<0.002		19.4	4	5.9	1.0		
RA1DGN3	19-Nov-91	6.19	96				0.02	4.4	4	4.3	11.0	15.4	86.34
RA1DGN3	13-Aug-91	6.30	82					2.4	4		11.0		87.09
RA1DGN3	13-May-91	6.11	132	20	48			7.8	3				87.89
RA1DGN3	05-Mar-91	6.71	92	20	20	<0.002	<0.02	2.9	<1	5.0	7.0		85.86
RA1DGN3	15-Nov-90	6.37	103	39	40			4.0	3			3.8	87.00
RA1DGN3	29-Sep-90	6.47	109	16	36	<0.002		4.3	4	17.5			
RA1DGN4	07-Apr-92	6.00	38	12	12	<0.002		1.0	<1	1.2	8.0		
RA1DGN4	19-Nov-91	5.98	32				<0.02	<0.2	1	1.4	1.0	<3.0	86.34
RA1DGN4	13-Aug-91	6.56	28					<0.2	1		6.0		87.09
RA1DGN4	13-May-91	6.00	33	4	12			0.3	<1				87.89
RA1DGN4	05-Mar-91	6.38	31	5	16	<0.002	<0.02	0.3	<1	26.0	5.0		85.86
RA1DGN4	15-Nov-90	6.49	31	5	4			0.4	<1			4.7	87.00
RA1DGN4	29-Sep-90	6.35	34	6	16	<0.002		0.4	1	1.5			
RA1DGS1	13-May-91	5.78	140	8	48			9.8	1				88.37
RA1DGS1	15-Nov-90	6.15	206	10	80			12.1	2			6.6	87.47
RA1DGS1	29-Sep-90	6.15	237	10	84	<0.002		12.6	6	6.5			
RA1DGS2	19-Nov-91	6.01	63				<0.02	1.0	2	2.0	13.0	4.1	86.90
RA1DGS2	13-May-91	5.88	133	8	40			5.2	1				88.37
RA1DGS2	05-Mar-91	6.11	112	17	40	<0.002	<0.02	5.4	<1	4.0	1.0		86.33
RA1DGS2	15-Nov-90	6.30	205	13	68			12.2	7			5.2	87.47
RA1DGS2	29-Sep-90	5.74	341	10	100	<0.002		22.4	28	22.0			
RA1DGS3	19-Nov-91	6.30	48				<0.02	<0.2	1	1.2	12.0	5.6	86.90
RA1DGS3	13-May-91	5.76	91	8	24			3.2	2				88.37
RA1DGS3	05-Mar-91	6.04	71	15	20	<0.002	<0.02	1.2	<1	5.0	8.0		86.33
RA1DGS3	15-Nov-90	6.53	103	13	40			3.5	<1			4.7	87.47
RA1DGS3	29-Sep-90	5.88	181	11	60	<0.002		10.8	10	10.0			
RA1DGS4	19-Nov-91	5.86	40				<0.02	<0.2	1	1.1	11.0	7.6	86.90
RA1DGS4	13-May-91	5.78	42	4	12			<0.2	1				88.37
RA1DGS4	05-Mar-91		36	6	8	<0.002	<0.02	<0.2	<1	2.4			86.33
RA1DGS4	15-Nov-90	6.11	47	6	8			0.2	1			5.2	87.47
RA1DGS4	29-Sep-90	6.07	52	7	16	0.002		0.6	2	4.5			
RA1DGW1	12-Jun-92	4.41	712	<4	336	<0.002	1.9	60	60		50		
RA1DGW2	12-Jun-92	4.39	785	<4	168	<0.002	2.5	70	65		52		
RA1DGW3	12-Jun-92	5.14	78	7.6	28	<0.002	0.05	3.2	4		13		
RA1DGW4	12-Jun-92	5.81	38	7.2	28	<0.002	<.02	0.5	1		9		
RA1UG1	13-May-91	5.99	60	12	20			<0.2	1				86.72
RA1UG1	29-Sep-90	6.57	64	2	24	<0.002		0.6	2	4.0			
RA1UG2	07-Apr-92	5.82	48	8	16	<0.002		0.7	<1	2.0	1.0		
RA1UG2	19-Nov-91	6.10	39				<0.02	<0.2	2	1.7	11.0	<3.0	85.14
RA1UG2	13-Aug-91	6.39	39					0.6	2		7.0		86.77
RA1UG2	13-May-91	5.75	44	12	16			0.5	2				86.71
RA1UG2	05-Mar-91	5.99	38	7	20	<0.002	<0.02	0.3	1	1.4	7.5		84.67
RA1UG2	15-Nov-90	5.98	39	7	16			0.2	1			3.8	85.79

Well ID	Date	pH	Cond. mhos	Alk. mg/l	T. Hard mg/l	React P mg/l	NH4-N mg/l	NO2+NO3-N mg/l	Cl mg/l	Na mg/l	Fluor. mg/l	COD	GW Elev.
RA2DGN1	06-Apr-92	6.43	45	6	16			1.6	<1	1.1	15.5		87.05
RA2DGN1	13-May-91	6.06	49	12	16			1.1	<1				87.53
RA2DGN1	15-Nov-90	6.80	48	10	24			0.7	<1			<3.0	86.65
RA2DGN1	29-Sep-90	6.18	54	12	32	<0.002		1.8	1	1.0			
RA2DGN2	06-Apr-92	6.56	569	71	212			35.1	25	19.0	58.0		87.05
RA2DGN2	19-Nov-91	5.99	409				<0.02	34.4	23	23.2	44.0	7.6	86.02
RA2DGN2	13-Aug-91	6.24	239					13.1	18		29.0		86.73
RA2DGN2	13-May-91	6.30	192	28	60			9.2	8				87.53
RA2DGN2	05-Mar-91	6.44	400	28	124	<0.002	0.02	27.1	21	27.4	33.0		85.54
RA2DGN2	15-Nov-90	6.44	213	25	72			14.7	9			7.9	86.65
RA2DGN2	29-Sep-90	6.25	286	32	100	<0.002		20.2	14	96.0			
RA2DGN3	06-Apr-92	6.58	319	39	108			19.7	8	15.0	75.5		87.05
RA2DGN3	19-Nov-91	6.47	131				0.02	2.0	4	10.6	8.0	7.6	86.02
RA2DGN3	13-Aug-91	6.36	441					20.7	32		55.0		86.73
RA2DGN3	13-May-91	6.44	511	56	164			31.5	29				87.53
RA2DGN3	05-Mar-91	6.59	450	52	140	<0.002	<0.02	31.5	21	31.4	37.5		85.54
RA2DGN3	15-Nov-90	6.52	667	84	252			48.2	33			11.6	86.65
RA2DGN3	29-Sep-90	6.82	614	96	216	<0.002		42.2	26	37.0			
RA2DGN4	06-Apr-92	6.44	158	13	64			10.9	1	4.3	24.0		87.05
RA2DGN4	19-Nov-91	6.80	131				0.22	2.2	3	6.6	79.0	13.3	86.02
RA2DGN4	13-Aug-91	6.57	838					59.2	37		67.0		86.73
RA2DGN4	13-May-91	6.47	643	115	220			37.6	36				
RA2DGN4	05-Mar-91	6.64	543	88	208	<0.002	<0.02	32.5	27	3.0	48.0		85.54
RA2DGN4	15-Nov-90	6.62	760	104	268			49.5	37			22.0	86.65
RA2DGN4	29-Sep-90	6.50	869	118	320	<0.002		77.4	34	108.0			
RA2DGS1	06-Apr-92	6.11	450	18	136			34.7	24	23.2	31.5		85.34
RA2DGS1	13-Aug-91	6.72	169					11.8	9		2.0		84.95
RA2DGS1	13-May-91	5.96	123	12	32			5.8	4				85.86
RA2DGS1	15-Nov-90	6.39	198	6	60			15.5	13			1.0	84.98
RA2DGS1	29-Sep-90	6.12	165	9	52	<0.002		12.7	11	7.0			
RA2DGS2	06-Apr-92	6.58	547	74	192			34.6	30	23.8	59.5		85.34
RA2DGS2	19-Nov-91	6.60	455				0.05	30.7	25	26.2	68.0	9.9	84.30
RA2DGS2	13-Aug-91	6.62	424					25.8	23		52.0		84.95
RA2DGS2	13-May-91	6.68	552	72	172			33.3	31				85.86
RA2DGS2	05-Mar-91	6.72	522	75	180	<0.002	<0.02	35.0	32	34.8	57.5		83.87
RA2DGS2	15-Nov-90	6.52	521	61	152			34.5	30			11.2	84.98
RA2DGS2	29-Sep-90	6.57	467	57	140	<0.002		32.3	32	110.0			
RA2DGS3	06-Apr-92	6.92	605	136	244			30.5	30	19.1	76.5		85.34
RA2DGS3	19-Nov-91	7.48	607				<0.02	39.3	31	29.0	87.0	8.7	84.30
RA2DGS3	13-Aug-91	6.81	635					33.3	30		64.0		84.95
RA2DGS3	13-May-91	6.91	750	156	252			38.3	36				85.86
RA2DGS3	05-Mar-91	6.94	631	110	204	<0.002	<0.02	40.3	36	39.0	43.0		83.87
RA2DGS3	15-Nov-90	6.89	692	143	248			36.0	32			14.1	84.98
RA2DGS3	29-Sep-90	6.93	724	176	252	<0.002		37.2	37	166.0			
RA2DGS4	06-Apr-92	6.85	252	52	100			12.0	6	7.4	59.5		85.34
RA2DGS4	19-Nov-91	6.78	706				0.02	46.0	34	29.9	81.0	16.0	84.30
RA2DGS4	13-Aug-91	7.04	219					7.0	9		48.0		84.95
RA2DGS4	13-May-91	7.05	570	132	196			26.0	26				85.86
RA2DGS4	05-Mar-91	6.93	658	154	240	<0.002	0.05	33.2	35	32.0	46.0		83.87
RA2DGS4	15-Nov-90	6.80	666	150	256			29.4	30			10.4	84.98
RA2DGS4	29-Sep-90	7.11	270	70	96	<0.002		11.6	11	14.0			
RA2UG1	13-May-91	5.81	55	8	12			<0.2	3				86.85
RA2UG1	15-Nov-90	6.24	28	4	8			<0.2	<1			<3.0	85.92
RA2UG1	29-Sep-90	5.90	31	3	12	0.010		0.3	1	0.5			
RA2UG2	06-Apr-92	5.89	50	12	12			0.3	<1	3.2	13.0		86.37
RA2UG2	19-Nov-91	5.74	46				<0.02	<0.2	2	3.1	13.0	6.8	85.25
RA2UG2	13-Aug-91	6.27	50					<0.2	2		1.0		87.04
RA2UG2	13-May-91	5.64	31	4	8			<0.2	1				86.85
RA2UG2	05-Mar-91	5.84	48	73	16	<0.002	<0.02	0.2	2	4.0	9.0		84.80
RA2UG2	15-Nov-90	6.00	46	9	12			0.2	2			4.2	85.92

Well ID	Date	pH	Cond. mhos	Alk. mg/l	T. Hard mg/l	React P mg/l	NH4-N mg/l	NO2+NO3-N mg/l	Cl mg/l	Na mg/l	Fluor. mg/l	COD	GW Elev.
RA3DGN1	06-Apr-92	6.76	88	16	28			5.1	<1	2.7	15.5		86.37
RA3DGN1	13-May-91	6.22	112	16	40			5.6	4				86.84
RA3DGN1	29-Sep-90	6.57	90	20	36	<0.002		3.3	2	5.0			
RA3DGN2	06-Apr-92	6.44	458	32	164			39.2	22	15.1	26.0		86.37
RA3DGN2	19-Nov-91	6.29	564				0.02	42.1	38	17.9	3.0	4.6	85.36
RA3DGN2	13-Aug-91	6.42	369					24.0	21		34.0		86.00
RA3DGN2	13-May-91	6.40	582	68	208			35.7	30				86.84
RA3DGN2	05-Mar-91	6.61	650	76	244	<0.002	<0.02	46.1	33	24.4	23.0		84.88
RA3DGN2	15-Nov-90	6.65	338	85	132			11.3	10			8.0	85.99
RA3DGN2	29-Sep-90	6.73	364	80	156	<0.002		17.6	18	15.5			
RA3DGN3	06-Apr-92	6.67	798	108	288			57.0	45	24.9	45.5		86.37
RA3DGN3	19-Nov-91	6.42	694				0.02	51.2	37	24.9	45.0	<3.0	85.36
RA3DGN3	13-Aug-91	6.50	682					39.6	39		38.0		86.00
RA3DGN3	13-May-91	6.54	777	136	292			42.8	38				86.84
RA3DGN3	05-Mar-91	6.69	753	104	296	<0.002	<0.02	52.6	42	27.6	23.5		84.88
RA3DGN3	15-Nov-90	6.57	769	135	328			47.2	35			9.2	85.99
RA3DGN3	29-Sep-90	6.71	586	115	240	<0.002		32.2	32	20.5			
RA3DGN4	06-Apr-92	6.52	834	144	344			53.0	17	24.7	49.0		86.37
RA3DGN4	19-Nov-91	6.57	602				0.02	43.7	30	22.5	46.0	4.2	85.36
RA3DGN4	13-Aug-91	6.63	466					23.7	22		45.0		86.00
RA3DGN4	13-May-91	6.56	903	184	356			44.8	45				86.84
RA3DGN4	05-Mar-91	6.79	710	116	300	<0.002	<0.02	46.1	46	24.0	23.5		84.88
RA3DGN4	15-Nov-90	6.60	669	105	280			41.3	33			5.8	85.99
RA3DGN4	29-Sep-90	6.72	403	88	164	<0.002		19.4	21	26.0			
RA3DGS1	06-Apr-92	6.84	223	20	84			17.3	6	6.5	14.5		85.93
RA3DGS1	13-May-91	6.28	163	20	60			9.8	7				86.41
RA3DGS1	29-Sep-90	6.45	183	24	76	0.002		11.9	9	5.0			
RA3DGS2	06-Apr-92	6.66	472	48	180			35.4	20	16.7	28.0		85.93
RA3DGS2	19-Nov-91	6.49	544				0.02	32.9	28	19.9	41.0	27.7	84.94
RA3DGS2	13-Aug-91	6.42	538					36.4	33		32.0		85.74
RA3DGS2	13-May-91	6.39	524	60	188			32.9	30				86.41
RA3DGS2	05-Mar-91	6.76	581	77	220	<0.002	<0.02	38.5	29	19.8	22.0		84.45
RA3DGS2	15-Nov-90	6.57	485	71	180			30.1	22			9.2	85.56
RA3DGS2	29-Sep-90	6.58	496	75	196	<0.002		32.6	23	16.5			
RA3DGS3	06-Apr-92	6.66	781	136	328			56.0	44	24.5	43.5		85.93
RA3DGS3	19-Nov-91	6.57	687				<0.02	41.1	36	24.3	5.0	9.0	84.94
RA3DGS3	13-Aug-91	6.69	810					48.0	39		58.0		85.74
RA3DGS3	13-May-91	6.55	782	124	288			42.8	42				86.41
RA3DGS3	05-Mar-91	6.65	714	108	260	<0.002	<0.02	45.2	39	24.2	25.0		84.45
RA3DGS3	15-Nov-90	6.57	791	211	304			54.9	36			9.7	85.56
RA3DGS3	29-Sep-90	6.41	754	103	292	<0.002		51.6	38	26.0			
RA3DGS4	06-Apr-92	6.82	559	116	236			33.5	23	16.6	42.5		85.93
RA3DGS4	19-Nov-91	6.63	372				<0.02	20.1	17	14.6	3.0	6.7	84.94
RA3DGS4	13-Aug-91	6.73	543					27.6	19		32.0		85.74
RA3DGS4	13-May-91	6.64	734	156	284			34.6	39				86.41
RA3DGS4	05-Mar-91	6.84	484	60	196	<0.002	<0.02	28.6	25	16.2	17.0		84.45
RA3DGS4	15-Nov-90	6.67	632	103	240			39.0	28			7.7	85.56
RA3DGS4	29-Sep-90	6.34	534	91	220	<0.002		31.2	25	18.0			
RA3UG1	13-May-91	6.00	67	8	20			<0.2	2				86.88
RA3UG2	06-Apr-92	5.92	70	6	12			0.5	1	6.1	9.5		86.40
RA3UG2	19-Nov-91	5.89	49				0.02	<0.2	4	3.7	9.0	<3.0	85.31
RA3UG2	13-Aug-91	6.50	48					<0.2	4		1.0		86.95
RA3UG2	05-Mar-91	6.07	67	4	24	<0.002	<0.02	<0.2	7	4.8	5.5		84.87
RA3UG2	15-Nov-90	6.24	59	4	8			<0.2	6			3.3	85.97

Well ID	Date	pH	Cond. mhos	Alk. mg/l	T. Hard mg/l	React P mg/l	NH4-N mg/l	NO2+NO3-N mg/l	Cl mg/l	Na mg/l	Fluor. mg/l	COD	GW Elev.
RA4DGN1	06-Apr-92	6.34	41	12	16			0.7	<1	1.1	11.5		86.32
RA4DGN1	13-May-91	6.08	114	16	40			6.6	2				86.82
RA4DGN1	15-Nov-90	6.31	231	76	92			16.4	10			6.2	85.95
RA4DGN2	06-Apr-92	6.70	240	48	100			13.3	3	8.5	37.5		86.32
RA4DGN2	09-Dec-91	6.73	555				<0.02	42.1	30	19.3	26.0	8.7	85.68
RA4DGN2	13-Aug-91	6.50	494					17.7	14		56.0		86.20
RA4DGN2	13-May-91	6.65	435	56	156			28.5	24				86.82
RA4DGN2	05-Mar-91	6.68	599	93	256	<0.002	<0.02	40.7	35	20.4	24.0		84.91
RA4DGN2	15-Nov-90	6.76	624	372	256			40.3	31			20.9	85.95
RA4DGN3	06-Apr-92	6.70	684	84	276			54.0	12	23.3	46.0		86.32
RA4DGN3	09-Dec-91	7.72	668				<0.02	52.6	37	23.0	34.0	9.2	85.68
RA4DGN3	13-Aug-91	6.71	439					5.7	4		64.0		86.20
RA4DGN3	13-May-91	6.67	679	116	268			42.3	34				86.82
RA4DGN3	05-Mar-91	6.75	665	105	276	<0.002	<0.02	43.5	38	23.2	24.0		84.91
RA4DGN3	15-Nov-90	6.77	651	528	268			36.0	31			11.5	85.95
RA4DGN4	06-Apr-92	6.71	738	104	304			55.0	14	23.2	49.0		86.32
RA4DGN4	09-Dec-91	6.90	435				<0.02	32.1	21	11.3	19.0	15.0	85.68
RA4DGN4	13-Aug-91	6.67	317					16.3	13		59.0		86.20
RA4DGN4	13-May-91	6.76	708	136	280			39.9	35				86.82
RA4DGN4	05-Mar-91	6.75	680	122	280	<0.002	<0.02	42.3	37	22.6	24.0		84.91
RA4DGN4	15-Nov-90	6.83	404	404	164			18.3	16			13.6	85.95
RA4DGS1	13-Aug-91	6.20	120					10.2	8		27.0		86.18
RA4DGS1	13-May-91	5.66	90	8	28			5.1	<1				86.79
RA4DGS1	15-Nov-90	5.96	121	24	40			7.4	2			6.3	85.92
RA4DGS2	13-Aug-91	6.79	260					7.4	6		39.0		86.20
RA4DGS2	13-May-91	6.30	241	28	80			11.2	8				86.79
RA4DGS2	05-Mar-91	6.60	431	284	180	<0.002	<0.02	26.5	20	14.5	28.0		84.87
RA4DGS2	15-Nov-90	6.47	245	64	84			14.7	9			8.4	85.92
RA4DGS3	13-Aug-91	6.91	144					0.2	3		25.0		86.20
RA4DGS3	13-May-91	6.48	156	32	56			6.4	5				86.79
RA4DGS3	05-Mar-91	6.71	357	252	144	<0.002	<0.02	22.3	16	11.2	19.0		84.87
RA4DGS3	15-Nov-90	6.98	110	76	36			5.7	2			4.2	85.92
RA4DGS4	13-Aug-91	6.78	57					<0.2	3		12.0		86.20
RA4DGS4	13-May-91	6.41	56	16	16			0.5	56				86.79
RA4DGS4	05-Mar-91	6.67	211	34	100	<0.002	<0.02	12.3	9	6.4	11.0		84.87
RA4DGS4	15-Nov-90	7.09	57	36	16			1.1	2			4.7	85.92
RA4UG1	13-May-91	6.15	61	8	20			0.2	2				86.80
RA4UG2	06-Apr-92	6.28	45	12	340			<0.2	<1	2.2	8.5		86.32
RA4UG2	09-Dec-91	6.54	41				<0.02	<0.2	2	2.0	5.0	<3.0	85.63
RA4UG2	13-Aug-91	5.92	53					30.4	21		11.0		87.04
RA4UG2	13-May-91	6.46	53	4	12			0.4	2				86.80
RA4UG2	05-Mar-91	6.24	50	24	12	<0.002	<0.02	<0.2	2	3.5	5.5		84.85
RA4UG2	15-Nov-90	6.68	50	12	8			0.4	3			3.1	85.90

Well ID	Date	pH	Cond. mhos	Alk. mg/l	T. Hard mg/l	React P mg/l	NH4-N mg/l	NO2+NO3-N mg/l	Cl mg/l	Na mg/l	Fluor. mg/l	COD	GW Elev.
RA5DGE1	30-Mar-92	5.53	343	8	108	<0.002		26.9	18	14.5	14.0		85.29
RA5DGE1	13-Feb-92	6.20	348					30.4	22				84.71
RA5DGE1	06-Jan-92	6.75	389	56	140		<0.02	24.6	20	14.8	18.0	4.9	
RA5DGE1	13-May-91	5.65	261	9	44			5.9	54				86.22
RA5DGE1	15-Nov-90	6.41	152	32	28			7.1	8			5.2	85.49
RA5DGE2	30-Mar-92	6.71	435	60	164	<0.002		25.8	20	16.5	12.0		85.29
RA5DGE2	13-Feb-92	7.04	467					33.9	28				84.71
RA5DGE2	06-Jan-92	5.98	357	12	112		<0.02	28.5	20	15.8	18.0	4.0	
RA5DGE2	13-May-91	5.30	396	7	120			33.1	29				86.22
RA5DGE2	05-Mar-91	5.56	378	5	120	<0.002	<0.02	32.2	29	18.8	8.0		84.49
RA5DGE2	15-Nov-90	5.97	309	24	88			25.0	20			5.7	85.49
RA5DGE3	30-Mar-92	7.84	235	70	96	<0.002		4.9	11	9.2	6.0		85.29
RA5DGE3	13-Feb-92	7.94	400					20.6	22				84.71
RA5DGE3	06-Jan-92	7.97	470	96	188		<0.02	26.2	27	12.9	16.0	5.8	
RA5DGE3	13-May-91	7.54	509	91	200			29.6	29				86.20
RA5DGE3	05-Mar-91	7.68	646	128	260	<0.002	<0.02	35.6	33	2.0	7.0		84.49
RA5DGE3	15-Nov-90	7.52	574	432	216			33.4	22			<3.0	85.49
RA5DGE4	30-Mar-92	8.13	165	50	72	<0.002		1.7	6	4.0	5.0		85.29
~~RA5DGE4~~	~~13-Feb-92~~	~~8.46~~	232					6.3	14				84.71
RA5DGE4	06-Jan-92	8.15	476	92	192		<0.02	25.2	26	12.7	15.0	4.9	
RA5DGE4	13-May-91	7.77	369	88	144			15.4	18				86.20
RA5DGE4	05-Mar-91	7.92	388	103	168	<0.002	<0.02	16.3	22	13.2	7.0		84.49
RA5DGE4	15-Nov-90	7.90	433	360	152			21.9	23			7.3	85.49
RA5DGW1	13-May-91	6.02	80	12	28			1.8	6				86.63
RA5DGW1	05-Mar-91	5.78	380	4	124	<0.002	<0.02	33.6	30	18.5	7.0		84.91
RA5DGW1	15-Nov-90	7.05	69	36	20			2.2	2			8.3	85.89
RA5DGW2	30-Mar-92	4.97	356	<4	116	<0.002		28.2	12	12.8	21.0		85.30
RA5DGW2	13-Feb-92	4.90	315					26.4	18				84.66
RA5DGW2	06-Jan-92	5.07	318	4	96		<0.02	26.8	19	12.2	22.0	4.9	84.78
RA5DGW2	19-Nov-91	5.20	341				<0.02	29.9	21	16.1	25.0	4.9	84.78
RA5DGW2	13-May-91	5.15	377	3	116			30.1	27				86.63
RA5DGW2	05-Mar-91	5.35	446	3	128	<0.002	<0.02	39.1	36	21.0	7.0		84.91
RA5DGW2	15-Nov-90	5.54	421	4	124			37.8	27			6.2	85.89
RA5DGW3	30-Mar-92	5.54	247	8	72	<0.002		18.3	11	11.8	11.0		85.30
RA5DGW3	13-Feb-92	5.24	245					19.3	16				84.66
RA5DGW3	06-Jan-92	5.16	404	4	132		0.02	35.4	22	15.3	23.0	11.2	84.78
RA5DGW3	13-May-91	5.92	361	13	116			26.1	26				86.63
RA5DGW3	05-Mar-91	6.03	346	10	96	<0.002	<0.02	28.6	24	16.4	6.0		84.91
RA5DGW3	15-Nov-90	6.84	316	40	88			24.5	20			7.3	85.89
RA5DGW4	30-Mar-92	7.96	265	80	108	<0.002		8.5	8	10.6	9.0		85.30
RA5DGW4	13-Feb-92	7.94	262					7.4	15				84.66
RA5DGW4	06-Jan-92	7.86	350	88	144		<0.02	14.6	20	12.4	13.0	<3.0	84.78
RA5DGW4	13-May-91	7.72	383	79	152			18.0	24				86.63
RA5DGW4	05-Mar-91	7.82	557	91	224	<0.002	<0.02	36.1	30	19.8	8.0		84.91
RA5DGW4	15-Nov-90	7.69	307	296	116			12.3	15			3.6	85.89
RA5UG1	30-Mar-92	6.30	150	18	24	<0.002		1.8	17	15.4	21.0		85.65
RA5UG1	13-May-91	6.47	169	20	40			1.7	27				86.35
RA5UG2	30-Mar-92	6.89	74	20	32	<0.002		0.5	<1	2.4	7.0		85.65
RA5UG2	13-Feb-92	6.73	80					0.5	4				85.01
RA5UG2	19-Nov-91	6.55	94				<0.02	0.4	10	3.2	9.0	<3.0	85.04
RA5UG2	13-May-91	6.52	77	20	68			0.2	3				86.35
RA5UG2	05-Mar-91	6.93	103	26	64	<0.002	<0.02	0.4	3	2.2	4.0		84.54
RA5UG2	15-Nov-90	6.97	78	88	28			<0.2	1			6.2	85.53

Well ID	Date	pH	Cond. mhos	Alk. mg/l	T. Hard mg/l	React P mg/l	NH4-N mg/l	NO2+NO3-N mg/l	Cl mg/l	Na mg/l	Fluor. mg/l	COD	GW Elev.
RA6DGN1	30-Mar-92	5.48	337	<4	104	<0.002		25.0	18	16.6	15.0		86.35
RA6DGN1	13-May-91	5.48	240	6	64			18.7	17				87.03
RA6DGN1	15-Nov-90	6.00	343	8	132			33.1	24			6.8	86.25
RA6DGN2	30-Mar-92	5.05	417	<4	136	<0.002		31.8	27	18.2	19.0		86.35
RA6DGN2	19-Nov-91	5.18	408				<0.02	36.0	27	16.4	22.0	4.0	85.79
RA6DGN2	13-Aug-91	5.96	417					26.9	23		24.0		87.43
RA6DGN2	13-May-91	5.09	437	4	120			33.9	30				87.03
RA6DGN2	05-Mar-91	5.86	398	2	120	<0.002	<0.02	35.0	31	16.8	9.0		85.18
RA6DGN2	15-Nov-90	5.20	518	3	160			53.3	29			4.4	86.25
RA6DGN3	30-Mar-92	5.60	328	8	108	<0.002		24.2	21	14.7	14.0		86.35
RA6DGN3	19-Nov-91	5.56	288				<0.02	23.1	21	14.1	19.0	9.0	85.79
RA6DGN3	13-Aug-91	5.76	359					6.1	13		21.0		87.43
RA6DGN3	13-May-91	5.53	383	9	116			28.3	28				87.03
RA6DGN3	05-Mar-91	5.85	392	7	120	<0.002	<0.02	33.2	31	16.8	8.0		85.18
RA6DGN3	15-Nov-90	5.74	306	9	100			25.7	22			3.9	86.25
RA6DGN4	30-Mar-92	6.26	60	8	16			1.5	<1	4.0	8.0		86.35
RA6DGN4	19-Nov-91	6.26	51				<0.02	0.3	2	2.3	11.0	4.5	85.79
RA6DGN4	13-Aug-91	6.09	144					28.5	28		12.0		87.43
RA6DGN4	13-May-91	5.96	121	9	32			6.2	7				87.03
RA6DGN4	05-Mar-91	6.28	116	10	28	<0.002	<0.02	2.3	14	12.0	5.0		85.18
RA6DGN4	15-Nov-90	6.20	692	9	24			2.3	2			<3.0	86.25
RA6DGS1	30-Mar-92	5.82	69	<4	20	<0.002		2.9	<1	2.4	8.0		86.39
RA6DGS1	13-May-91	5.76	94	7	32			4.2	8				87.07
RA6DGS1	15-Nov-90	5.73	141	8	52			11.4	5			8.7	86.28
RA6DGS2	30-Mar-92	5.13	282	<4	80	<0.002		35.0	32	13.3	18.0		86.39
RA6DGS2	19-Nov-91	5.33	291				0.02	23.7	19	15.7	19.0	4.5	85.82
RA6DGS2	13-Aug-91	5.55	373					27.3	25		22.0		86.57
RA6DGS2	13-May-91	5.04	364	4	108			27.3	28				87.07
RA6DGS2	05-Mar-91	5.23	420	2	120	0.002	<0.02	36.8	33	17.4	8.0		85.22
RA6DGS2	15-Nov-90	4.88	472	2	144			46.5	29			10.5	86.28
RA6DGS3	30-Mar-92	5.14	395	<4	124	<0.002		30.2	26	17.1	14.0		86.39
RA6DGS3	19-Nov-91	5.18	341				0.02	27.7	20	14.2	18.0	7.2	85.82
RA6DGS3	13-Aug-91	5.32	351					7.8	9		19.0		86.57
RA6DGS3	13-May-91	5.13	372	6	112			28.7	28				87.07
RA6DGS3	05-Mar-91	5.75	370	7	152	<0.002	0.05	33.7	26	14.5	7.0		85.22
RA6DGS3	15-Nov-90	5.14	423	5	160			42.3	20			<3.0	86.28
RA6DGS4	30-Mar-92	5.50	99	<4	28	<0.002		4.6	<1	4.5	7.0		86.39
RA6DGS4	19-Nov-91	5.35	203				0.02	14.8	13	10.1	11.0	3.6	85.82
RA6DGS4	13-Aug-91	5.57	134					0.3	3		12.0		86.57
RA6DGS4	13-May-91	5.55	115	5	36			6.0	7				87.07
RA6DGS4	05-Mar-91	5.90	103	4	28	<0.002	0.05	4.0	8	4.6	4.0		85.22
RA6DGS4	15-Nov-90	5.60	299	5	100			28.2	14			3.3	86.28
RA6UG1	13-May-91	5.82	69	12	16			1.5	4				86.39
RA6UG2	30-Mar-92	6.12	48	<4	16	<0.002		0.5	<1	1.6	9.0		85.68
RA6UG2	19-Nov-91	5.89	48				<0.02	0.7	1	1.8	11.0	<3.0	84.99
RA6UG2	13-Aug-91	7.87	407					33.8	27		11.0		85.82
RA6UG2	13-May-91	5.87	55	6	16			1.0	1				86.39
RA6UG2	05-Mar-91	6.42	51	5	12	<0.002	<0.02	0.3	1	1.4	5.0		84.49
RA6UG2	15-Nov-90	6.28	73	6	28			3.5	3			8.2	85.55

Well ID	Date	pH	Cond. mhos	Alk. mg/l	T. Hard mg/l	React P mg/l	NH4-N mg/l	NO2+NO3-N mg/l	Cl mg/l	Na mg/l	Fluor. mg/l	COD	GW Elev.
RA7DGN1	30-Mar-92	7.44	698	128	256	<0.002		37.6	29	20.1	14.0		83.22
RA7DGN1	09-Dec-91	7.79	676				<0.02	47.0	29	19.7	9.0	<3.0	83.08
RA7DGN1	13-Aug-91	7.78	434					20.1	14		16.0		83.76
RA7DGN1	13-May-91	7.48	768	137	316			43.3	44				83.90
RA7DGN1	15-Nov-90	7.62	593	140	264			32.5	22			<3.0	83.34
RA7DGN2	30-Mar-92	7.83	300	88	124	<0.002		8.6	1	4.0	8.0		83.22
RA7DGN2	09-Dec-91	8.04	412				<0.02	22.7	14	9.5	7.0	4.7	83.08
RA7DGN2	13-Aug-91	7.95	221					8.7	3		9.0		83.76
RA7DGN2	13-May-91	7.81	347	103	144			12.2	11				83.90
RA7DGN2	05-Mar-91	7.82	235	68	112	0.005	<0.02	9.5	6	3.4	6.0		82.40
RA7DGN2	15-Nov-90	7.98	324	152	152			12.3	6			<3.0	83.34
RA7DGN3	30-Mar-92	8.00	200	60	80	<0.002		3.0	<1	2.7	5.0		83.22
RA7DGN3	09-Dec-91	7.86	678				<0.02	48.1	29	20.2	1.0	4.3	83.08
RA7DGN3	13-Aug-91	7.97	242					10.5	7		1.0		83.76
RA7DGN3	13-May-91	7.95	230	58	100			9.0	8				83.90
RA7DGN3	05-Mar-91	7.98	176	49	92	0.005	<0.02	6.1	7	3.2	6.0		82.40
RA7DGN3	15-Nov-90	7.41	267	64	112			13.3	16			<3.0	83.34
RA7DGN4	30-Mar-92	8.08	208	66	84	<0.002		2.4	1	3.5	6.0		83.22
RA7DGN4	09-Dec-91	8.02	158				<0.02	2.0	5	6.3	6.0	<3.0	83.08
RA7DGN4	13-Aug-91	8.05	366					15.3	16		1.0		83.76
RA7DGN4	13-May-91	8.05	306	77	128			12.9	13				83.90
RA7DGN4	05-Mar-91	7.39	243	55	108	0.005	0.05	11.5	12	5.8	7.0		82.40
RA7DGN4	15-Nov-90	7.89	261	72	128			10.4	9			<3.0	83.34
RA7DGS1	30-Mar-92	7.29	632	62	220	<0.002		40.0	28	19.0	15.0		83.32
RA7DGS1	09-Dec-91	7.69	746				<0.02	63.0	48	30.9	11.0	3.8	83.08
RA7DGS1	13-Aug-91	7.33	550					35.7	25		19.0		83.65
RA7DGS1	13-May-91	6.95	674	53	236			50.2	50				83.90
RA7DGS2	30-Mar-92	7.75	410	88	154	<0.002		18.6	8	11.7	12.0		83.32
RA7DGS2	09-Dec-91	7.84	636				<0.02	48.5	31	21.4	1.0	6.5	83.08
RA7DGS2	13-Aug-91	7.66	658					19.1	18		17.0		83.65
RA7DGS2	13-May-91	7.69	494	94	188			26.2	28				83.90
RA7DGS2	05-Mar-91	7.65	474	96	200	0.005	<0.02	29.7	22	15.0	14.0		82.39
RA7DGS2	15-Nov-90	7.74	610	120	250			39.2	23			<3.0	83.32
RA7DGS3	30-Mar-92	7.89	351	82	136	0.020		13.9	6	6.6	11.0		83.32
RA7DGS3	09-Dec-91	7.94	525				<0.02	30.5	20	16.6	1.0	7.4	83.08
RA7DGS3	13-Aug-91	7.71	663					0.5	1		12.0		83.65
RA7DGS3	13-May-91	7.88	461	103	176			21.2	28				83.90
RA7DGS3	05-Mar-91	7.81	266	76	112	0.025	<0.02	9.6	10	6.4	8.0		82.39
RA7DGS3	15-Nov-90	7.97	427	108	184			19.7	17			<3.0	83.32
RA7DGS4	30-Mar-92	7.92	219	60	84	0.015		5.3	3	5.7	7.0		83.32
RA7DGS4	09-Dec-91	8.06	309				<0.02	14.1	11	1.0	6.0	3.1	83.08
RA7DGS4	13-Aug-91	7.85	268			<0.002		9.5	12		8.0		83.65
RA7DGS4	13-May-91	7.99	258	66	104			7.9	15				83.90
RA7DGS4	05-Mar-91	7.93	226	66	96	0.005	0.05	6.8	13	7.0	5.0		82.39
RA7DGS4	15-Nov-90	8.04	255	48	92			6.6	14			<3.0	83.32
RA7UG1	15-Nov-90	7.93	300	160	164			2.3	<1			<3.0	83.66
RA7UG2	30-Mar-92	8.04	248	92	116	<0.002		6.4	4	7.7	8.0		83.67
RA7UG2	09-Dec-91	8.19	188				<0.02	1.0	10	4.7	9.0	4.5	83.41
RA7UG2	13-Aug-91	8.01	304					12.0	12		11.0		85.08
RA7UG2	13-May-91	7.89	276	85	108			9.0	9				84.26
RA7UG2	05-Mar-91	7.96	264	59	104	0.005	<0.02	9.0	25	10.5	8.0		82.74
RA7UG2	15-Nov-90	8.05	177	72	72			2.6	13			<3.0	83.66

Well ID	Date	pH	Cond. mhos	Alk. mg/l	T. Hard mg/l	React P mg/l	NH4-N mg/l	NO2+NO3-N mg/l	Cl mg/l	Na mg/l	Fluor. mg/l	COD	GW Elev.
RO4	17-Sep-90	5.60	278	5	96	<0.002		20.9	21	8.4			
RODGE1	13-Aug-91	6.54	53				<0.02	<0.2	2		9.0		91.22
RODGE1	13-May-91	5.64	55	16	16			<0.2	2				92.48
RODGE1	15-Nov-90	6.66	52	8	16			<0.2	4			4.4	91.14
RODGE2	13-Aug-91	6.11	48				<0.02	<0.2	2		9.0		91.22
RODGE2	13-May-91	5.63	45	5	16			<0.2	2				92.45
RODGE2	05-Mar-91	6.35	45	4	12	<0.002	<0.02	<0.2	3	1.8	7.0		89.96
RODGE2	15-Nov-90	6.71	45	7	12			<0.2	3			7.7	91.10
RODGE3	13-Aug-91	6.15	47				0.10	<0.2	2		1.0		91.22
RODGE3	13-May-91	5.67	45	5	12			<0.2	2				92.39
RODGE3	05-Mar-91	5.90	40	4	8	<0.002	<0.02	<0.2	2	1.0	8.0		89.96
RODGE3	15-Nov-90	6.29	47	7	16			<0.2	3			3.4	91.03
RODGE4	13-Aug-91	6.12	48				0.02	<0.2	2		9.0		91.22
RODGE4	13-May-91	5.64	44	5	16			<0.2	2				92.33
RODGE4	05-Mar-91	5.89	39	4	8	<0.002	<0.02	<0.2	2	1.0	8.0		89.96
RODGE4	15-Nov-90	6.23	46	7	16			<0.2	2			3.9	90.97
RODGW1	07-Apr-92	6.71	132	20	36	<0.002		4.3	<1	5.6	41.0		
RODGW1	13-Aug-91	6.63	502				<0.02	25.8	52		5.0		91.08
RODGW1	13-May-91	6.31	210	17	64			10.6	14				92.52
RODGW1	15-Nov-90	5.56	868	8	268			82.7	64				91.15
RODGW2	07-Apr-92	5.22	357	8	96	<0.002		23.3	27	18.0	52.0		
RODGW2	13-Aug-91	5.98	496				0.05	27.5	53		54.0		91.08
RODGW2	13-May-91	4.58	643	-1	160			48.4	57				92.47
RODGW2	05-Mar-91	4.58	859	-1	228	<0.002	2.42	80.0	70	4.0	81.0		90.10
RODGW2	15-Nov-90	4.43	715	1	176			66.7	51			14.0	91.11
RODGW3	07-Apr-92	4.63	491	4	120	<0.002		33.0	44	24.0	66.0		
RODGW3	15-Nov-91	4.58	634				0.08	42.5	67	35.8	105.0	17.1	90.11
RODGW3	13-Aug-91	4.85	546				0.30	37.2	55		96.0		91.08
RODGW3	13-May-91	4.53	699	-1	148			56.8	58				92.44
RODGW3	05-Mar-91	4.55	771	-1	208	<0.002	1.78	75.5	60	34.5	75.0		90.10
RODGW3	15-Nov-90	4.45	773	2	200			70.6	55			15.5	91.07
RODGW4	07-Apr-92	4.72	494	4	120	<0.002		32.5	44	25.0	67.0		
RODGW4	15-Nov-91	4.66	635				0.05	42.2	66	36.4	102.0	26.9	90.11
RODGW4	13-Aug-91	5.41	474				0.10	27.8	48		84.0		91.08
RODGW4	13-May-91	4.56	667	-1	168			50.4	56				92.40
RODGW4	05-Mar-91	4.55	845	-1	224	<0.002	1.92	74.0	64	38.2	77.0		90.10
RODGW4	15-Nov-90	4.52	781	4	192			69.2	53			11.6	91.04
ROTW	17-Sep-90	6.85	244	68	96	<0.002		0.8	37	14.8			
ROUG	17-Sep-90	6.87	404	96	12	<0.002		6.6	14	67.5			
ROUG1	13-May-91	8.10	421	72	4			3.5	9				92.54
ROUG1	15-Nov-90	7.97	388	76	4			0.9	42			63.9	91.27
ROUG2	07-Apr-92	6.88	236	40	20	<0.002		1.9	18	41.2	7.0		
ROUG2	15-Nov-91	6.93	312				<0.02	1.7	42	52.0	129.0	33.1	90.13
ROUG2	13-Aug-91	6.85	364			0.360	0.62	4.0	27		93.0		91.91
ROUG2	13-May-91	6.65	479	91	72			5.0	46				92.32
ROUG2	05-Mar-91	6.78	465	74	48	<0.002	<0.02	5.4	56	77.0	59.0		90.16
ROUG2	15-Nov-90	7.38	509	112	8			4.8	36				91.02

Well ID	Date	pH	Cond. mhos	Alk. mg/l	T. Hard mg/l	React P mg/l	NH4-N mg/l	NO2+NO3-N mg/l	Cl mg/l	Na mg/l	Fluor. mg/l	COD	GW Elev.
RUDGE1	13-May-91	6.20	68	8	20			<0.2	10				93.24
RUDGE2	13-May-91	5.87	76	8	20			<0.2	13				93.01
RUDGE2	15-Nov-90	6.28	88	12	32			<0.2	15			<3.0	91.35
RUDGE3	13-Aug-91	6.03	99					<0.2	21		15.0		90.63
RUDGE3	13-May-91	5.85	3	4	-4			<0.2	<1				92.95
RUDGE3	05-Mar-91	6.18	66	8	16	<0.002	<0.02	<0.2	7	1.8	3.0		90.44
RUDGE3	15-Nov-90	6.34	83	20	20			<0.2	13			<3.0	91.32
RUDGE4	13-Aug-91	6.39	87					0.2	13		9.0		90.63
RUDGE4	13-May-91	5.73	69	8	20			<0.2	10				92.91
RUDGE4	15-Nov-90	6.02	63	16	20			<0.2	7			<3.0	91.31
RUDGW1	20-Mar-92	5.96	190	12	28			8.5	15	24.6	18.0		92.43
RUDGW1	13-May-91	5.85	68	8	16			1.2	6				93.24
RUDGW2	20-Mar-92	6.32	172	8	28			7.7	13	23.5	19.0		92.43
RUDGW2	09-Dec-91	6.37	280				<0.02	11.3	31	29.0	13.0	8.1	92.09
RUDGW2	13-Aug-91	5.91	590					39.6	50		28.0		90.90
RUDGW2	13-May-91	6.01	106	6	20			4.0	10				
RUDGW3	20-Mar-92	6.15	129	10	28			4.0	8	12.7	15.0		92.43
RUDGW3	09-Dec-91	6.12	287				<0.02	10.8	31	29.5	13.0	7.7	92.09
RUDGW3	13-Aug-91	6.14	607					39.2	50		24.0		90.90
RUDGW3	13-May-91	5.85	80	8	24			<0.2	14				93.03
RUDGW3	05-Mar-91	6.11	410		44	<0.002	<0.02	23.5	34	5.0	7.0		90.55
RUDGW3	15-Nov-90	5.66	331	20	48			18.5	29			<3.0	91.42
RUDGW4	20-Mar-92	5.98	189	8	28			8.6	15	24.6	19.0		92.43
RUDGW4	09-Dec-91	5.90	274				<0.02	10.5	31	29.0	13.0	5.0	92.09
RUDGW4	13-Aug-91	5.50	554					44.2	41		22.0		90.90
RUDGW4	13-May-91	5.79	96	12	20			3.0	9				92.93
RUDGW4	05-Mar-91	5.72	372	4	60	<0.002	<0.02	22.9	33	65.0	7.0		90.55
RUDGW4	15-Nov-90	5.57	327	40	52			17.7	29			4.1	91.33
RUUG	09-Dec-91	6.17	72				<0.02	0.7	4	3.2	8.0	3.6	-8.09
RUUG	05-Mar-91	5.83	69	12	24	<0.002	0.02	0.4	3	1.8	5.0		-9.49
RUUG2	20-Mar-92	5.84	69	12	28			0.9	6	1.7	11.0		92.36
RUUG2	13-Aug-91	5.95	71					0.9	5		19.0		91.54
RUUG2	13-May-91	5.93	68	12	24			0.5	2				93.07
RUUG2	15-Nov-90	5.87	72	20	28			1.1	3			<3.0	91.43
RUWW	15-Nov-90	7.10	147	40	64			1.8	13			<3.0	

Well ID	Date	pH	Cond. mhos	Alk. mg/l	T. Hard mg/l	React P mg/l	NH4-N mg/l	NO2+NO3-N mg/l	Cl mg/l	Na mg/l	Fluor. mg/l	COD	GW Elev.
SN11	17-Sep-90	6.42	660	31	276	<0.002		50.9	31	28.2			
SN12	17-Sep-90	6.72	644	89	260	<0.002		46.9	34	3.0			
SN13	17-Sep-90	6.04	50	4	16	<0.002		0.8	2	0.8			
SN1DGE1	27-Mar-92	6.88	489	76	180		0.12	32.0	24	23.8	43.0		91.22
SN1DGE1	13-May-91	6.61	530	57	164			36.2	29				92.45
SN1DGE1	15-Nov-90	6.78	720	88	264			44.8	30			8.7	90.94
SN1DGE2	27-Mar-92	6.73	534	76	192		0.08	34.4	27	26.6	4.0		91.22
SN1DGE2	13-Nov-91	7.24	649	36	224		<0.02	49.3	42	33.0	36.0		89.74
SN1DGE2	09-Sep-91	7.06	495				<0.02	24.9	21		55.0		90.06
SN1DGE2	13-Aug-91	6.91	599					37.1	30		54.0		90.61
SN1DGE2	13-May-91	6.69	610	83	204			41.5	34				92.45
SN1DGE2	05-Mar-91	7.14	553	80	204	<0.002	<0.02	36.8	31	25.0			89.96
SN1DGE2	15-Nov-90	6.81	718	106	272			44.8	26			6.3	90.95
SN1DGE3	27-Mar-92	6.79	533	80	172		0.05	34.2	28	27.0	39.0		91.22
SN1DGE3	13-Nov-91	7.03	653	80	224		<0.02	45.9	38	32.8	34.0		89.74
SN1DGE3	09-Sep-91	6.78	544				<0.02	29.5	25		57.0		90.06
SN1DGE3	13-Aug-91	6.88	606					36.4	30		56.0		90.61
SN1DGE3	13-May-91	6.69	623	84	208			40.5	34				92.42
SN1DGE3	05-Mar-91	6.84	552	76	204	<0.002	<0.02	35.8	31	25.5			89.96
SN1DGE3	15-Nov-90	6.84	731	108	276			45.3	28			14.1	90.90
SN1DGE4	27-Mar-92	6.84	542	80	176		0.02	34.3	28	27.7	39.0		91.22
SN1DGE4	13-Nov-91	6.97	631	76	216		0.02	45.5	39	31.9	36.0		89.74
SN1DGE4	09-Sep-91	6.85	542				<0.02	29.1	25		55.0		90.06
SN1DGE4	13-Aug-91	6.90	593					36.3	30		58.0		90.61
SN1DGE4	13-May-91	6.75	616	80	204			40.0	33				92.41
SN1DGE4	05-Mar-91	6.86	558	80	200	<0.002	<0.02	36.3	30	25.0			89.96
SN1DGE4	15-Nov-90	6.96	714	104	272			44.9	27			13.6	90.90
SN1DGW1	27-Mar-92	6.60	245	52	84		0.08	11.7	7	12.5	3.0		91.20
SN1DGW1	13-May-91	6.46	239	32	80			14.0	11				92.44
SN1DGW1	15-Nov-90	6.84	625	74	220			40.3	28			7.8	90.92
SN1DGW2	27-Mar-92	6.63	485	60	172		0.02	32.3	26	24.9	37.0		91.20
SN1DGW2	13-Nov-91	6.93	610	60	208		<0.02	44.9	38	31.4	36.0		89.71
SN1DGW2	13-Aug-91	6.75	478					27.5	22		52.0		90.48
SN1DGW2	13-May-91	6.63	539	87	188			32.3	27				92.43
SN1DGW2	05-Mar-91	6.94	448	68	160	<0.002	<0.02	28.0	22	19.2			-11.51
SN1DGW2	15-Nov-90	6.67	722	104	276			45.9	33			19.8	90.92
SN1DGW3	27-Mar-92	6.59	464	64	164		0.02	30.9	23	23.8	36.0		91.20
SN1DGW3	13-Nov-91	6.74	643	80	232		<0.02	45.2	36	32.4	36.0		89.71
SN1DGW3	09-Sep-91	6.53	654				<0.02	40.6	31		55.0		90.02
SN1DGW3	13-Aug-91	6.61	500					30.0	24		52.0		90.48
SN1DGW3	13-May-91	6.64	554	84	188			33.6	28				92.43
SN1DGW3	05-Mar-91	6.71	512	76	184	<0.002	<0.02	33.8	26	22.0			89.92
SN1DGW3	15-Nov-90	6.84	732	102	276			46.1	32			16.1	90.92
SN1DGW4	27-Mar-92	6.61	452	60	156		0.08	30.1	22	22.6	37.0		91.20
SN1DGW4	13-Nov-91	6.68	641	80	224		<0.02	46.2	36	33.0	35.0		89.71
SN1DGW4	05-Mar-91	6.83	533	80	204	<0.002	<0.02	34.7	28	23.2			89.92
SN1DGW4	15-Nov-90	6.71	731	109	272			45.5	32			19.8	90.92
SN1P	27-Mar-92	6.48	254	28	24		0.30	<0.2	59	48.2	36.0		
SN1P	13-Nov-91	6.39	436	36	75		0.02	<0.2	128	75.0	15.0		
SN1UG	17-Sep-90	5.81	89	4	28	0.010		4.7	3	1.7			
SN1UG1	27-Mar-92	5.62	93	8	36		0.05	4.1	<1	2.5	17.0		91.23
SN1UG1	13-May-91	5.46	96	4	32			5.6	3				92.45
SN1UG1	15-Nov-90	6.18	95	6	24			1.9	2			6.8	90.91
SN1UG2	27-Mar-92	5.80	104	8	40		0.02	5.4	<1	2.2	22.0		91.13
SN1UG2	13-Nov-91	6.11	115	12	36		0.05	5.5	3	1.9	18.0		89.70
SN1UG2	09-Sep-91	5.97	118				<0.02	6.9	2		29.0		89.81
SN1UG2	13-Aug-91	5.98	106					5.1	2		31.0		90.36
SN1UG2	13-May-91	5.86	109	10	32			5.0	3				92.30
SN1UG2	05-Mar-91	5.91	104	16	24	0.025	<0.02	3.4	2	2.0			89.77
SN1UG2	15-Nov-90	6.06	100	9	28			2.7	3			5.2	90.76

Well ID	Date	pH	Cond. mhos	Alk. mg/l	T. Hard mg/l	React P mg/l	NH4-N mg/l	NO2+NO3-N mg/l	Cl mg/l	Na mg/l	Fluor. mg/l	COD	GW Elev.
SN21	17-Sep-90	6.34	397	3	100	0.002		30.4	47	38.5			
SN2DGE1	13-May-91	5.97	38	7	8			<0.2	2				92.08
SN2DGE1	15-Nov-90	5.76	422	10	84			23.0	38			<3.0	90.67
SN2DGE2	09-Apr-92	5.48	290	8	40			16.0	14	20.2	17.0		91.24
SN2DGE2	15-Nov-91	5.48	530				<0.02	37.5	45	38.0	25.0	21.1	89.67
SN2DGE2	13-Aug-91	5.84	109					5.9	8		13.0		90.66
SN2DGE2	13-May-91	5.74	171	6	40			5.5	10				92.07
SN2DGE2	05-Mar-91	5.53	355	2	96	0.005	0.05	21.0	32	41.2	13.0		89.66
SN2DGE2	15-Nov-90	5.46	566	6	148			34.0	49			7.7	90.67
SN2DGE3	09-Apr-92	5.44	325	8	52			19.2	18	21.8	16.0		91.24
SN2DGE3	15-Nov-91	5.40	401				<0.02	26.7	32	28.4	21.0	10.9	89.67
SN2DGE3	13-Aug-91	5.71	140					6.6	10		14.0		90.66
SN2DGE3	13-May-91	5.50	215	5	48			9.1	15				92.04
SN2DGE3	05-Mar-91	5.58	405	6	100	0.002	0.05	24.4	37	33.4	16.0		89.66
SN2DGE3	15-Nov-90	5.44	426	8	112			26.3	34			<3.0	90.65
SN2DGE4	09-Apr-92	5.42	298	8	40			17.4	20	20.8	16.0		91.24
SN2DGE4	15-Nov-91	5.39	403				<0.02	27.6	34	28.9	22.0	8.9	89.67
SN2DGE4	13-Aug-91	5.61	141					6.7	10		12.0		90.66
SN2DGE4	13-May-91	5.48	237	6	56			11.4	17				92.02
SN2DGE4	05-Mar-91	5.54	403	4	104	0.002	<0.02	22.5	37	34.2	17.0		89.66
SN2DGE4	15-Nov-90	5.56	465	9	120			27.8	38			7.3	90.63
SN2DGW1	13-May-91	5.75	36	5	8			0.5	1				92.06
SN2DGW1	15-Nov-90	6.26	32	7	8			0.2	1			<3.0	90.65
SN2DGW2	13-Aug-91	5.76	52					1.1	3		9.0		90.64
SN2DGW2	13-May-91	5.67	71	3	20			3.2	2				92.05
SN2DGW2	15-Nov-90	5.96	48	6	16			0.9	2			<3.0	90.63
SN2DGW3	13-Aug-91	5.77	57			<0.002	<0.02	1.6	2		9.0		90.64
SN2DGW3	13-May-91	5.63	69	17	20			2.7	3				92.02
SN2DGW3	05-Mar-91	5.64	69	3	20	<0.002	0.08	2.7	4	2.6	5.0		89.64
SN2DGW3	15-Nov-90	5.87	47	5	12			0.8	2			<3.0	90.61
SN2DGW4	13-Aug-91	6.10	57					1.4	2		11.0		90.64
SN2DGW4	13-May-91	5.64	69	4	20			2.8	2				91.98
SN2DGW4	05-Mar-91	5.89	88	3	24	<0.002	<0.02	5.4	4	2.8	7.0		89.64
SN2DGW4	15-Nov-90	5.86	47	5	12			0.9	2			<3.0	90.58
SN2UG	17-Sep-90	6.41	37	6	36	<0.002		0.9	<1	2.5			
SN2UG1	09-Apr-92	6.26	60	8	20			3.3	<1	1.5	7.0		91.30
SN2UG1	13-May-91	6.00	47	-1	16			1.7	2				92.14
SN2UG1	15-Nov-90	6.53	47	11	12			0.9	1			6.8	90.75
SN2UG2	09-Apr-92	5.40	52	4	12			1.9	<1	1.0	9.0		91.30
SN2UG2	15-Nov-91	5.49	43				<0.02	0.4	1	1.2	13.0	5.5	89.74
SN2UG2	13-Aug-91	6.22	55					2.4	1		14.0		90.57
SN2UG2	13-May-91	5.71	53	3	12			2.1	1				91.98
SN2UG2	05-Mar-91	5.63	44	2	12	0.005	0.05	0.8	<1	1.2	9.0		89.64
SN2UG2	15-Nov-90	6.23	49	6	12			2.0	<1			<3.0	90.62
SNP	13-Nov-91	6.39	436	36	28		0.02	<0.2	128	75.0	15.0		89.93

Well ID	Date	pH	Cond. mhos	Alk. mg/l	T. Hard mg/l	React P mg/l	NH4-N mg/l	NO2+NO3-N mg/l	Cl mg/l	Na mg/l	Fluor. mg/l	COD	GW Elev.
STDGE1	20-Mar-92	4.99	740	4	172			49.6	97	63.0	37.0		90.45
STDGE1	13-Aug-91	5.21	866					71.0	105		56.0		9.00
STDGE1	13-May-91	5.38	898	3	188			64.2	105				91.56
STDGE1	15-Nov-90	5.86	1138	6	265			108.0	94			24.0	89.91
STDGE1	29-Sep-90	6.43	439	17	200	<0.002		39.5	16	6.5			
STDGE2	20-Mar-92	5.48	844	8	196			60.0	118	74.5	19.0		90.45
STDGE2	15-Nov-91	5.63	548				<0.02	40.9	56	38.0	2.0	7.7	89.29
STDGE2	13-Aug-91	5.64	429					27.2	51		3.0		9.00
STDGE2	13-May-91	5.64	644	6	128			41.0	74				91.56
STDGE2	05-Mar-91	5.47	925	6	224	<0.002	0.02	74.5	99	7.0	15.0		88.90
STDGE2	15-Nov-90	5.91	868	7	200			76.0	65			16.3	89.92
STDGE2	29-Sep-90	6.37	463	17	192	<0.002		41.1	19	7.0			
STDGE3	20-Mar-92	5.70	653	12	156			46.8	77	54.0	2.0		90.45
STDGE3	15-Nov-91	5.79	438				<0.02	28.8	40	32.4	26.0	10.4	89.29
STDGE3	13-Aug-91	5.90	416					26.3	42		35.0		9.00
STDGE3	13-May-91	5.80	687	9	148			42.5	75				91.56
STDGE3	05-Mar-91	5.17	722	8	180	<0.002	<0.02	53.6	82	52.5	18.0		88.90
STDGE3	15-Nov-90	6.06	694	8	156			51.8	65			13.9	89.91
STDGE3	29-Sep-90	6.40	355	14	132	<0.002		29.0	21	9.0			
STDGE4	20-Mar-92	6.11	435	24	104			24.2	52	33.1	36.0		90.69
STDGE4	15-Nov-91	6.11	591				<0.02	41.8	62	40.8	33.0	14.1	89.29
STDGE4	13-Aug-91	6.00	472					29.0	54		45.0		9.00
STDGE4	13-May-91	6.13	555	21	124			31.1	59				91.48
STDGE4	05-Mar-91	6.40	588	24	152	<0.002	<0.02	36.7	75	44.5	27.0		88.90
STDGE4	15-Nov-90	6.37	435	20	115			24.6	49			10.1	89.83
STDGE4	29-Sep-90	6.37	391	19	148	<0.002		26.9	30	18.5			
STDGW1	20-Mar-92	6.44	237	18	76			24.6	17	2.2	16.0		90.52
STDGW1	13-May-91	6.13	442	12	152			32.7	31				91.64
STDGW2	20-Mar-92	6.45	176	20	60			9.4	10	3.4	28.0		90.52
STDGW2	15-Nov-91	6.51	246				<0.02	13.1	13	4.4	42.0	6.0	89.21
STDGW2	13-Aug-91	6.12	435					27.9	37		54.0		90.03
STDGW2	13-May-91	6.31	555	13	204			42.1	43				91.64
STDGW2	05-Mar-91	7.09	155	19	52	<0.002	<0.02	6.4	10	4.6	24.0		89.00
STDGW2	15-Nov-90	6.20	634	17	252			55.6	23			10.1	89.99
STDGW3	20-Mar-92	6.28	156	20	52			3.5	19	3.9	23.0		90.52
STDGW3	15-Nov-91	6.29	211				<0.02	11.0	15	4.7	34.0	9.0	89.21
STDGW3	13-Aug-91	6.12	428					30.1	40		37.0		90.03
STDGW3	13-May-91	6.31	316	16	100			18.6	26				91.64
STDGW3	05-Mar-91	6.66	147	15	44	<0.002	0.08	4.6	16	12.0	22.0		89.00
STDGW3	15-Nov-90	6.46	371	16	136			29.0	22			9.1	89.98
STDGW4	20-Mar-92	6.31	330	20	120			22.2	20	10.3	34.0		90.52
STDGW4	15-Nov-91	6.34	359				<0.02	24.0	24	8.6	49.0	13.4	89.21
STDGW4	13-Aug-91	6.21	391					28.4	26		52.0		90.03
STDGW4	13-May-91	6.28	333	23	120			21.0	20				91.64
STDGW4	05-Mar-91	6.35	391	14	148	<0.002	0.15	30.5	31	12.5	25.0		89.00
STDGW4	15-Nov-90	6.77	372	13	132			29.5	19			14.9	89.94
STP	20-Mar-92	5.55	245	16	20			<0.2	60	40.8	62.0		92.07
STP	15-Nov-91	5.34	615				<0.02	0.4	184	89.0	41.0	53.4	90.94
STP	16-Oct-91	5.42	560	8	56	<0.002	<0.02	0.8	174		31.0		90.63
STT	17-Sep-90	6.94	380	84	108			<0.2	68				
STUG1	13-May-91	5.48	40	5	12			<0.2	3				93.32
STUG1	29-Sep-90	6.45	60	4	20	<0.002		0.3	7	2.5			
STUG2	20-Mar-92	5.55	359	10	40			2.1	87	76.0	38.0		92.77
STUG2	15-Nov-91	5.70	518				<0.02	0.4	148	78.0	41.0	26.3	91.74
STUG2	13-Aug-91	5.45	354					<0.2	91		62.0		91.76
STUG2	13-May-91	5.25	331	9	52			0.3	86				93.32
STUG2	05-Mar-91	5.56	271	7	36	<0.002	<0.02	<0.2	78	36.0	31.0		91.56
STUG2	15-Nov-90	5.64	371	5	72			0.8	113			11.5	91.98
STWW	29-Sep-90	6.32	313	28	76	<0.002		<0.2	79	31.4			

Monitoring well depths and reletive elevations.

Single Family Sites

Well I.D.	Well Depth (m)	Point Elevation (m)	WI DNR Unique No.
HADGE1	3.44	33.29	EG221
HADGE2	3.93	33.29	EG222
HADGE3	4.42	33.29	EG223
HADGE4	4.90	33.29	EG224
HADGW1	3.39	33.27	EG225
HADGW2	3.88	33.27	EG226
HADGW3	4.36	33.27	EG227
HADGW4	4.86	33.27	EG228
HAP	3.45	32.75	EG374
HAUG1	2.80	32.98	EG229
HAUG2	4.59	32.98	EG230
HODGE1	3.35	33.11	EG231
HODGE2	3.85	33.11	EG232
HODGE3	4.67	33.11	EG233
HODGE4	5.16	33.11	EG234
HODGW1	3.35	32.92	EG235
HODGW2	4.00	32.92	EG236
HODGW3	4.65	32.92	EG237
HODGW4	5.31	32.92	EG238
HOUG1	2.85	32.54	EG239
HOUG2	4.66	32.54	EG240
PODGE1	2.66	31.69	EG241
PODGE2	3.13	31.69	EG242
PODGE3	3.22	31.69	EG243
PODGE4	4.23	31.69	EG244
PODGW1	2.74	31.78	EG245
PODGW2	3.23	31.78	EG246
PODGW3	3.70	31.78	EG247
PODGW4	4.20	31.78	EG248
POUG1	2.95	31.97	EG249
POUG2	4.72	31.97	EG250
RODGE3	4.03	32.74	EG323
RODGE4	4.51	32.74	EG324
RODGW1	3.31	32.91	EG325
RODGW2	3.79	32.91	EG326
RODGW3	4.28	32.91	EG327
RODGW4	4.78	32.91	EG328
ROUG1	2.38	32.60	EG329
ROUG2	4.15	32.60	EG330
RUDGE1	3.44	32.91	EG362
RUDGE2	3.93	32.91	EG363
RUDGE3	4.42	32.91	EG364
RUDGE4	4.91	32.91	EG365

Single Family Sites

Well I.D.	Well Depth (m)	Point Elevation (m)	WI DNR Unique No.
RUDGW1	6.06	32.84	EG366
RUDGW2	3.26	32.84	EG367
RUDGW3	3.76	32.84	EG368
RUDGW4	4.25	32.84	EG369
RUUG1	2.40	32.81	EG370
RUUG2	4.23	32.81	EG371
SN1DGE1	3.63	33.28	EG331
SN1DGE2	4.12	33.28	EG332
SN1DGE3	4.61	33.28	EG333
SN1DGE4	4.61	33.28	EG334
SN1DGW1	3.57	33.28	EG335
SN1DGW2	4.05	33.28	EG336
SN1DGW3	4.53	33.28	EG337
SN1DGW4	4.47	33.28	EG338
SN1UG1	2.60	32.96	EG339
SN1UG2	2.64	32.96	EG340
SN2DGE1	3.67	33.21	EG341
SN2DGE2	4.17	33.21	EG342
SN2DGE3	4.66	33.21	EG343
SN2DGE4	5.15	33.21	EG344
SN2DGW1	3.74	33.28	EG345
SN2DGW2	4.23	33.28	EG346
SN2DGW3	4.71	33.28	EG347
SN2DGW4	5.19	33.28	EG348
SN2UG1	3.27	32.92	EG349
SN2UG2	5.11	32.92	EG350
SNP	4.20	32.81	EG373
STDGE1	3.82	33.08	EG351
STDGE2	4.30	33.08	EG352
STDGE3	4.78	33.08	EG353
STDGE4	5.28	33.08	EG354
STDGW1	3.61	33.03	EG356
STDGW2	4.09	33.03	EG357
STDGW3	4.77	33.03	EG358
STDGW4	5.27	33.03	EG359
STP	3.92	32.94	EG372
STUG1	2.92	33.11	EG360
STUG2	4.76	33.11	EG361

Monitoring well depths and reletive elevations.

Multiple Family Sites

Well I.D.	Well Depth (m)	Point Elevation (m)	WI DNR Unique No.
RA1DGN1	3.32	31.77	EG251
RA1DGN2	3.77	31.77	EG252
RA1DGN3	4.22	31.77	EG253
RA1DGN4	4.67	31.77	EG254
RA1DGS1	3.41	31.85	EG255
RA1DGS2	4.01	31.85	EG256
RA1DGS3	4.56	31.85	EG257
RA1DGS4	4.72	31.85	EG258
RA1UG1	3.43	31.55	EG259
RA1UG2	5.27	31.55	EG260
RA2DGN1	3.54	31.85	EG261
RA2DGN2	3.99	31.85	EG262
RA2DGN3	4.46	31.85	EG263
RA2DGN4	4.90	31.85	EG264
RA2DGS1	3.78	31.57	EG265
RA2DGS2	4.24	31.57	EG266
RA2DGS3	4.69	31.57	EG267
RA2DGS4	5.18	31.57	EG268
RA2UG1	3.57	31.70	EG269
RA2UG2	5.37	31.70	EG270
RA3DGN1	3.53	31.61	EG271
RA3DGN2	4.01	31.61	EG272
RA3DGN3	4.50	31.61	EG273
RA3DGN4	4.98	31.61	EG274
RA3DGS1	3.54	31.46	EG275
RA3DGS2	4.02	31.46	EG276
RA3DGS3	4.50	31.46	EG277
RA3DGS4	4.99	31.46	EG278
RA3UG1	3.45	31.58	EG279
RA3UG2	5.28	31.58	EG280
RA4DGN1	3.79	31.78	EG281
RA4DGN2	4.27	31.78	EG282
RA4DGN3	4.75	31.78	EG283
RA4DGN4	5.25	31.78	EG284

Multiple Family Sites

Well I.D.	Well Depth (m)	Point Elevation (m)	WI DNR Unique No.
RA4DGS1	3.71	31.77	EG285
RA4DGS2	4.17	31.77	EG286
RA4DGS3	4.63	31.77	EG287
RA4DGS4	5.08	31.77	EG288
RA4UG1	3.87	31.74	EG289
RA4UG2	5.70	31.74	EG290
RA5DGE1	5.31	31.99	EG291
RA5DGE2	5.93	31.99	EG292
RA5DGE3	6.52	31.99	EG293
RA5DGE4	7.24	31.99	EG294
RA5DGW1	3.79	32.00	EG295
RA5DGW2	4.68	32.00	EG296
RA5DGW3	4.97	32.00	EG297
RA5DGW4	5.87	32.00	EG298
RA5UG1	3.87	31.85	EG299
RA5UG2	5.70	31.85	EG300
RA6DGN1	3.71	31.77	EG301
RA6DGN2	4.38	31.77	EG302
RA6DGN3	5.01	31.77	EG303
RA6DGN4	5.69	31.77	EG304
RA6DGS1	3.74	31.78	EG305
RA6DGS2	4.38	31.78	EG306
RA6DGS3	5.03	31.78	EG307
RA6DGS4	5.62	31.78	EG308
RA6UG1	3.59	31.63	EG309
RA6UG2	5.46	31.63	EG310
RA7DGN1	5.45	32.45	EG311
RA7DGN2	6.10	32.45	EG312
RA7DGN3	6.76	32.45	EG313
RA7DGN4	7.41	32.45	EG314
RA7DGS1	5.48	32.52	EG315
RA7DGS2	6.14	32.52	EG316
RA7DGS3	6.79	32.52	EG317
RA7UG1	5.76	33.14	EG319

051246 - A COMPARATIVE STUDY ON NITRATE-N LOADING TO GROUNDWATER FROM MOUND, IN GROUND PRESSURE AND AT GRADE SEPTIC SYSTEMS

[illegible] Gretchen Rupp