Soil and groundwater quality monitoring under a research feedlot in southern Alberta

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ABSTRACT

Environmental concerns related to manure management have often focused on land application and the potential for negative effects on soil and water quality. However, there is also potential for contamination of soil and water directly from feedlot sites. In late 1995 and early 1996, a research cattle (*Bos taurus*) feedlot was constructed at the Agriculture and Agri-Food Canada Research Centre at Lethbridge, Alberta. This provided an opportunity to study the effects of a new feedlot on soil quality and shallow groundwater quality. Sixteen groundwater wells were installed at the feedlot site: nine wells within the pen area, four wells south of the pens, and three wells north of the pens. Groundwater chemistry was monitored from April, 1996 to November, 2000. Groundwater microbiology was measured twice in 1996 and from May, 1998 to January, 2001. Baseline soil samples were collected from the pen area in 1996, and a second set of soil samples was collected in 1999. The water-table depth, on average, ranged from 1.23 to 2.50 m during the study. The surface topography of the water table changed under the feedlot. By late 1997, the water-table was at a higher elevation under the pen area than outside the pen area. This difference in water-table elevation between the pen area and outside the pen area persisted throughout the rest of the study. Some soil chemical properties were only affected in the top layer (0-15 cm), such as an increase in extractable phosphate-P, extractable nitrate-N, extractable ammonium-N, and extractable potassium. These increases may simply be as much the result of mechanical mixing by the action of animal hooves, as to leaching. Other soil properties increased significantly to greater depths (down to 60 cm), such as electrical conductivity, sulphate-S, extractable magnesium, extractable calcium, extractable sodium, and SAR. However, chloride content increased significantly throughout the entire soil profile (0-150 cm), providing evidence that leaching occurred under the feedlot pens. Groundwater analysis also indicated that contaminants had leached to the water table. The strongest evidence was from increased chloride concentrations, *E. coli* counts, and total coliform counts in the wells within the pen area, whereas there was very little change in the wells outside of the pen area. The pen area may not contribute uniformly to downward movement of contaminants to the water table. We believe that the drainage alleys may be a significant means whereby water can infiltrate into the soil below the feedlot.

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INTRODUCTION

Intensive livestock operations (feedlots) are a major component of the cattle industry in Alberta. Of the 5.813 million cattle in 1998 (Jaipaul 2001) about one million were fed in about 4,500 feedlots (Dey 1998) in Alberta. Cattle feedlot densities are highest in the Counties of Lethbridge, Red Deer, and Lacombe. Alberta's livestock industry has the potential to increase in size during the next several years. However, there is great concern about the effects of disposing of large quantities of manure on surrounding farm land in areas where the density of feedlots are high. Improper manure disposal can adversely affect soil, groundwater, and surface water quality (Ap Dewi et al. 1994). Research has shown that manure can cause an accumulation of nutrients in soil (Kingery et al. 1994; Dormaar and Chang 1995; Sharpley and Smith 1995; Chang and Janzen 1996) and increase concentrations of nutrients in surface runoff and groundwater (Heathman et al. 1995; Sharpley 1997; Sharpley et al. 1998; Wood et al. 1999).

Though most of the concern has been with land application of manure, there is also potential for contamination of soil and water directly from feedlot sites. Coote and Hore (1979) reported contamination of groundwater by nitrate, chloride, and sodium from a feedlot in eastern Canada. Elliott et al. (1976) found greater concentrations of calcium, magnesium, and manganese in soil solution below a feedlot, compared to nearby crop land. In contrast, earlier work in Nebraska, United States showed that infiltration into the subsurface below feedlots was essentially zero (Lorimor et al. 1972; Mielke et al. 1974; Ellis et al. 1975; Mielke and Mazurak 1976). Miller (1971) sampled beneath 80 feedlots in the Texas High Plain, and concluded there was no regional subsurface nitrate pollution from cattle feedlot runoff. Maulé and Fonstad (1998, 2000) sampled groundwater near five 25- to 35-year old cattle feedlots in central Saskatchewan and concluded that 50 to 67 percent of the samples had elevated concentrations of solutes due to the presence of manure. There has been very little work on hydrology of feedlots in Alberta with respect to nutrients and other pollutants. The only major recent study in this regard was carried out by Kennedy et al. (1999) on a feedlot in central Alberta. They studied surface runoff and infiltration, but did not examine the groundwater beneath the feedlot. Earlier work by Sommerfeldt et al. (1973) found that nitrate-N and phosphate-P concentrations in shallow groundwater were increased adjacent to feedlots, but the values generally remained within safe limits. In general, studies that looked at only soil tended to conclude there was minimal or no leaching beneath feedlots, whereas studies that examined groundwater usually found some contamination.

Groundwater contamination is of particular concern where the water table is near the soil surface, with rapid recharge from precipitation or irrigation events. However, Betcher et al. (1996) pointed out that groundwater contamination may occur in the long term as stable pollutants migrate slowly through low-permeability materials. Maulé and Fonstad (2002) sampled soil and groundwater at 30-year-old feedlots in Saskatchewan and concluded that most manure solutes moved slowly by matrix flow, but that sufficient bypass flow occurred to contaminate shallow groundwater 20 m outside of the feedlots.

In the fall of 1995, Agriculture and Agri-Food Canada began to construct a research feedlot at the Lethbridge Research Centre. The initial construction phase included 32 pens with a capacity to hold about 480 head of cattle. An expansion phase added another 16 pens with the capacity to hold an additional 240 head. Construction of the research feedlot provided a unique opportunity to monitor soil and groundwater quality at a newly constructed feedlot and with time as cattle occupied the site.

The objective of this study was to determine if a newly constructed feedlot would change soil and shallow groundwater quality under the feedlot. Expected contributions of the study will provide baseline data to document the effect of a feedlot on soil and groundwater quality. The data will provide the basis for future studies on soil and groundwater dynamics adjacent to feedlots, and studies on potential mitigation or remediation strategies.

MATERIALS AND METHODS

Feedlot Site

The feedlot was located at the Agriculture and Agri-Food Canada Lethbridge Research Centre (SE quarter section of section 34, township 8, range 21, W of the fourth) on the east side of Lethbridge, Alberta. Construction on the feedlot began during the second half of 1995, and the first phase (32 of the 48 pens) was completed in late spring, 1996. The first phase included land grading, utility installation, and construction of four rows of eight pens in each row. The rows were orientated north-south (Fig. 1). Topsoil that was removed during land grading was stock piled on the south side of the feedlot. The overall site was sloped from south to north for drainage. A catch basin, to hold drainage from the feedlot, was constructed on the north side of the feedlot.

Two more rows of pens (16 pens total) were located on the east side of the initial 32 pens during the construction of phase two. Construction of phase two began in 1998. A few larger pens were also constructed along the west side of the initial 32 pens. The original 32 pens had a capacity to hold about 480 head of cattle (*Bos Taurus*).

A tile drain was installed along the south, east and north sides of the feedlot area.

The soil type at the site was predominantly an Orthic Dark Brown Chernozem (Kocaoglu and Pettapiece 1980). Composition include a fine-loamy to fine-silty lacustrine blanket and veneer, and fine-loamy morainal material, with a nearly level (0.5 to 2.5%) to very gentle slope (2 to 5%) topography. The majority of the soils in the site area have developed on lacustrine blanket or lacustrine veneer (Kocaoglu and Pettapiece 1980). The AGRASID (Agricultural Region of Alberta Soil Inventory Database) map unit is LEWN4/U1l, with Lethbridge and Whitney as co-dominant soils (CAESA-Soil Inventory Project Working Group 1998).

Groundwater Well Installation

Groundwater wells were installed at 16 locations in and around the feedlot (phase 1) as shown in Fig. 1. Approximate distances between wells are shown in Fig. 2. The wells were located so that they were protected from normal feedlot activity. The wells were installed from March 20, 1996 to May 10, 1996. Slotted plastic (PVC; 5.08 cm diameter) and stainless steel (3.81 cm diameter) wells were installed to a depth of about 5.87 m below ground level. Stainless steel pipe was used for Wells 1-4, and 14-16, and PVC pipe was used for the other wells (Fig. 1). The wells protruded (i.e. the wellhead) about 24 cm above the soil surface. The wells were slotted to within 1.5 m from the top end of the wellhead, and the slotted portion was covered with a filter sock. The sides of the wells were backfilled with sand to within about 1.1 m below the soil surface. There was some difficulty getting the sand down the sides for wells 5, 6, 8, and 9. This may have been caused by soil collapsing around the wells. The remaining distance to the soil surface was backfilled with bentonite clay. A protective steel casing (1 m long; 16.9 cm dia.) was installed around each well. The steel casing protruded about 26 cm above the soil surface. The wells and steel casings were capped. Details about the installation of the wells are shown in

Fig. 3 and Appendix 1. Soil log notes were taken during the installation of the groundwater wells (Appendix 2).

The elevation (i.e. metres above sea level) of the top of each wellhead, and the elevation of the soil surface adjacent to each well were surveyed on May 10, 1996. A benchmark survey pin (elevation of 910.921 m), located about 120 m northeast of well 16, was used in the survey. The steel casings and wellheads of wells 7, 8, 10, 11, and 13 were shortened in 1998 to prevent potential interference from feedlot activity. However, this proved to potentially compromise the wells from the build-up of the manure pack at the edges of the pens, so in 1999 the steel casings and wellheads were lengthened. Details are shown in Table 1.2 in Appendix 1.

Between September 28 and October 13, 1998, Well 2 was damaged by a vehicle. The well hole was re-drilled and a new well casing installed on October 19, 1998.

Groundwater Sampling and Analyses

The wells were bailed several times during a 10-day period prior to the first groundwater sampling. Bailing was performed by hand with a PVC Waterra™ foot value, which was attached to high-density polyethylene tubing.

The first groundwater samples were collected May 22, 1996. Sampling protocol involved first measuring the water-table depth with a Solinst™ water-level recorder. Depths were recorded from the top of the wellhead. Water samples were collected with a Waterra™ foot value attached to high-density polyethylene tubing. The foot value and tubing were first flushed with water from the well. Then a 250-mL sample bottle was rinsed once with well water before collecting the sample volume. The wells were not bailed prior to sampling. Groundwater samples were collected once each week during a three-month period from May 22, 1996 to August 21, 1996, for a total of 11 sampling sets. This served as the base-line period. Conditions were relatively dry during this period, and only a few animals occupied the feedlot.

Starting in May, 1998, water samples were collected with a stainless steel bailer. The bailer was first rinsed with de-ionized distilled water prior to sampling each well. The bailer and sample bottles were then rinsed with well water before taking the sample for analysis.

Samples were placed in coolers with ice-packs and transported to the Alberta Agriculture, Food and Rural Development Soil and Water Laboratory in Lethbridge. The samples were filtered under vacuum through 0.45 µm filter paper. Water samples were analysed for the following during the baseline phase: pH, electrical conductivity, calcium, magnesium, sodium, potassium, sulphate-sulphur (sulphate-S), chloride, carbonate, bicarbonate, nitrate-nitrogen (nitrate-N), manganese, iron, copper, and zinc. Sodium adsorption ratio (SAR) was calculated using the sodium, magnesium, and calcium data. The following methods were used:

- pH - Orion pH metre.
- Electrical conductivity - Radiameter CDM 83 conductivity metre.
- Calcium and magnesium - Atomic absorption (Philips PU9400X).

- Sodium and potassium - flame photometer (IL 943).
- Sulphate-S - turbidimetric method (Milton Roy Spectronic 1001 plus).
- Carbonate and bicarbonate - acid titration with a Fisher titration unit.
- Nitrate-N - hydrazine reduction colorimetric method using the Technicon TrAAcs 800™.
- Chloride - thiocyanate colorimetric method using the Technican TrAAcs 800™.
- Manganese, iron, copper, and zinc - atomic absorption (Philips PU94000X).

Additional samples were collected on July 23 and August 21, 1996, and these samples were submitted to the Provincial Laboratory of Public Health for Southern Alberta in Calgary for fecal coliform and *Escherichia coli* analysis. A membrane filtration method was used for the biological analyses.

Groundwater sampling was continued on a monthly basis (weather permitting) after the baseline period. Nine sample sets were collected from September 26, 1996 to February 18, 1998. Samples were submitted to the Alberta Agriculture, Food and Rural Development Soil and Water Laboratory in Lethbridge for nitrate-N and chloride analysis. Electrical conductivity and pH were also measured on a few selected sample sets during this time period.

A more extensive analytical suite was re-initiated in April, 1998 (sample set 21). The analytical suite included phosphate-phosphorus (phosphate-P), ammonium-nitrogen (ammonium-N), pH, electrical conductivity, calcium, magnesium, sodium, potassium, SAR, sulphate-S, chloride, carbonate, bicarbonate, nitrate-N, manganese, iron, copper, and zinc. Selected biological parameters were also measured, and these included *Escherichia coli*, total coliform, and total aerobic heterotrophs. The wells were sampled twice each month from May to November, 1998. All of the above listed parameters were analysed for the mid-month sampling. The sample sets collected at the end of each month were analysed for electrical conductivity, nitrate-N, chloride, ammonium-N (occasionally), and phosphate-P. Only mid-month samples were collected in December, 1998 and January, February, and March 1999. The twice-per-month sampling schedule was resumed in April, 1999 and continued until November, 1999. Mid-month samples were collected from December, 1999 until April, 2000, after which twice-per-month sampling was continued from May until November, 2000. Groundwater chemical analyses were carried out by the Alberta Agriculture, Food and Rural Development Soil and Water Laboratory in Lethbridge, and the microbiological analyses were carried out by Agriculture and Agri-Food Canada at the Lethbridge Research Centre. A chronological record of groundwater analyses is shown in Appendix 3.

Agriculture and Agri-Food Canada used the following mirobiology analytical procedures. Groundwater samples were serially diluted to the appropriate levels in sodium phosphate buffer (pH 6.5; 0.05M). An alliquote (1 mL) from each dilution was added to 9 mL of Fluorocult LMX (Merk) broth in tubes for enumeration of total coliform and *Escherichia coli*. The tubes were incubated aerobically at 37 ^{o}C for 48 h. *Escherichia coli* was enumerated after 24 and 48 h as those colonies with the ability to hydrolyse 5-bromo-4-chloro-3-indolyl-β-D-galactopyranoside (X-GAL) and 4-methylumbelliferyl-β-D-glucuronide (MUG). Total coliforms were enumerated after 48 h as those colonies with the ability to hydrolyse X-GAL but not MUG. Samples from selected positive tubes were streaked onto LMX agar plates to check the most probable number

(MPN) accuracy, and to allow isolation of positive colonies for identification. Selected colonies of presumptive total coliforms and *Escherichia coli* were isolated for confirmation of identity through membrane fatty acid composition, cellular morphology, and biochemical characteristics.

Alliquotes (100 µL) of the appropriate serial dilution were added to tryptic soy agar plates, in triplicate, for enumeration of total aerobic heterotrophs and incubated (48 h) at 27 ^{o}C and at 37 ^{o}C. The 37 ^{o}C incubation procedure was discontinued after February, 1999.

The microbiological results were presented as common log colony forming units per 100 mL (log CFU 100 mL^{-1}) for the total coliform and *Escherichia coli* data, and as common log MPN per 100 mL (log MPN 100 mL^{-1}) for the heterotroph data. The detection limit for the log CFU 100 mL^{-1} was 1.56. A value of half the detection limit was assigned to those samples that were below the detection limit. The antilog of 1.56 is 36.3. Half this value is 18.15, which has a common log of 1.26.

Soil Sampling

Baseline soil samples were collected on March 26 and 27, 1996, from 16 of the 32 pens (Pens #1, 3, 5, 7, 10, 12, 14, 16, 17, 19, 21, 23, 26, 28, 30, and 32) using a core tube and a B-30 sample truck. Three core samples were collected to a depth of 1.5 m from each pen. Composite samples were prepared from the three cores in depth increments of 0-15, 15-30, 30-60, 60-90, 90-120, and 120-150 cm. A total of 96 samples were collected (16 pens by 6 depths). The soil samples were air-dried and ground (< 2 mm).

The following soil analyses were carried out by the Alberta Agriculture, Food and Rural Development Soil and Water Laboratory in Lethbridge:

- Saturated-paste extract chemistry: pH (Orion pH metre), electrical conductivity (Radiameter CDM 83 conductivity meter), calcium and magnesium (Philips PU9400X atomic absorption spectrophotometer), sodium and potassium (IL 943 flame photometer), chloride (thiocyanate colorimetric method using a Technicon TrAAcs 800™), bicarbonate (acid titration using a Fisher titration unit), and sulphate-S (turbidimetric method using a Milton Roy Spectronic 1001 Plus).
- Extractable nitrate-N and ammonium-N: Subsamples (10 g) were extracted with 2-M potassium chloride (KCl) (100 mL) by shaking for 30 min. The mixtures were filtered through pre-washed (with distilled water and KCl solution) filter paper (Whatman #42). The filtrates were then analysed for nitrate-N and ammonium-N content using a Technicon TrAAcs 800™. The hydrazine reduction colorimetric method was used for the nitrate-N analysis, and the indophenol blue colorimetric method (phenate method) was used for the ammonium-N analysis.
- Extractable phosphate-P: Subsamples (10 g) were extracted with 100 mL of the Modified-Kelowna extraction solution (0.015M ammonium floride, 0.25M acetic acid, 0.25M ammonium acetate) by shaking for 30 min. The mixtures were filtered through #42 Whatman filter paper. The filtrate were analysed for phosphate-P content using the ammonium molybdate/ascorbic acid/antimony colorimetric method and a Technicon TrAAcs 800™.
- Extractable manganese, iron, copper, and zinc: Subsamples (10 g) were extracted with 20 mL

of diethylene triamine pentaacetic acid (DTPA) extraction solution (0.005-M DTPA, 0.01-M calcium chloride, and 0.1-M triethanolamine) by shaking for 2 h. The mixtures were then filtered through #42 Whatman filter paper and the manganese, iron, copper, and zinc contents in the filtrates measured with a Philips PU400X atomic absorption spectrophotometer.

The following analyses were carried out by the Agriculture and Agri-Food Canada Research Centre in Lethbridge:

- Total nitrogen and carbon: Subsamples were finely ground (<0.149 mm) using a roller grinder with steel bars. The finely ground samples were analysed for total N and C content using a dry combustion/chromotography method (Carlo Erba C/N/S Analyser, Milan, Italy).
- Inorganic carbon: The acid treatment/gas chromatography method was used (Amundson et al. 1988). Finely ground (0.149 mm) soil sample (0.2 g) was placed in a 60-mL septum-sealed bottle and treated with 5-mL of 0.5-M hydrochloric acid. The liberated carbon dioxide in the head space was measured with a Varian 34 gas chromatograph.
- Sand, silt, and clay: The hydrometer method was used to measure particle size distribution. Subsamples (40 g) were treated with 30% hydrogen peroxide and sodium hexametaphosphate solution. A ASTM 152H hydrometer was used, and readings were taken at 30 seconds, one minute, and 270 minutes.

Additional soil samples were collected on July 25, and August 1, 1996 to determine soil bulk densities. Nine cores were taken with a sample truck using a 4.0-cm diameter core tube. Three cores were taken in the feeding alley, and three cores were taken in the each of the two drainage alleys (Fig. 1). Cores were taken to a depth of 150 cm in six incremental depths (0-15, 15-30, 30-60, 60-90, 90-120, and 120-150 cm). A 5-cm section was removed from the mid-section of each incremental depth and oven dried (105 ^{o}C) to determine soil bulk density.

A second set of soil samples was collected on August 9 and 10, 1999. The same pens were sampled by collecting three soil cores per pen and making composites as described for the 1996 samples. The pens were empty of cattle, and were in the process of being cleaned of manure at the time of soil sampling in 1999. Conditions were dry, and the soil-sampling truck was able to easily drive on the surface of the pens that still contained manure. In those pens that were cleaned or partly cleaned, the surface condition varied. In some places a thin layer of manure was still present, while in other places the compact organic layer was exposed. At other pen locations the manure pack and organic layer were gone and the underlying soil was exposed. The compact organic layer was about 3 to 5 cm thick where it was intact. Where the underlying soil was not exposed, the manure pack and compact organic layer were first removed with a shovel before soil cores were collected. Therefore the 0-15 cm soil increment was the soil layer immediately below the compact organic layer.

The 1999 samples were air dried and ground (< 2 mm). The 1999 soil samples were analysed for extractable phosphate-P (Modified-Kelowna method), extractable nitrate-N and ammonium-N (KCl method), pH, electrical conductivity, calcium, magnesium, sodium, potassium, sulphate-S, chloride, carbonate, and bicarbonate (saturated paste extraction method). Soil samples were also collected from Pens 3, 7, 10, 14, 19, 23, 26, and 30 for bulk density measurements. Analyses of the 1999 soil samples were carried out by the Alberta Agriculture, Food and Rural

Development Soil and Water Laboratory in Lethbridge.

Climatic Data

Climatic data were obtained from a meteorological station operated by the Agriculture and Agri-Food Canada Research Centre. The station was located about 0.8 km north of the feedlot on the border between the NW and NE quarter sections of section 34, township 8, range 21, W of the fourth (49^{o} 42' N, 122^{o} 47' W, 899 m elevation).

Data Processing and Statistical Analysis

Data were stored in Excel™ spreadsheets, and all data processing was carried out using SAS (SAS Institute Inc. 2000). Graphical presentations were generated using SAS, PowerPoint™, SigmaPlot™, and Surfer™.

The 1996 and 1999 soil data were treated as paired samples to test for differences between the two years per soil depth. The null hypothesis that the means between years were the same was tested using the UNIVARIATE procedure in SAS. Since the data were not normally distributed, the nonparametric statistic, Wilcoxon Signed Rank Test, was used.

RESULTS AND DISCUSSION

Climatic Conditions

A selection of climatic data are summarized in Appendix 4. Precipitation during the base-line period (May 22, 1996 to August 21, 1996) was below normal (Fig. 4a). Precipitation was 54 percent below the long-term average from June to August, 1996. The total precipitation in 1996 and 1997 was 18 percent and 8 percent below the long-term average, respectively. In contrast, precipitation during 1998 was 20 percent above the long-term average, with March and June being particularly high. Precipitation was below the long-term average in 1999 by 15 percent and by 31 percent in 2000. The months May to August, October, and November were particularly dry in 2000. Mean monthly temperatures were similar to the long-term values from 1996 to 1998 (Fig. 4b). Temperatures were above the long-term average in the early and late parts of 1999. Temperature tended to be slightly above the long-term average throughout most of 2000.

Soil Analysis

The soil surface in the pen area and the areas adjacent to the north and south side of the pens sloped downward from south to north (Fig. 5). The average elevation among the 16 measurements was 911.34 m with a range between 910.97 m to 911.74 m (Appendix 1, Table 1.2). The general south to north gradient was about 0.35 percent. There was a slight ridge along the north-south direction starting about 50 m and ending about 125 m south from Well 15. This ridge caused shallow east and west slopes in this section of the pen area (Fig. 5).

Soil log notes were recorded during the installation of the 16 groundwater wells. The notes are summarized in Appendix 2. The site consisted of lacustrine material over an oxidized till deposit at Wells 1 to 4, and Wells 14 to 16. The top soil layer had been removed from the pen area where Wells 5 to 13 were located. Sand lenses were observed throughout the area. Soil texture was relatively uniform, and generally ranged from sandy-clay-loam to clay-loam based on hand texturing.

Mean soil bulk density ranged from 1.70 to 1.87 Mg m^{-3} for the six soil depths. The 0-15 cm depth had a mean bulk density of 1.73 Mg m^{-3}. The bulk density of this layer increased to 2.08 Mg m^{-3} in 1999, showing that soil compaction had occurred from pen activity through cattle movement and pen cleaning. Soil bulk density values were similar for the 15-30 cm depth between the two sample dates (Appendix 5). Others have reported that soils in feedlots are generally compacted to a depth of about 15 cm (Mielke et al. 1974).

Detailed soil chemistry data are shown in Appendix 6, with mean values summarized in Tables 6.1 and 6.2 in Appendix 6. Soil parameters measured in 1996 and 1999 are compared in Figs. 6 to 9.

Twelve parameters were measured in 1996. These included total nitrogen, total phosphorus, total carbon, inorganic carbon, organic carbon, four micronutrients, and particle size distribution. Total nitrogen tended to decrease with depth, whereas total phosphorus increased with depth.

Total carbon increased with depth in the upper half of the profile but decreased with depth in the lower half of the soil profile. The proportion of total carbon as inorganic carbon ranged from 40 to 66 percent. The proportion of total carbon as inorganic carbon tended to increase with depth. Extractable manganese and iron contents were relatively uniform through the profile. Manganese content mean values ranged from 10.8 to 17.9 kg ha^{-1}, and iron content ranged from 18.2 to 28.3 kg ha^{-1}. Extractable copper and zinc decreased with depth. Copper content mean values ranged from 2.9 to 7.0 kg ha^{-1}, and zinc content ranged from 0.47 to 1.1 kg ha^{-1}. The site clay-loam texture was uniform throughout site and with depth. Mean (n=96) particle size values were 33 percent for sand, 34 percent for silt, and 33 percent for clay.

The manure pack and underlying compact organic layer were removed prior to collecting soil core samples in 1999. For the purpose of comparing the 1996 results with the 1999 results, it was assumed that the six incremental depths corresponded between years. In the three years between the two sampling dates, the pens were cleaned of manure at least three times and some compaction occurred in the top soil layer. Some soil was probably removed during the removal of manure, and this was probably not uniform throughout the feedlot site. Four layers were visible where manure was still present at the time of soil sampling in August, 1999. The top layer was the fresh manure pack. Located under the manure pack was the compact organic layer, which was on top of the soil. The soil was visibly darker in colour within the top 15 cm, representing the third layer. This colouring of the soil is most likely the result of organic material from the manure pack and the compact organic layer moving into the soil or mixing with the top soil layer. Below this layer was the visually unaltered soil material. However, chemically, the soil was affected by the manure pack to depths greater than 15 cm, as evident from the following results comparing data between the two sampling dates. Mielke et al. (1974) also described three distinctive layers above the unaltered soil, referring to the second layer as the interface layer (i.e. compact organic layer) of mixed organic material and mineral soil that forms under the manure layer.

Chloride. Chloride content was significantly higher throughout the soil profile in 1999 as compared to 1996 (Fig. 6a). The largest increase was more than 111 fold in the 0- to 15-cm layer. The smallest increase was about two fold in the 90- to 120-m layer. Chloride readily leaches downward with the movement of water. The only source of chloride would have been from the manure, and as a result serves as a good indicator. These results show that within the three-year period chloride moved below the manure pack and compact organic layer and throughout the soil profile. Therefore, the compact organic layer was not completely impermeable to the movement of contaminants from the manure pack and into the underlying soil. Kennedy et al. (1999) collected 1-m deep soil cores from five-year old, two-year old, and newly constructed pens at a feedlot in central Alberta. They also observed significantly elevated chloride content in the 0- to 20-cm depth in five-year old and two-year old pens, as compared to newly constructed pens. They concluded that this was evidence that some water movement occurred from the pen surface and into the soil profile.

Nitrate-N. Extractable nitrate-N increased from 17 kg ha^{-1} in 1996 to 45 kg ha^{-1} in the 0-15 cm soil depth (Fig. 6b). However, for lower depths, nitrate-N content tended to be less in 1999, though there were no significant differences. The soil profile (0-150 cm) actually contained less nitrate-N in 1999 (157 kg ha^{-1}) than in 1996 (184 kg ha^{-1}), representing a 15 percent decrease during the three-year period. This would suggest that no nitrate leached from the manure pack and into the soil, perhaps as the result of the impermeable compact organic layer. However, data for the 0- to 15-cm layer clearly shows that some nitrate-N did move into the soil, and this may have occurred after pen cleaning and prior to the reformation of the compact organic layer where it had been removed. If more nitrate-N did move into the soil, it may be possible that leaching below the 150 cm depth or possibly denitrification had occurred.

Kennedy et al. (1999) found no significant difference in the nitrate-N gradient under the five-year old and two-year old pens, as compared to the newly constructed pens. They proposed that the most likely explanation is that any nitrate that leached into the soil was lost through denitrification under anaerobic conditions. Saint-Fort et al. (1995) also concluded that denitrification can occur in feedlots. Elliott and McCalla (1972) measured the composition of soil air beneath a feedlot near Lincoln, Nebraska, and found high concentrations of methane (8 to 27.5 percent average range) and carbon dioxide (12.5 to 23 percent average range). They concluded that their data showed the feedlot soil profile had a low redox potential, in order to facilitate methane production, and provided favourable conditions for denitrification. They reported that previous work at this feedlot showed that nitrate-N concentrations in the shallow groundwater (0.93 to 1.52 m below the soil surface) was generally below 10 mg L^{-1} (Mielke et al. 1970), and suggested that the reduced conditions prevented nitrate from reaching the water table. In a field study carried out in Nebraska by Ellis et al. (1975), soil core samples were collected beneath 15 feedlots ranging in age (new to 50 years) and soil texture (clay to coarse sand). They found that continuously stocked feedlots did not have problems with nitrate-N accumulation, whereas soil under abandoned feedlots contained large amounts of nitrate-N. Maulé and Fonstad (2002) suggested that nitrate-N is not always a reliable indicator of solute leaching from manure.

Like chloride, nitrate-N is also very soluble and can readily leach. However, as shown in Fig. 6b, nitrate-N did not increase in the soil profile, except in the 0- to 15-cm layer. Some workers have suggested that changes in chloride to nitrate-N ratio can be an indicator of denitrification (Kimble et al. 1972; Saint-Fort et al. 1995). However, we caution that the ratio alone may be misleading and the actual distribution of the two anions needs to be examined (Figs 6a, b) and the amount of chloride and nitrate-N added to the pen surface needs to be considered. The chloride concentration in the manure pack was about 250 times greater than nitrate-N concentration (Miller et al. 2002, unpublished data, Agriculture and Agri-Food Canada, Lethbridge, Alberta, Canada). Even without denitrification, chloride content in the soil would increase more than nitrate-N simply because there was more chloride added than nitrate-N, relative to the levels measured in 1996.

Ammonium-N and phosphate-P. Ammonium-N was relatively uniform throughout the soil profile in 1996, with a slight increase below the 15-30 cm depth (Fig. 6c). There were no changes in 1999, expect for the 0-15 cm and 15-30 cm depths. Ammonium-N was increased by a factor of 19 in the 0-15 cm depth and by a factor of two in the 15-30 cm depth. Elliott et al. (1972) also reported that ammonium-N was high in soil water at the 15-cm depth, but declined markedly at greater depths. The movement of ammonium-N can be restricted by interactions with the soil matrix and microbial reduction (Saint-Fort et al. 1995).

Phosphate-P followed a similar pattern with a three-fold increase in the 0- to 15-cm soil layer after three years (Fig. 6d). There were no differences between 1996 and 1999 below 15 cm. Campbell and Racz (1975) measured phosphorus content below a 13-year old feedlot, and they found higher phosphorus content to the 120-cm depth, as compared to adjacent cropped land. They concluded that the movement of phosphorus occurred in organic and inorganic forms. One possible reason why we observed elevated phosphorus content only in the 0 to 15 cm layer is because our site was only three years old at the time the 1999 soil samples were collected.

Sodium, magnesium, calcium, and SAR. Extractable sodium, calcium, and magnesium significantly increased in the upper soil profile (Fig 7a-c). The largest increase occurred in the 0- to 15-cm layer, particularly for sodium (Fig. 7a). Sodium tended to increase more than calcium and magnesium, and this resulted in a significantly larger sodium absorption ratios (SAR) in the 0- to 15-cm and 15- to 30-cm layers (Fig. 7d). Sodium absorption ratio increased from 0.72 in 1996 to 3.21 in 1999 in the 0- to 15-cm layer. The increase in SAR may have contributed to soil structure degradation, which may have partly facilitated the increase in soil bulk density in this layer.

Electrical conductivity and pH. Electrical conductivity was significantly greater in the 0- to 60-cm soil layer after three years of feedlot operation (Fig. 8a). The 0- to 15-cm layer increased from a weakly saline condition (2.6 dS m^{-1}) in 1996 to a strongly saline condition (6.4 dS m^{-1}) in 1999. Soil pH changed very little (Fig. 8b). However, there was a slight but significant decrease in pH below 15 cm after three years.

Sulphate-S. Sulphate-S followed a pattern similar to sodium. Sulphate-S tended to increase throughout most of the soil profile, with significant increases in the top 60 cm (Fig. 8c).

Potassium. Potassium increased more than 23 times in the 0- to 15-cm layer (Fig. 8d). There was also a slight increase in the 15- to 30-cm layer. Potassium content remained unchanged below the 30-cm depth after three years. Unlike many of the other nutrients, the accumulation of potassium was essentially restricted to the 0-15 cm soil layer. Schuman and McCalla (1975) measured high exchangeable potassium in the surface of a feedlot soil profile. Potassium was the dominate cation in this layer, and they suggested the high potassium content caused deterioration of soil physical properties.

Bicarbonate. Except for the 0- to 15-cm soil layer, bicarbonate decreased in the soil profile after three years (Fig. 9).

Groundwater Elevation

Water levels in Wells 10, 11, and 12 at the north end of the feedlot recovered more slowly than the other wells following installation and bailing. The relatively slow recovery indicates a low hydraulic conductivity for these wells. However, soil descriptions, which were taken during well installation, give no reason why these wells took longer to recover. Soil texture ranged from sandy-clay-loam to clay-loam, with some sand lenses, throughout the site. The water table elevations were stabilized in all wells by early June, 1996, within one month of drilling.

The average water-table depth below the soil surface for the site ranged from 1.23 m (June 12, 1997) to 2.50 m (February 17, 1998) during the 4.5-yr period. The minimum depth measured in a single well was 0.14 m for Well 13 on June 12, 1997. The maximum water-table depth in a single well was 4.77 m for Well 12 on May 8, 1996. A maximum fluctuation of 4.08 m was observed in well 12 during the 4.5-yr period. The least fluctuation of 1.50 m occurred in Well 6. The variation of the average water-table elevation with time is shown in Fig. 10. The highest average elevation was measured on June 12, 1997, and the lowest average elevation was measured on February 17, 1998, with a 1.27 m difference between the minimum and maximum average elevations. There was a clear annual fluctuation of water-table elevation, with the lowest elevation occurring early in each year, and the maximum occurring in the mid-May to mid-July period (Fig. 10). Detailed water-table elevation data are presented in Appendix 7.

After the water-table levels had stabilized by early June, 1996, it was apparent the water table sloped downward from south to north (Fig. 11a). Most of the slope occurred in the south half of the study area, and the north half was relatively flat. By July 4, 1996, the water table was generally flat (Fig 11b.), and remained relatively flat until about August 21, 1996 (Fig. 11c). A water-table mound began to develop by November 14, 1996 (Fig. 12a) and became more distinctive throughout 1997 (Fig. 12b). The feedlot pens are located directly over the water-table mound. Using the long axis (west side) in Fig. 12, the pens are positioned from 43.9 m to 156.1 m along the axis. The water-table mound was persistent throughout 1998, 1999, and 2000, and was still present on November 27, 2000 (Fig. 12c). The water-table mound reflects increased recharge to groundwater below the pen area. Topographic maps for each date water-table depths were measured, from May 8, 1996 to November 27, 2000, are shown in Appendix 8.

Groundwater Chemistry

All groundwater chemistry measured from 1996 to 2000 is shown in Appendix 9.

Baseline sampling phase. Summary results of the baseline sampling phase (May 22, 1996 to August 21, 1996) are shown in Table 1. Groundwater chemistry, particularly nitrate-N, chloride, sodium, and SAR, varied widely among wells. For example, Well 1 consistently had low nitrate-N concentrations, with a range of 0.0 to 1.5 mg L^{-1}, whereas Well 2 had higher concentrations, with a range of 152 to 185 mg L^{-1}. Many of the parameters exceeded water quality guidelines, such as nitrate-N, sodium, sulphate-S, SAR, manganese, iron, and electrical conductivity.

Nitrate is not stable in an iron-reducing environment (Korom 1992). This explains why nitrate-N was present at a maximum of 5 mg L^{-1} in groundwater with more than 1 mg L^{-1} iron and 1 mg L^{-1} manganese (Table 2). Nitrate is completely denitrified below the redox boundary in fine-textured and course-textured sediments (Robertson et al. 1996; Rodvang and Simpkins 2001). The redox boundary was not noted during well installation. However, the low nitrate-N and elevated reduced iron and manganese in Wells 1, 10, 12, and 14 suggest this groundwater was reduced.

Table 1. Descriptive statistics of groundwater chemical parameters measured 11 times from May 22, 1996 to August 21, 1996 (baseline data).

Parameter	Mean	Min.	Max.	Standard deviation	No. of samples	Guideline limits
nitrate-N (mg L^{-1})	41.9	0	185	46	176	10^{z}
chloride (mg L^{-1})	97.9	7.1	291	79	176	250^{z}
calcium (mg L^{-1})	429	289	515	28	176	1000^{y}
magnesium (mg L^{-1})	535	300	930	164	176	
sodium (mg L^{-1})	1080	166	1791	381	176	200^{z}
potassium (mg L^{-1})	15.4	7.4	22.7	3.4	176	
sulphate-S (mg L^{-1})	1599	826	2411	362	176	$500^{z,x}$
bicarbonate (mg L^{-1})	707	336	1159	145	176	
carbonate (mg L^{-1})	0.2	0	12.3	1.4	176	
SAR	8.2	1.4	12.7	2.8	176	4^{w}
manganese (mg L^{-1})	1.1	0	9	2.2	160	0.05^{z}
iron (mg L^{-1})	1.1	0	14.6	2.9	160	0.3^{v}
copper (mg L^{-1})	0.01	0	0	0.01	160	1.0^{z}
zinc (mg L^{-1})	0.01	0	0.21	0.02	160	5.0^{v}
pH	8	7.2	8.3	0.2	176	$6.5\text{-}8.5^{z}$
electrical cond. (dS m^{-1})	7.6	4.3	10.8	1.5	176	1.0^{w}

[z] Canadian water quality guidelines (CCME 1987; FPCEOH 1996) for drinking water.
[y] Canadian water quality guidelines (CCME 1987) for livestock watering.
[x] As sulphate (CCME 1987).
[w] Canadian water quality guidelines (CCME 1987) for irrigation.
[v] Canadian water quality guidelines (FPCEOH 1996) for aesthetic objective.

Most measured parameters did not show a consistent spatial pattern. The main exceptions were chloride and nitrate-N concentrations, which tended to decrease along the south to north direction within the study area. Calcium concentration and pH were relatively uniform throughout the site. The four micronutrients (manganese, iron, copper, and zinc) were generally low. Copper and zinc concentrations were below 0.01 mg L^{-1}. Iron and manganese concentrations were generally below 1 mg L^{-1}. However, groundwater from Wells 1 and 10 consistently had higher iron and manganese concentrations. Wells 12 and 14 also contained elevated iron and manganese concentrations. Generally there were no obvious trends during the three-month period. However, there were slight trends with time of decreased sodium concentration and SAR, and a slight trend of decreased bicarbonate concentration. A consistent increase in manganese concentration was observed, with a mean value of 0.52 mg L^{-1} on May 22,

Table 2. Mean nitrate-N, iron, and manganese concentrations for individual wells during the three-month, baseline, sampling period.

Well no.	Nitrate-N (mg L^{-1})	Iron (mg L^{-1})	Manganese (mg L^{-1})
1	0.2	5.72	4.76
2	160	0.03	0.45
3	46.8	0	0.06
4	27.4	0.01	0.11
5	36.5	0.01	0.19
6	109.1	0.01	0.01
7	62.4	0.01	0.14
8	92.2	0.01	0.1
9	7.0	0.31	0.3
10	0.2	7.35	6.87
11	23.3	0.01	0.37
12	0.6	1.16	2.17
13	67.9	0.02	0.25
14	5.1	2.89	1.78
15	20.6	0.56	0.6
16	11.1	0.08	0.16

1996, increasing to 1.91 mg L^{-1} by August 22, 1996. Iron also increased with time, but remained consistently low (0.45 to 0.81 mg L^{-1}) during the first half of the three-month period, and then increased (1.47 to 1.96 mg L^{-1}) after the July 4, 1996 sampling date.

Rodvang et al. (1998) showed that nitrate-N occurs naturally in groundwater in oxidized till at many locations in southern Alberta. Natural nitrate is related to redox conditions. Sodium, sulphate, and magnesium have also been shown to occur naturally at high concentrations in oxidized till in southern Alberta (Rodvang et al. 1998). High natural concentrations in southern Alberta are common in oxidized till (Rodvang and Simpkins 2001).

Post-baseline sampling phase. Groundwater mean data are presented in Figs. 13 to 17, including the baseline sampling period. The data for each parameter were grouped according to three locations at the site: the south wells (n=4), the pen wells (n=9), and the north wells (n=3). If the feedlot affected groundwater chemistry, then any affect would most likely appear in some or all of the nine wells within the pen area, and not in the seven wells outside of the pen area.

Chloride - Chloride concentration in groundwater increased with time in the pen wells. There was essentially no change in the south and north wells (Fig. 13a). There was an annual cycle in chloride concentration in the pen wells. Periods of maximum mean concentrations occurred in June 1997, June-July, 1998, August, 1999, and October, 2000. It is interesting that the period of maximum concentration occurred later in each subsequent year. This annual cycle in chloride concentration followed the annual recharge events of the water-table levels (Fig. 10). The difference between the pen wells and the seven wells outside of the pen area is strong evidence that chloride was able to leach to the groundwater from the manure pack in the feedlot. Because chloride is water soluble and does not interact with the soil matrix, either chemically or biologically, it serves as a good tracer for water movement through the soil profile.

Nitrate-N - The site mean nitrate-N concentration (n=16) was highest during the three-month baseline period. Subsequent measurements showed mean nitrate-N concentrations were lower, but consistently remained around 29 mg L^{-1}. Nitrate-N mean concentration was generally highest in the south wells and lowest in the north wells (Fig. 13b). There was a slight, but steady increase in nitrate-N concentration from October, 1998 to May, 1999, followed by a decrease for about two months, after which nitrate-N concentration slowly increased after July, 1999 until the end of the study. The increase during the October, 1998 to May, 1999 can mainly be attributed to the wells within the pen area, whereas the trend increase after July, 1999 was observed for the three locations (Fig. 13b).

As previously stated, the nitrate-N concentration was well above the Canadian drinking water quality guidelines of 10 mg L^{-1} at the time the feedlot was constructed. Prior to the construction of the feedlot, the pen area and south (i.e. south wells) was in crop/forage production and may have received applications of fertilizer and irrigation water. The area may have also been used to graze livestock. The area where the north wells were located was not used for any particular purpose. The higher nitrate-N in the groundwater under the pens and in the south wells, particularly in Wells 2, 6, and 8, may be the result of previous land use activities or natural sources. The presence of the feedlot for three years generally did not affect nitrate-N concentration in the groundwater. Some researchers have concluded that feedlots will not contribute significant amounts of nitrate, if any, to groundwater (Elliott et al. 1972; Lorimor et al. 1972; Schuman and McCalla 1975) due to reduced infiltration and denitrification. However, other researchers have reported groundwater contamination by nitrate from feedlots (Coote and Hore 1979). The clear effects on chloride, combined with the lack of effects on nitrate-N, suggests denitrification may have prevented an increase in nitrate-N.

Electrical conductivity - Groundwater electrical conductivity remained very constant during the study (data not shown). Electrical conductivity generally was slightly greater in the north wells (5.4 to 9.5 dS m^{-1}) compared to the south and pen wells (5.4 to 8.1 dS m^{-1}).

Calcium and magnesium - Calcium concentration was similar among the three locations throughout the study (Fig. 13c). There was a slight increase in calcium concentration with time for the whole site. Magnesium concentration also increased slightly with time, and the north wells consistently had the highest concentration (Fig. 14a). The feedlot pens did not have any noticeable influence on groundwater calcium and magnesium concentrations.

Sodium and sulphate-S - There were no obvious trends for these two ions in the groundwater between April, 1998 to November, 2000, with regard to the presence of the feedlot pens (Figs. 14b-c). Sodium concentration was noticeably lower during this period compared to the baseline sampling phase (Fig. 14b). As a result, SAR followed a similar pattern to sodium concentration (data not shown). Sodium concentrations were greater in the north wells relative to the south and pen wells. As with calcium and magnesium, sodium concentration also increased slightly with time, with annual fluctuations. These annual fluctuations correspond to the annual recharged events (Fig. 10). As the water table level increased, sodium concentration decreased because of dilution. This effect was particularly noticeable for the pen wells, and is probably related to the water-table mound that formed under the pen area (Figs. 11 and 12). Sulphate-S remained fairly steady from April, 1998 to November, 2000, but was consistently less than the values obtained during the baseline sampling phase. Groundwater in the north wells generally contained more sulphate-S than the other two locations (Fig. 14c). Sulphate-S concentrations were similar between the south-well the pen-well locations, but after May, 1999, the pen wells contained less sulphate-S than the south wells. Sulphate-S concentrations in the pen wells also varied with the dilution effect of annual recharge events.

Potassium and ammonium-N - Potassium concentration was similar between the north and south wells, with a slight increase with time (Fig. 15a). Ammonium-N concentration was very low in the north and south wells, with very little change with time (Fig. 15b). In contrast, potassium and ammonium-N concentrations increased in the pen wells during April, 1998 until early 2000. These increases occurred mainly in Well 5, and to a lesser extent in Wells 7, 8, 10, 12, and 13. The increase in concentration for these two cations corresponded closely with the chloride changes in 1998 and 1999. After March, 2000, potassium and ammonium-N concentrations were only slightly more than the other two well locations. An increase in ammonium-N concentration, particularly since it occurred in conjunction with an increase in chloride concentration, provides further evidence of nitrate reduction.

Bicarbonate and phosphorus - Bicarbonate concentration increased with time during the three-month baseline sampling phase, and this increase was consistent among the three well locations (Fig. 15c). After bicarbonate analysis was resumed in 1998, this tend of increasing bicarbonate concentrations was not observed. On average, the pen wells contained the highest bicarbonate concentration, and the south wells contained the lowest concentrations after April, 1998. Phosphate-P was not measured during the 1996 baseline period. Analysis of groundwater from April, 1998 to November, 2000 showed no major fluctuations in the north and south wells (Fig.16a). Phosphate-P concentration in these wells were usually less than the suggested aquatic life water quality guideline used in Alberta of 0.05 mg L^{-1} for total phosphorus (Alberta Environment 1999). There were several instances in 1998 and 1999 when phosphate-P concentration increased in pen wells. These increases occurred in Wells 5, 7, and 13. The largest concentration measured was 7.2 mg L^{-1} in Well 5 on May 17, 1999.

Manganese, iron, zinc, and copper - Manganese concentration was generally greater in the pen wells than in the south and north wells in 1999 and 2000 (Fig. 16b), whereas iron and zinc concentrations were generally similar among the three well locations (Figs. 16c and 17a). The increase in manganese was attributed to Well 5. Iron concentration increased slightly in the north wells in November, 1998 and September, 1999. Both of these increases were attributed to Well 14. Iron concentration in Well 5 also increased in 1999 and this caused a slight increase in the mean concentration in the pen wells. Zinc concentration remained relatively consistent and was similar among the three locations. The only exception was on March 15, 1999 when a large increase was observed for the south wells and to a lesser extent for the north and pen wells. We have no good explanation for this increase and it could be due to analytical error. Copper concentration, in contrast, substantially increased after March, 1999, and this was consistent among the three well locations (Fig 17b).

Chloride results in detail. Of the parameters that were measured, chloride showed the strongest evidence that contaminants from the feedlot had moved into the shallow groundwater. The seven wells (1 to 4 and 14 to 16) outside of the pen area had no increase in groundwater chloride content with time, whereas chloride concentration increased in the pen area (Fig. 13b). Of the nine pen wells, chloride concentration increased in six of these wells. There were only short-term, minor increases in Well 7, and there were no changes with time in Wells 6 and 9.

The nine pen wells were located adjacent to the pens and not in the pens (Fig. 1). Three wells (Wells 6, 9, and 12) were located in the feeding alley. The other six wells were located in the two handling/drainage alleys. The individual pens were sloped towards the drainage alleys and the movement of animals to and from the pens occurred in these alleys. As a result, the drainage alleys were often wet. The drainage alleys consisted of a gravel layer overlaying compacted subsoil. In contrast, the feeding alley was generally dry and any surface water would move into the pens. Most of the increases occurred in the wells located in the drainage alleys. The three wells in the feeding alley either had no increase (Wells 6 and 9) or a modest increase (Well 12) in chloride concentration. Perhaps the drainage alleys allowed more water infiltration and leaching than other parts of the feedlot. Unfortunately soil samples were not collected from the drainage alleys for chloride analysis. However, the soil samples collected from within the pens showed that chloride leached to the 1.5-m depth. The drainage alleys did not have the compact organic layer, which was observed in the pens. The compact organic layer that forms below the manure pack is believed to restrict the downward movement of water and solutes (Mielke and Mazurak 1976).

Before making any conclusions about the influence of the feedlot pen area on shallow groundwater, a few points need to be raised. On July 3, 1998 about 22.8 mm of rain fell at the feedlot. When the wells were sampled on July 6, 1998, it was discovered that Well 13 was submerged under water. Water was drained from around the protective steel casing. The water inside the steel casing was bailed out before the cap was removed from the wellhead. The well was first bailed by hand with a Waterra™ foot value and hose and allowed to recover before taking a sample with the steel bailer. About 15.7 mm of rain fell on July 7 and 8, 1998. When the wells were sampled on July 14, 1998 we observed that water had collected around Wells 5, 8, and 13 within the protective steel casing. The wellheads of Wells 5 and 13 were still above the water line, but Well 8 was submerged. The question here is whether the groundwater in these three wells was contaminated directly from the surface under these conditions. We feel that it is unlikely the groundwater was contaminated for the following reasons. First, bentonite clay was used to backfill around the wells to a depth of 1 m below the ground surface, and the protective steel casings were imbedded in the bentonite clay (Fig. 3). The bentonite clay should have provided a good seal. In addition, the wellheads were closed with threaded caps. The chloride concentration had already begun to increase long before July, 1998 in Wells 5 and 13, and to a lesser extent, in Well 8. In addition, Wells 6, 7, 10, and 12 experienced some increase in chloride concentration after the July 3, 1998 rainfall. When 34.8 mm of rain fell from July 31 to August 2, 1998, none of the wells experienced flooded conditions. However, when groundwater was sampled on August 10, chloride concentration had increased in Wells 5, 8, 11, 12, and 13, as compared to the previous values measured on July 27, 1998.

On a second occasion, Well 13 was flooded after about 42.5 mm of rain fell on June 1 to 3, 1999. However, chloride concentration actually decreased after this rainfall. Also, prior to this rainfall event, chloride concentration had increased in May, 1999 following a 44.9 mm rainfall event on May 13 to 15. Chloride concentration began to increase again after a 42.5 mm rainfall in mid-July, 1999 and generally continued to increase through the rest of 1999 and throughout 2000. The data show that chloride concentration increased several times following significant rainfall events (about 40 mm), in addition to the two occasions when the Well 13 was submerged (Fig. 18). In June, 1999, the steel casing around Well 13, and casings round four other wells in the pen area, were lengthened in order to prevent flooding of the wellheads.

Well 5. Even though there was a general increase in groundwater chloride concentration in the pen wells, there was a wide range of variability among these wells. Some wells were not affected, whereas large increases in chloride concentration were observed in other wells. In addition to chloride, other measured parameters changed with time, particular in Well 5. After April 12, 1999 bicarbonate, ammonium-N, potassium, manganese, and phosphorus concentrations increased, whereas nitrate-N concentration decreased to near zero (Figs. 19, 20, and 21). The colour of the water samples from Well 5 also changed. Generally, the colour of the filtered groundwater samples ranged from colourless to pale yellow. However, in July, 1999, water from Well 5 became blackish in colour. After filtration, the sample was brown in colour; darker than the other samples. The material that caused the blackish colour did not pass through the filter paper. We suspect the dark colour may have been caused by organic material, which may have promoted the denitrification of nitrate-N. The dark colour may have also been caused by manganese released to the groundwater under reduced conditions. Chloride concentration began increasing around mid-1997 and continued to increase in stages until a peak concentration was reached in August, 1999, followed by a decrease (Fig. 19a). Bicarbonate followed a similar pattern, except the increase did not start until mid-1998 (Fig. 19b). Ammonium-N concentration was essentially zero when analysis began in 1998 (Fig. 19c). However, from 1998 to 1999 two peaks of ammonium-N were observed, and after each peak the concentration returned to near zero. Potassium followed a similar pattern as ammonium-N (Fig. 20a). The change in manganese concentration was essentially opposite to the change in nitrate-N concentration (Fig. 20b-c). Manganese content remained less than 1 mg L^{-1} until mid-May, 1999, after which its concentration increased rapidly. At the same time, the nitrate-N concentration deceased to essentially zero and remained low during the latter half of 1999. By the end of 2000, manganese concentration was less than 1 mg L^{-1}, and nitrate-N showed some modest increase. Phosphorus concentration increased for only short periods of time in 1998 and 1999 (Fig. 21).

Groundwater Microbiology

Fecal coliform and *Escherichia coli (E. coli)* contents in the groundwater were below detection limits in essentially all the wells for the two sampling events that these parameters were measured in 1996 (Appendix 10). However, when groundwater microbiology measurements were resumed on a more regular basis in 1998, *E. coli*, total coliforms, and aerobic heterotrophs were detected in groundwater samples (Fig. 22 and Appendix 11). Mean values for *E. coli* and total coliforms varied annually (Fig. 22a-b). During the winter months, the values were below the detection limit of 1.56 log MPN 100 mL^{-1}. From July to October, 1998 and from April to October, 1999 the count increased substantially. The increase in 2000 was not as large, with a modest increase in April followed by a larger increase from August to November.

Aerobic heterotroph populations remained relatively stable throughout the period of measurement (Fig. 22c), ranging from 5.6 to 7.3 log CFU 100 mL^{-1}. However, the higher values tended to correspond to the peaks observed for *E. coli* and total coliforms.

Figure 23 clearly shows that essentially all of the increase in the measured microbial populations occurred within the pen area. Even the aerobic heterotrophs tended to be higher in the pen wells during the peak periods (Fig. 23c). The modest increases that were observed in the north and south wells generally occurred during the same peak period as for the pen wells (Fig. 23a-b). The short-term increase that was observed in April, 2000 for *E. coli* was not within the pen area, but rather in the south wells, and this can be mainly attributed to Well 3 and to a lesser extend, Well 4. Of the nine wells within the pen area, only Well 9 did not show the same increases as the other wells. Well 11 also contained lower populations, but not to the same extent as Well 9. The mean values of *E. coli* and total coliforms in the other seven wells (Wells 5-8, 10, 12-13), during the period of measurement, were 11- to 13-fold greater than in Well 9, and eight-fold greater than in Well 11. Aerobic heterotrophs were, on average, five-fold and two-fold greater in the seven wells, as compared to Wells 9 and 11, respectively.

The annual increase-decrease cycles of *E. coli* and total coliforms in the nine pen wells closely followed the annual precipitation patterns (Fig. 24). The amount of precipitation in 1998 was 20 percent above the long-term average, with June being particularly wet. In 1999, the precipitation was about 25 percent below the long-term average, and the higher amounts of precipitation were spread over a longer period of time, as compared to 1998. Lower microbial populations found in the groundwater in 2000 reflect the fact that precipitation in 2000 was 31 percent below the long-term average.

Livestock manure is a source of microorganisms including pathogens, and these microorganisms can move vertically through soil (Mawdsley et al 1995; Betcher et al. 1996). Betcher et al. (1996) reviewed the findings of a 1991 farm drinking water well survey in Ontario reported by Rudolph and Goss (1993). Twenty to forty-four percent of the wells tested for bacteria exceeded the recommended maximum concentrations. The major point sources for bacteria on farms were septic tanks, manure storage facilities, and feedlots. Coliform bacteria contamination of groundwater decreased as the separation distance between wells and feedlots increased. Others worker have shown that bacteria can readily move downward through soil.

Fleming and Bradshaw (1991) applied liquid hog manure to undisturbed soil cores (15 cm diameter by 60 cm long) and found that a little more than two percent of the bacteria load in the manure was in the effluent that drained from the cores. The amount of bacteria in the effluent from the cores that received manure was 60 to 99 times greater than observed from the control soil cores. Stoddard et al. (1998) reported a significant increase of fecal bacteria in leachate at the 90-cm depth after dairy manure was applied to soil, and that this persisted for 60 days. Fecal bacteria moved beyond the root zone when sufficient rainfall occurred. They pointed out that groundwater contamination depends on soil structure and water flow more than on fecal bacteria survival at the soil surface. McMurry et al. (1998) showed that fecal coliforms moved through excavated soils blocks, which were treated with poultry manure, with preferential water flow.

Clearly from the literature and from our study, microorganisms can move from a manure source and downward through soil. The groundwater chloride data provide evidence that the drainage alleys may be an important area where water can infiltrate and move downwards. The six wells located in the drainage alleys contained more chloride than the three wells in the feeding alley. However, the soil data from beneath the pens showed that chloride leached to the 1.5-m depth. The distinction between the drainage-alley wells and the feeding-alley wells was not as clear for the microbiology data.

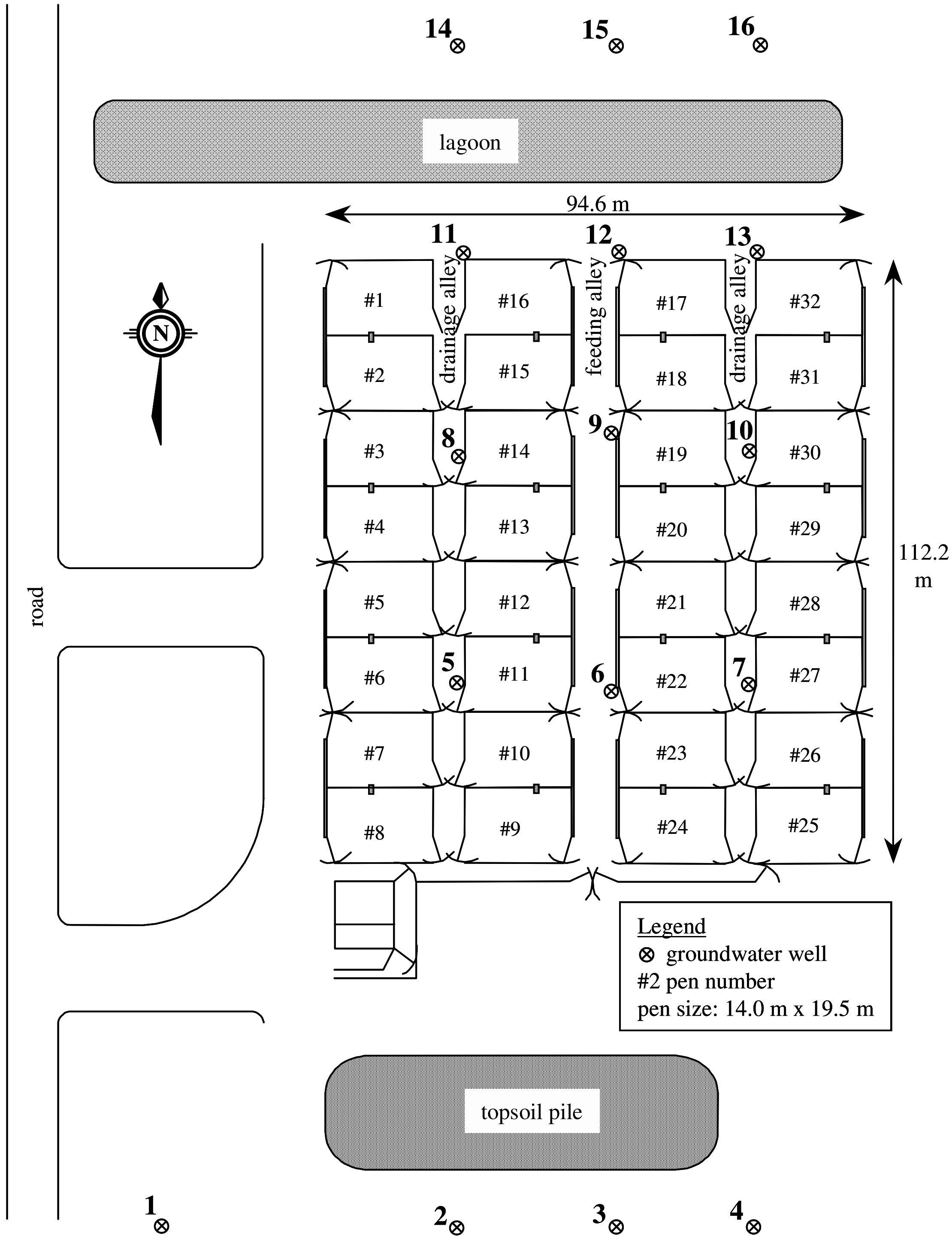

Fig. 1. Phase one of the Research Feedlot at the Agriculture and Agri-Food Canada, Lethbridge Research Centre.

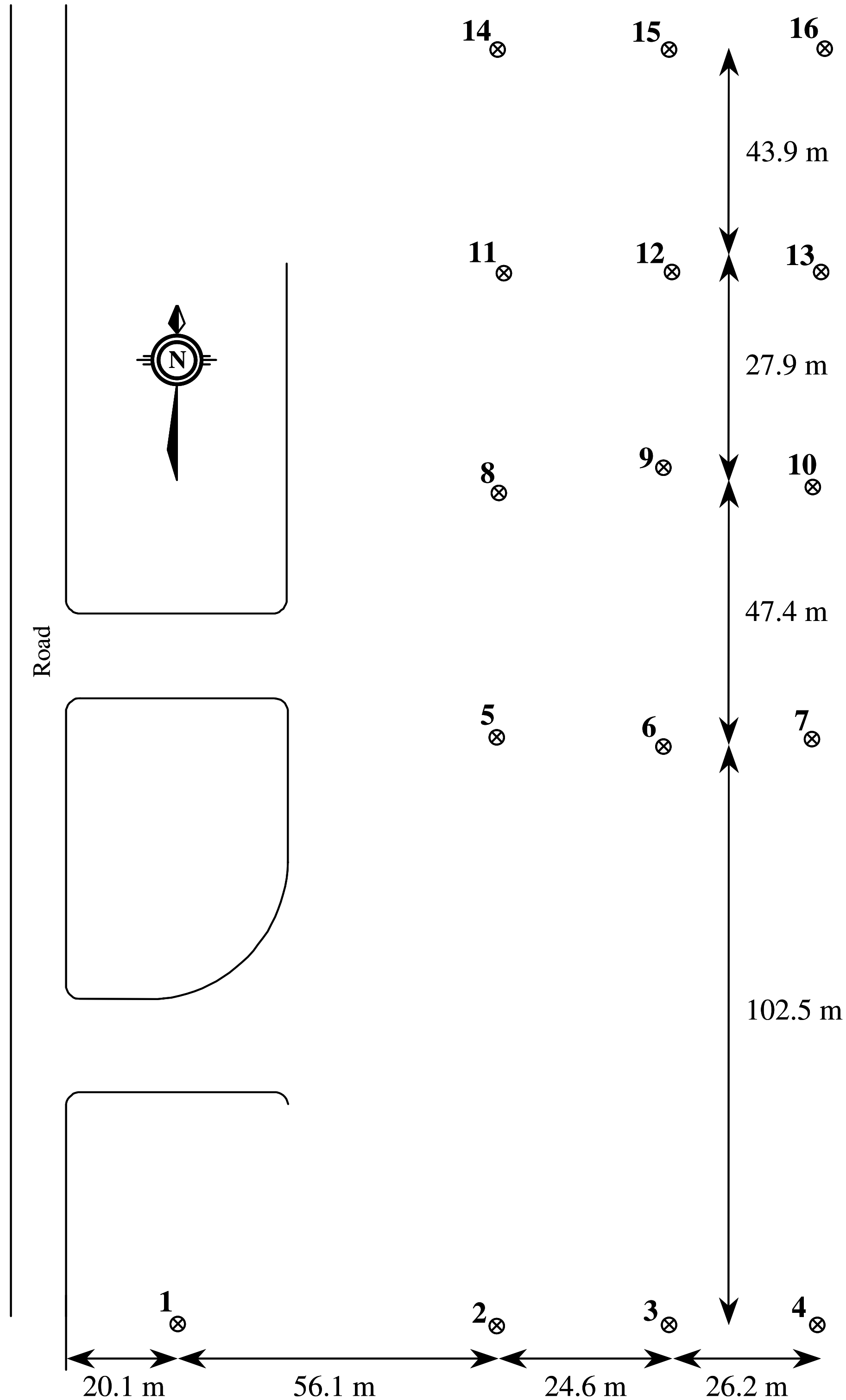

Fig. 2. Approximate distances between the groundwater wells at the Research Feedlot.

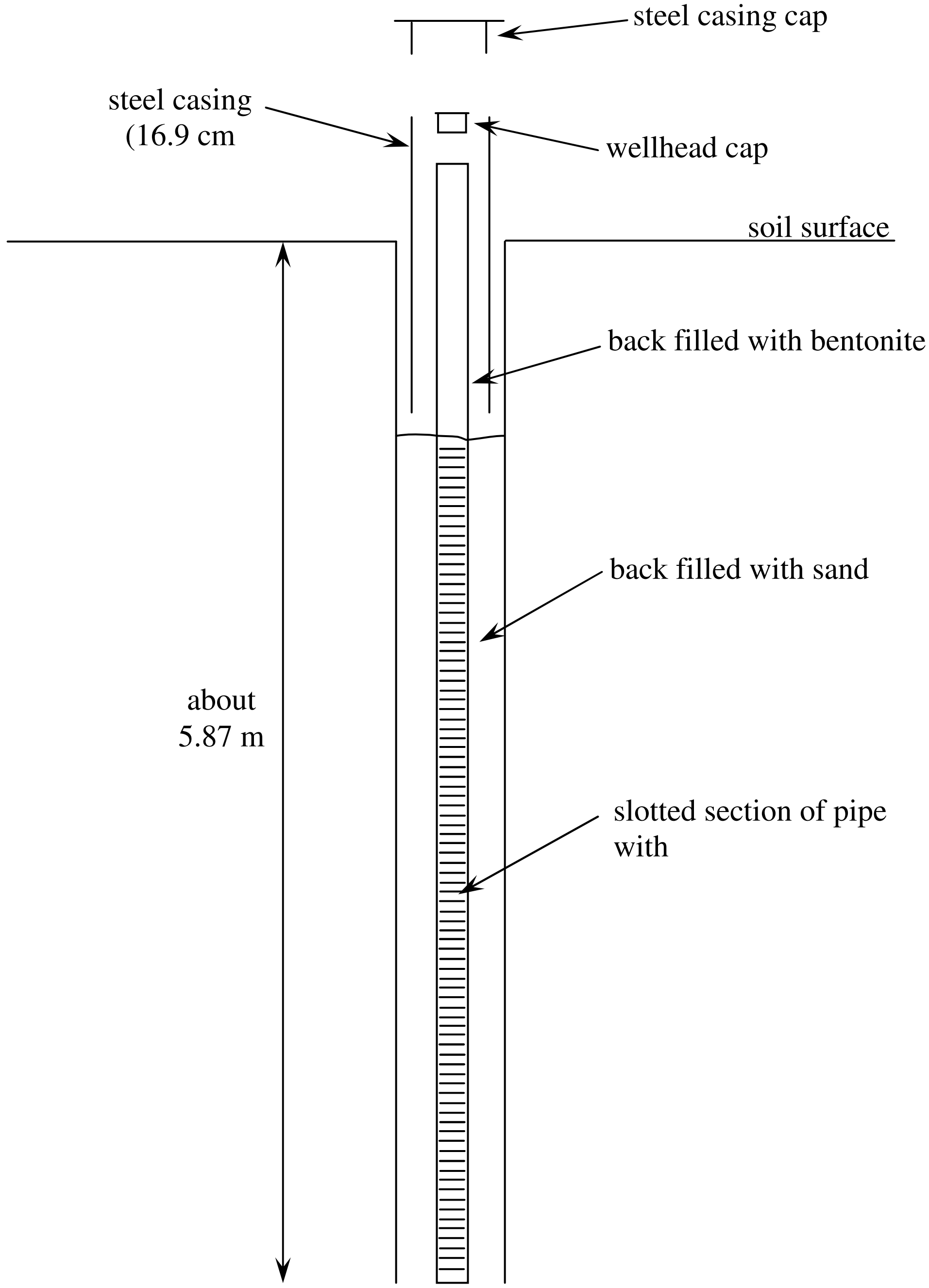

Fig. 3. Typical groundwater well installation at the Research Feedlot. Not drawn to scale.

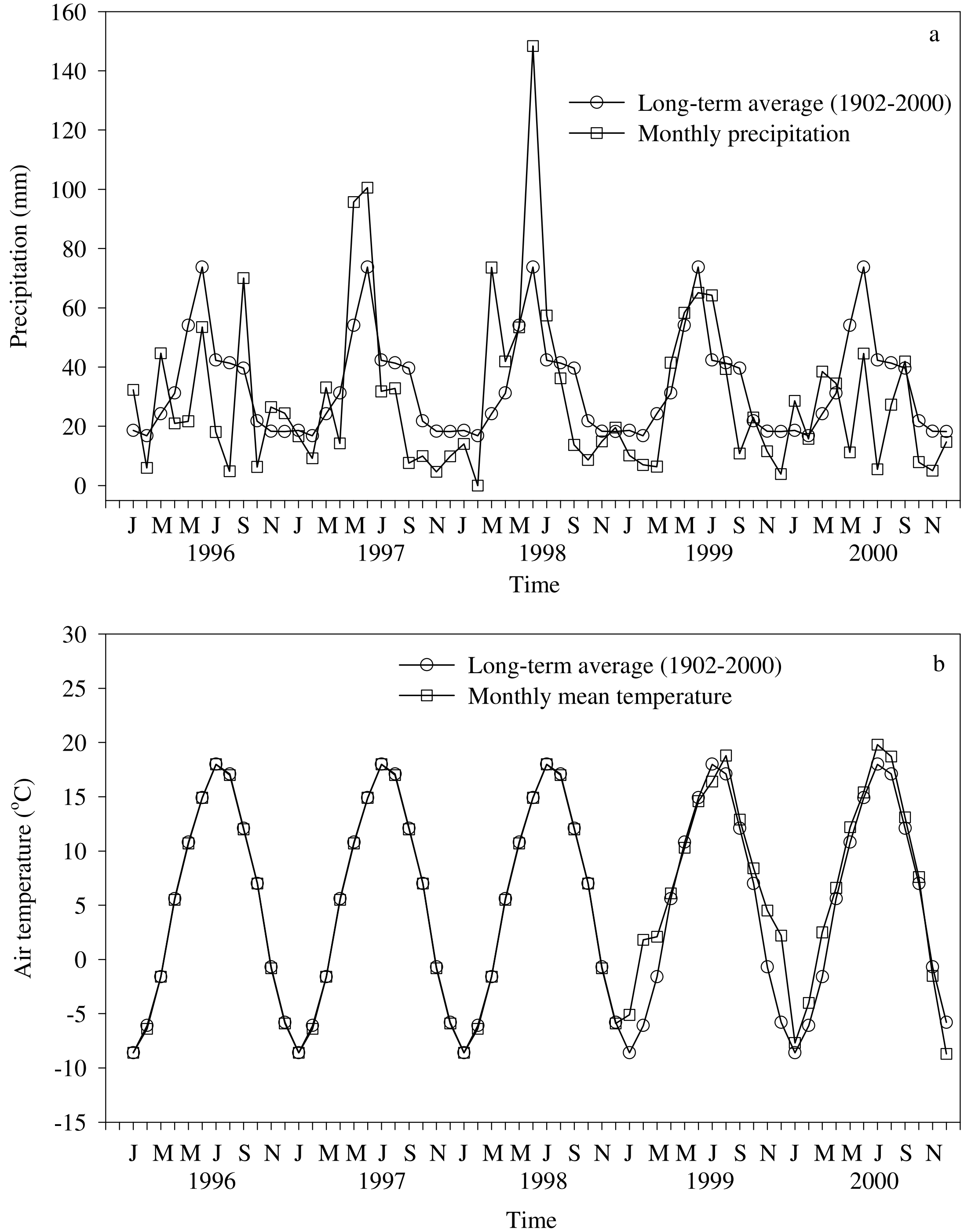

Fig. 4. Monthly precipitation (a) and monthly mean temperature (b) at the Agriculture and Agri-Food Canada Resaerch Centre, Lethbridge, Alberta.

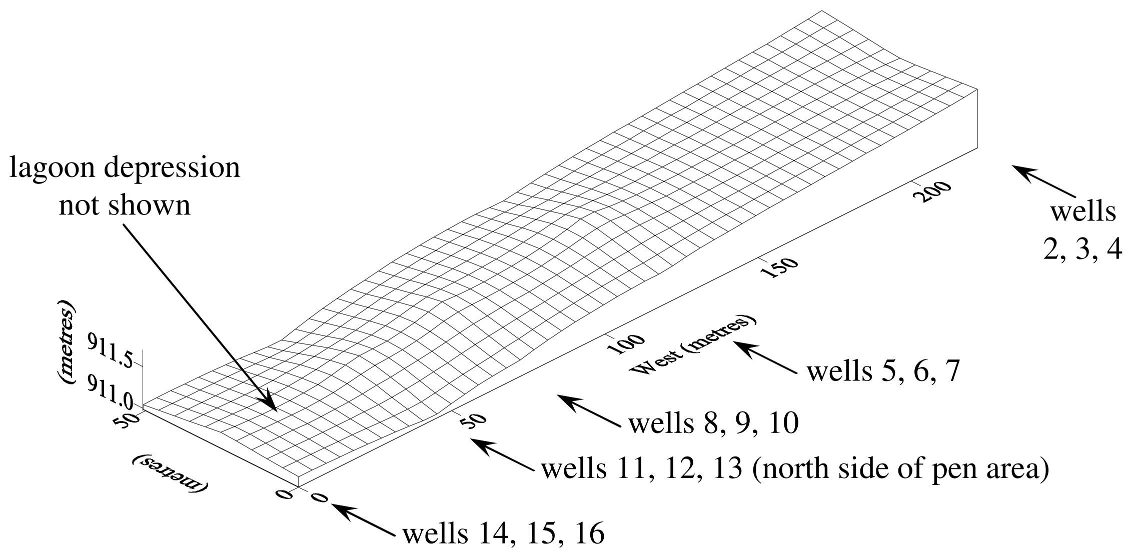

Fig. 5. Soil-surface elevation at the Research Feedlot on May 10, 1996, based on elevation measurements that were taken beside each well. Well 14 is located in the NW corner at x:y coordinates of 0:0 metres. Well 1 is not included in the above surface plot. The vertical scale is exaggerated by 24.4 times relative to the two horizontal scales.

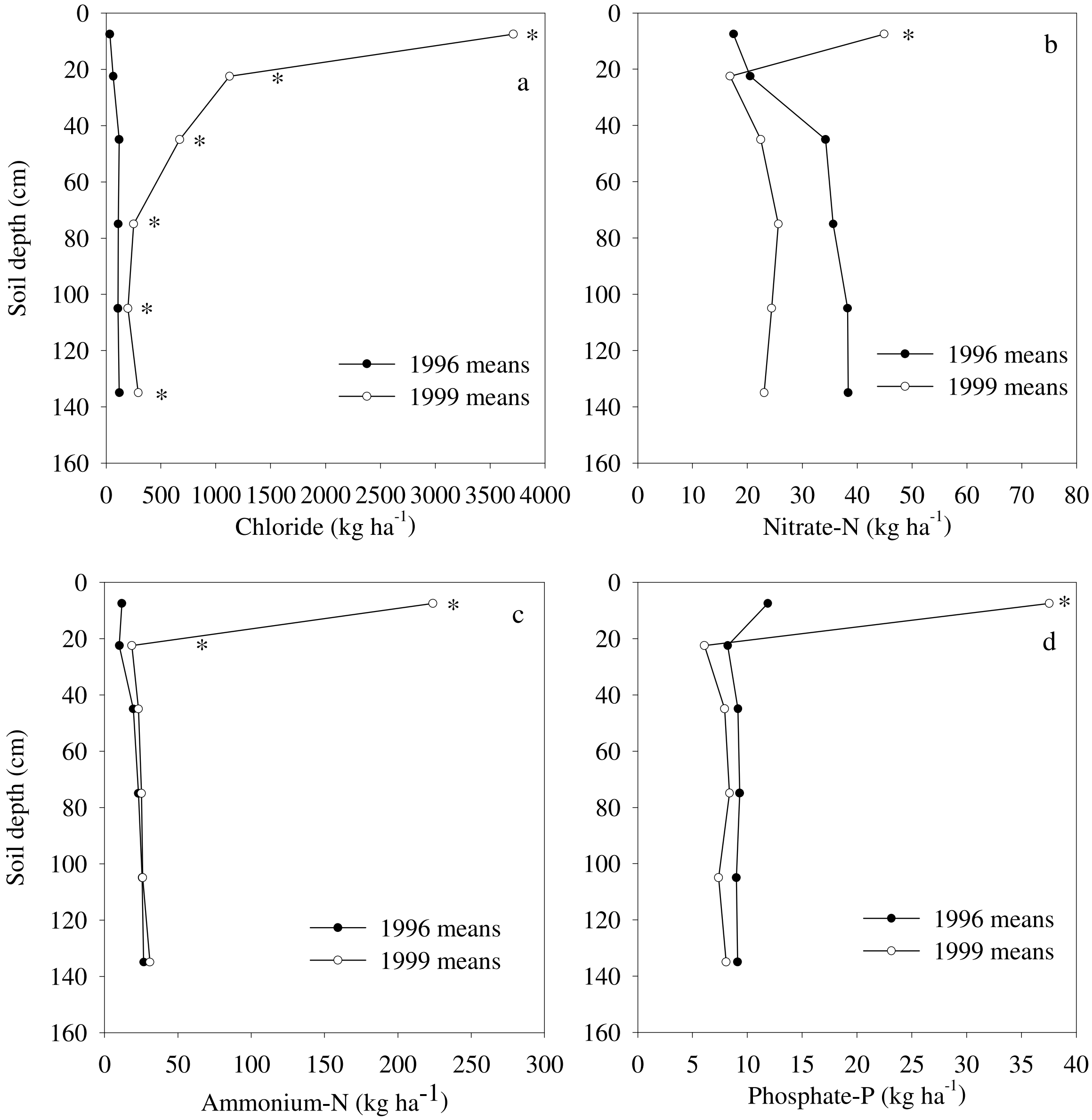

Fig. 6. Soil extractable chloride (a), extractable nitrate-N (b), extractable ammonium-N (c), and extractable phosphate-P (d) mean values (n = 16 per incremental depth) in 1996 and 1999 at the Research Feedlot. Means for each incremental depth with an asterisk are significantly different ($P \leq 0.05$).

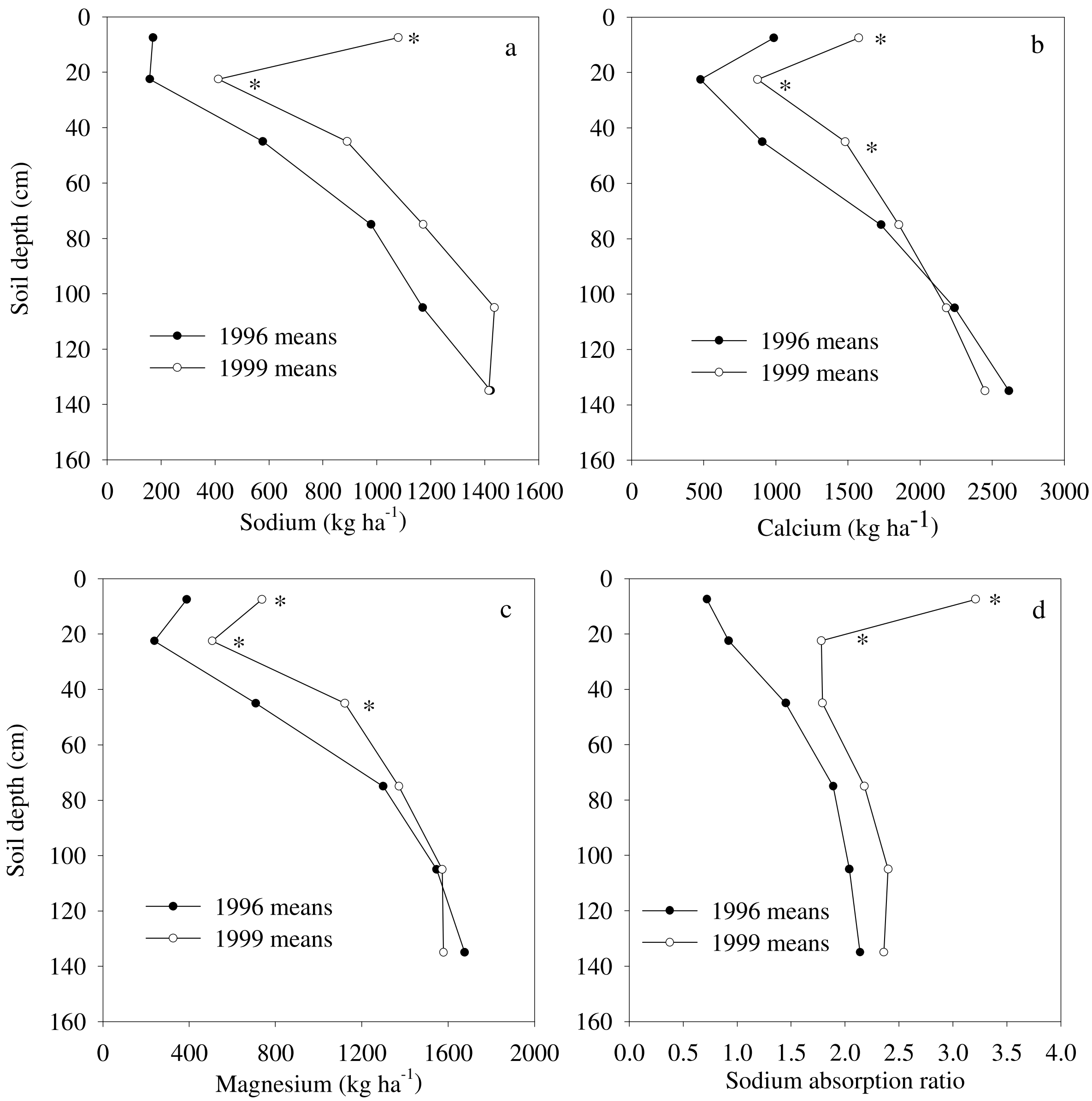

Fig. 7. Soil extractable sodium (a), extractable calcium (b), extractable magnesium (c), and sodium absorption ratio (d) mean values (n = 16 per incremental depth) in 1996 and 1999 at the Research Feedlot. Means for each incremental depth with an asterisk are significantly different ($P \leq 0.05$).

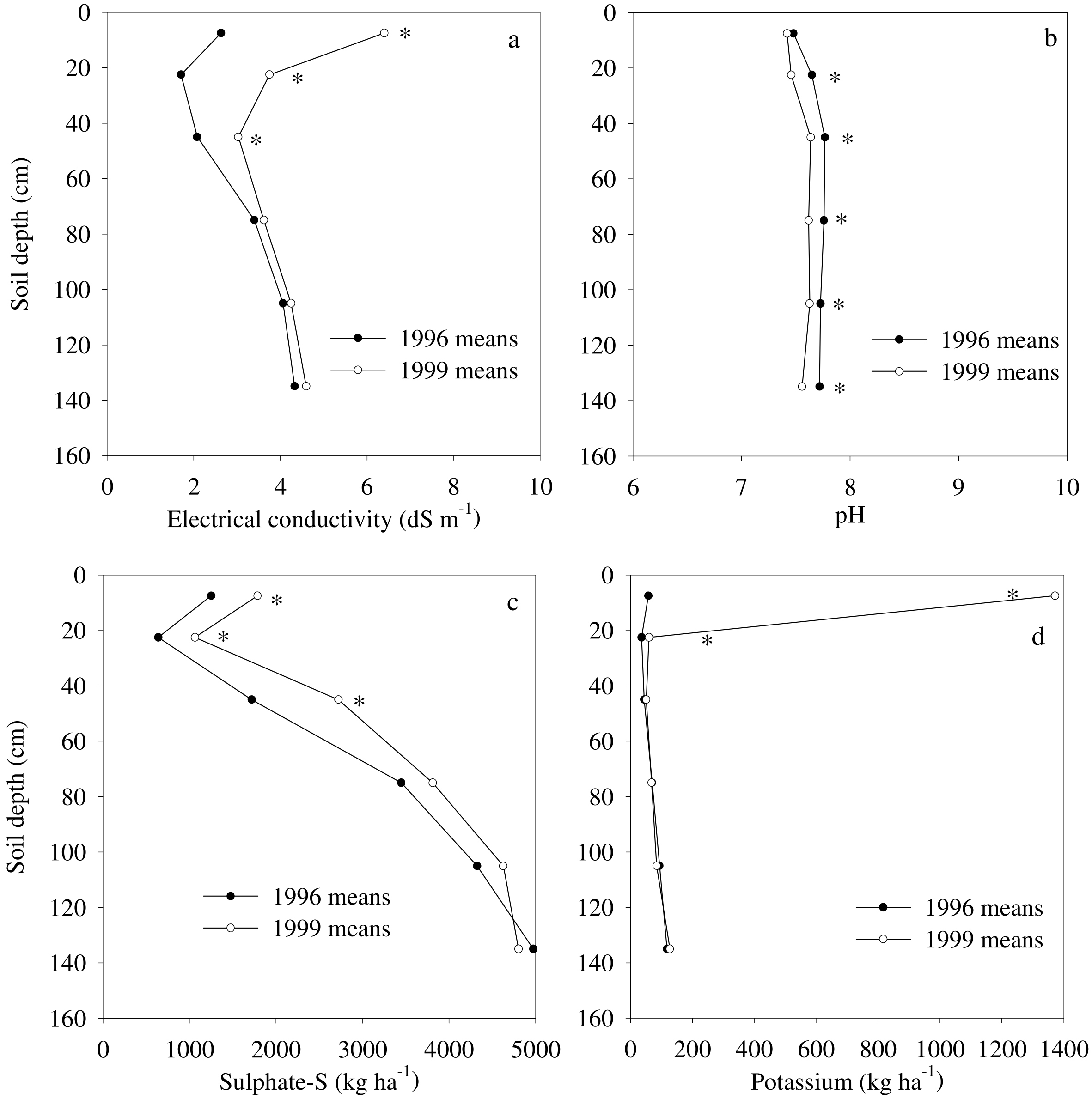

Fig. 8. Soil electrical conductivity (a), pH (b), extractable sulphate-S (c), and extractable potassium (d) mean values (n = 16 per incremental depth) in 1996 and 1999 at the Research Feedlot. Means for each incremental depth with an asterisk are significantly different ($P \leq 0.05$).

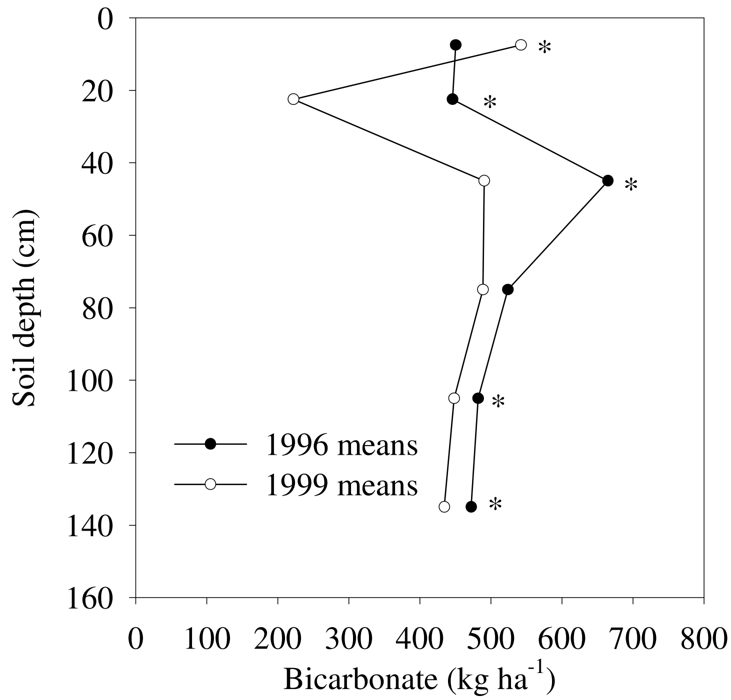

Fig. 9. Soil extractable bicarbonate mean values (n = 16 per incremental depth) in 1996 and 1999 at the Research Feedlot. Means for each incremental depth with an asterisk are significantly different ($P \leq 0.05$).

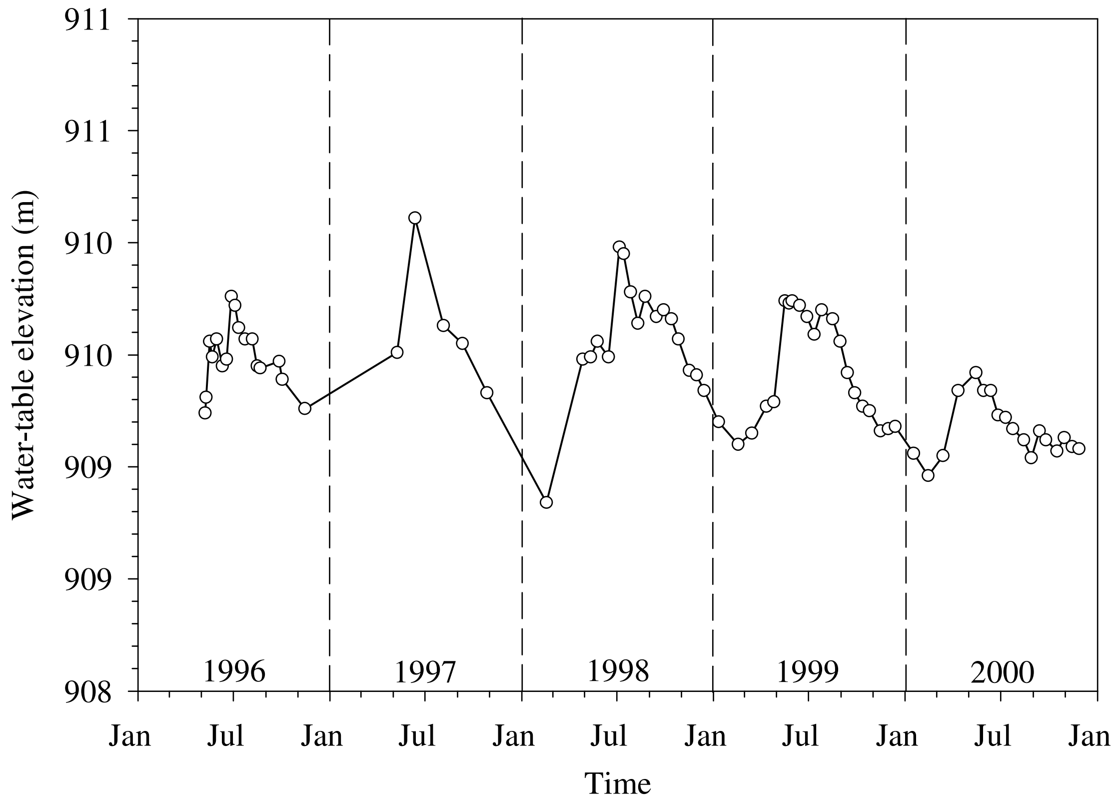

Fig. 10. Mean (n=16) water-table elevations at Research Feedlot from May 8, 1996 to November 27, 2000.

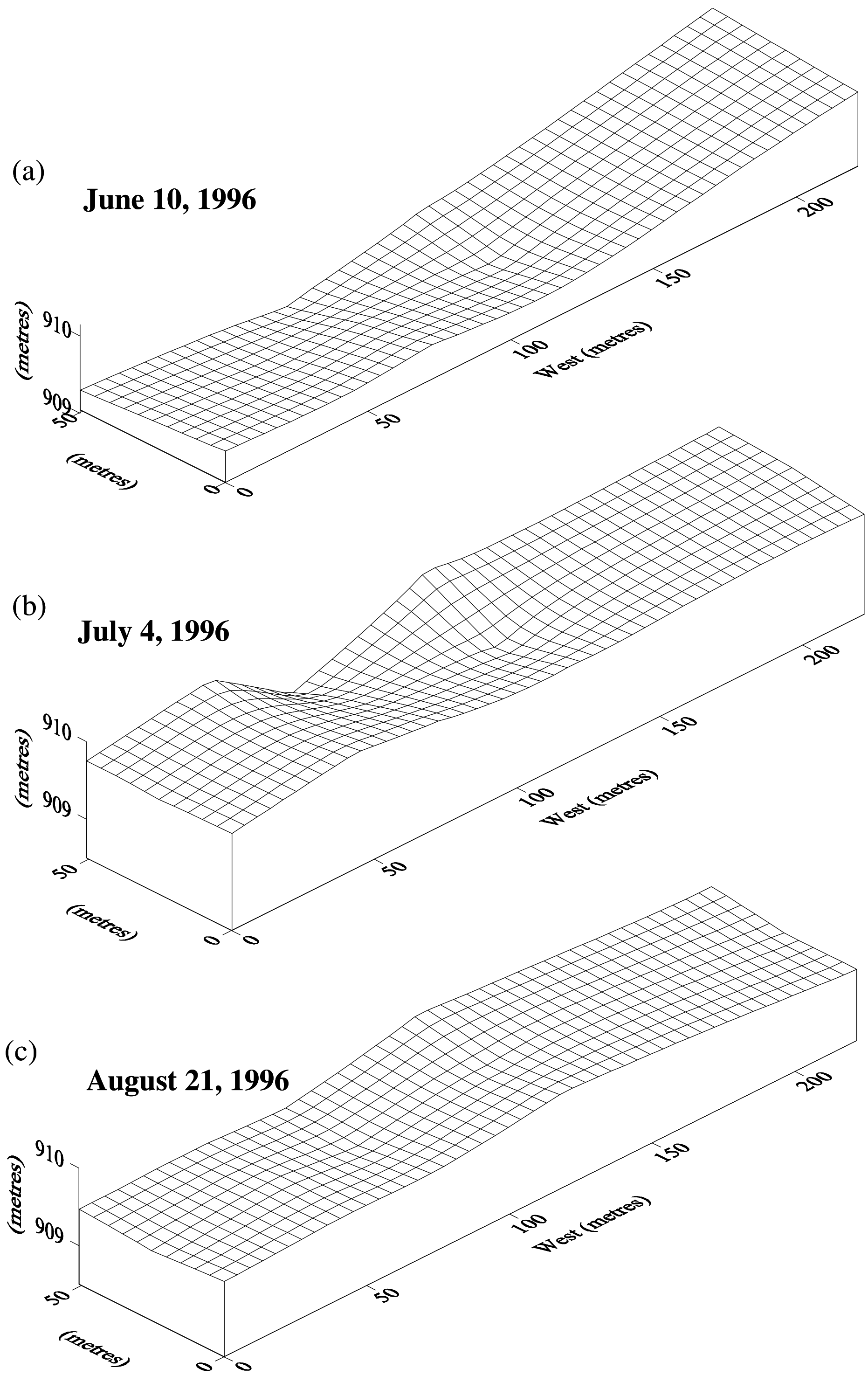

Fig. 11. Water-table elevation on June 10 (a), July 4 (b), and August 21 (c), 1996 at the Research Feedlot. Well 14 is located in the NW corner at x:y coordinates of 0:0 metres. Well 1 is not included. The vertical scale is exaggerated by 24.4 times relative to the two horizontal scales.

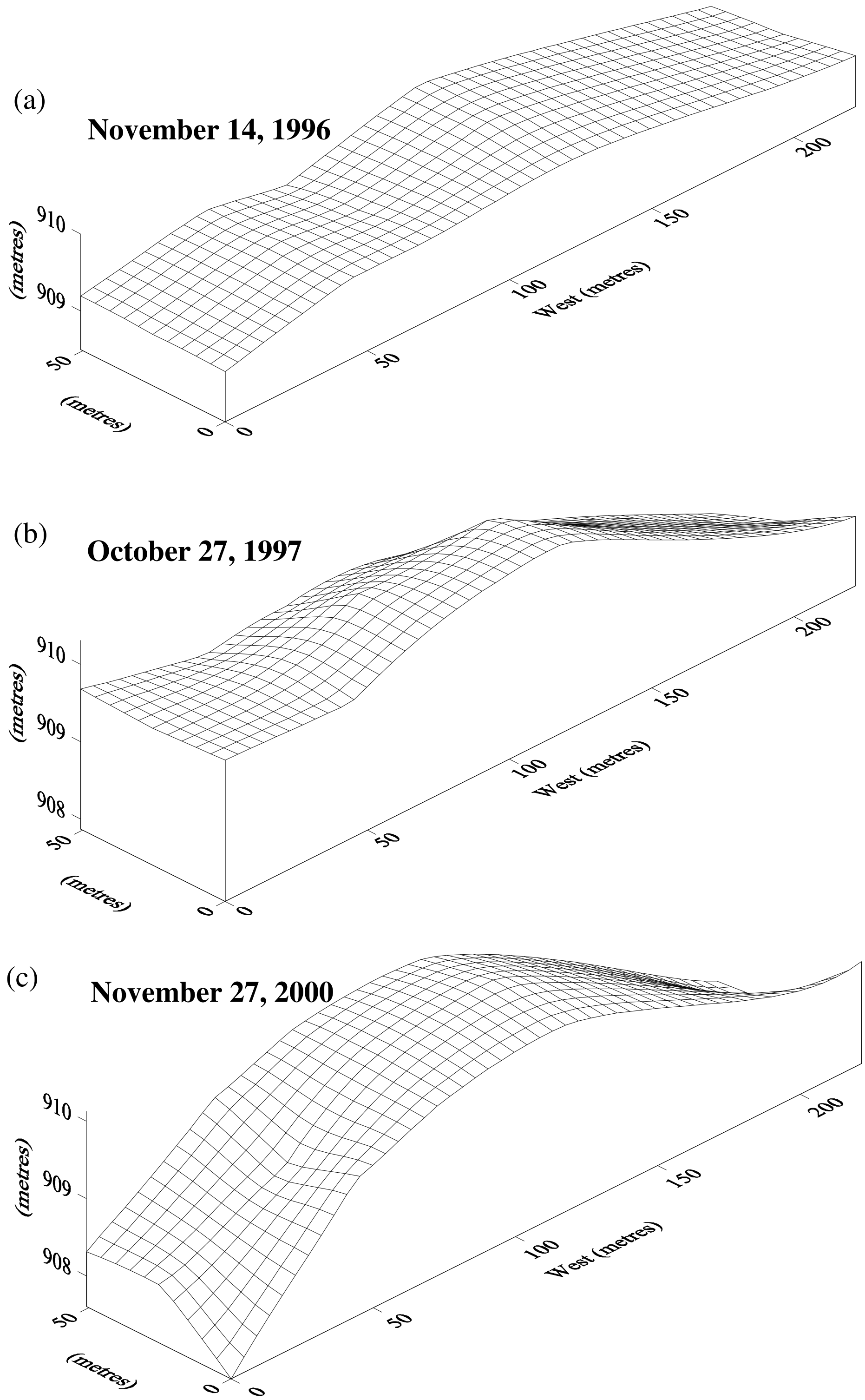

Fig. 12. Water-table elevation on November 14, 1996 (a), October 27, 1997 (b), and November 27, 2000 (c) at the Research Feedlot. Well 14 is located in the NW corner at x:y coordinates of 0:0 metres. Well 1 is not included. The vertical scale is exaggerated by 24.4 times relative to the two horizontal scales.

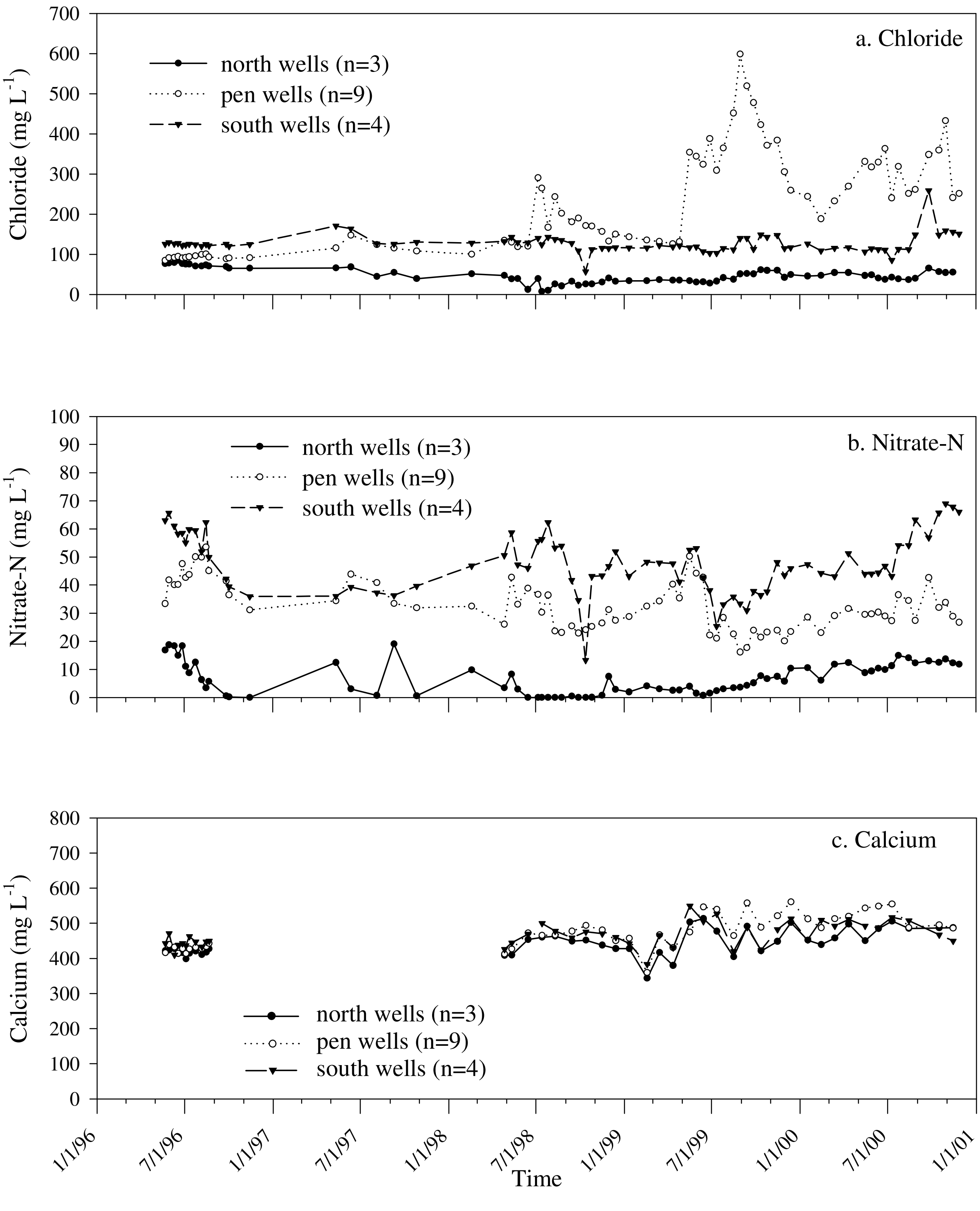

Fig. 13. Mean concentrations in groundwater of (a) chloride, (b) nitrate-N, and (c) calcium for the north wells (n=3), pen wells (n=9), and south wells (n=4) from May, 1996 to November, 2000.

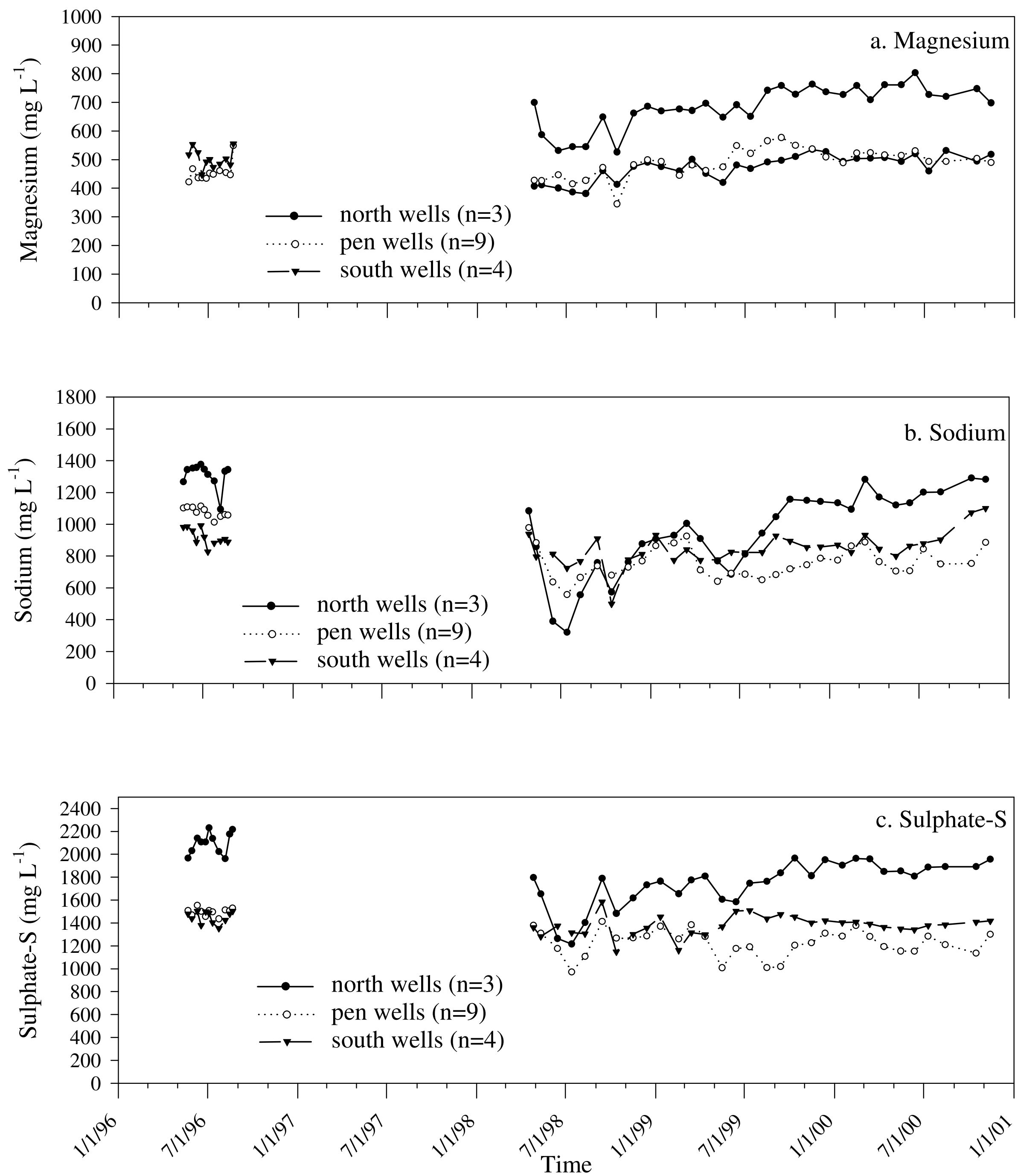

Fig. 14. Mean concentrations in groundwater of (a) magnesium, (b) sodium, and (c) sulphate-S for the north wells (n=3), pen wells (n=9), and south wells (n=4) from May, 1996 to November, 2000.

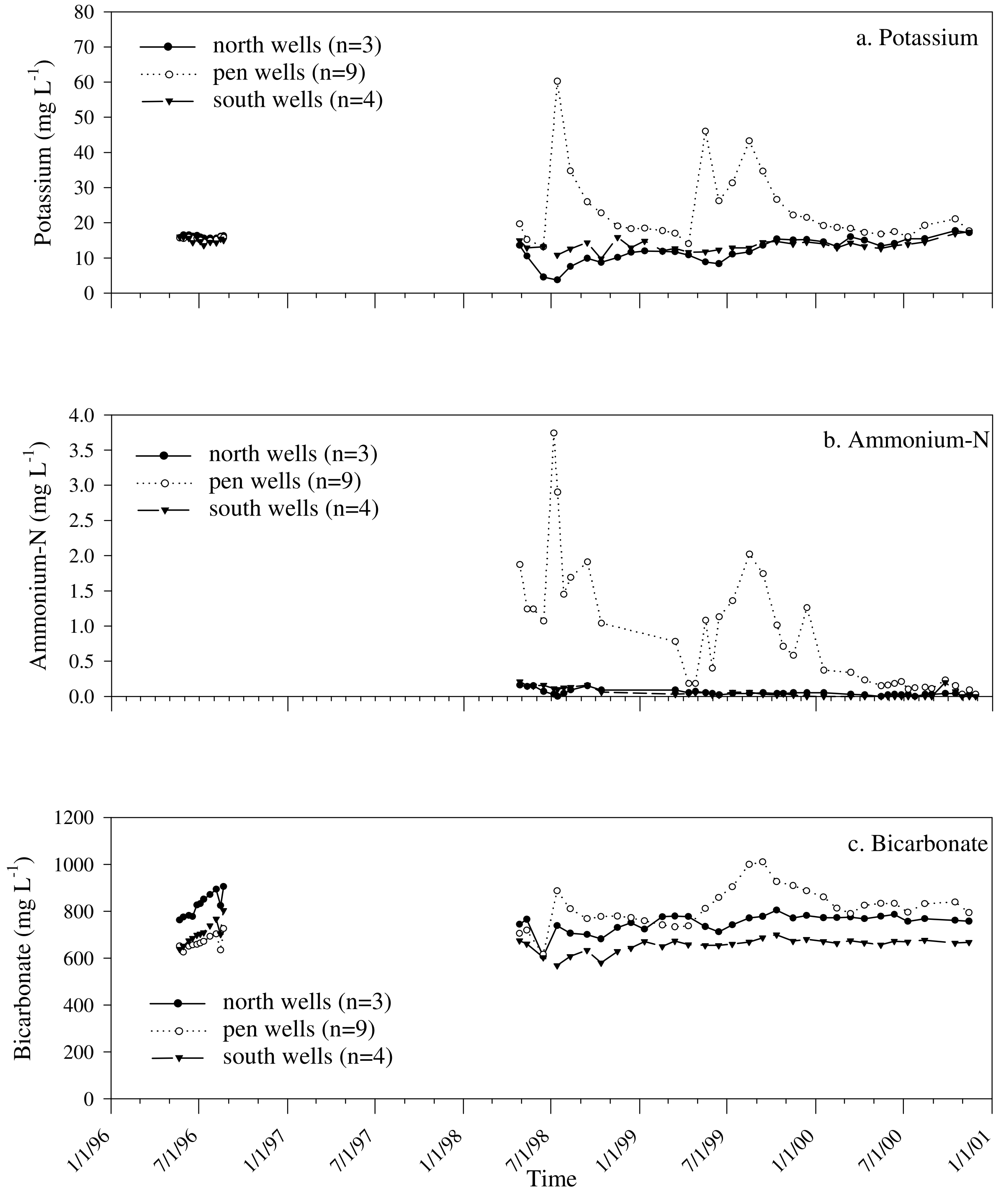

Fig. 15. Mean concentrations in groundwater of (a) potassium, (b), ammonium-N, and (c) bicarbonate for the north wells (n=3), pen wells (n=9), and south wells (n=4) from May, 1996 to November, 2000.

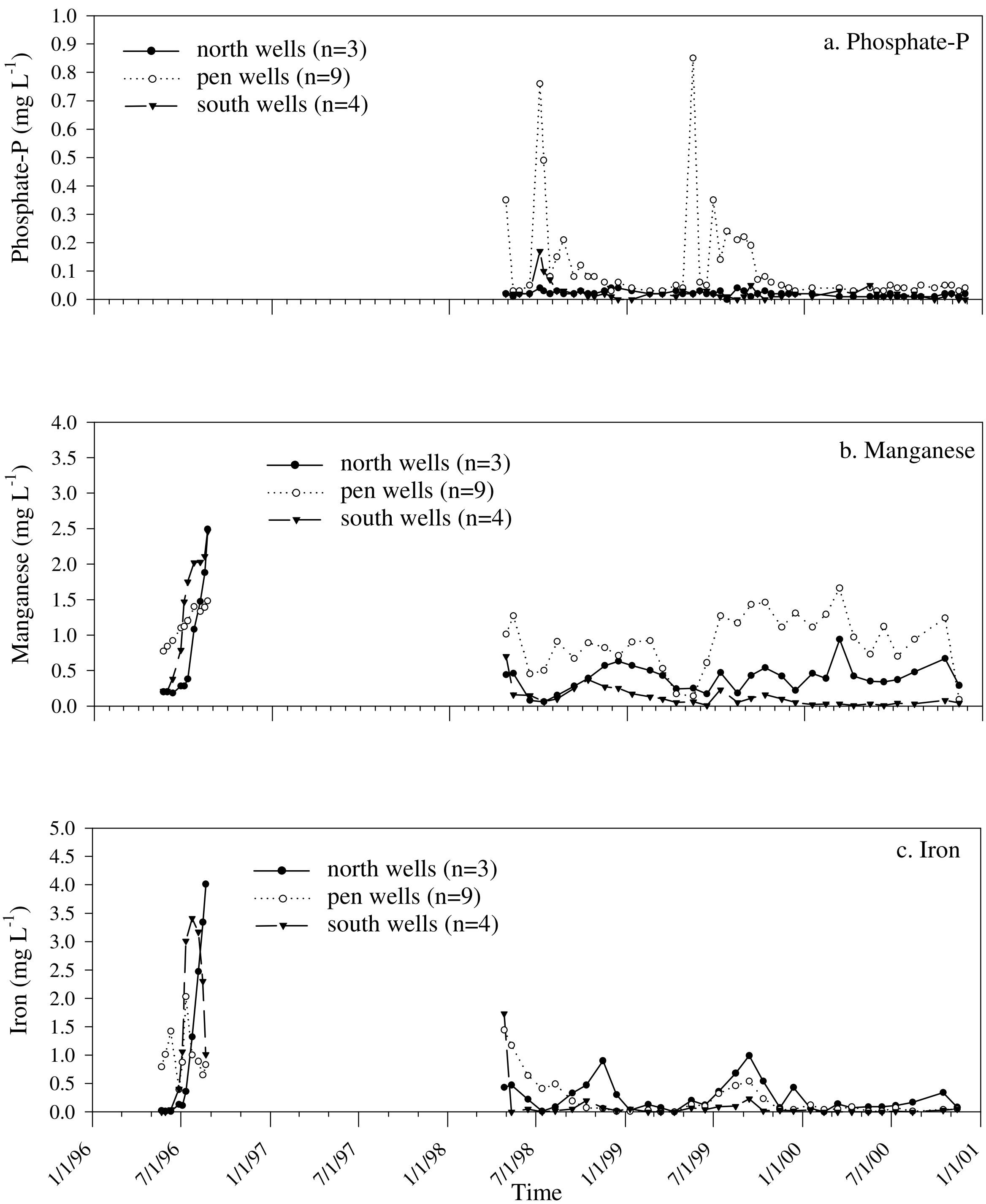

Fig. 16. Mean concentrations in groundwater of (a) phosphate-P, (b), manganese, and (c) iron for the north wells (n=3), pen wells (n=9), and south wells (n=4) from May, 1996 to November, 2000.

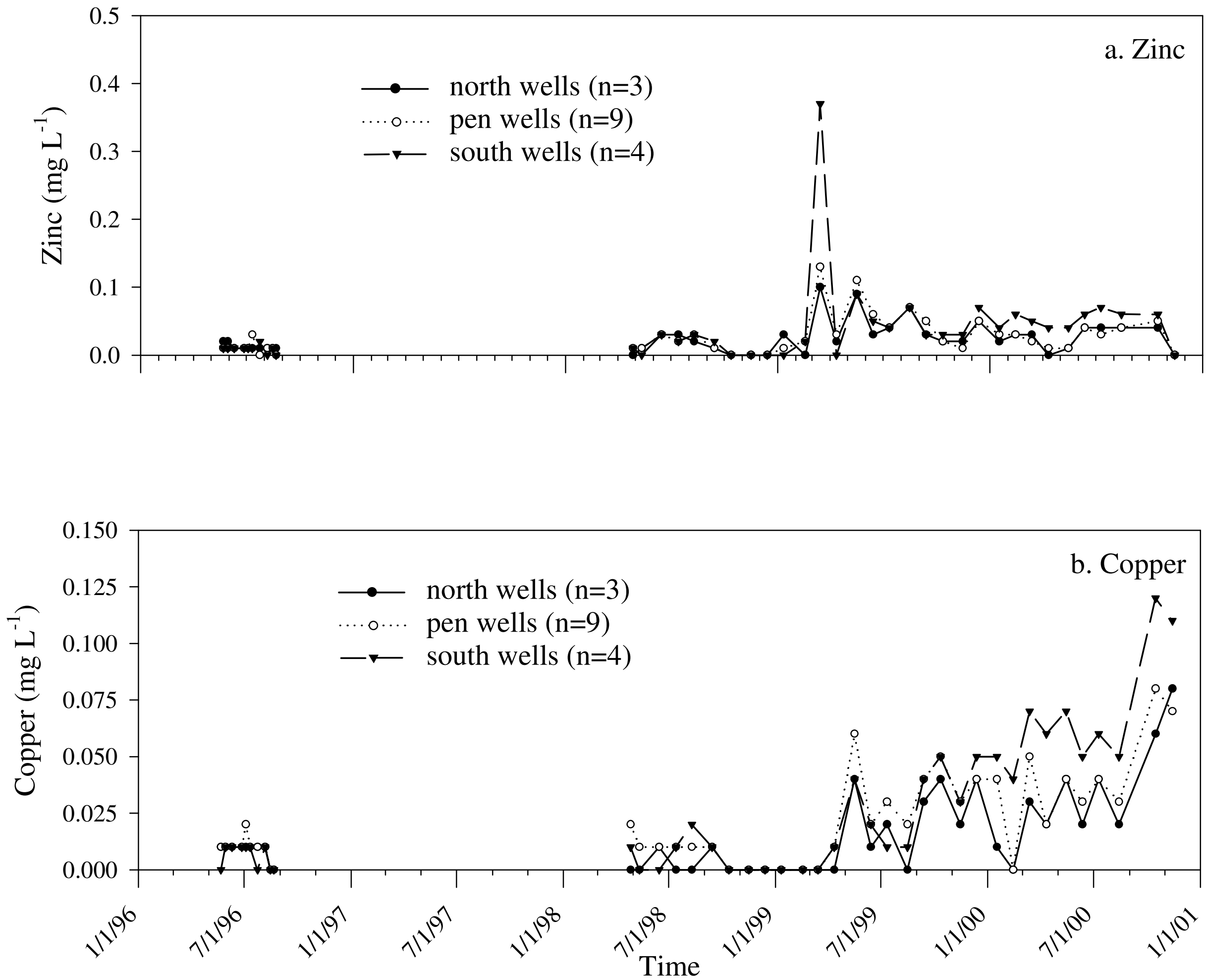

Fig. 17. Mean concentrations in groundwater of (a) zinc and (b) copper for the north wells (n=3), pen wells (n=9), and south wells (n=4) from May, 1996 to November, 2000.

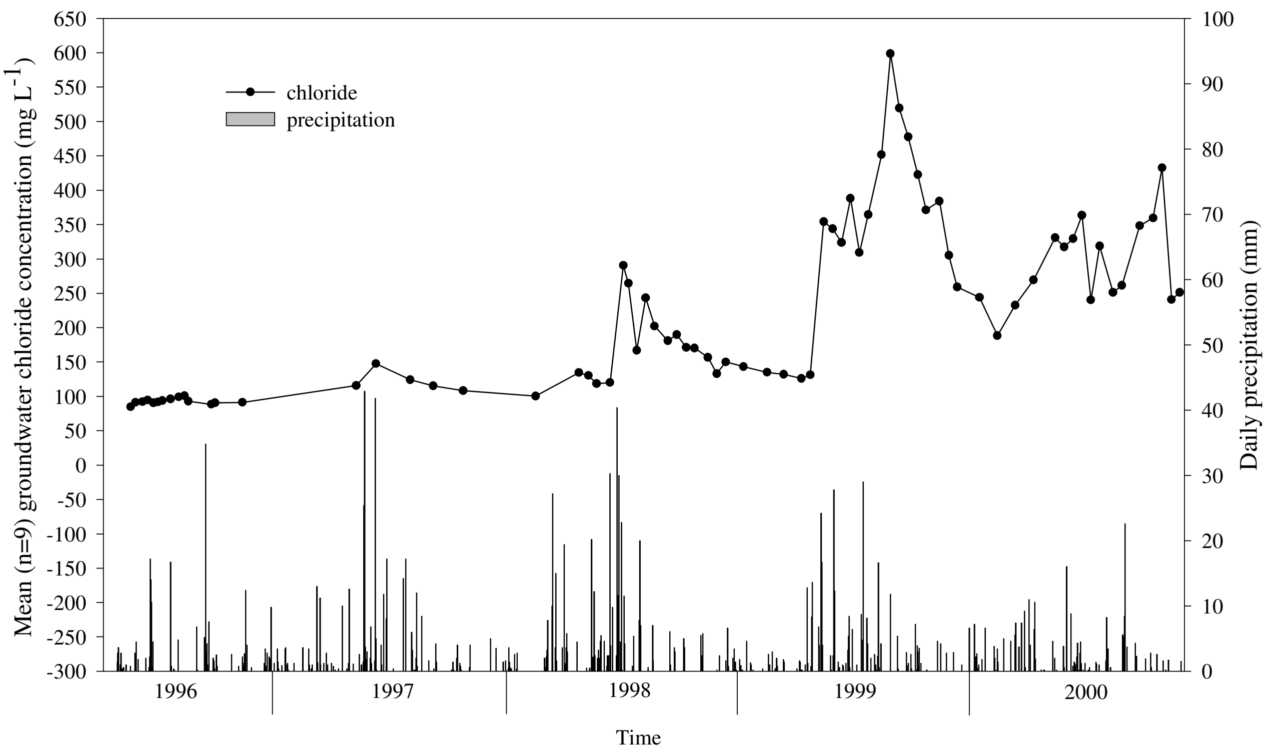

Fig. 18. Mean groundwater chloride concentration in the nine wells within the pen area and daily precipitation from May, 1996 to November, 2000.

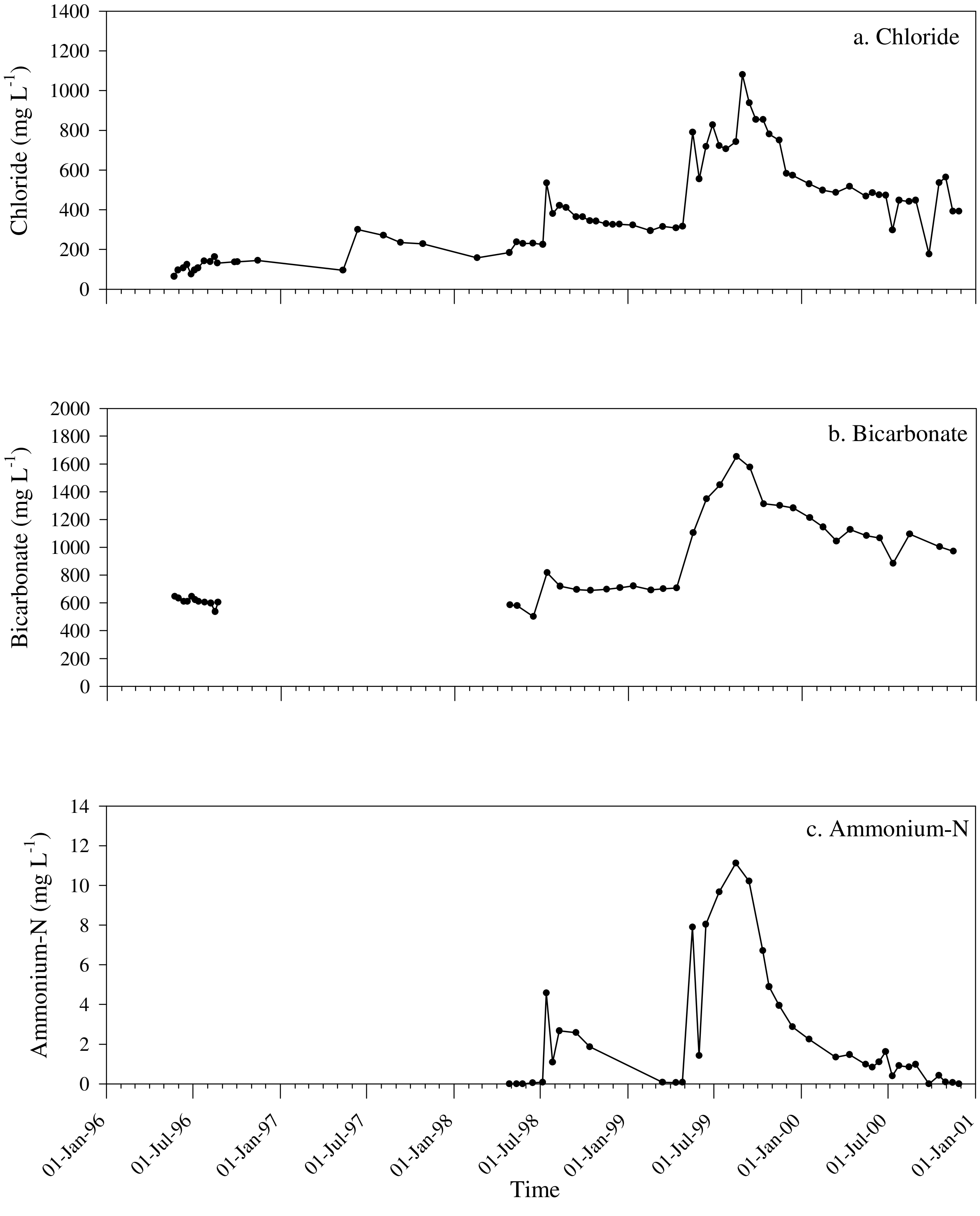

Fig. 19. Groundwater concentration of (a) chloride, (b) bicarbonate, and (c) ammonium-N in Well 5 from May, 1996 to November, 2000.

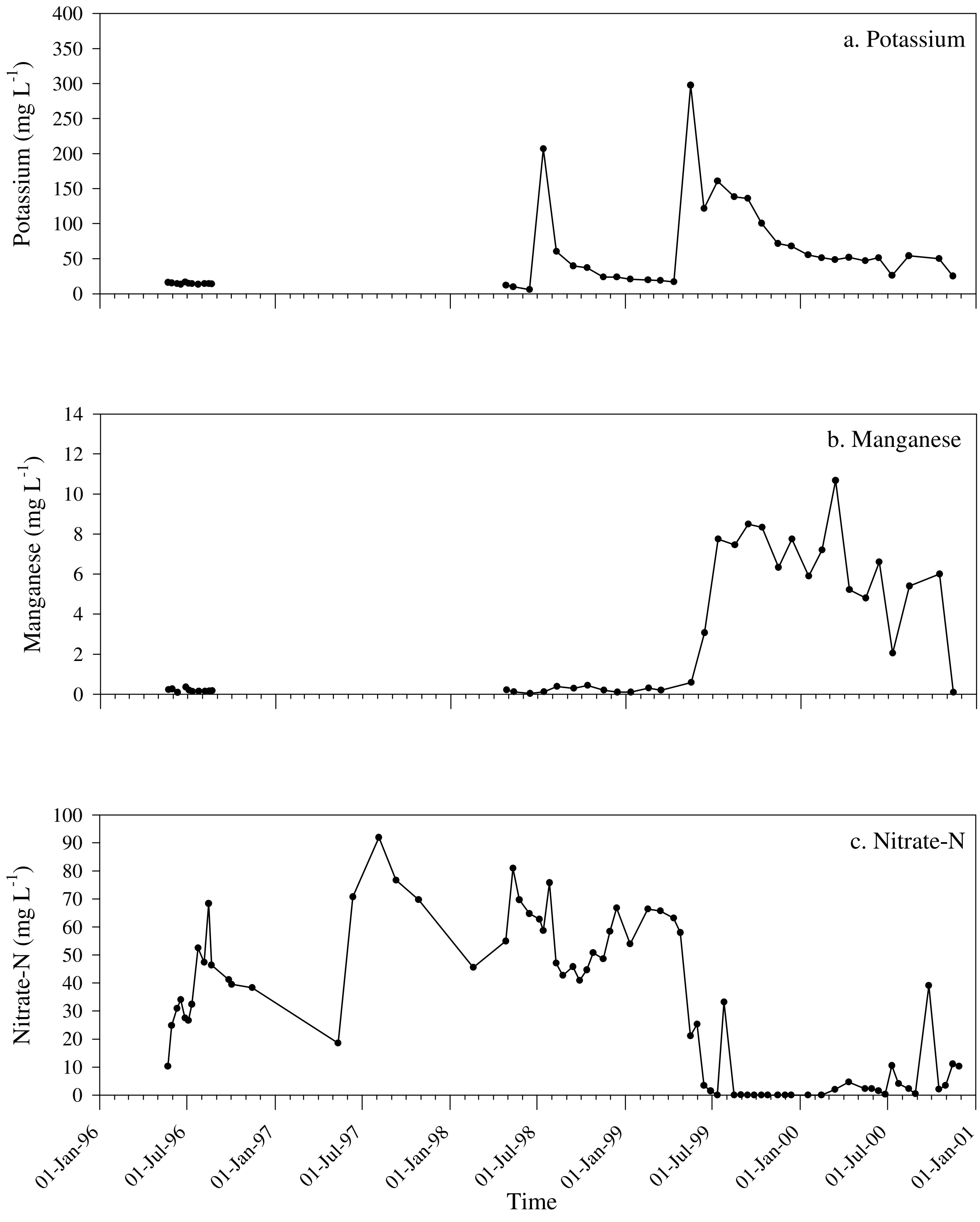

Fig. 20. Groundwater concentrations of (a) potassium, (b) manganese, and (c) nitrate-N in Well 5 from May, 1996 to November, 2000.

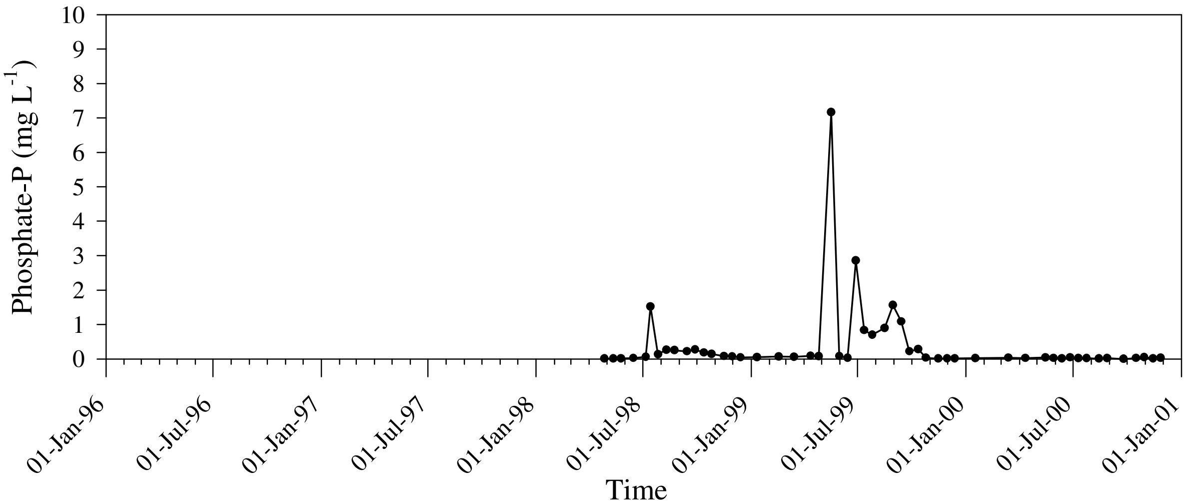

Fig. 21. Groundwater concentration of phosphate-P in Well 5 from May, 1996 to November, 2000.

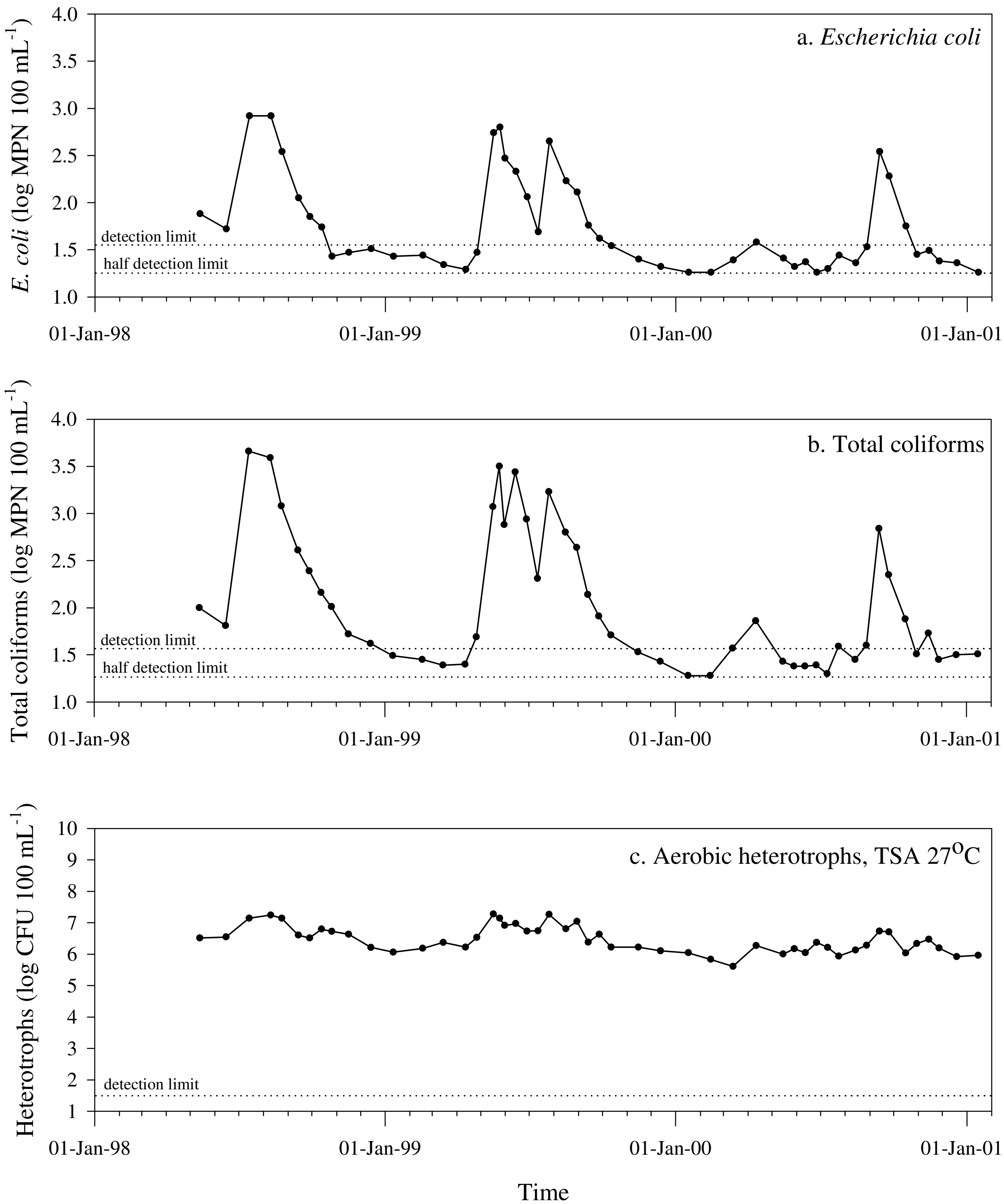

Fig. 22. Mean (n=16) values of (a) *Escherichia coli*, (b) total coliforms, and (c) aerobic heterotrophs content in groundwater.

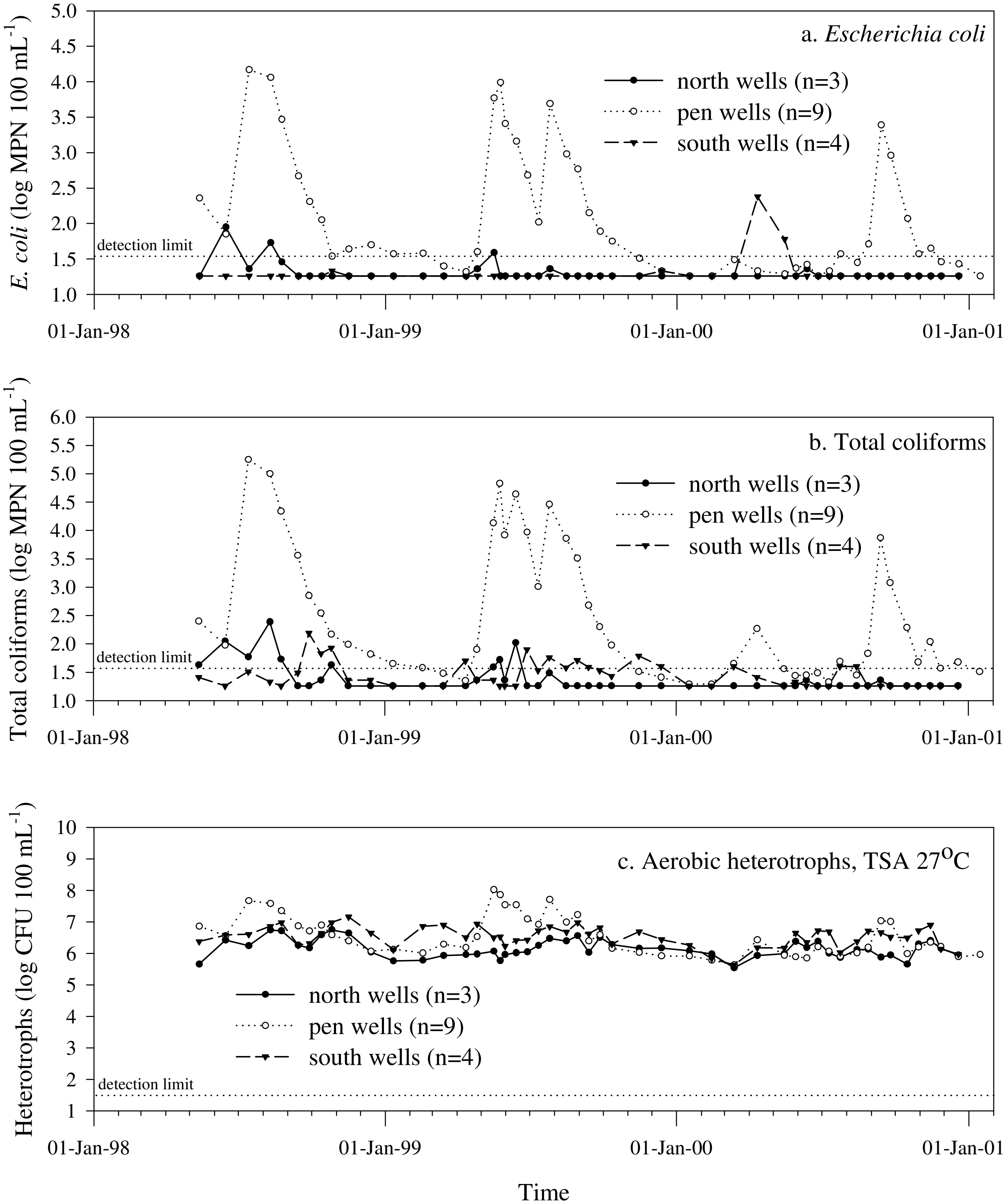

Fig. 23. Mean values in groundwater of (a) *Escherichia coli*, (b) total coliforms, and (c) aerobic heterotrophs within the three study-site locations: north wells, pen wells, and south wells.

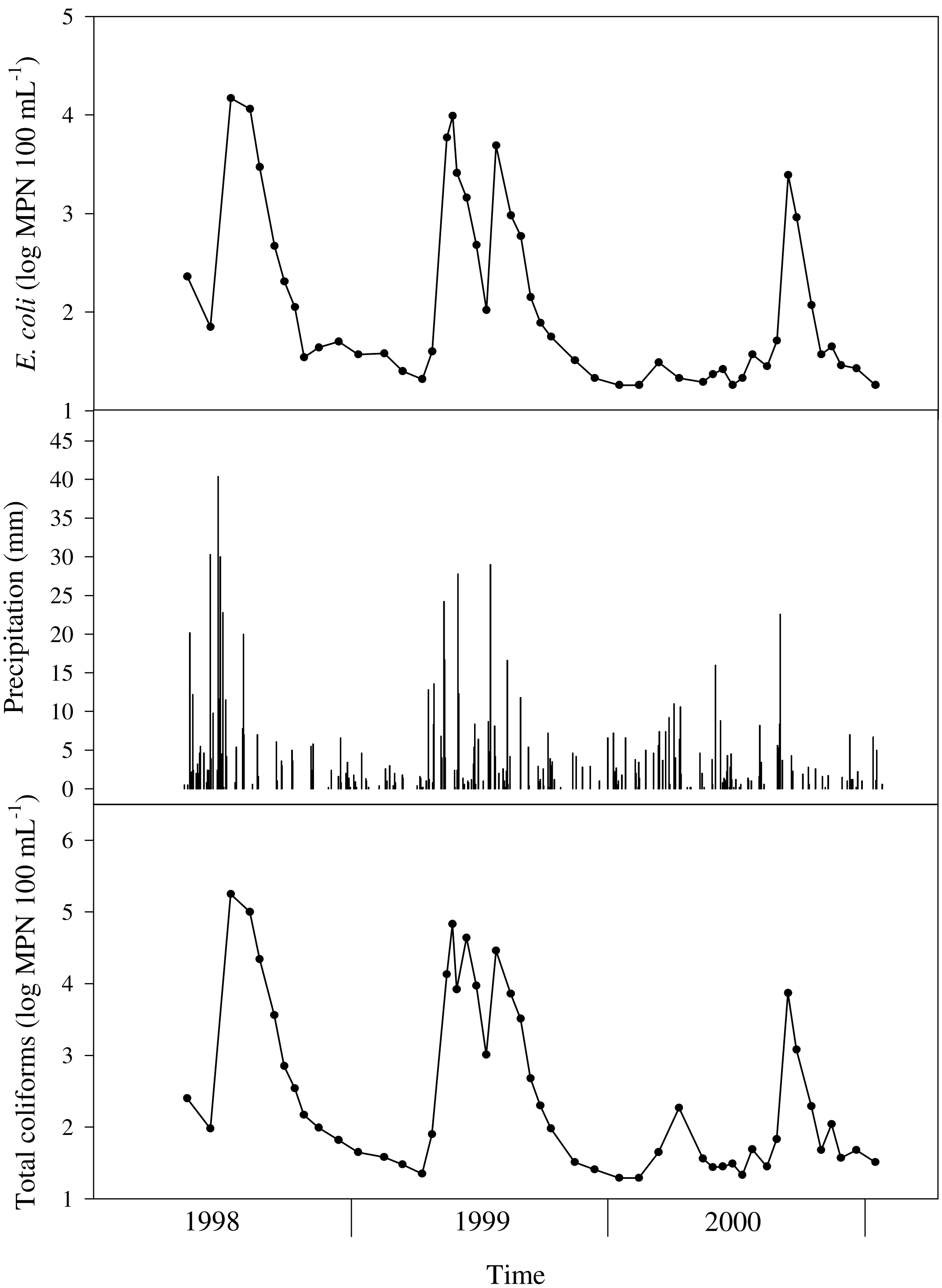

Fig. 24. Mean *Escherichia coli* and total coliforms content in the nine wells within the pen area and daily precipitation from May, 1998 to January, 2001.

CONCLUSIONS

The purpose of this study was to determine whether or not a newly constructed cattle feedlot would change soil and shallow groundwater quality under the feedlot. The data show that the soil beneath the feedlot pens did change, and the shallow groundwater was affected by the feedlot. The water table averaged 1.23 to 2.50 m below the soil surface. The surface topography of the water table changed under the feedlot. By late 1997, the water-table was at a higher elevation under the pen area than outside the pen area. This difference in water-table elevation between the pen area and outside the pen area persisted throughout the rest of the study. It is probable that increased recharge in the pen area resulted from cattle urination and the lack of transpiration through plants. The response of the water table under the pen area indicates that the compact organic layer was not effective in reducing the overall recharge rate below the pens. The top soil layer (0 to 15 cm) became more compacted from the action of cattle hoofs under wet conditions. Some soil properties were only affected in the top layer, such as an increase in extractable phosphate-P, extractable nitrate-N, extractable ammonium-N, and extractable potassium. These increases may simply be the result of mechanical mixing. Other soil properties increased significantly to greater depths (down to 60 cm), such as electrical conductivity, sulphate-S, extractable magnesium, extractable calcium, extractable sodium, and SAR. However, chloride content significantly increased through the entire soil profile (0 to 150 cm) providing evidence that leaching occurred under the feedlot pens. It is generally thought that the compact organic layer that forms under the manure pack will prevent the downward movement of water and other material. However, we observed a large section of the compact layer was removed during annual pen cleaning. The groundwater analysis also indicated that water had moved to the water table. The strongest evidence for the movement of contaminants to the groundwater was from increased chloride concentrations, *E. coli* counts, and total coliform counts in the wells within the pen area. Potassium, ammonium-N, and manganese concentrations were also affected by the pens. Data showed that drainage alleys, which did not have the compact organic layer, may promote leaching of contaminants through the soil profile.

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Appendix 1. Groundwater well installation details, wellhead elevation, and soil surface elevation at each well.

Table 1.1. Well-casing length, depth of sand pack, and height of wellhead.

Well no.	Well casing length (m)	Depth of sand pack from surface (m)	Length of well casing above surface (cm)	Well no.	Well casing length (m)	Depth of sand pack from surface (m)	Length of well casing above surface (cm)
1	6.19	0.9	25	9	6.35	na	25
2	6.19	1.5	na	10	5.30	1.2	25
3	6.18	1.5	25	11	6.07	1.0	10
4	6.18	1.1	24	12	6.08	1.2	25
5	6.06	na	25	13	6.07	0.9	26
6	6.35	1.25	25	14	6.21	0.6	25
7	6.10	1.1	25	15	6.18	1.2	25
8	6.05	na	25	16	6.18	1.0	22

Table 1.2. Wellhead and soil surface at the Research Feedlot measured on March 10, 1996.

Well number	Wellhead elevation (m)	Soil surface elevation[z] (m)
1	911.997	911.736
2	911.857	911.693
3	911.813	911.593
4	911.915	911.695
5	911.526	911.380
6	911.864	911.602
7	911.555 [y]	911.315
8	911.462 [x]	911.185
9	911.738	911.417
10	911.466 [w]	911.199
11	911.094 [v]	911.023
12	911.433	911.270
13	911.208 [u]	910.972
14	911.356	911.113
15	911.393	911.182
16	911.316	911.041

[z] Measured adjacent to the wellheads.
[y] On May 11, 1998, 19 cm was removed from the wellhead, lowering the elevation to 911.365 m. On June 11, 1999, 52 cm was added to the wellhead, increasing the elevation to 911.885 m.
[x] On May 11, 1998, 25 cm was removed from the wellhead, lowering the elevation to 911.212 m. On June 11, 1999, 24 cm was added to the wellhead, increasing the elevation to 911.452 m.
[w] On May 11, 1998, 26 cm was removed from the wellhead, lowering the elevation to 911.206 m. On June 11, 1999, 25 cm was added to the wellhead, increasing the elevation to 911.456 m.
[v] On May 11, 1998, 4 cm was removed from the wellhead, lowering the elevation to 911.054 m. On June 11, 1999, 41 cm was added to the wellhead, increasing the elevation to 911.464 m.
[u] On May 11, 1998, 22 cm was removed from the wellhead, lowering the elevation to 910.988 m. On June 11, 1999, 52 cm was added to the wellhead, increasing the elevation to 911.508 m.

Appendix 2. Soil log notes recorded during the installation of the groundwater wells.

Well #1

Depth (m)	Hand texture	Moisture	Parent material	Remarks
0.0-0.40	CL	m	lacustrine	top soil.
0.40-0.60	CL	m	lacustrine	showing some till features.
0.60-0.90	VFSC	vm	lacustrine	weak till features, few rock chips and pebbles.
0.90-2.30	CL	m-vm	till	thin sand lenses look saturated.
2.30-4.00	CL-SCL	m	till	fairly clean and uniform.
4.00-5.30	CL-SCL	m	till	similar to above but not as uniform, oxidation, more pebbles, more rock chips, coal, saturated sand lenses.
5.30-6.10	CL-SCL	m	till	till cleaner and more uniform.

Well #2

Depth (m)	Hand texture	Moisture	Parent material	Remarks
	CL	m	lacustrine	
0.20-0.45	CL-VFSC L	vm	lacustrine	fairly clean, few rock chips and pebbles, some weak till features.
0.0-0.2	CL-FSCL	vm-sat	till	weak to moderate till features, few more pebbles and rock chips, fairly uniform.
2.50-3.00	CL-FSCL	sat	till	till very moist, saturated sand lenses, more pebbles.
3.00-4.20	CL-FSCL	m-vm	till	some oxidation, coal chips, no sand lenses, more uniform again.
4.20-5.50	CL-FSCL	m	till	
5.50-6.10	CL	m	till	few signs of non weathered till in sample, more oxidation, coal chips and coal streaks, more pebbles.

Well #3

Depth (m)	Hand texture	Moisture	Parent material	Remarks
0.0-0.2	CL	m	lacustrine	weak till features, fairly clean, uniform, sand lenses.
0.2-0.75	CL		lacustrine	sand lenses, fairly clean, few rock chips, few pebbles.
0.75-1.5	CL-SCL	vm-sat	lacustrine	less sand, till features, rock chips, pebbles, some oxidation.
1.5-3.0	CL	m	till	
3.0-3.5	SCL	sat	till	slightly heavier than above.
3.5-3.8	SCL-SC	vm	till	coal, back to till features.
3.8-5.0	CL	m	till	uniform.
5.0-6.1	CL	m	till	

Well #4

Depth (m)	Hand texture	Moisture	Parent material	Remarks
0.0-0.2	CL	m	lacustrine	
0.2-1.5	CL	m	lacustrine	weak till features, fairly clean, few pebbles, few coal and rock chips.
1.5-4.0	CL-SCL	m-vm	till	sandier than above, more moisture.
4.0-4.9	CL	m	till	not as much sand, more dense.
4.9-6.1	CL	m	till	fine sand, not as dense.

Well #5

Depth (m)	Hand texture	Moisture	Parent material	Remarks
0-1.5	CL	m	till	salts, coal, oxidation, top soil stripped and replaced with fill.
1.5-3.0	CL-C	vm	till	
3.0-6.0	FSC-C	m-vm	till	

Well #6

Depth (m)	Hand texture	Moisture	Parent material	Remarks
0-0.60	CL	m	till	top of feedlot has been stripped and fill brought in.
0.60-0.90	SCL-CL	m	till	
0.90-1.6	CL	m	till	sand lenses.
1.6-2.4	CL-SCL	m-vm	till	uniform
2.4-3.0	CL		till	more dense, some layering, grey colour streaks, oxidation layers.
3.0-4.2	CL-SCL	m-vm	till	sand lenses, fine sand in sample.
4.2-4.6	FSCL	vm-sat	till	
4.6-5.3	CL	m-vm	till	
5.3-6.1	CL-C	m	till	very dense.

Well #7

Depth (m)	Hand texture	Moisture	Parent material	Remarks
0-0.75	FSCL	m	Fill	top soil removed and fill brought in, sand lenses, salts, few coal
0.75-2.15	CL-C	m	till	salts, oxidation, coal
2.15-2.3	VFSCL	vm-sat	till	
2.3-2.5	CL	m	till	fine sand in sample not as much as above or below
2.5-2.8	VFSCL	sat	till	clean sample
2.8-3.8	CL-C	m	till	coal
3.8-4.2	CL	m	till	lighter colour, not as dense, more sand in sample
4.2-6.1	CL	m	till	sand in sample similar tex to above

Well #8

Depth (m)	Hand texture	Moisture	Parent material	Remarks
0-0.60	C	m	Fill	top soil removed and fill brought in.
0.60-2.1	FSCL-CL	vm	till	fine sand in sample.
2.1-3.0	CL	m	till	
3.0-5.3	CL-SCL	vm	till	more uniform, more sand than above and below.
5.3-6.1	CL	m	till	

Well #9

Depth (m)	Hand texture	Moisture	Parent material	Remarks
0-0.25	CL-C	m	Fill	top soil removed and fill brought in.
0.25-0.75	SiCL-SiC	m	till	fairly clean.
0.75-1.2	FSCL	m	till	
1.2-3.6	CL-SCL	m	till	sand in sample, thin sand lenses.
3.6-4.1	FSCL	vm	till	
4.1-4.7	CL	m	till	
4.7-5.4	SCL	vm	till	
5.4-6.1	CL-SCL	m-vm	till	

Well #10

Depth (m)	Hand texture	Moisture	Parent material	Remarks
0-1.8	CL	m	till	top soil stripped and replaced with fill, salts.
1.8-2.1	CL-FSCL	m-vm	till	sandier area, not saturated, oxidation.
2.1-3.0	CL	m	till	oxidation
3.0-3.8	CL-FSCL	m-vm	till	not as dense as above and below, little more sand.
3.8-4.5	CL	m	till	oxidation
4.5-5.5	CL-FSCL	vm	till	sandier, lighter soil.
5.5-6.1	CL	m	till	oxidation.

Well #11

Depth (m)	Hand texture	Moisture	Parent material	Remarks
0.0-0.20	CL-C	m	Fill	
0.20-3.0	CL	m-vm	till	
3.0-3.3	FSCL	vm-sat	till	
3.3-3.9	CL-SCL	m-vm	till	sand lenses.
3.9-6.1	CL-SCL	m	till	little more uniform, oxidation, some coal, thin sand lenses, sand in sample also.

Well #12

Depth (m)	Hand texture	Moisture	Parent material	Remarks
0.0-0.3	CL-C	m	Fill	
0.3-0.6	CL-C	m	till	
0.6-1.2	CL	m	till	
1.2-1.5	CL-SCL	m	till	coal, oxidation, saturated sand lenses.
1.5-3.1	SCL	m-vm	till	more uniform.
3.1-6.1	CL-SCL	m	till	fairly uniform, coal.

Well #13

Depth (m)	Hand texture	Moisture	Parent material	Remarks
0.0-0.3	SiCL-SiC	m	till	
0.3-0.4	CL-SiCL	m	till	mixture of fill and till.
0.4-3.3	CL	m	till	oxidation, sand lenses.
3.3-3.7	CL-SCL	m	till	oxidation, more sand lenses.
3.7-4.4	SCL	vm-sat	till	
4.4-4.8	CL-SCL	m	till	oxidation, also some darker grey colours.
4.8-6.1	SCL	sat	till	

Well #14

Depth (m)	Hand texture	Moisture	Parent material	Remarks
0.0-1.2	SiCL	m	lacustrine	
1.2-4.5	CL	m-vm	till	fairly clean, fairly uniform, fairly sandy.
4.5-5.3	CL-SCL	vm-sat	till	
5.3-6.2	CL	m-vm	till	similar to CL above.

Well #15

Depth (m)	Hand texture	Moisture	Parent material	Remarks
0.0-0.2	CL	m	lacustrine	
0.2-0.6	C-FSC	m	lacustrine	weak till features, few rock chips and pebbles.
0.6-1.5	CL-SCL	m	till	sand lenses, very moist to saturated.
1.5-1.8	SCL	sat	till	
1.8-3.0	CL-SCL	m	till	back to fairly uniform till.
3.0-4.8	CL-C	m	till	thin sand lenses, some oxidation, not as uniform.
4.8-5.2	CL-SCL	m	till	
5.2-5.5	SCL	sat	till	
5.5-6.1	CL-C	m	till	sand lenses, heavy oxidation, lots of pebbles and rock chips.

Well #16

Depth (m)	Hand texture	Moisture	Parent material	Remarks
0.0-0.2	CL	m	lacustrine	
0.2-0.4	C-SiC	m	lacustrine	few small pebbles, few rock chips, weak till like features.
0.4-1.2	CL-FSCL	m	till	rock chips, pebbles, coal chips.
1.2-1.5	CL-FSCL	m-sat	till	saturated sand lenses, oxidation, coal, rock chips and pebbles.
1.5-3.4	CL-FSCL	vm	till	fairly uniform.
3.4-3.8	CL-FSCL	vm-sat	till	more saturated sand lenses, oxidation.
3.8-4.5	SCL	sat	till	
4.5-4.9	SCL-SC	vm-sat	till	heavier than above.
4.9-5.2	CL-SCL	m	till	
5.2-6.1	CL-C	m	till	

Soil colour and effervescence were checked at one well site (Well #7):

Depth (m)	Colour	Effervescence
0-0.75	2.5Y 5/4	3 - 4
0.75-2.15	2.5Y 4/2	3
2.15-2.3	2.5Y 4/4	1
2.3-2.5	2.5Y 4/4	1 - 2
2.5-2.8	2.5Y 4/4	1
2.8-3.8	2.5Y 4/2	0
3.8-4.2	2.5Y 4/4	0
4.2-6.1	2.5Y 4/2	1

Key to abbrevations

Soil texture:

C - clay
L - loam
Si - silt
S - sand
Gr - gravel
CL - clay loam
SiL - silty loam
SL - sandy loam
CS - coarse sand
HC - heavy clay
SCL - sandy clay loam
SC - sandy clay
SiC - silty clay
SiCL - silty clay loam
VF - very fine
F - fine
M - medium
C - coarse
H - heavy

Moisture:

D - dry
SM - slightly moist
M - moist
VM - very moist
SAT - saturated

Appendix 3. Chronological record of the analyses carried out on groundwater samples. Shaded cells indicate the analysis was preformed for the designated sample dates.

Date	pH	EC	NO_3-N Cl	PO_4-P	NH_4-N	SO_4-S CO_3 HCO_3	Na K Mg Ca	Mn Fe Cu Zn	Micro- biology
May 22/96	■	■	■			■	■	■	
May 30/96	■	■	■			■	■	■	
Jun 10/96	■	■	■			■	■	■	
Jun 18/96	■	■	■			■	■		
Jun 27/96	■	■	■			■	■	■	
Jul 4/96	■	■	■			■	■	■	
Jul 11/96	■	■	■			■	■	■	
[z] Jul 24/96	■	■	■			■	■	■	■
Aug 6/96	■	■	■			■	■	■	
Aug 15/96	■	■	■			■	■	■	
Aug 21/96	■	■	■			■	■	■	■
Sep 26/96			■						
Oct 2/96		■	■						
Nov 14/96			■						
May 12/97	■	■	■						
June 12/97			■						
Aug 5/97			■						
Sep 10/97			■						
Oct 27/97			■						
Feb 18/98	■	■	■						
Apr 27/98	■	■	■	■	■	■	■		
May 12/98	■	■	■	■	■	■	■		■
May 25/98		■	■	■	■				
Jun 15/98	■	■	■	■	■	■	■		■
Jul 6/98		■	■	■	■				
Jul 14/98	■	■	■	■	■	■	■		■

[z] The samples for the biological samples were taken on July 23, 1996.

Date	pH	EC	NO_3-N Cl	PO_4-P	NH_4-N	SO_4-S CO_3 HCO_3	Na K Mg Ca	Mn Fe Cu Zn	Micro- biology
Jul 27/98		■	■	■	■				
Aug 10/98	■	■	■	■	■	■	■	■	■
Aug 24/98		■	■	■				■	■
Sep 14/98	■	■	■	■	■	■	■	■	
Sep 28/98		■	■	■				■	■
Oct 13/98	■	■	■	■	■	■	■	■	■
Oct 26/98		■	■	■				■	■
Nov 16/98	■	■	■	■		■	■	■	■
Nov 30/98		■	■	■				■	
Dec 14/98	■	■	■	■		■	■	■	■
Jan 11/99	■	■	■	■		■	■	■	■
Feb 17/99	■	■	■	■		■	■	■	■
Mar 15/99	■	■	■	■	■	■	■	■	■
Apr 12/99	■	■	■	■	■	■	■	■	■
Apr 26/99	■	■	■	■	■				■
May 17/99	■	■	■	■	■	■	■	■	■
May 25/99									■
May 31/99	■	■	■	■	■				■
Jun 14/99	■	■	■	■	■	■	■	■	■
Jun 28/99	■	■	■	■					■
Jul 12/99	■	■	■	■	■	■	■	■	■
Jul 26/99	■	■	■	■					■
Aug 16/99	■	■	■	■	■	■	■	■	■
Aug 30/99	■	■	■	■					■
Sep 13/00	■	■	■	■	■	■	■	■	■
Sep 27/99	■	■	■	■					■

Date	pH	EC	NO_3-N Cl	PO_4-P	NH_4-N	SO_4-S CO_3 HCO_3	Na K Mg Ca	Mn Fe Cu Zn	Micro- biology
Oct 12/99									
Oct 25/99									
Nov 15/99									
Nov 30/99									
Dec 13/99									
Jan 17/00									
Feb 14/00									
Mar 13/00									
Apr 11/00									
May 15/00									
May 29/00									
Jun 12/00									
Jun 26/00									
Jul 10/00									
Jul 24/00									
Aug 14/00									
Aug 28/00									
Sep 13/00									
Sep 25/00									
Oct 16/00									
Oct 30/00									
Nov 14/00									
Nov 27/00									
Dec 19/00									
Jan 15/01									

Appendix 4. Mean monthly temperature, monthly precipitation, and monthly evaporation in 1996 to 2000 at the Agriculture and Agri-Food Canada Lethbridge Research Centre. The climatic data collection station is located on the border between the NW and NE quarter sections of section 34, township 8, range 21, W of the fourth (49^o 42' N, 122^o 47' W, 899 m elevation).

	Mean temperature (°C)				Precipitation (mm)				Evaporation (mm) [z]			
	1996	1997	1998	Ave [y]	1996	1997	1998	Ave [y]	1996	1997	1998	Ave [x]
January	-14.5	-10.2	-10.3	-8.6	32.3	16.7	14.0	18.6	na [w]	na	na	na
February	-3.7	0.0	0.3	-6.1	6.0	9.2	0.0	16.8	na	na	na	na
March	-3.9	-0.7	-2.2	-1.6	44.7	33.1	73.6	24.2	na	na	na	na
April	7.4	3.9	8.0	5.6	21.0	14.2	41.9	31.2	202.9	200.2	0.0	121.1
May	8.8	11.3	13.7	10.8	21.7	95.7	53.4	54.1	187.7	232.4	213.2	188.8
June	15.7	16.0	14.4	14.9	53.5	100.6	148.4	73.7	320.9	244.7	190.5	237.1
July	18.5	18.2	20.3	18.0	18.1	31.8	57.4	42.3	331.4	288.4	319.6	227.4
August	19.6	18.6	20.2	17.1	4.8	32.8	36.2	41.4	189.1	250.0	309.5	198.0
September	11.1	15.9	16.0	12.1	70.0	7.6	13.7	39.6	152.2	241.5	225.4	150.1
October	6.3	7.7	9.0	7.0	6.3	10.0	8.6	21.8	200.0	207.0	157.4	91.5
November	-7.1	0.0	0.6	-0.7	26.5	4.6	14.9	18.3	na	na	na	na
December	-10.8	-0.6	-6.0	-5.8	24.4	9.9	19.6	18.2	na	na	na	na
Year	4.0	6.7	7.0	5.2	329.3	366.2	481.7	400.2	1584	1664	1416	1214

[z] Class A pan evaporation.
[y] Long-term average (1902 to 2000). Data from 1902 to 1908 came from the City of Lethbridge, Alberta.
[x] Long-term average (1909 to 2000).
[w] Not available.

	Mean temperature (°C)			Precipitation (mm)			Evaporation (mm) [z]		
	1999	2000	Ave [y]	1999	2000	Ave [y]	1999	2000	Ave [x]
January	-5.1	-7.7	-8.6	10.2	28.6	18.6	na	na	na
February	1.8	-4.0	-6.1	7.0	15.8	16.8	na	na	na
March	2.1	2.5	-1.6	6.4	38.5	24.2	na	na	na
April	6.1	6.6	5.6	41.5	34.5	31.2	181.3	116.5	121.1
May	10.3	12.2	10.8	58.3	11.2	54.1	249.4	300.7	188.8
June	14.6	15.4	14.9	65.1	44.6	73.7	264.4	262.0	237.1
July	16.4	19.8	18.0	64.2	5.5	42.3	305.7	357.7	227.4
August	18.8	18.7	17.1	39.3	27.3	41.4	264.6	313.0	198.0
September	12.9	13.1	12.1	10.8	41.9	39.6	217.5	141.7	150.1
October	8.4	7.6	7.0	23.0	7.9	21.8	192.0	163.2	91.5
November	4.5	-1.5	-0.7	11.6	5.0	18.3	na	na	na
December	2.2	-8.7	-5.8	3.9	14.7	18.2	na	na	na
Year	7.8	6.2	5.2	341.3	275.5	400.2	1674.9	1654.8	1214

[z] Class A pan evaporation.
[y] Long-term average (1902 to 2000). Data from 1902 to 1908 came from the City of Lethbridge, Alberta.
[x] Long-term average (1909 to 2000).
[w] Not available.

Appendix 5. Soil bulk density data.

Table 4.1. Soil bulk density values for the 1996 baseline soil samples.

Core number	Soil incremental depth					
	0-15 cm ($g\ cm^{-3}$)	15-30 cm ($g\ cm^{-3}$)	30-60 cm ($g\ cm^{-3}$)	60-90 cm ($g\ cm^{-3}$)	90-120 cm ($g\ cm^{-3}$)	120-150 cm($g\ cm^{-3}$)
1	1.75	1.62	1.65	1.59	1.48	1.90
2	1.72	1.44	1.79	1.66	1.71	1.80
3	1.77	1.69	1.65	1.74	1.67	1.81
4	1.68	1.78	1.83	1.85	1.73	1.76
5	1.82	1.74	1.69	1.76	1.75	1.85
6	1.68	1.74	1.66	1.70	2.06	1.93
7	1.82	1.56	1.70	1.73	1.83	1.85
8	1.69	1.99	1.86	2.08	1.90	2.13
9	1.83	1.74	1.79	1.81	1.80	1.80
Average	1.75	1.70	1.73	1.77	1.77	1.87
s.d.	0.06	0.15	0.08	0.14	0.16	0.11

Table 4.2. Soil bulk density values for the 1999 soil samples.

Pen number	Soil incremental depth					
	0-15 cm ($g\ cm^{-3}$)	15-30 cm ($g\ cm^{-3}$)	30-60 cm ($g\ cm^{-3}$)	60-90 cm ($g\ cm^{-3}$)	90-120 cm ($g\ cm^{-3}$)	120-150 cm($g\ cm^{-3}$)
3	2.18	2.09	2.08	1.97	1.93	1.71
7	2.37	1.85	1.72	1.75	1.72	1.68
10	2.31	1.67	1.64	1.59	1.58	1.34
14	2.20	1.83	1.77	1.79	1.50	1.50
19	1.88	1.76	1.67	1.49	1.52	1.37
23	2.03	2.02	2.04	2.03	1.90	1.93
26	1.95	1.18	1.36	1.54	1.54	1.35
30	1.72	1.41	1.57	1.42	1.38	1.24
Average	2.08	1.73	1.73	1.70	1.63	1.52
s.d.	0.22	0.30	0.24	0.22	0.20	0.24

Appendix 6. Chemical analysis and particle size analysis of the 1996 (baseline) soil samples and chemical analysis of the 1999 soil samples.

Table 6.1. Baseline (1996) soil nitrogen, phosphorus, carbon, and electrical conductivity values (1 of 4 pages).

Pen	Depth (cm)	Total N [z] (%)	NO_3-N [y] (kg ha^{-1})	NH_4-N [y] (kg ha^{-1})	Total P [x] (Mg ha^{-1})	PO_4-P [w] (kg ha^{-1})	Total C [z] (Mg ha^{-1})	Inorganic C [v] (Mg ha^{-1})	Organic C [u] (Mg ha^{-1})	EC [t] (dS m^{-1})
1	0	2.1	7.7	12.1	3.4	4.2	43.3	23.1	20.2	2.7
	15-30	2.3	5.2	20.4	3.8	2.5	42.0	21.4	20.5	1.0
	30-60	2.5	4.4	25.8	7.7	4.2	78.5	51.5	27.0	1.5
	60-90	2.1	3.5	24.6	8.2	4.2	67.0	41.9	25.1	4.0
	90-120	1.9	9.3	27.3	8.0	5.3	63.8	3.2	60.6	4.1
	120-150	1.8	42.5	28.7	8.4	6.7	52.1	30.8	21.3	4.2
3	0	2.6	20.2	13.8	3.8	8.1	41.1	27.8	13.3	3.2
	15-30	2.2	5.0	8.0	4.2	4.3	49.2	28.8	20.3	1.6
	30-60	3.5	6.4	16.9	7.8	9.4	115.1	79.1	36.0	2.2
	60-90	2.3	15.2	18.9	8.5	12.7	91.2	72.2	19.1	3.6
	90-120	1.8	16.8	18.2	8.2	5.8	68.0	43.6	24.4	4.3
	120-150	1.9	65.3	23.8	9.0	6.2	63.3	40.4	22.9	4.2
5	0	3.9	16.8	12.5	4.5	22.3	56.5	17.3	39.2	2.4
	15-30	3.2	8.3	12.2	4.4	9.2	52.2	21.9	30.3	2.9
	30-60	3.4	5.3	25.0	7.9	7.8	83.5	55.2	28.3	1.3
	60-90	2.8	8.1	24.9	7.8	5.8	79.9	49.9	30.0	2.1
	90-120	2.3	12.4	29.4	8.5	7.4	63.4	38.8	24.7	3.7
	120-150	2.1	22.7	29.9	9.1	22.4	53.1	32.0	21.1	3.8
7	0	2.7	12.8	16.4	4.2	8.1	44.3	17.6	26.7	3.5
	15-30	3.7	46.8	8.0	4.4	30.6	46.3	12.2	34.0	1.2
	30-60	6.4	61.2	16.4	9.7	26.5	124.5	65.6	58.9	1.0
	60-90	2.6	35.5	19.2	8.8	8.5	101.0	75.4	25.6	1.7
	90-120	2.0	60.5	23.2	7.5	4.8	70.7	48.3	22.4	1.9
	120-150	2.0	59.7	23.7	8.7	3.9	80.9	59.4	21.5	2.2

[z] Dry combustion/chromotography method.
[y] Potassium chloride extraction/colorimetric method.
[x] Hot acid digestion/colorimetric method.
[w] Modified Kelowna extraction/colorimetric method.
[v] Cold acid digestion/gas chromotography method
[u] Organic C = total C less inorganic C.
[t] EC = electrical conductivity (saturated paste extraction method).

Table 6.1. Baseline (1996) soil nitrogen, phosphorus, carbon, and electrical conductivity values (2 of 4 pages).

Pen	Depth (cm)	Total N [z] (%)	NO_3-N [y] (kg ha^{-1})	NH_4-N [y] (kg ha^{-1})	Total P [x] (Mg ha^{-1})	PO_4-P [w] (kg ha^{-1})	Total C [z] (Mg ha^{-1})	Inorganic C [v] (Mg ha^{-1})	Organic C [u] (Mg ha^{-1})	EC [t] (dS m^{-1})
10	0	2.8	19.7	14.6	4.0	9.5	42.4	15.5	26.9	3.2
	15-30	2.8	26.0	11.4	4.4	4.3	63.7	35.7	28.0	1.6
	30-60	3.9	23.5	16.8	8.2	5.7	97.5	58.3	39.2	1.8
	60-90	2.4	65.1	23.9	7.9	6.4	73.9	41.9	32.0	2.8
	90-120	1.9	62.0	27.8	8.4	5.8	52.9	35.6	17.3	3.4
	120-150	1.9	22.8	29.4	8.6	8.4	44.3	24.1	20.2	3.4
12	0	3.3	22.1	10.7	4.2	10.0	46.9	17.3	29.6	3.0
	15-30	3.2	17.7	11.5	4.2	12.0	47.4	16.1	31.3	1.8
	30-60	2.5	3.9	23.9	7.8	4.2	66.5	38.0	28.5	2.1
	60-90	2.0	3.4	14.5	8.1	4.2	49.1	27.6	21.5	3.8
	90-120	2.0	6.3	30.4	8.4	5.8	48.7	25.0	23.7	4.2
	120-150	1.7	19.7	18.1	9.1	7.8	50.6	32.0	18.6	4.6
14	0	3.1	15.3	11.9	4.1	11.3	42.4	14.4	27.9	3.2
	15-30	2.8	7.2	8.7	4.5	4.1	54.1	28.6	25.6	2.5
	30-60	2.9	4.3	22.1	9.2	8.8	95.2	61.4	33.8	3.8
	60-90	2.5	7.9	25.5	8.4	17.5	91.1	60.5	30.6	4.0
	90-120	1.8	14.5	27.5	9.5	11.2	60.4	39.8	20.6	3.9
	120-150	2.1	20.2	31.3	8.6	8.4	60.6	36.4	24.2	4.1
16	0	2.2	6.0	15.7	3.7	4.2	46.1	24.2	21.9	3.0
	15-30	1.2	3.2	11.5	3.7	4.1	39.8	27.3	12.5	1.5
	30-60	2.1	0.0	25.9	7.7	7.3	60.5	32.8	27.7	1.1
	60-90	2.0	0.0	29.7	7.6	6.4	56.5	30.8	25.8	3.5
	90-120	1.7	0.0	25.0	7.7	8.0	54.2	33.5	20.7	3.3
	120-150	1.7	0.0	33.5	9.2	8.4	56.7	40.4	16.3	3.3

[z] Dry combustion/chromotography method.
[y] Potassium chloride extraction/colorimetric method.
[x] Hot acid digestion/colorimetric method.
[w] Modified Kelowna extraction/colorimetric method.
[v] Cold acid digestion/gas chromotography method
[u] Organic C = total C less inorganic C.
[t] EC = electrical conductivity (saturated paste extraction method).

Table 6.1. Baseline (1996) soil nitrogen, phosphorus, carbon, and electrical conductivity values (3 of 4 pages).

Pen	Depth (cm)	Total N [z] (%)	NO_3-N [y] (kg ha^{-1})	NH_4-N [y] (kg ha^{-1})	Total P [x] (Mg ha^{-1})	PO_4-P [w] (kg ha^{-1})	Total C [z] (Mg ha^{-1})	Inorganic C [v] (Mg ha^{-1})	Organic C [u] (Mg ha^{-1})	EC [t] (dS m^{-1})
17	0	2.9	10.8	11.3	4.3	5.3	59.4	29.4	30.0	2.8
	15-30	2.2	4.9	8.5	3.9	4.1	61.9	42.8	19.1	0.7
	30-60	2.7	0.0	22.4	8.9	10.9	88.4	59.9	28.5	1.1
	60-90	2.3	0.0	23.4	7.8	9.0	63.4	37.7	25.8	3.6
	90-120	1.8	0.0	28.3	7.2	9.0	46.1	26.6	19.6	3.6
	120-150	1.7	6.1	28.0	8.0	8.4	43.7	26.4	17.4	3.3
19	0	3.3	14.4	10.7	4.1	7.1	51.9	19.4	32.5	1.4
	15-30	1.8	3.0	7.2	3.8	3.8	51.3	33.7	17.6	1.8
	30-60	2.5	5.0	16.3	7.4	6.2	84.8	57.3	27.5	2.8
	60-90	2.0	14.0	23.0	7.1	7.4	68.3	45.6	22.7	4.4
	90-120	2.0	16.5	24.9	7.4	6.9	54.9	31.3	23.6	4.6
	120-150	1.9	19.4	26.0	7.8	7.8	52.4	30.3	22.1	4.6
21	0	3.5	27.0	10.2	4.3	15.5	47.9	16.3	31.6	3.5
	15-30	3.0	13.5	13.8	3.8	11.0	51.2	22.2	29.0	2.3
	30-60	2.8	0.0	20.5	8.4	9.4	85.3	55.2	30.1	2.8
	60-90	2.2	0.0	24.0	8.6	26.5	60.3	38.2	22.1	5.4
	90-120	1.8	27.9	24.8	8.7	27.1	44.8	29.2	15.5	6.5
	120-150	1.8	42.1	21.9	7.7	12.3	42.7	28.6	14.2	7.7
23	0	3.9	24.7	10.0	4.8	19.7	51.5	15.2	36.3	2.0
	15-30	2.6	137.2	8.8	4.4	10.2	54.9	30.9	24.1	3.6
	30-60	3.6	332.1	16.9	8.4	9.9	83.7	50.5	33.2	4.1
	60-90	2.4	259.0	21.2	8.0	8.0	79.1	58.4	20.7	3.9
	90-120	2.1	215.2	23.0	7.8	8.5	57.0	36.7	20.3	3.7
	120-150	2.1	131.8	22.7	8.1	9.0	55.0	30.8	24.2	5.5

[z] Dry combustion/chromotography method.
[y] Potassium chloride extraction/colorimetric method.
[x] Hot acid digestion/colorimetric method.
[w] Modified Kelowna extraction/colorimetric method.
[v] Cold acid digestion/gas chromotography method
[u] Organic C = total C less inorganic C.
[t] EC = electrical conductivity (saturated paste extraction method).

Table 6.1. Baseline (1996) soil nitrogen, phosphorus, carbon, and electrical conductivity values (4 of 4 pages).

Pen	Depth (cm)	Total N [z] (%)	NO_3-N [y] (kg ha^{-1})	NH_4-N [y] (kg ha^{-1})	Total P [x] (Mg ha^{-1})	PO_4-P [w] (kg ha^{-1})	Total C [z] (Mg ha^{-1})	Inorganic C [v] (Mg ha^{-1})	Organic C [u] (Mg ha^{-1})	EC [t] (dS m^{-1})
26	0	4.7	31.9	7.3	4.6	38.1	58.3	14.4	43.9	2.0
	15-30	3.5	24.8	7.7	3.9	16.3	56.3	15.3	41.0	1.8
	30-60	2.6	60.7	20.0	7.1	8.8	112.6	51.5	61.0	2.3
	60-90	2.1	99.5	24.0	7.4	5.8	63.2	39.3	24.0	2.3
	90-120	2.0	109.6	25.9	7.2	5.3	53.1	30.3	22.8	3.9
	120-150	1.9	102.7	29.4	7.9	7.3	50.0	28.0	22.0	4.1
28	0	3.2	17.0	11.6	4.1	5.8	66.7	38.3	28.3	3.1
	15-30	2.4	10.0	10.6	4.0	4.8	79.8	38.3	41.5	1.6
	30-60	4.2	6.0	16.1	7.9	10.4	108.1	66.6	41.5	2.5
	60-90	2.2	0.0	23.7	7.2	9.6	67.0	48.3	18.7	5.0
	90-120	1.9	4.8	27.0	6.9	11.2	56.3	35.1	21.2	5.6
	120-150	1.9	13.7	24.4	7.2	9.5	47.6	27.5	20.2	6.7
30	0	4.0	17.9	8.2	3.9	11.0	47.3	11.6	35.7	1.1
	15-30	2.6	10.1	8.2	4.1	5.6	43.9	19.9	24.0	1.0
	30-60	3.1	32.7	15.9	7.2	7.3	94.0	61.9	32.1	2.3
	60-90	2.2	50.6	22.9	7.4	6.4	71.0	45.1	25.9	3.0
	90-120	1.9	35.3	24.2	7.2	10.6	59.4	39.3	20.1	4.2
	120-150	1.9	16.7	24.7	7.2	7.8	51.0	32.5	18.5	3.8
32	0	3.4	15.1	11.8	4.0	9.7	50.4	18.9	31.5	2.0
	15-30	2.6	5.3	6.8	4.6	4.6	52.9	28.8	24.1	0.6
	30-60	3.4	2.6	14.5	7.9	9.4	111.9	7.3	104.6	0.8
	60-90	2.1	8.4	27.6	7.7	10.1	71.0	49.4	21.7	1.4
	90-120	1.8	21.4	25.5	7.6	11.2	51.9	48.3	3.5	4.3
	120-150	1.9	28.5	33.9	7.8	11.2	47.6	28.0	19.5	4.2

[z] Dry combustion/chromotography method.
[y] Potassium chloride extraction/colorimetric method.
[x] Hot acid digestion/colorimetric method.
[w] Modified Kelowna extraction/colorimetric method.
[v] Cold acid digestion/gas chromotography method
[u] Organic C = total C less inorganic C.
[t] EC = electrical conductivity (saturated paste extraction method).

Table 6.2. Baseline (1996) soil cation and anion values from saturated paste analysis (1 of 4 pages).

Pen	Depth (cm)	Ca (kg ha^{-1})	Mg (kg ha^{-1})	Na (kg ha^{-1})	K (kg ha^{-1})	SO_4-S (kg ha^{-1})	Cl (kg ha^{-1})	CO3 (kg ha^{-1})	HCO_3 (kg ha^{-1})	SAR
1	0	953	440	223	38.0	1360	37.2	0.0	337	0.93
	15-30	261	121	82	17.9	307	27.1	0.0	436	0.66
	30-60	709	500	251	38.7	1135	36.9	0.0	572	0.77
	60-90	2531	1838	549	78.8	4679	56.4	0.0	453	0.88
	90-120	2555	1860	672	87.2	4710	56.5	0.0	454	1.07
	120-150	2686	1922	864	118.4	5258	39.8	0.0	479	1.31
3	0	1274	552	211	31.8	1655	27.9	0.0	401	0.77
	15-30	439	226	176	11.0	601	27.1	0.0	342	1.06
	30-60	1054	727	562	28.5	1952	73.8	0.0	572	1.43
	60-90	1914	1477	939	53.9	3828	56.4	0.0	518	1.70
	90-120	2587	1789	1014	74.8	4769	37.7	0.0	454	1.63
	120-150	3854	1138	941	103.0	4925	39.8	0.0	445	1.45
5	0	968	342	133	42.1	1069	46.6	0.0	609	0.58
	15-30	1104	434	158	47.9	1275	36.2	0.0	420	0.64
	30-60	730	361	215	32.6	943	18.5	0.0	730	0.71
	60-90	1202	684	415	51.9	1906	18.8	0.0	518	1.03
	90-120	2609	1337	647	91.4	4003	18.8	0.0	454	1.11
	120-150	2775	1404	799	107.4	4206	19.9	0.0	479	1.30
7	0	1353	552	223	56.5	1798	46.6	0.0	449	0.80
	15-30	388	121	70	51.8	323	135.6	0.0	747	0.50
	30-60	501	215	179	65.1	492	203.0	0.0	953	0.74
	60-90	681	555	451	39.4	1174	169.3	0.0	648	1.35
	90-120	735	659	489	51.9	1329	207.2	0.0	584	1.37
	120-150	989	831	567	70.2	1896	178.9	0.0	513	1.36

Table 6.2. Baseline (1996) soil cation and anion values from saturated paste analysis (2 of 4 pages).

Pen	Depth (cm)	Ca (kg ha^{-1})	Mg (kg ha^{-1})	Na (kg ha^{-1})	K (kg ha^{-1})	SO_4-S (kg ha^{-1})	Cl (kg ha^{-1})	CO3 (kg ha^{-1})	HCO_3 (kg ha^{-1})	SAR
10	0	1379	469	127	82.2	1621	27.9	0.0	433	0.46
	15-30	465	208	141	40.9	564	108.5	0.0	436	0.85
	30-60	1022	506	299	36.6	1368	276.8	0.0	635	0.84
	60-90	1978	845	439	58.1	2595	282.2	0.0	421	0.90
	90-120	2790	917	403	85.2	3390	207.2	0.0	421	0.73
	120-150	2933	1022	400	114.0	3739	139.1	0.0	411	0.68
12	0	1226	431	151	53.4	1474	27.9	0.0	417	0.58
	15-30	572	263	94	35.9	674	27.1	0.0	545	0.51
	30-60	1095	803	299	61.1	1811	0.0	0.0	603	0.73
	60-90	2542	1580	512	107.9	4347	0.0	0.0	453	0.85
	90-120	2566	1866	660	130.9	4812	0.0	0.0	454	1.05
	120-150	2573	2262	954	160.0	5537	19.9	0.0	445	1.40
14	0	1221	469	254	83.2	1617	37.2	0.0	465	0.96
	15-30	659	384	305	26.9	1161	27.1	0.0	389	1.46
	30-60	1679	1512	1304	54.9	3846	73.8	0.0	572	2.44
	60-90	1170	1645	1940	68.5	3998	94.1	0.0	615	3.72
	90-120	1139	1569	1905	76.9	3815	75.3	0.0	584	3.73
	120-150	2000	1485	1624	96.5	4350	59.6	0.0	582	2.83
16	0	1126	476	121	33.9	1490	37.2	0.0	369	0.47
	15-30	347	232	100	23.9	531	54.2	0.0	342	0.64
	30-60	459	348	203	38.7	793	55.4	0.0	699	0.76
	60-90	2627	1142	390	93.4	3735	37.6	0.0	453	0.70
	90-120	2800	930	391	112.2	3526	37.7	0.0	454	0.71
	120-150	2933	1008	387	125.0	3748	39.8	0.0	445	0.66

Table 6.2. Baseline (1996) soil cation and anion values from saturated paste analysis (3 of 4 pages).

Pen	Depth (cm)	Ca (kg ha^{-1})	Mg (kg ha^{-1})	Na (kg ha^{-1})	K (kg ha^{-1})	SO_4-S (kg ha^{-1})	Cl (kg ha^{-1})	CO3 (kg ha^{-1})	HCO_3 (kg ha^{-1})	SAR
17	0	1137	402	103	28.8	1398	18.6	0.0	369	0.41
	15-30	164	87	64	11.0	172	9.0	0.0	436	0.64
	30-60	459	310	227	30.5	776	18.5	0.0	699	0.88
	60-90	2467	1290	573	74.7	4066	18.8	0.0	486	1.01
	90-120	2662	1072	611	103.9	4062	0.0	0.0	454	1.10
	120-150	2809	1002	477	129.3	3802	0.0	0.0	411	0.83
19	0	453	188	91	19.5	518	18.6	0.0	529	0.56
	15-30	409	291	152	16.9	711	27.1	0.0	327	0.88
	30-60	1137	1107	622	48.8	2595	55.4	0.0	572	1.38
	60-90	2159	1799	1122	87.1	4892	56.4	0.0	486	1.87
	90-120	2491	1860	1344	97.6	5221	56.5	0.0	486	2.15
	120-150	2674	1874	1418	127.1	5528	59.6	0.0	479	2.17
21	0	1311	520	296	66.7	1688	37.2	0.0	481	1.08
	15-30	547	322	328	34.9	928	36.2	0.0	482	1.72
	30-60	855	892	1221	54.9	2470	55.4	0.0	699	3.05
	60-90	2340	2032	2550	87.1	5836	94.1	0.0	550	4.04
	90-120	2310	2447	3811	108.0	7171	169.5	0.0	454	5.72
	120-150	2382	3053	5414	125.0	8620	278.3	0.0	445	7.31
23	0	611	246	187	93.4	728	46.6	0.0	625	1.00
	15-30	971	539	317	133.6	1275	334.5	0.0	373	1.27
	30-60	1314	1493	1723	77.3	2912	627.4	0.0	603	3.38
	60-90	830	1290	2208	60.2	2680	508.0	0.0	583	4.85
	90-120	873	1149	2125	76.9	2598	470.9	0.0	616	4.83
	120-150	2551	2276	2578	125.0	6256	556.6	0.0	513	3.78

Table 6.2. Baseline (1996) soil cation and anion values from saturated paste analysis (4 of 4 pages).

Pen	Depth (cm)	Ca (kg ha^{-1})	Mg (kg ha^{-1})	Na (kg ha^{-1})	K (kg ha^{-1})	SO_4-S (kg ha^{-1})	Cl (kg ha^{-1})	CO3 (kg ha^{-1})	HCO_3 (kg ha^{-1})	SAR
26	0	763	220	97	134.5	842	55.9	0.0	240	0.49
	15-30	598	214	111	72.8	703	126.6	0.0	576	0.62
	30-60	1210	734	467	48.8	1852	276.8	0.0	603	1.15
	60-90	1181	742	476	58.1	1855	207.0	0.0	486	1.16
	90-120	2704	1240	647	93.5	3833	226.0	0.0	421	1.12
	120-150	2877	1451	877	120.6	4341	238.5	0.0	479	1.40
28	0	932	520	332	31.8	1524	18.6	0.0	401	1.33
	15-30	291	211	287	14.0	556	18.1	0.0	436	1.96
	30-60	949	841	862	34.6	2161	18.5	0.0	730	2.15
	60-90	2425	2186	1891	85.1	5691	18.8	0.0	486	2.91
	90-120	2193	2273	2492	105.9	6430	37.7	0.0	486	3.86
	120-150	2393	2848	3996	122.8	8134	99.4	0.0	513	5.52
30	0	374	118	72	37.0	354	27.9	0.0	609	0.52
	15-30	291	105	82	16.9	347	27.1	0.0	389	0.66
	30-60	1085	778	515	40.7	1977	92.3	0.0	572	1.28
	60-90	1287	1232	720	66.4	2833	75.3	0.0	518	1.49
	90-120	2406	1814	794	95.6	4514	56.5	0.0	454	1.29
	120-150	2708	1438	632	118.4	4350	39.8	0.0	445	1.03
32	0	700	275	109	99.6	914	18.6	0.0	481	0.54
	15-30	128	68	64	16.9	135	18.1	0.0	467	0.72
	30-60	240	215	287	22.4	442	36.9	0.0	826	1.42
	60-90	340	451	488	43.6	1055	75.3	0.0	712	1.77
	90-120	2417	1963	721	108.0	5016	94.2	0.0	486	1.15
	120-150	2730	1819	825	131.5	4898	119.3	0.0	479	1.27

Table 6.3. Baseline (1996) soil pH, manganese, iron, copper, zinc, particle size distribution, and textural class values (1 of 4 pages).

Pen	Depth (cm)	pH [z]	Mn [y] (kg ha^{-1})	Fe [y] (kg ha^{-1})	Cu [y] (kg ha^{-1})	Zn [y] (kg ha^{-1})	Sand (%)	Silt (%)	Clay (%)	Texture class [x]
1	0	7.6	10.8	14.7	1.84	0.74	36.3	30.0	33.6	CL
	15-30	7.7	7.9	13.3	1.79	0.38	33.0	33.6	33.4	CL
	30-60	7.8	15.1	21.9	3.12	0.57	31.9	33.6	34.6	CL
	60-90	7.7	13.5	20.2	3.18	0.58	31.7	32.2	36.2	CL
	90-120	7.7	13.8	19.1	7.70	1.06	32.4	36.0	31.7	CL
	120-150	7.7	14.0	22.4	5.89	1.23	34.3	36.6	29.1	CL
3	0	7.5	12.0	21.0	2.89	0.55	35.4	30.8	33.8	CL
	15-30	7.7	7.0	13.8	2.17	0.26	34.7	28.7	36.6	CL
	30-60	7.8	10.2	22.9	3.90	0.42	41.5	24.3	34.3	CL
	60-90	7.8	12.7	21.2	3.98	0.53	48.7	20.6	30.7	SCL
	90-120	7.7	10.6	17.0	2.92	0.74	49.9	22.1	28.1	SCL
	120-150	7.7	13.5	16.8	3.36	0.79	41.3	28.8	30.0	CL
5	0	7.4	17.3	29.9	2.89	0.79	33.6	33.0	33.4	CL
	15-30	7.4	12.6	24.5	2.17	0.59	33.5	31.6	34.9	CL
	30-60	7.6	16.4	23.9	3.38	0.52	33.1	33.6	33.3	CL
	60-90	7.7	13.0	22.3	4.25	0.74	31.8	33.6	34.6	CL
	90-120	7.7	11.7	21.3	3.72	0.74	30.1	33.8	36.2	CL
	120-150	7.7	12.9	20.2	3.92	1.18	31.6	33.7	34.7	CL
7	0	7.5	13.1	17.3	2.89	0.66	34.2	33.7	32.1	CL
	15-30	7.5	15.8	32.6	2.68	0.64	32.0	34.6	33.3	CL
	30-60	7.7	18.7	46.8	4.94	0.78	36.3	31.5	32.2	CL
	60-90	7.7	11.7	22.3	3.71	0.42	45.0	23.4	31.7	CL
	90-120	7.8	13.8	22.3	3.45	0.74	38.4	29.2	32.4	CL
	120-150	7.8	13.7	20.2	3.08	1.01	39.9	33.5	26.7	L

[z] Saturated paste extraction method.

[y] Diethylene triamine pentaacetic acid (DTPA) extraction/atomic absorption method.

[x] CL = clay loam, L =loam, SCL = sandy clay loam, C = clay, SiL = silty loam.

Table 6.3. Baseline (1996) soil pH, manganese, iron, copper, zinc, particle size distribution, and textural class values (2 of 4 pages).

Pen	Depth (cm)	pH[z]	Mn[y] (kg ha^{-1})	Fe[y] (kg ha^{-1})	Cu[y] (kg ha^{-1})	Zn[y] (kg ha^{-1})	Sand (%)	Silt (%)	Clay (%)	Texture class[x]
10	0	7.4	14.1	21.5	2.36	0.81	30.8	34.6	34.6	CL
	15-30	7.6	10.7	15.8	1.91	0.51	21.1	41.0	37.9	CL
	30-60	7.6	15.6	26.0	3.38	0.68	23.7	39.6	36.7	CL
	60-90	7.6	17.5	22.3	3.71	0.53	28.3	35.9	35.7	CL
	90-120	7.5	14.9	21.3	7.70	1.22	28.4	38.9	32.8	CL
	120-150	7.5	14.3	21.3	5.05	1.12	31.1	28.1	40.8	C
12	0	7.4	13.7	21.0	2.23	1.16	30.2	35.2	34.6	CL
	15-30	7.5	13.0	23.5	3.19	0.74	30.9	34.5	34.5	CL
	30-60	7.7	15.9	27.1	4.16	0.62	31.9	35.0	33.1	CL
	60-90	7.6	14.6	21.2	9.02	1.11	31.8	36.6	31.7	CL
	90-120	7.7	13.3	19.1	3.72	0.74	31.4	30.9	37.7	CL
	120-150	7.7	11.2	17.9	3.08	1.01	24.0	54.5	21.5	SiL
14	0	7.5	18.9	25.2	3.02	0.92	29.6	36.1	34.4	CL
	15-30	7.6	10.3	18.4	3.57	0.48	29.1	36.6	34.3	CL
	30-60	7.7	13.3	26.0	4.68	0.52	27.3	38.3	34.4	CL
	60-90	7.9	19.1	25.5	3.98	0.74	26.6	39.5	34.0	CL
	90-120	7.9	17.3	23.4	3.98	0.80	28.7	40.2	31.1	CL
	120-150	7.8	16.0	26.9	3.92	1.01	29.0	36.6	34.4	CL
16	0	7.5	10.6	23.1	5.52	0.84	33.0	32.2	34.8	CL
	15-30	7.8	6.6	14.8	2.17	0.33	33.1	32.1	34.7	CL
	30-60	7.9	11.5	29.1	3.64	0.68	35.7	30.6	33.6	CL
	60-90	7.6	12.7	28.7	3.71	0.80	34.8	31.6	33.6	CL
	90-120	7.6	15.9	27.6	3.45	0.90	37.8	32.7	29.5	CL
	120-150	7.6	17.1	25.8	5.89	1.40	32.8	32.3	34.9	CL

[z] Saturated paste extraction method.
[y] Diethylene triamine pentaacetic acid (DTPA) extraction/atomic absorption method.
[x] CL = clay loam, L =loam, SCL = sandy clay loam, C = clay, SiL = silty loam.

Table 6.3. Baseline (1996) soil pH, manganese, iron, copper, zinc, particle size distribution, and textural class values (3 of 4 pages).

Pen	Depth (cm)	pH [z]	Mn [y] (kg ha^{-1})	Fe [y] (kg ha^{-1})	Cu [y] (kg ha^{-1})	Zn [y] (kg ha^{-1})	Sand (%)	Silt (%)	Clay (%)	Texture class [x]
17	0	7.4	13.3	18.4	2.89	0.45	26.1	41.2	32.7	CL
	15-30	7.8	9.8	15.3	2.55	0.26	21.7	43.2	35.1	CL
	30-60	7.9	34.1	29.1	4.68	0.52	25.0	42.6	32.4	CL
	60-90	7.6	17.8	29.7	7.96	1.06	35.1	37.4	27.6	CL
	90-120	7.6	17.5	27.6	4.52	0.90	31.0	31.0	38.0	CL
	120-150	7.6	19.9	28.0	3.92	0.90	34.3	33.6	32.1	L
19	0	7.5	19.4	24.7	3.55	0.74	32.8	33.9	33.3	CL
	15-30	7.7	8.7	12.8	2.17	0.28	35.2	34.1	30.6	CL
	30-60	7.8	16.4	26.0	3.90	0.47	37.1	32.1	30.8	CL
	60-90	7.8	18.3	25.5	3.71	0.64	39.1	31.2	29.7	CL
	90-120	7.7	15.7	25.5	39.85	0.85	35.6	29.2	35.1	CL
	120-150	7.7	15.1	23.5	5.89	1.01	32.8	32.3	35.0	CL
21	0	7.5	13.9	18.9	1.97	0.66	33.4	33.1	33.5	CL
	15-30	7.7	11.1	17.9	2.81	0.54	29.7	36.0	34.3	CL
	30-60	7.9	24.7	29.1	5.21	0.78	24.5	37.2	38.3	CL
	60-90	7.8	21.2	23.4	5.04	0.96	24.6	35.4	40.0	C
	90-120	7.9	18.1	22.3	5.05	1.06	27.4	35.3	37.3	CL
	120-150	8.0	19.9	28.0	4.49	1.01	31.4	32.3	36.3	CL
23	0	7.4	14.3	19.4	2.10	0.76	32.2	34.5	33.2	CL
	15-30	7.5	8.4	13.3	1.66	0.59	30.4	33.6	36.0	CL
	30-60	7.7	14.1	22.9	3.64	0.73	31.8	35.0	33.2	CL
	60-90	8.0	16.7	19.1	3.71	0.58	29.2	36.5	34.3	CL
	90-120	7.9	17.3	19.1	3.45	0.74	33.2	35.0	31.8	CL
	120-150	7.8	13.7	20.2	6.73	1.29	35.8	35.1	29.2	CL

[z] Saturated paste extraction method.

[y] Diethylene triamine pentaacetic acid (DTPA) extraction/atomic absorption method.

[x] CL = clay loam, L =loam, SCL = sandy clay loam, C = clay, SiL = silty loam.

Table 6.3. Baseline (1996) soil pH, manganese, iron, copper, zinc, particle size distribution, and textural class values (4 of 4 pages).

Pen	Depth (cm)	pH [z]	Mn [y] ($kg\ ha^{-1}$)	Fe [y] ($kg\ ha^{-1}$)	Cu [y] ($kg\ ha^{-1}$)	Zn [y] ($kg\ ha^{-1}$)	Sand (%)	Silt (%)	Clay (%)	Texture class [x]
26	0	7.4	21.5	31.0	3.41	1.08	36.2	37.5	26.3	L
	15-30	7.5	17.9	25.5	3.70	0.99	32.2	34.5	33.3	CL
	30-60	7.7	20.6	27.1	4.42	0.57	38.5	33.5	28.0	CL
	60-90	7.7	18.6	29.7	4.51	0.48	34.5	35.0	30.5	CL
	90-120	7.5	17.3	27.6	4.25	0.74	35.7	33.6	30.7	CL
	120-150	7.6	19.9	26.9	6.17	0.84	35.4	29.4	35.2	CL
28	0	7.6	14.4	20.0	2.89	0.55	26.4	44.0	29.6	CL
	15-30	7.8	11.5	17.9	3.44	0.43	25.0	45.5	29.5	CL
	30-60	7.8	21.3	32.3	5.47	0.88	26.4	44.0	29.6	CL
	60-90	7.7	17.0	25.5	3.98	0.64	31.6	30.7	37.7	CL
	90-120	7.9	19.7	26.6	5.31	0.85	33.5	31.6	34.9	CL
	120-150	7.9	21.0	26.9	5.05	1.57	32.5	32.6	34.9	CL
30	0	7.6	21.0	31.5	3.02	0.97	33.8	32.6	33.6	CL
	15-30	7.7	12.2	20.9	2.81	0.31	40.2	30.1	29.7	CL
	30-60	7.7	18.2	27.1	4.16	0.36	39.9	32.0	28.1	CL
	60-90	7.9	21.8	27.6	3.98	0.58	39.8	29.1	31.1	CL
	90-120	7.8	22.3	26.6	9.56	1.12	38.5	32.0	29.5	CL
	120-150	7.7	16.5	25.8	4.49	0.95	25.5	39.0	35.5	CL
32	0	7.5	16.8	21.5	2.89	0.66	23.5	41.3	35.2	CL
	15-30	7.9	8.7	11.5	2.30	0.23	23.6	41.1	35.3	CL
	30-60	8.1	20.0	35.4	6.25	0.57	31.4	39.9	28.7	CL
	60-90	8.0	18.3	26.5	3.98	0.53	38.6	33.4	27.9	CL
	90-120	7.8	18.9	24.4	3.98	0.74	35.8	32.1	32.1	CL
	120-150	7.8	21.6	29.2	4.49	1.01	35.5	30.7	33.8	CL

[z] Saturated paste extraction method.

[y] Diethylene triamine pentaacetic acid (DTPA) extraction/atomic absorption method.

[x] CL = clay loam, L =loam, SCL = sandy clay loam, C = clay, SiL = silty loam.

Table 6.4. Extractable nitrate-N, extractable ammonium-N, extractable phosphate-P, pH, and electrical conductivity for the 1999 soil samples (1 of 4 pages).

Pen	Depth (cm)	NO_3-N [z] (kg ha^{-1})	NH_4-N [z] (kg ha^{-1})	PO_4-P [y] (kg ha^{-1})	pH [x]	EC [t] (dS m^{-1})
1	0	9.5	224.6	25.6	7.4	4.8
	15-30	6.1	11.6	3.0	7.5	2.9
	30-60	8.9	23.1	6.7	7.6	2.2
	60-90	8.1	25.4	5.7	7.5	3.8
	90-120	6.1	26.9	5.6	7.5	4.2
	120-150	11.9	26.7	6.9	7.5	4.2
3	0	15.2	215.0	42.1	7.4	4.9
	15-30	10.4	12.5	4.1	7.4	2.6
	30-60	21.7	20.5	6.7	7.6	1.9
	60-90	29.7	26.3	7.8	7.7	2.4
	90-120	43.0	21.3	7.1	7.7	2.3
	120-150	57.4	18.9	4.4	7.6	3.0
5	0	28.5	380.3	30.0	7.4	7.6
	15-30	7.7	27.9	11.1	7.3	3.5
	30-60	5.7	28.4	6.7	7.5	2.5
	60-90	11.9	22.8	6.2	7.2	3.7
	90-120	16.2	24.5	5.1	7.4	3.6
	120-150	18.0	23.6	8.3	7.4	3.8
7	0	13.0	229.2	20.3	7.5	6.5
	15-30	11.0	31.8	16.8	7.3	3.0
	30-60	4.6	29.6	11.9	7.5	2.9
	60-90	2.9	21.8	7.8	7.6	3.1
	90-120	10.6	26.1	7.6	7.7	2.6
	120-150	22.5	26.6	7.8	7.5	4.3

[z] Potassium chloride extraction/colorimetric method.
[y] Modified Kelowna extraction/colorimetric method.
[x] pH (saturated paste extraction method).
[w] EC = electrical conductivity (saturated paste extraction method).

Table 6.4. Extractable nitrate-N, extractable ammonium-N, extractable phosphate-P, pH, and electrical conductivity for the 1999 soil samples (2 of 4 pages).

Pen	Depth (cm)	NO_3-N [z] (kg ha^{-1})	NH_4-N [z] (kg ha^{-1})	PO_4-P [y] (kg ha^{-1})	pH [x]	EC [t] (dS m^{-1})
10	0	12.2	226.0	53.7	7.4	8.1
	15-30	9.1	45.6	10.9	7.3	4.2
	30-60	3.4	36.9	8.3	7.5	2.9
	60-90	11.1	24.6	5.2	7.5	3.7
	90-120	21.5	29.1	4.6	7.5	3.6
	120-150	13.6	25.8	7.8	7.4	3.6
12	0	5.1	160.1	33.7	7.4	7.1
	15-30	4.6	23.5	6.6	7.4	3.6
	30-60	3.3	32.5	4.7	7.6	2.7
	60-90	9.2	30.9	5.7	7.5	4.2
	90-120	17.6	30.4	8.1	7.6	4.6
	120-150	23.4	29.5	8.3	7.6	5.1
14	0	41.3	100.4	26.5	7.5	7.1
	15-30	18.6	17.4	5.7	7.6	4.3
	30-60	18.5	24.5	11.4	7.9	2.7
	60-90	11.6	22.1	17.7	7.9	2.7
	90-120	12.9	27.0	9.7	7.9	2.8
	120-150	10.1	24.3	7.8	7.8	3.5
16	0	64.5	70.7	36.8	7.5	7.2
	15-30	15.2	10.2	2.7	7.6	3.3
	30-60	10.2	26.7	8.8	7.7	2.5
	60-90	1.4	30.5	7.3	7.6	3.7
	90-120	1.0	32.3	8.7	7.6	3.7
	120-150	2.2	29.2	7.4	7.5	3.7

[z] Potassium chloride extraction/colorimetric method.
[y] Modified Kelowna extraction/colorimetric method.
[x] pH (saturated paste extraction method).
[w] EC = electrical conductivity (saturated paste extraction method).

Table 6.4. Extractable nitrate-N, extractable ammonium-N, extractable phosphate-P, pH, and electrical conductivity for the 1999 soil samples (3 of 4 pages).

Pen	Depth (cm)	NO_3-N [z] (kg ha^{-1})	NH_4-N [z] (kg ha^{-1})	PO_4-P [y] (kg ha^{-1})	pH [x]	EC [t] (dS m^{-1})
17	0	11.5	237.7	84.9	7.3	6.5
	15-30	8.9	16.4	3.4	7.6	3.0
	30-60	7.6	28.6	6.2	7.7	2.7
	60-90	11.4	26.8	7.8	7.6	3.7
	90-120	4.9	21.6	7.1	7.6	3.7
	120-150	7.8	23.0	6.4	7.6	3.5
19	0	6.2	424.0	50.9	7.4	6.3
	15-30	0.6	22.8	3.0	7.6	3.2
	30-60	10.5	23.4	6.2	7.8	2.3
	60-90	23.0	28.2	6.2	7.7	3.1
	90-120	18.7	26.7	6.1	7.7	5.1
	120-150	27.1	25.2	7.4	7.6	5.0
21	0	37.2	161.6	56.8	7.6	7.3
	15-30	3.0	27.5	3.9	7.5	5.0
	30-60	9.1	22.1	9.3	7.7	5.1
	60-90	12.1	27.1	13.0	7.8	5.1
	90-120	29.9	22.9	9.2	7.9	8.3
	120-150	15.0	24.7	9.3	7.8	7.3
23	0	218.4	286.5	41.2	7.5	6.3
	15-30	81.9	7.0	8.9	7.5	4.3
	30-60	143.4	17.5	8.3	7.8	3.8
	60-90	151.3	24.6	10.9	7.9	4.1
	90-120	83.4	27.0	10.7	7.8	6.1
	120-150	47.0	26.8	9.8	7.8	6.3

[z] Potassium chloride extraction/colorimetric method.
[y] Modified Kelowna extraction/colorimetric method.
[x] pH (saturated paste extraction method).
[w] EC = electrical conductivity (saturated paste extraction method).

Table 6.4. Extractable nitrate-N, extractable ammonium-N, extractable phosphate-P, pH, and electrical conductivity for the 1999 soil samples (4 of 4 pages).

Pen	Depth (cm)	NO_3-N [z] (kg ha^{-1})	NH_4-N [z] (kg ha^{-1})	PO_4-P [y] (kg ha^{-1})	pH [x]	EC [t] (dS m^{-1})
26	0	43.7	142.4	25.6	7.5	5.3
	15-30	34.8	7.2	5.2	7.4	4.4
	30-60	52.2	18.1	6.2	7.6	3.2
	60-90	52.4	22.7	4.7	7.4	2.6
	90-120	40.8	23.2	4.6	7.4	4.1
	120-150	41.2	109.2	12.3	7.3	4.9
28	0	55.2	205.8	13.4	7.3	6.7
	15-30	24.5	8.3	4.5	7.5	6.1
	30-60	21.2	11.7	10.4	7.6	5.6
	60-90	24.9	20.4	12.0	7.8	6.5
	90-120	22.5	22.6	8.7	7.8	7.4
	120-150	17.6	26.1	7.4	7.7	7.4
30	0	56.8	302.5	15.9	7.3	5.3
	15-30	25.8	9.3	3.9	7.4	2.9
	30-60	22.7	15.3	6.7	7.5	2.3
	60-90	17.4	27.1	7.3	7.6	2.7
	90-120	21.7	31.2	6.6	7.4	3.7
	120-150	15.7	30.4	8.3	7.4	3.8
32	0	100.8	216.2	43.4	7.4	5.4
	15-30	7.0	21.0	3.6	7.4	3.7
	30-60	15.9	12.8	8.3	7.6	3.1
	60-90	32.1	21.6	8.8	7.7	2.6
	90-120	39.6	24.0	8.7	7.6	2.4
	120-150	38.2	25.3	9.3	7.4	4.2

[z] Potassium chloride extraction/colorimetric method.
[y] Modified Kelowna extraction/colorimetric method.
[x] pH (saturated paste extraction method).
[w] EC = electrical conductivity (saturated paste extraction method).

Table 6.5. Cation and anion values from saturated paste analysis of the 1999 samples (1 of 4 pages).

Pen	Depth (cm)	Ca (kg ha^{-1})	Mg (kg ha^{-1})	Na (kg ha^{-1})	K (kg ha^{-1})	SO_4-S (kg ha^{-1})	Cl (kg ha^{-1})	CO3 (kg ha^{-1})	HCO_3 (kg ha^{-1})	SAR
1	0	1150	626	911	551	1175	2920	0.0	445	3.04
	15-30	656	403	282	26	758	878	0.0	182	1.42
	30-60	996	812	512	47	1643	679	0.0	474	1.28
	60-90	2469	1611	693	77	4525	203	0.0	435	1.17
	90-120	2673	1615	796	88	4856	180	0.0	385	1.33
	120-150	2603	1549	924	98	4636	174	0.0	395	1.60
3	0	1069	455	1090	788	625	3683	0.0	567	3.98
	15-30	619	284	272	20	430	1120	0.0	189	1.50
	30-60	924	636	440	34	1145	881	0.0	445	1.20
	60-90	1167	960	562	55	2067	276	0.0	492	1.29
	90-120	1000	866	609	58	1926	199	0.0	509	1.51
	120-150	1356	1108	721	77	2656	191	0.0	470	1.59
5	0	2088	823	925	1927	2501	4026	0.0	516	2.46
	15-30	1075	392	261	57	929	1192	0.0	229	1.15
	30-60	1785	787	440	45	2183	679	0.0	417	0.96
	60-90	2740	1131	681	65	4042	221	0.0	419	1.21
	90-120	2867	1114	691	80	4064	90	0.0	398	1.23
	120-150	2701	929	834	96	3968	122	0.0	386	1.59
7	0	2101	686	868	1330	2176	3418	0.0	470	2.38
	15-30	838	304	266	76	674	1072	0.0	358	1.33
	30-60	1951	931	571	45	2698	587	0.0	474	1.17
	60-90	1792	1131	693	53	3275	184	0.0	454	1.38
	90-120	1020	922	808	62	2514	108	0.0	522	1.96
	120-150	2348	1448	902	105	4558	191	0.0	428	1.63

Table 6.5. Cation and anion values from saturated paste analysis of the 1999 samples (2 of 4 pages).

Pen	Depth (cm)	Ca (kg ha^{-1})	Mg (kg ha^{-1})	Na (kg ha^{-1})	K (kg ha^{-1})	SO_4-S (kg ha^{-1})	Cl (kg ha^{-1})	CO3 (kg ha^{-1})	HCO_3 (kg ha^{-1})	SAR
10	0	1751	876	1427	2049	2901	4225	0.0	573	3.94
	15-30	847	483	423	145	1020	1587	0.0	304	1.91
	30-60	1961	919	571	57	2266	1322	0.0	458	1.17
	60-90	3021	1213	586	63	3942	479	0.0	412	1.00
	90-120	2714	1083	480	76	3795	253	0.0	413	0.87
	120-150	2790	1084	440	92	3575	295	0.0	488	0.81
12	0	2038	929	1169	1244	2626	3363	0.0	466	3.05
	15-30	979	475	329	78	1067	1015	0.0	281	1.43
	30-60	1608	938	488	83	2490	477	0.0	496	1.05
	60-90	2876	1687	657	116	5150	129	0.0	444	1.06
	90-120	2714	1986	890	121	5819	126	0.0	457	1.40
	120-150	2672	2145	1082	128	5933	104	0.0	434	1.71
14	0	2038	902	1420	1163	2701	4248	0.0	388	3.73
	15-30	897	591	601	44	1111	1442	0.0	189	2.54
	30-60	830	963	1143	32	2075	844	0.0	610	2.81
	60-90	438	783	1219	43	2167	166	0.0	673	3.54
	90-120	602	959	1182	58	2554	126	0.0	609	3.09
	120-150	1307	1126	1206	75	3222	104	0.0	511	2.67
16	0	1663	758	1470	1409	1901	3783	0.0	440	4.25
	15-30	578	373	334	50	656	1233	0.0	196	1.77
	30-60	1193	780	488	63	2017	643	0.0	521	1.19
	60-90	2594	1219	550	100	3859	221	0.0	441	0.98
	90-120	2693	1089	515	117	3999	126	0.0	401	0.94
	120-150	2456	1108	575	153	3968	70	0.0	380	1.09

Table 6.5. Cation and anion values from saturated paste analysis of the 1999 samples (3 of 4 pages).

Pen	Depth (cm)	Ca (kg ha^{-1})	Mg (kg ha^{-1})	Na (kg ha^{-1})	K (kg ha^{-1})	SO_4-S (kg ha^{-1})	Cl (kg ha^{-1})	CO3 (kg ha^{-1})	HCO_3 (kg ha^{-1})	SAR
17	0	1419	637	1133	1410	1800	3783	0.0	676	3.56
	15-30	628	282	340	40	546	1225	0.0	169	1.88
	30-60	1463	749	619	53	2241	863	0.0	436	1.44
	60-90	2667	1017	693	100	3900	350	0.0	438	1.27
	90-120	2857	897	655	94	3656	271	0.0	385	1.21
	120-150	2643	816	575	103	3379	156	0.0	386	1.13
19	0	988	557	1148	1504	1150	4347	0.0	771	4.10
	15-30	610	406	293	28	710	1257	0.0	190	1.49
	30-60	861	780	607	45	1851	551	0.0	521	1.59
	60-90	1094	1156	1100	59	3125	92	0.0	527	2.42
	90-120	2500	1980	1826	94	5794	72	0.0	432	2.94
	120-150	2417	1805	1769	100	5383	87	0.0	410	3.00
21	0	1469	811	1456	1966	1876	4281	0.0	668	4.28
	15-30	1184	737	616	84	1694	1394	0.0	197	2.30
	30-60	2708	2077	1869	71	5644	661	0.0	458	2.89
	60-90	2605	2433	3120	87	6917	258	0.0	450	4.63
	90-120	2357	3044	5548	94	9222	379	0.0	398	7.88
	120-150	2407	2758	4361	94	7936	278	0.0	422	6.50
23	0	1244	705	825	1992	1225	3916	0.0	702	2.62
	15-30	870	663	470	103	1220	1192	0.0	236	1.94
	30-60	1069	1605	1512	59	3055	844	0.0	553	3.00
	60-90	865	1611	2199	63	3542	535	0.0	590	4.48
	90-120	2571	2759	2715	104	6447	397	0.0	450	3.93
	120-150	2495	2478	2874	117	6640	400	0.0	485	4.41

Table 6.5. Cation and anion values from saturated paste analysis of the 1999 samples (4 of 4 pages).

Pen	Depth (cm)	Ca (kg ha^{-1})	Mg (kg ha^{-1})	Na (kg ha^{-1})	K (kg ha^{-1})	SO_4-S (kg ha^{-1})	Cl (kg ha^{-1})	CO3 (kg ha^{-1})	HCO_3 (kg ha^{-1})	SAR
26	0	1588	641	660	1121	1225	3020	0.0	482	2.00
	15-30	1348	585	439	96	1512	1015	0.0	212	1.67
	30-60	2034	1353	536	59	3071	477	0.0	427	0.99
	60-90	1271	1093	550	53	2417	203	0.0	479	1.20
	90-120	2724	1602	655	92	4774	180	0.0	379	1.09
	120-150	3163	1418	947	514	4283	1964	0.0	511	1.59
28	0	2082	1039	1349	1149	2076	3750	0.0	484	3.41
	15-30	1189	1066	1202	25	2532	878	0.0	237	4.04
	30-60	1857	2221	3238	38	5976	532	0.0	566	5.27
	60-90	1823	2635	4112	53	6834	406	0.0	517	6.32
	90-120	2245	2759	4436	74	8242	307	0.0	435	6.57
	120-150	2328	2657	4316	86	7779	243	0.0	428	6.55
30	0	1376	667	689	1011	1250	3363	0.0	465	2.16
	15-30	756	420	225	21	856	701	0.0	187	1.08
	30-60	1162	925	583	36	2158	239	0.0	477	1.36
	60-90	1292	1125	669	53	2750	92	0.0	492	1.44
	90-120	2398	1541	609	86	4350	144	0.0	441	1.06
	120-150	2721	1239	530	103	4283	139	0.0	404	0.95
32	0	1138	694	739	1337	1375	3274	0.0	565	2.41
	15-30	883	652	256	66	1304	814	0.0	204	1.06
	30-60	1287	1466	619	51	3055	441	0.0	521	1.23
	60-90	927	1150	669	53	2459	221	0.0	565	1.52
	90-120	979	953	562	68	2024	235	0.0	562	1.36
	120-150	2790	1591	586	98	4636	191	0.0	419	0.99

Table 6.6. Mean (n=16) values and standard deviations of measured soil parameters in 1996.

Soil parameter	Soil depth 0-15 cm	15-30 cm	30-60 cm	60-90 cm	90-120 cm	120-150 cm
Total N (%)	3.22 (0.69)	2.63 (0.63)	3.26 (1.02)	2.27 (0.22)	1.92 (0.14)	1.89 (0.13)
NO_3-N (kg ha^{-1})	17.4 (6.8)	20.5 (33.2)	34.3 (82.0)	35.6 (66.0)	38.3 (55.3)	38.4 (35.9)
NH_4-N (kg ha^{-1})	11.8 (2.5)	10.2 (3.4)	19.7 (4.0)	23.2 (3.5)	25.8 (2.9)	26.8 (4.4)
Total P (Mg ha^{-1})	4.12 (0.34)	4.13 (0.30)	8.07 (0.71)	7.92 (0.49)	7.88 (0.69)	8.27 (0.66)
PO_4-P (kg ha^{-1})	11.9 (8.7)	8.2 (7.1)	9.1 (5.1)	9.3 (5.7)	9.0 (5.3)	9.1 (4.0)
Total C (Mg ha^{-1})	49.8 (7.3)	52.9 (9.7)	93.1 (17.8)	72.1 (13.7)	56.6 (7.4)	53.2 (9.3)
Inorganic C (Mg ha^{-1})	20.1 (7.0)	26.5 (8.6)	53.3 (16.4)	47.6 (13.4)	34.0 (10.7)	33.0 (8.4)
Organic C (Mg ha^{-1})	29.7 (7.4)	26.4 (8.0)	39.9 (20.2)	24.4 (3.9)	22.6 (11.3)	20.3 (2.8)
EC (dS m^{-1})	2.63 (0.73)	1.71 (0.80)	2.09 (0.98)	3.40 (1.12)	4.06 (1.01)	4.33 (1.33)
Ca (kg ha^{-1})	986 (323)	477 (267)	906 (374)	1730 (762)	2240 (681)	2617 (579)
Mg (kg ha^{-1})	389 (139)	239 (132)	709 (406)	1299 (535)	1546 (518)	1677 (665)
Na (kg ha^{-1})	171 (78)	158 (96)	577 (466)	979 (736)	1170 (952)	1422 (1417)
K (kg ha^{-1})	58.3 (32.2)	35.8 (31.3)	44.6 (15.0)	69.6 (19.2)	93.7 (18.6)	118 (19.0)
SO_4-S (kg ha^{-1})	1253 (452)	642 (362)	1720 (951)	3448 (1496)	4325 (1380)	4974 (1659)
Cl (kg ha^{-1})	33.2 (11.8)	65.0 (82.1)	120 (161)	111 (130)	109 (122)	121 (142)
CO_3 (kg ha^{-1})	0	0	0	0	0	0
HCO_3 (kg ha^{-1})	451 (105)	446 (106)	665 (108)	524 (80)	482 (59)	473 (44)
SAR	0.72 (0.27)	0.92 (0.45)	1.45 (0.86)	1.89 (1.29)	2.04 (1.58)	2.14 (1.88)
pH	7.48 (0.08)	7.65 (0.14)	7.78 (0.13)	7.76 (0.14)	7.73 (0.14)	7.73 (0.12)
Mn (kg ha^{-1})	15.3 (3.4)	10.8 (3.1)	17.9 (5.7)	16.5 (3.1)	16.1 (3.0)	16.3 (3.3)
Fe (kg ha^{-1})	22.5 (4.9)	18.2 (5.8)	28.3 (6.1)	24.4 (3.4)	23.2 (3.5)	23.8 (3.9)
Cu (kg ha^{-1})	2.90 (0.85)	2.57 (0.64)	4.31 (0.86)	4.53 (1.61)	7.04 (8.95)	4.71 (1.15)
Zn (kg ha^{-1})	0.77 (0.19)	0.47 (0.21)	0.61 (0.14)	0.68 (0.21)	0.87 (0.16)	1.08 (0.21)
Sand (%)	31.7 (3.7)	30.3 (5.2)	32.3 (5.7)	34.5 (6.5)	34.2 (5.5)	32.9 (4.5)
Silt (%)	35.2 (3.9)	35.7 (4.7)	35.2 (5.0)	32.6 (5.0)	32.7 (4.2)	34.3 (6.1)
Clay (%)	33.0 (2.2)	34.0 (2.3)	32.6 (3.0)	32.9 (3.5)	33.1 (3.1)	32.8 (4.6)

Table 6.7. Mean (n=16) values and standard deviations of measured soil parameters in 1999.

Soil parameter	Soil depth					
	0-15 cm	15-30 cm	30-60 cm	60-90 cm	90-120 cm	120-150 cm
NO_3-N (kg ha^{-1})	44.9 (53.3)	16.8 (19.7)	22.4 (34.4)	25.6 (35.9)	24.4 (20.2)	23.0 (15.4)
NH_4-N (kg ha^{-1})	224 (93)	18.8 (10.8)	23.2 (7.1)	25.2 (3.2)	26.1 (3.4)	31.0 (21.0)
PO_4-P (kg ha^{-1})	37.5 (18.2)	6.1 (3.9)	7.9 (2.0)	8.4 (3.4)	7.4 (1.8)	8.1 (1.7)
EC (dS m^{-1})	6.40 (1.01)	3.75 (0.92)	3.03 (1.01)	3.62 (1.06)	4.25 (1.72)	4.60 (1.34)
Ca (kg ha^{-1})	1575 (402)	872 (233)	1481 (533)	1853 (852)	2182 (788)	2450 (485)
Mg (kg ha^{-1})	738 (151)	507 (204)	1121 (484)	1372 (515)	1573 (737)	1579 (621)
Na (kg ha^{-1})	1080 (286)	413 (242)	890 (750)	1172 (1055)	1436 (1517)	1415 (1288)
K (kg ha^{-1})	1372 (436)	59.9 (35.5)	51.0 (13.8)	68.2 (21.4)	85.1 (19.3)	127 (105)
SO_4-S (kg ha^{-1})	1786 (671)	1064 (523)	2723 (1314)	3811 (1475)	4627 (2091)	4802 (1557)
Cl (kg ha^{-1})	3712 (452)	1126 (239)	670 (248)	252 (129)	200 (99)	294 (454)
CO_3 (kg ha^{-1})	0	0	0	0	0	0
HCO_3 (kg ha^{-1})	542 (110)	222 (51)	491 (54)	489 (71)	448 (68)	435 (45)
SAR	3.21 (0.79)	1.78 (0.73)	1.79 (1.16)	2.18 (1.65)	2.40 (2.09)	2.36 (1.86)
pH	7.43 (0.09)	7.46 (0.11)	7.64 (0.12)	7.63 (0.18)	7.63 (0.17)	7.56 (0.16)

Appendix 7. Water-table elevations (metres above sea level) at the Research Feedlot from May 8, 1996 to November 27, 2000.

Well no.	May 8, 1996	May 10, 1996	May 17, 1996	May 22, 1996	May 30, 1996	June 10, 1996	June 18, 1996
1	909.30	909.33	909.35	909.26	909.18	908.98	908.86
2	910.27	909.55	910.31	910.00	910.17	910.00	909.91
3	910.38	910.38	910.36	910.29	910.21	910.07	910.01
4	910.46	910.45	910.45	910.36	910.30	910.15	910.10
5	909.40	908.84	909.22	909.24	909.43	nm	909.54
6	909.07	909.01	909.22	909.18	909.23	909.22	909.33
7	909.44	909.31	909.53	909.47	909.46	909.42	909.49
8	909.15	909.54	909.61	909.56	909.53	909.49	909.50
9	909.15	909.18	909.30	909.26	909.31	909.31	909.37
10	909.02	907.91	908.59	908.62	909.88	909.04	909.08
11	907.68	909.35	909.56	909.49	909.44	909.40	909.38
12	906.50	907.97	909.26	909.24	909.28	909.25	909.29
13	909.24	909.31	909.37	909.29	909.26	909.18	909.20
14	nm	nm	909.46	909.43	909.48	908.45	909.54
15	909.74	909.74	909.71	909.59	909.47	909.38	909.53
16	909.76	909.77	909.74	909.63	909.51	nm	909.59

Well #	June 27, 1996	July 4, 1996	July 11, 1996	July 23, 1996	Aug. 6, 1996	Aug. 15, 1996	Aug. 21, 1996
1	908.75	908.73	908.65	908.53	908.37	908.22	908.13
2	909.83	909.79	909.70	909.63	909.62	909.37	909.42
3	909.96	909.92	909.84	909.72	909.62	909.50	909.42
4	910.03	909.98	909.89	909.80	909.71	909.62	909.55
5	909.65	909.73	909.71	909.71	909.80	909.74	909.73
6	909.42	909.50	909.45	909.51	909.65	909.63	909.63
7	909.80	910.02	909.99	909.96	910.02	909.91	909.80
8	909.93	909.87	909.76	909.64	909.63	909.57	909.53
9	909.53	909.63	909.60	909.56	909.58	909.49	909.42
10	909.13	909.29	909.34	909.44	909.57	909.47	909.44
11	910.18	909.99	909.81	909.66	909.72	909.59	909.54
12	909.90	909.88	909.80	909.64	909.69	909.59	909.54
13	910.25	909.99	909.76	909.58	909.80	909.60	909.49
14	909.85	909.75	909.59	909.54	909.51	909.36	909.47
15	909.95	909.72	909.52	909.55	909.39	909.27	909.40
16	909.98	909.75	909.58	909.58	909.45	909.35	909.47

nm = not measured.

Well no.	Sept. 26, 1996	Oct. 2, 1996	Nov. 14, 1996	May 9, 1997	June 12, 1997	Aug. 5, 1997	Sept. 5, 1997
1	907.65	907.55	907.64	908.34	908.46	907.76	907.58
2	909.28	909.17	909.16	909.11	909.31	909.08	908.93
3	909.07	909.03	908.97	909.31	909.42	908.75	908.50
4	909.14	909.05	908.86	908.83	908.78	908.36	908.13
5	909.80	909.74	909.65	909.84	910.66	910.51	910.49
6	909.68	909.66	909.75	909.73	910.51	910.50	910.41
7	909.81	909.84	909.74	909.87	910.74	909.71	909.49
8	909.73	909.66	909.54	909.87	910.74	910.34	910.22
9	909.50	909.48	909.44	909.89	910.67	910.43	910.31
10	909.35	909.28	909.29	909.36	910.61	909.91	909.73
11	910.17	909.68	909.54	909.77	910.71	910.16	909.92
12	909.85	909.78	909.54	909.79	910.58	910.21	910.03
13	910.08	909.90	909.49	909.69	910.83	910.06	909.75
14	909.41	909.31	909.15	909.60	909.88	909.45	909.77
15	909.48	909.52	909.16	909.61	909.90	909.35	909.74
16	909.52	909.57	909.19	909.60	909.97	909.44	909.88

Well #	Oct. 27, 1997	Feb. 17, 1998	April 27, 1998	May 12, 1998	May 25, 1998	June 15, 1998	July 6, 1998
1	907.44	907.42	907.67	907.86	907.83	907.77	909.06
2	908.77	908.58	908.94	909.02	909.07	909.01	909.70
3	908.25	908.04	908.45	908.56	908.57	908.48	909.87
4	907.87	907.48	907.47	907.56	907.58	907.73	907.76
5	910.31	909.95	910.13	910.21	910.21	910.26	910.29
6	910.20	909.65	909.93	910.08	910.07	910.17	910.27
7	909.23	909.11	909.81	909.87	909.85	909.89	909.95
8	910.06	909.67	910.00	910.04	910.06	910.10	910.10
9	910.07	909.35	910.01	910.06	910.07	910.10	910.19
10	909.42	909.02	909.57	909.61	909.62	909.68	909.76
11	909.62	909.13	909.97	909.92	910.00	909.89	910.47
12	909.70	908.91	909.94	909.94	909.96	909.92	910.30
13	909.31	908.72	909.94	909.85	909.95	909.83	910.48
14	909.70	908.80	909.92	909.74	910.04	909.68	910.45
15	909.64	908.77	909.93	909.73	910.05	909.69	910.49
16	909.68	908.88	909.96	909.76	910.09	909.70	910.51

Well no.	July 14, 1998	July 27, 1998	Aug. 10, 1998	Aug. 24, 1998	Sept. 15, 1998	Sept. 28, 1998	Oct. 13, 1998
1	909.15	908.80	908.58	908.36	908.05	907.95	907.92
2	909.70	909.46	908.23	909.34	909.31	909.99	910.00
3	909.60	909.33	909.14	909.12	909.12	909.69	909.75
4	908.22	908.29	908.13	908.32	908.35	909.18	909.35
5	910.37	909.96	910.15	910.42	910.38	910.35	910.31
6	910.31	910.29	910.35	910.35	910.27	910.23	910.26
7	909.99	909.98	910.02	910.01	909.94	909.89	909.88
8	910.12	910.15	910.19	910.13	910.09	910.01	910.02
9	910.24	910.24	910.25	910.22	910.12	910.05	910.05
10	909.81	909.79	908.80	909.81	909.81	909.78	909.74
11	910.33	910.17	910.31	910.08	909.86	909.82	909.71
12	910.31	910.22	910.25	910.13	909.95	909.84	909.80
13	910.37	910.17	910.30	910.05	909.80	909.69	909.63
14	910.22	909.85	909.59	909.87	909.71	909.51	909.27
15	910.26	909.92	909.94	910.00	909.89	909.58	909.40
16	910.27	909.91	909.94	909.99	910.15	909.58	909.42

Well #	Oct. 26, 1998	Nov. 16, 1998	Nov. 30, 1998	Dec. 14, 1998	Jan. 11, 1999	Feb. 17, 1999	Mar. 15, 1999
1	907.92	907.99	908.01	908.05	908.17	908.13	908.15
2	910.00	909.29	909.37	909.28	909.12	909.07	909.01
3	909.47	909.20	909.12	909.00	909.00	908.88	908.78
4	909.24	908.93	908.81	908.71	908.65	908.50	908.42
5	910.29	910.24	910.20	910.14	909.99	909.88	909.89
6	910.21	910.15	910.11	910.02	909.89	909.73	909.79
7	909.88	909.86	909.85	909.82	909.73	909.66	909.77
8	909.97	909.91	909.89	909.86	909.62	909.57	909.68
9	909.97	909.88	909.85	909.79	909.36	909.22	909.44
10	909.75	909.73	909.70	909.63	909.53	909.39	909.49
11	909.62	909.56	909.53	909.47	909.21	909.18	909.28
12	909.70	909.60	909.57	909.48	908.98	908.90	909.12
13	909.57	909.49	909.48	909.42	909.16	909.01	909.16
14	909.11	908.96	908.89	908.83	908.90	908.74	908.70
15	909.20	909.08	909.04	908.96	908.93	908.87	908.86
16	909.20	909.08	909.07	908.98	908.97	908.92	908.93

Well no.	Apr. 12, 1999	Apr. 26, 1999	May 17, 1999	May 25, 1999	May 31, 1999	June 14, 1999	June 28, 1999
1	908.24	908.27	908.30	908.41	908.47	908.54	908.54
2	908.99	908.93	909.00	908.97	909.12	908.82	909.58
3	908.76	908.74	908.74	908.91	908.92	908.93	908.78
4	908.39	908.40	908.38	908.48	908.51	908.69	908.73
5	909.94	909.99	910.79	910.44	910.64	910.29	910.29
6	909.95	910.01	910.04	910.11	910.16	910.08	910.17
7	909.78	909.86	910.28	910.27	910.25	910.22	910.24
8	909.80	909.82	910.50	910.32	910.28	910.19	910.20
9	909.89	909.91	910.01	910.03	910.06	910.04	910.08
10	909.55	909.59	910.36	910.25	910.23	910.26	909.81
11	909.43	909.49	910.51	910.27	910.19	910.24	910.15
12	909.60	909.62	909.89	909.97	909.99	909.64	909.61
13	909.39	909.47	910.60	910.34	910.24	910.40	910.31
14	908.73	908.75	909.19	909.56	909.52	909.69	909.42
15	908.88	908.84	909.67	909.73	909.66	909.75	909.46
16	908.95	908.93	909.66	909.69	909.62	909.70	909.43

Well #	July 12, 1999	July 26, 1999	Aug. 16, 1999	Aug. 30, 1999	Sept. 13, 1999	Sept. 27, 1999	Oct. 12, 1999
1	908.44	908.47	908.42	908.35	908.19	908.06	908.00
2	909.43	909.41	909.38	909.32	909.23	909.17	909.16
3	908.63	908.59	908.44	908.39	908.24	908.13	908.11
4	908.67	908.74	908.71	908.65	908.53	908.43	908.38
5	910.26	910.33	910.36	910.35	910.28	910.28	910.23
6	910.18	910.22	910.28	910.36	910.26	910.24	910.23
7	910.24	910.33	910.41	910.41	910.27	910.23	910.19
8	910.18	910.26	910.33	910.26	910.14	910.05	909.99
9	910.11	910.26	910.19	910.25	910.18	910.13	910.08
10	910.22	910.34	910.47	910.29	910.17	910.14	910.03
11	909.73	910.27	910.42	910.12	909.93	909.80	909.70
12	909.58	909.67	909.68	909.66	909.56	909.47	909.40
13	910.14	910.56	910.56	910.25	910.04	909.91	909.82
14	909.19	909.16	908.92	908.75	908.56	908.43	908.31
15	909.20	909.22	908.94	908.78	908.55	908.37	908.28
16	909.20	909.30	909.02	908.83	908.62	908.46	908.39

Well no.	Oct. 25, 1999	Nov. 15, 1999	Nov. 30, 1999	Dec. 13, 1999	Jan. 17, 2000	Feb. 14, 2000	Mar. 13, 2000
1	907.98	907.93	907.98	907.96	907.90	907.92	908.08
2	909.13	908.90	908.83	909.02	909.11	909.07	909.03
3	908.11	908.09	908.18	908.18	908.17	908.23	908.25
4	908.36	908.31	908.33	908.32	908.26	908.26	908.21
5	910.21	910.12	910.11	910.10	910.00	909.84	909.83
6	910.22	910.16	910.22	910.17	910.01	909.83	909.64
7	910.19	910.09	910.09	910.10	910.00	909.87	909.88
8	909.98	909.89	909.90	909.86	909.75	909.55	909.60
9	910.07	909.99	910.00	909.92	909.74	909.32	909.27
10	910.04	909.97	909.94	909.94	909.84	909.71	909.74
11	909.68	909.56	909.52	909.50	909.35	909.29	909.54
12	909.38	909.27	909.25	909.18	908.91	908.50	908.48
13	909.80	909.69	909.69	909.65	909.49	909.33	909.70
14	908.24	908.14	908.10	908.40	908.03	908.01	908.51
15	908.24	908.14	908.19	908.15	908.08	908.14	908.42
16	908.40	908.34	908.41	908.39	908.37	908.46	908.64

Well #	Apr. 11, 2000	May 15, 2000	May 29, 2000	June 12, 2000	June 26, 2000	July 10, 2000	July 24, 2000
1	908.24	908.37	908.16	908.03	907.80	907.65	907.65
2	909.05	909.19	909.13	909.14	909.05	909.09	909.04
3	908.32	908.42	908.20	908.12	907.96	907.93	907.87
4	908.24	908.38	908.31	908.32	908.22	908.19	908.12
5	909.99	910.08	910.14	910.16	910.10	910.14	910.19
6	909.96	910.11	910.08	910.16	910.06	910.17	910.19
7	910.00	910.14	910.14	910.16	910.13	910.21	910.22
8	909.83	909.93	909.93	909.99	909.94	910.00	910.01
9	910.03	910.06	910.03	910.09	910.04	910.09	910.10
10	909.93	910.04	910.07	910.07	910.13	910.17	910.08
11	909.90	909.86	909.76	909.85	909.70	909.69	909.65
12	909.44	909.47	909.38	909.41	909.32	909.32	909.30
13	910.13	910.02	909.91	910.00	909.86	909.86	909.78
14	908.72	908.90	908.76	908.69	908.49	908.38	908.21
15	908.72	908.79	908.58	908.55	908.32	908.20	908.10
16	908.91	909.01	908.79	908.64	908.53	908.42	908.26

Well no.	Aug. 14, 2000	Aug. 28, 2000	Sept. 13, 2000	Sept. 25, 2000	Oct. 16, 2000	Oct. 30, 2000	Nov. 14, 2000
1	907.78	907.53	907.41	907.35	907.23	nm	nm
2	909.06	908.99	909.06	908.99	908.97	908.93	908.94
3	907.81	907.78	907.76	907.78	907.76	907.70	907.75
4	908.02	907.94	907.90	907.86	907.77	907.71	907.70
5	910.19	910.17	910.31	910.22	910.15	910.10	910.03
6	910.19	910.18	910.18	910.19	910.19	910.11	910.09
7	910.24	910.21	910.30	910.23	910.13	910.05	909.96
8	909.95	909.87	910.18	910.11	909.96	909.88	909.85
9	910.09	910.05	910.08	910.07	910.00	909.93	909.87
10	910.06	910.04	910.24	910.15	910.06	909.99	909.89
11	909.53	909.41	909.98	909.78	909.61	909.52	909.40
12	909.21	909.15	909.31	909.29	909.23	909.16	909.06
13	909.68	909.57	910.31	910.04	909.80	909.68	909.55
14	908.06	907.91	907.84	907.79	907.72	907.64	907.61
15	907.94	907.83	907.87	908.04	908.27	908.26	908.34
16	908.08	907.96	907.91	908.02	908.22	908.22	908.29

Well #	Nov. 27, 2000
1	nm
2	908.92
3	907.81
4	907.73
5	910.01
6	910.13
7	909.92
8	909.79
9	909.84
10	909.85
11	909.37
12	909.04
13	909.46
14	907.60
15	908.35
16	908.31

nm = not measured.

Appendix 8. Table-table elevation maps from May, 1996 to November, 2000.

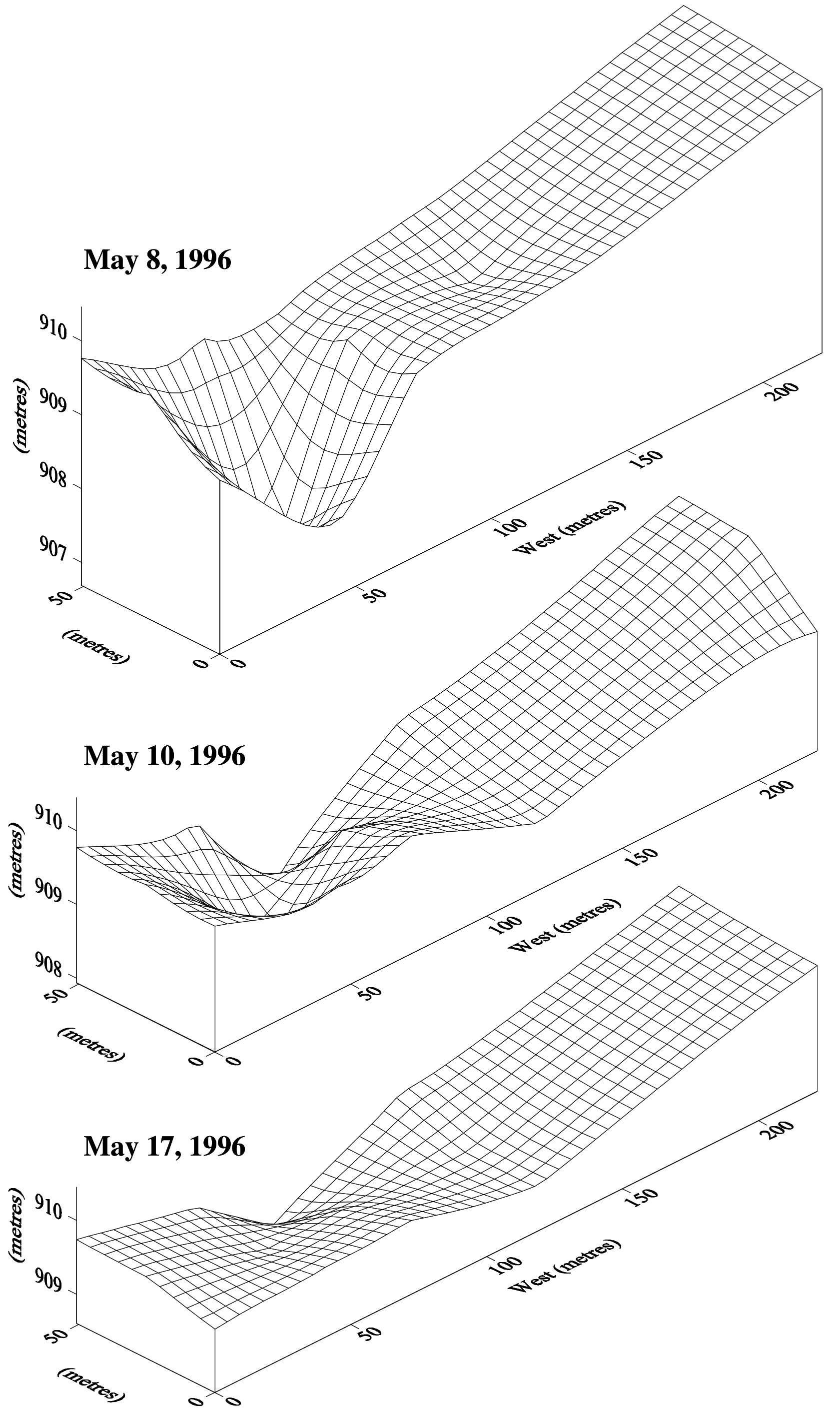

Fig. 8.1. Water-table elevations on May 8, May 10, and May 17, 1996 at the Research Feedlot. Well 14 is located in the NW corner at x:y coordinates of 0:0 metres. Well 1 is not included. The vertical scale is over exaggerated by 24.4 times relative to the two horizontal scales.

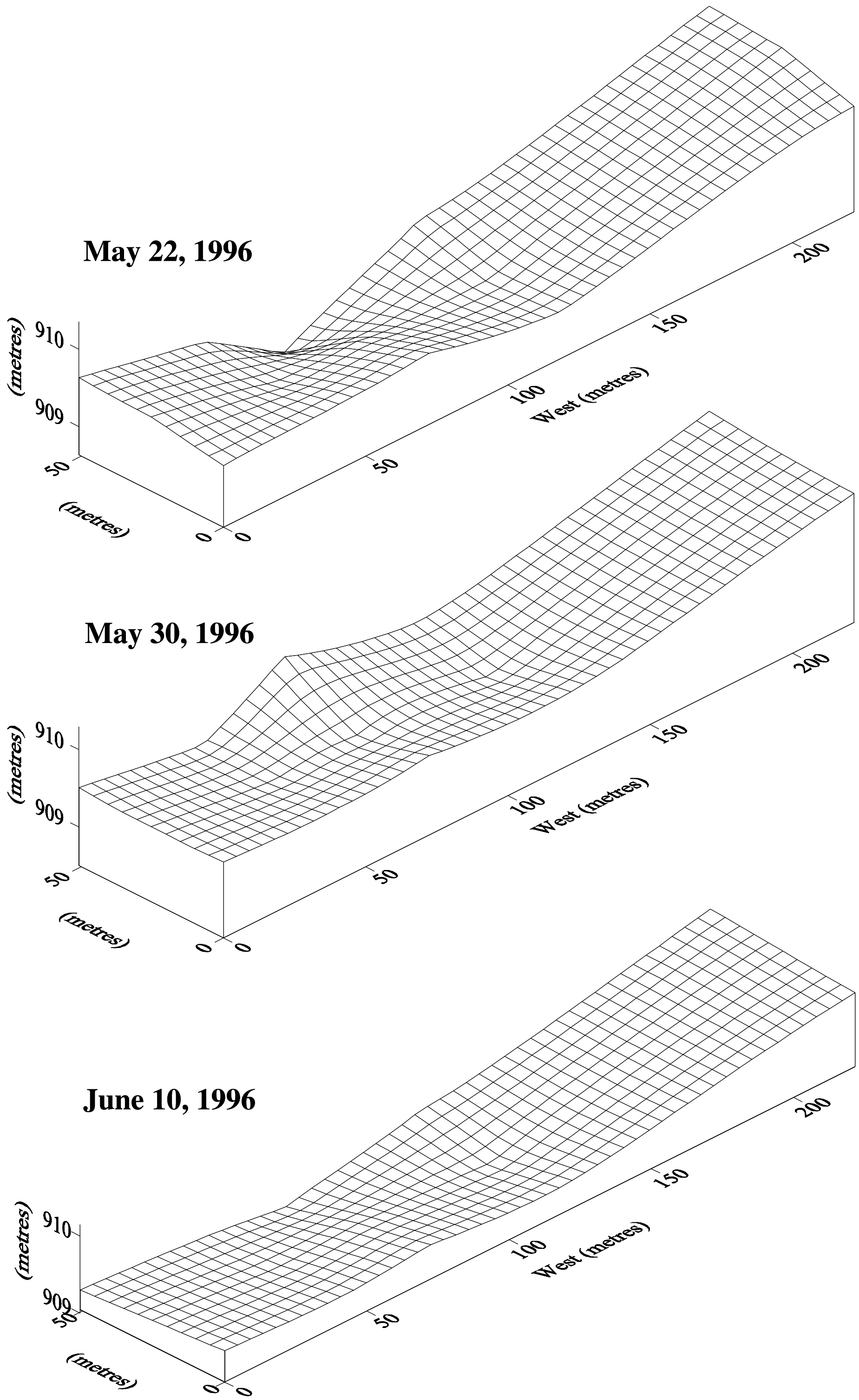

Fig. 8.2. Water-table elevations on May 22, May 30, and June 10, 1996 at the Research Feedlot. Well 14 is located in the NW corner at x:y coordinates of 0:0 metres. Well 1 is not included. The vertical scale is over exaggerated by 24.4 times relative to the two horizontal scales.

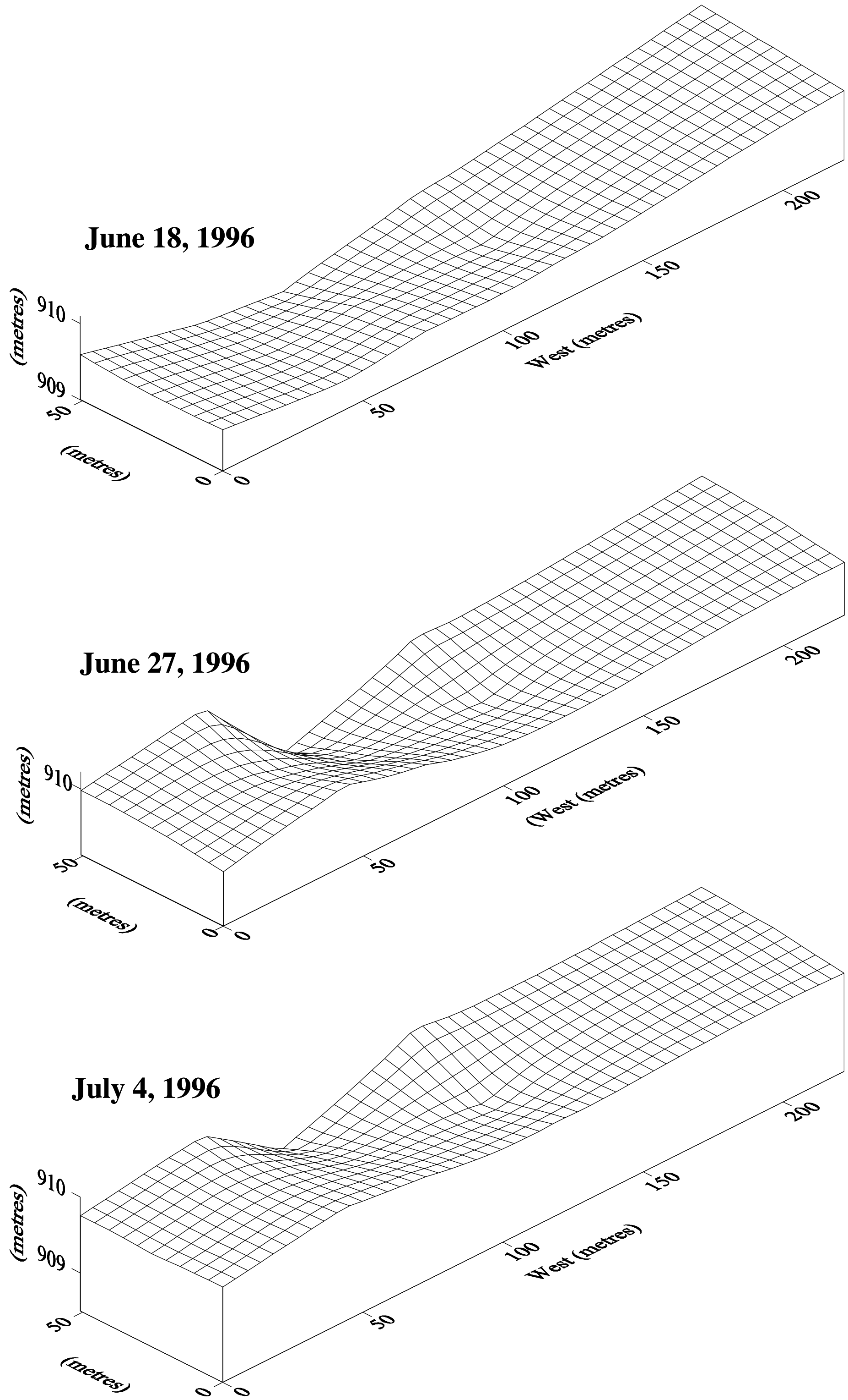

Fig. 8.3. Water-table elevations on June 18, June 27, and July 4, 1996 at the Research Feedlot. Well 14 is located in the NW corner at x:y coordinates of 0:0 metres. Well 1 is not included. The vertical scale is over exaggerated by 24.4 times relative to the two horizontal scales.

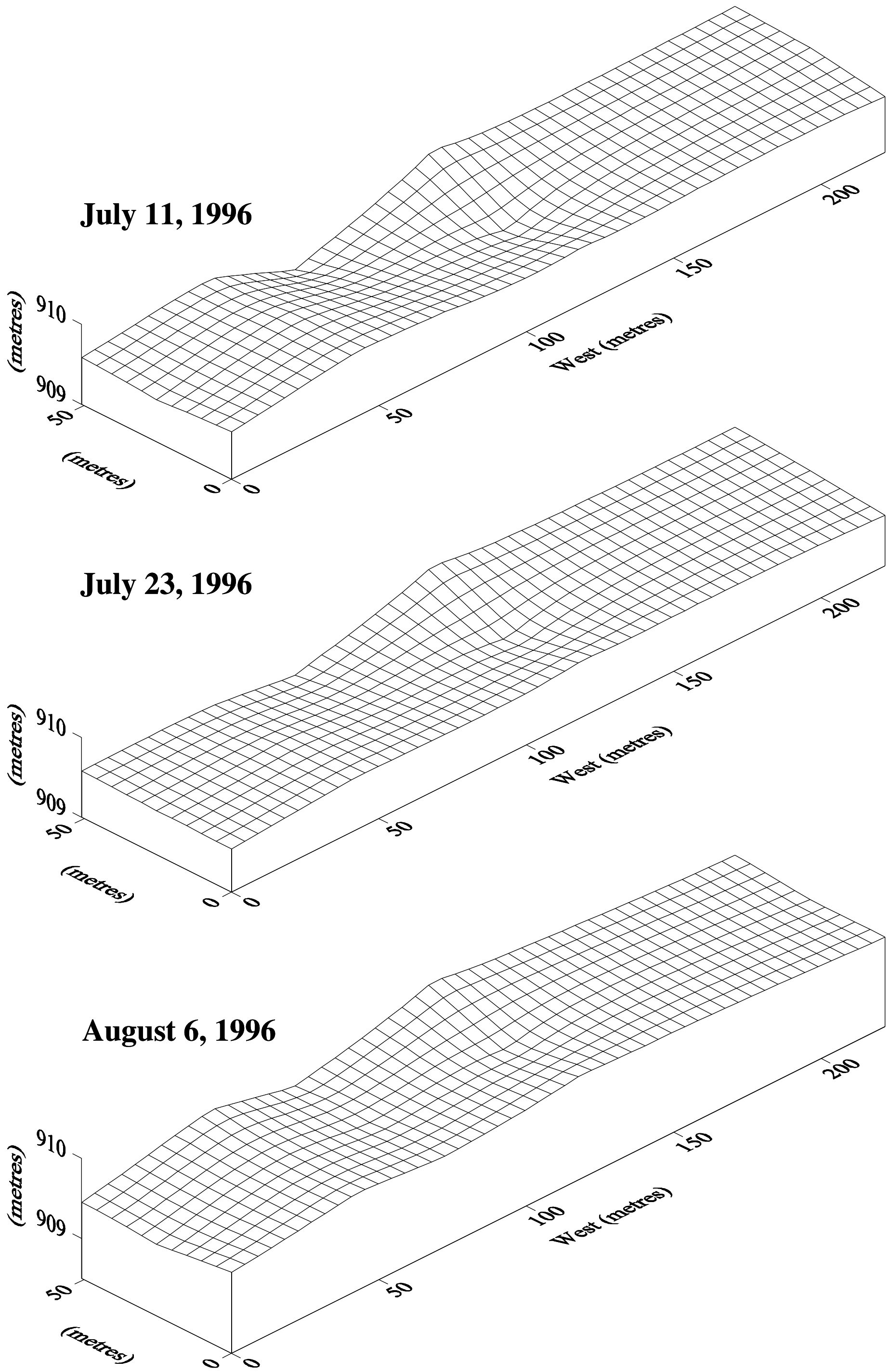

Fig. 8.4. Water-table elevations on July 11, July 23, and August 6, 1996 at the Research Feedlot. Well 14 is located in the NW corner at x:y coordinates of 0:0 metres. Well 1 is not included. The vertical scale is over exaggerated by 24.4 times relative to the two horizontal scales.

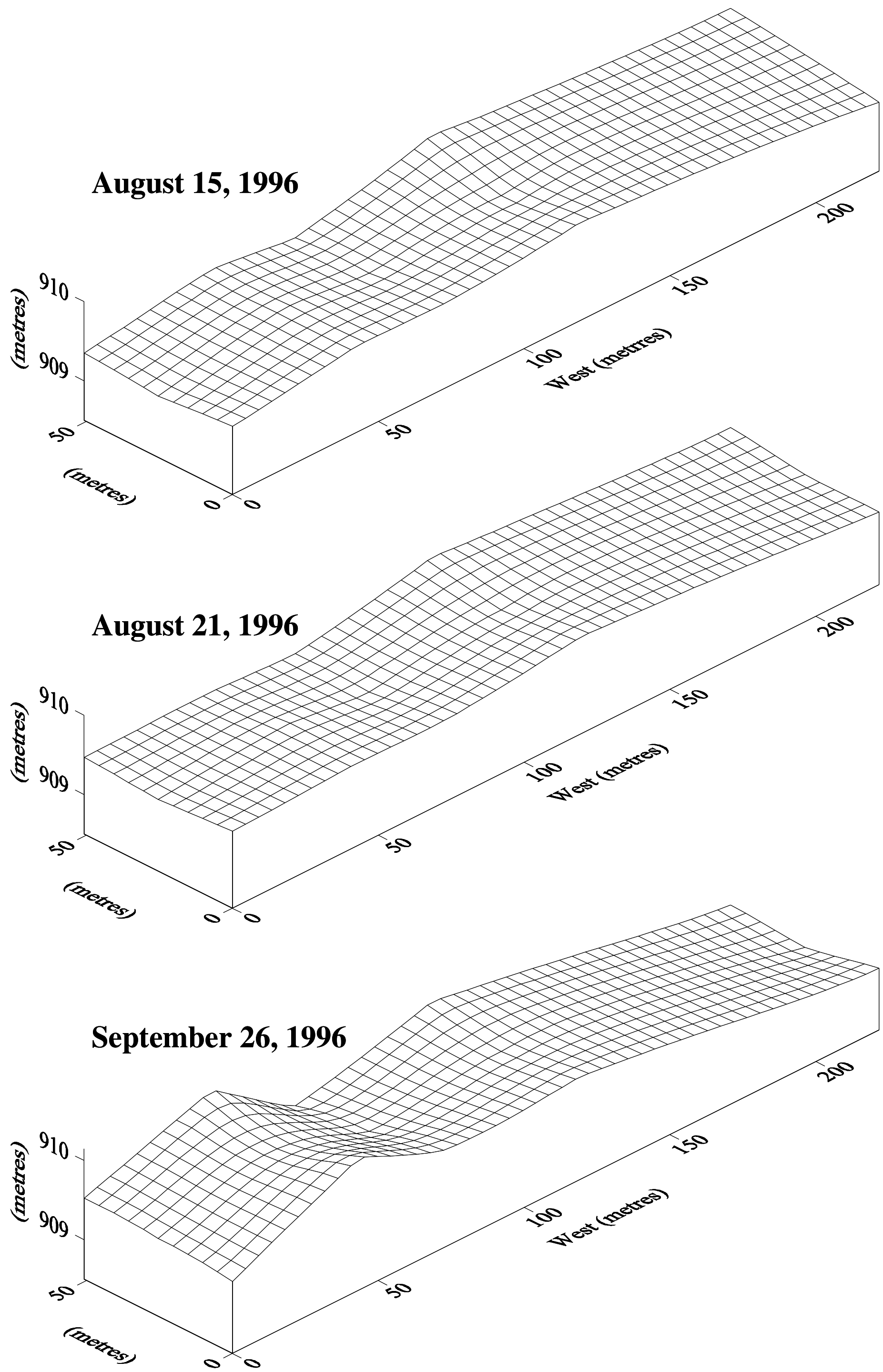

Fig. 8.5. Water-table elevations on August 15, 21, and September 26, 1996 at the Research Feedlot. Well 14 is located in the NW corner at x:y coordinates of 0:0 metres. Well 1 is not included. The vertical scale is over exaggerated by 24.4 times relative to the two horizontal scales.

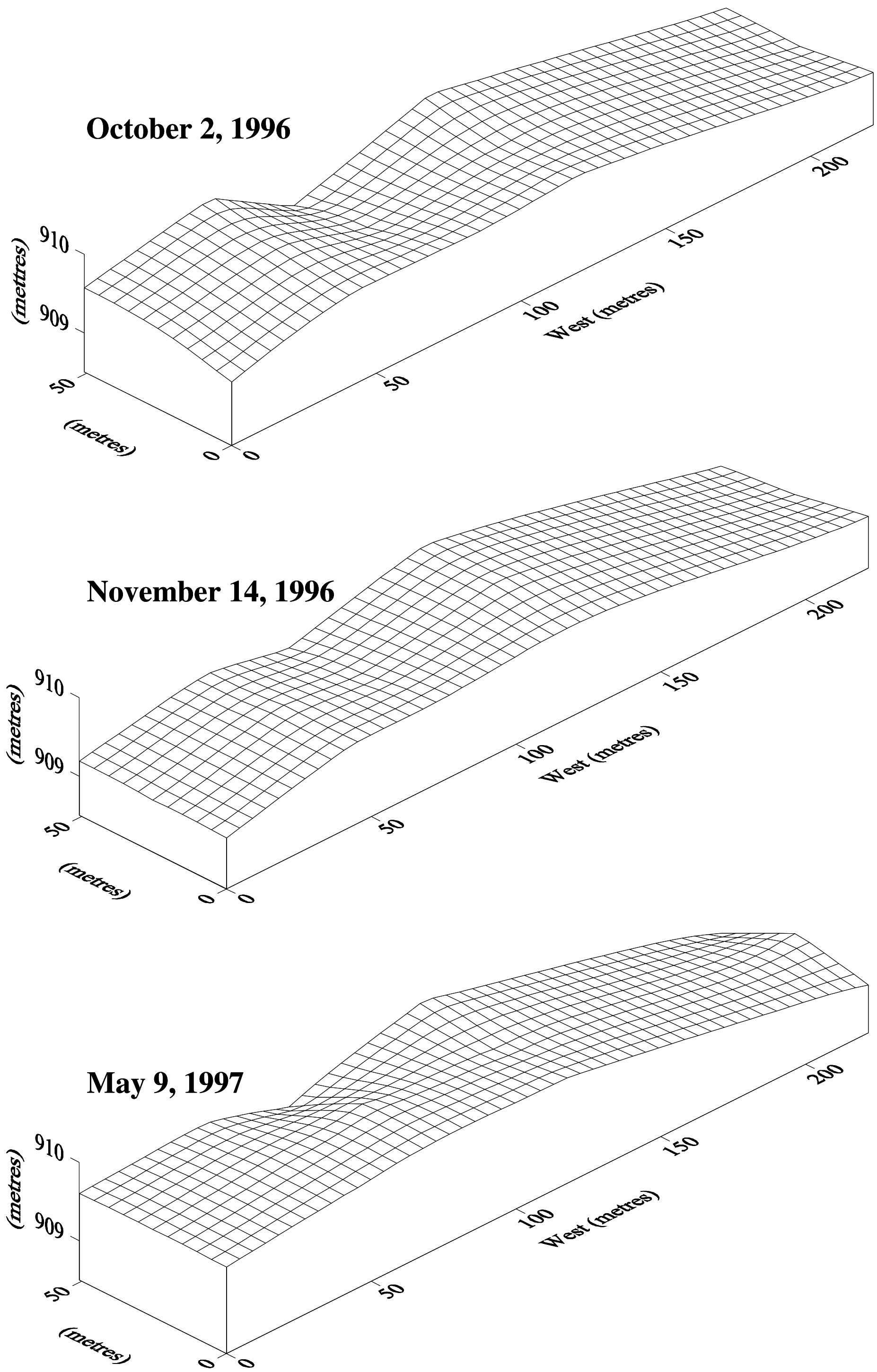

Fig. 8.6. Water-table elevations on October 2, November 14, 1996 and May 9, 1997 at the Research Feedlot. Well 14 is located in the NW corner at x:y coordinates of 0:0 metres. Well 1 is not included. The vertical scale is over exaggerated by 24.4 times relative to the two horizontal scales.

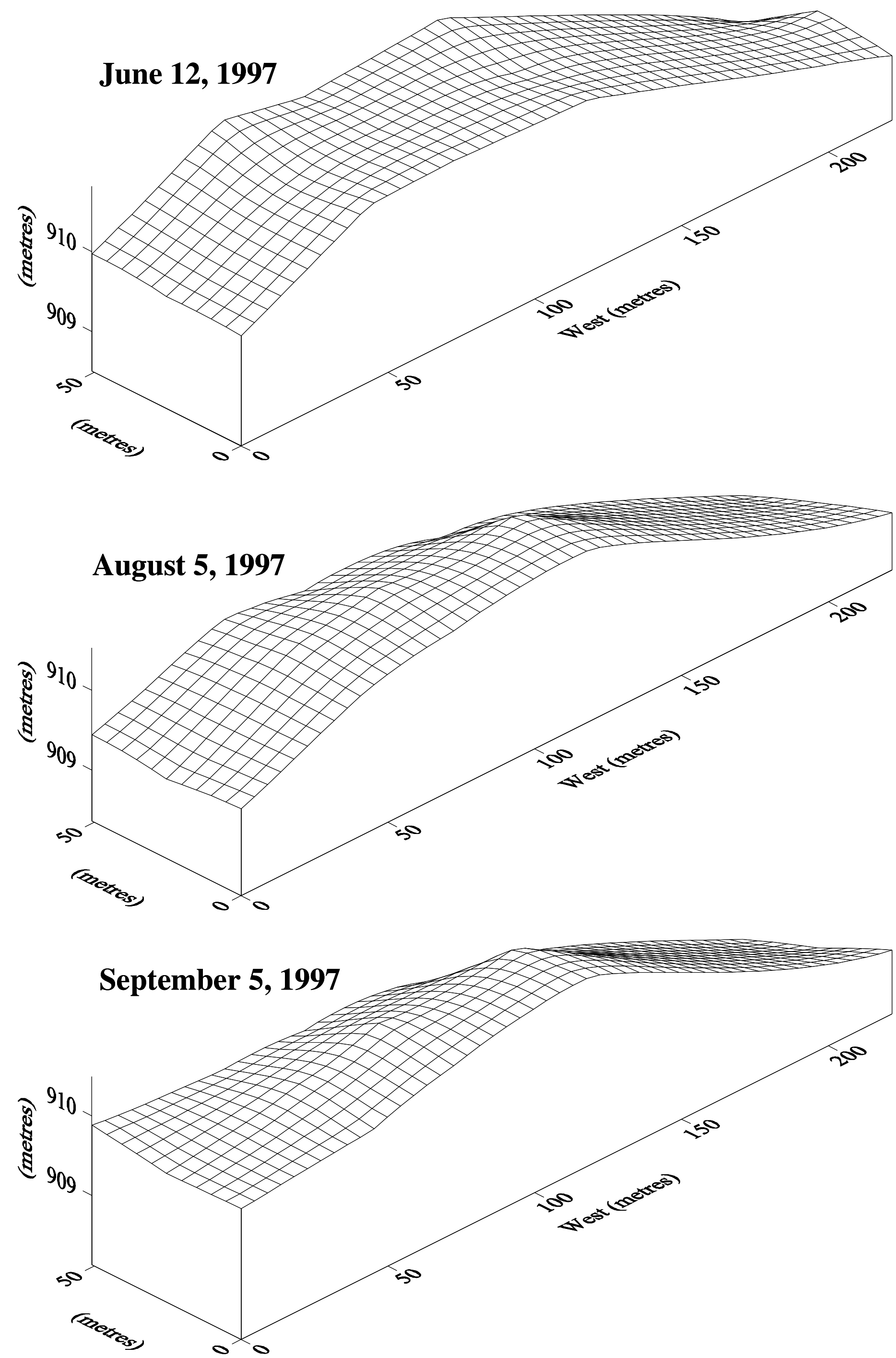

Fig. 8.7. Water-table elevations on June 12, August 5, and September 5, 1997 at the Research Feedlot. Well 14 is located in the NW corner at x:y coordinates of 0:0 metres. Well 1 is not included. The vertical scale is over exaggerated by 24.4 times relative to the two horizontal scales.

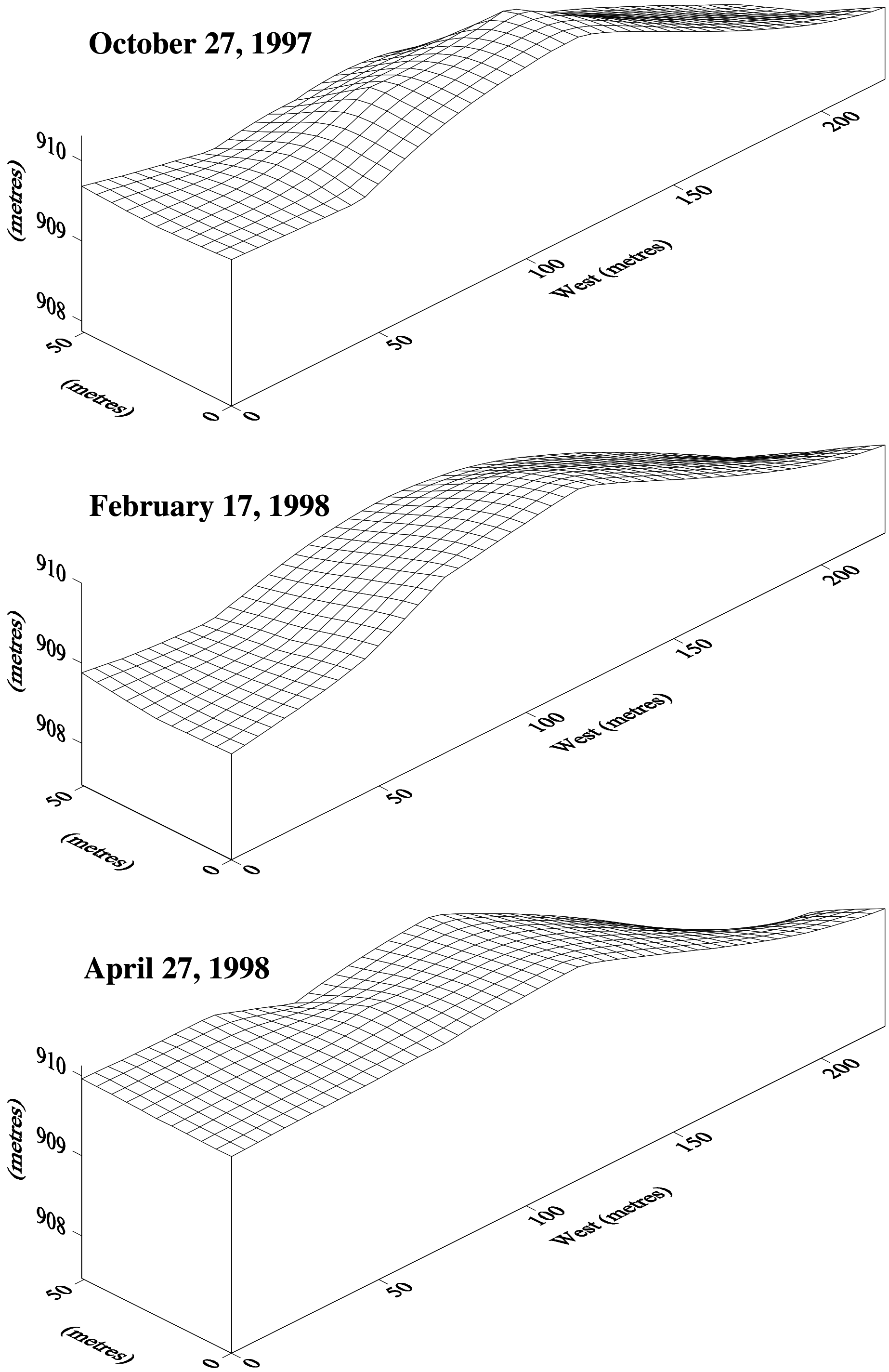

Fig. 8.8. Water-table elevations on August 27, 1997, February 17, and April 27, 1998 at the Research Feedlot. Well 14 is located in the NW corner at x:y coordinates of 0:0 metres. Well 1 is not included. The vertical scale is over exaggerated by 24.4 times relative to the two horizontal scales.

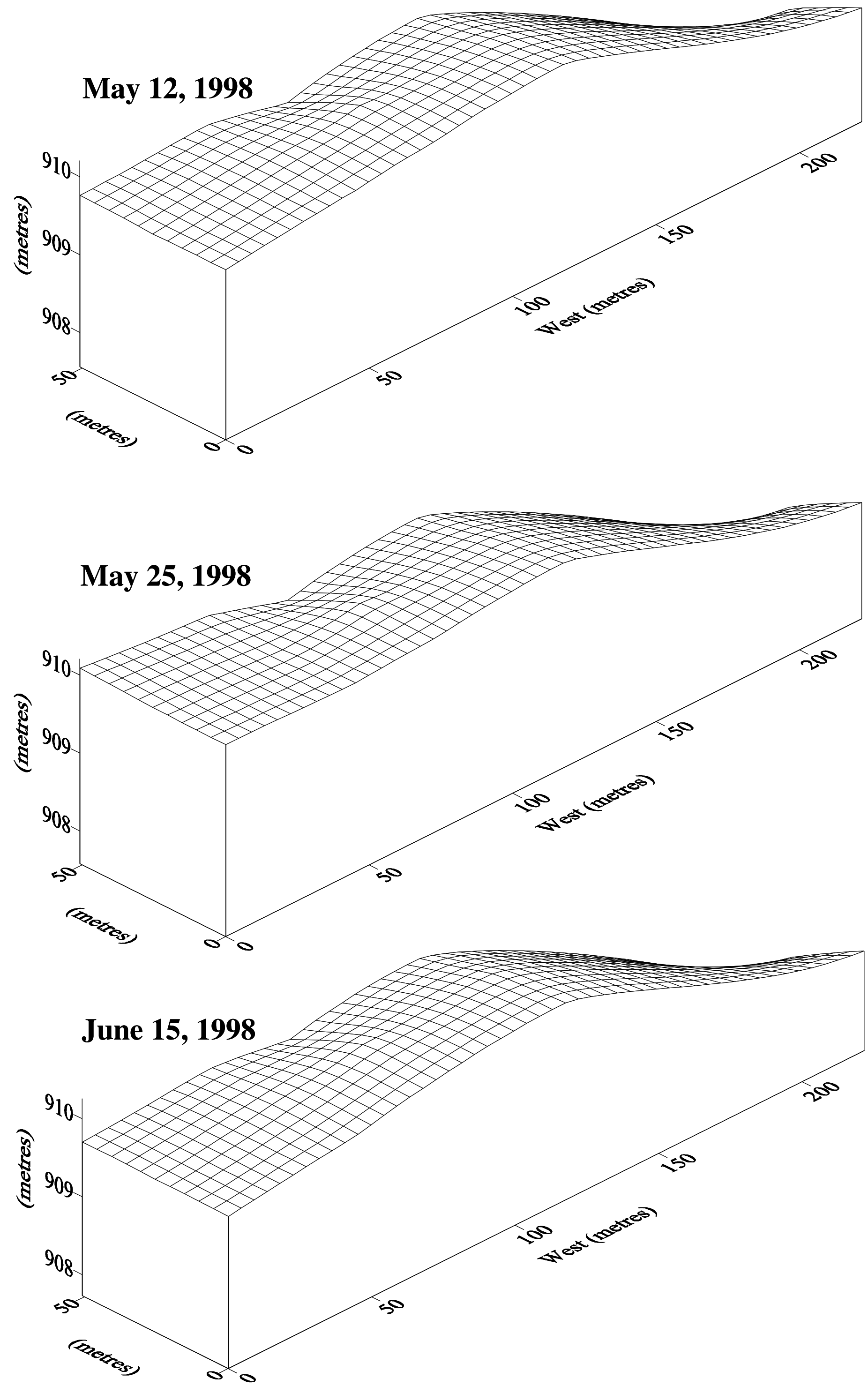

Fig. 8.9. Water-table elevations on May 12, May 25, and June 15, 1998 at the Research Feedlot. Well 14 is located in the NW corner at x:y coordinates of 0:0 metres. Well 1 is not included. The vertical scale is over exaggerated by 24.4 times relative to the two horizontal scales.

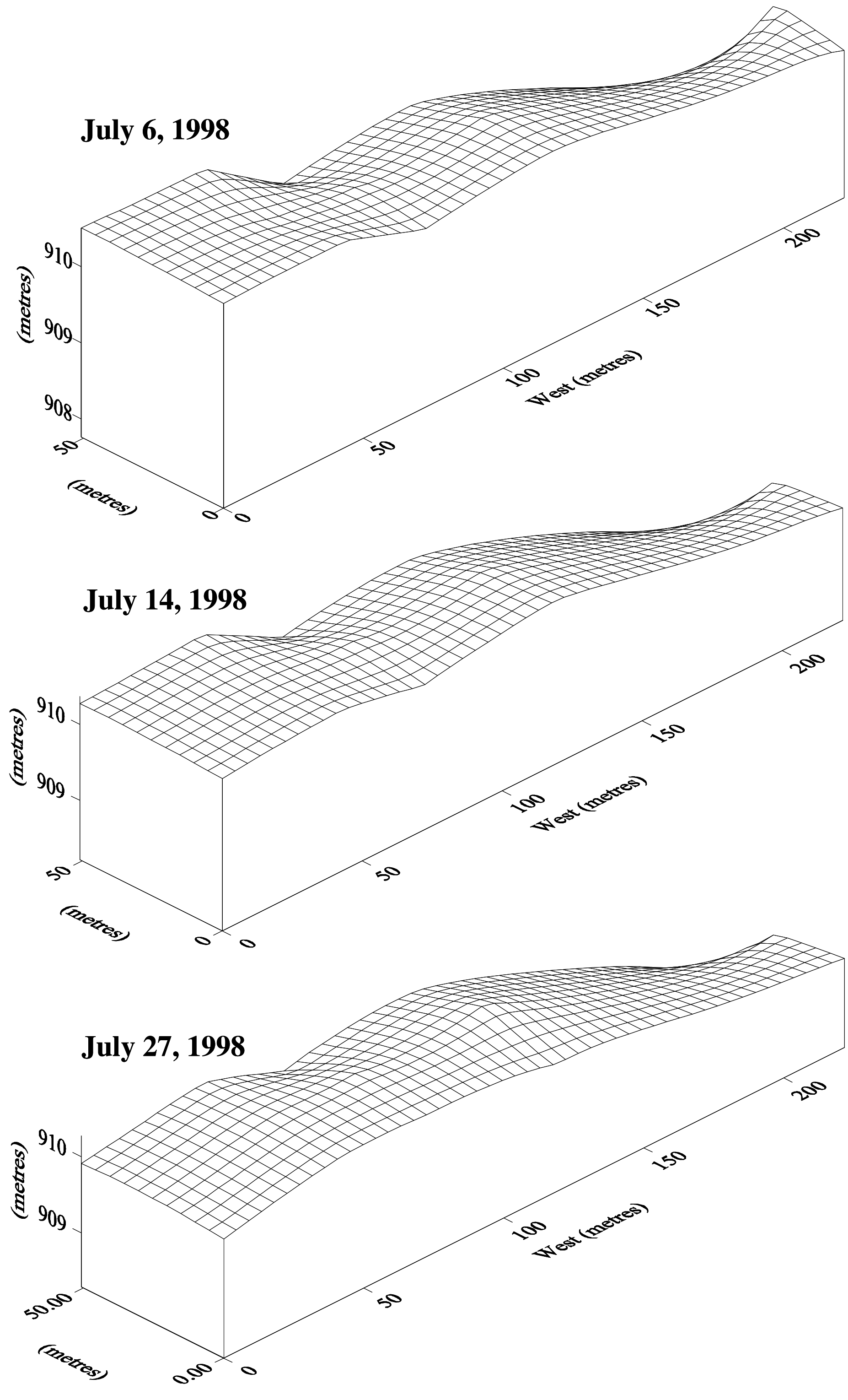

Fig. 8.10. Water-table elevations on July 6, July 14, and July 27, 1998 at the Research Feedlot. Well 14 is located in the NW corner at x:y coordinates of 0:0 metres. Well 1 is not included. The vertical scale is over exaggerated by 24.4 times relative to the two horizontal scales.

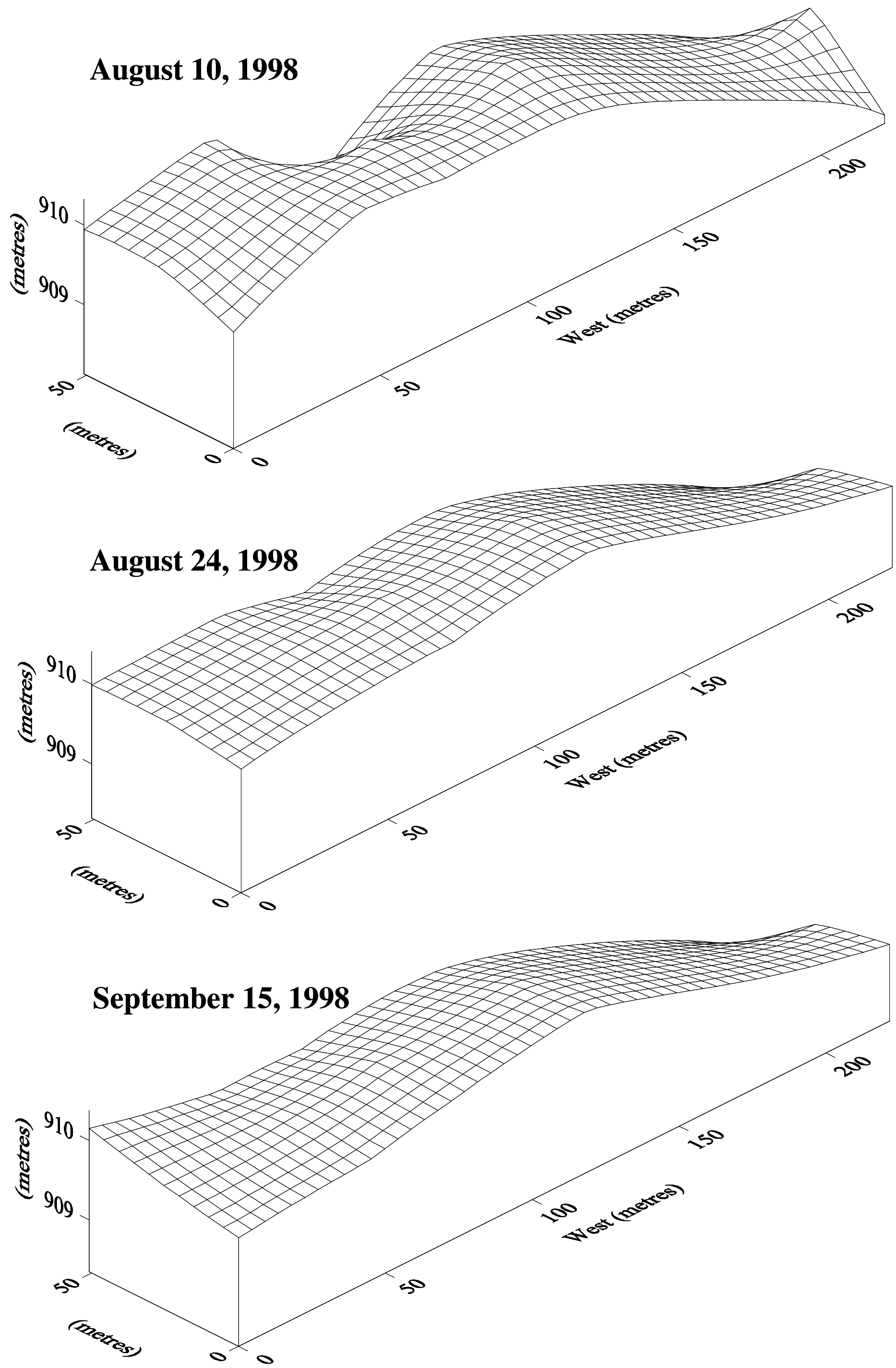

Fig. 8.11. Water-table elevations on August 10, 24, and September 15, 1998 at the Research Feedlot. Well 14 is located in the NW corner at x:y coordinates of 0:0 metres. Well 1 is not included. The vertical scale is over exaggerated by 24.4 times relative to the two horizontal scales.

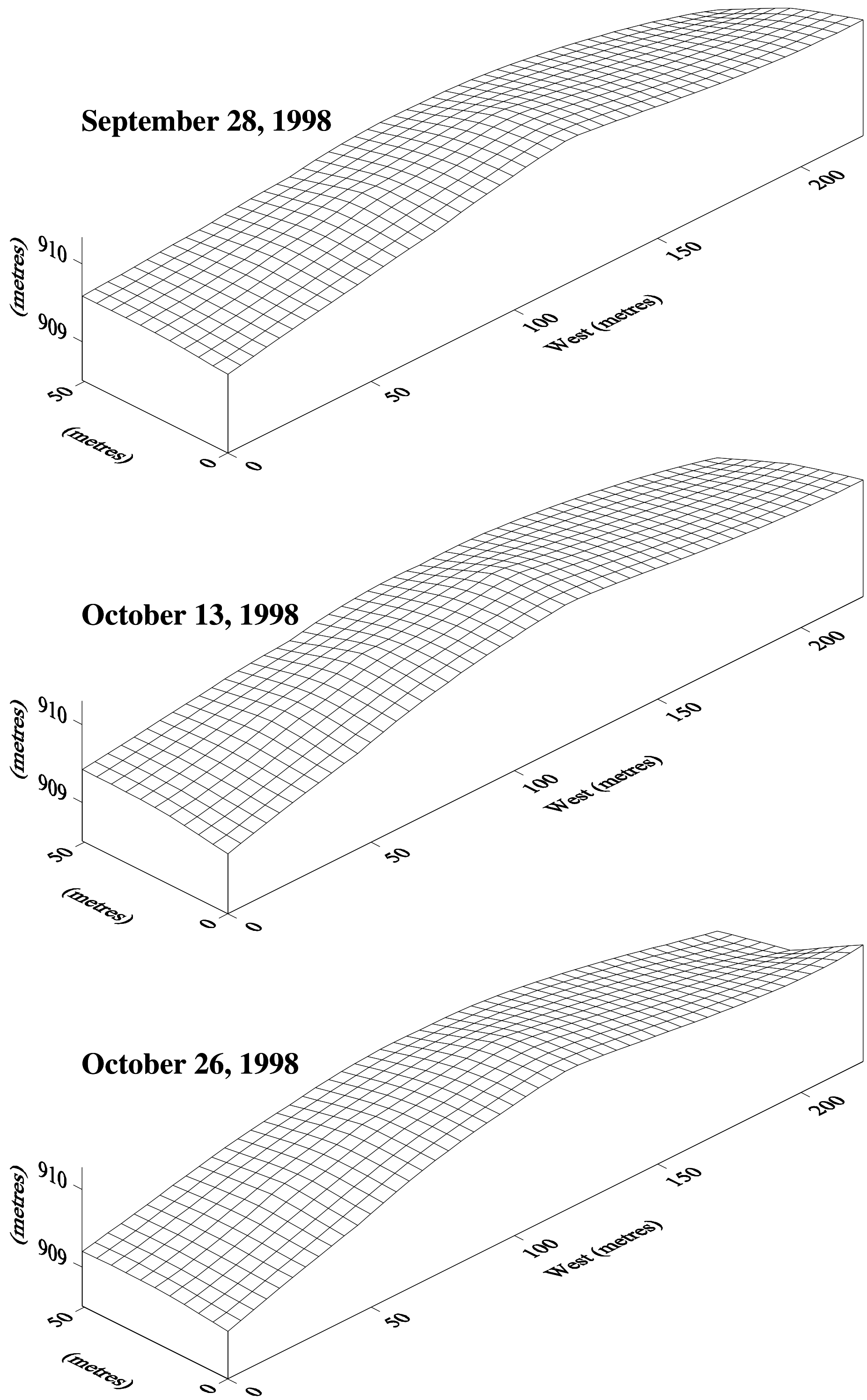

Fig. 8.12. Water-table elevations on September 28, October 13, and 26, 1998 at the Research Feedlot. Well 14 is located in the NW corner at x:y coordinates of 0:0 metres. Well 1 is not included. The vertical scale is over exaggerated by 24.4 times relative to the two horizontal scales.

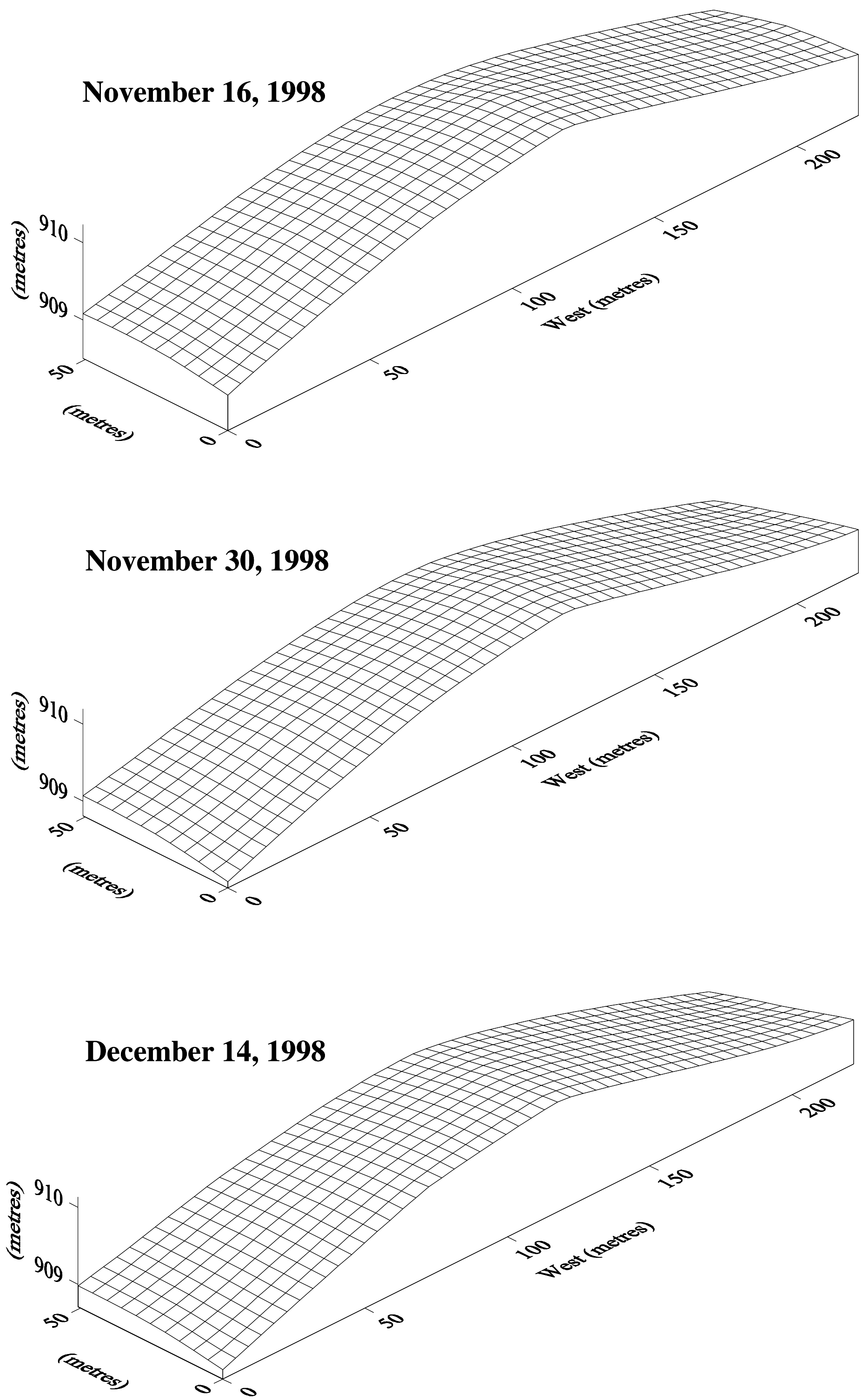

Fig. 8.13. Water-table elevations on November 16, 30, and December 14, 1998 at the Research Feedlot. Well 14 is located in the NW corner at x:y coordinates of 0:0 metres. Well 1 is not included. The vertical scale is over exaggerated by 24.4 times relative to the two horizontal scales.

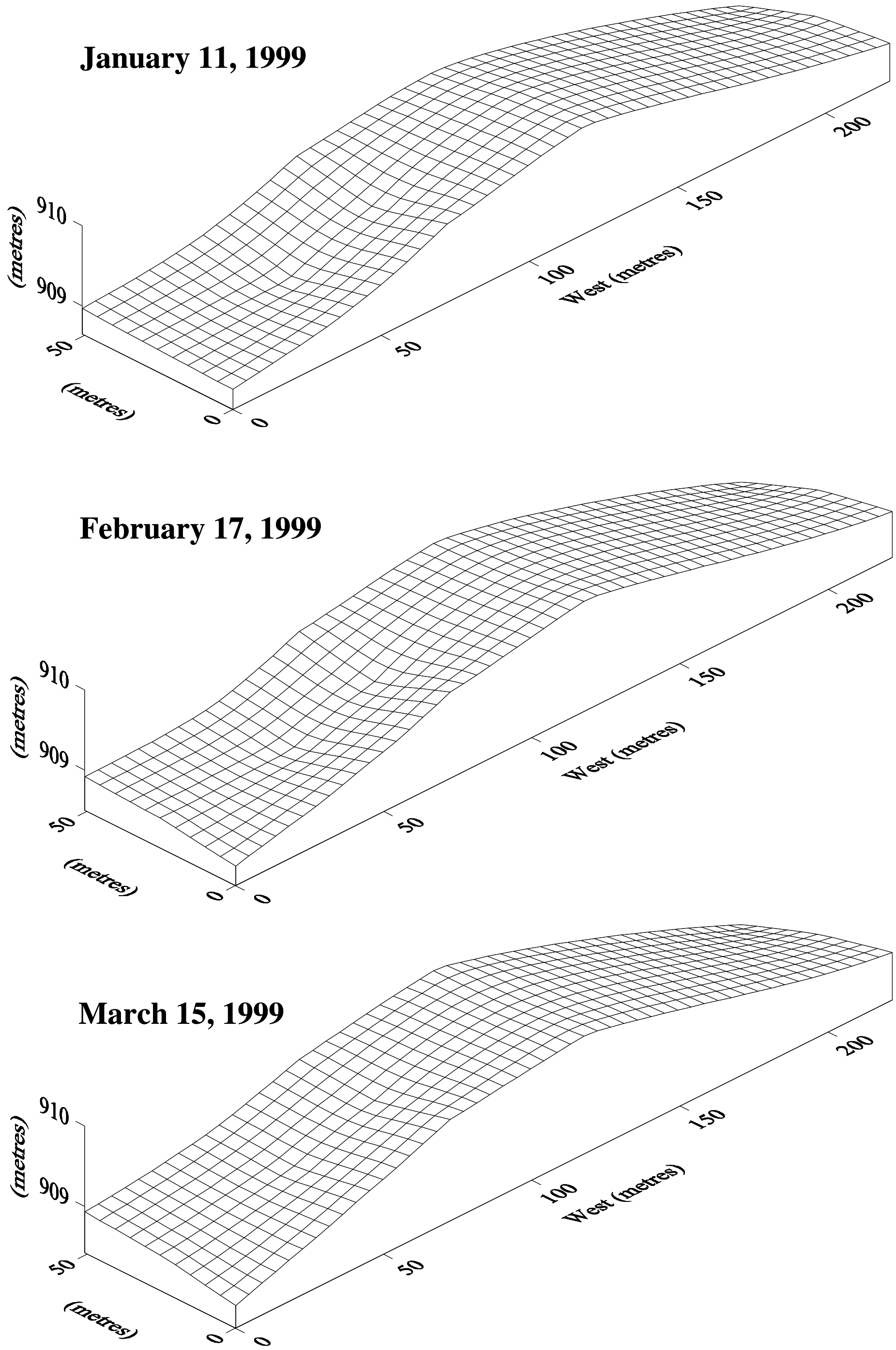

Fig. 8.14. Water-table elevations on January 11, February 17, and March 15, 1999 at the Research Feedlot. Well 14 is located in the NW corner at x:y coordinates of 0:0 metres. Well 1 is not included. The vertical scale is over exaggerated by 24.4 times relative to the two horizontal scales.

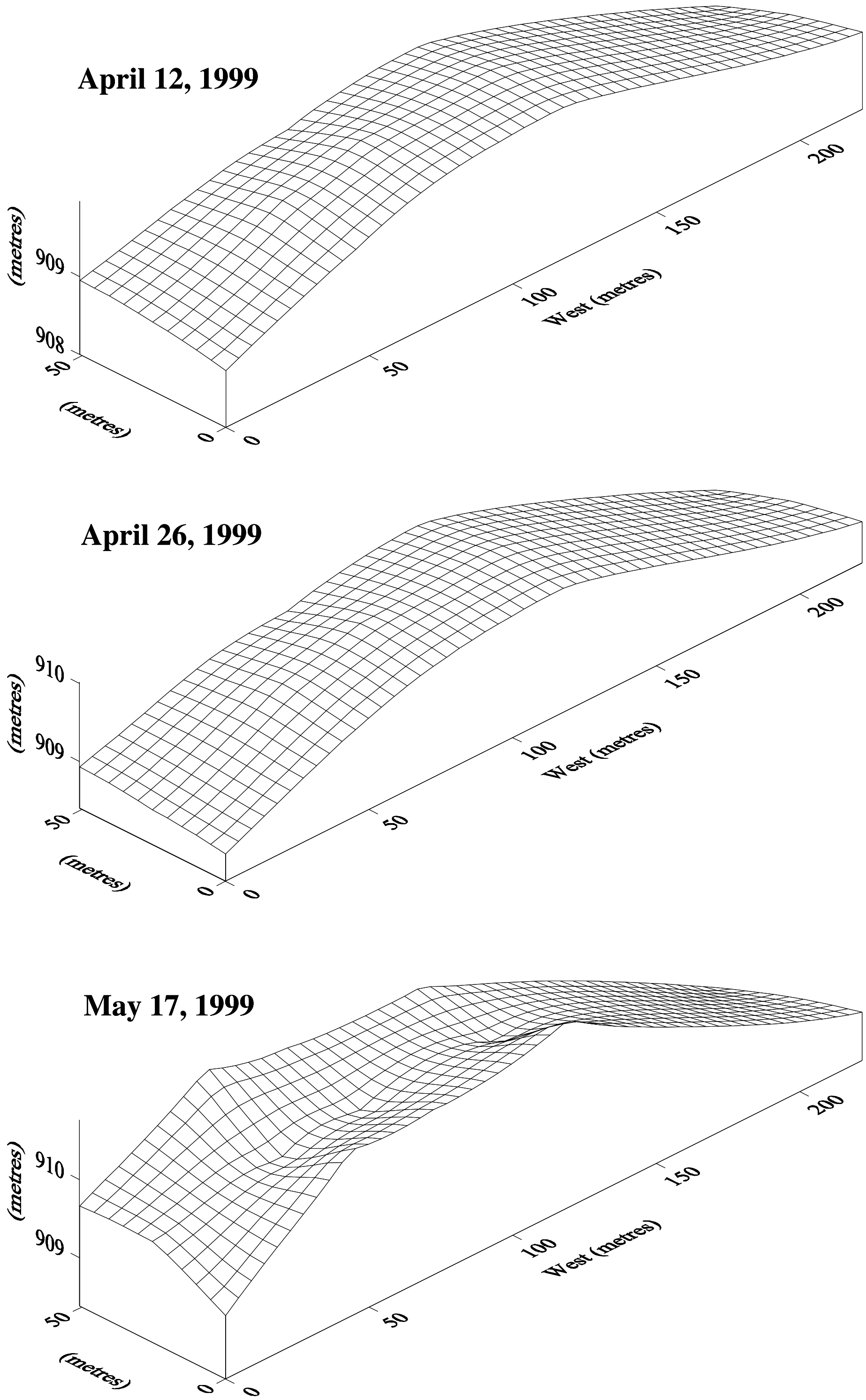

Fig. 8.15. Water-table elevations on April 12, April 26, and May 17, 1999 at the Research Feedlot. Well 14 is located in the NW corner at x:y coordinates of 0:0 metres. Well 1 is not included. The vertical scale is over exaggerated by 24.4 times relative to the two horizontal scales.

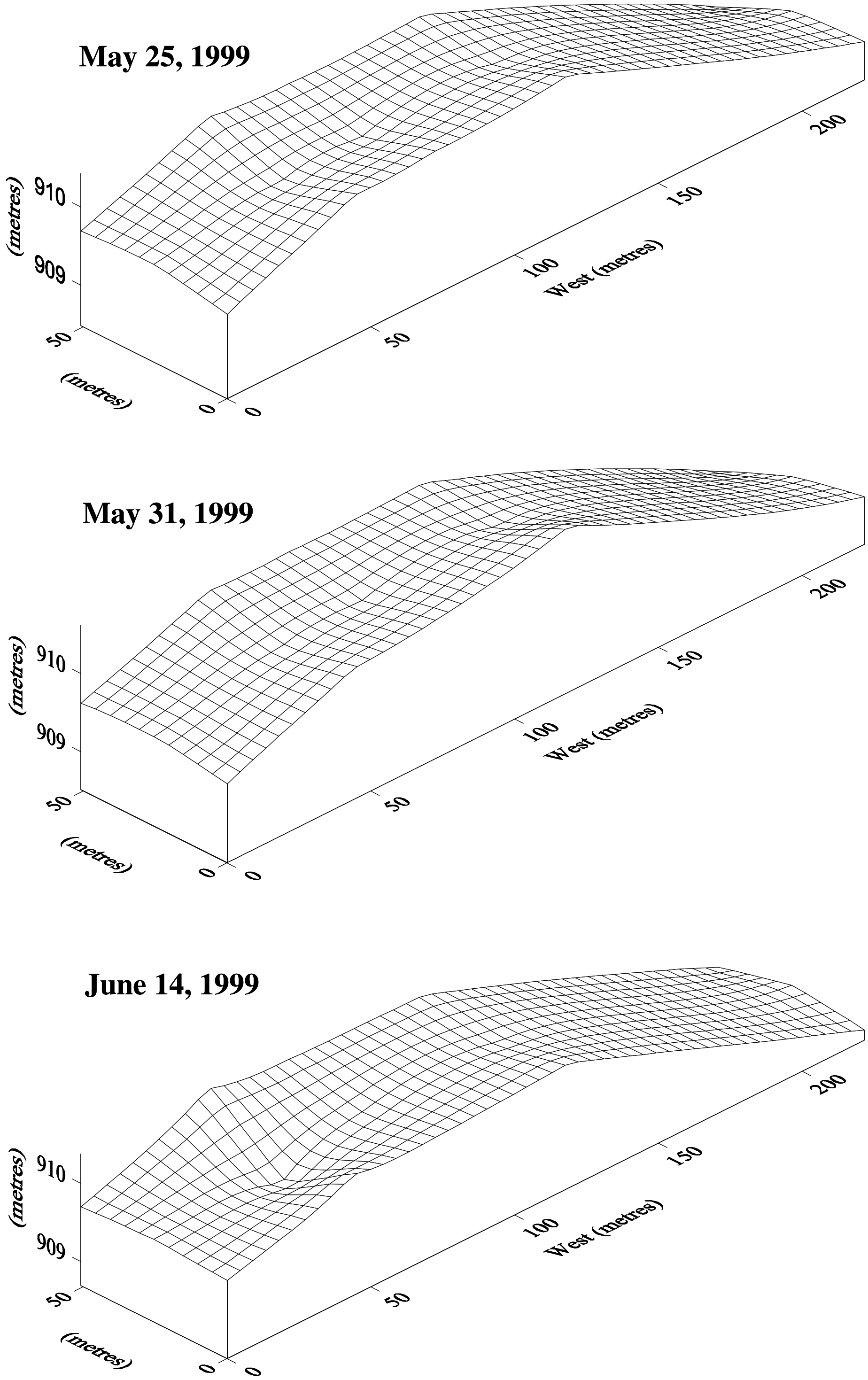

Fig. 8.16. Water-table elevations on May 25, May 31, and June 14, 1999 at the Research Feedlot. Well 14 is located in the NW corner at x:y coordinates of 0:0 metres. Well 1 is not included. The vertical scale is over exaggerated by 24.4 times relative to the two horizontal scales.

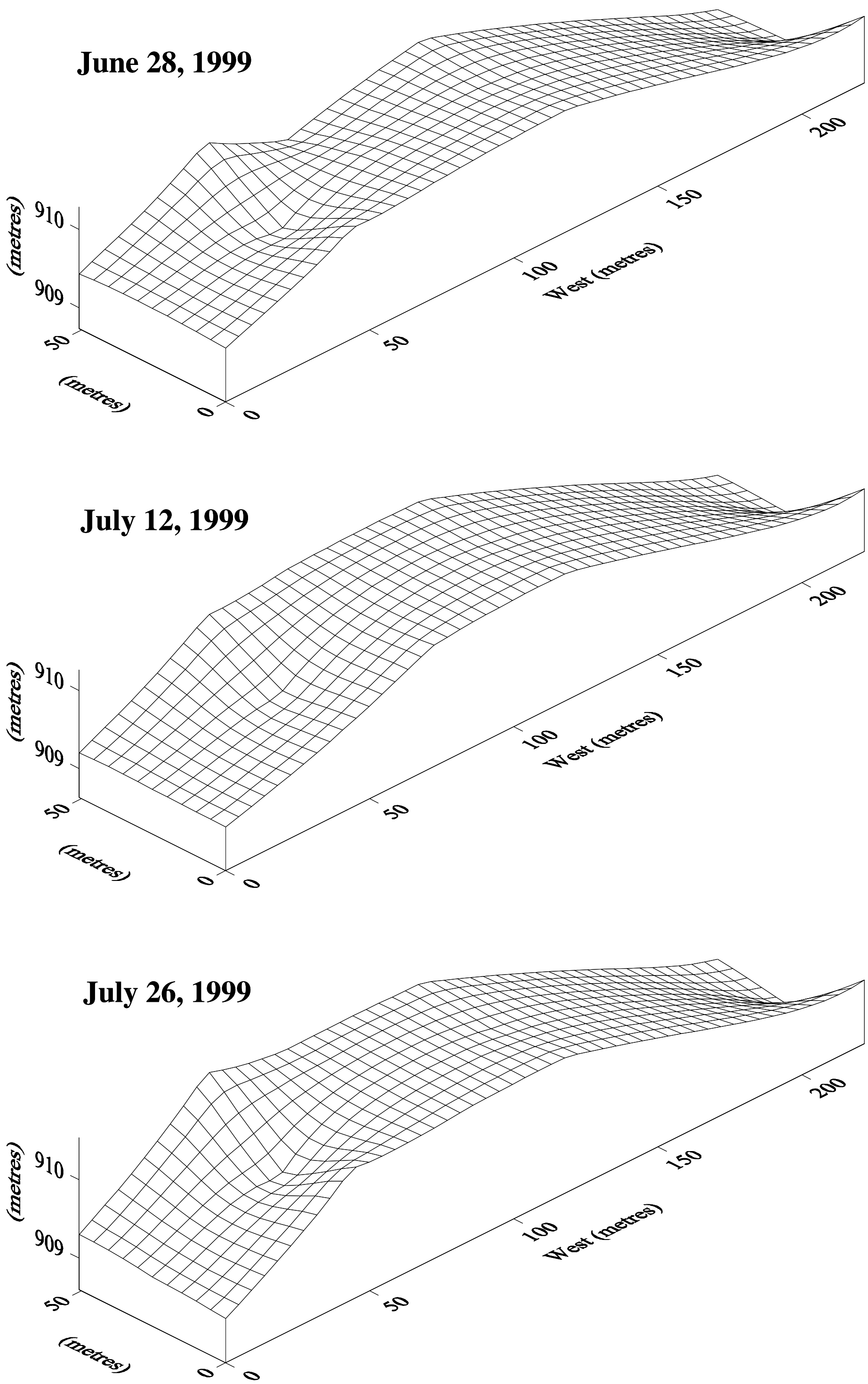

Fig. 8.17. Water-table elevations on June 28, July 12, and July 26, 1999 at the Research Feedlot. Well 14 is located in the NW corner at x:y coordinates of 0:0 metres. Well 1 is not included. The vertical scale is over exaggerated by 24.4 times relative to the two horizontal scales.

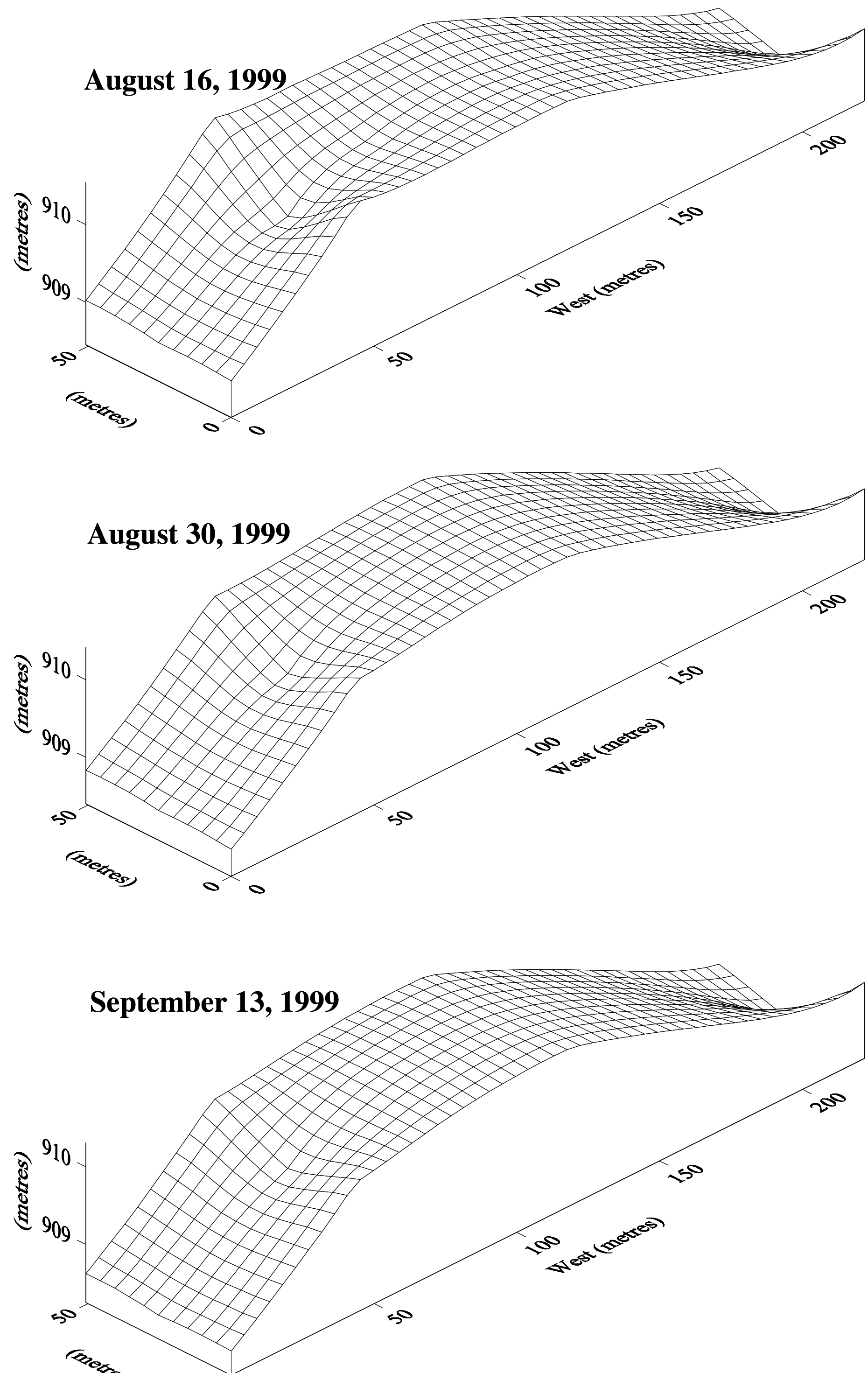

Fig. 8.18. Water-table elevations on August 16, August 30, and September 13, 1999 at the Research Feedlot. Well 14 is located in the NW corner at x:y coordinates of 0:0 metres. Well 1 is not included. The vertical scale is over exaggerated by 24.4 times relative to the two horizontal scales.

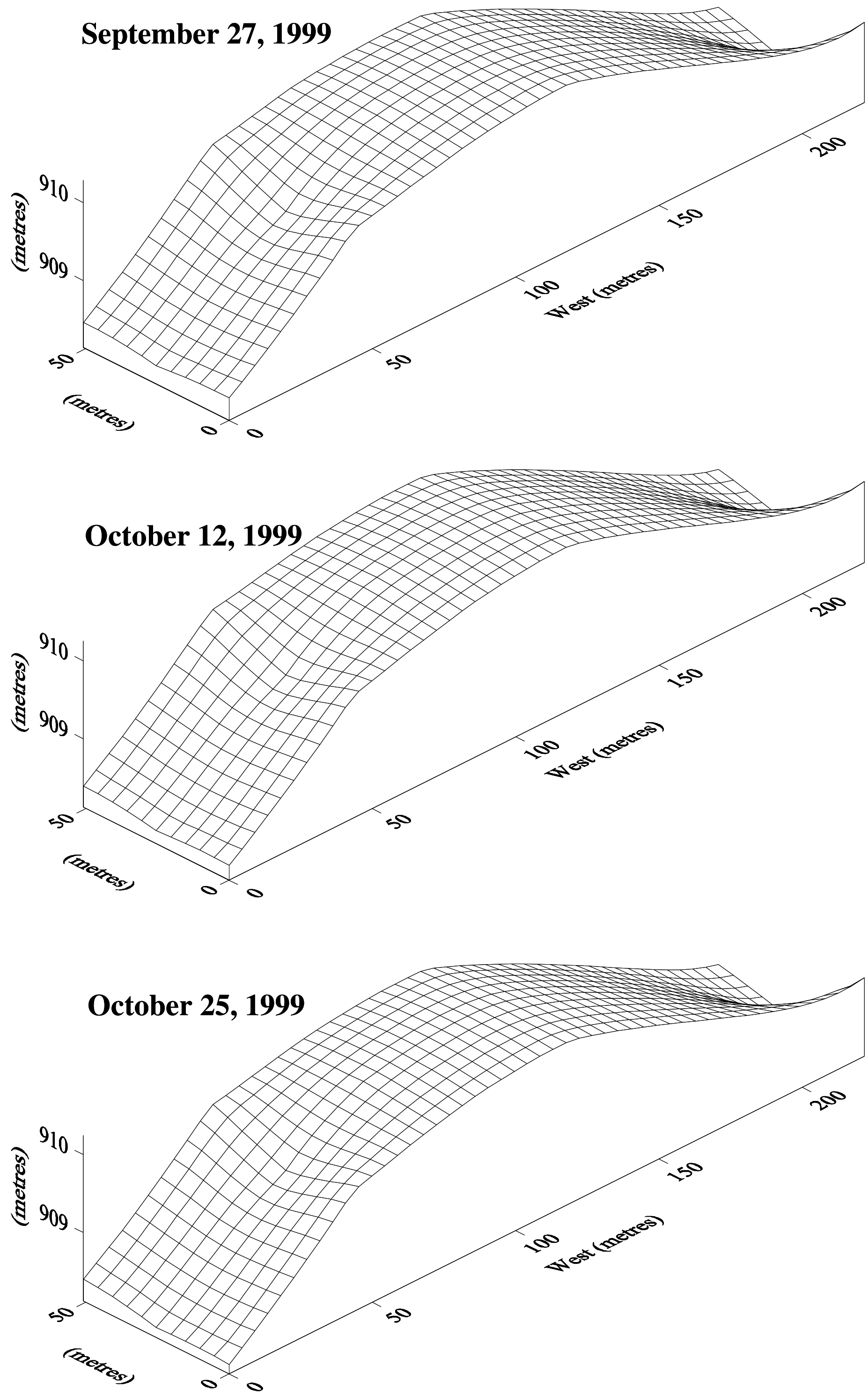

Fig. 8.19. Water-table elevations on September 27, October 12, and October 25, 1999 at the Research Feedlot. Well 14 is located in the NW corner at x:y coordinates of 0:0 metres. Well 1 is not included. The vertical scale is over exaggerated by 24.4 times relative to the two horizontal scales.

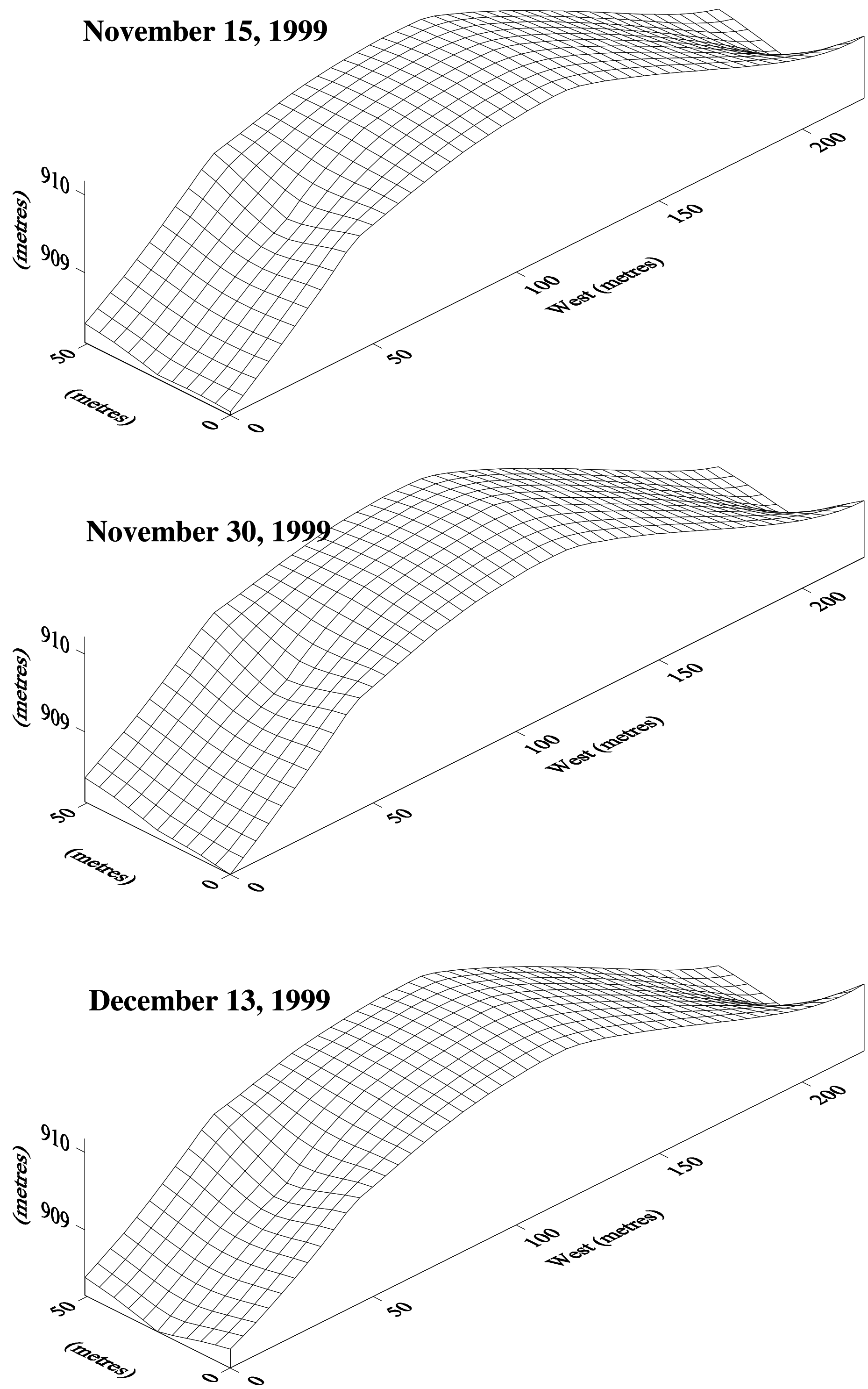

Fig. 8.20. Water-table elevations on November 15, November 30, and December 13, 1999 at the Research Feedlot. Well 14 is located in the NW corner at x:y coordinates of 0:0 metres. Well 1 is not included. The vertical scale is over exaggerated by 24.4 times relative to the two horizontal scales.

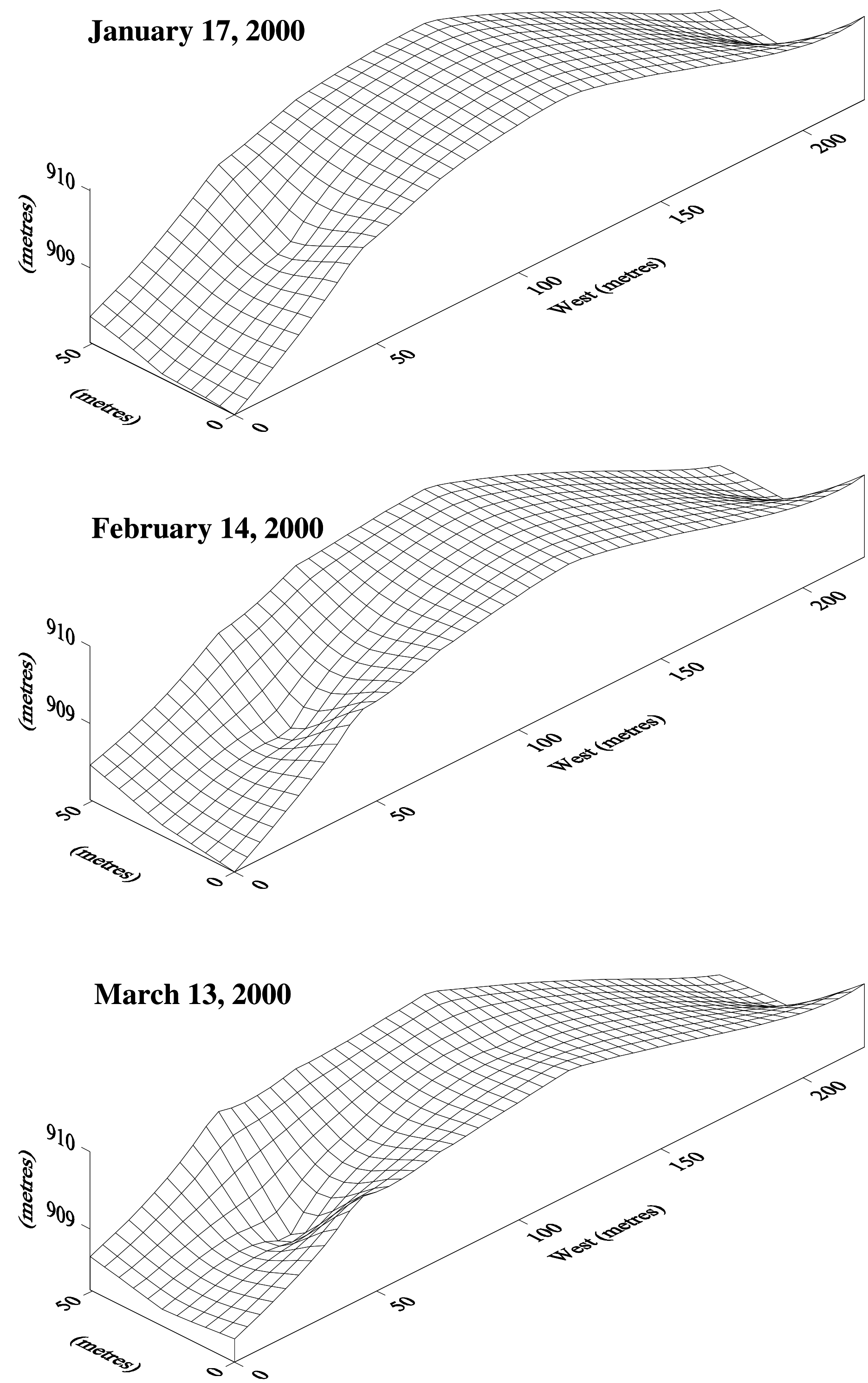

Fig. 8.21. Water-table elevations on January 17, February 14, and March 13, 2000 at the Research Feedlot. Well 14 is located in the NW corner at x:y coordinates of 0:0 metres. Well 1 is not included. The vertical scale is over exaggerated by 24.4 times relative to the two horizontal scales.

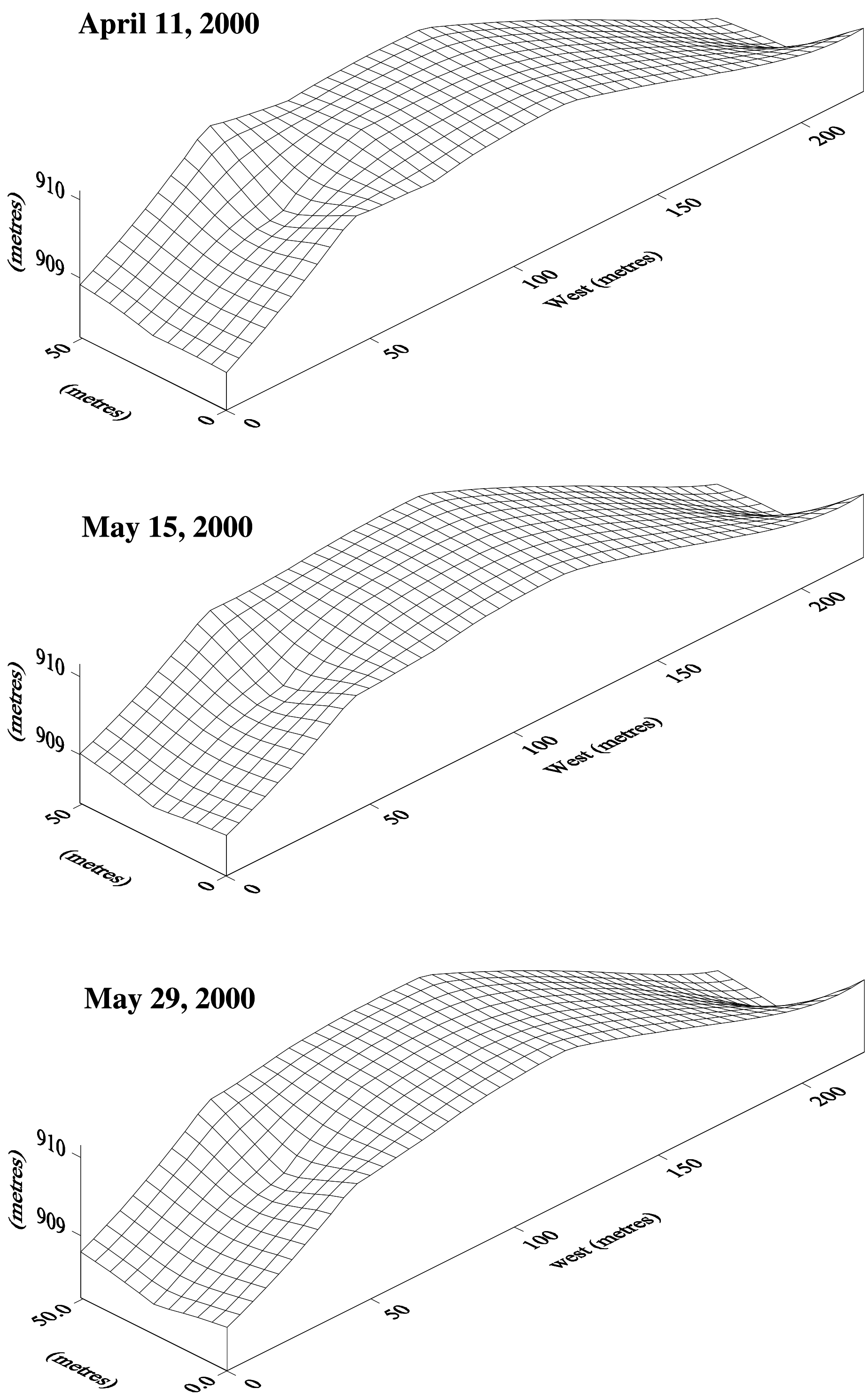

Fig. 8.22. Water-table elevations on April 11, May 15, and May 29, 2000 at the Research Feedlot. Well 14 is located in the NW corner at x:y coordinates of 0:0 metres. Well 1 is not included. The vertical scale is over exaggerated by 24.4 times relative to the two horizontal scales.

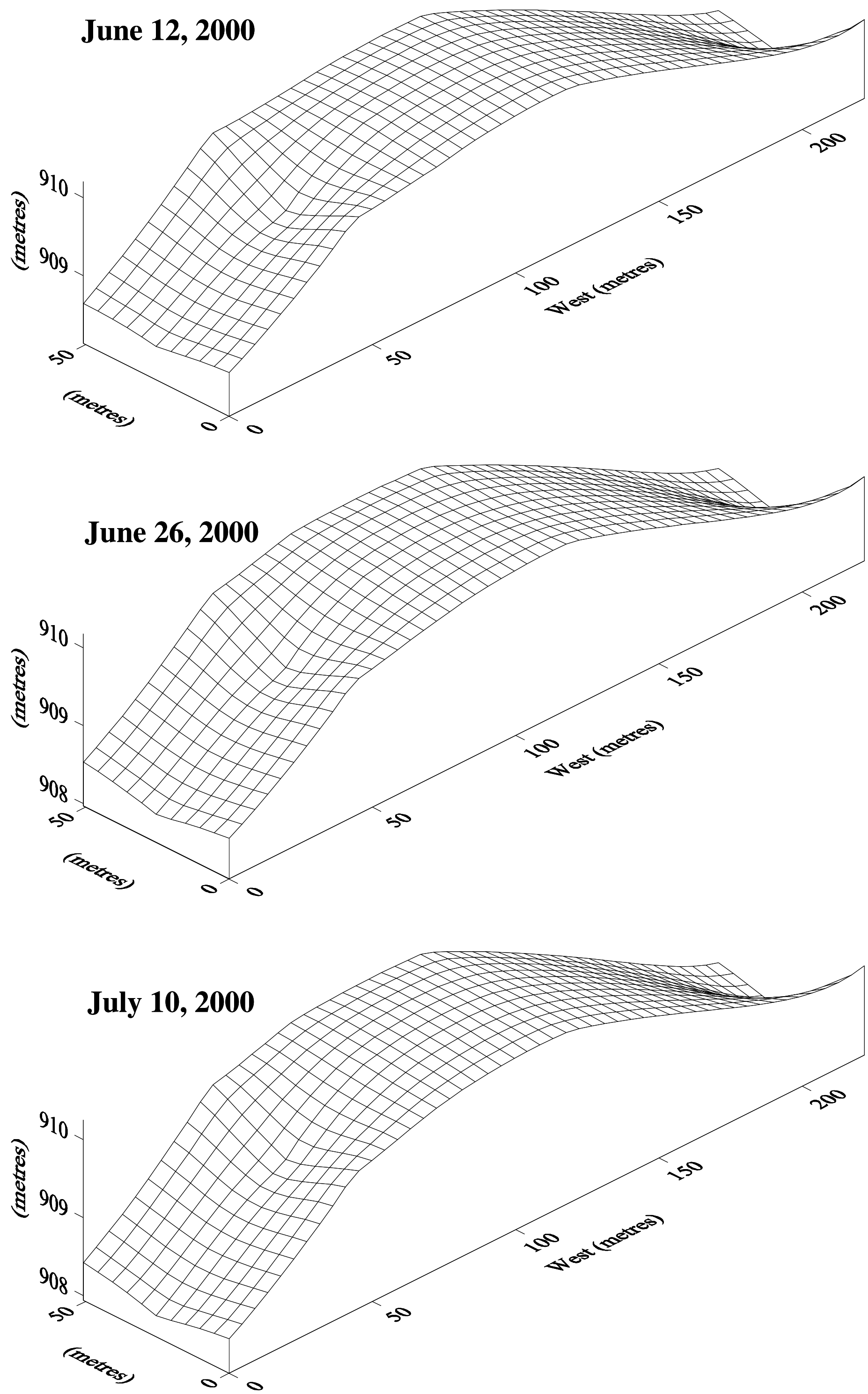

Fig. 8.23. Water-table elevations on June 12, June 26, and July 10, 2000 at the Research Feedlot. Well 14 is located in the NW corner at x:y coordinates of 0:0 metres. Well 1 is not included. The vertical scale is over exaggerated by 24.4 times relative to the two horizontal scales.

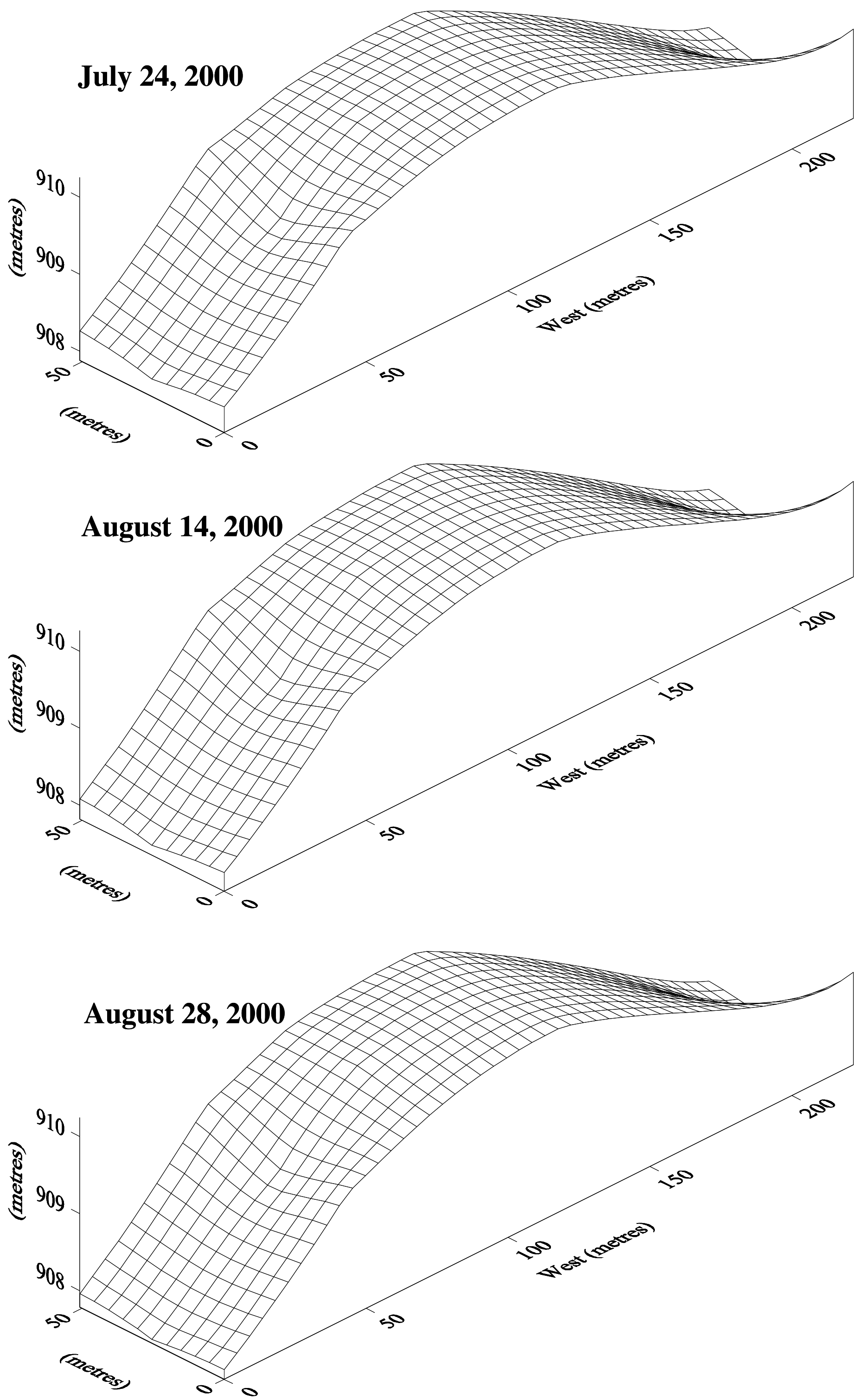

Fig. 8.24. Water-table elevations on July 24, August 14, and August 28, 2000 at the Research Feedlot. Well 14 is located in the NW corner at x:y coordinates of 0:0 metres. Well 1 is not included. The vertical scale is over exaggerated by 24.4 times relative to the two horizontal scales.

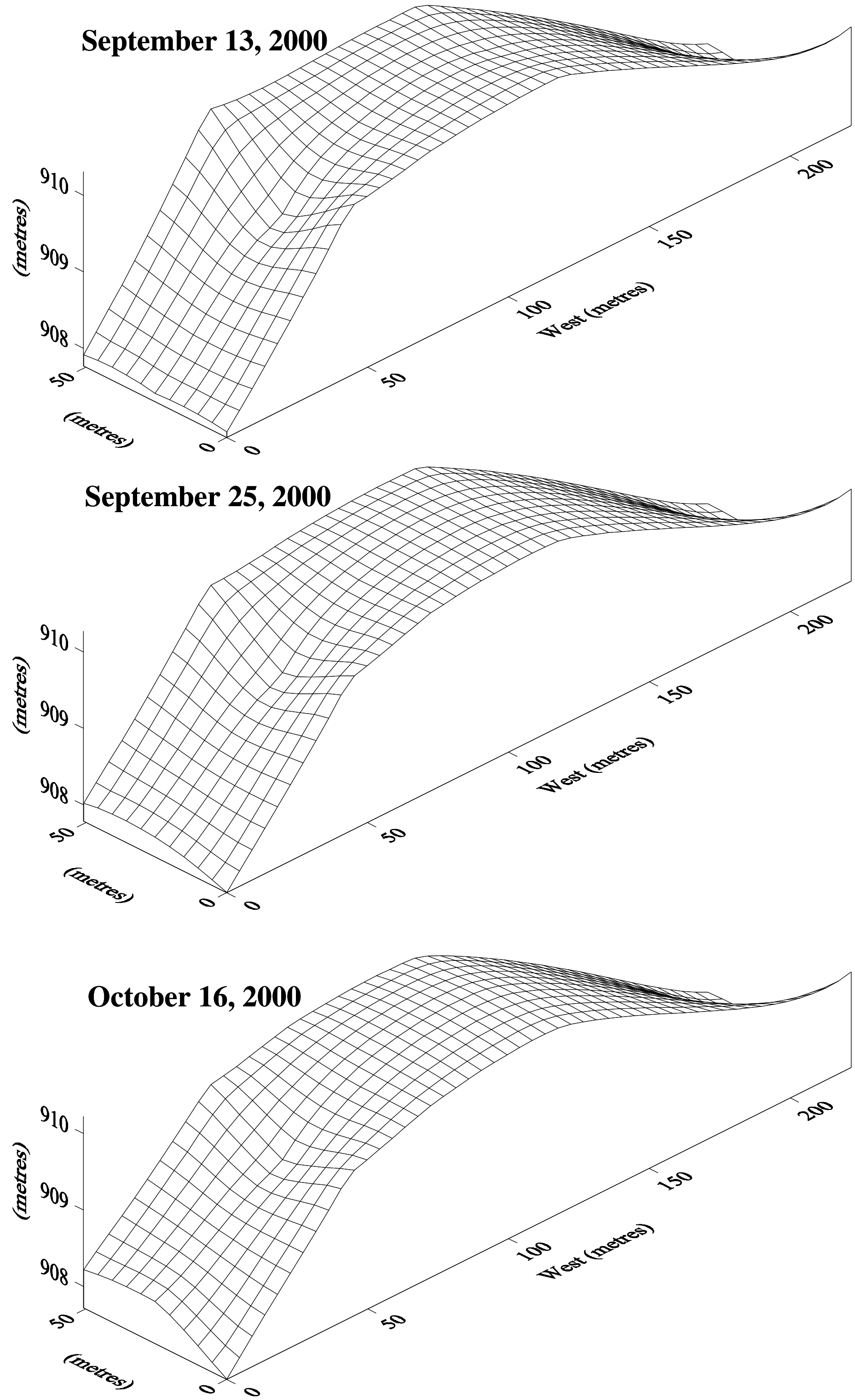

Fig. 8.25. Water-table elevations on September 13, September 25, and October 16, 2000 at the Research Feedlot. Well 14 is located in the NW corner at x:y coordinates of 0:0 metres. Well 1 is not included. The vertical scale is over exaggerated by 24.4 times relative to the two horizontal scales.

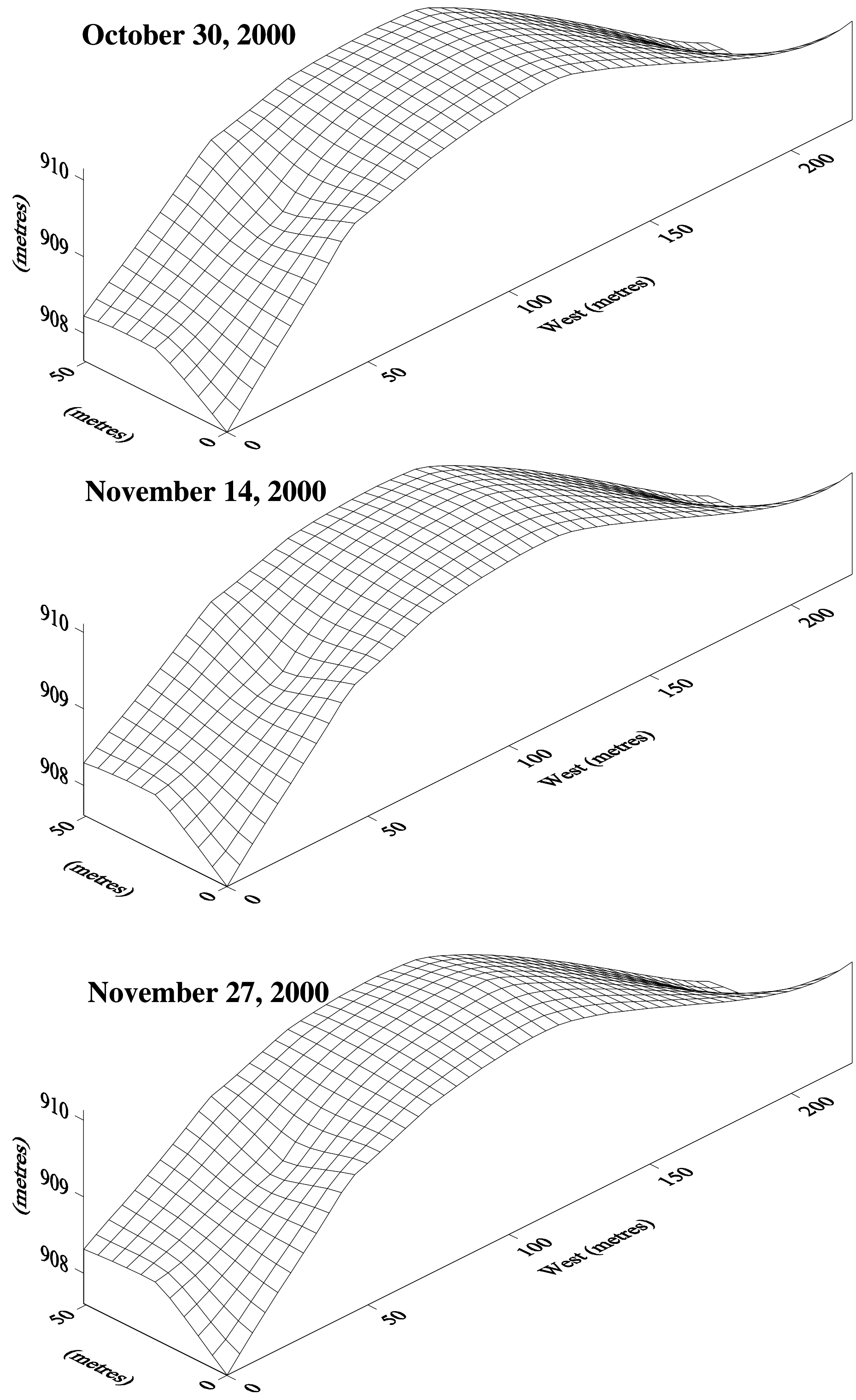

Fig. 8.26. Water-table elevations on October 30, November 14, and November 27, 2000 at the Research Feedlot. Well 14 is located in the NW corner at x:y coordinates of 0:0 metres. Well 1 is not included. The vertical scale is over exaggerated by 24.4 times relative to the two horizontal scales.

Appendix 9. Research Feedlot groundwater chemistry data from May 22, 1996 to November 27, 2000.

Table 9.1. Research Feedlot groundwater chemistry data on May 22, 1996.

Well no.	pH	EC dS m^{-1}	NO_3-N mg L^{-1}	Cl mg L^{-1}	Na mg L^{-1}	K mg L^{-1}	Ca mg L^{-1}	Mg mg L^{-1}	SAR mg L^{-1}	SO_4-S mg L^{-1}	CO_3 mg L^{-1}	HCO_3 mg L^{-1}	NH_4-N mg L^{-1}	PO_4-P mg L^{-1}	Mn mg L^{-1}	Fe mg L^{-1}	Cu mg L^{-1}	Zn mg L^{-1}
1	8.1	6.2	0.0	7	809	16.0	411	436	6.6	1428	0.0	713	nm	nm	0.47	0.00	0.00	0.01
2	8.0	10.4	154.2	287	1687	21.1	463	811	11.0	2060	0.0	667	nm	nm	0.23	0.00	0.01	0.01
3	8.0	5.1	61.2	71	526	12.5	447	337	4.6	997	0.0	419	nm	nm	0.09	0.00	0.00	0.00
4	8.1	6.9	36.3	138	903	14.5	449	486	7.0	1438	0.0	752	nm	nm	0.04	0.00	0.01	0.01
5	8.0	7.4	10.2	64	1161	16.0	399	431	9.6	1606	0.0	647	nm	nm	0.22	0.00	0.01	0.01
6	8.2	8.3	113.7	266	1393	16.0	427	394	11.7	1484	0.0	689	nm	nm	0.01	0.00	0.02	0.01
7	8.0	7.9	55.0	184	1179	16.4	445	476	9.3	1654	0.0	720	nm	nm	0.07	0.00	0.01	0.00
8	8.0	6.5	63.0	53	986	13.3	417	350	8.6	1257	0.0	561	nm	nm	0.10	0.00	0.01	0.01
9	8.1	8.0	9.9	32	1214	16.0	393	560	9.2	1802	0.0	669	nm	nm	0.19	0.00	0.02	0.00
10	7.7	7.2	0.0	32	1235	16.0	381	345	11.0	1557	0.0	702	nm	nm	5.10	7.10	0.00	0.01
11	8.2	6.7	17.6	57	894	15.2	427	439	7.3	1393	0.0	598	nm	nm	0.23	0.01	0.02	0.01
12	8.2	7.6	3.2	28	1271	18.8	433	414	10.5	1659	0.0	775	nm	nm	0.51	0.00	0.01	0.01
13	8.2	5.5	27.6	46	579	13.3	423	388	4.9	1154	0.0	506	nm	nm	0.52	0.00	0.00	0.01
14	8.1	8.9	16.7	103	1372	19.2	457	733	9.3	2102	0.0	744	nm	nm	0.31	0.07	0.01	0.01
15	8.1	9.5	27.7	71	1430	19.9	403	863	9.2	2095	0.0	715	nm	nm	0.17	0.00	0.00	0.05
16	8.2	7.5	6.2	57	995	8.2	405	589	7.4	1704	0.0	827	nm	nm	0.11	0.00	0.01	0.01

nm = not measured.

Table 9.2. Research Feedlot groundwater chemistry data on May 30, 1996.

Well no.	pH	EC dS m^{-1}	NO_3-N mg L^{-1}	Cl mg L^{-1}	Na mg L^{-1}	K mg L^{-1}	Ca mg L^{-1}	Mg mg L^{-1}	SAR mg L^{-1}	SO_4-S mg L^{-1}	CO_3 mg L^{-1}	HCO_3 mg L^{-1}	NH_4-N mg L^{-1}	PO_4-P mg L^{-1}	Mn mg L^{-1}	Fe mg L^{-1}	Cu mg L^{-1}	Zn mg L^{-1}
1	7.7	6.1	1.5	11	759	14.9	431	469	6.0	1279	0.0	708	nm	nm	0.53	0.00	0.00	0.01
2	7.7	10.8	162.8	291	1791	21.9	489	828	11.5	2138	0.0	689	nm	nm	0.26	0.01	0.02	0.01
3	8.0	5.1	61.1	74	430	11.7	485	379	3.6	901	0.0	421	nm	nm	0.00	0.00	0.01	0.01
4	7.8	7.3	37.3	142	966	15.2	479	540	7.2	1438	0.0	787	nm	nm	0.05	0.00	0.01	0.01
5	7.9	7.4	24.8	96	1069	15.2	445	504	8.2	1544	0.0	635	nm	nm	0.26	0.02	0.01	0.01
6	8.1	8.6	116.0	266	1499	16.4	441	448	12.0	1520	0.0	689	nm	nm	0.01	0.01	0.03	0.02
7	7.9	8.2	62.9	181	1260	17.6	463	491	9.7	1569	0.0	726	nm	nm	0.09	0.01	0.01	0.01
8	8.1	6.4	86.0	57	867	11.3	437	386	7.3	1194	0.0	336	nm	nm	0.08	0.00	0.02	0.01
9	8.1	8.3	6.4	35	1301	16.4	409	587	9.7	1750	0.0	677	nm	nm	0.37	0.00	0.02	0.01
10	7.8	7.3	0.0	32	1290	16.0	413	390	10.9	1451	0.0	708	nm	nm	5.50	9.00	0.00	0.01
11	8.1	6.8	21.0	60	961	16.0	447	472	7.6	1465	0.0	610	nm	nm	0.25	0.00	0.01	0.01
12	8.1	7.8	2.2	28	1338	19.2	453	429	10.8	1630	0.0	781	nm	nm	0.73	0.00	0.02	0.01
13	8.0	5.3	57.0	67	386	10.9	443	498	3.0	1109	0.0	464	nm	nm	0.28	0.02	0.01	0.01
14	8.1	8.5	15.4	103	1471	19.5	463	832	9.5	2049	0.0	787	nm	nm	0.32	0.02	0.01	0.01
15	8.2	8.6	32.8	67	1462	20.7	419	879	9.3	2263	0.0	720	nm	nm	0.19	0.02	0.01	0.04
16	8.3	8.0	7.8	64	1094	9.4	389	645	7.9	1779	0.0	818	nm	nm	0.08	0.00	0.01	0.01

nm = not measured.

Table 9.3. Research Feedlot groundwater chemistry data on April 10, 1996.

Well no.	pH	EC dS m^{-1}	NO_3-N mg L^{-1}	Cl mg L^{-1}	Na mg L^{-1}	K mg L^{-1}	Ca mg L^{-1}	Mg mg L^{-1}	SAR mg L^{-1}	SO_4-S mg L^{-1}	CO_3 mg L^{-1}	HCO_3 mg L^{-1}	NH_4-N mg L^{-1}	PO_4-P mg L^{-1}	Mn mg L^{-1}	Fe mg L^{-1}	Cu mg L^{-1}	Zn mg L^{-1}
1	7.8	6.3	0.0	11	770	15.2	419	453	6.2	1308	0.0	714	nm	nm	1.13	0.12	0.01	0.01
2	7.9	10.6	155.6	287	1717	21.1	289	773	12.0	2204	0.0	732	nm	nm	0.30	0.04	0.02	0.02
3	7.9	4.9	54.1	67	414	11.3	467	346	3.5	968	0.0	433	nm	nm	0.04	0.00	0.01	0.00
4	8.0	7.3	34.5	142	938	14.9	465	527	7.1	1536	0.0	818	nm	nm	0.05	0.00	0.01	0.00
5	8.0	7.2	31.0	106	933	14.1	425	512	7.2	1581	0.0	610	nm	nm	0.08	0.00	0.01	0.01
6	8.1	8.6	110.9	259	1490	16.0	439	403	12.4	1566	0.0	696	nm	nm	0.00	0.00	0.03	0.01
7	8.1	8.1	61.5	177	1241	17.6	459	470	9.7	1680	0.0	732	nm	nm	0.08	0.00	0.01	0.01
8	8.1	6.6	80.4	53	979	13.3	419	354	8.5	1367	0.0	531	nm	nm	0.06	0.00	0.01	0.00
9	8.1	8.3	5.3	39	1324	18.0	411	542	10.1	1917	0.0	671	nm	nm	0.21	0.00	0.01	0.00
10	7.8	7.4	0.0	28	1285	15.6	405	376	11.1	1585	0.0	732	nm	nm	6.80	12.80	0.00	0.01
11	8.1	7.1	16.7	67	1041	17.6	437	427	8.5	1558	0.0	622	nm	nm	0.28	0.00	0.01	0.00
12	8.1	7.7	0.4	32	1299	19.5	453	386	10.8	1621	0.0	787	nm	nm	0.52	0.00	0.01	0.01
13	8.1	5.2	54.5	67	354	10.9	437	457	2.8	1109	0.0	470	nm	nm	0.25	0.00	0.00	0.01
14	8.1	9.5	11.6	99	1435	18.8	461	797	9.4	2223	0.0	824	nm	nm	0.30	0.02	0.01	0.02
15	8.1	9.5	26.6	67	1418	19.9	413	843	9.2	2230	0.0	751	nm	nm	0.21	0.02	0.00	0.01
16	8.3	8.7	16.8	71	1202	10.9	409	794	8.0	1965	0.0	769	nm	nm	0.03	0.00	0.01	0.00

nm = not measured.

Table 9.4. Research Feedlot groundwater chemistry data on June 18, 1996.

Well no.	pH	EC dS m^{-1}	NO_3-N mg L^{-1}	Cl mg L^{-1}	Na mg L^{-1}	K mg L^{-1}	Ca mg L^{-1}	Mg mg L^{-1}	SAR mg L^{-1}	SO_4-S mg L^{-1}	CO_3 mg L^{-1}	HCO_3 mg L^{-1}	NH_4-N mg L^{-1}	PO_4-P mg L^{-1}	Mn mg L^{-1}	Fe mg L^{-1}	Cu mg L^{-1}	Zn mg L^{-1}
1	8.0	5.9	0.0	14	595	12.5	411	446	4.8	1268	0.0	708	nm	nm	nm	nm	nm	nm
2	8.1	10.6	159.1	287	1678	20.7	445	664	11.8	2042	0.0	751	nm	nm	nm	nm	nm	nm
3	8.2	4.9	43.1	60	359	10.2	449	345	3.1	973	0.0	452	nm	nm	nm	nm	nm	nm
4	8.1	7.4	30.4	149	913	14.5	449	335	7.9	1241	0.0	830	nm	nm	nm	nm	nm	nm
5	8.1	7.2	34.0	124	846	13.3	409	525	6.5	1516	0.0	610	nm	nm	nm	nm	nm	nm
6	8.3	8.8	110.9	262	1471	16.0	419	395	12.4	1590	0.0	702	nm	nm	nm	nm	nm	nm
7	8.1	7.2	57.3	177	1205	17.2	435	463	9.6	1598	0.0	738	nm	nm	nm	nm	nm	nm
8	8.3	6.8	80.8	53	959	14.1	403	350	8.4	1287	0.0	537	nm	nm	nm	nm	nm	nm
9	8.3	8.5	4.8	39	1297	17.2	399	542	9.9	1802	5.1	671	nm	nm	nm	nm	nm	nm
10	8.0	7.6	0.0	28	1258	15.6	395	373	10.9	1520	0.0	751	nm	nm	nm	nm	nm	nm
11	8.2	7.2	19.3	67	993	16.8	415	430	8.2	1456	0.0	628	nm	nm	nm	nm	nm	nm
12	8.2	7.8	0.3	32	1297	18.8	427	383	11.0	1666	0.0	793	nm	nm	nm	nm	nm	nm
13	8.2	5.3	53.9	67	343	10.9	425	463	2.7	1076	0.0	476	nm	nm	nm	nm	nm	nm
14	8.3	9.8	7.3	110	1439	18.4	437	834	9.3	2175	10.2	830	nm	nm	nm	nm	nm	nm
15	8.3	9.7	23.4	74	1430	20.3	393	853	9.3	2209	7.8	751	nm	nm	nm	nm	nm	nm
16	8.3	8.9	14.1	71	1200	9.8	593	815	7.5	1938	12.3	751	nm	nm	nm	nm	nm	nm

nm = not measured.

Table 9.5. Research Feedlot groundwater chemistry data on June 27, 1996.

Well no.	pH	EC dS m^{-1}	NO_3-N mg L^{-1}	Cl mg L^{-1}	Na mg L^{-1}	K mg L^{-1}	Ca mg L^{-1}	Mg mg L^{-1}	SAR mg L^{-1}	SO_4-S mg L^{-1}	CO_3 mg L^{-1}	HCO_3 mg L^{-1}	NH_4-N mg L^{-1}	PO_4-P mg L^{-1}	Mn mg L^{-1}	Fe mg L^{-1}	Cu mg L^{-1}	Zn mg L^{-1}
1	7.7	6.5	0.0	7	844	15.2	409	440	6.9	1448	0.0	714	nm	nm	2.37	1.54	0.00	0.00
2	8.0	10.4	158.3	277	1683	20.7	447	666	11.8	2049	0.0	781	nm	nm	0.56	0.05	0.02	0.01
3	8.0	5.2	46.6	60	487	12.5	459	350	4.2	1034	0.0	452	nm	nm	0.12	0.00	0.01	0.01
4	8.1	7.3	29.0	142	954	15.2	457	515	7.3	1465	0.0	848	nm	nm	0.13	0.00	0.02	0.01
5	8.0	7.6	27.5	74	1163	16.4	409	469	9.3	1605	0.0	647	nm	nm	0.35	0.00	0.02	0.01
6	8.1	8.8	112.3	252	1540	16.8	425	418	12.7	1505	0.0	702	nm	nm	0.01	0.00	0.02	0.00
7	8.1	8.3	68.2	181	1264	18.0	443	486	9.9	1609	0.0	744	nm	nm	0.15	0.00	0.01	0.01
8	8.1	6.6	89.2	53	961	13.3	411	365	8.3	1226	0.0	543	nm	nm	0.14	0.00	0.01	0.00
9	8.2	8.5	4.9	39	1354	18.0	393	551	10.3	1784	0.0	677	nm	nm	0.37	0.01	0.02	0.00
10	7.8	7.6	0.0	28	1292	15.2	397	393	11.0	1516	0.0	781	nm	nm	5.96	3.25	0.00	0.00
11	8.1	7.0	27.5	53	954	16.4	427	458	7.6	1443	0.0	622	nm	nm	0.42	0.00	0.01	0.00
12	8.1	7.8	0.0	28	1320	18.4	427	407	11.0	1581	0.0	793	nm	nm	2.42	0.20	0.01	0.01
13	8.1	4.6	98.2	106	166	7.4	515	361	1.4	826	0.0	409	nm	nm	0.08	0.06	0.00	0.04
14	8.2	9.8	4.6	99	1497	18.8	441	851	9.6	2223	0.0	873	nm	nm	0.43	0.11	0.01	0.01
15	8.2	9.6	31.1	67	1460	20.3	403	854	9.5	2198	0.0	781	nm	nm	0.32	0.11	0.01	0.01
16	8.3	8.6	19.5	64	1172	10.2	403	784	7.8	1901	0.0	824	nm	nm	0.10	0.16	0.00	0.00

nm = not measured.

Table 9.6. Research Feedlot groundwater chemistry data on July 4, 1996.

Well no.	pH	EC dS m^{-1}	NO_3-N mg L^{-1}	Cl mg L^{-1}	Na mg L^{-1}	K mg L^{-1}	Ca mg L^{-1}	Mg mg L^{-1}	SAR mg L^{-1}	SO_4-S mg L^{-1}	CO_3 mg L^{-1}	HCO_3 mg L^{-1}	NH_4-N mg L^{-1}	PO_4-P mg L^{-1}	Mn mg L^{-1}	Fe mg L^{-1}	Cu mg L^{-1}	Zn mg L^{-1}
1	7.4	6.3	0.0	7	710	12.5	405	463	5.7	1385	0.0	702	nm	nm	5.08	4.18	0.00	0.01
2	7.9	10.3	152.4	280	1644	20.3	437	666	11.6	2060	0.0	799	nm	nm	0.59	0.04	0.03	0.02
3	7.9	5.0	41.5	60	400	11.3	455	354	3.4	994	0.0	458	nm	nm	0.06	0.01	0.01	0.00
4	8.0	7.2	26.3	145	926	14.9	449	521	7.1	1507	0.0	854	nm	nm	0.14	0.03	0.02	0.01
5	8.0	7.3	26.6	96	966	14.5	401	513	7.5	1585	0.0	622	nm	nm	0.20	0.01	0.02	0.01
6	8.1	8.8	102.2	252	1501	16.4	417	424	12.4	1579	0.0	708	nm	nm	0.01	0.01	0.03	0.01
7	8.0	8.5	63.2	188	1230	17.2	435	531	9.4	1648	0.0	763	nm	nm	0.15	0.03	0.02	0.01
8	8.1	6.7	86.4	50	1161	12.9	403	376	10.0	1297	0.0	537	nm	nm	0.11	0.03	0.02	0.01
9	8.2	8.5	5.0	35	1304	17.6	387	577	9.8	1856	0.0	683	nm	nm	0.34	0.01	0.02	0.01
10	7.8	7.6	0.0	28	1269	14.9	387	388	10.9	1550	0.0	812	nm	nm	6.73	7.57	0.00	0.01
11	8.2	7.1	14.8	50	929	16.0	403	465	7.5	1496	0.0	622	nm	nm	0.47	0.00	0.02	0.01
12	8.2	7.8	0.0	28	1278	18.0	415	394	10.8	1659	0.0	793	nm	nm	1.92	0.15	0.02	0.01
13	8.2	4.8	85.4	99	177	7.8	473	401	1.5	893	0.0	433	nm	nm	0.12	0.01	0.02	0.01
14	8.2	9.9	0.0	99	1446	18.0	431	854	9.3	2364	0.0	891	nm	nm	0.47	0.21	0.01	0.01
15	8.2	9.6	21.2	64	1384	19.2	385	849	9.0	2265	0.0	793	nm	nm	0.34	0.11	0.01	0.01
16	8.3	8.9	12.0	64	1205	10.6	379	796	8.1	2065	0.0	812	nm	nm	0.02	0.01	0.02	0.01

nm = not measured.

Table 9.7. Research Feedlot groundwater chemistry data on July 11, 1996.

Well no.	pH	EC dS m^{-1}	NO_3-N mg L^{-1}	Cl mg L^{-1}	Na mg L^{-1}	K mg L^{-1}	Ca mg L^{-1}	Mg mg L^{-1}	SAR mg L^{-1}	SO_4-S mg L^{-1}	CO_3 mg L^{-1}	HCO_3 mg L^{-1}	NH_4-N mg L^{-1}	PO_4-P mg L^{-1}	Mn mg L^{-1}	Fe mg L^{-1}	Cu mg L^{-1}	Zn mg L^{-1}
1	7.2	5.8	0.0	14	559	11.3	433	458	4.5	1284	0.0	726	nm	nm	6.40	12.00	0.01	0.01
2	7.6	10.1	155.6	280	1605	20.3	449	631	11.5	1985	0.0	805	nm	nm	0.47	0.02	0.02	0.01
3	7.7	4.3	57.7	64	228	8.2	505	300	2.0	851	0.0	433	nm	nm	0.03	0.00	0.01	0.01
4	7.7	7.3	25.8	145	920	14.5	461	504	7.0	1489	0.0	873	nm	nm	0.11	0.02	0.02	0.01
5	7.8	7.2	32.4	106	917	14.1	411	510	7.1	1523	0.0	610	nm	nm	0.13	0.02	0.01	0.01
6	7.9	8.7	101.3	245	1494	16.0	431	420	12.3	1565	0.0	708	nm	nm	0.01	0.01	0.02	0.21
7	7.9	8.4	64.9	195	1225	17.2	459	533	9.2	1658	0.0	775	nm	nm	0.11	0.00	0.01	0.01
8	7.9	6.5	94.4	60	885	8.2	423	377	7.5	1292	0.0	525	nm	nm	0.07	0.00	0.01	0.01
9	8.0	8.4	5.5	39	1304	17.6	399	555	9.9	1832	0.0	683	nm	nm	0.31	3.01	0.01	0.01
10	7.6	7.6	0.0	28	1267	14.9	397	389	10.8	1573	0.0	866	nm	nm	8.20	14.60	0.00	0.01
11	8.0	6.9	21.2	53	933	15.6	419	455	7.5	1497	0.0	622	nm	nm	0.38	0.01	0.01	0.01
12	8.0	7.7	0.0	28	1278	18.4	431	389	10.8	1593	0.0	793	nm	nm	1.44	0.55	0.02	0.01
13	7.9	4.8	74.1	89	198	8.2	471	411	1.6	933	0.0	458	nm	nm	0.17	0.04	0.00	0.01
14	8.0	9.8	0.0	99	1453	18.0	445	847	9.3	2251	0.0	891	nm	nm	0.73	0.86	0.01	0.01
15	8.1	9.3	16.1	60	1308	18.4	401	839	8.5	2175	0.0	830	nm	nm	0.37	0.21	0.02	0.01
16	8.2	8.7	10.1	67	1177	10.6	397	770	7.9	1983	0.0	830	nm	nm	0.04	0.01	0.01	0.00

nm = not measured.

Table 9.8. Research Feedlot groundwater chemistry data on July 24, 1996.

Well no.	pH	EC dS m^{-1}	NO_3-N mg L^{-1}	Cl mg L^{-1}	Na mg L^{-1}	K mg L^{-1}	Ca mg L^{-1}	Mg mg L^{-1}	SAR mg L^{-1}	SO_4-S mg L^{-1}	CO_3 mg L^{-1}	HCO_3 mg L^{-1}	NH_4-N mg L^{-1}	PO_4-P mg L^{-1}	Mn mg L^{-1}	Fe mg L^{-1}	Cu mg L^{-1}	Zn mg L^{-1}
1	7.4	6.0	0.0	11	616	11.7	415	473	4.9	1231	0.0	757	nm	nm	7.40	13.60	0.00	0.02
2	7.9	10.0	160.1	280	1598	20.3	443	612	11.5	1791	0.0	842	nm	nm	0.47	0.03	0.01	0.03
3	8.1	4.9	50.3	60	391	10.6	471	345	3.3	922	0.0	458	nm	nm	0.07	0.01	0.00	0.01
4	8.1	7.3	27.6	145	924	15.6	459	510	7.1	1467	0.0	897	nm	nm	0.13	0.01	0.00	0.01
5	8.1	6.9	52.5	142	761	13.3	423	535	5.8	1435	0.0	604	nm	nm	0.15	0.01	0.00	0.01
6	8.1	9.0	101.0	241	1531	17.2	437	436	12.4	1584	0.0	726	nm	nm	0.01	0.01	0.00	0.01
7	8.2	8.5	67.4	199	1228	17.6	443	548	9.2	1590	0.0	799	nm	nm	0.15	0.01	0.00	0.01
8	8.2	6.5	117.7	64	814	12.1	433	385	6.9	1180	0.0	531	nm	nm	0.06	0.01	0.00	0.00
9	8.2	8.3	10.8	35	1269	18.0	405	570	9.5	1795	0.0	683	nm	nm	0.28	0.02	0.00	0.00
10	7.9	7.6	0.6	25	1260	14.5	401	403	10.6	1502	0.0	970	nm	nm	8.30	7.00	0.00	0.00
11	8.2	6.5	33.2	50	793	14.9	435	447	6.4	1332	0.0	610	nm	nm	0.41	0.01	0.02	0.00
12	8.2	7.7	0.0	28	1246	18.0	429	391	10.5	1565	0.0	799	nm	nm	3.00	1.90	0.02	0.00
13	8.2	4.9	67.2	82	205	9.0	473	434	1.6	931	0.0	506	nm	nm	0.28	0.03	0.01	0.00
14	8.0	9.8	0.0	96	1425	17.6	443	896	9.0	2188	0.0	891	nm	nm	2.20	3.20	0.01	0.01
15	8.2	9.4	22.6	64	1347	19.5	401	870	8.7	2127	0.0	842	nm	nm	0.89	0.74	0.01	0.01
16	8.3	8.1	15.0	53	1044	9.8	417	670	7.4	1755	0.0	879	nm	nm	0.15	0.01	0.02	0.00

nm = not measured.

Table 9.9. Research Feedlot groundwater chemistry data on August 6, 1996.

Well no.	pH	EC dS m^{-1}	NO_3-N mg L^{-1}	Cl mg L^{-1}	Na mg L^{-1}	K mg L^{-1}	Ca mg L^{-1}	Mg mg L^{-1}	SAR mg L^{-1}	SO_4-S mg L^{-1}	CO_3 mg L^{-1}	HCO_3 mg L^{-1}	NH_4-N mg L^{-1}	PO_4-P mg L^{-1}	Mn mg L^{-1}	Fe mg L^{-1}	Cu mg L^{-1}	Zn mg L^{-1}
1	7.3	6.3	0.0	7	687	11.7	407	489	5.4	1375	0.0	793	nm	nm	7.50	12.60	0.00	0.00
2	7.7	10.0	159.8	280	1586	19.9	433	598	11.6	1763	0.0	873	nm	nm	0.48	0.04	0.02	0.01
3	7.8	5.1	26.1	46	379	10.6	437	417	3.1	1058	0.0	488	nm	nm	0.02	0.02	0.01	0.00
4	7.8	7.4	21.7	149	929	15.2	453	508	7.1	1510	0.0	915	nm	nm	0.12	0.03	0.01	0.01
5	7.8	7.1	47.3	138	795	14.1	417	544	6.0	1520	0.0	598	nm	nm	0.15	0.02	0.02	0.01
6	7.9	9.1	110.9	245	1536	16.8	433	441	12.4	1593	0.0	726	nm	nm	0.01	0.02	0.24	0.01
7	7.9	8.5	63.3	202	1235	17.6	445	533	9.3	1701	0.0	805	nm	nm	0.16	0.03	0.01	0.01
8	7.9	6.7	106.6	60	913	13.3	423	377	7.8	1268	0.0	543	nm	nm	0.10	0.02	0.01	0.01
9	7.7	7.8	0.0	28	1281	17.6	419	401	10.7	1669	0.0	799	nm	nm	3.30	2.40	0.02	0.01
10	8.0	7.0	28.7	53	931	16.0	413	459	7.5	1544	0.0	616	nm	nm	0.38	0.03	0.01	0.00
11	7.8	7.8	0.0	25	1264	15.6	401	405	10.7	1581	0.0	1062	nm	nm	7.40	5.40	0.00	0.00
12	8.0	8.6	8.3	39	1320	18.8	395	548	10.1	1880	0.0	683	nm	nm	0.28	0.02	0.01	0.01
13	8.2	8.8	12.9	60	1179	11.7	395	781	7.9	1880	0.0	860	nm	nm	0.03	0.02	0.01	0.00
14	8.1	9.3	6.0	57	1260	18.0	393	864	8.1	2081	0.0	903	nm	nm	0.77	0.58	0.00	0.01
15	7.9	10.1	0.0	96	841	17.2	443	869	5.4	1919	0.0	915	nm	nm	3.60	6.80	0.01	0.01
16	8.0	4.7	83.9	103	168	7.4	497	382	1.4	862	0.0	494	nm	nm	0.17	0.03	0.01	0.01

nm = not measured.

Table 9.10. Research Feedlot groundwater chemistry data on August 15, 1996.

Well no.	pH	EC dS m^{-1}	NO_3-N mg L^{-1}	Cl mg L^{-1}	Na mg L^{-1}	K mg L^{-1}	Ca mg L^{-1}	Mg mg L^{-1}	SAR mg L^{-1}	SO_4-S mg L^{-1}	CO_3 mg L^{-1}	HCO_3 mg L^{-1}	NH_4-N mg L^{-1}	PO_4-P mg L^{-1}	Mn mg L^{-1}	Fe mg L^{-1}	Cu mg L^{-1}	Zn mg L^{-1}
1	7.4	5.9	0.0	11	658	11.7	421	473	5.2	1375	0.0	793	nm	nm	7.70	9.20	0.00	0.01
2	7.8	9.4	184.7	287	1593	22.7	443	566	11.8	1887	0.0	775	nm	nm	0.55	0.02	0.00	0.01
3	7.9	5.0	41.5	50	430	11.7	459	386	3.6	1127	0.0	439	nm	nm	0.06	0.00	0.00	0.01
4	7.9	7.0	23.0	152	943	15.6	467	502	7.2	1528	0.0	799	nm	nm	0.15	0.00	0.00	0.01
5	7.9	6.5	68.4	163	692	14.1	435	543	5.2	1403	0.0	537	nm	nm	0.16	0.00	0.00	0.01
6	8.0	8.7	117.2	245	1566	17.6	443	437	12.6	1709	0.0	659	nm	nm	0.02	0.00	0.00	0.01
7	8.0	8.1	66.4	191	1239	18.0	453	516	9.5	1706	0.0	696	nm	nm	0.19	0.02	0.00	0.01
8	8.0	6.5	114.3	60	908	14.1	433	372	7.7	1306	0.0	476	nm	nm	0.10	0.00	0.00	0.00
9	8.0	8.3	7.1	39	1347	19.2	405	531	10.4	1840	0.0	610	nm	nm	0.32	0.00	0.01	0.01
10	7.7	7.4	1.3	25	1290	16.0	411	401	10.9	1555	0.0	1007	nm	nm	7.10	3.10	0.00	0.01
11	8.0	6.8	28.7	60	1005	17.6	415	439	8.2	1520	0.0	555	nm	nm	0.48	0.00	0.01	0.01
12	7.9	7.5	0.0	28	1299	18.4	425	389	11.0	1627	0.0	714	nm	nm	3.80	2.70	0.01	0.01
13	7.9	4.6	77.9	96	200	9.4	481	385	1.7	877	0.0	458	nm	nm	0.30	0.00	0.00	0.01
14	7.8	9.7	0.0	106	1497	18.0	443	870	9.5	2393	0.0	854	nm	nm	4.20	7.80	0.00	0.01
15	8.0	8.9	2.5	57	1306	19.2	405	869	8.4	2151	0.0	842	nm	nm	1.36	2.20	0.00	0.01
16	8.2	8.4	7.8	57	1195	11.3	405	729	8.2	1981	0.0	775	nm	nm	0.08	0.03	0.00	0.00

nm = not measured.

Table 9.11. Research Feedlot groundwater chemistry data on August 21, 1996.

Well no.	pH	EC dS m^{-1}	NO_3-N mg L^{-1}	Cl mg L^{-1}	Na mg L^{-1}	K mg L^{-1}	Ca mg L^{-1}	Mg mg L^{-1}	SAR mg L^{-1}	SO_4-S mg L^{-1}	CO_3 mg L^{-1}	HCO_3 mg L^{-1}	NH_4-N mg L^{-1}	PO_4-P mg L^{-1}	Mn mg L^{-1}	Fe mg L^{-1}	Cu mg L^{-1}	Zn mg L^{-1}
1	7.3	5.9	0.6	11	579	11.3	427	598	4.2	1321	0.0	903	nm	nm	9.00	4.00	0.00	0.01
2	7.5	9.7	157.7	280	1595	21.1	635	555	11.2	1925	0.0	897	nm	nm	0.62	0.03	0.01	0.01
3	7.6	5.1	31.7	50	444	12.1	461	453	3.5	1273	0.0	482	nm	nm	0.07	0.00	0.00	0.00
4	7.8	7.2	9.7	145	936	15.6	475	617	6.7	1497	0.0	934	nm	nm	0.16	0.01	0.01	0.00
5	7.7	6.9	46.4	131	812	13.7	435	671	5.7	1531	0.0	604	nm	nm	0.17	0.00	0.00	0.00
6	7.9	9.0	103.5	234	1579	17.2	453	533	11.9	1725	0.0	726	nm	nm	0.01	0.01	0.02	0.00
7	7.9	8.2	56.2	181	1246	18.4	457	620	8.9	1698	0.0	812	nm	nm	0.23	0.02	0.00	0.00
8	7.9	6.6	95.8	60	943	14.5	441	430	7.7	1305	0.0	561	nm	nm	0.13	0.01	0.00	0.00
9	8.0	8.3	8.4	39	1308	18.4	417	681	9.2	1818	0.0	683	nm	nm	0.31	0.01	0.01	0.00
10	7.9	7.6	0.6	25	1290	16.4	423	484	10.2	1568	0.0	1159	nm	nm	7.60	3.70	0.00	0.01
11	8.0	6.7	27.7	53	876	16.4	435	559	6.6	1515	0.0	616	nm	nm	0.44	0.01	0.01	0.00
12	8.0	7.5	0.6	25	1246	17.6	439	489	9.7	1633	0.0	824	nm	nm	4.10	3.70	0.00	0.00
13	8.1	4.7	66.7	89	209	10.2	481	470	1.6	967	0.0	543	nm	nm	0.32	0.02	0.00	0.01
14	8.0	9.9	0.6	96	1471	17.6	447	930	9.1	2411	0.0	964	nm	nm	5.20	9.80	0.00	0.01
15	8.2	9.4	10.2	64	1366	19.5	411	898	8.7	2316	0.0	879	nm	nm	2.10	2.20	0.00	0.01
16	8.3	8.7	6.3	53	1191	11.7	423	832	7.7	1919	0.0	873	nm	nm	0.17	0.02	0.00	0.00

nm = not measured.

Table 9.12. Research Feedlot groundwater chemistry data on September 26, 1996.

Well no.	pH	EC dS m^{-1}	NO_3-N mg L^{-1}	Cl mg L^{-1}	Na mg L^{-1}	K mg L^{-1}	Ca mg L^{-1}	Mg mg L^{-1}	SAR mg L^{-1}	SO_4-S mg L^{-1}	CO_3 mg L^{-1}	HCO_3 mg L^{-1}	NH_4-N mg L^{-1}	PO_4-P mg L^{-1}	Mn mg L^{-1}	Fe mg L^{-1}	Cu mg L^{-1}	Zn mg L^{-1}
1	nm	nm	0.0	7	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
2	nm	nm	138.5	288	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
3	nm	nm	30.1	50	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
4	nm	nm	0.3	158	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
5	nm	nm	41.2	137	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
6	nm	nm	99.1	244	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
7	nm	nm	43.9	145	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
8	nm	nm	66.8	59	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
9	nm	nm	4.6	46	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
10	nm	nm	0.0	25	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
11	nm	nm	50.5	23	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
12	nm	nm	0.0	27	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
13	nm	nm	66.7	92	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
14	nm	nm	0.0	97	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
15	nm	nm	1.8	62	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
16	nm	nm	0.0	49	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm

nm = not measured.

Table 9.13. Research Feedlot groundwater chemistry data on October 2, 1996.

Well no.	pH	EC dS m^{-1}	NO_3-N mg L^{-1}	Cl mg L^{-1}	Na mg L^{-1}	K mg L^{-1}	Ca mg L^{-1}	Mg mg L^{-1}	SAR mg L^{-1}	SO_4-S mg L^{-1}	CO_3 mg L^{-1}	HCO_3 mg L^{-1}	NH_4-N mg L^{-1}	PO_4-P mg L^{-1}	Mn mg L^{-1}	Fe mg L^{-1}	Cu mg L^{-1}	Zn mg L^{-1}
1	nm	6.4	0.0	11	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
2	nm	9.7	136.9	273	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
3	nm	5.3	19.4	41	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
4	nm	7.2	1.3	158	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
5	nm	7.2	39.5	138	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
6	nm	9.3	97.3	240	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
7	nm	8.1	41.9	147	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
8	nm	7.0	58.7	58	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
9	nm	8.7	5.0	44	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
10	nm	7.9	0.0	25	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
11	nm	6.8	23.2	44	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
12	nm	7.8	0.0	29	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
13	nm	4.6	63.0	91	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
14	nm	10.0	0.0	100	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
15	nm	8.9	0.0	49	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
16	nm	8.5	0.6	47	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm

nm = not measured.

Table 9.14. Research Feedlot groundwater chemistry data on November 14, 1996.

Well no.	pH	EC dS m^{-1}	NO_3-N mg L^{-1}	Cl mg L^{-1}	Na mg L^{-1}	K mg L^{-1}	Ca mg L^{-1}	Mg mg L^{-1}	SAR mg L^{-1}	SO_4-S mg L^{-1}	CO_3 mg L^{-1}	HCO_3 mg L^{-1}	NH_4-N mg L^{-1}	PO_4-P mg L^{-1}	Mn mg L^{-1}	Fe mg L^{-1}	Cu mg L^{-1}	Zn mg L^{-1}
1	nm	nm	0.0	10	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
2	nm	nm	118.6	283	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
3	nm	nm	24.3	44	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
4	nm	nm	0.7	164	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
5	nm	nm	38.3	144	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
6	nm	nm	93.3	235	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
7	nm	nm	41.5	140	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
8	nm	nm	37.5	59	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
9	nm	nm	4.3	52	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
10	nm	nm	0.0	25	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
11	nm	nm	24.1	47	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
12	nm	nm	0.0	28	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
13	nm	nm	41.4	91	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
14	nm	nm	0.0	104	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
15	nm	nm	0.0	58	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
16	nm	nm	0.0	36	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm

nm = not measured.

Table 9.15. Research Feedlot groundwater chemistry data on May 12, 1997.

Well no.	pH	EC dS m^{-1}	NO_3-N mg L^{-1}	Cl mg L^{-1}	Na mg L^{-1}	K mg L^{-1}	Ca mg L^{-1}	Mg mg L^{-1}	SAR mg L^{-1}	SO_4-S mg L^{-1}	CO_3 mg L^{-1}	HCO_3 mg L^{-1}	NH_4-N mg L^{-1}	PO_4-P mg L^{-1}	Mn mg L^{-1}	Fe mg L^{-1}	Cu mg L^{-1}	Zn mg L^{-1}
1	7.3	6.3	0.0	16	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
2	7.7	9.5	122.5	390	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
3	7.6	5.8	16.8	55	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
4	7.7	7.3	4.9	222	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
5	7.4	7.8	18.6	95	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
6	7.8	9.7	90.6	316	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
7	7.7	8.5	51.6	272	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
8	7.5	7.0	59.1	72	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
9	7.5	8.4	10.1	45	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
10	7.5	8.0	0.0	37	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
11	7.6	7.0	21.0	80	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
12	7.7	7.9	0.0	39	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
13	7.4	5.1	58.5	88	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
14	7.5	10.4	0.7	97	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
15	7.6	10.0	35.6	72	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
16	7.9	7.0	1.0	29	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm

nm = not measured.

Table 9.16. Research Feedlot groundwater chemistry data on June 12, 1997.

Well no.	pH	EC dS m^{-1}	NO_3-N mg L^{-1}	Cl mg L^{-1}	Na mg L^{-1}	K mg L^{-1}	Ca mg L^{-1}	Mg mg L^{-1}	SAR mg L^{-1}	SO_4-S mg L^{-1}	CO_3 mg L^{-1}	HCO_3 mg L^{-1}	NH_4-N mg L^{-1}	PO_4-P mg L^{-1}	Mn mg L^{-1}	Fe mg L^{-1}	Cu mg L^{-1}	Zn mg L^{-1}
1	nm	nm	0.0	16	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
2	nm	nm	138.7	373	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
3	nm	nm	15.3	55	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
4	nm	nm	3.2	211	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
5	nm	nm	70.7	300	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
6	nm	nm	75.0	236	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
7	nm	nm	57.0	276	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
8	nm	nm	127.5	94	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
9	nm	nm	12.1	39	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
10	nm	nm	1.6	27	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
11	nm	nm	34.6	44	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
12	nm	nm	0.0	37	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
13	nm	nm	15.8	276	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
14	nm	nm	0.0	133	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
15	nm	nm	9.1	52	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
16	nm	nm	0.0	21	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm

nm = not measured.

Table 9.17. Research Feedlot groundwater chemistry data on August 5, 1997.

Well no.	pH	EC $dS\ m^{-1}$	NO_3-N $mg\ L^{-1}$	Cl $mg\ L^{-1}$	Na $mg\ L^{-1}$	K $mg\ L^{-1}$	Ca $mg\ L^{-1}$	Mg $mg\ L^{-1}$	SAR $mg\ L^{-1}$	SO_4-S $mg\ L^{-1}$	CO_3 $mg\ L^{-1}$	HCO_3 $mg\ L^{-1}$	NH_4-N $mg\ L^{-1}$	PO_4-P $mg\ L^{-1}$	Mn $mg\ L^{-1}$	Fe $mg\ L^{-1}$	Cu $mg\ L^{-1}$	Zn $mg\ L^{-1}$
1	nm	nm	0.3	12	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
2	nm	nm	129.8	289	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
3	nm	nm	14.6	40	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
4	nm	nm	4.4	166	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
5	nm	nm	91.9	271	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
6	nm	nm	64.8	114	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
7	nm	nm	52.5	172	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
8	nm	nm	107.6	132	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
9	nm	nm	24.5	23	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
10	nm	nm	0.0	19	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
11	nm	nm	23.6	45	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
12	nm	nm	2.6	17	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
13	nm	nm	0.2	326	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
14	nm	nm	0.0	93	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
15	nm	nm	2.1	19	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
16	nm	nm	0.0	23	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm

nm = not measured.

Table 9.18. Research Feedlot groundwater chemistry data on September 10, 1997

Well no.	pH	EC dS m^{-1}	NO_3-N mg L^{-1}	Cl mg L^{-1}	Na mg L^{-1}	K mg L^{-1}	Ca mg L^{-1}	Mg mg L^{-1}	SAR mg L^{-1}	SO_4-S mg L^{-1}	CO_3 mg L^{-1}	HCO_3 mg L^{-1}	NH_4-N mg L^{-1}	PO_4-P mg L^{-1}	Mn mg L^{-1}	Fe mg L^{-1}	Cu mg L^{-1}	Zn mg L^{-1}
1	nm	nm	0.0	8	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
2	nm	nm	134.0	294	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
3	nm	nm	5.8	34	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
4	nm	nm	5.3	169	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
5	nm	nm	76.7	235	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
6	nm	nm	71.1	139	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
7	nm	nm	48.8	149	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
8	nm	nm	81.2	98	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
9	nm	nm	6.8	43	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
10	nm	nm	0.0	20	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
11	nm	nm	16.0	61	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
12	nm	nm	0.0	28	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
13	nm	nm	0.0	266	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
14	nm	nm	0.0	88	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
15	nm	nm	57.1	58	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
16	nm	nm	0.0	18	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm

nm = not measured.

Table 9.19. Research Feedlot groundwater chemistry data on October 27, 1997.

Well no.	pH	EC dS m^{-1}	NO_3-N mg L^{-1}	Cl mg L^{-1}	Na mg L^{-1}	K mg L^{-1}	Ca mg L^{-1}	Mg mg L^{-1}	SAR mg L^{-1}	SO_4-S mg L^{-1}	CO_3 mg L^{-1}	HCO_3 mg L^{-1}	NH_4-N mg L^{-1}	PO_4-P mg L^{-1}	Mn mg L^{-1}	Fe mg L^{-1}	Cu mg L^{-1}	Zn mg L^{-1}
1	nm	nm	0.0	9	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
2	nm	nm	142.5	302	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
3	nm	nm	7.2	34	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
4	nm	nm	8.8	179	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
5	nm	nm	69.8	228	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
6	nm	nm	75.1	157	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
7	nm	nm	41.3	123	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
8	nm	nm	73.9	89	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
9	nm	nm	9.1	39	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
10	nm	nm	0.1	23	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
11	nm	nm	17.6	73	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
12	nm	nm	0.1	18	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
13	nm	nm	0.1	226	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
14	nm	nm	0.0	86	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
15	nm	nm	1.8	20	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
16	nm	nm	0.0	13	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm

nm = not measured.

Table 9.20. Research Feedlot groundwater chemistry data on February 18, 1998.

Well no.	pH	EC dS m^{-1}	NO_3-N mg L^{-1}	Cl mg L^{-1}	Na mg L^{-1}	K mg L^{-1}	Ca mg L^{-1}	Mg mg L^{-1}	SAR mg L^{-1}	SO_4-S mg L^{-1}	CO_3 mg L^{-1}	HCO_3 mg L^{-1}	NH_4-N mg L^{-1}	PO_4-P mg L^{-1}	Mn mg L^{-1}	Fe mg L^{-1}	Cu mg L^{-1}	Zn mg L^{-1}
1	7.5	6.7	0.0	8	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
2	7.8	9.2	161.5	288	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
3	7.7	6.6	2.8	29	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
4	7.6	7.0	23.1	186	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
5	7.5	7.1	45.6	158	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
6	7.7	8.1	116.6	229	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
7	7.8	7.6	40.8	106	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
8	7.7	6.9	58.0	75	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
9	7.8	8.5	7.2	42	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
10	7.6	7.7	0.0	28	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
11	7.8	7.2	20.0	79	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
12	7.9	7.8	0.0	31	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
13	7.2	5.1	3.7	156	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
14	7.4	10.1	0.0	84	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
15	7.9	9.6	29.3	54	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
16	8.0	6.6	0.0	16	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm

nm = not measured.

Table 9.21. Research Feedlot groundwater chemistry data on April 27, 1998.

Well no.	pH	EC dS m^{-1}	NO_3-N mg L^{-1}	Cl mg L^{-1}	Na mg L^{-1}	K mg L^{-1}	Ca mg L^{-1}	Mg mg L^{-1}	SAR mg L^{-1}	SO_4-S mg L^{-1}	CO_3 mg L^{-1}	HCO_3 mg L^{-1}	NH_4-N mg L^{-1}	PO_4-P mg L^{-1}	Mn mg L^{-1}	Fe mg L^{-1}	Cu mg L^{-1}	Zn mg L^{-1}
1	8.0	6.1	0.0	10	641	12.5	395	450	5.2	1322	0.0	635	0.28	0.01	2.30	6.90	0.00	0.01
2	8.3	9.3	166.4	293	1483	18.4	435	463	11.8	1577	10.2	712	0.56	0.03	0.36	0.00	0.00	0.01
3	8.2	6.2	4.6	32	747	15.2	415	396	6.3	1306	0.0	533	0.00	0.01	0.12	0.01	0.00	0.01
4	8.2	6.9	31.2	194	885	13.7	459	401	7.3	1243	0.0	817	0.00	0.02	0.03	0.00	0.03	0.02
5	8.2	6.7	54.9	184	639	12.1	431	533	4.9	1294	0.0	586	0.00	0.01	0.21	0.01	0.01	0.01
6	8.3	8.7	94.5	226	1384	14.9	433	431	11.3	1584	0.0	769	0.07	0.01	0.00	0.00	0.02	0.00
7	8.2	6.8	3.2	203	970	16.8	427	323	8.6	1182	0.0	761	1.48	0.10	0.42	0.03	0.05	0.02
8	8.3	6.9	56.0	72	1002	14.1	423	349	8.7	1333	6.0	638	0.00	0.01	0.15	0.01	0.00	0.00
9	8.3	8.5	5.7	46	1322	17.6	387	531	10.2	1871	13.8	667	0.00	0.01	0.24	0.01	0.01	0.01
10	8.2	7.7	0.0	26	1235	16.0	395	403	10.4	1676	0.0	705	0.35	0.06	3.60	9.60	0.00	0.00
11	8.3	6.8	19.6	57	825	13.7	407	459	6.7	1415	6.6	599	0.00	0.01	0.28	0.01	0.01	0.01
12	8.3	7.8	0.0	29	1235	16.4	419	406	10.3	1629	0.0	804	0.24	0.00	2.20	1.55	0.01	0.01
13	8.5	3.9	0.4	369	195	55.5	385	226	2.0	422	37.8	812	14.69	2.92	2.00	1.70	0.03	0.03
14	8.3	9.9	0.0	86	1448	16.4	417	839	9.4	2010	13.8	828	0.47	0.02	0.90	1.25	0.00	0.00
15	8.4	8.9	10.4	44	1170	17.6	405	785	7.8	2066	22.8	746	0.00	0.02	0.28	0.01	0.00	0.00
16	8.4	6.1	0.0	13	632	6.6	403	474	5.1	1313	40.8	659	0.00	0.01	0.15	0.03	0.00	0.00

nm = not measured.

Table 9.22. Research Feedlot groundwater chemistry data on May 12, 1998.

Well no.	pH	EC dS m^{-1}	NO_3-N mg L^{-1}	Cl mg L^{-1}	Na mg L^{-1}	K mg L^{-1}	Ca mg L^{-1}	Mg mg L^{-1}	SAR mg L^{-1}	SO_4-S mg L^{-1}	CO_3 mg L^{-1}	HCO_3 mg L^{-1}	NH_4-N mg L^{-1}	PO_4-P mg L^{-1}	Mn mg L^{-1}	Fe mg L^{-1}	Cu mg L^{-1}	Zn mg L^{-1}
1	7.9	5.2	5.3	14	361	9.0	423	411	3.0	1058	0.0	613	0.08	0.01	0.25	0.00	0.00	0.01
2	7.8	9.6	181.7	319	1508	18.4	457	478	11.8	1645	0.0	727	0.54	0.03	0.34	0.00	0.00	0.00
3	7.9	5.5	11.8	35	439	10.9	437	427	3.6	1154	0.0	497	0.00	0.01	0.01	0.00	0.00	0.00
4	7.9	6.9	35.9	202	878	13.3	461	389	7.3	1274	0.0	808	0.00	0.02	0.04	0.00	0.01	0.01
5	7.9	6.3	81.0	238	485	9.8	449	490	3.8	1130	0.0	579	0.00	0.01	0.12	0.00	0.00	0.00
6	7.9	8.8	109.4	234	1407	14.5	439	430	11.4	1691	0.0	782	0.07	0.01	0.01	0.04	0.00	0.00
7	8.1	6.9	14.0	227	961	18.8	429	345	8.4	1186	0.0	892	2.12	0.13	0.71	0.07	0.03	0.01
8	8.0	6.5	103.9	78	761	10.2	447	368	6.5	1127	0.0	603	0.00	0.00	0.07	0.01	0.01	0.00
9	8.0	7.9	21.6	28	1069	13.7	393	531	8.3	1683	0.0	690	0.00	0.01	0.15	0.00	0.00	0.02
10	7.8	7.8	8.0	25	1223	14.9	387	390	10.5	1595	0.0	709	0.35	0.01	3.70	7.50	0.00	0.00
11	7.5	6.0	34.7	43	579	10.9	419	429	4.8	1217	0.0	555	0.00	0.01	0.30	0.01	0.00	0.00
12	7.9	7.9	4.6	28	1225	16.0	417	400	10.3	1475	0.0	799	0.20	0.00	2.60	1.90	0.00	0.00
13	8.2	4.7	7.4	273	237	28.2	459	316	2.1	686	0.0	858	8.41	0.09	3.80	1.00	0.01	0.03
14	7.9	9.9	8.7	82	1400	16.0	411	736	9.6	2254	0.0	840	0.42	0.01	0.99	1.35	0.01	0.01
15	8.1	7.3	11.5	25	745	10.9	403	637	5.4	1649	0.0	767	0.00	0.02	0.24	0.00	0.00	0.01
16	8.2	5.2	4.6	11	428	4.7	415	388	3.6	1058	0.0	687	0.00	0.01	0.14	0.05	0.00	0.01

nm = not measured.

Table 9.23. Research Feedlot groundwater chemistry data on May 25, 1998.

Well no.	pH	EC dS m^{-1}	NO_3-N mg L^{-1}	Cl mg L^{-1}	Na mg L^{-1}	K mg L^{-1}	Ca mg L^{-1}	Mg mg L^{-1}	SAR mg L^{-1}	SO_4-S mg L^{-1}	CO_3 mg L^{-1}	HCO_3 mg L^{-1}	NH_4-N mg L^{-1}	PO_4-P mg L^{-1}	Mn mg L^{-1}	Fe mg L^{-1}	Cu mg L^{-1}	Zn mg L^{-1}
1	nm	5.2	0.8	14	nm	nm	nm	nm	nm	nm	nm	nm	0.04	0.01	nm	nm	nm	nm
2	nm	9.9	147.1	280	nm	nm	nm	nm	nm	nm	nm	nm	0.55	0.03	nm	nm	nm	nm
3	nm	5.4	12.5	38	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.01	nm	nm	nm	nm
4	nm	6.9	28.6	187	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.02	nm	nm	nm	nm
5	nm	6.1	69.7	229	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.01	nm	nm	nm	nm
6	nm	9.0	85.9	206	nm	nm	nm	nm	nm	nm	nm	nm	0.08	0.02	nm	nm	nm	nm
7	nm	7.1	8.9	193	nm	nm	nm	nm	nm	nm	nm	nm	1.83	0.10	nm	nm	nm	nm
8	nm	6.5	86.4	77	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.01	nm	nm	nm	nm
9	nm	7.9	15.3	27	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.01	nm	nm	nm	nm
10	nm	7.8	0.0	25	nm	nm	nm	nm	nm	nm	nm	nm	0.36	0.03	nm	nm	nm	nm
11	nm	5.8	30.1	39	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.00	nm	nm	nm	nm
12	nm	7.6	1.4	24	nm	nm	nm	nm	nm	nm	nm	nm	0.19	0.02	nm	nm	nm	nm
13	nm	4.3	0.1	246	nm	nm	nm	nm	nm	nm	nm	nm	8.70	0.11	nm	nm	nm	nm
14	nm	9.9	0.0	82	nm	nm	nm	nm	nm	nm	nm	nm	0.41	0.02	nm	nm	nm	nm
15	nm	7.3	8.7	25	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.02	nm	nm	nm	nm
16	nm	6.2	0.0	12	nm	nm	nm	nm	nm	nm	nm	nm	0.04	0.02	nm	nm	nm	nm

nm = not measured.

Table 9.24. Research Feedlot groundwater chemistry data on June 15, 1998.

Well no.	pH	EC dS m^{-1}	NO_3-N mg L^{-1}	Cl mg L^{-1}	Na mg L^{-1}	K mg L^{-1}	Ca mg L^{-1}	Mg mg L^{-1}	SAR mg L^{-1}	SO_4-S mg L^{-1}	CO_3 mg L^{-1}	HCO_3 mg L^{-1}	NH_4-N mg L^{-1}	PO_4-P mg L^{-1}	Mn mg L^{-1}	Fe mg L^{-1}	Cu mg L^{-1}	Zn mg L^{-1}
1	8.3	5.3	1.0	12	368	8.6	447	414	3.0	1095	0.0	594	0.10	0.01	0.26	0.20	0.01	0.04
2	8.3	10.2	145.0	280	1559	19.5	483	543	11.6	1826	0.0	635	0.53	0.04	0.30	0.01	0.00	0.03
3	8.3	5.6	9.8	35	455	11.3	465	423	3.7	1245	0.0	467	0.00	0.01	0.02	0.00	0.00	0.02
4	8.2	7.0	28.2	190	871	13.3	481	403	7.1	1337	0.0	714	0.00	0.02	0.02	0.00	0.01	0.03
5	8.2	5.3	64.7	231	225	5.9	527	414	1.8	868	0.0	502	0.06	0.02	0.03	0.00	0.01	0.05
6	8.3	9.0	81.0	210	1377	14.5	455	445	11.0	1688	0.0	741	0.15	0.02	0.01	0.00	0.01	0.02
7	8.2	7.3	8.8	192	1014	19.9	447	382	8.5	1306	0.0	749	1.79	0.08	0.56	0.15	0.01	0.03
8	8.2	5.6	96.8	126	444	5.1	489	373	3.7	950	0.0	532	0.00	0.00	0.01	0.00	0.00	0.03
9	8.3	6.5	30.1	22	644	8.6	451	473	5.1	1347	12.0	636	0.00	0.02	0.00	0.00	0.01	0.02
10	8.5	7.3	3.4	19	993	10.2	425	434	8.1	1531	34.2	627	0.08	0.00	1.45	4.50	0.01	0.03
11	8.2	4.3	43.0	30	138	7.0	507	317	1.2	812	0.0	450	0.00	0.00	0.03	0.00	0.01	0.04
12	8.3	6.8	5.0	18	745	8.2	449	489	5.8	1473	13.8	760	0.05	0.02	0.15	0.00	0.02	0.05
13	8.2	4.2	16.8	233	152	39.1	497	275	1.4	619	0.0	546	7.48	0.29	1.80	1.10	0.02	0.02
14	8.5	8.1	0.0	26	763	7.8	417	794	5.1	1843	52.2	748	0.18	0.03	0.18	0.61	0.00	0.03
15	8.4	4.7	0.0	4	145	3.1	451	437	1.2	999	16.8	500	0.04	0.02	0.05	0.05	0.01	0.04
16	8.3	4.7	0.0	7	260	2.7	493	363	2.2	951	0.0	574	0.00	0.02	0.00	0.01	0.01	0.03

nm = not measured.

Table 9.25. Research Feedlot groundwater chemistry data on July 6, 1998.

Well no.	pH	EC dS m^{-1}	NO_3-N mg L^{-1}	Cl mg L^{-1}	Na mg L^{-1}	K mg L^{-1}	Ca mg L^{-1}	Mg mg L^{-1}	SAR mg L^{-1}	SO_4-S mg L^{-1}	CO_3 mg L^{-1}	HCO_3 mg L^{-1}	NH_4-N mg L^{-1}	PO_4-P mg L^{-1}	Mn mg L^{-1}	Fe mg L^{-1}	Cu mg L^{-1}	Zn mg L^{-1}
1	nm	4.8	14.3	23	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.54	nm	nm	nm	nm
2	nm	10.7	127.4	272	nm	nm	nm	nm	nm	nm	nm	nm	0.43	0.09	nm	nm	nm	nm
3	nm	3.5	52.3	84	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.01	nm	nm	nm	nm
4	nm	7.0	28.6	183	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.03	nm	nm	nm	nm
5	nm	5.3	62.7	225	nm	nm	nm	nm	nm	nm	nm	nm	0.08	0.06	nm	nm	nm	nm
6	nm	5.6	68.4	249	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.14	nm	nm	nm	nm
7	nm	7.9	0.1	941	nm	nm	nm	nm	nm	nm	nm	nm	13.46	2.48	nm	nm	nm	nm
8	nm	5.5	115.4	152	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.00	nm	nm	nm	nm
9	nm	6.0	31.7	25	nm	nm	nm	nm	nm	nm	nm	nm	0.98	0.01	nm	nm	nm	nm
10	nm	7.2	3.6	20	nm	nm	nm	nm	nm	nm	nm	nm	0.16	0.00	nm	nm	nm	nm
11	nm	3.8	47.9	37	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.00	nm	nm	nm	nm
12	nm	6.1	0.0	536	nm	nm	nm	nm	nm	nm	nm	nm	5.96	0.32	nm	nm	nm	nm
13	nm	4.3	0.0	432	nm	nm	nm	nm	nm	nm	nm	nm	13.06	3.85	nm	nm	nm	nm
14	nm	7.3	0.0	110	nm	nm	nm	nm	nm	nm	nm	nm	0.04	0.03	nm	nm	nm	nm
15	nm	4.3	0.0	0	nm	nm	nm	nm	nm	nm	nm	nm	0.05	0.06	nm	nm	nm	nm
16	nm	4.6	0.0	8	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.02	nm	nm	nm	nm

nm = not measured.

Table 9.26. Research Feedlot groundwater chemistry data on July 14, 1998.

Well no.	pH	EC dS m^{-1}	NO_3-N mg L^{-1}	Cl mg L^{-1}	Na mg L^{-1}	K mg L^{-1}	Ca mg L^{-1}	Mg mg L^{-1}	SAR mg L^{-1}	SO_4-S mg L^{-1}	CO_3 mg L^{-1}	HCO_3 mg L^{-1}	NH_4-N mg L^{-1}	PO_4-P mg L^{-1}	Mn mg L^{-1}	Fe mg L^{-1}	Cu mg L^{-1}	Zn mg L^{-1}
1	8.0	4.7	14.8	27	251	6.6	469	367	2.1	970	0.0	531	0.00	0.28	0.01	0.00	0.01	0.03
2	8.0	11.1	118.1	281	1685	19.5	493	711	11.4	2324	0.0	726	0.40	0.09	0.22	0.00	0.00	0.03
3	8.0	3.5	66.7	13	90	4.3	573	160	0.9	628	0.0	250	0.00	0.00	0.00	0.00	0.00	0.01
4	8.0	7.0	25.5	176	874	12.9	463	423	7.1	1339	0.0	769	0.00	0.02	0.01	0.00	0.02	0.02
5	8.2	6.3	58.7	535	331	206.8	531	447	2.6	858	0.0	818	4.58	1.52	0.12	0.28	0.01	0.03
6	8.2	6.2	47.3	322	807	8.6	345	351	7.3	818	0.0	1172	0.58	0.17	0.10	0.01	0.01	0.02
7	8.2	7.6	0.0	572	963	119.3	449	414	7.9	1090	0.0	1172	6.34	1.01	0.95	0.43	0.01	0.01
8	8.2	6.1	89.9	256	490	93.8	505	394	4.0	914	0.0	744	2.71	0.44	0.17	0.05	0.01	0.02
9	8.1	6.2	31.1	24	598	8.6	465	457	4.7	1258	0.0	781	0.00	0.02	0.00	0.00	0.00	0.01
10	8.3	7.1	2.5	79	956	10.2	411	427	7.9	1459	0.0	805	0.48	0.04	0.74	2.15	0.01	0.02
11	8.1	3.8	40.8	39	87	5.5	525	266	0.8	718	0.0	543	0.00	0.00	0.01	0.00	0.00	0.03
12	8.2	6.4	1.7	235	607	11.7	465	461	4.8	1058	0.0	1104	2.66	0.26	0.48	0.16	0.00	0.00
13	8.3	4.3	0.1	319	170	77.4	495	261	1.5	577	0.0	836	8.75	0.96	1.95	0.58	0.00	0.00
14	8.3	7.4	0.0	14	584	5.5	429	803	3.8	1707	0.0	921	0.00	0.04	0.17	0.03	0.00	0.01
15	8.2	4.5	0.0	0	122	2.7	461	451	1.0	978	0.0	635	0.00	0.03	0.01	0.00	0.00	0.03
16	8.3	4.8	0.0	8	255	3.1	489	380	2.1	962	0.0	659	0.00	0.02	0.01	0.00	0.00	0.04

nm = not measured.

Table 9.27. Research Feedlot groundwater chemistry data on July 27, 1998.

Well no.	pH	EC dS m^{-1}	NO_3-N mg L^{-1}	Cl mg L^{-1}	Na mg L^{-1}	K mg L^{-1}	Ca mg L^{-1}	Mg mg L^{-1}	SAR mg L^{-1}	SO_4-S mg L^{-1}	CO_3 mg L^{-1}	HCO_3 mg L^{-1}	NH_4-N mg L^{-1}	PO_4-P mg L^{-1}	Mn mg L^{-1}	Fe mg L^{-1}	Cu mg L^{-1}	Zn mg L^{-1}
1	nm	4.8	12.9	25	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.16	nm	nm	nm	nm
2	nm	11.3	138.5	283	nm	nm	nm	nm	nm	nm	nm	nm	0.47	0.09	nm	nm	nm	nm
3	nm	3.6	71.0	93	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.00	nm	nm	nm	nm
4	nm	7.1	26.7	173	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.02	nm	nm	nm	nm
5	nm	6.1	75.8	381	nm	nm	nm	nm	nm	nm	nm	nm	1.09	0.13	nm	nm	nm	nm
6	nm	6.6	41.7	302	nm	nm	nm	nm	nm	nm	nm	nm	0.79	0.09	nm	nm	nm	nm
7	nm	7.6	0.0	318	nm	nm	nm	nm	nm	nm	nm	nm	2.07	0.15	nm	nm	nm	nm
8	nm	5.7	116.1	137	nm	nm	nm	nm	nm	nm	nm	nm	0.72	0.06	nm	nm	nm	nm
9	nm	6.1	35.1	26	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.02	nm	nm	nm	nm
10	nm	7.2	2.9	58	nm	nm	nm	nm	nm	nm	nm	nm	0.59	0.02	nm	nm	nm	nm
11	nm	3.8	50.4	44	nm	nm	nm	nm	nm	nm	nm	nm	0.30	0.00	nm	nm	nm	nm
12	nm	6.3	0.0	32	nm	nm	nm	nm	nm	nm	nm	nm	1.53	0.23	nm	nm	nm	nm
13	nm	4.5	5.8	205	nm	nm	nm	nm	nm	nm	nm	nm	5.96	0.06	nm	nm	nm	nm
14	nm	7.5	0.0	13	nm	nm	nm	nm	nm	nm	nm	nm	0.08	0.03	nm	nm	nm	nm
15	nm	4.8	0.0	5	nm	nm	nm	nm	nm	nm	nm	nm	0.05	0.02	nm	nm	nm	nm
16	nm	5.1	0.0	11	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.01	nm	nm	nm	nm

nm = not measured.

Table 9.28. Research Feedlot groundwater chemistry data on August 10, 1998.

Well no.	pH	EC dS m^{-1}	NO_3-N mg L^{-1}	Cl mg L^{-1}	Na mg L^{-1}	K mg L^{-1}	Ca mg L^{-1}	Mg mg L^{-1}	SAR mg L^{-1}	SO_4-S mg L^{-1}	CO_3 mg L^{-1}	HCO_3 mg L^{-1}	NH_4-N mg L^{-1}	PO_4-P mg L^{-1}	Mn mg L^{-1}	Fe mg L^{-1}	Cu mg L^{-1}	Zn mg L^{-1}
1	8.1	5.0	3.1	17	368	9.4	453	395	3.0	1082	0.0	635	0.07	0.04	0.19	0.01	0.00	0.04
2	8.2	10.8	121.6	278	1706	21.5	465	700	11.7	2212	0.0	726	0.46	0.03	0.21	0.00	0.01	0.03
3	8.2	3.6	63.3	88	103	5.5	535	202	1.0	612	0.0	305	0.00	0.00	0.00	0.00	0.04	0.02
4	8.1	6.9	25.1	1692	894	14.1	459	411	7.3	1314	0.0	763	0.00	0.05	0.00	0.09	0.02	0.03
5	8.2	5.9	47.1	422	336	60.2	523	427	2.6	938	0.0	720	2.67	0.26	0.38	0.07	0.01	0.03
6	8.2	7.6	52.4	237	1097	12.1	437	417	9.0	1339	0.0	1068	0.50	0.17	0.05	0.00	0.01	0.03
7	8.2	8.2	14.1	258	1143	27.8	467	440	9.1	1403	0.0	976	1.79	0.05	1.01	0.21	0.01	0.04
8	8.4	5.3	19.7	663	487	88.0	339	299	4.7	601	18.6	757	2.09	0.64	1.08	0.08	0.02	0.04
9	8.3	6.2	32.1	24	616	9.8	475	448	4.9	1298	0.0	787	0.00	0.05	0.00	0.00	0.00	0.03
10	8.2	7.7	0.0	24	1228	16.8	405	406	10.3	1675	0.0	714	0.36	0.03	2.80	3.00	0.00	0.04
11	8.2	3.9	37.0	95	113	6.3	573	235	1.0	702	0.0	531	0.00	0.03	0.01	0.00	0.00	0.03
12	8.3	6.9	2.2	144	782	12.1	457	475	6.1	1298	0.0	1068	0.55	0.03	0.59	0.32	0.00	0.02
13	8.2	4.6	8.0	324	182	79.8	519	283	1.6	713	0.0	665	7.28	0.11	2.30	0.69	0.00	0.04
14	8.2	9.1	0.0	57	1175	14.9	413	770	7.9	2084	0.0	860	0.26	0.03	0.44	0.26	0.00	0.02
15	8.3	4.7	0.0	6	136	3.5	471	445	1.1	1018	16.2	622	0.00	0.03	0.01	0.00	0.00	0.03
16	8.4	5.2	0.0	15	354	4.3	505	419	2.8	1106	21.6	635	0.00	0.03	0.00	0.00	0.00	0.02

nm = not measured.

Table 9.29. Research Feedlot groundwater chemistry data on August 24, 1998.

Well no.	pH	EC dS m^{-1}	NO_3-N mg L^{-1}	Cl mg L^{-1}	Na mg L^{-1}	K mg L^{-1}	Ca mg L^{-1}	Mg mg L^{-1}	SAR mg L^{-1}	SO_4-S mg L^{-1}	CO_3 mg L^{-1}	HCO_3 mg L^{-1}	NH_4-N mg L^{-1}	PO_4-P mg L^{-1}	Mn mg L^{-1}	Fe mg L^{-1}	Cu mg L^{-1}	Zn mg L^{-1}
1	nm	5.0	3.4	17	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.05	nm	nm	nm	nm
2	nm	11.0	123.7	270	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.04	nm	nm	nm	nm
3	nm	3.6	63.5	86	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.01	nm	nm	nm	nm
4	nm	7.0	25.1	166	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.02	nm	nm	nm	nm
5	nm	5.6	42.7	410	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.25	nm	nm	nm	nm
6	nm	8.0	55.9	220	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.10	nm	nm	nm	nm
7	nm	8.0	12.6	242	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.56	nm	nm	nm	nm
8	nm	5.2	12.8	619	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.41	nm	nm	nm	nm
9	nm	6.2	32.1	24	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.02	nm	nm	nm	nm
10	nm	7.5	5.7	22	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.01	nm	nm	nm	nm
11	nm	4.0	40.8	74	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.01	nm	nm	nm	nm
12	nm	6.7	0.8	178	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.01	nm	nm	nm	nm
13	nm	4.4	4.2	31	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.48	nm	nm	nm	nm
14	nm	8.4	0.0	41	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.02	nm	nm	nm	nm
15	nm	4.6	0.0	6	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.02	nm	nm	nm	nm
16	nm	5.3	0.0	16	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.02	nm	nm	nm	nm

nm = not measured.

Table 9.30. Research Feedlot groundwater chemistry data on September 14, 1998.

Well no.	pH	EC dS m^{-1}	NO_3-N mg L^{-1}	Cl mg L^{-1}	Na mg L^{-1}	K mg L^{-1}	Ca mg L^{-1}	Mg mg L^{-1}	SAR mg L^{-1}	SO_4-S mg L^{-1}	CO_3 mg L^{-1}	HCO_3 mg L^{-1}	NH_4-N mg L^{-1}	PO_4-P mg L^{-1}	Mn mg L^{-1}	Fe mg L^{-1}	Cu mg L^{-1}	Zn mg L^{-1}
1	7.9	5.7	0.7	12	529	11.3	435	440	4.3	1314	0.0	635	0.12	0.01	0.69	0.20	0.00	0.04
2	8.1	11.1	117.4	279	1754	21.5	479	717	11.9	2517	0.0	720	0.52	0.05	0.21	0.00	0.01	0.01
3	8.1	4.8	23.8	47	444	10.6	449	284	4.0	986	0.0	421	0.00	0.00	0.11	0.00	0.01	0.01
4	8.1	7.1	24.9	172	913	14.1	471	447	7.2	1523	0.0	757	0.00	0.01	0.00	0.00	0.02	0.02
5	8.1	6.0	45.8	364	363	39.5	533	493	2.7	1010	0.0	696	2.58	0.22	0.29	0.10	0.01	0.01
6	8.2	9.3	67.1	198	791	16.8	467	535	5.9	197	0.0	891	0.11	0.03	0.01	0.00	0.02	0.00
7	8.1	8.1	7.8	234	1179	25.8	473	489	9.1	1608	0.0	958	1.82	0.06	0.85	0.00	0.01	0.01
8	8.2	6.3	50.3	309	715	31.7	453	372	6.0	1114	0.0	702	2.03	0.12	0.49	0.00	0.01	0.01
9	8.3	8.1	12.5	39	1152	16.4	429	557	8.6	1908	0.0	702	0.00	0.03	0.34	0.00	0.01	0.00
10	8.2	7.7	5.9	22	1143	13.7	425	472	9.1	1651	0.0	708	0.24	0.03	0.93	0.70	0.00	0.02
11	8.3	4.9	35.7	55	271	10.2	-104	751	2.2	1098	0.0	555	0.05	0.02	0.17	0.00	0.01	0.01
12	8.3	7.1	0.3	136	839	12.5	475	529	6.3	1539	0.0	995	0.96	0.02	1.01	0.60	0.01	0.01
13	8.3	4.6	3.2	273	177	66.9	521	324	1.5	818	0.0	702	9.37	0.20	1.94	0.30	0.01	0.01
14	8.3	9.8	0.0	73	1356	16.4	427	832	8.8	2421	0.0	818	0.37	0.02	0.74	0.80	0.01	0.00
15	8.3	5.5	1.5	10	345	7.0	451	566	2.6	1371	31.8	616	0.00	0.02	0.03	0.10	0.01	0.01
16	8.4	6.2	0.0	15	575	6.3	469	546	4.3	1579	25.2	667	0.07	0.02	0.08	0.10	0.00	0.01

nm = not measured.

Table 9.31. Research Feedlot groundwater chemistry data on September 28, 1998.

Well no.	pH	EC dS m^{-1}	NO_3-N mg L^{-1}	Cl mg L^{-1}	Na mg L^{-1}	K mg L^{-1}	Ca mg L^{-1}	Mg mg L^{-1}	SAR mg L^{-1}	SO_4-S mg L^{-1}	CO_3 mg L^{-1}	HCO_3 mg L^{-1}	NH_4-N mg L^{-1}	PO_4-P mg L^{-1}	Mn mg L^{-1}	Fe mg L^{-1}	Cu mg L^{-1}	Zn mg L^{-1}
1	nm	5.7	0.7	13	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.01	nm	nm	nm	nm
2	nm	11.6	99.0	254	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.07	nm	nm	nm	nm
3	nm	3.1	13.9	22	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.00	nm	nm	nm	nm
4	nm	7.3	24.7	148	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.03	nm	nm	nm	nm
5	nm	5.8	40.9	365	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.27	nm	nm	nm	nm
6	nm	8.7	51.6	197	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.09	nm	nm	nm	nm
7	nm	8.2	7.9	224	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.07	nm	nm	nm	nm
8	nm	5.8	29.4	438	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.15	nm	nm	nm	nm
9	nm	6.6	27.9	23	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.03	nm	nm	nm	nm
10	nm	7.7	7.7	21	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.03	nm	nm	nm	nm
11	nm	4.8	37.9	50	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.02	nm	nm	nm	nm
12	nm	7.0	0.8	146	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.04	nm	nm	nm	nm
13	nm	4.6	2.0	244	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.38	nm	nm	nm	nm
14	nm	9.2	0.0	52	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.03	nm	nm	nm	nm
15	nm	4.9	0.0	6	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.03	nm	nm	nm	nm
16	nm	4.9	0.0	10	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.02	nm	nm	nm	nm

nm = not measured.

Table 9.32. Research Feedlot groundwater chemistry data on October 13, 1998.

Well no.	pH	EC dS m^{-1}	NO_3-N mg L^{-1}	Cl mg L^{-1}	Na mg L^{-1}	K mg L^{-1}	Ca mg L^{-1}	Mg mg L^{-1}	SAR mg L^{-1}	SO_4-S mg L^{-1}	CO_3 mg L^{-1}	HCO_3 mg L^{-1}	NH_4-N mg L^{-1}	PO_4-P mg L^{-1}	Mn mg L^{-1}	Fe mg L^{-1}	Cu mg L^{-1}	Zn mg L^{-1}
1	8.1	5.8	0.7	11	503	11.3	431	429	4.1	1266	0.0	641	0.18	0.00	1.11	0.60	0.00	0.00
2	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
3	8.2	3.2	15.1	21	71	4.3	539	137	0.7	609	0.0	378	0.00	0.00	0.00	0.00	0.00	0.00
4	8.2	7.4	24.0	139	922	13.7	457	469	7.2	1571	0.0	720	0.00	0.03	0.01	0.00	0.00	0.00
5	8.1	5.8	44.7	344	278	37.1	545	439	2.2	938	0.0	689	1.87	0.18	0.44	0.00	0.00	0.00
6	8.2	8.9	56.0	188	1331	14.1	467	476	10.4	1683	0.0	976	0.21	0.07	0.15	0.00	0.00	0.00
7	8.2	8.1	8.5	207	1161	24.2	467	433	9.3	1595	0.0	934	1.19	0.05	1.22	0.00	0.00	0.00
8	8.2	6.0	32.9	381	517	34.8	505	350	4.3	906	0.0	744	2.17	0.08	0.88	0.10	0.00	0.00
9	8.2	6.5	29.7	22	616	9.8	491	470	4.8	1419	0.0	781	0.00	0.02	0.00	0.00	0.00	0.00
10	8.3	7.8	5.5	21	1113	14.5	427	436	9.1	1715	15.6	671	0.23	0.03	1.54	0.10	0.00	0.00
11	8.3	4.6	38.8	51	177	8.2	543	323	1.5	906	0.0	543	0.00	0.02	0.08	0.00	0.00	0.00
12	8.3	7.1	0.1	112	763	10.9	465	487	5.9	1475	27.0	946	0.47	0.03	1.17	0.10	0.00	0.00
13	8.3	4.6	0.4	214	149	51.2	531	303	1.3	757	0.0	708	3.26	0.21	2.50	0.30	0.00	0.00
14	8.3	9.7	0.0	62	1255	16.4	421	746	8.5	2228	0.0	824	0.26	0.02	1.05	1.40	0.00	0.00
15	8.4	4.9	0.0	6	170	5.1	455	451	1.4	1130	22.8	610	0.00	0.02	0.12	0.00	0.00	0.00
16	8.4	5.1	0.0	9	297	4.7	479	380	2.5	1090	27.0	610	0.00	0.03	0.01	0.00	0.00	0.00

nm = not measured.

Table 9.33. Research Feedlot groundwater chemistry data on October 26, 1998.

Well no.	pH	EC dS m^{-1}	NO_3-N mg L^{-1}	Cl mg L^{-1}	Na mg L^{-1}	K mg L^{-1}	Ca mg L^{-1}	Mg mg L^{-1}	SAR mg L^{-1}	SO_4-S mg L^{-1}	CO_3 mg L^{-1}	HCO_3 mg L^{-1}	NH_4-N mg L^{-1}	PO_4-P mg L^{-1}	Mn mg L^{-1}	Fe mg L^{-1}	Cu mg L^{-1}	Zn mg L^{-1}
1	nm	5.7	0.3	11	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.00	nm	nm	nm	nm
2	nm	10.3	132.2	272	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.02	nm	nm	nm	nm
3	nm	3.1	14.3	21	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.00	nm	nm	nm	nm
4	nm	7.4	25.6	144	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.03	nm	nm	nm	nm
5	nm	5.6	50.8	342	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.14	nm	nm	nm	nm
6	nm	8.8	60.0	194	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.08	nm	nm	nm	nm
7	nm	8.0	9.6	212	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.05	nm	nm	nm	nm
8	nm	5.8	34.5	387	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.10	nm	nm	nm	nm
9	nm	6.5	30.6	23	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.02	nm	nm	nm	nm
10	nm	7.8	4.8	21	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.01	nm	nm	nm	nm
11	nm	4.8	36.8	47	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.01	nm	nm	nm	nm
12	nm	6.9	0.3	98	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.02	nm	nm	nm	nm
13	nm	4.5	0.1	207	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.27	nm	nm	nm	nm
14	nm	9.5	0.0	60	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.02	nm	nm	nm	nm
15	nm	5.1	0.1	8	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.02	nm	nm	nm	nm
16	nm	5.1	0.0	10	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.03	nm	nm	nm	nm

nm = not measured.

Table 9.34. Research Feedlot groundwater chemistry data on November 16, 1998.

Well no.	pH	EC dS m^{-1}	NO_3-N mg L^{-1}	Cl mg L^{-1}	Na mg L^{-1}	K mg L^{-1}	Ca mg L^{-1}	Mg mg L^{-1}	SAR mg L^{-1}	SO_4-S mg L^{-1}	CO_3 mg L^{-1}	HCO_3 mg L^{-1}	NH_4-N mg L^{-1}	PO_4-P mg L^{-1}	Mn mg L^{-1}	Fe mg L^{-1}	Cu mg L^{-1}	Zn mg L^{-1}
1	7.8	5.4	0.7	13	435	10.2	1058	129	3.4	1162	0.0	682	nm	0.02	0.60	0.30	0.00	0.00
2	8.0	10.2	124.8	269	1630	22.7	437	695	11.3	1924	0.0	715	nm	0.02	0.50	0.00	0.00	0.00
3	8.0	3.3	23.4	37	113	5.5	527	209	1.1	641	0.0	389	nm	0.01	0.00	0.00	0.00	0.00
4	8.0	7.2	24.4	145	933	25.4	459	529	7.0	1483	0.0	730	nm	0.03	0.00	0.00	0.00	0.00
5	8.1	5.6	48.6	330	260	23.9	547	487	1.9	922	0.0	698	nm	0.08	0.20	0.00	0.00	0.00
6	8.1	8.9	68.2	194	1412	14.5	457	496	10.9	1651	0.0	916	nm	0.04	0.00	0.00	0.00	0.00
7	8.1	7.9	10.4	204	1166	22.7	451	493	9.0	1491	0.0	936	nm	0.06	1.00	0.00	0.00	0.00
8	8.1	5.9	41.3	328	536	24.6	505	403	4.3	930	0.0	764	nm	0.07	0.60	0.00	0.00	0.00
9	8.1	6.7	28.7	23	708	10.6	475	580	5.2	1467	0.0	760	nm	0.02	0.00	0.00	0.00	0.00
10	8.2	7.8	3.6	21	1193	15.2	413	490	9.4	1683	0.0	699	nm	0.02	2.00	0.10	0.00	0.00
11	8.2	5.1	36.3	45	290	9.4	521	422	2.3	1034	0.0	567	nm	0.02	0.20	0.10	0.00	0.00
12	8.2	7.0	1.0	75	858	11.3	447	551	6.4	1483	0.0	948	nm	0.02	0.90	0.10	0.00	0.00
13	8.2	4.5	0.4	189	145	39.5	507	363	1.2	758	0.0	721	nm	0.18	2.50	0.20	0.00	0.00
14	8.2	9.7	0.0	70	1384	16.8	419	873	8.8	2324	0.0	798	nm	0.03	1.40	2.50	0.00	0.00
15	8.3	5.6	2.2	10	384	7.8	431	595	2.8	1250	0.0	691	nm	0.03	0.20	0.10	0.00	0.00
16	8.3	5.8	0.0	12	517	5.9	463	518	3.9	1274	0.0	701	nm	0.03	0.10	0.10	0.00	0.00

nm = not measured.

Table 9.35. Research Feedlot groundwater chemistry data on November 30, 1998.

Well no.	pH	EC dS m^{-1}	NO_3-N mg L^{-1}	Cl mg L^{-1}	Na mg L^{-1}	K mg L^{-1}	Ca mg L^{-1}	Mg mg L^{-1}	SAR mg L^{-1}	SO_4-S mg L^{-1}	CO_3 mg L^{-1}	HCO_3 mg L^{-1}	NH_4-N mg L^{-1}	PO_4-P mg L^{-1}	Mn mg L^{-1}	Fe mg L^{-1}	Cu mg L^{-1}	Zn mg L^{-1}
1	nm	5.3	2.3	13	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.01	nm	nm	nm	nm
2	nm	10.5	140.3	266	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.01	nm	nm	nm	nm
3	nm	5.7	15.6	38	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.00	nm	nm	nm	nm
4	nm	7.4	28.7	143	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.01	nm	nm	nm	nm
5	nm	5.7	58.4	325	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.07	nm	nm	nm	nm
6	nm	9.2	92.3	194	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.01	nm	nm	nm	nm
7	nm	8.0	14.2	196	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.04	nm	nm	nm	nm
8	nm	6.8	55.1	145	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.02	nm	nm	nm	nm
9	nm	7.4	25.1	31	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.01	nm	nm	nm	nm
10	nm	8.0	3.1	21	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.00	nm	nm	nm	nm
11	nm	6.8	29.5	65	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.00	nm	nm	nm	nm
12	nm	7.8	1.7	40	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.04	nm	nm	nm	nm
13	nm	4.6	1.8	179	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.10	nm	nm	nm	nm
14	nm	10.0	1.8	74	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.03	nm	nm	nm	nm
15	nm	7.8	18.8	34	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.04	nm	nm	nm	nm
16	nm	6.5	1.8	15	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.04	nm	nm	nm	nm

nm = not measured.

Table 9.36. Research Feedlot groundwater chemistry data on December 14, 1998.

Well no.	pH	EC dS m^{-1}	NO_3-N mg L^{-1}	Cl mg L^{-1}	Na mg L^{-1}	K mg L^{-1}	Ca mg L^{-1}	Mg mg L^{-1}	SAR mg L^{-1}	SO_4-S mg L^{-1}	CO_3 mg L^{-1}	HCO_3 mg L^{-1}	NH_4-N mg L^{-1}	PO_4-P mg L^{-1}	Mn mg L^{-1}	Fe mg L^{-1}	Cu mg L^{-1}	Zn mg L^{-1}
1	7.7	5.3	3.6	14	395	9.0	441	475	3.1	1186	0.0	653	nm	0.00	0.20	0.10	0.00	0.00
2	7.7	10.7	144.5	266	1697	21.5	451	718	11.6	1972	0.0	776	nm	0.00	0.80	0.00	0.00	0.00
3	7.8	4.1	31.8	45	205	7.4	499	265	1.8	769	0.0	405	nm	0.00	0.00	0.00	0.00	0.00
4	7.7	7.5	27.7	145	952	13.7	451	536	7.2	1499	0.0	740	nm	0.00	0.00	0.00	0.00	0.00
5	7.8	5.8	66.8	327	269	23.9	537	502	2.0	946	0.0	709	nm	0.04	0.10	0.00	0.00	0.00
6	7.6	9.3	20.2	198	1506	15.2	425	563	11.3	1651	0.0	854	nm	0.00	0.00	0.00	0.00	0.00
7	7.8	8.1	14.3	195	1198	22.3	399	493	9.5	1512	0.0	924	nm	0.07	0.80	0.00	0.00	0.00
8	7.8	6.1	55.9	308	536	23.1	461	427	4.3	962	0.0	768	nm	0.09	0.30	0.00	0.00	0.00
9	7.6	7.0	36.1	24	766	10.2	439	586	5.6	1563	0.0	766	nm	0.07	0.10	0.00	0.00	0.00
10	7.6	8.1	2.1	21	1264	16.0	397	491	10.0	1619	0.0	703	nm	0.04	2.50	0.00	0.00	0.00
11	7.7	5.1	47.9	45	274	9.0	507	418	2.2	986	0.0	574	nm	0.04	0.10	0.00	0.00	0.00
12	7.7	7.3	1.5	51	929	11.3	411	554	7.0	1539	0.0	934	nm	0.05	0.50	0.00	0.00	0.00
13	7.8	4.6	2.0	180	166	33.6	473	383	1.4	810	0.0	714	nm	0.12	2.00	0.10	0.00	0.00
14	7.6	10.1	1.3	71	1458	18.0	423	852	9.4	2276	0.0	793	nm	0.05	1.50	0.80	0.00	0.00
15	7.8	6.3	5.9	13	497	9.4	421	629	3.6	1427	0.0	721	nm	0.05	0.20	0.10	0.00	0.00
16	7.8	6.6	1.3	14	676	7.4	439	577	5.0	1491	0.0	738	nm	0.04	0.20	0.00	0.00	0.00

nm = not measured.

Table 9.37. Research Feedlot groundwater chemistry data on January 11, 1999.

Well no.	pH	EC dS m^{-1}	NO_3-N mg L^{-1}	Cl mg L^{-1}	Na mg L^{-1}	K mg L^{-1}	Ca mg L^{-1}	Mg mg L^{-1}	SAR mg L^{-1}	SO_4-S mg L^{-1}	CO_3 mg L^{-1}	HCO_3 mg L^{-1}	NH_4-N mg L^{-1}	PO_4-P mg L^{-1}	Mn mg L^{-1}	Fe mg L^{-1}	Cu mg L^{-1}	Zn mg L^{-1}
1	8.1	5.4	0.8	14	446	10.2	449	452	3.6	1164	0.0	661	nm	0.00	0.30	0.20	0.00	0.00
2	8.1	10.1	135.7	269	1628	20.3	429	637	11.7	1928	0.0	758	nm	0.00	0.20	0.00	0.00	0.00
3	8.1	5.9	11.8	35	713	15.2	425	369	6.1	1252	0.0	507	nm	0.00	0.20	0.00	0.00	0.00
4	8.2	7.3	24.1	145	940	13.7	463	516	7.1	1472	0.0	757	nm	0.00	0.00	0.00	0.00	0.00
5	8.2	5.7	53.9	323	269	20.7	535	506	2.0	987	0.0	722	nm	0.05	0.10	0.00	0.00	0.00
6	8.2	8.9	86.1	206	1451	15.2	433	509	11.2	1648	0.0	838	nm	0.00	0.00	0.00	0.00	0.00
7	8.3	7.9	13.2	184	1175	21.1	443	481	9.2	1544	0.0	924	nm	0.07	1.00	0.00	0.00	0.00
8	8.3	6.1	13.2	262	582	19.9	497	412	4.7	1045	0.0	748	nm	0.07	0.30	0.00	0.00	0.00
9	8.3	7.8	48.0	35	1044	14.5	427	572	7.8	1633	0.0	723	nm	0.03	0.20	0.00	0.00	0.00
10	8.3	8.0	15.3	21	1237	15.6	403	474	9.9	1621	0.0	705	nm	0.02	2.20	0.00	0.00	0.10
11	8.3	6.3	26.6	53	637	12.9	467	495	4.9	1388	0.0	614	nm	0.02	0.30	0.00	0.00	0.00
12	8.3	7.8	0.4	35	1216	16.8	417	448	9.8	1622	0.0	827	nm	0.01	2.00	0.00	0.00	0.00
13	8.3	4.6	2.2	170	168	28.9	489	380	1.4	843	0.0	724	nm	0.07	2.00	0.10	0.00	0.00
14	8.3	9.9	0.0	71	1432	17.2	415	804	9.5	2263	6.0	794	nm	0.02	1.40	0.10	0.00	0.00
15	8.4	6.7	5.9	18	630	11.7	415	649	4.5	1560	23.4	691	nm	0.03	0.20	0.00	0.00	0.00
16	8.5	6.6	0.0	14	658	7.0	453	555	4.9	1470	31.2	685	nm	0.03	0.10	0.00	0.00	0.10

nm = not measured.

Table 9.38. Research Feedlot groundwater chemistry data on February 17, 1999.

Well no.	pH	EC dS m^{-1}	NO_3-N mg L^{-1}	Cl mg L^{-1}	Na mg L^{-1}	K mg L^{-1}	Ca mg L^{-1}	Mg mg L^{-1}	SAR mg L^{-1}	SO_4-S mg L^{-1}	CO_3 mg L^{-1}	HCO_3 mg L^{-1}	NH_4-N mg L^{-1}	PO_4-P mg L^{-1}	Mn mg L^{-1}	Fe mg L^{-1}	Cu mg L^{-1}	Zn mg L^{-1}
1	7.8	5.2	2.0	14	370	8.2	379	433	3.1	995	0.0	638	nm	0.02	0.00	0.00	0.00	0.10
2	7.7	10.2	131.4	259	924	19.5	357	594	7.0	1529	0.0	793	nm	0.02	0.50	0.00	0.00	0.00
3	7.9	4.0	33.8	50	179	7.0	427	273	1.7	725	0.0	414	nm	0.01	0.00	0.00	0.00	0.00
4	7.8	7.4	25.8	142	931	13.3	369	478	7.5	1399	0.0	753	nm	0.02	0.00	0.00	0.00	0.00
5	7.7	6.0	66.4	294	349	19.5	423	514	2.7	981	0.0	693	nm	0.06	0.30	0.00	0.00	0.00
6	7.8	8.7	108.7	213	1372	15.2	329	453	11.5	1407	0.0	790	nm	0.01	0.00	0.10	0.00	0.20
7	7.8	8.0	17.9	177	1186	20.3	331	459	9.9	1350	0.0	912	nm	0.04	0.90	0.00	0.00	0.00
8	7.8	6.3	47.9	220	683	19.5	381	401	5.8	1003	0.0	730	nm	0.05	0.30	0.00	0.00	0.00
9	7.8	8.1	14.4	39	1099	14.9	345	541	8.6	1595	0.0	716	nm	0.01	0.20	0.10	0.00	0.00
10	7.8	8.0	1.4	21	1235	15.2	333	463	10.3	1523	0.0	696	nm	0.01	2.50	0.00	0.00	0.00
11	7.9	6.3	29.6	57	600	12.1	385	478	4.8	1226	0.0	619	nm	0.01	0.30	0.00	0.00	0.00
12	7.8	7.9	1.0	35	1225	16.8	321	434	10.5	1465	0.0	810	nm	0.01	2.00	0.00	0.00	0.00
13	7.9	4.7	4.8	160	186	25.8	389	394	1.6	782	0.0	704	nm	0.03	1.80	0.10	0.00	0.00
14	7.8	10.0	1.3	71	1409	17.6	333	815	9.5	2121	0.0	800	nm	0.01	1.10	0.20	0.00	0.00
15	7.9	6.9	9.7	18	639	10.6	343	660	4.7	1451	0.0	754	nm	0.02	0.20	0.00	0.00	0.00
16	7.9	6.9	1.3	14	743	7.4	355	554	5.7	1393	0.0	774	nm	0.01	0.20	0.20	0.00	0.00

nm = not measured.

Table 9.39. Research Feedlot groundwater chemistry data on March 15, 1999.

Well no.	pH	EC dS m^{-1}	NO_3-N mg L^{-1}	Cl mg L^{-1}	Na mg L^{-1}	K mg L^{-1}	Ca mg L^{-1}	Mg mg L^{-1}	SAR mg L^{-1}	SO_4-S mg L^{-1}	CO_3 mg L^{-1}	HCO_3 mg L^{-1}	NH_4-N mg L^{-1}	PO_4-P mg L^{-1}	Mn mg L^{-1}	Fe mg L^{-1}	Cu mg L^{-1}	Zn mg L^{-1}
1	8.2	5.0	2.2	14	384	8.2	467	455	3.0	1026	0.0	639	0.00	0.02	0.00	0.00	0.00	0.30
2	8.0	10.2	138.2	280	1729	20.3	437	622	12.4	1924	0.0	797	0.11	0.02	0.40	0.00	0.00	0.60
3	8.0	4.3	27.5	46	264	8.2	481	307	2.3	906	0.0	438	0.00	0.01	0.00	0.00	0.00	0.40
4	8.0	7.3	24.0	149	989	14.1	477	541	7.4	1411	0.0	817	0.00	0.02	0.00	0.00	0.00	0.20
5	7.9	5.9	65.7	316	354	18.8	563	586	2.5	1050	0.0	701	0.08	0.06	0.20	0.00	0.00	0.20
6	8.0	8.7	110.8	223	1481	14.9	423	504	11.5	1555	0.0	803	0.00	0.02	0.00	0.00	0.00	0.10
7	8.0	8.0	18.9	188	1255	20.7	447	518	9.6	1523	0.0	896	1.30	0.05	0.50	0.00	0.00	0.20
8	8.0	6.5	43.6	174	832	18.4	501	411	6.7	1242	0.0	713	0.31	0.05	0.30	0.00	0.00	0.10
9	7.9	7.8	16.8	35	1094	13.7	425	583	8.1	1667	0.0	746	0.00	0.02	0.10	0.00	0.00	0.10
10	7.9	8.0	1.4	21	1322	15.6	413	521	10.2	1699	0.0	700	0.06	0.01	1.40	0.00	0.00	0.10
11	8.0	5.8	33.2	53	515	10.6	493	499	3.9	1202	0.0	582	0.00	0.01	0.20	0.00	0.00	0.10
12	7.8	7.8	1.4	35	1304	16.8	411	476	10.4	1635	0.0	813	0.16	0.01	1.20	0.00	0.00	0.10
13	8.0	4.6	16.7	142	161	23.9	525	410	1.3	874	0.0	641	5.11	0.04	0.90	0.00	0.00	0.20
14	8.0	10.0	0.0	74	1513	17.2	417	768	10.2	2276	0.0	796	0.28	0.01	1.10	0.20	0.00	0.10
15	8.0	7.0	8.5	18	701	10.9	401	666	5.0	1523	0.0	756	0.00	0.03	0.10	0.00	0.00	0.10
16	8.0	6.9	0.6	18	800	7.0	433	578	5.9	1523	0.0	783	0.00	0.01	0.10	0.00	0.00	0.10

nm = not measured.

Table 9.40. Research Feedlot groundwater chemistry data on April 12, 1999.

Well no.	pH	EC dS m^{-1}	NO_3-N mg L^{-1}	Cl mg L^{-1}	Na mg L^{-1}	K mg L^{-1}	Ca mg L^{-1}	Mg mg L^{-1}	SAR mg L^{-1}	SO_4-S mg L^{-1}	CO_3 mg L^{-1}	HCO_3 mg L^{-1}	NH_4-N mg L^{-1}	PO_4-P mg L^{-1}	Mn mg L^{-1}	Fe mg L^{-1}	Cu mg L^{-1}	Zn mg L^{-1}
1	7.7	5.4	1.8	14	352	7.4	417	412	2.9	1039	0.0	641	0.00	0.02	0.00	0.00	0.00	0.00
2	7.6	10.8	136.4	269	1593	18.8	377	650	11.5	1943	0.0	799	0.16	0.02	0.17	0.00	0.01	0.00
3	7.6	4.6	27.3	46	237	7.4	441	300	2.1	824	0.0	439	0.00	0.00	0.00	0.00	0.00	0.00
4	7.7	7.7	24.9	145	910	12.9	489	486	7.0	1390	0.0	751	0.00	0.02	0.02	0.00	0.02	0.01
5	7.6	6.1	63.2	308	264	16.8	409	481	2.1	1034	0.0	708	0.07	0.09	nm	nm	nm	nm
6	7.6	9.5	99.2	213	1418	14.5	373	475	11.5	1649	0.0	824	0.00	0.00	0.00	0.00	0.01	0.01
7	7.7	8.5	22.6	181	1179	19.9	391	463	9.6	1539	0.0	897	0.67	0.08	0.18	0.00	0.01	0.01
8	7.8	6.4	49.6	241	563	17.6	465	393	4.7	1016	0.0	720	0.26	0.14	0.22	0.00	0.02	0.07
9	7.7	6.8	31.7	21	614	7.0	419	527	4.7	1319	0.0	860	0.00	0.05	0.00	0.00	0.00	0.00
10	7.8	7.9	12.2	21	1035	10.6	385	478	8.3	1619	0.0	689	0.06	0.02	0.42	0.00	0.00	0.01
11	7.8	5.2	40.8	43	257	8.2	491	400	2.1	1021	0.0	537	0.00	0.01	0.01	0.00	0.00	0.00
12	7.7	7.8	5.5	32	979	10.9	389	499	7.7	1505	0.0	897	0.00	0.01	0.23	0.00	0.01	0.00
13	7.7	4.4	37.8	74	97	20.7	547	346	0.8	832	0.0	500	0.55	0.10	0.27	0.00	0.00	0.12
14	7.6	10.4	0.0	74	1393	16.4	395	808	9.2	2315	0.0	793	0.14	0.02	0.65	0.00	0.00	0.05
15	7.8	7.3	7.6	18	614	9.4	385	711	4.3	1611	0.0	763	0.00	0.04	0.01	0.00	0.00	0.00
16	7.9	7.2	0.0	14	722	6.6	359	570	5.5	1502	0.0	775	0.00	0.03	0.05	0.00	0.01	0.02

nm = not measured.

Table 9.41. Research Feedlot groundwater chemistry data on April 26, 1999.

Well no.	pH	EC dS m^{-1}	NO_3-N mg L^{-1}	Cl mg L^{-1}	Na mg L^{-1}	K mg L^{-1}	Ca mg L^{-1}	Mg mg L^{-1}	SAR mg L^{-1}	SO_4-S mg L^{-1}	CO_3 mg L^{-1}	HCO_3 mg L^{-1}	NH_4-N mg L^{-1}	PO_4-P mg L^{-1}	Mn mg L^{-1}	Fe mg L^{-1}	Cu mg L^{-1}	Zn mg L^{-1}
1	7.7	5.2	1.6	15	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.04	nm	nm	nm	nm
2	7.7	10.8	116.7	277	nm	nm	nm	nm	nm	nm	nm	nm	0.21	0.03	nm	nm	nm	nm
3	7.6	4.6	25.7	45	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.01	nm	nm	nm	nm
4	7.6	7.7	20.8	149	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.02	nm	nm	nm	nm
5	7.6	6.1	58.0	316	nm	nm	nm	nm	nm	nm	nm	nm	0.08	0.08	nm	nm	nm	nm
6	7.5	9.6	86.7	213	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.02	nm	nm	nm	nm
7	7.6	8.6	22.0	185	nm	nm	nm	nm	nm	nm	nm	nm	0.70	0.05	nm	nm	nm	nm
8	7.7	6.3	45.5	259	nm	nm	nm	nm	nm	nm	nm	nm	0.29	0.06	nm	nm	nm	nm
9	7.5	7.0	27.0	24	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.03	nm	nm	nm	nm
10	7.5	8.1	7.0	22	nm	nm	nm	nm	nm	nm	nm	nm	0.11	0.02	nm	nm	nm	nm
11	7.6	5.3	35.9	44	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.02	nm	nm	nm	nm
12	7.6	7.7	5.7	33	nm	nm	nm	nm	nm	nm	nm	nm	0.05	0.02	nm	nm	nm	nm
13	7.5	4.4	30.9	86	nm	nm	nm	nm	nm	nm	nm	nm	0.37	0.08	nm	nm	nm	nm
14	7.4	10.4	0.0	73	nm	nm	nm	nm	nm	nm	nm	nm	0.20	0.02	nm	nm	nm	nm
15	7.8	7.4	7.7	19	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.03	nm	nm	nm	nm
16	7.7	7.2	0.0	15	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.02	nm	nm	nm	nm

nm = not measured.

Table 9.42. Research Feedlot groundwater chemistry data on May 17, 1999.

Well no.	pH	EC dS m^{-1}	NO_3-N mg L^{-1}	Cl mg L^{-1}	Na mg L^{-1}	K mg L^{-1}	Ca mg L^{-1}	Mg mg L^{-1}	SAR mg L^{-1}	SO_4-S mg L^{-1}	CO_3 mg L^{-1}	HCO_3 mg L^{-1}	NH_4-N mg L^{-1}	PO_4-P mg L^{-1}	Mn mg L^{-1}	Fe mg L^{-1}	Cu mg L^{-1}	Zn mg L^{-1}
1	7.7	5.2	3.5	14	347	7.4	509	452	2.7	1090	0.0	635	0.00	0.04	0.00	0.07	0.04	0.10
2	7.5	10.7	147.5	266	1595	18.8	469	699	10.9	2004	0.0	787	0.20	0.03	0.23	0.06	0.03	0.10
3	7.6	4.7	29.6	46	253	8.2	533	329	2.1	922	0.0	445	0.00	0.01	0.00	0.07	0.05	0.07
4	7.5	7.7	29.3	142	913	12.5	685	418	6.8	1459	0.0	751	0.00	0.02	0.00	0.08	0.05	0.08
5	7.9	5.9	21.2	791	416	297.5	433	271	3.9	465	0.0	1104	7.89	7.17	0.58	0.37	0.11	0.29
6	7.5	8.9	97.2	245	1308	13.7	455	497	10.1	1547	0.0	909	0.00	0.00	0.00	0.09	0.05	0.08
7	7.7	8.5	32.6	209	1136	18.8	477	568	8.3	1611	0.0	921	0.67	0.05	0.36	0.08	0.04	0.08
8	7.7	5.9	92.7	879	506	26.6	339	371	4.5	393	0.0	769	0.45	0.11	0.00	0.08	0.06	0.08
9	7.5	6.9	36.3	21	639	8.2	501	526	4.8	1387	0.0	842	0.00	0.01	0.00	0.09	0.05	0.09
10	7.8	6.7	51.0	659	648	6.3	495	482	5.0	858	0.0	677	0.42	0.07	0.00	0.12	0.06	0.08
11	7.7	4.3	52.1	57	108	5.1	531	294	0.9	745	0.0	543	0.00	0.00	0.00	0.10	0.06	0.08
12	7.6	7.5	11.8	39	848	8.6	495	520	6.4	1467	0.0	1013	0.00	0.03	0.29	0.10	0.06	0.09
13	7.6	4.3	57.4	287	152	29.3	545	249	1.4	601	0.0	519	0.30	0.26	0.00	0.10	0.06	0.11
14	7.3	10.5	1.7	74	1402	15.6	513	864	8.8	2212	0.0	805	0.15	0.00	0.75	0.40	0.04	0.08
15	7.7	6.6	8.1	14	446	6.6	441	627	3.2	1387	0.0	726	0.00	0.03	0.00	0.09	0.05	0.10
16	7.8	6.0	2.1	14	457	4.3	555	452	3.5	1218	0.0	671	0.00	0.02	0.00	0.10	0.04	0.10

nm = not measured.

Table 9.43. Research Feedlot groundwater chemistry data on May 31, 1999.

Well no.	pH	EC dS m^{-1}	NO_3-N mg L^{-1}	Cl mg L^{-1}	Na mg L^{-1}	K mg L^{-1}	Ca mg L^{-1}	Mg mg L^{-1}	SAR mg L^{-1}	SO_4-S mg L^{-1}	CO_3 mg L^{-1}	HCO_3 mg L^{-1}	NH_4-N mg L^{-1}	PO_4-P mg L^{-1}	Mn mg L^{-1}	Fe mg L^{-1}	Cu mg L^{-1}	Zn mg L^{-1}
1	7.8	5.2	3.0	15	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.06	nm	nm	nm	nm
2	7.6	10.7	151.3	270	nm	nm	nm	nm	nm	nm	nm	nm	0.08	0.02	nm	nm	nm	nm
3	7.7	4.4	31.3	47	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.00	nm	nm	nm	nm
4	7.7	7.7	26.6	143	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.02	nm	nm	nm	nm
5	7.7	6.7	25.3	555	nm	nm	nm	nm	nm	nm	nm	nm	1.43	0.08	nm	nm	nm	nm
6	7.6	8.8	69.7	255	nm	nm	nm	nm	nm	nm	nm	nm	0.07	0.00	nm	nm	nm	nm
7	7.7	8.7	35.2	214	nm	nm	nm	nm	nm	nm	nm	nm	0.73	0.08	nm	nm	nm	nm
8	7.7	6.1	85.8	970	nm	nm	nm	nm	nm	nm	nm	nm	0.52	0.11	nm	nm	nm	nm
9	7.5	6.6	35.3	23	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.03	nm	nm	nm	nm
10	7.7	7.1	34.2	525	nm	nm	nm	nm	nm	nm	nm	nm	0.25	0.05	nm	nm	nm	nm
11	7.7	4.3	50.8	64	nm	nm	nm	nm	nm	nm	nm	nm	0.05	0.02	nm	nm	nm	nm
12	7.7	7.3	12.4	61	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.02	nm	nm	nm	nm
13	7.6	4.6	48.7	427	nm	nm	nm	nm	nm	nm	nm	nm	0.54	0.17	nm	nm	nm	nm
14	7.5	10.4	1.0	71	nm	nm	nm	nm	nm	nm	nm	nm	0.13	0.03	nm	nm	nm	nm
15	7.7	5.1	1.7	8	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.03	nm	nm	nm	nm
16	7.8	5.6	1.6	13	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.02	nm	nm	nm	nm

nm = not measured.

Table 9.44. Research Feedlot groundwater chemistry data on June 14, 1999.

Well no.	pH	EC dS m^{-1}	NO_3-N mg L^{-1}	Cl mg L^{-1}	Na mg L^{-1}	K mg L^{-1}	Ca mg L^{-1}	Mg mg L^{-1}	SAR mg L^{-1}	SO_4-S mg L^{-1}	CO_3 mg L^{-1}	HCO_3 mg L^{-1}	NH_4-N mg L^{-1}	PO_4-P mg L^{-1}	Mn mg L^{-1}	Fe mg L^{-1}	Cu mg L^{-1}	Zn mg L^{-1}
1	7.6	5.4	2.4	15	356	8.2	511	485	2.7	1130	0.0	641	0.05	0.03	0.02	0.13	0.01	0.08
2	7.6	11.1	115.0	229	1589	18.0	473	783	10.4	2228	0.0	751	0.05	0.04	0.03	0.01	0.03	0.06
3	7.5	5.5	25.9	41	446	10.6	517	428	3.5	1146	0.0	476	0.00	0.02	0.00	0.01	0.01	0.04
4	7.6	7.7	27.6	141	915	12.5	521	501	6.9	1515	0.0	751	0.00	0.03	0.00	0.01	0.02	0.04
5	7.6	7.0	3.4	718	416	121.6	609	478	3.1	914	0.0	1348	8.04	0.03	3.07	0.48	0.06	0.06
6	7.6	9.0	66.4	287	1317	13.7	499	572	9.6	1571	0.0	1043	0.15	0.07	0.00	0.02	0.02	0.09
7	7.6	9.0	41.5	194	1212	19.9	543	600	8.5	1739	0.0	891	0.72	0.07	0.59	0.01	0.02	0.05
8	7.7	6.3	65.7	685	499	21.1	525	423	3.9	713	0.0	805	0.71	0.11	0.88	0.03	0.02	0.06
9	7.6	7.8	29.1	27	871	12.1	477	661	6.1	1707	0.0	744	0.00	0.02	0.00	0.02	0.02	0.05
10	7.7	6.6	30.3	508	616	8.2	521	459	4.7	930	0.0	836	0.27	0.04	0.00	0.07	0.02	0.05
11	7.8	4.2	51.4	78	94	5.5	605	297	0.8	729	0.0	537	0.00	0.02	0.00	0.02	0.03	0.08
12	7.6	8.0	61.3	69	1035	12.9	513	557	7.5	1619	0.0	891	0.19	0.02	0.91	0.23	0.01	0.05
13	7.5	4.7	35.2	349	161	20.7	621	283	1.3	665	0.0	622	0.10	0.13	0.00	0.03	0.02	0.06
14	7.5	10.4	0.0	70	1336	15.2	497	933	8.2	2356	0.0	805	0.07	0.02	0.52	0.28	0.00	0.02
15	7.7	5.4	2.1	10	214	4.7	541	591	1.5	1186	0.0	659	0.00	0.03	0.00	0.02	0.02	0.04
16	7.8	6.1	0.0	14	506	5.1	501	549	3.7	1210	0.0	671	0.00	0.02	0.00	0.06	0.01	0.03

nm = not measured.

Table 9.45. Research Feedlot groundwater chemistry data on June 28, 1999.

Well no.	pH	EC dS m^{-1}	NO_3-N mg L^{-1}	Cl mg L^{-1}	Na mg L^{-1}	K mg L^{-1}	Ca mg L^{-1}	Mg mg L^{-1}	SAR mg L^{-1}	SO_4-S mg L^{-1}	CO_3 mg L^{-1}	HCO_3 mg L^{-1}	NH_4-N mg L^{-1}	PO_4-P mg L^{-1}	Mn mg L^{-1}	Fe mg L^{-1}	Cu mg L^{-1}	Zn mg L^{-1}
1	7.6	5.5	1.9	14	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.02	nm	nm	nm	nm
2	7.6	11.2	106.4	220	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.03	nm	nm	nm	nm
3	7.5	5.7	18.7	40	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.01	nm	nm	nm	nm
4	7.7	7.7	25.4	139	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.02	nm	nm	nm	nm
5	7.8	7.2	1.5	827	nm	nm	nm	nm	nm	nm	nm	nm	nm	2.86	nm	nm	nm	nm
6	7.6	8.9	28.4	297	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.04	nm	nm	nm	nm
7	7.7	9.0	26.3	194	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.01	nm	nm	nm	nm
8	7.8	5.9	16.7	947	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.01	nm	nm	nm	nm
9	7.4	6.8	35.1	23	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.02	nm	nm	nm	nm
10	7.6	6.6	18.4	512	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.00	nm	nm	nm	nm
11	7.6	4.1	44.6	98	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.00	nm	nm	nm	nm
12	7.6	7.5	1.4	245	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.02	nm	nm	nm	nm
13	7.5	4.6	27.3	348	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.18	nm	nm	nm	nm
14	7.5	9.6	1.1	56	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.01	nm	nm	nm	nm
15	7.6	5.2	1.8	8	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.02	nm	nm	nm	nm
16	7.7	6.0	1.6	20	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.02	nm	nm	nm	nm

nm = not measured.

Table 9.46. Research Feedlot groundwater chemistry data on July 12, 1999.

Well no.	pH	EC dS m^{-1}	NO_3-N mg L^{-1}	Cl mg L^{-1}	Na mg L^{-1}	K mg L^{-1}	Ca mg L^{-1}	Mg mg L^{-1}	SAR mg L^{-1}	SO_4-S mg L^{-1}	CO_3 mg L^{-1}	HCO_3 mg L^{-1}	NH_4-N mg L^{-1}	PO_4-P mg L^{-1}	Mn mg L^{-1}	Fe mg L^{-1}	Cu mg L^{-1}	Zn mg L^{-1}
1	7.9	5.3	0.6	14	382	8.6	521	470	2.9	1218	0.0	655	0.10	0.00	0.51	0.17	0.00	0.05
2	8.0	10.8	63.5	220	1618	19.2	495	732	10.8	2228	0.0	766	0.13	0.02	0.38	0.06	0.01	0.04
3	7.9	5.0	17.8	43	377	10.9	545	369	3.1	1074	0.0	467	0.00	0.00	0.02	0.07	0.02	0.03
4	8.0	7.4	19.5	135	908	12.9	543	514	6.7	1515	0.0	752	0.00	0.00	0.02	0.07	0.01	0.04
5	7.6	6.7	0.0	722	407	160.7	561	474	3.1	802	0.0	1449	9.67	0.84	7.75	1.83	0.03	0.03
6	7.9	9.2	51.4	215	1421	16.0	541	524	10.4	1803	0.0	935	0.12	0.00	0.05	0.07	0.06	0.03
7	8.0	8.7	23.8	182	1209	20.7	555	576	8.6	1795	0.0	914	0.61	0.03	0.95	0.07	0.02	0.04
8	7.9	6.0	29.0	664	543	22.3	521	399	4.4	710	0.0	915	0.28	0.05	0.67	0.07	0.02	0.05
9	7.9	6.8	23.1	24	692	10.2	555	568	4.9	1475	0.0	819	0.00	0.03	0.01	0.08	0.03	0.03
10	8.0	6.5	8.8	454	664	10.2	489	451	5.2	1034	0.0	871	0.21	0.03	0.35	0.30	0.02	0.04
11	8.0	4.6	31.9	72	191	8.2	547	390	1.5	914	0.0	571	0.00	0.02	0.18	0.06	0.02	0.05
12	8.0	7.4	2.2	146	890	12.1	517	551	6.5	1475	0.0	1024	0.53	0.07	1.16	0.33	0.02	0.01
13	7.9	4.4	18.9	303	145	21.5	565	284	1.2	705	0.0	637	0.87	0.18	0.34	0.08	0.02	0.06
14	7.9	9.9	0.0	68	1299	16.0	483	797	8.4	2372	0.0	809	0.13	0.03	1.12	0.92	0.02	0.04
15	8.0	6.7	7.1	18	563	10.6	467	622	4.0	1499	0.0	716	0.00	0.04	0.17	0.06	0.02	0.05
16	8.0	6.2	0.0	14	575	6.6	481	533	4.3	1371	0.0	699	0.00	0.03	0.11	0.10	0.02	0.03

nm = not measured.

Table 9.47. Research Feedlot groundwater chemistry data on July 26, 1999.

Well no.	pH	EC dS m^{-1}	NO_3-N mg L^{-1}	Cl mg L^{-1}	Na mg L^{-1}	K mg L^{-1}	Ca mg L^{-1}	Mg mg L^{-1}	SAR mg L^{-1}	SO_4-S mg L^{-1}	CO_3 mg L^{-1}	HCO_3 mg L^{-1}	NH_4-N mg L^{-1}	PO_4-P mg L^{-1}	Mn mg L^{-1}	Fe mg L^{-1}	Cu mg L^{-1}	Zn mg L^{-1}
1	7.8	5.9	0.3	13	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.00	nm	nm	nm	nm
2	7.9	10.8	94.7	258	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.02	nm	nm	nm	nm
3	7.9	5.6	14.4	46	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.00	nm	nm	nm	nm
4	7.9	7.4	23.0	143	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.02	nm	nm	nm	nm
5	7.7	6.6	33.2	707	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.70	nm	nm	nm	nm
6	8.0	8.8	72.9	330	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.07	nm	nm	nm	nm
7	7.9	8.8	35.5	208	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.02	nm	nm	nm	nm
8	7.9	6.3	42.1	554	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.03	nm	nm	nm	nm
9	7.9	7.7	17.9	41	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.00	nm	nm	nm	nm
10	8.1	7.0	0.7	690	nm	nm	nm	nm	nm	nm	nm	nm	nm	1.14	nm	nm	nm	nm
11	7.8	4.5	35.8	72	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.00	nm	nm	nm	nm
12	7.9	7.5	2.6	257	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.00	nm	nm	nm	nm
13	7.9	4.3	15.0	421	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.20	nm	nm	nm	nm
14	7.8	9.9	0.0	82	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.00	nm	nm	nm	nm
15	8.0	7.1	9.2	24	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.01	nm	nm	nm	nm
16	8.0	6.9	0.0	19	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.00	nm	nm	nm	nm

nm = not measured.

Table 9.48. Research Feedlot groundwater chemistry data on August 16, 1999.

Well no.	pH	EC dS m^{-1}	NO_3-N mg L^{-1}	Cl mg L^{-1}	Na mg L^{-1}	K mg L^{-1}	Ca mg L^{-1}	Mg mg L^{-1}	SAR mg L^{-1}	SO_4-S mg L^{-1}	CO_3 mg L^{-1}	HCO_3 mg L^{-1}	NH_4-N mg L^{-1}	PO_4-P mg L^{-1}	Mn mg L^{-1}	Fe mg L^{-1}	Cu mg L^{-1}	Zn mg L^{-1}
1	8.0	5.2	0.7	15	366	8.6	447	489	2.8	1106	0.0	659	0.10	0.00	0.04	0.11	0.00	0.08
2	7.9	10.7	98.9	243	1630	19.2	377	791	10.9	2196	0.0	775	0.13	0.00	0.15	0.11	0.03	0.06
3	8.0	5.0	19.9	43	384	10.2	435	434	3.1	978	0.0	476	0.00	0.00	0.00	0.09	0.01	0.06
4	8.0	7.4	23.7	145	915	13.3	421	548	6.9	1467	0.0	763	0.00	0.00	0.00	0.09	0.01	0.07
5	7.6	6.8	0.0	742	409	138.4	569	589	2.9	665	0.0	1654	11.12	0.89	7.45	1.07	0.03	0.06
6	7.9	8.6	60.5	301	1278	14.5	409	535	9.8	1483	0.0	1086	0.76	0.11	0.00	0.12	0.01	0.06
7	8.0	8.7	33.3	199	1225	20.7	435	577	9.1	1755	0.0	891	0.66	0.00	0.20	0.12	0.02	0.06
8	7.9	5.9	20.7	830	538	25.0	365	433	4.5	505	0.0	1056	0.59	0.07	0.39	0.13	0.03	0.08
9	7.9	6.6	27.0	26	662	9.0	443	586	4.9	1419	0.0	854	0.00	0.02	0.00	0.12	0.01	0.06
10	7.9	7.2	12.6	1049	676	138.4	449	497	5.2	705	0.0	1019	2.90	0.52	1.92	2.13	0.02	0.07
11	8.0	4.1	35.0	127	92	6.6	517	323	0.8	681	0.0	561	0.00	0.00	0.00	0.13	0.01	0.08
12	7.9	7.4	1.8	385	793	10.9	453	598	5.8	1282	0.0	1141	0.72	0.06	0.25	0.16	0.00	0.06
13	7.9	4.4	12.2	406	170	25.4	541	287	1.5	585	0.0	732	1.40	0.24	0.28	0.14	0.03	0.08
14	7.8	10.0	0.0	74	1405	16.4	423	913	8.8	2228	0.0	793	0.11	0.04	0.51	1.76	0.00	0.07
15	8.1	7.1	10.1	20	669	10.6	395	722	4.6	1579	0.0	744	0.00	0.06	0.04	0.14	0.01	0.07
16	8.1	6.9	0.0	19	756	8.2	395	591	5.6	1483	0.0	775	0.00	0.04	0.00	0.14	0.00	0.07

nm = not measured.

Table 9.49. Research Feedlot groundwater chemistry data on August 30, 1999.

Well no.	pH	EC $dS\ m^{-1}$	NO_3-N $mg\ L^{-1}$	Cl $mg\ L^{-1}$	Na $mg\ L^{-1}$	K $mg\ L^{-1}$	Ca $mg\ L^{-1}$	Mg $mg\ L^{-1}$	SAR $mg\ L^{-1}$	SO_4-S $mg\ L^{-1}$	CO_3 $mg\ L^{-1}$	HCO_3 $mg\ L^{-1}$	NH_4-N $mg\ L^{-1}$	PO_4-P $mg\ L^{-1}$	Mn $mg\ L^{-1}$	Fe $mg\ L^{-1}$	Cu $mg\ L^{-1}$	Zn $mg\ L^{-1}$
1	7.6	5.2	0.0	18	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.00	nm	nm	nm	nm
2	7.6	10.6	99.2	308	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.02	nm	nm	nm	nm
3	7.6	5.7	11.5	49	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.00	nm	nm	nm	nm
4	7.6	7.3	22.6	184	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.01	nm	nm	nm	nm
5	7.6	6.9	0.1	1080	nm	nm	nm	nm	nm	nm	nm	nm	nm	1.56	nm	nm	nm	nm
6	7.5	8.2	43.1	406	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.14	nm	nm	nm	nm
7	7.7	8.7	27.5	272	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.02	nm	nm	nm	nm
8	7.5	5.7	0.6	1330	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.05	nm	nm	nm	nm
9	7.5	6.3	26.7	36	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.00	nm	nm	nm	nm
10	7.6	6.8	2.9	1135	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.00	nm	nm	nm	nm
11	7.6	4.1	32.0	181	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.00	nm	nm	nm	nm
12	7.5	7.4	2.9	373	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.00	nm	nm	nm	nm
13	7.5	4.5	9.2	577	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.22	nm	nm	nm	nm
14	7.4	10.0	0.0	93	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.02	nm	nm	nm	nm
15	7.6	7.8	10.9	34	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.04	nm	nm	nm	nm
16	7.7	7.1	0.0	27	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.02	nm	nm	nm	nm

nm = not measured.

Table 9.50. Research Feedlot groundwater chemistry data on September 13, 1999.

Well no.	pH	EC dS m^{-1}	NO_3-N mg L^{-1}	Cl mg L^{-1}	Na mg L^{-1}	K mg L^{-1}	Ca mg L^{-1}	Mg mg L^{-1}	SAR mg L^{-1}	SO_4-S mg L^{-1}	CO_3 mg L^{-1}	HCO_3 mg L^{-1}	NH_4-N mg L^{-1}	PO_4-P mg L^{-1}	Mn mg L^{-1}	Fe mg L^{-1}	Cu mg L^{-1}	Zn mg L^{-1}
1	7.6	5.2	0.0	17	368	9.4	507	501	2.8	1082	0.0	674	0.00	0.05	0.08	0.22	0.03	0.03
2	7.6	10.5	95.2	313	1658	19.5	475	783	10.9	2132	0.0	774	0.12	0.06	0.26	0.23	0.07	0.05
3	7.5	6.2	6.0	41	747	15.2	469	463	5.9	1298	0.0	532	0.00	0.04	0.06	0.24	0.04	0.02
4	7.6	7.3	22.6	189	933	13.7	503	560	6.8	1395	0.0	768	0.00	0.05	0.03	0.25	0.04	0.04
5	7.7	6.7	0.0	938	402	136.1	701	521	2.8	721	0.0	1576	10.21	1.08	8.50	1.28	0.07	0.05
6	7.5	9.2	63.5	286	1464	16.0	507	537	10.8	1635	0.0	965	0.15	0.08	0.06	0.28	0.04	0.04
7	7.7	8.8	31.9	244	1262	21.5	523	591	9.0	1659	0.0	897	0.76	0.09	0.48	0.30	0.05	0.05
8	7.5	5.8	1.4	1217	561	31.3	347	423	4.8	297	0.0	1294	0.90	0.13	0.94	0.39	0.03	0.10
9	7.5	6.5	24.4	32	632	8.6	547	564	4.5	1298	0.0	880	0.00	0.06	0.02	0.30	0.04	0.03
10	7.6	7.0	0.0	946	690	58.3	563	565	4.9	834	0.0	1031	1.94	0.18	1.57	1.23	0.04	0.01
11	7.7	4.1	31.1	175	94	6.6	657	334	0.7	713	0.0	556	0.07	0.00	0.06	0.33	0.05	0.06
12	7.6	7.4	2.7	277	848	10.9	535	588	6.0	1379	0.0	1114	0.24	0.01	0.40	0.37	0.05	0.04
13	7.5	4.7	4.1	560	182	22.7	637	345	1.4	641	0.0	774	1.44	0.04	0.81	0.35	0.03	0.03
14	7.4	10.0	0.0	96	1407	17.2	487	865	8.9	2212	0.0	787	0.14	0.01	0.89	2.23	0.02	0.02
15	7.7	7.9	12.3	32	867	13.3	485	778	5.7	1739	0.0	757	0.00	0.01	0.19	0.37	0.04	0.03
16	7.7	7.3	0.4	28	864	10.2	501	632	6.1	1563	0.0	789	0.00	0.00	0.20	0.38	0.03	0.03

nm = not measured.

Table 9.51. Research Feedlot groundwater chemistry data on September 27, 1999.

Well no.	pH	EC dS m^{-1}	NO_3-N mg L^{-1}	Cl mg L^{-1}	Na mg L^{-1}	K mg L^{-1}	Ca mg L^{-1}	Mg mg L^{-1}	SAR mg L^{-1}	SO_4-S mg L^{-1}	CO_3 mg L^{-1}	HCO_3 mg L^{-1}	NH_4-N mg L^{-1}	PO_4-P mg L^{-1}	Mn mg L^{-1}	Fe mg L^{-1}	Cu mg L^{-1}	Zn mg L^{-1}
1	7.8	5.0	0.6	17	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.01	nm	nm	nm	nm
2	7.7	10.4	116.0	207	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.01	nm	nm	nm	nm
3	7.6	5.6	9.3	46	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.00	nm	nm	nm	nm
4	7.7	7.3	25.3	181	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.05	nm	nm	nm	nm
5	7.6	6.7	0.0	854	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.22	nm	nm	nm	nm
6	7.6	9.2	69.2	290	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.03	nm	nm	nm	nm
7	7.7	8.8	34.9	246	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.05	nm	nm	nm	nm
8	7.6	6.1	19.3	1001	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.07	nm	nm	nm	nm
9	7.6	6.8	26.3	30	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.03	nm	nm	nm	nm
10	7.7	7.0	0.7	854	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.11	nm	nm	nm	nm
11	7.7	4.4	35.6	170	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.01	nm	nm	nm	nm
12	7.6	7.4	3.0	291	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.03	nm	nm	nm	nm
13	7.6	4.8	26.0	564	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.11	nm	nm	nm	nm
14	7.4	9.9	0.0	91	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.02	nm	nm	nm	nm
15	7.7	7.9	14.7	32	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.03	nm	nm	nm	nm
16	7.7	7.4	0.9	31	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.02	nm	nm	nm	nm

nm = not measured.

Table 9.52. Research Feedlot groundwater chemistry data on October 12, 1999.

Well no.	pH	EC dS m^{-1}	NO_3-N mg L^{-1}	Cl mg L^{-1}	Na mg L^{-1}	K mg L^{-1}	Ca mg L^{-1}	Mg mg L^{-1}	SAR mg L^{-1}	SO_4-S mg L^{-1}	CO_3 mg L^{-1}	HCO_3 mg L^{-1}	NH_4-N mg L^{-1}	PO_4-P mg L^{-1}	Mn mg L^{-1}	Fe mg L^{-1}	Cu mg L^{-1}	Zn mg L^{-1}
1	8.1	5.3	0.4	18	379	9.8	447	536	2.9	1146	0.0	682	0.09	0.00	0.29	0.07	0.05	0.03
2	8.1	10.3	112.3	330	1600	19.9	401	682	11.3	1988	0.0	782	0.00	0.02	0.27	0.02	0.07	0.03
3	8.1	6.1	7.3	46	692	14.9	401	451	5.6	1290	0.0	544	0.00	0.00	0.01	0.00	0.04	0.03
4	8.2	7.2	25.4	202	908	14.1	443	530	6.9	1387	0.0	790	0.00	0.00	0.07	0.01	0.06	0.02
5	7.6	6.4	0.0	854	377	100.5	575	513	2.8	834	0.0	1314	6.72	0.28	8.33	1.38	0.07	0.01
6	8.2	9.3	57.3	280	1462	16.8	437	540	11.1	1715	0.0	942	0.00	0.03	0.02	0.00	0.05	0.02
7	8.2	8.8	35.0	241	1244	21.5	455	578	9.1	1619	0.0	917	0.55	0.06	0.63	0.05	0.05	0.02
8	8.0	6.3	35.2	783	586	17.6	501	442	4.6	842	0.0	920	0.37	0.02	0.69	0.02	0.05	0.02
9	8.1	7.0	23.5	32	749	11.3	481	591	5.4	1595	0.0	800	0.00	0.00	0.03	0.03	0.04	0.03
10	8.2	7.1	0.8	723	802	27.8	465	553	6.0	1090	0.0	987	0.73	0.14	1.52	0.26	0.04	0.00
11	8.1	4.7	34.7	121	200	9.0	507	439	1.6	930	0.0	595	0.00	0.01	0.16	0.08	0.04	0.03
12	8.1	7.4	3.8	238	871	12.1	451	574	6.4	1515	0.0	1100	0.00	0.02	0.63	0.09	0.04	0.03
13	7.9	4.7	2.0	532	175	22.7	521	368	1.4	697	0.0	759	0.74	0.12	1.11	0.19	0.06	0.02
14	8.0	9.9	0.0	92	1395	17.2	413	803	9.2	2276	0.0	807	0.12	0.03	0.98	1.42	0.04	0.03
15	8.2	8.9	22.3	60	1152	17.6	421	775	7.7	1988	0.0	777	0.00	0.03	0.29	0.05	0.04	0.01
16	8.2	7.5	0.8	32	922	11.3	429	605	6.7	1635	0.0	828	0.00	0.02	0.34	0.14	0.04	0.02

nm = not measured.

Table 9.53. Research Feedlot groundwater chemistry data on October 25, 1999.

Well no.	pH	EC dS m^{-1}	NO_3-N mg L^{-1}	Cl mg L^{-1}	Na mg L^{-1}	K mg L^{-1}	Ca mg L^{-1}	Mg mg L^{-1}	SAR mg L^{-1}	SO_4-S mg L^{-1}	CO_3 mg L^{-1}	HCO_3 mg L^{-1}	NH_4-N mg L^{-1}	PO_4-P mg L^{-1}	Mn mg L^{-1}	Fe mg L^{-1}	Cu mg L^{-1}	Zn mg L^{-1}
1	7.6	5.2	0.0	16	nm	nm	nm	nm	nm	nm	nm	nm	0.09	0.01	nm	nm	nm	nm
2	7.6	10.2	118.7	320	nm	nm	nm	nm	nm	nm	nm	nm	0.05	0.03	nm	nm	nm	nm
3	7.6	6.1	5.4	43	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.01	nm	nm	nm	nm
4	7.6	7.1	26.4	194	nm	nm	nm	nm	nm	nm	nm	nm	0.01	0.02	nm	nm	nm	nm
5	7.6	6.4	0.0	781	nm	nm	nm	nm	nm	nm	nm	nm	4.89	0.04	nm	nm	nm	nm
6	7.6	9.1	70.9	282	nm	nm	nm	nm	nm	nm	nm	nm	0.02	0.04	nm	nm	nm	nm
7	7.7	6.3	37.0	737	nm	nm	nm	nm	nm	nm	nm	nm	0.31	0.05	nm	nm	nm	nm
8	7.7	8.6	34.3	229	nm	nm	nm	nm	nm	nm	nm	nm	0.49	0.08	nm	nm	nm	nm
9	7.6	6.9	24.7	32	nm	nm	nm	nm	nm	nm	nm	nm	0.01	0.06	nm	nm	nm	nm
10	7.7	7.3	0.3	506	nm	nm	nm	nm	nm	nm	nm	nm	0.66	0.17	nm	nm	nm	nm
11	7.6	5.1	34.4	103	nm	nm	nm	nm	nm	nm	nm	nm	0.02	0.03	nm	nm	nm	nm
12	7.6	7.3	4.8	164	nm	nm	nm	nm	nm	nm	nm	nm	0.02	0.03	nm	nm	nm	nm
13	7.7	4.7	2.6	508	nm	nm	nm	nm	nm	nm	nm	nm	0.02	0.07	nm	nm	nm	nm
14	7.5	9.6	0.0	94	nm	nm	nm	nm	nm	nm	nm	nm	0.12	0.02	nm	nm	nm	nm
15	7.7	8.5	17.7	48	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.03	nm	nm	nm	nm
16	7.7	7.8	2.2	37	nm	nm	nm	nm	nm	nm	nm	nm	0.01	0.02	nm	nm	nm	nm

nm = not measured.

Table 9.54. Research Feedlot groundwater chemistry data on November 15, 1999.

Well no.	pH	EC dS m^{-1}	NO_3-N mg L^{-1}	Cl mg L^{-1}	Na mg L^{-1}	K mg L^{-1}	Ca mg L^{-1}	Mg mg L^{-1}	SAR mg L^{-1}	SO_4-S mg L^{-1}	CO_3 mg L^{-1}	HCO_3 mg L^{-1}	NH_4-N mg L^{-1}	PO_4-P mg L^{-1}	Mn mg L^{-1}	Fe mg L^{-1}	Cu mg L^{-1}	Zn mg L^{-1}
1	7.7	5.4	0.0	16	386	9.8	497	508	2.9	1122	0.0	674	0.08	0.00	0.22	0.06	0.02	0.03
2	7.7	10.3	153.5	329	1559	19.2	467	694	10.7	1940	0.0	744	0.00	0.02	0.17	0.03	0.04	0.04
3	7.7	5.9	10.4	44	577	13.7	479	442	4.6	1186	0.0	503	0.00	0.00	0.00	0.01	0.03	0.03
4	7.8	7.3	28.3	201	899	13.3	485	503	6.8	1355	0.0	767	0.00	0.01	0.03	0.02	0.03	0.02
5	7.7	6.5	0.0	750	372	71.6	579	538	2.7	874	0.0	1301	3.95	0.01	6.33	0.12	0.04	0.00
6	7.7	9.4	82.9	279	1455	16.0	487	566	10.6	1683	0.0	923	0.00	0.02	0.03	0.01	0.03	0.01
7	7.7	8.8	35.9	238	1225	19.9	489	625	8.7	1651	0.0	894	0.45	0.05	0.45	0.02	0.04	0.02
8	7.7	6.4	30.4	835	540	16.8	529	458	4.2	777	0.0	976	0.49	0.07	0.58	0.03	0.04	0.00
9	7.7	7.5	18.9	37	858	12.1	475	656	6.0	1579	0.0	791	0.00	0.04	0.11	0.02	0.03	0.02
10	7.9	7.3	3.5	571	844	21.5	489	526	6.3	1234	0.0	924	0.21	0.15	0.83	0.05	0.03	0.01
11	7.7	5.3	37.5	95	301	9.4	537	473	2.3	1050	0.0	588	0.00	0.02	0.19	0.01	0.03	0.01
12	7.7	7.7	3.4	174	956	12.5	507	593	6.8	1475	0.0	1018	0.06	0.02	0.55	0.03	0.02	0.04
13	7.8	4.8	2.5	478	147	19.9	593	379	1.2	713	0.0	765	0.06	0.10	0.89	0.05	0.03	0.01
14	7.5	9.9	0.0	96	1384	16.8	435	819	9.0	2020	0.0	777	0.15	0.03	0.73	0.19	0.01	0.01
15	7.8	8.7	19.5	44	1005	14.9	459	812	6.5	1795	0.0	749	0.00	0.03	0.19	0.01	0.03	0.03
16	7.8	8.1	2.9	40	1060	13.7	451	659	7.4	1619	0.0	785	0.00	0.02	0.35	0.01	0.03	0.02

nm = not measured.

Table 9.55. Research Feedlot groundwater chemistry data on November 30, 1999.

Well no.	pH	EC dS m^{-1}	NO_3-N mg L^{-1}	Cl mg L^{-1}	Na mg L^{-1}	K mg L^{-1}	Ca mg L^{-1}	Mg mg L^{-1}	SAR mg L^{-1}	SO_4-S mg L^{-1}	CO_3 mg L^{-1}	HCO_3 mg L^{-1}	NH_4-N mg L^{-1}	PO_4-P mg L^{-1}	Mn mg L^{-1}	Fe mg L^{-1}	Cu mg L^{-1}	Zn mg L^{-1}
1	8.1	5.5	0.0	13	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.02	nm	nm	nm	nm
2	8.1	10.0	133.5	255	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.03	nm	nm	nm	nm
3	8.1	5.4	12.7	35	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.01	nm	nm	nm	nm
4	8.1	7.2	27.7	155	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.02	nm	nm	nm	nm
5	7.6	6.2	0.0	583	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.01	nm	nm	nm	nm
6	8.1	9.3	71.8	210	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.02	nm	nm	nm	nm
7	8.2	8.7	33.7	179	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.04	nm	nm	nm	nm
8	7.7	6.1	15.7	776	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.03	nm	nm	nm	nm
9	8.2	7.6	16.9	26	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.01	nm	nm	nm	nm
10	8.1	7.2	3.4	400	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.14	nm	nm	nm	nm
11	8.1	5.1	32.9	71	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.02	nm	nm	nm	nm
12	8.0	7.4	3.9	148	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.03	nm	nm	nm	nm
13	7.8	4.6	2.5	355	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.06	nm	nm	nm	nm
14	8.3	9.7	0.0	74	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.02	nm	nm	nm	nm
15	8.3	8.5	17.3	30	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.02	nm	nm	nm	nm
16	8.3	7.7	0.0	23	nm	nm	nm	nm	nm	nm	nm	nm	nm	0.01	nm	nm	nm	nm

nm = not measured.

Table 9.56. Research Feedlot groundwater chemistry data on December 13, 1999.

Well no.	pH	EC dS m^{-1}	NO_3-N mg L^{-1}	Cl mg L^{-1}	Na mg L^{-1}	K mg L^{-1}	Ca mg L^{-1}	Mg mg L^{-1}	SAR mg L^{-1}	SO_4-S mg L^{-1}	CO_3 mg L^{-1}	HCO_3 mg L^{-1}	NH_4-N mg L^{-1}	PO_4-P mg L^{-1}	Mn mg L^{-1}	Fe mg L^{-1}	Cu mg L^{-1}	Zn mg L^{-1}
1	7.8	5.3	0.0	13	375	9.8	545	491	2.8	1114	0.0	697	0.00	0.01	0.03	0.04	0.05	0.08
2	7.7	9.9	147.4	265	1543	19.9	477	625	10.9	1843	0.0	728	0.00	0.03	0.12	0.02	0.07	0.08
3	7.6	5.9	8.8	34	614	14.5	513	436	4.8	1274	0.0	522	0.00	0.00	0.02	0.00	0.04	0.05
4	7.7	7.2	27.6	157	899	14.1	515	484	6.8	1451	0.0	773	0.00	0.02	0.04	0.01	0.06	0.06
5	7.7	6.3	0.0	573	359	68.0	637	509	2.6	866	0.0	1283	2.87	0.02	7.75	0.14	0.04	0.06
6	7.7	9.3	79.1	211	1485	16.0	523	577	10.6	1779	0.0	887	0.00	0.03	0.06	0.02	0.04	0.05
7	7.7	8.6	34.9	184	1221	20.3	523	591	8.7	1635	0.0	896	4.38	0.05	0.74	0.01	0.05	0.04
8	7.7	6.4	37.5	559	563	16.0	599	441	4.3	866	0.0	922	3.66	0.03	0.58	0.00	0.05	0.05
9	7.7	7.6	17.4	30	878	12.5	529	629	6.1	1707	0.0	780	0.00	0.01	0.14	0.00	0.03	0.05
10	7.7	7.5	2.4	290	963	16.8	537	544	7.0	1435	0.0	889	0.36	0.07	1.10	0.16	0.03	0.04
11	7.7	5.7	31.9	64	416	10.9	561	507	3.1	1194	0.0	601	0.00	0.02	0.33	0.01	0.06	0.05
12	7.7	7.7	2.7	79	1028	14.1	531	576	7.4	1579	0.0	972	0.05	0.02	0.64	0.01	0.03	0.05
13	7.8	4.7	4.9	342	152	18.8	601	371	1.2	729	0.0	749	0.04	0.06	0.43	0.03	0.04	0.08
14	7.5	9.6	0.0	78	1363	17.6	511	756	9.0	2132	0.0	788	0.14	0.03	0.57	1.28	0.03	0.06
15	7.8	8.9	20.0	45	1094	17.2	505	792	7.1	1908	0.0	752	0.00	0.02	0.07	0.00	0.04	0.06
16	7.8	7.8	10.9	26	968	10.9	489	661	6.7	1819	0.0	803	0.00	0.01	0.02	0.01	0.06	0.03

nm = not measured.

Table 9.57. Research Feedlot groundwater chemistry data on January 17, 2000.

Well no.	pH	EC dS m^{-1}	NO_3-N mg L^{-1}	Cl mg L^{-1}	Na mg L^{-1}	K mg L^{-1}	Ca mg L^{-1}	Mg mg L^{-1}	SAR mg L^{-1}	SO_4-S mg L^{-1}	CO_3 mg L^{-1}	HCO_3 mg L^{-1}	NH_4-N mg L^{-1}	PO_4-P mg L^{-1}	Mn mg L^{-1}	Fe mg L^{-1}	Cu mg L^{-1}	Zn mg L^{-1}
1	7.7	5.2	0.0	13	354	9.0	465	442	2.8	1098	0.0	682	0.00	0.01	0.02	0.02	0.04	0.05
2	7.6	9.9	146.9	287	1531	18.8	439	637	10.9	1795	0.0	711	0.00	0.03	0.07	0.04	0.08	0.05
3	7.5	6.2	7.1	33	703	14.9	447	412	5.8	1314	0.0	529	0.00	0.01	0.00	0.03	0.03	0.03
4	7.6	7.2	35.3	173	892	13.3	461	465	7.0	1411	0.0	762	0.00	0.01	0.00	0.04	0.04	0.03
5	7.5	6.3	0.0	530	359	55.5	629	502	2.6	906	0.0	1213	2.25	0.02	5.90	0.48	0.03	0.01
6	7.6	9.3	95.8	229	1481	15.6	457	514	11.3	1715	0.0	872	0.00	0.03	0.00	0.04	0.06	0.01
7	7.7	8.5	41.7	199	1218	19.2	467	575	8.9	1619	0.0	879	0.35	0.06	0.52	0.04	0.05	0.03
8	7.6	6.3	29.3	576	526	15.2	553	424	4.1	826	0.0	918	0.45	0.05	0.47	0.06	0.03	0.05
9	7.6	6.6	33.3	30	644	8.2	501	600	4.6	1387	0.0	870	0.00	0.04	0.00	0.05	0.06	0.04
10	7.7	7.7	3.4	207	1064	16.0	439	468	8.4	1555	0.0	817	0.22	0.03	1.14	0.26	0.05	0.03
11	7.6	5.6	41.0	60	375	10.2	527	504	2.8	1162	0.0	600	0.00	0.03	0.21	0.04	0.04	0.02
12	7.6	7.8	2.9	43	1143	15.2	459	478	8.9	1643	0.0	862	0.09	0.03	0.97	0.04	0.02	0.03
13	7.7	4.7	9.7	323	149	17.2	575	371	1.2	729	0.0	710	0.00	0.06	0.81	0.05	0.03	0.02
14	7.5	9.6	0.0	75	1352	16.8	443	747	9.1	2020	0.0	783	0.15	0.02	0.94	0.10	0.01	0.02
15	7.8	8.8	29.3	37	1058	15.6	445	791	7.0	1892	0.0	741	0.00	0.03	0.20	0.04	0.02	0.02
16	7.7	7.9	2.4	26	995	11.3	467	642	7.0	1803	0.0	791	0.00	0.02	0.23	0.05	0.01	0.01

nm = not measured.

Table 9.58. Research Feedlot groundwater chemistry data on February 14, 2000.

Well no.	pH	EC dS m^{-1}	NO_3-N mg L^{-1}	Cl mg L^{-1}	Na mg L^{-1}	K mg L^{-1}	Ca mg L^{-1}	Mg mg L^{-1}	SAR mg L^{-1}	SO_4-S mg L^{-1}	CO_3 mg L^{-1}	HCO_3 mg L^{-1}	NH_4-N mg L^{-1}	PO_4-P mg L^{-1}	Mn mg L^{-1}	Fe mg L^{-1}	Cu mg L^{-1}	Zn mg L^{-1}
1	8.1	5.2	0.0	12	347	7.8	503	485	2.6	1130	0.0	674	nm	nm	0.02	0.00	0.02	0.05
2	8.1	9.8	140.5	245	1478	17.6	519	647	10.2	1859	0.0	701	nm	nm	0.08	0.00	0.11	0.12
3	8.0	6.0	6.9	32	628	13.7	501	461	4.9	1266	0.0	521	nm	nm	0.02	0.00	0.02	0.03
4	8.0	7.1	29.7	148	844	12.5	513	499	6.4	1379	0.0	758	nm	nm	0.01	0.00	0.01	0.03
5	7.7	6.1	0.0	498	331	51.2	543	524	2.4	885	0.0	1147	nm	nm	7.20	0.33	0.01	0.03
6	8.0	9.0	89.9	202	1349	14.1	495	527	10.1	1683	0.0	834	nm	nm	0.00	0.00	0.03	0.02
7	8.1	8.4	36.8	166	1156	17.2	493	581	8.4	1595	0.0	874	nm	nm	0.49	0.00	0.00	0.02
8	8.0	6.7	39.4	276	802	13.7	541	418	6.3	1186	0.0	791	nm	nm	0.35	0.00	0.00	0.02
9	8.0	8.2	10.5	40	1108	14.5	421	615	8.1	1811	0.0	735	nm	nm	0.30	0.00	0.00	0.02
10	8.1	7.6	3.5	155	1037	14.1	431	506	8.0	1459	0.0	810	nm	nm	0.73	0.00	0.00	0.04
11	8.0	6.4	18.1	65	676	12.5	477	502	5.2	1298	0.0	624	nm	nm	0.52	0.00	0.00	0.02
12	8.0	7.8	0.0	39	1154	15.6	439	473	9.1	1659	0.0	822	nm	nm	1.15	0.00	0.00	0.02
13	8.0	4.6	9.0	255	149	14.9	541	390	1.2	810	0.0	677	nm	nm	0.86	0.00	0.00	0.04
14	8.0	9.4	0.0	76	1299	15.6	433	785	8.6	2100	0.0	788	nm	nm	0.80	0.00	0.00	0.04
15	8.1	8.8	17.9	39	1030	14.5	449	817	6.7	2028	0.0	738	nm	nm	0.18	0.00	0.00	0.04
16	8.1	7.8	0.4	28	952	9.8	435	673	6.7	1763	0.0	793	nm	nm	0.19	0.00	0.00	0.02

nm = not measured.

Table 9.59. Research Feedlot groundwater chemistry data on March 13, 2000.

Well no.	pH	EC dS m^{-1}	NO_3-N mg L^{-1}	Cl mg L^{-1}	Na mg L^{-1}	K mg L^{-1}	Ca mg L^{-1}	Mg mg L^{-1}	SAR mg L^{-1}	SO_4-S mg L^{-1}	CO_3 mg L^{-1}	HCO_3 mg L^{-1}	NH_4-N mg L^{-1}	PO_4-P mg L^{-1}	Mn mg L^{-1}	Fe mg L^{-1}	Cu mg L^{-1}	Zn mg L^{-1}
1	8.3	5.2	0.0	12	372	8.6	505	502	2.8	1098	0.0	668	0.00	0.03	0.03	0.00	0.06	0.04
2	8.2	9.8	140.2	261	1614	18.8	467	606	11.6	1843	0.0	708	0.00	0.04	0.04	0.00	0.15	0.14
3	8.1	6.3	3.9	31	798	16.0	487	465	6.2	1298	0.0	550	0.00	0.02	0.05	0.00	0.04	0.01
4	8.1	7.1	28.2	158	945	13.7	509	521	7.0	1330	0.0	771	0.00	0.03	0.02	0.00	0.04	0.01
5	7.8	6.1	2.0	487	382	48.5	629	548	2.7	994	0.0	1045	1.35	0.03	10.67	0.27	0.08	0.04
6	8.1	8.7	102.8	214	1474	16.0	493	507	11.1	1523	0.0	832	0.00	0.03	0.04	0.00	0.09	0.02
7	8.1	8.4	41.2	174	1281	18.8	509	564	9.3	1627	0.0	879	1.20	0.05	0.47	0.00	0.02	0.01
8	8.1	6.7	44.0	267	851	14.5	565	431	6.6	1162	0.0	779	0.09	0.04	0.77	0.00	0.09	0.04
9	8.1	8.2	8.7	44	1232	16.0	481	591	8.9	1731	0.0	735	0.00	0.02	0.29	0.00	0.01	0.01
10	8.1	7.6	6.2	153	1090	14.1	507	544	8.0	1427	0.0	822	0.23	0.03	1.00	0.19	0.04	0.02
11	8.1	4.9	38.1	147	237	7.4	583	429	1.8	930	0.0	566	0.00	0.03	0.11	0.00	0.07	0.03
12	8.1	7.8	0.7	39	1283	16.4	381	480	10.3	1539	0.0	829	0.06	0.02	1.40	0.00	0.01	0.01
13	7.9	4.8	18.2	568	147	13.3	463	445	1.2	601	0.0	614	0.11	0.14	0.21	0.00	0.05	0.04
14	8.1	9.4	0.0	79	1435	16.8	453	730	9.7	2068	0.0	778	0.10	0.02	2.00	0.42	0.02	0.03
15	8.1	9.1	31.0	51	1290	18.8	459	768	8.6	2068	0.0	745	0.00	0.01	0.40	0.00	0.04	0.04
16	8.2	8.0	4.3	33	1120	12.5	461	628	8.0	1739	0.0	802	0.00	0.01	0.42	0.00	0.03	0.02

nm = not measured.

Table 9.60. Research Feedlot groundwater chemistry data on April 11, 2000.

Well no.	pH	EC dS m^{-1}	NO_3-N mg L^{-1}	Cl mg L^{-1}	Na mg L^{-1}	K mg L^{-1}	Ca mg L^{-1}	Mg mg L^{-1}	SAR mg L^{-1}	SO_4-S mg L^{-1}	CO_3 mg L^{-1}	HCO_3 mg L^{-1}	NH_4-N mg L^{-1}	PO_4-P mg L^{-1}	Mn mg L^{-1}	Fe mg L^{-1}	Cu mg L^{-1}	Zn mg L^{-1}
1	7.9	5.1	1.0	14	354	7.8	531	456	2.7	1114	0.0	669	0.00	0.02	0.01	0.00	0.02	0.01
2	7.7	9.9	165.1	266	1538	18.4	475	666	10.7	1779	0.0	700	0.00	0.03	0.03	0.00	0.17	0.15
3	7.7	5.9	8.1	32	591	13.7	535	467	4.5	1226	0.0	529	0.00	0.00	0.00	0.00	0.02	0.01
4	7.7	7.2	30.7	156	897	13.3	503	478	6.9	1339	0.0	763	0.00	0.02	0.01	0.01	0.03	0.01
5	7.8	6.1	4.6	518	352	51.6	591	520	2.5	898	0.0	1129	1.47	0.02	5.22	0.06	0.03	0.03
6	7.7	9.1	97.8	216	1446	15.2	487	518	10.9	1619	0.0	854	0.00	0.01	0.00	0.00	0.02	0.00
7	7.7	8.6	42.0	177	1228	18.8	485	612	8.7	1683	0.0	879	0.14	0.03	0.44	0.00	0.03	0.00
8	7.8	6.4	46.5	418	602	14.1	541	427	4.7	962	0.0	830	0.17	0.05	0.36	0.00	0.05	0.01
9	7.7	7.3	24.0	46	828	10.6	501	657	5.7	1427	0.0	793	0.00	0.01	0.00	0.00	0.01	0.00
10	7.6	7.8	6.2	142	1094	14.1	503	531	8.1	1419	0.0	796	0.24	0.01	1.98	0.73	0.02	0.00
11	7.8	4.5	39.6	284	120	5.9	577	399	0.9	721	0.0	551	0.00	0.01	0.00	0.00	0.01	0.00
12	7.7	7.7	4.5	67	1078	12.9	479	554	8.0	1443	0.0	932	0.00	0.00	0.66	0.00	0.01	0.00
13	7.7	4.8	19.2	557	131	12.1	507	344	1.1	577	0.0	656	0.05	0.13	0.05	0.00	0.02	0.01
14	7.6	9.7	0.6	82	1361	16.8	525	791	8.8	2036	0.0	760	0.07	0.01	0.96	0.20	0.01	0.00
15	7.9	9.1	32.8	50	1154	16.8	497	828	7.4	1956	0.0	740	0.00	0.02	0.14	0.00	0.02	0.01
16	7.9	7.9	3.8	32	998	11.3	471	666	6.9	1555	0.0	802	0.00	0.01	0.17	0.00	0.02	0.00

nm = not measured.

Table 9.61. Research Feedlot groundwater chemistry data on May 15, 2000.

Well no.	pH	EC dS m^{-1}	NO_3-N mg L^{-1}	Cl mg L^{-1}	Na mg L^{-1}	K mg L^{-1}	Ca mg L^{-1}	Mg mg L^{-1}	SAR mg L^{-1}	SO_4-S mg L^{-1}	CO_3 mg L^{-1}	HCO_3 mg L^{-1}	NH_4-N mg L^{-1}	PO_4-P mg L^{-1}	Mn mg L^{-1}	Fe mg L^{-1}	Cu mg L^{-1}	Zn mg L^{-1}
1	8.1	5.1	0.0	11	356	8.6	487	452	2.8	1066	0.0	662	0.00	0.08	0.04	0.00	0.04	0.03
2	8.1	10.0	140.2	245	1563	18.4	471	649	11.0	1859	0.0	704	0.00	0.12	0.05	0.00	0.13	0.11
3	8.1	5.4	10.6	32	384	10.6	525	475	2.9	1162	0.0	502	0.00	0.00	0.01	0.00	0.05	0.01
4	8.1	7.1	24.9	138	894	13.3	485	480	6.9	1314	0.0	758	0.00	0.00	0.04	0.00	0.05	0.02
5	7.8	6.1	2.2	468	361	46.9	569	548	2.6	938	0.0	1084	0.98	0.04	4.80	0.05	0.06	0.03
6	8.1	9.1	75.2	199	1474	15.2	505	527	10.9	1667	0.0	1064	0.00	0.02	0.02	0.00	0.04	0.01
7	8.1	8.6	36.8	163	1251	19.5	501	603	8.9	1683	0.0	880	0.13	0.03	0.48	0.00	0.03	0.00
8	8.1	6.2	43.1	411	552	14.5	567	430	4.3	930	0.0	806	0.21	0.06	0.51	0.00	0.05	0.02
9	8.1	6.9	22.3	39	763	9.8	503	617	5.4	1427	0.0	830	0.00	0.02	0.05	0.00	0.03	0.00
10	8.2	6.8	25.2	627	662	12.9	531	487	5.0	986	0.0	760	0.06	0.04	0.11	0.00	0.04	0.01
11	8.1	4.5	30.8	337	103	5.9	589	374	0.8	673	0.0	533	0.00	0.02	0.01	0.00	0.05	0.02
12	8.0	7.5	6.6	64	1000	11.3	509	537	7.4	1507	0.0	948	0.00	0.01	0.44	0.00	0.05	0.01
13	8.0	5.0	23.7	670	172	14.9	613	317	1.4	569	0.0	592	0.00	0.15	0.14	0.00	0.03	0.02
14	8.0	9.7	0.0	78	1375	16.4	441	803	9.0	2132	0.0	757	0.00	0.01	0.87	0.28	0.05	0.02
15	8.2	9.0	26.5	43	1129	15.6	465	828	7.3	1956	0.0	752	0.00	0.02	0.12	0.00	0.03	0.02
16	8.2	7.3	0.0	21	855	8.2	443	654	6.0	1475	0.0	826	0.00	0.01	0.05	0.00	0.04	0.00

nm = not measured.

Table 9.62. Research Feedlot groundwater chemistry data on May 29, 2000.

Well no.	pH	EC $dS\ m^{-1}$	NO_3-N $mg\ L^{-1}$	Cl $mg\ L^{-1}$	Na $mg\ L^{-1}$	K $mg\ L^{-1}$	Ca $mg\ L^{-1}$	Mg $mg\ L^{-1}$	SAR $mg\ L^{-1}$	SO_4-S $mg\ L^{-1}$	CO_3 $mg\ L^{-1}$	HCO_3 $mg\ L^{-1}$	NH_4-N $mg\ L^{-1}$	PO_4-P $mg\ L^{-1}$	Mn $mg\ L^{-1}$	Fe $mg\ L^{-1}$	Cu $mg\ L^{-1}$	Zn $mg\ L^{-1}$
1	8.1	5.1	0.0	14	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.02	nm	nm	nm	nm
2	8.1	10.0	145.1	262	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.03	nm	nm	nm	nm
3	8.0	3.1	5.0	32	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.01	nm	nm	nm	nm
4	8.1	7.2	26.1	149	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.02	nm	nm	nm	nm
5	7.7	6.1	2.2	486	nm	nm	nm	nm	nm	nm	nm	nm	0.85	0.02	nm	nm	nm	nm
6	8.0	9.3	79.8	216	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.01	nm	nm	nm	nm
7	8.1	8.6	38.8	184	nm	nm	nm	nm	nm	nm	nm	nm	0.13	0.04	nm	nm	nm	nm
8	8.1	6.2	51.3	362	nm	nm	nm	nm	nm	nm	nm	nm	0.20	0.03	nm	nm	nm	nm
9	8.1	7.4	19.3	32	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.00	nm	nm	nm	nm
10	8.1	7.0	16.0	447	nm	nm	nm	nm	nm	nm	nm	nm	0.24	0.02	nm	nm	nm	nm
11	8.1	4.7	32.8	323	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.01	nm	nm	nm	nm
12	8.1	7.4	6.6	167	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.02	nm	nm	nm	nm
13	8.0	5.0	20.5	642	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.12	nm	nm	nm	nm
14	8.0	9.7	0.0	78	nm	nm	nm	nm	nm	nm	nm	nm	0.06	0.01	nm	nm	nm	nm
15	8.2	8.9	27.5	43	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.02	nm	nm	nm	nm
16	8.2	7.3	0.6	25	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.01	nm	nm	nm	nm

nm = not measured.

Table 9.63. Research Feedlot groundwater chemistry data on June 12, 2000.

Well no.	pH	EC dS m^{-1}	NO_3-N mg L^{-1}	Cl mg L^{-1}	Na mg L^{-1}	K mg L^{-1}	Ca mg L^{-1}	Mg mg L^{-1}	SAR mg L^{-1}	SO_4-S mg L^{-1}	CO_3 mg L^{-1}	HCO_3 mg L^{-1}	NH_4-N mg L^{-1}	PO_4-P mg L^{-1}	Mn mg L^{-1}	Fe mg L^{-1}	Cu mg L^{-1}	Zn mg L^{-1}
1	8.2	5.1	0.4	11	347	8.2	485	462	2.7	1034	0.0	664	0.00	0.02	0.01	0.00	0.02	0.05
2	8.1	10.1	144.7	261	1545	18.4	473	694	10.6	1763	0.0	705	0.00	0.02	0.02	0.00	0.11	0.12
3	8.1	6.2	5.2	28	664	14.1	483	459	5.2	1266	0.0	543	0.00	0.01	0.00	0.00	0.03	0.04
4	8.1	7.2	27.0	147	897	13.3	509	508	6.7	1298	0.0	777	0.00	0.02	0.00	0.00	0.04	0.04
5	7.8	6.0	1.5	475	338	51.2	577	526	2.4	898	0.0	1067	1.11	0.01	6.60	0.06	0.03	0.06
6	8.2	9.3	79.4	212	1485	16.0	505	537	11.0	1667	0.0	882	0.00	0.02	0.01	0.00	0.05	0.05
7	8.2	8.7	39.1	190	1230	18.8	517	672	8.4	1651	0.0	904	0.12	0.04	0.73	0.00	0.03	0.03
8	8.2	6.2	49.0	417	563	14.1	585	451	4.3	930	0.0	809	0.21	0.04	1.01	0.00	0.03	0.03
9	8.2	7.0	23.5	35	763	10.2	517	664	5.2	1387	0.0	849	0.00	0.02	0.03	0.00	0.02	0.03
10	8.2	6.9	23.1	570	701	12.9	557	518	5.1	1034	0.0	806	0.16	0.04	0.36	0.00	0.02	0.04
11	8.2	4.7	32.9	347	124	7.0	555	407	1.0	745	0.0	550	0.00	0.01	0.00	0.00	0.02	0.03
12	8.2	7.6	5.3	117	1005	12.5	525	549	7.3	1411	0.0	997	0.00	0.02	1.09	0.00	0.02	0.03
13	8.1	5.0	19.0	602	145	14.5	597	360	1.2	649	0.0	632	0.00	0.11	0.27	0.00	0.02	0.04
14	8.1	9.8	0.0	62	1375	16.8	485	853	8.7	2068	0.0	782	0.08	0.01	0.80	0.27	0.01	0.04
15	8.2	9.0	29.6	37	1108	15.2	487	860	7.0	1908	0.0	755	0.00	0.02	0.09	0.00	0.02	0.05
16	8.2	7.5	1.4	23	922	10.2	481	696	6.3	1451	0.0	821	0.00	0.01	0.14	0.00	0.02	0.03

nm = not measured.

Table 9.64. Research Feedlot groundwater chemistry data on June 26, 2000.

Well no.	pH	EC dS m^{-1}	NO_3-N mg L^{-1}	Cl mg L^{-1}	Na mg L^{-1}	K mg L^{-1}	Ca mg L^{-1}	Mg mg L^{-1}	SAR mg L^{-1}	SO_4-S mg L^{-1}	CO_3 mg L^{-1}	HCO_3 mg L^{-1}	NH_4-N mg L^{-1}	PO_4-P mg L^{-1}	Mn mg L^{-1}	Fe mg L^{-1}	Cu mg L^{-1}	Zn mg L^{-1}
1	8.1	5.1	0.0	10	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.01	nm	nm	nm	nm
2	8.2	10.0	152.8	256	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.03	nm	nm	nm	nm
3	8.2	5.9	6.7	28	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.01	nm	nm	nm	nm
4	8.1	7.2	27.6	149	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.01	nm	nm	nm	nm
5	7.9	5.9	0.3	473	nm	nm	nm	nm	nm	nm	nm	nm	1.62	0.05	nm	nm	nm	nm
6	8.2	9.1	77.5	207	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.02	nm	nm	nm	nm
7	8.3	8.6	39.5	189	nm	nm	nm	nm	nm	nm	nm	nm	0.08	0.04	nm	nm	nm	nm
8	8.0	6.0	35.9	625	nm	nm	nm	nm	nm	nm	nm	nm	0.16	0.04	nm	nm	nm	nm
9	8.0	6.6	27.3	37	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.02	nm	nm	nm	nm
10	8.0	6.8	24.1	586	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.04	nm	nm	nm	nm
11	8.3	4.6	30.3	444	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.06	nm	nm	nm	nm
12	8.1	7.3	7.8	132	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.02	nm	nm	nm	nm
13	8.0	4.9	18.2	581	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.13	nm	nm	nm	nm
14	8.2	9.6	0.0	60	nm	nm	nm	nm	nm	nm	nm	nm	0.06	0.01	nm	nm	nm	nm
15	8.3	8.8	29.3	33	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.03	nm	nm	nm	nm
16	8.3	7.4	0.4	19	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.02	nm	nm	nm	nm

nm = not measured.

Table 9.65. Research Feedlot groundwater chemistry data on July 10, 2000.

Well no.	pH	EC dS m^{-1}	NO_3-N mg L^{-1}	Cl mg L^{-1}	Na mg L^{-1}	K mg L^{-1}	Ca mg L^{-1}	Mg mg L^{-1}	SAR mg L^{-1}	SO_4-S mg L^{-1}	CO_3 mg L^{-1}	HCO_3 mg L^{-1}	NH_4-N mg L^{-1}	PO_4-P mg L^{-1}	Mn mg L^{-1}	Fe mg L^{-1}	Cu mg L^{-1}	Zn mg L^{-1}
1	8.1	5.2	0.0	10	361	8.6	517	459	2.8	1106	0.0	677	0.00	0.01	0.07	0.01	0.02	0.07
2	8.1	9.8	138.9	157	1545	18.8	513	656	10.7	1795	0.0	691	0.00	0.03	0.04	0.01	0.12	0.12
3	8.1	6.2	5.9	28	738	15.2	505	406	5.9	1274	0.0	544	0.00	0.01	0.04	0.02	0.05	0.05
4	8.1	7.1	27.7	146	874	12.9	531	453	6.7	1330	0.0	764	0.00	0.02	0.01	0.02	0.05	0.04
5	8.1	6.4	10.5	297	579	25.8	539	482	4.4	1130	0.0	885	0.40	0.02	2.05	0.09	0.04	0.04
6	8.1	9.2	79.3	206	1494	16.0	511	484	11.4	1715	0.0	866	0.00	0.02	0.00	0.01	0.04	0.03
7	8.1	8.5	38.1	184	1209	18.8	521	530	8.9	1683	0.0	891	0.08	0.04	0.53	0.01	0.04	0.03
8	8.1	6.4	47.9	275	738	14.1	549	399	5.9	1058	0.0	750	0.12	0.04	0.44	0.01	0.05	0.03
9	8.1	7.7	12.3	38	1041	14.5	521	524	7.7	1579	0.0	776	0.00	0.02	0.24	0.02	0.04	0.02
10	8.0	7.1	12.0	383	835	14.5	567	463	6.3	1210	0.0	818	0.18	0.03	0.86	0.32	0.04	0.03
11	8.0	5.6	27.9	184	490	11.3	561	424	3.8	1042	0.0	581	0.00	0.03	0.60	0.00	0.03	0.03
12	8.0	7.5	3.9	69	1048	13.3	525	470	8.0	1451	0.0	941	0.05	0.02	0.80	0.11	0.03	0.04
13	8.0	4.8	13.4	526	156	16.0	691	366	1.2	681	0.0	645	0.12	0.10	0.76	0.02	0.03	0.03
14	8.0	9.5	0.0	60	1366	16.4	509	756	9.0	2084	0.0	747	0.09	0.00	0.80	0.32	0.03	0.04
15	8.1	9.1	31.0	41	1193	17.6	509	784	7.7	2004	0.0	729	0.00	0.02	0.17	0.00	0.04	0.05
16	8.1	7.9	2.8	27	1046	12.5	499	640	7.3	1571	0.0	794	0.00	0.02	0.13	0.00	0.04	0.03

nm = not measured.

Table 9.66. Research Feedlot groundwater chemistry data on July 24, 2000.

Well no.	pH	EC dS m^{-1}	NO_3-N mg L^{-1}	Cl mg L^{-1}	Na mg L^{-1}	K mg L^{-1}	Ca mg L^{-1}	Mg mg L^{-1}	SAR mg L^{-1}	SO_4-S mg L^{-1}	CO_3 mg L^{-1}	HCO_3 mg L^{-1}	NH_4-N mg L^{-1}	PO_4-P mg L^{-1}	Mn mg L^{-1}	Fe mg L^{-1}	Cu mg L^{-1}	Zn mg L^{-1}
1	7.8	5.2	1.4	10	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.01	nm	nm	nm	nm
2	7.6	9.8	177.9	261	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.03	nm	nm	nm	nm
3	7.5	6.4	3.8	26	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.01	nm	nm	nm	nm
4	7.6	7.1	33.5	157	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.01	nm	nm	nm	nm
5	7.6	6.0	4.1	447	nm	nm	nm	nm	nm	nm	nm	nm	0.92	0.02	nm	nm	nm	nm
6	7.6	9.2	97.8	209	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.02	nm	nm	nm	nm
7	7.6	8.6	47.2	193	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.04	nm	nm	nm	nm
8	7.7	6.1	57.6	473	nm	nm	nm	nm	nm	nm	nm	nm	0.17	0.05	nm	nm	nm	nm
9	7.6	6.9	31.0	30	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.01	nm	nm	nm	nm
10	7.7	6.8	25.6	510	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.04	nm	nm	nm	nm
11	7.7	4.8	36.3	415	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.01	nm	nm	nm	nm
12	7.6	7.5	10.6	64	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.02	nm	nm	nm	nm
13	7.6	4.9	18.5	526	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.13	nm	nm	nm	nm
14	7.4	9.5	1.7	58	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.01	nm	nm	nm	nm
15	7.7	9.0	39.2	34	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.02	nm	nm	nm	nm
16	7.7	7.9	3.9	25	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.01	nm	nm	nm	nm

nm = not measured.

Table 9.67. Research Feedlot groundwater chemistry data on August 14, 2000.

Well no.	pH	EC dS m^{-1}	NO_3-N mg L^{-1}	Cl mg L^{-1}	Na mg L^{-1}	K mg L^{-1}	Ca mg L^{-1}	Mg mg L^{-1}	SAR mg L^{-1}	SO_4-S mg L^{-1}	CO_3 mg L^{-1}	HCO_3 mg L^{-1}	NH_4-N mg L^{-1}	PO_4-P mg L^{-1}	Mn mg L^{-1}	Fe mg L^{-1}	Cu mg L^{-1}	Zn mg L^{-1}
1	7.7	5.2	1.3	10	366	9.4	509	496	2.8	1106	0.0	691	0.00	0.02	0.02	0.00	0.03	0.05
2	7.7	9.8	178.2	256	1561	19.2	509	603	11.1	1811	0.0	689	0.00	0.03	0.05	0.00	0.10	0.10
3	7.6	6.4	3.9	25	784	16.0	487	420	6.3	1298	0.0	550	0.00	0.01	0.02	0.00	0.04	0.05
4	7.7	7.1	33.3	158	901	13.7	523	455	7.0	1322	0.0	776	0.00	0.02	0.02	0.00	0.04	0.04
5	7.7	6.0	2.2	441	297	54.0	577	492	2.2	906	0.0	1096	0.85	0.01	5.40	0.06	0.04	0.04
6	7.6	9.2	94.8	107	1513	16.8	511	508	11.3	1683	0.0	898	0.00	0.02	0.01	0.00	0.04	0.03
7	7.7	8.7	44.5	189	1244	19.9	511	621	8.7	1667	0.0	901	0.00	0.04	0.60	0.00	0.03	0.04
8	7.7	6.2	63.7	371	579	14.5	577	417	4.5	938	0.0	790	0.12	0.04	0.46	0.01	0.03	0.04
9	7.7	6.8	28.9	32	699	10.6	549	599	4.9	1387	0.0	857	0.00	0.02	0.00	0.00	0.03	0.04
10	7.7	7.0	17.5	424	763	15.2	569	499	5.6	1154	0.0	826	0.14	0.04	0.54	0.01	0.03	0.06
11	7.7	5.4	37.3	180	372	10.6	561	440	2.9	1018	0.0	580	0.00	0.01	0.01	0.00	0.03	0.04
12	7.6	7.8	4.9	46	1129	15.2	-106	843	8.7	1467	0.0	863	0.07	0.01	0.90	0.00	0.03	0.03
13	7.7	4.9	16.5	470	143	16.4	635	362	1.1	681	0.0	669	0.00	0.12	0.57	0.01	0.02	0.04
14	7.5	9.6	1.3	55	1389	17.2	483	713	9.4	2020	0.0	752	0.09	0.01	1.03	0.00	0.01	0.04
15	7.8	9.1	38.1	32	1145	16.8	481	795	7.4	1940	0.0	740	0.00	0.02	0.15	0.50	0.02	0.05
16	7.8	8.1	2.9	24	1076	12.5	491	651	7.5	1715	0.0	812	0.00	0.01	0.27	0.00	0.03	0.04

nm = not measured.

Table 9.68. Research Feedlot groundwater chemistry data on August 28, 2000.

Well no.	pH	EC dS m^{-1}	NO_3-N mg L^{-1}	Cl mg L^{-1}	Na mg L^{-1}	K mg L^{-1}	Ca mg L^{-1}	Mg mg L^{-1}	SAR mg L^{-1}	SO_4-S mg L^{-1}	CO_3 mg L^{-1}	HCO_3 mg L^{-1}	NH_4-N mg L^{-1}	PO_4-P mg L^{-1}	Mn mg L^{-1}	Fe mg L^{-1}	Cu mg L^{-1}	Zn mg L^{-1}
1	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
2	7.6	9.8	154.2	258	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.02	nm	nm	nm	nm
3	7.6	6.4	2.2	26	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.00	nm	nm	nm	nm
4	7.6	7.1	33.5	162	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.01	nm	nm	nm	nm
5	7.5	6.0	0.4	448	nm	nm	nm	nm	nm	nm	nm	nm	0.98	0.02	nm	nm	nm	nm
6	7.6	9.3	78.7	217	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.02	nm	nm	nm	nm
7	7.7	8.7	39.4	201	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.05	nm	nm	nm	nm
8	7.6	6.1	34.0	628	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.07	nm	nm	nm	nm
9	7.5	6.8	25.6	34	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.02	nm	nm	nm	nm
10	7.7	7.1	17.4	109	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.07	nm	nm	nm	nm
11	7.6	5.4	31.5	189	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.02	nm	nm	nm	nm
12	7.6	7.5	8.1	76	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.05	nm	nm	nm	nm
13	7.6	4.9	11.1	452	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.13	nm	nm	nm	nm
14	7.4	9.5	0.0	56	nm	nm	nm	nm	nm	nm	nm	nm	0.09	0.01	nm	nm	nm	nm
15	7.7	9.2	32.8	36	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.02	nm	nm	nm	nm
16	7.7	8.4	3.9	29	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.01	nm	nm	nm	nm

nm = not measured.

Table 9.69. Research Feedlot groundwater chemistry data on September 25, 2000.

Well no.	pH	EC dS m^{-1}	NO_3-N mg L^{-1}	Cl mg L^{-1}	Na mg L^{-1}	K mg L^{-1}	Ca mg L^{-1}	Mg mg L^{-1}	SAR mg L^{-1}	SO_4-S mg L^{-1}	CO_3 mg L^{-1}	HCO_3 mg L^{-1}	NH_4-N mg L^{-1}	PO_4-P mg L^{-1}	Mn mg L^{-1}	Fe mg L^{-1}	Cu mg L^{-1}	Zn mg L^{-1}
1	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
2	8.2	9.9	163.3	260	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.00	nm	nm	nm	nm
3	8.2	6.3	3.9	38	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.00	nm	nm	nm	nm
4	7.9	6.2	3.5	480	nm	nm	nm	nm	nm	nm	nm	nm	0.59	0.00	nm	nm	nm	nm
5	8.2	7.2	39.1	176	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.00	nm	nm	nm	nm
6	8.2	9.0	92.2	252	nm	nm	nm	nm	nm	nm	nm	nm	0.18	0.00	nm	nm	nm	nm
7	8.2	9.0	40.6	199	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.02	nm	nm	nm	nm
8	8.1	6.5	60.2	803	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.03	nm	nm	nm	nm
9	8.2	7.6	19.0	51	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.00	nm	nm	nm	nm
10	8.2	7.3	33.3	613	nm	nm	nm	nm	nm	nm	nm	nm	1.79	0.11	nm	nm	nm	nm
11	8.2	5.5	34.3	188	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.00	nm	nm	nm	nm
12	8.2	7.8	7.4	93	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.00	nm	nm	nm	nm
13	8.2	5.5	57.0	760	nm	nm	nm	nm	nm	nm	nm	nm	0.14	0.16	nm	nm	nm	nm
14	8.2	9.8	0.0	81	nm	nm	nm	nm	nm	nm	nm	nm	0.13	0.00	nm	nm	nm	nm
15	8.3	9.5	33.9	69	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.02	nm	nm	nm	nm
16	8.2	8.6	5.0	45	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.00	nm	nm	nm	nm

nm = not measured.

Table 9.70. Research Feedlot groundwater chemistry data on October 16, 2000.

Well no.	pH	EC dS m^{-1}	NO_3-N mg L^{-1}	Cl mg L^{-1}	Na mg L^{-1}	K mg L^{-1}	Ca mg L^{-1}	Mg mg L^{-1}	SAR mg L^{-1}	SO_4-S mg L^{-1}	CO_3 mg L^{-1}	HCO_3 mg L^{-1}	NH_4-N mg L^{-1}	PO_4-P mg L^{-1}	Mn mg L^{-1}	Fe mg L^{-1}	Cu mg L^{-1}	Zn mg L^{-1}
1	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
2	8.1	10.3	159.7	250	1531	19.9	471	593	11.1	1699	0.0	677	0.00	0.02	0.10	0.03	0.17	0.10
3	8.1	6.7	2.1	30	795	16.0	449	452	6.3	1298	0.0	547	0.00	0.00	0.07	0.03	0.08	0.04
4	8.1	7.4	35.6	164	892	14.9	481	464	7.0	1226	0.0	767	0.22	0.02	0.07	0.03	0.10	0.05
5	7.9	6.4	2.1	536	347	50.0	585	515	2.5	866	0.0	1003	0.42	0.02	6.00	0.12	0.06	0.06
6	8.1	9.1	79.8	224	1398	16.8	457	492	10.8	1507	0.0	938	0.10	0.03	0.08	0.02	0.09	0.04
7	8.2	9.1	38.7	172	1278	21.1	489	578	9.3	1651	0.0	895	0.00	0.03	0.60	0.02	0.09	0.03
8	8.1	6.7	51.8	748	577	18.8	505	429	4.6	721	0.0	834	0.00	0.04	0.67	0.02	0.10	0.04
9	8.1	7.9	14.8	43	947	13.7	433	586	7.0	1499	0.0	808	0.00	0.01	0.27	0.03	0.11	0.04
10	8.2	7.5	23.5	540	784	27.8	441	513	6.0	1034	0.0	900	0.83	0.11	2.15	0.12	0.09	0.09
11	8.1	5.4	30.8	271	234	10.2	545	436	1.8	898	0.0	562	0.00	0.02	0.06	0.01	0.07	0.04
12	8.2	7.8	9.1	88	1007	13.7	401	538	7.7	1443	0.0	993	0.00	0.03	0.63	0.02	0.07	0.04
13	8.1	5.4	37.0	615	205	17.6	599	360	1.6	609	0.0	614	0.00	0.13	0.69	0.04	0.06	0.04
14	8.1	9.8	0.0	78	1386	18.0	419	762	9.3	1988	0.0	761	0.11	0.01	1.43	0.91	0.06	0.04
15	8.2	9.7	32.5	51	1246	18.8	421	794	8.3	1940	0.0	721	0.00	0.03	0.19	0.10	0.06	0.06
16	8.2	8.9	4.9	41	1237	16.4	619	687	8.1	1747	0.0	800	0.00	0.01	0.38	0.00	0.07	0.03

nm = not measured.

Table 9.71. Research Feedlot groundwater chemistry data on October 30, 2000.

Well no.	pH	EC dS m^{-1}	NO_3-N mg L^{-1}	Cl mg L^{-1}	Na mg L^{-1}	K mg L^{-1}	Ca mg L^{-1}	Mg mg L^{-1}	SAR mg L^{-1}	SO_4-S mg L^{-1}	CO_3 mg L^{-1}	HCO_3 mg L^{-1}	NH_4-N mg L^{-1}	PO_4-P mg L^{-1}	Mn mg L^{-1}	Fe mg L^{-1}	Cu mg L^{-1}	Zn mg L^{-1}
1	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
2	8.2	9.4	162.6	269	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.03	nm	nm	nm	nm
3	8.2	6.0	5.9	29	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.02	nm	nm	nm	nm
4	8.1	6.9	38.4	178	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.02	nm	nm	nm	nm
5	7.6	5.8	3.4	564	nm	nm	nm	nm	nm	nm	nm	nm	0.09	0.05	nm	nm	nm	nm
6	8.2	8.6	81.4	235	nm	nm	nm	nm	nm	nm	nm	nm	0.05	0.05	nm	nm	nm	nm
7	8.2	8.2	37.7	184	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.07	nm	nm	nm	nm
8	7.7	6.3	57.3	1156	nm	nm	nm	nm	nm	nm	nm	nm	0.04	0.05	nm	nm	nm	nm
9	8.0	6.9	22.1	35	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.00	nm	nm	nm	nm
10	8.3	6.6	28.4	576	nm	nm	nm	nm	nm	nm	nm	nm	0.08	0.16	nm	nm	nm	nm
11	7.8	4.8	32.2	448	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.02	nm	nm	nm	nm
12	8.1	7.2	10.6	88	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.03	nm	nm	nm	nm
13	7.9	4.8	31.0	608	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.02	nm	nm	nm	nm
14	7.9	8.7	1.3	76	nm	nm	nm	nm	nm	nm	nm	nm	0.07	0.01	nm	nm	nm	nm
15	8.2	8.9	33.1	48	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.03	nm	nm	nm	nm
16	8.2	8.3	6.6	40	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.01	nm	nm	nm	nm

nm = not measured.

Table 9.72. Research Feedlot groundwater chemistry data on November 14, 2000.

Well no.	pH	EC dS m^{-1}	NO_3-N mg L^{-1}	Cl mg L^{-1}	Na mg L^{-1}	K mg L^{-1}	Ca mg L^{-1}	Mg mg L^{-1}	SAR mg L^{-1}	SO_4-S mg L^{-1}	CO_3 mg L^{-1}	HCO_3 mg L^{-1}	NH_4-N mg L^{-1}	PO_4-P mg L^{-1}	Mn mg L^{-1}	Fe mg L^{-1}	Cu mg L^{-1}	Zn mg L^{-1}
1	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
2	8.0	9.8	164.3	263	1533	19.9	463	600	11.1	1667	0.0	671	0.00	0.00	0.03	0.04	0.09	0.00
3	7.9	6.6	0.6	28	876	17.6	435	423	7.2	1314	0.0	559	0.00	0.00	0.04	0.06	0.12	0.00
4	8.0	7.0	38.5	175	894	14.9	451	445	7.2	1274	0.0	771	0.00	0.00	0.04	0.05	0.11	0.00
5	8.0	6.4	11.1	392	439	25.0	507	593	3.1	1034	0.0	971	0.07	0.01	0.09	0.06	0.09	0.00
6	8.1	9.3	80.7	219	1527	17.6	471	560	11.3	1651	0.0	859	0.00	0.00	0.05	0.05	0.08	0.00
7	8.1	8.7	38.1	179	1262	19.9	457	600	9.1	1651	0.0	892	0.00	0.02	0.07	0.05	0.06	0.00
8	8.1	6.6	59.7	325	738	14.1	467	417	6.0	1050	0.0	735	0.00	0.01	0.08	0.06	0.05	0.00
9	8.0	7.7	12.7	35	943	14.5	471	621	6.7	1595	0.0	747	0.00	0.00	0.07	0.04	0.08	0.00
10	8.0	7.5	4.9	317	945	18.4	457	566	7.0	1282	0.0	834	0.63	0.05	0.11	0.06	0.05	0.00
11	8.0	6.5	23.8	99	697	14.9	503	490	5.3	1258	0.0	607	0.00	0.01	0.10	0.07	0.09	0.00
12	8.0	7.9	1.5	39	1221	17.6	473	459	9.6	1523	0.0	864	0.08	0.00	0.11	0.04	0.06	0.00
13	8.1	5.1	26.8	563	191	17.2	567	360	1.5	649	0.0	632	0.00	0.16	0.13	0.03	0.05	0.00
14	7.9	9.3	0.0	76	1352	17.6	497	694	9.2	2004	0.0	751	0.09	0.00	0.65	0.18	0.07	0.00
15	8.1	9.5	32.1	54	1297	19.2	493	751	8.6	2052	0.0	728	0.00	0.02	0.12	0.02	0.09	0.00
16	8.1	8.5	4.8	37	1195	14.9	471	649	8.4	1811	0.0	793	0.00	0.01	0.09	0.05	0.07	0.00

nm = not measured.

Table 9.73. Research Feedlot groundwater chemistry data on November 27, 2000.

Well no.	pH	EC dS m^{-1}	NO_3-N mg L^{-1}	Cl mg L^{-1}	Na mg L^{-1}	K mg L^{-1}	Ca mg L^{-1}	Mg mg L^{-1}	SAR mg L^{-1}	SO_4-S mg L^{-1}	CO_3 mg L^{-1}	HCO_3 mg L^{-1}	NH_4-N mg L^{-1}	PO_4-P mg L^{-1}	Mn mg L^{-1}	Fe mg L^{-1}	Cu mg L^{-1}	Zn mg L^{-1}
1	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm	nm
2	8.0	9.8	158.7	251	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.00	nm	nm	nm	nm
3	8.0	6.6	1.5	28	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.00	nm	nm	nm	nm
4	8.0	7.2	37.8	174	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.00	nm	nm	nm	nm
5	8.0	6.5	10.2	392	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.03	nm	nm	nm	nm
6	8.1	9.5	77.3	211	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.01	nm	nm	nm	nm
7	8.1	8.8	35.6	173	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.04	nm	nm	nm	nm
8	8.1	6.6	56.3	502	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.04	nm	nm	nm	nm
9	8.1	8.3	10.5	38	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.04	nm	nm	nm	nm
10	8.1	7.7	4.6	270	nm	nm	nm	nm	nm	nm	nm	nm	0.27	0.05	nm	nm	nm	nm
11	8.0	6.5	22.8	117	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.03	nm	nm	nm	nm
12	8.0	7.9	3.8	48	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.03	nm	nm	nm	nm
13	8.0	5.1	19.2	512	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.13	nm	nm	nm	nm
14	7.9	9.4	0.0	79	nm	nm	nm	nm	nm	nm	nm	nm	0.07	0.02	nm	nm	nm	nm
15	8.1	9.6	29.6	54	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.03	nm	nm	nm	nm
16	8.1	8.8	5.7	42	nm	nm	nm	nm	nm	nm	nm	nm	0.00	0.02	nm	nm	nm	nm

nm = not measured.

Appendix 10. Fecal coliform and *Escherichia coli* content in groundwater at the Research Feedlot on July 23 and August 21, 1996.

Well number	Fecal coliform[z] (counts per 100 mL)		*Escherichia coli*[z] (counts per 100 mL)	
	July 23, 1996	August 21, 1996	July 23, 1996	August 21, 1996
1	<2	<1	<2	<1
2	<2	<1	<2	<1
3	<2	<1	<2	<1
4	<2	<1	<2	<1
5	<2	<1	<2	<1
6	<2	<1	<2	<1
7	<2	<1	<2	<1
8	<2	<1	<2	<1
9	<2	<1	<2	<1
10	<2	<1	<2	<1
11	<2	<1	2	<1
12	<2	<1	5	<1
13	<2	<1	2	<1
14	<2	<1	<2	<1
15	<2	<1	<2	<1
16	<2	<1	<2	<1

[z] Analysis was carried out by the Provincial Laboratory of Public Health for southern Alberta, 3030 Hospital Drive N.W., Calgary, Alberta.

Appendix 11. Microbiological analyses of groundwater samples taken from May 12, 1998 to January 15, 2001.

Table 11.1. *Escherichia coli* in groundwater samples from the Research Feedlot (log MPN 100 mL^{-1})[z]. (1 of 4 pages)

Well no.	May 12 1998	June 15 1998	July 14 1998	Aug 10 1998	Aug 24 1998	Sept 14 1998	Sept 28 1998	Oct 13 1998	Oct 26 1998	Nov 16 1998	Dec 11 1998	Jan 14 1999	Feb 17 1999
1	y												
2								nm	1.56				
3													
4													
5	2.32	1.56	5.63	5.66	4.97	3.97	2.96	2.63	2.36	1.56	2.36	2.36	2.63
6	3.66	2.15	4.04	2.96	2.56	2.18							
7	4.38		5.97	2.97	2.63		1.96	1.48		1.56	2.18		
8		1.56	5.38	6.04	5.63	3.63	2.56	2.97	2.36	3.18	1.87	2.63	2.18
9					1.48								
10	1.56	1.96	4.97	1.96	1.96	1.56							
11				3.18	1.96		1.96	1.48			1.56		1.56
12			3.66	6.88	5.97	4.97	4.18	3.36		1.87	1.56		
13	4.32	4.38	5.38	5.66	3.96	3.97	3.36	2.63	1.56	1.56	1.96	1.56	1.56
14		1.96	1.56										
15				1.56	1.56								
16		2.63		2.36	1.56								

[z] Most probable number (MPN) per 100 mL^{-1} values are expressed as common log (base 10) numbers.
[y] No number indicates below the detection limit of 1.56.
nm = not measured.

Table 11.1. *Escherichia coli* in groundwater samples from the Research Feedlot (log MPN 100 mL^{-1})[z]. (2 of 4 pages)

Well no.	Mar 15 1999	Apr 12 1999	Apr 26 1999	May 17 1999	May 25 1999	May 31 1999	June 14 1999	June 28 1999	July 12 1999	July 26 1999	Aug 16 1999	Aug 30 1999	Sept 13 1999
1	y												
2													
3													
4													
5						5.63	5.63	3.36	2.97	4.63	4.63	5.38	4.88
6	2.18	1.56	1.87	7.18	6.63	2.87	4.18	2.56		5.36	3.97	2.56	
7				3.48	2.96	4.36	2.87		1.56	1.96		1.56	
8				4.38	5.36	5.97		3.18	1.56	2.36	2.18	2.36	1.56
9	1.56	1.48	1.87	5.63	6.32								
10						3.48	5.97	3.36	3.97	6.04	5.63	3.96	3.36
11				5.63	4.97			1.56				1.96	
12			1.96		1.56		3.36	3.97	2.36	4.38	2.97	2.97	2.18
13						4.63	2.63	3.63	1.96	5.97	3.63	2.96	2.36
14			2.36	3.88	5.63								
15										1.56			
16				1.56									

[z] Most probable number (MPN) per 100 mL^{-1} values are expressed as common log (base 10) numbers.
[y] No number indicates below the detection limit of 1.56.
nm = not measured.

Table 11.1. *Escherichia coli* in groundwater samples from the Research Feedlot (log MPN 100 mL^{-1})[z]. (3 of 4 pages)

Well no.	Sept 27 1999	Oct 12 1999	Nov 15 1999	Dec 13 1999	Jan 17 2000	Feb 14 2000	Mar 13 2000	Apr 11 2000	May 15 2000	May 29 2000	June 12 2000	June 26 2000	July 10 2000
1	y												
2													
3													
4													
5	4.66	2.88	2.97	1.56				4.36	3.36	1.96			1.56
6	1.56							2.63			1.48		
7											1.48		
8			1.56	1.56			1.96	1.56	1.56		1.48		
9								1.56			2.04		
10	2.97	3.38	1.48	1.56			1.56						
11													
12													
13	1.56	1.96					2.36			1.56			1.56
14													
15													
16											1.56		

[z] Most probable number (MPN) per 100 mL^{-1} values are expressed as common log (base 10) numbers.
[y] No number indicates below the detection limit of 1.56.
nm = not measured.

Table 11.1. *Escherichia coli* in groundwater samples from the Research Feedlot (log MPN 100 mL^{-1}) [z]. (4 of 4 pages)

Well no.	July 24 2000	Aug 14 2000	Aug 28 2000	Sept 13 2000	Sept 25 2000	Oct 16 2000	Oct 30 2000	Nov 14 2000	Nov 27 2000	Dec 19 2000	Jan 15 2001
1	y		nm	nm	nm	nm	nm	nm	nm	nm	nm
2											nm
3											nm
4											nm
5	2.97	2.63	1.56	4.97	5.36	4.18	2.97	3.38	1.96		
6		1.56		4.36	3.63		2.36				
7				1.56						nm	nm
8				4.36	3.36	1.56					
9											nm
10	2.36		3.38	6.04	4.63	3.63		2.36	2.36	2.63	
11			1.56								nm
12			2.63	2.36	1.56						nm
13				4.36	4.36	2.97		1.56			nm
14											nm
15											nm
16											nm

[z] Most probable number (MPN) per 100 mL^{-1} values are expressed as common log (base 10) numbers.

[y] No number indicates below the detection limit of 1.56.

nm = not measured.

Table 11.2. Total coliforms in groundwater samples from the Research Feedlot (log MPN 100 mL^{-1})[z]. (1 of 4 pages)

Well no.	May 12 1998	June 15 1998	July 14 1998	Aug 10 1998	Aug 24 1998	Sept 14 1998	Sept 28 1998	Oct 13 1998	Oct 26 1998	Nov 16 1998	Dec 11 1998	Jan 14 1999	Feb 17 1999
1	1.56	y											
2	1.56							nm	nm	nm	nm	nm	nm
3			1.56	1.56		2.18	2.63		1.56		1.56		
4			1.96				3.63	2.97	2.97	1.56			
5	2.32	1.56	6.04	5.66	4.97	3.97	2.96	2.63	3.36	2.36	2.36	2.36	2.63
6	3.66	2.58	5.66	5.66	3.97	3.97	2.63	2.63	2.63				
7	4.66		6.04	3.66	3.63	2.36	1.96	1.48		2.36	2.18		
8		1.56	5.66	6.04	5.63	3.88	2.56	2.97	2.36	3.18	1.87	2.63	2.18
9		1.56	3.38		1.56								
10	1.56	2.36	5.36	5.36	2.63	2.88	2.36				1.56		
11			4.04	3.66	4.63	3.38	2.63	2.63	1.56		1.56		1.56
12			5.66	8.04	7.66	6.36	5.97	4.97	3.63	3.38	2.36	1.96	
13	4.32	4.38	5.38	5.66	4.36	3.97	3.36	2.97	2.18	1.56	1.96	1.56	1.56
14		1.96	1.56	2.18									
15	2.36	1.56	1.56	2.63	1.96				2.36				
16		2.63	2.18	2.36	1.96			1.56					

[z] Most probable number (MPN) per 100 mL^{-1} values are expressed as common log (base 10) numbers.
[y] No number indicates below the detection limit of 1.56.
nm = not measured.

Table 11.2. Total coliforms in groundwater samples from the Research Feedlot (log MPN 100 mL^{-1})[z]. (2 of 4 pages)

Well no.	Mar 15 1999	Apr 12 1999	Apr 26 1999	May 17 1999	May 25 1999	May 31 1999	June 14 1999	June 28 1999	July 12 1999	July 26 1999	Aug 16 1999	Aug 30 1999	Sept 13 1999
1	y							2.63		1.56	1.56		1.48
2	nm	nm	nm	nm	nm	nm	nm	2.46	2.36	2.97	1.96	2.36	2.36
3		1.48	1.56	1.56							1.56	1.96	
4		2.36											
5	2.63	1.56	2.04	7.97	7.81	5.97	6.36	4.32	4.18	4.97	4.97	5.38	4.88
6		1.56	2.63	5.18	6.04	4.63	5.66	5.18	3.32	7.38	6.38	3.63	3.18
7				4.38	5.97	4.36	2.87	2.96	1.56	2.36	1.96	1.96	
8	1.56	1.48	2.18	6.36	7.36	5.97	3.63	4.36	2.63	2.63	2.63	2.63	2.36
9					1.87	1.56	2.36	2.18		3.38	2.36	1.96	
10			2.18	5.63	4.97	3.87	5.97	3.63	3.97	6.04	5.97	5.18	3.97
11			1.96		1.56	2.36	3.63	3.32	2.18	2.36	1.87	2.63	
12	1.56				1.96	1.96	8.66	5.36	5.63	5.04	4.97	4.66	3.63
13			2.36	3.88	5.97	4.63	2.63	4.38	2.36	5.97	3.63	3.58	2.36
14													
15				1.56	2.63		2.18			1.96			
16			1.56	1.96		1.56	2.63						

[z] Most probable number (MPN) per 100 mL^{-1} values are expressed as common log (base 10) numbers.
[y] No number indicates below the detection limit of 1.56.
nm = not measured.

Table 11.2. Total coliforms in groundwater samples from the Research Feedlot (log MPN 100 mL^{-1})[z]. (3 of 4 pages)

Well no.	Sept 27 1999	Oct 12 1999	Nov 15 1999	Dec 13 1999	Jan 17 2000	Feb 14 2000	Mar 13 2000	Apr 11 2000	May 15 2000	May 29 2000	June 12 2000	June 26 2000	July 10 2000
1	y												
2	2.36	1.96	3.38	2.63			2.63	1.56		1.56			
3								1.56					
4													
5	4.66	2.88	2.97	1.56				4.36	3.36	2.30		2.63	1.56
6	2.18	1.96						2.63			1.48		
7											1.48		
8			1.56	1.56			2.36	2.88	1.56		1.48		
9								2.63	1.56	1.56	2.30	1.96	
10	3.97	3.38	1.48	2.04	1.56		1.56						
11								1.87					
12	2.45	2.63						1.96					
13	2.36	1.96				1.56	3.38	1.56		1.56			1.56
14													
15													
16											1.56		

[z] Most probable number (MPN) per 100 mL^{-1} values are expressed as common log (base 10) numbers.
[y] No number indicates below the detection limit of 1.56.
nm = not measured.

Table 11.2. Total coliforms in groundwater samples from the Research Feedlot (log MPN 100 mL^{-1})[z]. (4 of 4 pages)

Well no.	July 24 2000	Aug 14 2000	Aug 28 2000	Sept 13 2000	Sept 25 2000	Oct 16 2000	Oct 30 2000	Nov 14 2000	Nov 27 2000	Dec 19 2000	Jan 15 2001
1	[y]		nm	nm	nm	nm	nm	nm	nm	nm	nm
2	2.63	2.63									nm
3											nm
4											nm
5	2.97	2.63	1.56	5.38	5.36	4.18	3.36	3.66	2.36		
6		1.56		4.36	3.63	1.56	2.36	2.36		1.56	
7				2.36						NS	nm
8				4.36	3.63	2.63	1.56	2.36	1.87	2.63	1.96
9	2.36		2.32	1.96			1.56				nm
10	2.36		3.38	6.04	5.36	3.63		2.97	2.36	2.97	1.56
11			1.56	2.36							nm
12			2.63	3.63	1.56						nm
13				4.36	4.36	3.58		1.96			nm
14											nm
15											nm
16				1.56							nm

[z] Most probable number (MPN) per 100 mL^{-1} values are expressed as common log (base 10) numbers.
[y] No number indicates below the detection limit of 1.56.
nm = not measured.

Table 11.3. Aerobic heterotrophs (TSA, 27 ^{o}C) in groundwater samples from the Research Feedlot (log CFU 100 mL^{-1})^{z}. (1 of 4 pages)

Well no.	May 12 1998	June 15 1998	July 14 1998	Aug 10 1998	Aug 24 1998	Sept 14 1998	Sept 28 1998	Oct 13 1998	Oct 26 1998	Nov 16 1998	Dec 11 1998	Jan 14 1998	Feb 17 1998
1	6.08	6.83	7.22	6.96	7.21	6.79	6.88	7.10	6.78	6.93	6.22	6.09	6.43
2	6.29	6.74	7.27	6.88	7.15	6.47	6.84	nm	8.35	7.75	6.98	6.59	7.45
3	6.62	6.54	6.19	6.77	6.71	5.80	5.61	6.06	6.11	6.79	6.16	6.03	6.57
4	6.52	6.20	5.78	6.82	6.86	5.99	5.91	6.75	6.68	7.18	7.25	5.76	7.00
5	6.26	6.17	8.20	8.29	7.97	7.04	6.25	7.28	6.56	6.05	6.15	5.84	6.06
6	7.69	6.80	8.91	6.83	6.77	6.59	6.76	6.72	6.57	6.22	5.62	6.48	5.78
7	8.34	6.65	8.18	7.43	7.03	6.49	6.39	6.51	6.22	6.17	6.11	5.96	5.90
8	6.21	6.54	7.87	8.71	8.28	7.43	6.94	7.12	7.19	7.11	6.78	6.72	6.46
9	5.81	5.81	5.78	6.78	6.55	6.67	6.54	6.50	6.08	5.99	5.62	6.15	5.83
10	7.89	7.14	8.06	7.18	6.82	6.51	6.66	7.06	6.92	6.80	6.08	6.04	6.15
11	5.72	6.67	5.88	6.15	6.57	6.12	6.10	6.59	6.56	6.11	6.53	5.90	6.20
12	5.92	6.19	8.40	8.35	7.96	7.26	7.20	7.00	6.29	6.15	5.68	5.51	5.64
13	7.86	7.09	7.74	8.50	8.20	7.72	7.54	7.35	6.90	6.88	6.07	6.56	6.07
14	6.15	6.70	6.36	7.01	6.98	6.34	6.11	6.97	6.76	6.93	6.34	5.63	6.13
15	5.67	6.06	5.85	6.55	6.79	6.08	6.17	6.51	6.70	6.50	6.11	5.96	5.30
16	5.16	6.51	6.51	6.67	6.38	6.35	6.24	6.29	6.80	6.50	5.66	5.70	5.92

^{z} Colony forming units (CFU) per 100 mL^{-1} values are expressed as common log (base 10) numbers.
nm = not measured.

Table 11.3. Aerobic heterotrophs (TSA, 27 ^{o}C) in groundwater samples from the Research Feedlot (log MPN 100 mL^{-1})[z]. (2 of 4 pages)

Well no.	Mar 15 1999	Apr 12 1999	Apr 26 1999	May 17 1999	May 25 1999	May 31 1999	June 14 1999	June 28 1999	July 12 1999	July 26 1999	Aug 16 1999	Aug 30 1999	Sept 13 1999
1	6.59	6.37	6.85	6.94	6.68	6.59	6.70	6.56	6.70	7.21	7.70	7.51	7.05
2	7.12	6.86	7.45	7.12	7.10	6.73	7.10	7.11	7.27	6.97	6.63	7.10	6.84
3	6.38	5.83	6.14	5.90	5.98	5.46	5.92	5.97	6.70	6.68	6.06	6.89	6.36
4	7.50	6.95	7.30	6.06	6.35	6.16	5.93	6.09	6.20	6.55	6.32	6.41	6.22
5	5.66	6.14	6.56	10.49	9.85	8.80	8.84	7.48	7.52	7.84	7.48	8.29	7.17
6	5.73	5.85	6.24	9.64	8.92	8.78	8.14	6.67	6.51	8.95	7.73	6.30	6.00
7	5.84	6.40	6.25	8.52	8.22	7.76	6.66	7.28	6.01	6.49	5.96	7.40	5.96
8	6.58	6.73	6.90	8.36	8.77	8.53	7.53	7.59	7.22	7.10	6.61	7.21	6.38
9	6.53	5.74	6.61	6.06	5.87	5.94	5.61	5.68	6.07	6.46	5.52	6.09	5.74
10	6.79	7.04	7.16	8.93	8.18	7.36	8.09	7.02	7.24	8.79	8.14	8.26	7.33
11	6.63	6.18	6.49	6.03	6.44	6.65	6.17	6.64	7.25	7.01	6.81	7.25	6.22
12	6.70	5.54	5.76	5.92	6.01	5.82	9.23	8.44	7.80	8.20	7.50	7.19	6.34
13	6.13	6.01	6.83	8.19	8.49	8.18	7.59	7.02	6.65	8.52	7.12	7.12	6.33
14	5.66	5.99	5.95	5.81	5.78	6.28	6.51	6.27	6.60	6.41	6.61	6.45	5.71
15	6.24	5.76	6.12	6.01	5.97	6.06	5.62	5.98	6.10	6.57	6.23	6.71	6.12
16	5.89	6.12	5.88	6.38	5.56	5.53	5.92	5.91	6.05	6.43	6.33	6.53	6.26

[z] Most probable number (MPN) per 100 mL^{-1} values are expressed as common log (base 10) numbers.
[y] No number indicates below the detection limit of 1.56.
nm = not measured.

Table 11.3. Aerobic heterotrophs (TSA, 27 °C) in groundwater samples from the Research Feedlot (log MPN 100 mL^{-1})^{z}. (3 of 4 pages)

Well no.	Sept 27 1999	Oct 12 1999	Nov 15 1999	Dec 13 1999	Jan 17 2000	Feb 14 2000	Mar 13 2000	Apr 11 2000	May 15 2000	May 29 2000	June 12 2000	June 26 2000	July 10 2000
1	7.20	6.51	7.13	7.11	6.39	5.63	5.03	5.45	5.87	6.53	6.58	6.91	7.13
2	7.12	6.73	6.81	6.78	6.67	6.14	6.41	5.87	6.43	6.25	6.37	6.74	6.71
3	6.21	5.83	5.77	5.74	5.83	5.65	5.05	5.55	5.41	6.82	5.82	5.64	5.82
4	6.75	6.14	7.04	6.12	6.15	5.93	6.04	7.86	6.96	6.99	6.65	7.59	7.11
5	7.33	6.81	7.14	6.58	6.09	6.41	5.64	7.95	7.11	6.70	6.49	7.56	6.52
6	5.84	5.40	5.70	5.54	5.61	5.32	4.90	5.89	6.32	5.88	5.63	6.54	5.71
7	6.11	6.35	5.86	6.09	5.54	5.79	5.26	5.81	5.09	5.69	4.85	5.34	5.85
8	6.86	6.33	5.91	5.83	5.98	5.26	5.54	6.22	5.53	6.00	5.93	6.51	6.24
9	5.92	5.75	5.96	5.19	5.62	5.56	5.27	6.22	5.84	6.30	6.38	5.88	6.42
10	7.49	6.68	6.14	6.39	6.41	5.72	5.64	5.98	5.37	5.82	5.97	6.10	6.74
11	6.69	6.23	5.87	6.31	6.54	6.38	6.34	6.42	6.04	5.62	5.58	5.68	5.96
12	6.91	6.16	5.89	5.66	5.84	6.00	4.95	7.48	6.42	5.94	6.07	6.65	5.88
13	6.17	5.76	5.84	5.71	5.68	5.61	7.12	5.92	5.72	5.10	5.79	5.61	5.32
14	6.07	5.87	6.03	5.76	6.22	6.40	5.50	6.10	5.98	5.77	6.11	6.60	5.74
15	6.57	6.33	5.95	5.97	5.86	5.54	5.36	6.04	6.00	6.97	6.88	6.53	6.53
16	6.88	6.65	6.49	6.77	6.16	5.99	5.77	5.64	5.98	6.4	5.57	6.01	5.76

^{z} Most probable number (MPN) per 100 mL^{-1} values are expressed as common log (base 10) numbers.
^{y} No number indicates below the detection limit of 1.56.
nm = not measured.

Table 11.3. Aerobic heterotrophs (TSA, 27 °C) in groundwater samples from the Research Feedlot (log MPN 100 mL^{-1})[z]. (4 of 4 pages)

Well no.	July 24 2000	Aug 14 2000	Aug 28 2000	Sept 13 2000	Sept 25 2000	Oct 16 2000	Oct 30 2000	Nov 14 2000	Nov 27 2000	Dec 19 2000	Jan 15 2001
1	5.92	5.99	nm	nm	nm	nm	nm	nm	nm	nm	nm
2	5.48	5.86	5.96	5.96	5.93	6.36	6.68	6.14	5.88	5.93	nm
3	5.36	5.83	6.11	6.04	5.93	5.61	5.68	6.70	5.70	5.57	nm
4	7.36	7.79	8.06	7.97	7.71	7.51	7.80	7.86	6.85	6.40	nm
5	6.80	6.98	6.95	7.78	7.75	6.79	6.63	6.98	7.13	5.76	5.86
6	6.75	5.99	6.37	8.10	7.71	5.61	6.89	6.74	5.90	5.78	6.01
7	5.59	5.36	5.31	5.51	7.22	5.73	5.74	5.54	6.10	NS	nm
8	5.19	5.89	6.07	7.36	6.40	5.85	5.87	6.21	5.70	6.14	5.63
9	5.58	5.93	5.77	5.99	5.91	5.61	5.98	6.09	6.84	5.48	nm
10	5.51	5.82	5.32	8.28	8.56	6.49	6.07	6.26	6.04	6.62	6.35
11	5.45	6.43	6.50	5.98	6.13	6.21	6.52	6.94	6.67	6.37	nm
12	7.11	6.10	7.65	6.85	6.41	5.91	6.37	6.74	6.12	5.62	nm
13	5.15	5.68	5.74	7.44	6.96	5.73	5.77	5.61	5.51	5.34	nm
14	5.94	6.16	6.13	5.86	5.89	5.45	6.54	6.61	6.61	6.29	nm
15	6.18	6.44	5.75	5.86	6.26	5.99	6.64	6.79	6.02	5.99	nm
16	5.50	5.77	6.51	5.88	5.71	5.54	5.73	5.79	5.85	5.56	nm

[z] Most probable number (MPN) per 100 mL^{-1} values are expressed as common log (base 10) numbers.
[y] No number indicates below the detection limit of 1.56.
nm = not measured.

Table 11.4. Aerobic heterotrophs (TSA, 39 °C) in groundwater samples from the Research Feedlot (log CFU 100 mL^{-1}) [z].

Well no.	May 12 1998	June 15 1998	July 14 1998	Aug 10 1998	Aug 24 1998	Sept 14 1998	Sept 28 1998	Oct 13 1998	Oct 26 1998	Nov 16 1998	Dec 11 1998	Jan 14 1998	Feb 17 1998
1	4.39	4.08	5.59	4.50	4.58	4.05	3.70	3.56	nm [y]	nm	nm	nm	nm
2	4.52	4.53	4.73	4.79	4.60	4.67	4.70	nm	nm	nm	nm	nm	nm
3	3.93	3.60	4.37	4.45	4.10	3.78	4.08	3.60	nm	nm	nm	nm	nm
4	5.12	4.58	4.38	4.91	4.08	4.09	4.19	6.06	nm	nm	nm	nm	nm
5	4.74	4.70	7.91	7.48	7.12	5.74	6.17	6.49	nm	nm	nm	nm	nm
6	6.60	5.59	7.31	5.90	5.76	4.87	5.52	5.42	nm	nm	nm	nm	nm
7	6.99	5.85	7.56	6.49	5.96	5.75	5.86	5.84	nm	nm	nm	nm	nm
8	4.82	5.06	7.38	7.74	7.37	5.93	5.62	5.49	nm	nm	nm	nm	nm
9	5.17	4.09	4.63	5.49	5.62	4.30	5.59	5.84	nm	nm	nm	nm	nm
10	6.06	4.97	7.26	5.86	5.32	5.51	6.09	6.05	nm	nm	nm	nm	nm
11	4.77	3.97	4.59	5.03	4.71	4.22	5.15	4.64	nm	nm	nm	nm	nm
12	4.74	4.64	7.77	7.92	7.29	6.43	5.73	5.67	nm	nm	nm	nm	nm
13	6.80	6.58	7.11	7.23	7.22	6.51	6.10	6.05	nm	nm	nm	nm	nm
14	5.25	5.09	5.44	5.09	5.19	4.72	5.05	5.11	nm	nm	nm	nm	nm
15	4.51	4.08	4.80	4.63	5.76	4.21	4.36	4.40	nm	nm	nm	nm	nm
16	4.45	5.03	5.64	5.15	4.61	4.11	4.97	4.68	nm	nm	nm	nm	nm

[z] Colony forming units (CFU) per 100 mL^{-1} values are expressed as common log (base 10) numbers.
[y] Not measured after October 13, 1998.