EFFECTS OF IRRIGATING WITH WASTEWATER ON GROUND-WATER QUALITY AT FORT CARSON MILITARY RESERVATION GOLF COURSE NEAR COLORADO SPRINGS, COLORADO

By Patrick Edelmann

U.S. GEOLOGICAL SURVEY

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METRIC CONVERSION FACTORS

Inch-pound units used in this report may be converted to International System of Units (SI) by using the following conversion factors:

To convert inch-pound unit	*Multiply by*	*To obtain metric unit*
acre	4,047	square meter
acre-foot (acre-ft)	1,233	cubic meter
acre-foot per year (acre-ft/yr)	1,233	cubic meter per year
foot (ft)	0.3048	meter
foot per day (ft/d)	0.3048	meter per day
foot per year (ft/yr)	0.3048	meter per year
inch (in.)	2.54	centimeter
micromho per centimeter at 25° Celsius	1.0	microsiemen per centimeter at 25° Celsius
mile (mi)	1.609	kilometer
pound (lb)	0.4536	kilogram
pound per square foot (lb/ft^2)	4.883	kilogram per square meter
pound per year (lb/yr)	0.4536	kilogram per year
square foot (ft^2)	0.0929	square meter
foot squared per day (ft^2/d)	0.0929	meter squared per day

EFFECTS OF IRRIGATING WITH WASTEWATER ON GROUND-WATER QUALITY AT FORT CARSON MILITARY RESERVATION GOLF COURSE NEAR COLORADO SPRINGS, COLORADO

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ABSTRACT

Fort Carson Military Reservation has used treated wastewater for irrigation of the Fort Carson golf course since 1971. The effect of the wastewater on ground-water quality at the golf course was evaluated using water levels and water-quality data from 20 observation wells. The water-quality constituents analyzed included dissolved solids, major ions, nutrients, detergents, dissolved organic carbon, chemical and biological oxygen demand, and trace elements. Effects of the applied wastewater on ground-water quality for most constituents were obscured by large areal variations and by large concentrations of the constituents upgradient from the golf course. The sources of nitrogen in the ground water beneath the golf course were applied wastewater, applied fertilizer, leachate from the organic-rich shale, and from unknown upgradient sources. Nitrogen loading at the golf course from wastewater and applied fertilizer was estimated to be 18,900 pounds per year. After 10 years, less than 1 percent of the nitrogen applied was actually present in the ground water. Loss of nitrogen to fixation by grass, to the atmosphere as nitrous oxides, and to adsorption accounted for most of the nitrogen applied.

INTRODUCTION

Fort Carson Military Reservation has used treated wastewater for irrigation of the Fort Carson golf course (fig. 1) since 1971. Because irrigating with treated wastewater may result in chemical degradation of ground water, the U.S. Geological Survey, at the request of the U.S. Department of the Army, Fort Carson Military Reservation, began an 18-month investigation to evaluate the effects of the treated wastewater on the quality of ground water in a 330-acre area including the golf course, in October 1980.

The scope of investigation included: (1) Collecting and evaluating all existing hydrologic, geologic, and water-quality data for the study area; (2) drilling sufficient observation wells to provide a network of sampling points encompassing the area potentially affected by the applied wastewater; (3) collecting and analyzing water samples from observation wells, the Fort Carson sewage treatment plant, and the golf-course retention pond and water hazard; and (4) performing aquifer tests to evaluate hydraulic characteristics.

The author wishes to thank the many personnel at Fort Carson including Michael Halla, Mary Staub, Robert Rothman, Craig Withee, and Richard Collins for their assistance and many helpful suggestions during the investigation, and M. Sgt. John Kelley, U.S. Air Force Weather Service, Butts Airfield, for the climatological data used in this report. Special appreciation is extended to the golf-course managers, Fred Heuval, and Don Bearrensen, and to the golf-course contractors for their patience, cooperation, and courtesy.

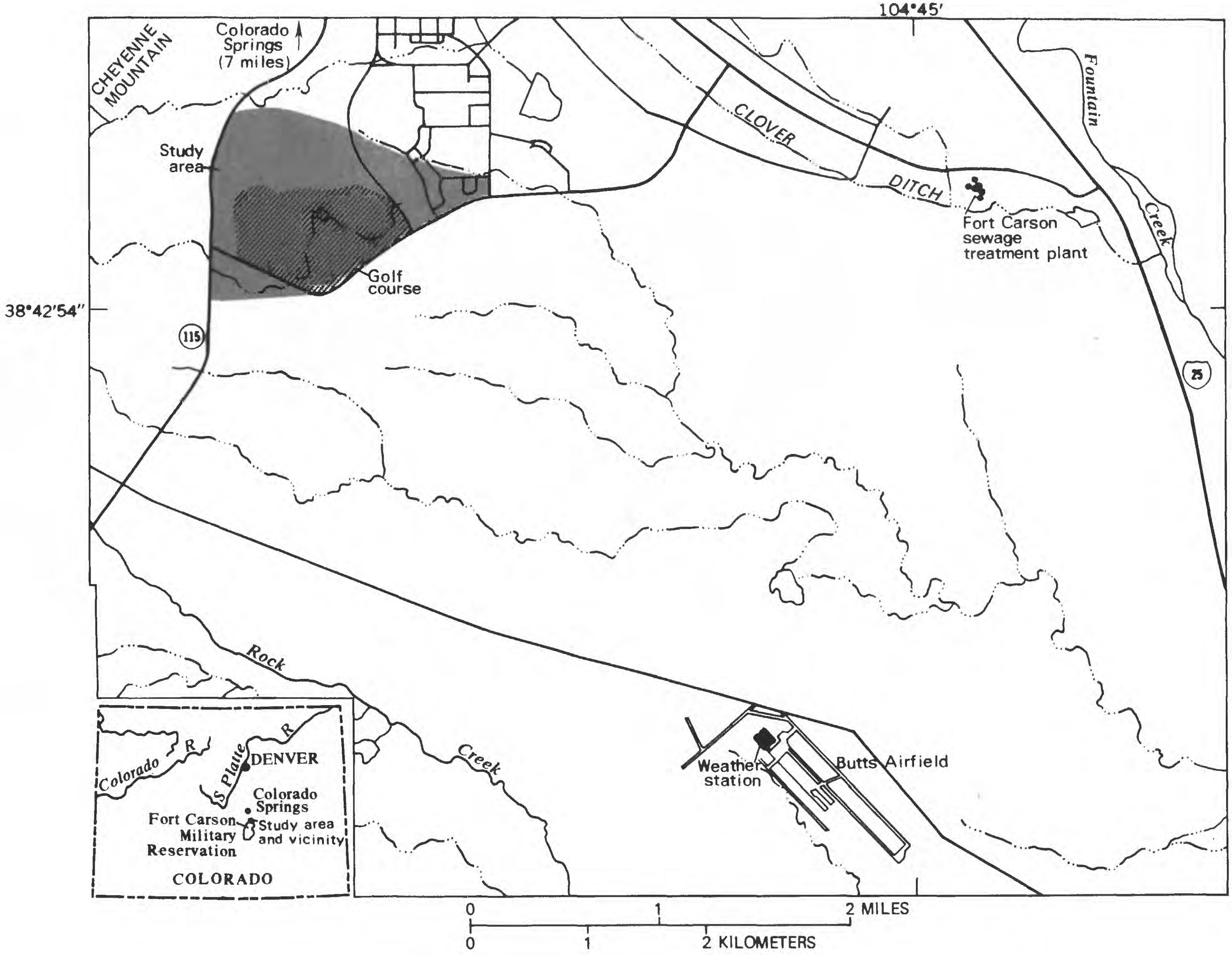

Figure 1.--Location of study area.

METHODS OF INVESTIGATION

In October 1980, 14 observation wells were drilled using a continuous flight auger. In 1981, six additional observation wells were drilled using the air-rotary method. The wells (fig. 2) were completed with a casing of 2-in. polyvinyl chloride (PVC) pipe and a 4-ft screened well point. The screened well points were placed at depths corresponding to saturated and permeable strata identified during drilling. Each well was backfilled with washed gravel to insure hydraulic connection between the well points and the permeable strata. At some sites, additional slotted casings were installed within a few feet of one another at various depths to define vertical variations in hydraulic head and water quality.

All the observation wells were developed by airlift and bailing. Prior to the collection of water samples in the spring of 1981, each well was bailed five times at 1-week intervals to eliminate potential contamination of the well water that may have occurred during drilling and airlifting (Hughes and others, 1974, p. 285). During each bailing, a volume equivalent of one to two times the volume of standing water in the well was removed. Before and after each bailing, onsite measurements for pH, water temperature, and specific conductance were made. Less than 10 percent variation occurred in the specific conductance during bailing between the fourth and fifth week, indicating the water quality contiguous to the wells had stabilized and the water in the well was representative of the ground-water system.

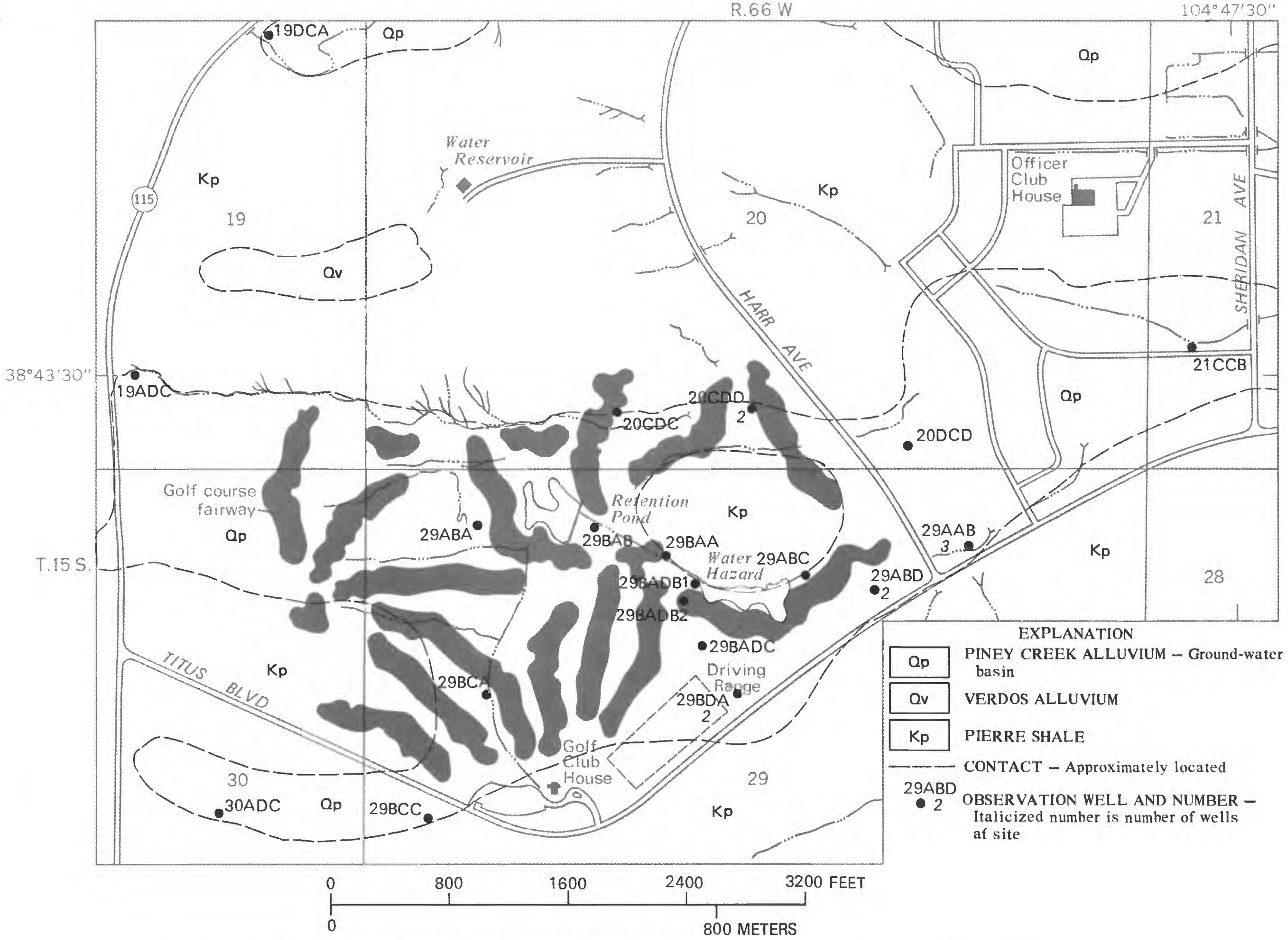

Figure 2.--Location of observation wells and generalized geology of study area.

The following data were obtained during the study: (1) Monthly water-level measurements in the observation wells using a calibrated steel tape; (2) estimates of transmissivity at seven observation wells using the bailer method (Skibitzke, 1963); and (3) chemical analysis of water samples collected in the spring and fall of 1981 from 20 observation wells, the sewage-treatment plant effluent, the golf-course retention pond, and the golf-course water hazard.

The procedure used to collect water samples from the observation wells involved removing one to two times the volume of standing water in the well with a PVC bailer. Before water-quality samples could be collected, a wait of 1 to 2 hours was necessary because of slow water-level recovery rates and to obtain the volume of water needed for the water-quality analysis. Water temperature, specific conductance, and pH were measured during sampling. All water samples were prepared for laboratory analysis at the sampling site according to procedures in Beetem and others (1981, p. 2-5, 2-6). Analyses for biochemical oxygen demand in the water samples were performed at the U.S. Geological Survey office in Pueblo, Colo.

PRECIPITATION, IRRIGATION, AND EVAPOTRANSPIRATION

The study area is in a semiarid region and receives an average annual precipitation of 14.97 in. with an average of 13 in. of precipitation occurring between April and November. The climatological data collected at the weather station at Butts Airfield (M. Sgt. John Kelley, U.S. Air Force Weather Service, written commun., 1981), 3 mi southeast of the study area (fig. 1), indicate that 88 percent of the average annual precipitation occurs during the irrigation season (April through November) (fig. 3), and most of the precipitation usually is in the form of rain. The annual precipitation was 17.71 in. during 1981. Of the total precipitation, 16.39 in. or 92 percent of the 1981 precipitation occurred during the irrigation season from April to November.

Irrigation water to be applied at the 180-acre golf course is obtained by pumping a part of the effluent from Fort Carson's sewage-treatment plant to the golf-course retention pond through a pipeline. A sprinkler system is then used to apply the wastewater from the retention pond to greens, fairways, and improved roughs. However, the retention pond is bypassed when wastewater pumpage from the sewage-treatment plant coincides with operation of the sprinkler system. When this occurs, the wastewater in the pipeline is applied directly to the golf course through the sprinkler system. During the irrigation season approximately 65 acres of the 180-acre golf course are irrigated nightly. Supplemental irrigation with effluent is performed during the daytime as needed.

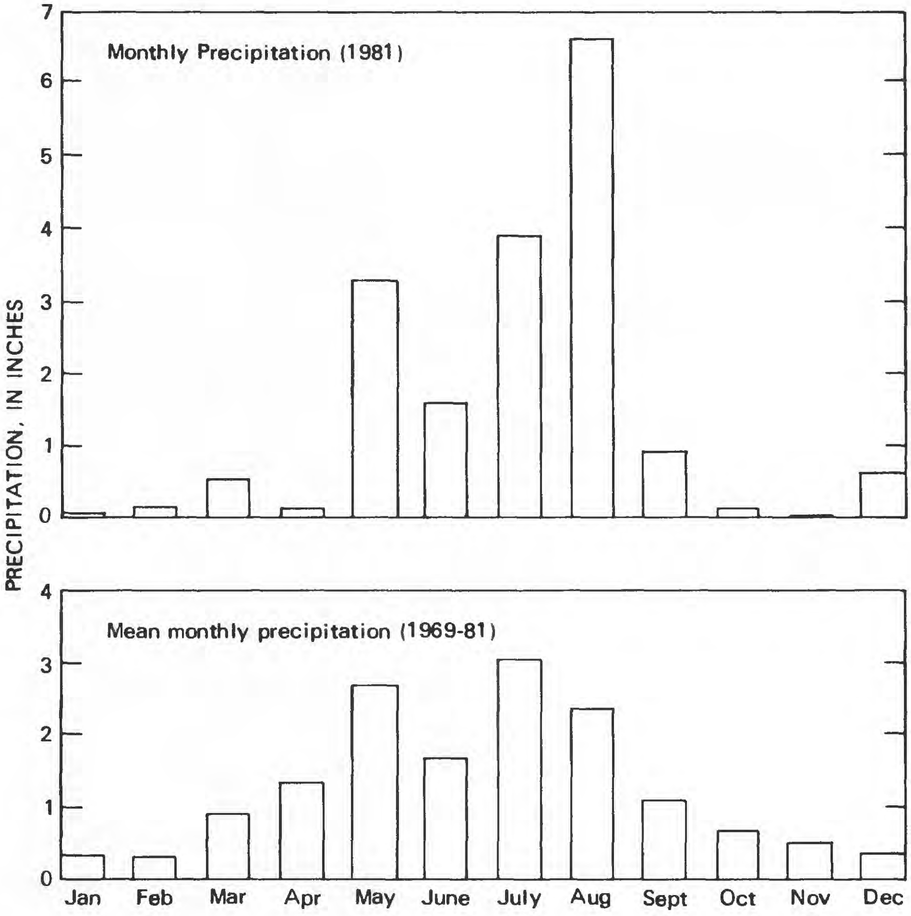

Figure 3.--Monthly (1981) and mean monthly (1969-81) precipitation at Butts Airfield.

During the 1981 irrigation season approximately 38 in. of wastewater effluent was applied to the golf course. Combined with precipitation, the available water supply at the golf course was approximately 54 in. Approximately 46 in., or 85 percent of the available 54 in. of water, was consumed by evapotranspiration between April and November (table 1). Of the remaining 8 in., an estimated 3 in. may be accounted for by runoff and 5 in. by groundwater recharge.

Monthly and annual evapotranspiration at the golf course were estimated using the Jensen-Haise equation and the Christiansen-Hargreaves equation. According to evaluations performed by the American Society of Civil Engineers (1973, p. 153) these equations produce reasonable estimates of evapotranspiration. The Jensen-Haise equation ranked first among 14 methods for estimating evapotranspiration from inland semiarid to arid regions. However, evapotranspiration calculations made using the Jensen-Haise equation generally result in larger than actual estimates of evapotranspiration. Calculations made using the Christiansen-Hargreaves equation generally result in smaller than actual estimates of evapotranspiration. Therefore, an average of the results of the two equations was used as the evapotranspiration at the golf course.

Table 1.--*Estimated evapotranspiration at golf course, 1981*

Method	Evapotranspiration, in inches												
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
Christiansen-Hargreaves equation--------	1.24	1.40	2.48	4.80	6.82	8.10	7.75	5.89	4.55	3.10	2.40	1.25	49.78
Jensen-Haise equation--------	1.29	1.48	2.23	5.54	5.64	9.37	9.32	7.48	5.37	3.39	2.41	1.12	54.64
Average-----------	1.26	1.44	2.35	5.17	6.23	8.74	8.54	6.68	4.96	3.24	2.40	1.18	52.21

GEOLOGIC SETTING

The exposed geologic units in the study area are: (1) Piney Creek Alluvium, (2) Verdos Alluvium, and (3) Pierre Shale (fig. 2). These units have been mapped by Scott and Wobus (1973, sheet 2).

The Piney Creek Alluvium of Holocene age, the youngest geologic unit, contains ground water in the study area. The Piney Creek Alluvium is a gray to brown, humic-rich, firmly compacted, clayey silt, which partly fills stream valleys eroded into bedrock. Particle-size-distribution analyses of drill cores from the upper 8 ft of alluvium at well sites 20CDD and 29ABD show an average composition of 2 percent gravel, 16 percent sand, 35 percent silt, and 47 percent clay.

The Verdos Alluvium of the Pleistocene Epoch consists of alluvial deposits on terraces between stream valleys and is localized on a pediment of Pierre Shale. These deposits are well drained and generally dry. The alluvium is brown, poorly sorted, moderately compacted, and consists of stratified gravel containing lenses of sand, silt, and clay.

The Pierre Shale of the Late Cretaceous Epoch is the oldest geologic unit exposed in the study area and is principally composed of organic-rich, clayey shale. The formation underlies both the Piney Creek and Verdos Alluvium within the study area and forms the bedrock surface.

GROUND WATER

Ground-Water Budget

The distribution of water within the ground may be expressed as a ground-water budget in which all water moving through the alluvial deposits is accounted for. The ground-water budget can be expressed in equation form as:

Water inflow - Water outflow = Change in storage

Water inflow.--Ground water within the golf course is recharged by precipitation, wastewater applied during irrigation, and ground-water inflow. The retention pond and water hazard on the golf course also are potential sources of recharge, but no increase in water levels was observed in observation wells downgradient from the ponds, indicating no recharge from these two sources occurred during 1981. Quantity of ground-water recharge from precipitation and irrigation was calculated for periods during 1981 where the water levels in the observation wells rose (fig. 4). These recharge periods occurred during the irrigation season following frequent local rain showers, indicating irrigation water generally is applied at rates that do not exceed the soil-moisture storage capacity. However, during some periods of rainfall this capacity was exceeded, and recharge occurred. Using an estimated specific yield of 5 percent and periods of water-level rise in the wells (fig. 4), approximately 7 acre-ft of water from irrigation and precipitation were recharged to the alluvium in the golf-course area.

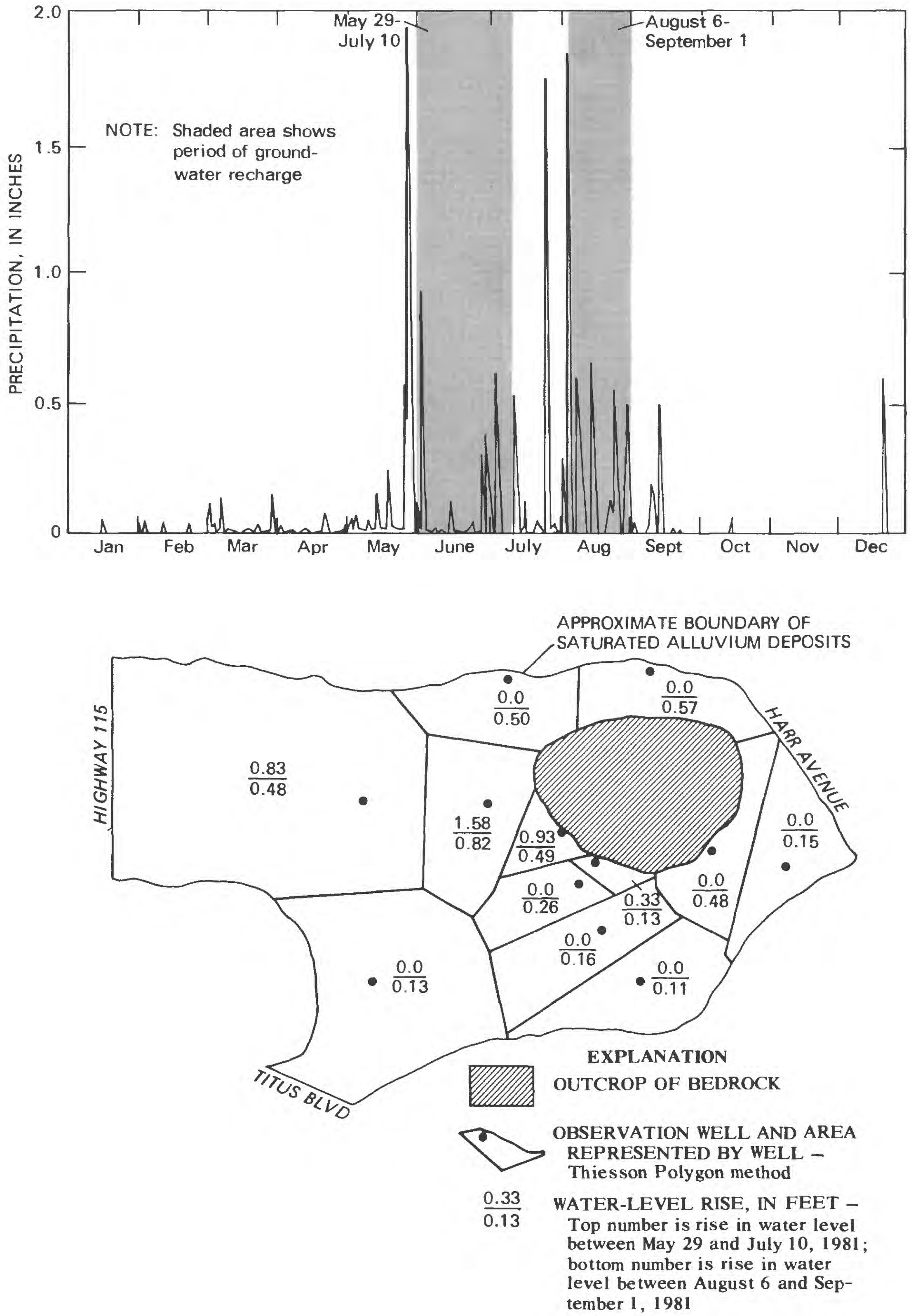

Figure 4.--Water-level rise after precipitation on golf course, 1981.

Underflow moves into the golf course area from the west and southwest. Ground-water inflow from the west was calculated using a cross-sectional area of 23,000 ft^2, hydraulic gradient of 3 percent, and a hydraulic conductivity of 0.0002 ft/d (well 19DCD, table 2). Ground-water inflow from the southwest was calculated using a cross-sectional area of 6,500 ft^2, hydraulic gradient of 3 percent, and a hydraulic conductivity of 0.01 ft/d (well 30ADC, table 2). The combined underflow moving into the golf course area was less than 1 acre-ft during 1981.

Water outflow.--Ground water seeps were observed at the westerly end of the water hazard during most of the study, indicating ground water is discharged into the water hazard. During 1981, an estimated 1 acre-ft of ground water was discharged into the water hazard.

Underflow moving from the golf course was calculated to be less than 1 acre-ft during 1981. Ground-water outflow was calculated using a cross-sectional area of 15,000 ft^2, hydraulic gradient of 2 percent, and a hydraulic conductivity of 0.2 (average of hydraulic conductivities from wells 29AAB and 20DCD, table 2).

Evapotranspiration from the water table was estimated to be 10 acre-ft. A shallow water table occurred in 93 acres of the 180-acre golf course with an average depth to water of 5.6 ft. Direct evapotranspiration from the ground water was estimated as the source of all water unaccounted for in the budget, therefore, evapotranspiration was assumed to be 0.11 ft/yr.

Change in storage.--Using an average of 10 ft of saturated alluvium (table 2) and assuming a specific yield of 5 percent, 90 acre-ft of water was estimated to be stored in the alluvium underlying the areal boundaries of the golf course. A summary of the water budget is shown in table 3.

Table 2.--*Ground-water data*

Well number	Transmissivity, in feet squared per day[1]	Hydraulic conductivity, in feet per day[2]	Average depth to water, in feet below land surface	Depth to bedrock, in feet below land surface	Saturated thickness, in feet
19ADC	-----	------	14.6	--	--
19DCD	0.004	0.0002	25.1	42	17
30ADC	.11	.01	14.7	26	11
29BCC	-----	------	21.7	26	4
29BCA	-----	------	8.2	20	12
29BBA	-----	------	25.2	30	5
29BAB	.02	.002	6.8	--	--
29BAA	-----	------	6.7	20	13
29BADB1	-----	------	4.9	--	--
29BADB2	-----	------	4.2	15	11
29BADC	.35	.05	12.8	20	7
29BDA1	-----	------	16.8	20	3
29BDA2	-----	------	16.8	20	3
20CDC	-----	------	5.8	15	9
20CDD	8.28	.8	4.2	--	--
29ABC	-----	------	4.8	17	12
29ABD	-----	------	5.6	26	20
29AAB	.25	.02	3.9	16	12
20DCD	3.78	.4	12.0	22	10
21CCB	-----	------	4.5	24	20

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[1] Transmissivities were estimated using the bailer method (Skibitzke, 1963).

[2] Hydraulic conductivities were calculated by dividing transmissivity by saturated thickness; where saturated thickness was unknown, an average saturated thickness of 10.5 was used.

Table 3.--*Summary of ground-water budget for golf course, 1981*

Source	Amount, in acre-feet	Remarks
Recharge from irrigation and precipitation	7	Inflow
Ground-water inflow	<1	Inflow
Ground-water seepage	1	Outflow
Ground-water outflow	<1	Outflow
Evapotranspiration	10	Outflow
Ground-water storage	-4	Decrease

Direction and Rate of Movement

Ground water moves slowly across the study area in an easterly direction (fig. 5). Rates of ground-water movement were calculated using values of transmissivity obtained from aquifer tests by the bailer method (Skibitzke, 1963), aquifer thickness, and hydraulic gradients. Transmissivity estimates ranged from 0.004 to 8.28 ft^2/d (table 2), but values less than 0.5 ft^2/d are typical. Transmissivity values varied by a factor of 10 between some wells within a few hundred feet of each other, indicating the ground-water system may be heterogeneous.

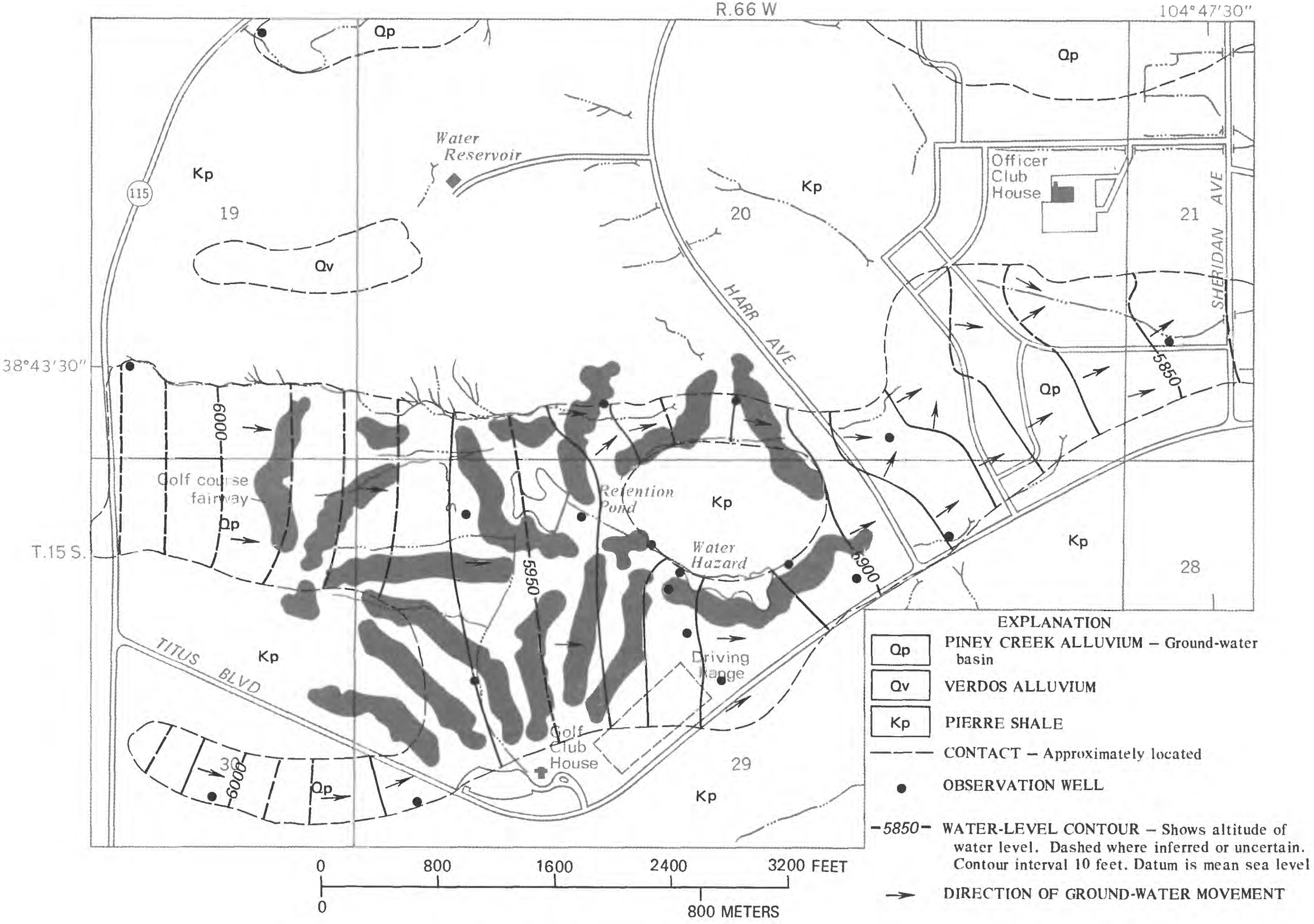

Figure 5.--Altitude of water table and direction of ground-water movement, March 1981.

To define the maximum area that could be affected by chemically degraded ground water moving away from the golf course, the velocity was calculated using a hydraulic conductivity of 0.8 ft/d (table 2), a hydraulic gradient of 0.02 (fig. 5), and an assumed effective porosity of 0.05 to 0.1. The calculations indicate that the maximum distance ground water would move to the east would be 50 to 100 ft/yr. These velocities are three to six times greater than the maximum velocity reported by Meyers (1977, p. 14) for water in the Piney Creek Alluvium in Fort Carson northeast of the golf course.

EFFECTS OF IRRIGATING WITH WASTEWATER ON GROUND-WATER QUALITY

Water-quality investigations involving applied wastewater require a careful, detailed review of the chemical characteristics of the wastewater and water system receiving the wastewater, and the potential chemical reactions that may occur between the applied wastewater and receiving water. The investigations also require isolating particular chemical constituents or compounds in the wastewater that can be used as indicators of any degradation resulting from its use. An evaluation of dissolved solids and the basic anion-cation balance usually provides valuable results and direction for supplementary-data collection and interpretation. Wastewater also contains many unique chemical characteristics that generally do not occur in nature, or are present in trace quantities.

The chemical composition of the wastewater applied to the Fort Carson golf course is shown in table 4 in the Supplemental-Information section. Analyses of the sewage-treatment plant effluent and of the water in the golf-course retention pond indicate significant concentrations of dissolved solids, 5-day biochemical oxygen demand (BOD_5), chemical oxygen demand (COD), dissolved organic carbon (DOC), methylene-blue-active substances, and various forms of nitrogen. The concentrations of cadmium, chromium, boron, iron and manganese are small and do not affect the quality of the ground water. Therefore, these chemical constituents are not addressed in this report.

Other water-quality data obtained for the sewage-treatment plant effluent and for water in Clover Ditch, which receives the effluent from the sewage-treatment plant that is not used to irrigate the golf course, indicate that the chemical analyses made during the study reasonably reflect the chemical quality of the wastewater used to irrigate the golf course.

Dissolved Solids

During 1981, the concentrations of dissolved solids in four water samples collected from the golf-course retention pond and from the sewage-treatment plant effluent ranged from 688 to 1,270 mg/L (milligrams per liter). The average concentration of dissolved solids in the ground water beneath the golf course was more than 2 times greater than the average concentration in the applied wastewater (fig. 6). (See also table 4 in the Supplemental-Information section.) The average concentration of dissolved solids in the ground water upgradient from the golf course (as represented by the southwesterly wells 30ADC and 29BCC and the westerly well 19DCD) was about 4 times greater than the average concentration in the applied wastewater and about 1.5 times greater than the average concentration in the ground water beneath the golf course. This indicates that: (1) A large percentage of the dissolved solids in the ground water could be attributed to interactions with sedimentary rocks and may be the result of the dissolution of soluble minerals in the alluvium and bedrock, and (2) recharge from precipitation and irrigation of applied wastewater has apparently diluted the dissolved-solids concentration in the ground water beneath the golf course. However, no apparent relationship exists between the quantity of surface recharge for a specific area within the golf course (fig. 4) during the study period and the concentration of dissolved solids. The concentrations of the dissolved solids in the ground water probably result from a combination of interactions with sedimentary rocks and evapotranspiration from a high water table.

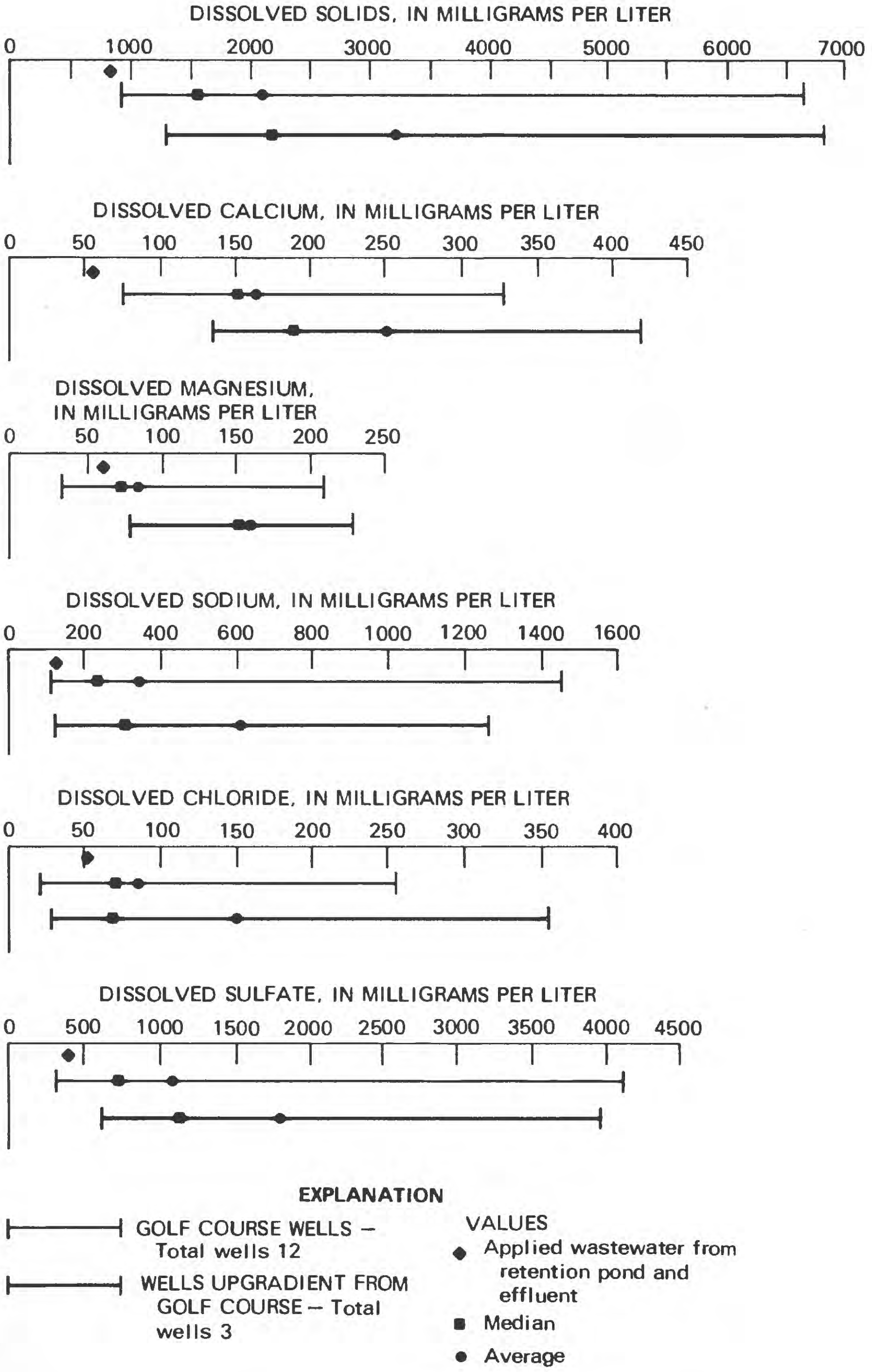

Figure 6.--Ranges, median, and average values in milligrams per liter of dissolved solids and other selected constituents in applied wastewater and in water from wells on golf course and upgradient from golf course, April-September 1981.

A chemical mass balance using a conservative element such as chloride indicates that the chloride concentration of recharge water should be approximately 380 mg/L, assuming that of the 8 in. of excess water applied to the golf course, 5 in. recharged the ground water system. No chloride concentrations were this large in the ground water beneath the golf course, indicating a large proportion of the dissolved ions in the recharge water have been precipitated in the unsaturated zone. An investigation by Toler and Pollack (1974) indicated that large quantities of chloride can be retained in the unsaturated zone. They concluded the quantity of chloride retained in the unsaturated zone was related directly to the surface area of the grains and inversely related to grain size.

Large areal variations occurred in the concentrations of dissolved solids and dissolved ions in the ground water. These variations may be related to: (1) Varying rates of evapotranspiration that may have occurred as a function of depth to water, and (2) varying contact time between ground water and soluble minerals in the alluvial deposits and in the Pierre Shale. Generally, concentrations of dissolved solids increase as the contact time increases. This effect has been observed by Klein and Bingham (1975), Livingston and others (1976), Hall and others (1980), Doug Cain (U.S. Geological Survey, oral commun., 1982), and G. E. Leonard (U.S. Geological Survey, written commun., 1982) in similar geologic settings in Colorado.

The predominant ions in the applied wastewater, in ground water beneath the golf course, and in ground water upgradient from the golf course are sodium and sulfate. The concentrations of major ions such as calcium, magnesium, sodium, chloride, and sulfate generally increased as concentrations of dissolved solids increased.

Five-Day Biochemical Oxygen Demand, Chemical Oxygen Demand, and Dissolved Organic Carbon

During the study, the average and median values for 5-day biochemical oxygen demand (BOD_5), chemical oxygen demand (COD), and dissolved organic carbon (DOC) in the ground water upgradient from the golf course were greater than in the ground water beneath the golf course (fig. 7). This indicates that a significant part of the BOD_5, COD, and DOC concentrations in the ground water occurs naturally and may be a result of leachate from the humic-rich alluvium and the organic-rich bedrock.

Generally, the BOD_5, COD, and DOC concentrations were greater in the applied wastewater than in the ground water. However, any effects from the applied wastewater on the natural occurrence of these constituents in the ground water were masked by large areal variations of these constituents in the ground water.

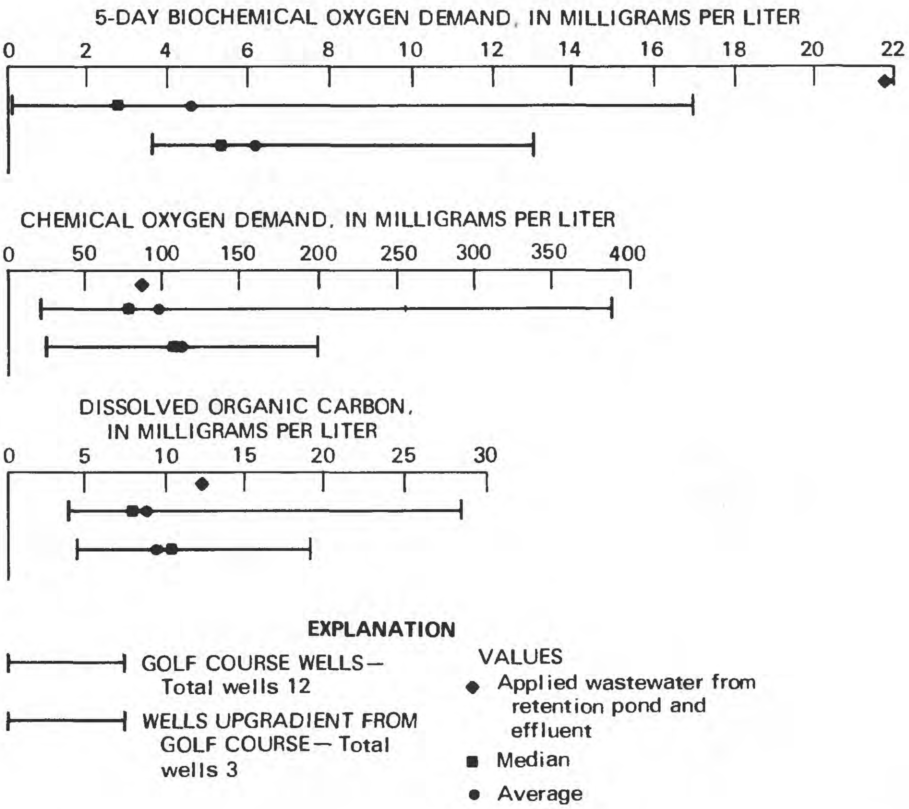

Figure 7.--Ranges, median, and average values in milligrams per liter of selected constituents in applied wastewater and in water from wells on golf course and upgradient from golf course, April-September 1981.

Detergents as Methylene-Blue-Active Substances

The methylene-blue method is a colorimetric, analytical method used to identify the presence of synthetic detergents in water. Because of a lack of specificity in the analysis, the materials determined are designated simply as methylene-blue-active substances (MBAS) (American Public Health Association and others, 1980). "Synthetic detergents are not indigenous to ground water; therefore, they can be used to detect degraded and polluted water" (Hughes, 1975, p. 22-23). Ground water at all sites in the study area contained concentrations of MBAS of at least 0.1 mg/L, indicating the background concentrations of MBAS were 0.1 mg/L. Concentrations of MBAS greater than 0.2 mg/L occurred in water collected from wells in the area extending from the western boundary of the study area to immediately east of the retention pond and immediately west of the water hazard (fig. 8).

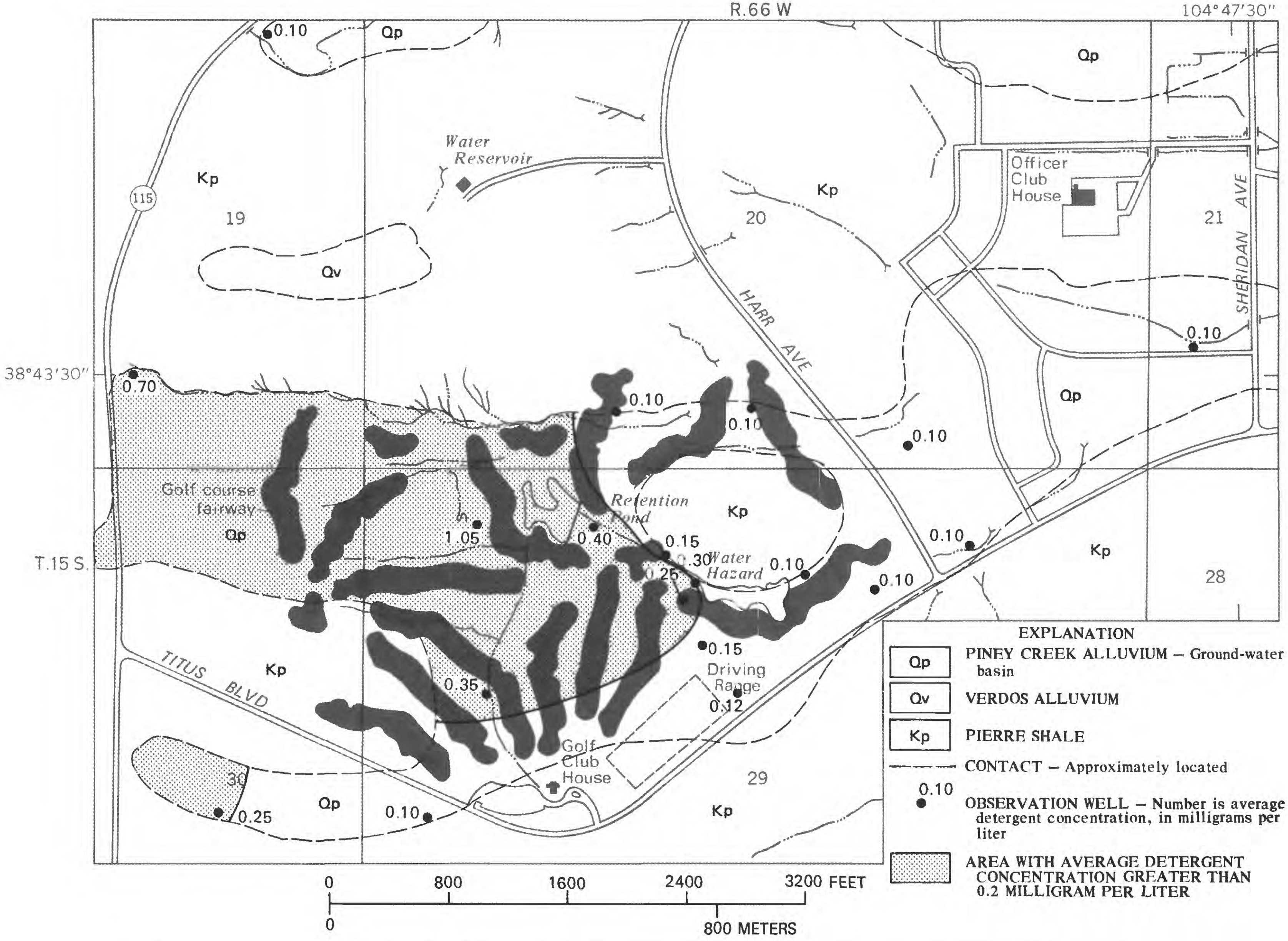

Figure 8.--Areal distribution of synthetic detergents (as MBAS) in ground water.

Water from well 19DCD, upgradient from the golf course, contained an average MBAS concentration of 0.7 mg/L, indicating an upgradient source of detergents. Ground-water inflow from the west accounted for less than 1 percent of the ground-water budget for the golf course area. Therefore, ground-water inflow would have to contain approximately 10 mg/L of MBAS instead of the measured 0.7 mg/L in order to account for the average concentration of 1.05 mg/L of MBAS observed in water collected from well 29BBA which is located about 800 yards downgradient from well 19DCD. This suggests that ground-water inflow is not the dominant source of detergents in the ground water underlying the golf course. MBAS concentrations greater than 0.2 mg/L probably result from the detergents in the applied wastewater that have not been removed by adsorption or by nutrient uptake of grasses on the Fort Carson golf course.

Nitrogen

The sources of nitrogen in water from observation wells in the study area are: (1) Nitrogen in ground-water inflow; (2) nitrogen in the applied wastewater; (3) leachates from commercial fertilizers applied to the greens, fairways, and improved roughs on the golf course; and (4) leachates from the Pierre Shale.

Ground water entering the study area from the southwest is represented by water from observation wells 30ADC and 29BCC. Water from these wells contained an average dissolved nitrogen concentration of 4.2 mg/L. Seventy percent (3.0 mg/L) of the dissolved nitrogen was in the form of nitrate. Ground water entering the study area from the west is represented by water from observation well 19DCD. Water from this well contained an average dissolved nitrogen concentration of 1.8 mg/L with 40 percent (0.72 mg/L) in the form of ammonia and nearly 50 percent in the form of organic nitrogen. The source of this nitrogen is unknown but may be from some undefined source upgradient from the study area and leachates from the organic-rich shale. The resultant loading rate for dissolved nitrogen from ground-water inflow is less than 1 lb/yr.

The dissolved nitrogen concentration in the wastewater applied during irrigation based on two samples collected during the study ranges from 1.1 to 24 mg/L. A study conducted by U.S. Army Environmental Hygiene Agency (1978, p. 3) determined a 3-day average total nitrogen concentration in the Fort Carson wastewater effluent of 12.8 mg/L. Assuming a total nitrogen concentration of 12.8 mg/L and 38 in. of applied wastewater on 65 acres during irrigation season each year, the resultant loading rate for nitrogen is about 7,000 lbs/yr.

Ammonium-nitrate fertilizer is applied three times per year on approximately 65 acres of the golf course at a rate of 5 to 7 lb per 1,000 ft^2. The fertilizer contains 20 percent nitrogen. The resultant loading rate for nitrogen is 11,900 lb/yr.

The cumulative loading rate for nitrogen applied directly on the golf course is 18,900 lb/yr, of which approximately 37 percent originates from wastewater used for irrigation, and approximately 63 percent originates from fertilizers. The origin of nitrogen in the ground water should be approximately proportional to the loading rates assuming: (1) The rate of movement of nitrogen species originating from an aqueous form versus a solid form are similar, and (2) the predominant form of nitrogen in the two sources are the same.

Analyses of water from wells completed at different depths at the same site indicate the nitrogen concentrations increased with depth and were greatest near the bedrock (fig. 9). This indicates that the organic-rich Pierre Shale is a source of nitrogen.

The following calculations were made to illustrate the effects of nitrogen fixation by the Kentucky bluegrass, the loss of nitrogen as nitrous oxide, adsorption, and other processes on the resultant concentrations of nitrogen in the ground water at the golf course. Assuming 18,900 lb/yr of nitrogen as a loading rate for 10 years, and 90 acre-ft of water in ground-water storage, and assuming no uptake or adsorption losses, the resulting nitrogen concentration in the ground water would be about 770 mg/L. The actual dissolved nitrogen concentrations in the ground water underlying the golf course ranged from 1.1 to 13 mg/L and averaged 5.2 mg/L. This calculation indicates that less than 1 percent of the nitrogen applied in the last 10 years is actually present in the ground water. Therefore, 99 percent of the applied nitrogen has been fixed by the grass, lost to the atmosphere as a gas, or adsorbed onto the sediments. Investigations by Eccles and Bradford (1977) and Klein and Bradford (1979) have indicated that large concentrations of nitrogen can be adsorbed, particularly in the unsaturated zone immediately above the water table, and pose a continuing threat of ground-water degradation.

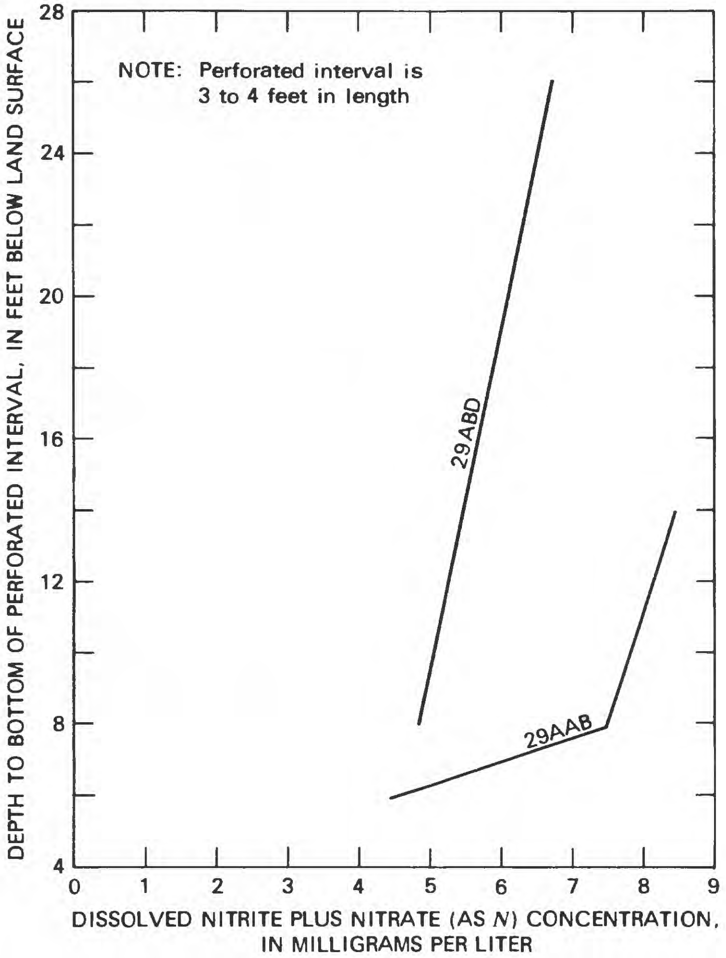

Figure 9.--Vertical stratification of dissolved nitrite plus nitrate at observation wells 29ABD and 29AAB (November 26, 1981).

The average concentrations and areal distribution of dissolved nitrogen in the ground water are illustrated in figure 10. Observation wells 29AAB and 20DCD are only a few hundred feet downgradient from the golf course--east of Harr Avenue. The average dissolved nitrogen concentrations in water from these wells were 8.2 and 4.4 mg/L. These values were approximately the same as those in water collected from observation wells a few hundred feet upgradient and on the eastern boundary of the golf course. This indicates that some nitrogen is being transported in ground water eastward from the golf course.

Observation well 21CCB is located approximately 2,000 ft downgradient from the golf course. Water from the well contained an average dissolved nitrogen concentration of 5.6 mg/L. Assuming that ground water moves approximately 100 ft/yr, well 21CCB would be too far from the golf course to be directly affected by nitrogen originating from irrigation water and fertilizer applied within the past 10 years. Thus, the origin of the nitrogen in the ground water at this site probably results from other sources, including leachate from the Pierre Shale, surface-water runoff from the golf course, and lawn fertilization within the immediate vicinity of the well.

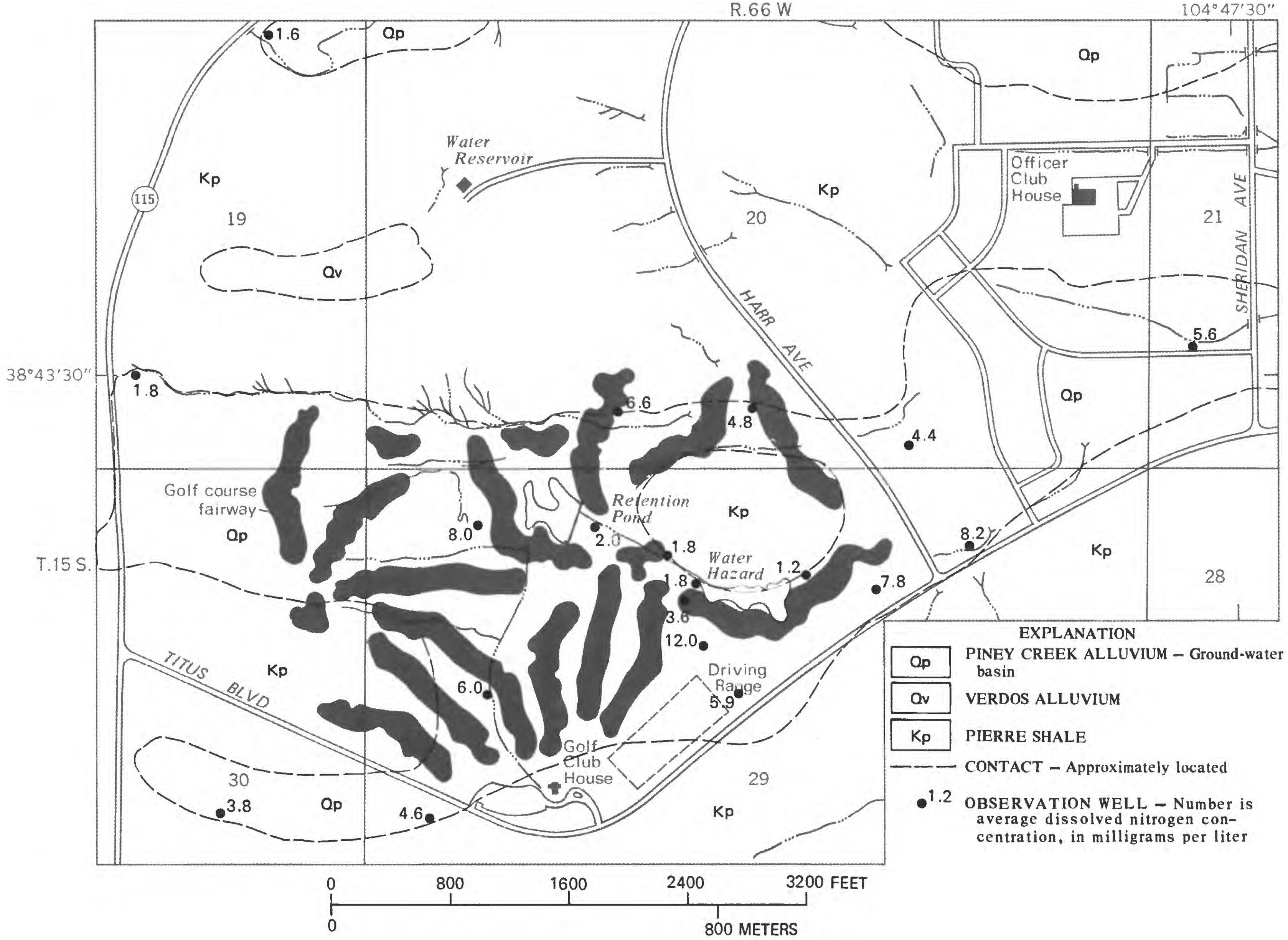

Figure 10.--Areal distribution of dissolved nitrogen in ground water.

SUMMARY AND CONCLUSIONS

The golf course receives an average of 13 in. of precipitation during the irrigation season, from April to November. Approximately 38 in. of treated wastewater are applied by sprinkler irrigation each year between April and November. Evapotranspiration consumes approximately 85 percent or 46 in. of the total available water each year.

The ground-water flow system and water-quality data indicate concentrations of nitrogen in the ground-water system come from unknown upgradient sources, from leachate from the organic-rich Pierre Shale, from applied fertilizer, and from wastewater applied during irrigation. Although nitrogen loading at the golf course from the wastewater and applied fertilizer was estimated to be 18,900 lb/yr and after 10 years would result in a nitrogen concentration in the ground water underlying the golf course of about 770 mg/L--assuming no losses, the measured concentration of dissolved nitrogen in the ground water was 1.1 to 13 mg/L. Thus, about 99 percent of the applied nitrogen has been lost to the atmosphere as nitrous oxide, to adsorption, and to fixation by the golf course grass. Effects of the applied wastewater on the concentrations of the other constituents, such as dissolved solids, were obscured by large areal variations and large concentrations of these constituents in the ground water upgradient from the golf course.

Ground water moves slowly beneath the golf course in an easterly direction and is recharged by water derived from precipitation and irrigation. Because of the negligible permeability of the predominantly clayey Piney Creek Alluvium, the maximum rate of movement is estimated to range from 50 to 100 ft/yr.

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SUPPLEMENTAL INFORMATION

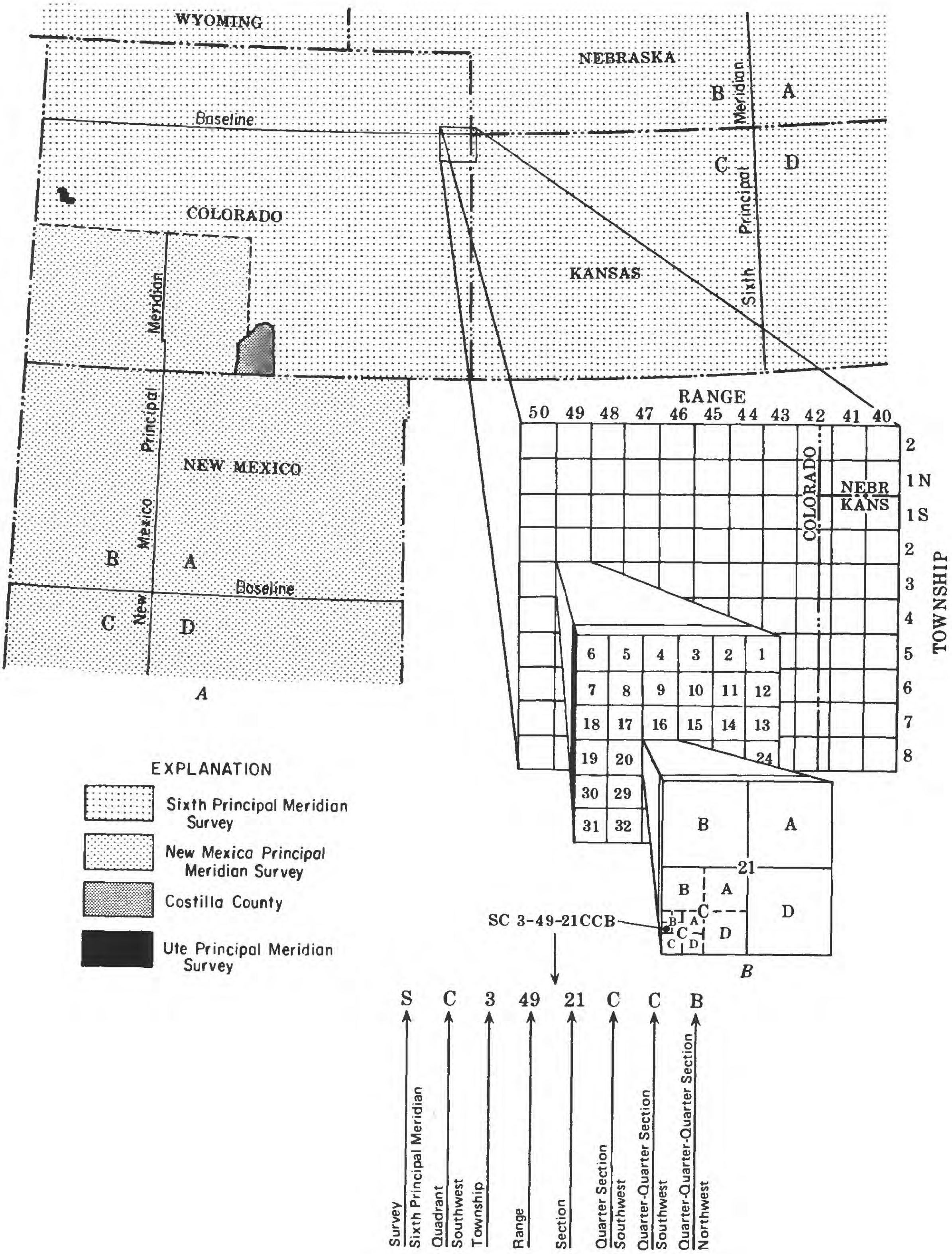

Figure 11.--System of numbering wells in Colorado.

Table 4.--*Water-quality data obtained at Fort Carson sewage-treatment plant and golf-course retention pond and water hazard*

[STP, sewage-treatment plant, DEG C, degrees Celsius; UMHO, micromhos per centimeter at 25° Celsius; MG/L, milligrams per liter; UG/L, micrograms per liter]

STATION NUMBER	STATION NAME	DATE OF SAMPLE	TIME	TEMPER-ATURE (DEG C)	PH (UNITS)	SPE-CIFIC CON-DUCT-ANCE LAB (UMHO)
384327104443400	FT CARSON STP EFFLUENT	81-05-01	1010	17.5	7.5	1380
		81-09-03	1400	20.5	7.4	1180
384320104482700	FT CARSON GOLF COURSE RETENTION POND	81-05-01	1200	17.5	9.4	1820
		81-09-03	1125	19.5	8.7	1230
384315104480700	FT CARSON GOLF COURSE WATER HAZARD	81-05-01	1300	19.0	8.7	1280
		81-09-03	1350	19.5	9.1	1550

STATION NUMBER	DATE OF SAMPLE	SOLIDS, SUM OF CONSTI-TUENTS, DIS-SOLVED (MG/L)	CALCIUM DIS-SOLVED (MG/L AS CA)	MAGNE-SIUM, DIS-SOLVED (MG/L AS MG)	SODIUM, DIS-SOLVED (MG/L AS NA)	POTAS-SIUM, DIS-SOLVED (MG/L AS K)	ALKA-LINITY LAB (MG/L AS CACO3)	CHLO-RIDE, DIS-SOLVED (MG/L AS CL)	SULFATE DIS-SOLVED (MG/L AS SO4)	FLUO-RIDE, DIS-SOLVED (MG/L AS F)	HARD-NESS (MG/L AS CACO3)
384327104443400	81-05-01	899	72	32	170	11	160	53	440	1.5	310
	81-09-03	688	50	27	140	8.7	65	38	350	.9	240
384320104482700	81-05-01	1270	84	72	240	1.5	200	71	680	1.1	510
	81-09-03	781	52	28	170	11	140	47	370	.9	250
384315104480700	81-05-01	780	65	22	150	11	61	60	410	1.5	250
	81-09-03	1060	77	56	210	3.5	210	66	520	1.0	420

STATION NUMBER	DATE OF SAMPLE	NITRO-GEN DIS-SOLVED (MG/L AS N)	NITRO-GEN, ORGANIC DIS-SOLVED (MG/L AS N)	NITRO-GEN, AMMONIA DIS-SOLVED (MG/L AS N)	NITRO-GEN, AM-MONIA + ORGANIC DIS. (MG/L AS N)	NITRO-GEN, NITRITE DIS-SOLVED (MG/L AS N)	NITRO-GEN, NITRATE DIS-SOLVED (MG/L AS N)	NITRO-GEN, NO2+NO3 DIS-SOLVED (MG/L AS N)	PHOS-PHORUS, DIS-SOLVED (MG/L AS P)	OXYGEN DEMAND, BIO-CHEM-ICAL, 5 DAY (MG/L)	OXYGEN DEMAND, CHEM-ICAL (HIGH LEVEL) (MG/L)
384327104443400	81-05-01	13	3.8	8.20	12	.230	.70	.93	1.10	27	110
	81-09-03	24	18	1.20	19	.710	4.30	5.0	7.70	4.8	93
384320104482700	81-05-01	1.1	.83	.140	.97	.030	.09	.12	.080	34	37
	81-09-03	9.6	3.9	5.00	8.9	.430	.25	.68	4.20	22	92
384315104480700	81-05-01	22	4.0	15.0	19	.280	2.90	3.2	4.30	4.2	120
	81-09-03	1.6	1.6	.050	1.6	.000	.04	.04	.440	.6	71

STATION NUMBER	DATE OF SAMPLE	CARBON, ORGANIC DIS-SOLVED (MG/L AS C)	SILICA, DIS-SOLVED (MG/L AS SIO2)	BORON, DIS-SOLVED (UG/L AS B)	CADMIUM DIS-SOLVED (UG/L AS CD)	CHRO-MIUM DIS-SOLVED (UG/L AS CR)	CHRO-MIUM, HEXA-VALENT, DIS. (UG/L AS CR)	IRON, DIS-SOLVED (UG/L AS FE)	MANGA-NESE, DIS-SOLVED (UG/L AS MN)	METHY-LENE BLUE ACTIVE SUB-STANCE (MG/L)
384327104443400	81-05-01	15	19	--	<1	1	0	50	20	1.1
	81-09-03	14	12	177	<1	6	0	56	32	.40
384320104482700	81-05-01	11	2.0	--	<1	1	0	40	20	.10
	81-09-03	12	15	272	<1	5	0	20	7	.20
384315104480700	81-05-01	15	10	--	9	--	--	40	0	.40
	81-09-03	8.6	.4	429	<1	2	0	14	5	.10

Table 5.--*Ground-water quality data*

[DEG C, degrees Celsius; UMHO, micromhos per centimeter at 25° Celsius; MG/L, milligrams per liter; UG/L, micrograms per liter]

LOCAL IDENT-I-FIER	DATE OF SAMPLE	TIME	DEPTH BELOW LAND SURFACE (WATER LEVEL) (FEET)	DEPTH OF WELL, TOTAL (FEET)	TEMPER-ATURE (DEG C)	PH (UNITS)	SPE-CIFIC CON-DUCT-ANCE LAB (UMHO)	SOLIDS, SUM OF CONSTI-TUENTS, DIS-SOLVED (MG/L)	CALCIUM DIS-SOLVED (MG/L AS CA)	MAGNE-SIUM, DIS-SOLVED (MG/L AS MG)
19ADC	81-04-29	1015	13.89	19	13.0	7.5	847	513	110	29
	81-09-02	1555	14.80	19	14.0	7.6	920	575	110	28
19DCD	81-04-29	1345	27.50	42	13.0	7.3	7360	6380	430	230
	81-09-03	1240	25.20	42	12.0	7.6	7460	6590	430	240
30ADC	81-04-28	1335	16.60	23	--	7.6	2850	2150	190	150
	81-09-02	1620	14.50	23	12.0	7.8	2850	2270	190	160
29BCC	81-04-28	1045	20.90	28	--	7.6	1890	1430	150	89
	81-09-02	1700	22.40	28	12.0	7.9	1990	1360	140	85
29BCA	81-04-29	1255	7.10	20	12.5	7.7	7410	6530	330	160
	81-09-01	1035	8.40	20	12.5	7.6	7230	5730	260	130
29BBA	81-04-30	0850	25.50	30	13.5	8.0	1640	1170	82	38
	81-09-02	0855	24.40	30	12.5	7.7	1650	1100	84	36
29BAB	81-04-29	1625	7.60	21	12.0	7.7	1520	1120	110	48
	81-09-01	1325	5.80	21	13.0	7.7	1510	983	85	38
29BAA	81-04-29	1715	8.00	20	11.0	7.5	1620	1130	120	53
	81-09-01	1405	6.30	20	13.0	7.6	1560	1050	110	48
29BADB1	81-04-29	1745	5.10	15	11.0	7.7	1740	1170	120	60
	81-09-01	1435	4.80	15	13.0	7.8	1700	1210	120	57
29BADB2	81-04-30	1205	4.80	15	11.0	7.6	2080	1530	150	75
	81-09-01	1500	4.00	15	13.5	7.8	2030	1410	130	67
29BADC	81-04-30	1240	12.60	20	12.0	7.6	3010	2300	180	110
	81-09-01	1530	12.90	20	12.0	7.9	3460	2680	220	140
29BDA1	81-04-30	1320	16.40	25	12.0	7.5	2040	1550	180	88
	81-09-01	1605	16.90	25	12.5	7.8	2000	1440	160	76
29BDA2	81-04-30	1930	16.40	19	11.0	7.4	1940	1470	190	92
	81-09-01	1640	16.90	19	14.0	7.8	2000	1410	154	76
20CDC	81-04-30	1400	5.60	12	9.0	7.4	3330	2520	220	130
	81-09-02	1415	6.00	12	14.5	7.3	2990	1950	120	96
20CDD	81-04-30	1730	3.50	12	9.0	7.2	4970	4160	350	210
	81-09-02	1250	4.30	12	13.0	7.6	5030	4090	330	200
29ABC	81-04-30	1445	4.60	15	9.5	7.5	2010	1490	160	68
	81-09-02	1350	4.60	15	14.5	7.7	2140	1620	170	73
29ABD	81-04-30	1520	5.20	24	10.0	7.5	2230	1580	170	62
	81-09-02	1320	5.60	24	13.5	7.7	2390	1630	140	70
29AAB	81-04-30	1820	3.10	14	10.5	7.3	2650	2040	210	120
	81-09-02	1115	4.00	14	15.0	7.6	2720	2030	220	130
20DCD	81-04-30	1645	10.60	16	9.0	7.3	4270	3550	280	210
	81-09-02	1010	12.00	16	11.5	7.7	4630	3990	350	240
21CCB	81-04-30	1845	4.30	18	11.0	7.6	2280	1640	160	100
	81-09-02	1040	4.40	18	15.0	7.6	2170	1550	140	98

Table 5.--*Ground-water quality data*--Continued

LOCAL IDENT-I-FIER	DATE OF SAMPLE	SODIUM, DIS-SOLVED (MG/L AS NA)	POTAS-SIUM, DIS-SOLVED (MG/L AS K)	ALKA-LINITY LAB (MG/L AS CACO3)	CHLO-RIDE, DIS-SOLVED (MG/L AS CL)	SULFATE DIS-SOLVED (MG/L AS SO4)	FLUO-RIDE, DIS-SOLVED (MG/L AS F)	HARD-NESS (MG/L AS CACO3)	NITRO-GEN DIS-SOLVED (MG/L AS N)	NITRO-GEN, ORGANIC DIS-SOLVED (MG/L AS N)
19ADC	81-04-29	43	3.3	160	13	200	1.5	390	1.8	1.4
	81-09-02	44	3.2	290	13	180	1.3	390	1.3	.77
19DCD	81-04-29	1300	7.2	410	350	3800	.3	2000	1.9	.97
	81-09-03	1300	6.9	400	360	4000	.2	2100	1.6	.79
30ADC	81-04-28	310	4.3	350	60	1200	.4	1100	4.4	1.1
	81-09-02	330	4.9	480	82	1200	.3	1100	3.3	1.2
29BCC	81-04-28	180	3.6	350	39	730	.5	740	5.5	.80
	81-09-02	180	3.5	350	31	690	.5	700	3.8	.97
29BCA	81-04-29	1500	7.1	440	140	4100	.3	1500	5.5	1.7
	81-09-01	1400	6.0	400	260	3400	.3	1200	6.4	1.4
29BBA	81-04-30	240	3.9	280	22	560	.9	360	10	1.3
	81-09-02	230	2.8	290	35	510	.9	360	5.9	1.3
29BAB	81-04-29	200	3.2	280	61	510	1.4	470	2.3	1.1
	81-09-01	190	2.8	310	71	390	1.4	370	1.7	.73
29BAA	81-04-29	180	1.7	250	56	550	1.1	520	1.3	.51
	81-09-01	180	1.6	280	62	460	1.1	470	2.4	.78
29BADB1	81-04-29	200	2.2	180	61	600	1.2	550	1.3	.65
	81-09-01	200	2.0	310	62	560	1.2	530	2.4	.64
29BADB2	81-04-30	240	1.6	330	70	770	.9	680	4.2	2.2
	81-09-01	250	1.9	290	70	690	.9	600	2.9	.77
29BADC	81-04-30	380	2.2	220	130	1300	.9	900	13	.98
	81-09-01	430	2.0	320	130	1500	.9	1100	12	.81
29BDA1	81-04-30	220	2.9	200	58	840	.8	810	5.8	.95
	81-09-01	220	2.5	400	57	650	.7	710	5.9	.94
29BDA2	81-04-30	210	2.9	160	52	790	.7	850	5.9	.78
	81-09-01	220	2.6	410	57	620	.6	700	6.1	.91
20CDC	81-04-30	410	4.1	180	120	1500	.7	1100	6.3	1.1
	81-09-02	390	3.9	340	100	1000	.7	700	7.0	1.2
20CDD	81-04-30	660	3.3	230	170	2400	.5	1700	--	.90
	81-09-02	710	3.5	460	140	2400	.5	1600	4.8	1.4
29ABC	81-04-30	220	3.2	290	71	780	1.3	680	1.3	1.0
	81-09-02	250	3.6	270	78	870	1.4	730	1.1	.90
29ABD	81-04-30	320	2.0	340	59	760	.8	560	10	1.1
	81-09-02	310	2.1	380	76	770	.8	640	5.6	1.5
29AAB	81-04-30	260	2.9	200	73	1200	.7	1000	9.7	1.4
	81-09-02	280	3.1	330	66	1100	.7	1100	6.6	1.3
20DCD	81-04-30	580	2.6	210	130	2200	.6	1600	4.5	.62
	81-09-02	590	2.4	430	120	2400	.5	1900	4.2	1.2
21CCB	81-04-30	250	2.3	210	73	890	.9	810	6.6	1.7
	81-09-02	240	1.7	370	49	770	.9	750	4.5	1.9

Table 5.--Ground-water *quality* data--Continued

LOCAL IDENT-I-FIER	DATE OF SAMPLE	NITRO-GEN, AMMONIA DIS-SOLVED (MG/L AS N)	NITRO-GEN, AM-MONIA + ORGANIC DIS. (MG/L AS N)	NITRO-GEN, NITRITE DIS-SOLVED (MG/L AS N)	NITRO-GEN, NITRATE DIS-SOLVED (MG/L AS N)	NITRO-GEN, NO2+NO3 DIS-SOLVED (MG/L AS N)	PHOS-PHORUS, DIS-SOLVED (MG/L AS P)	OXYGEN DEMAND, BIO-CHEM-ICAL, 5 DAY (MG/L)	OXYGEN DEMAND, CHEM-ICAL (HIGH LEVEL) (MG/L)	CARBON, ORGANIC DIS-SOLVED (MG/L AS C)
19ADC	81-04-29	.170	1.6	.020	.17	.19	.030	7.8	200	9.9
	81-09-02	.090	.86	.030	.42	.45	.030	3.9	83	3.5
19DCD	81-04-29	.730	1.7	.020	.22	.24	.030	13	100	19
	81-09-03	.710	1.5	.010	.07	.08	.030	3.9	130	9.2
30ADC	81-04-28	.150	1.2	.040	3.20	3.2	.030	7.8	170	12
	81-09-02	.090	1.3	.080	1.90	2.0	.010	3.9	27	5.6
29BCC	81-04-28	.190	.99	.040	4.50	4.5	.220	7.5	200	13
	81-09-02	.130	1.1	.060	2.60	2.7	.020	4.5	52	4.9
29BCA	81-04-29	.210	1.9	.200	3.40	3.6	.020	6.9	61	14
	81-09-01	.200	1.6	.120	4.70	4.8	.010	3.6	120	20
29BBA	81-04-30	.180	1.5	.240	8.70	8.9	.040	>17	390	11
	81-09-02	.090	1.4	.240	4.30	4.5	.010	9.0	140	6.3
29BAB	81-04-29	.470	1.6	.090	.65	.74	.030	12	150	7.5
	81-09-01	.470	1.2	.040	.41	.45	<.010	10	91	6.4
29BAA	81-04-29	.120	.63	.020	.69	.71	.020	4.2	25	9.1
	81-09-01	.220	1.0	.030	1.40	1.4	<.010	4.5	57	14
29BADB1	81-04-29	.160	.81	.050	.48	.53	.020	6.3	65	8.0
	81-09-01	.160	.80	.030	1.60	1.6	.010	2.1	60	4.8
29BADB2	81-04-30	.110	2.3	.030	1.90	1.9	.040	3.3	29	13
	81-09-01	.180	.95	.030	1.90	1.9	<.010	.3	58	5.8
29BADC	81-04-30	.120	1.1	.080	12.0	12	.030	5.4	93	29
	81-09-01	.160	.97	.040	11.0	11	.220	3.6	80	11
29BDA1	81-04-30	.150	1.1	.070	4.60	4.7	.030	4.5	86	8.6
	81-09-01	.360	1.3	.040	4.60	4.6	.010	6.9	79	5.4
29BDA2	81-04-30	.140	.92	.030	5.00	5.0	.030	3.0	72	16
	81-09-01	.290	1.2	.030	4.90	4.9	.020	7.2	110	4.6
20CDC	81-04-30	.170	1.3	.110	4.90	5.0	.040	3.9	370	7.2
	81-09-02	.100	1.3	.050	5.70	5.7	.030	2.4	120	5.4
20CDD	81-04-30	.100	1.0	.040	--	--	.030	3.3	55	10
	81-09-02	.090	1.5	.040	3.30	3.3	<.010	.3	97	7.0
29ABC	81-04-30	.200	1.2	.010	.13	.14	.030	2.4	52	7.8
	81-09-02	.200	1.1	.020	.01	.03	.030	1.2	52	4.4
29ABD	81-04-30	.110	1.2	.030	8.80	8.8	.020	2.4	23	8.7
	81-09-02	.050	1.5	.040	4.10	4.1	.030	3.0	52	4.5
29AAB	81-04-30	.110	1.5	.060	8.10	8.2	.020	3.9	150	5.0
	81-09-02	.070	1.4	.030	5.20	5.2	.010	2.1	86	5.5
20DCD	81-04-30	.680	1.3	.030	3.20	3.2	.050	4.5	130	13
	81-09-02	.100	1.3	.030	2.90	2.9	.010	4.8	130	6.6
21CCB	81-04-30	.150	1.8	.110	4.70	4.8	.160	2.7	37	5.4
	81-09-02	.090	2.0	.020	2.50	2.5	.010	1.2	72	3.8

Table 5.--*Ground-water quality data*--Continued

LOCAL IDENT- I- FIER	DATE OF SAMPLE	SILICA, DIS- SOLVED (MG/L AS SIO2)	BORON, DIS- SOLVED (UG/L AS B)	CADMIUM DIS- SOLVED (UG/L AS CD)	CHRO- MIUM, DIS- SOLVED (UG/L AS CR)	CHRO- MIUM, HEXA- VALENT, DIS. (UG/L AS CR)	IRON, DIS- SOLVED (UG/L AS FE)	MANGA- NESE, DIS- SOLVED (UG/L AS MN)	METHY- LENE BLUE ACTIVE SUB- STANCE (MG/L)
19ADC	81-04-29	16	--	0	1	0	110	100	.10
	81-09-02	19	56	<1	2	0	110	24	.10
19DCD	81-04-29	11	--	17	3	0	100	690	.50
	81-09-03	12	1165	0	3	0	30	830	.90
30ADC	81-04-28	11	--	0	0	0	90	190	.40
	81-09-02	9.2	586	0	5	0	40	80	.10
29BCC	81-04-28	11	--	9	1	0	60	100	.10
	81-09-02	8.8	328	0	2	0	80	90	.10
29BCA	81-04-29	10	--	26	1	0	670	90	.40
	81-09-01	8.8	664	0	5	0	70	80	.30
29BBA	81-04-30	12	--	0	1	0	70	60	1.5
	81-09-02	11	240	<1	3	0	40	55	.60
29BAB	81-04-29	15	--	9	1	0	60	710	.40
	81-09-01	16	--	<1	0	0	34	500	.40
29BAA	81-04-29	15	--	<1	1	0	70	200	.10
	81-09-01	16	--	<1	5	0	49	160	.20
29BADB1	81-04-29	14	--	0	1	0	60	730	.30
	81-09-01	16	--	<1	6	0	32	590	.30
29BADB2	81-04-30	14	--	9	1	0	60	120	.20
	81-09-01	14	--	0	6	0	40	180	.30
29BADC	81-04-30	11	--	0	2	0	80	110	.10
	81-09-01	12	--	0	6	0	100	70	.20
29BDA1	81-04-30	14	--	0	1	0	140	40	.10
	81-09-01	15	--	<1	5	0	11	77	.20
29BDA2	81-04-30	13	--	0	0	0	40	190	.10
	81-09-01	15	--	<1	0	0	<10	6	.10
20CDC	81-04-30	9.1	--	9	2	0	140	360	.10
	81-09-02	8.9	418	0	7	0	200	120	.10
20CDD	81-04-30	10	--	9	0	0	240	50	.10
	81-09-02	11	--	0	6	0	70	50	.10
29ABC	81-04-30	9.7	--	0	2	0	30	150	.10
	81-09-02	9.4	661	0	2	0	30	80	.10
29ABD	81-04-30	13	--	9	1	0	60	20	.10
	81-09-02	10	357	0	2	0	50	10	.10
29AAB	81-04-30	12	--	0	1	0	30	90	.10
	81-09-02	13	463	0	6	0	30	30	.10
20DCD	81-04-30	10	--	17	0	0	110	40	.10
	81-09-02	11	699	0	6	0	90	30	.10
21CCB	81-04-30	12	--	9	1	0	40	410	.10
	81-09-02	12	--	0	6	0	30	50	.10

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