THE DAKOTA AND CHEYENNE AQUIFERS IN THE CHEYENNE WELLS - LAS ANIMAS REGION, COLORADO

by
John C. Romero
edited by
George D. VanSlyke

Prepared by
COLORADO DIVISION OF WATER RESOURCES
in cooperation with
COLORADO OIL AND GAS CONSERVATION COMMISSION

1994

Water Resources Investigation 94-1

Roy Romer
Governor

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State Engineer

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Editor's Note

The report, mapping and research for this study were accomplished by John C. Romero. Unfortunately, prior to publication Mr. Romero fell victim to cancer, which he had fought for the past two years. John had worked for the Colorado Division of Water Resources for over 27 years, during which he conducted numerous studies concerning the ground water resources within the state. He was recognized as an expert in his field and was highly respected by the professional community.

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ABSTRACT

The project area consists of approximately 5,200 square miles in the Cheyenne Wells - Las Animas region, Colorado. The climate of the area is semi-arid with annual precipitation ranging from 14 to 15 inches. The area is drained by the Arkansas River, Big Sandy Creek, and several other drainages in the Northern High Plains part of the project area. Most of the area is covered by unconsolidated deposits of alluvial and eolian origin; bedrock strata are exposed along steep stream cuts. Principal bedrock aquifers are the Dakota and Cheyenne aquifers. These aquifers supply groundwater to a significant number of domestic and stock wells, and several public supply wells. Most of the Dakota and Cheyenne wells lie within 12 to 24 miles from the Arkansas River.

The Dakota and Cheyenne aquifers are extensively used for domestic and stock water supplies over a large portion of the eastern plains of Colorado. This area is also the focus of a considerable amount of oil and gas activity. During the past two years, the Colorado Division of Water Resources, in cooperation with the Colorado Oil and Gas Conservation Commission, has undertaken a study to map the Dakota and Cheyenne aquifers over a 5,200 square-mile area of the Colorado eastern plains. Field mapping of the outcrops was combined with available published mapping to determine the surface outcrop of the Dakota and Cheyenne aquifers. In addition to this, approximately 500 geophysical logs from oil and gas exploration holes were used to construct structural contour maps for the aquifers in the study area and to assemble a data base for the aquifers.

Within the study area, very little data concerning water quality in the bedrock aquifers is available; however, it is known that as the depth of burial and distance from the recharge source increases, the aquifers become more saline. For these reasons, the Division investigated various methods for the indirect determination of water quality using existing geophysical well logs. Based on the availability and reliability of existing geophysical logs and the few available water quality tests, the SP-method was selected as a tool for estimating water quality. From the detailed mapping of the aquifers and relationships developed from the SP-method, it was possible to produce an estimated water quality map of the area. These data can be used to determine the areas where domestic and stock wells may be possible and areas of poor water quality where produced water may be injected. This will enable both the Division of Water Resources and the Oil and Gas Conservation Commission to better administer and protect the aquifers.

INTRODUCTION

PURPOSE OF THE INVESTIGATION

This is the final technical report on a work project completed by the Colorado Division of Water Resources (DWR) for the Colorado Oil and Gas Conservation Commission (COGCC). The COGCC is expanding an effort to improve the methodology used to evaluate applications to inject produced water (saline water) in areas underlain by the Dakota and Cheyenne aquifers in the Cheyenne Wells-Las Animas region in southeastern Colorado.

The purpose of the project is twofold. The first part involved the mapping and delineation of the Dakota and Cheyenne aquifers within the 5200 square mile project area. The second part of the investigation centered on evaluating methods for determining water quality within the aquifers. Project results consist of structure contour maps of the top and base of the Dakota and Cheyenne aquifers at a scale of one inch = three miles, four geophysical-log cross sections, four diagrams showing the relationship between formation-water resistivity, total dissolved solids, sodium chloride concentrations, depth and distance from outcrop/ subcrop areas, and a computerized data base.

METHOD OF INVESTIGATION

The area of investigation or project area occupies an area approximately 12 townships square with its southern boundary along the Arkansas River between Las Animas and Holly (fig. 1). The top and base of the Dakota and Cheyenne aquifers within the 5,200 square mile area were identified on approximately 500 geophysical logs from oil and gas exploration holes. This work was accomplished at the COGCC office in Denver. Four east-west and north-south E-log cross sections were prepared and are presented on plates 1 and 2. Recorded data were ultimately transferred to 1 inch = 3 mile scale maps (pls. 3,4,5,6). Background or supporting water quality data were obtained from the Colorado Department of Health and from COGCC files.

The Kansas Geological Survey of Lawrence, Kansas supplied the author with a number of geophysical logs with their interpretation of formational boundaries.

The spontaneous potential method was used to generate estimates of formation-water resistivity. Total dissolved solids and sodium chloride concentration were estimated by methods described in Jorgensen (1989). The estimates were ultimately plotted on two Rw/TDS diagrams (figs. 3, 4) and two Rw/TDS determination location diagrams (figs. 5, 6).

ACKNOWLEDGEMENTS

The author extends gratitude to Mr. Ed DiMatteo of the COGCC who located a number of critically important water quality records, and members of the Commission who reviewed this report.

GEOGRAPHY

TOPOGRAPHY AND DRAINAGE

The project area occupies approximately 5,200 square miles north of the Arkansas River in southeastern Colorado (fig. 1). Big Sandy Creek trends diagonally from the northwest toward the southeast and nearly bifurcates the area into two distinct parts: High Plains topography predominates in the area east of Big Sandy Creek, whereas Colorado Piedmont topography occurs west of the High Plains. The High Plains is an eastward-sloping, gently-rolling plain with a surficial cover of eolian sand and loess. It has been cut by numerous ephemeral streams, the principal of which are the Smoky Hill River, Big Timber, White Woman, and Wild Horse Creeks. Slope of the land surface is toward the east and southeast at a rate of 20 to 30 feet per mile. The westward boundary of the High Plains is marked by a low westward-facing escarpment.

The land west of the High Plains escarpment is within the southeastern limit of the Colorado Piedmont. This is an elevated plain characterized by low gently rolling topography but one which has had a significant quantity of unconsolidated material stripped from the underlying bedrock formations. In many areas the eolian deposits which are present have internal drainage. This part of the area of investigation is drained primarily by Big Sandy and Rush Creeks and their tributaries. Regional land surface slope is toward the southeast at a rate of 15 to 20 feet per mile.

CLIMATE

The entire project area is classed as semiarid. Normal precipitation is low with most occurring from May through September. Mean annual precipitation at Cheyenne Wells is 14.23 inches (Boettcher, 1964) and at Holly 15.08 inches (Voegeli and Hershey, 1965). Boettcher indicates that normal or above normal precipitation does not guarantee good crop yields because the crops may wilt during a prolonged dry period. Many storms are accompanied by hail, and summer storms are erratic. Temperatures are usually high during the summer, and winters are mild except for short periods of extreme cold. (Boettcher, 1964.)

CULTURAL DEVELOPMENT

The economy of the area is predominantly agricultural and is based upon dryland farming, irrigation, stock-raising, and minor light industry. Irrigated farming is practiced in the Northern High Plains part of the area and along and near the Arkansas Valley floodplain. Dryland farming is practiced sporadically throughout the project area. Crops produced include wheat, sorghums, sugar beets, alfalfa, corn, oats, barley, and hay. (Boettcher, 1964, Voegeli and Hershey, 1965.) Cattle and sheep grazing is also practiced. Mineral resources are groundwater, raw construction materials, and oil and gas resources. There are approximately 50 petroleum-producing fields within the project area. The area is served by the Missouri Pacific and Union Pacific Railroad Companies, and a number of Federal and State highways, and county roads.

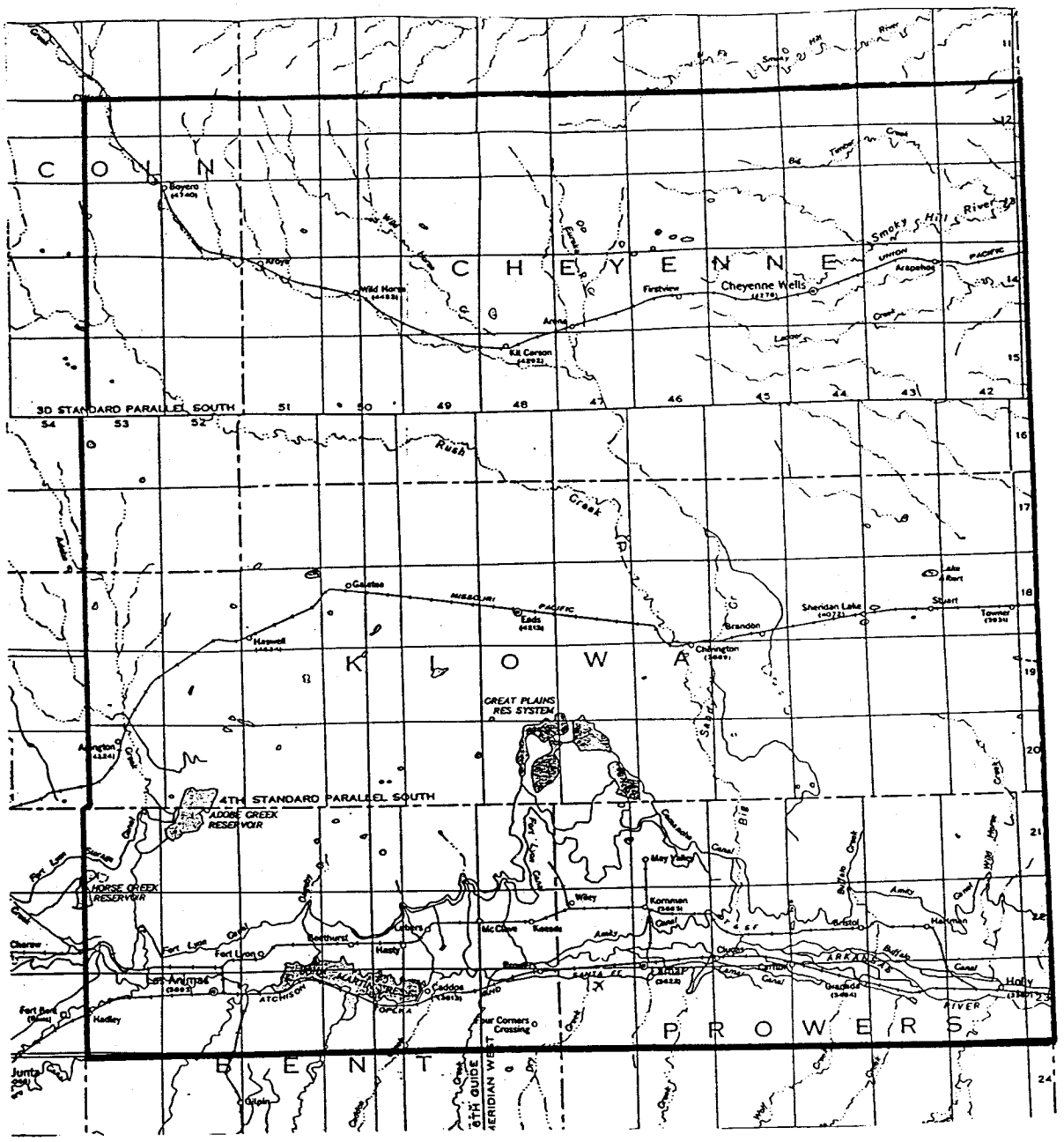

Figure 1. - Location of the project area

GEOLOGICAL FORMATIONS

SUMMARY OF REGIONAL GEOLOGY

All of the project area is underlain by formations of sedimentary origin and range in age from Cretaceous to Recent. The High Plains part of the area is underlain by eolian deposits and the Ogallala Formation. The Ogallala is the principal source of irrigation water throughout the entire High Plains. The Colorado Piedmont part of the area is underlain by eolian deposits, and old and recent valley fill alluvium. Strata of underlying bedrock formations are exposed along the slopes of many hills and in some deeply cut stream channels. Bedrock formations underlying the area of investigation are composed of sandstone, siltstone, shale and limestone; the oldest outcropping bedrock strata are sandstones of the Dakota Sandstone. Outcrops of the Dakota occur intermittently along the banks of the Arkansas River between Las Animas and Holly. Older strata underlie the Dakota and will be discussed in a later section of this report. The Dakota and Cheyenne Sandstones are hereinafter referred to as the Dakota and Cheyenne aquifers.

The project area is nearly bisected by the northeast-trending Las Animas Arch. This structure is responsible for exposing the Dakota and some older strata in the southern part of the project area. A number of faults with up to 200 feet of displacement have been identified and mapped by earlier investigators (Voegeli and Hershey, 1965). In this report no attempt has been made to refine the earlier work because the faults occur in areas where the Dakota and Cheyenne aquifers are generally less than two or three hundred feet from land surface. In these areas they are extensively used as sources of water for domestic and stock purposes. Hence petroleum exploration holes must include cemented surface casing sufficient to protect both aquifers.

SURFICIAL FORMATIONS

Surficial formations of Recent through Pleistocene age include eolian sand and stream alluvium of Recent age, and older deposits of commonly poorly-sorted clay, silt, sand, and gravel. Aggregate thickness of these deposits range from 0 to over 100 feet. The Ogallala Formation is of Pliocene age and is composed of clay, silt, sand and gravel, with caliche and localized deposits of algal limestone (Voegeli and Hershey, 1965, and Boettcher and Horr, 1964). Except for the eolian sand, most of the surficial deposits yield sufficient quantities of water to domestic and stock wells and, when sufficient saturated thickness is available, to large-capacity irrigation wells.

BEDROCK FORMATIONS

Normally, the term Purgatoire Formation is used to describe the geologic unit composed of the Kiowa Shale and the Cheyenne Sandstone. It should be noted that in the following narration the term Purgatoire Formation is dropped and the Kiowa Shale and Cheyenne aquifer are tentatively given formational rank. This follows Kansas nomenclature and simplifies narration.

Figure 2 is a generalized bedrock geologic map of the project area and shows the approximate boundaries of the bedrock formations underlying the surficial deposits and

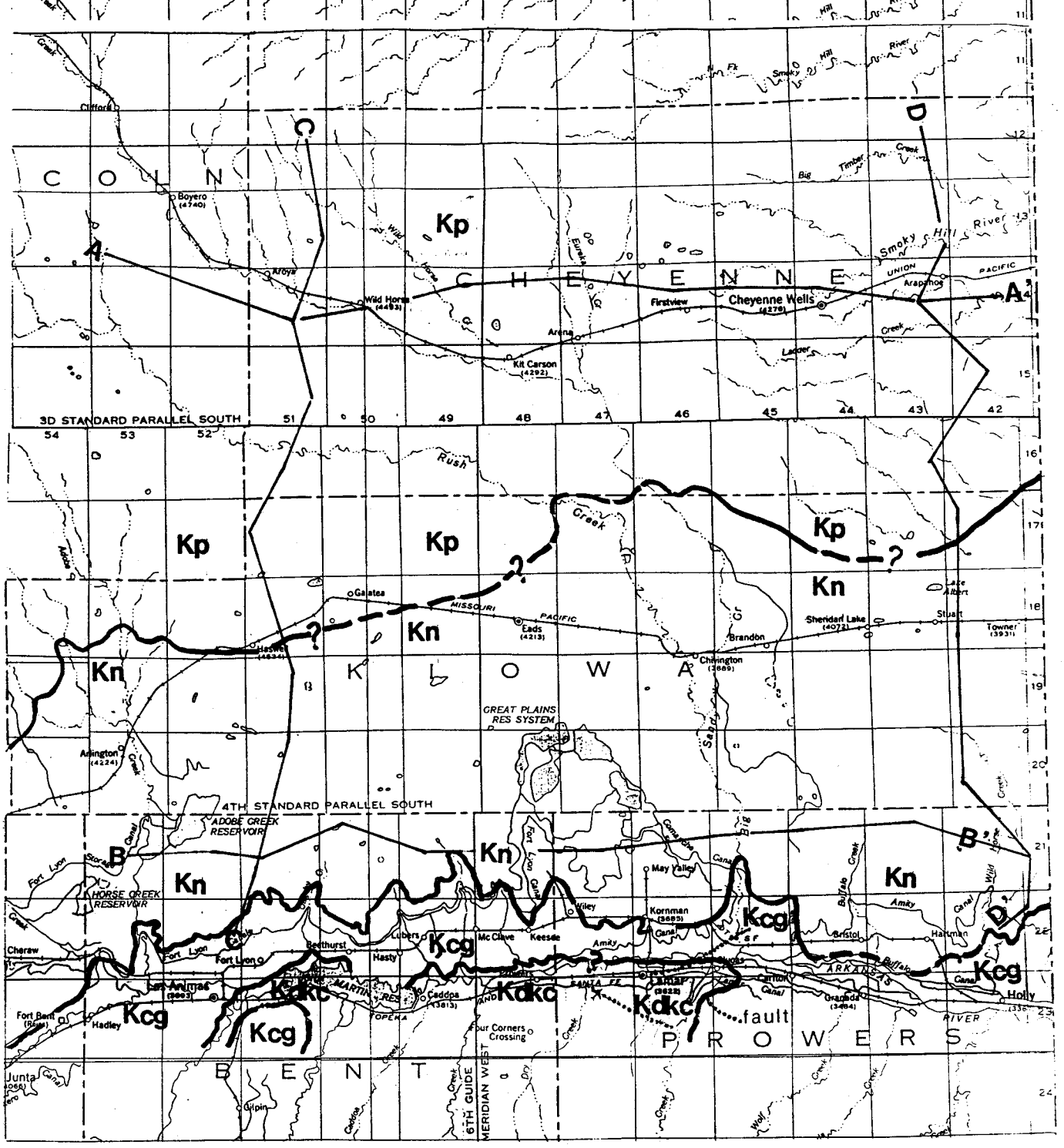

Figure 2. - Generalized bedrock geologic map of the project area. Kp - Pierre Shale; Kn, Kcg - Niobrara through Greenhorn strata undifferentiated; Kd/Kc - Dakota, Kiowa and Cheyenne strata undifferentiated. Three faults in the Lamar area are approximately located. A-A' etc. are locations of geophyscial log cross sections.

major fault traces identified by Voegeli and Hershey (1965). All strata except the Dakota and Cheyenne aquifers and the Kiowa Shale are given only a brief description in this report. Table 1 is a generalized section of the bedrock formations, and plates 1 and 2 illustrate standard geophysical logs from the base of the Pierre Shale to the Stone Corral Formation of Permian age.

The youngest bedrock formation in the project area is the Pierre Shale of Late Cretaceous age. This black to dark gray shale underlies the Ogallala Formation north of the Cheyenne-Kiowa County line (fig. 2). Exposures are limited to steep hill slopes and deep stream cuts. As interpreted from petroleum-exploration holes, the thickness of the Pierre Shale in the project area ranges from about 1,000 to about 1,200 feet. The Pierre Shale is underlain by shaley marls of the Niobrara Formation. Thickness of the Niobrara is approximately 150 feet in the southern part of the project area (Voegeli and Hershey) and approximately 700 feet in the northern part of the project area (Boettcher and Horr). The underlying Carlile Shale includes the Codell Sandstone, Blue Hill Shale, and Fairport Chalky Shale Members. The Codell and Fairport Members yield small quantities of water to wells downdip from outcrop areas. The Blue Hill Shale Member is reported to yield water from springs and seeps. Thickness of the Carlile ranges between 0 and 190 feet. The underlying Greenhorn Limestone ranges from 0 to 130 feet in the project area. Gray to black gypsiferous and bentonitic shale of the underlying Graneros Shale serves as a good marker formation for the underlying Dakota aquifer. One bentonite marker in the Graneros is regional in aerial extent. Thickness range of the Graneros Shale is 0 to 190 feet. Dakota, Kiowa, and Cheyenne strata will be described in the next section of this report. The Morrison Formation (Jurassic) consists of from 50 to 100 feet of multicolored mudstone, shale, and siltstone, with thin interbeds of sandstone and limestone. At localities where uppermost Morrison sandstones are nearly in contact with the overlying Cheyenne aquifer, they have been included with the Cheyenne aquifer.

Geologic strata between the base of the Morrison Formation and base of the Stone Corral Formation (Permian) are approximately 400 to 1,000 feet thick. They are composed predominantly of reddish-brown siltstone and sandstone, pink to yellowish-tan sandstone and dolomite, and generally light-colored gypsum. The only formation known to yield fresh water to wells in this section is the Dockum Group. The Dockum Group is Triassic in age and its red-orange sandstone yields sufficient quantities of water for irrigation purposes in Baca County, Colorado.

Detailed descriptions of strata above the Dakota aquifer and below the Morrison Formation can be found in geologic literature and the reference list at the end of this report.

Dakota Aquifer - The Dakota aquifer underlies the Graneros Shale and overlies the Kiowa Shale. The aquifer consists of 200 to 235 feet of thin to medium bedded sandstone with interbeds of sandy shale and shale. Geophysical log characteristics of the aquifer are shown on plates 1 and 2. The logs reveal that the thicker beds of sandstone usually occur in the lower half of the aquifer. Voegeli and Hershey (1965), McLaughlin (1954), and field experience of this investigator reveals the presence of iron oxide cemented sandstones in many outcrop areas. The cement gives the Dakota a red to brown color and renders the rock hard and brittle. Outcrop colors range from light gray to yellowish-brown and a dark brownish-red, depending upon iron content. Dakota aquifer sandstones are uniformly fine-grained, but grain size may differ widely from bed to bed (Voegeli, and Hershey, 1965).

Table 1. - Generalized section of the bedrock strata within the project area.

System	Series	Stratigraphic unit	Thickness (feet)	Physical character	Water supply
Cretaceous	Upper Cretaceous	Pierre Shale	0–1,100±	Black to dark-gray shale. Contains bentonitic clay and calcareous concretions. Occasionally the upper 4–8 ft is a yellow weathered zone.	Not known to yield water to wells in the project area.

System	Series	Subdivision	Member	Thickness (feet)	Physical character	Water supply
Cretaceous	Upper Cretaceous	Niobrara Formation	Smoky Hill Marl	150±	Chiefly yellowish chalk; contains thin beds of white limestone.	Do.
			Fort Hays Limestone	50–60	Chalky limestone and marl.	Yields water to stock wells and from springs north of the Arkansas River.
		Carlile Shale	Codell Sandstone	22±	Chiefly sandy shale; contains calcareous sandstone.	Yields water to a few stock wells.
			Blue Hill Shale	50–60	Chiefly black noncalcareous fissile shale; contains concretions in upper part.	Yields limited quantities of water from seeps north of the Arkansas River.
			Fairport Chalky Shale	100–125	Chalky shale; contains thin chalky limestone beds in lower part.	Yields water to a few stock wells.
			Bridge Creek Limestone	69–73	Thin-bedded limestone and shale.	Do.
		Greenhorn Limestone	Hartland Shale	20–38	Chalky shale and thin-bedded limestone; contains thin layers of bentonite.	Yields no water to wells.
			Lincoln Limestone	25–37	Thin-bedded hard crystalline limestone and calcareous shale; contains thin layers of bentonite.	Do.
		Graneros Shale		85–100	Gray to black gypsiferous shale and thin layers of bentonite; contains thin-bedded rusty limestone in middle to lower part.	Do.
	Lower Cretaceous	Dakota Sandstone		150–235	Fine-grained thin-bedded to massive sandstone; contains clayey to sandy shale. Color ranges from white to brown.	Yields adequate water for domestic and stock use in most places. In some areas it yields enough water for municipal and industrial supplies.
		Purgatoire Formation	Kiowa Shale	30–140	Gray to black calcareous clayey shale; thin-bedded fine-grained sandstone in upper part.	Yields no water to wells.
			Cheyenne Sandstone	30–200	Massive white to buff fine-grained sandstone.	Yields small to large quantities of water for domestic, stock, industrial, municipal, and irrigation use.
Jurassic	Upper Jurassic	Morrison Formation		20–240	Varicolored marl: locally contains thick sandstone lenses, thin beds of conglomerate, and platy limestone.	Yields water to some domestic and stock wells north of Two Buttes.
		Middle unit of Jurassic age		35–150	Sandstone, limestone, mudstone conglomerate, and chert zones.	Yields no water to wells.
		Entrada Sandstone		100±	Massive white to buff crossbedded fine- to medium-grained sandstone.	Do.
Triassic	Upper Triassic	Dockum Group		150–540	Chiefly sandstone, but locally contains thin beds of conglomerate, limestone, and shale.	Do.
Permian	Upper Permian	Taloga Formation (of Cragin)		100–400	Red siltstone and fine-grained sandstone.	Do.
		Day Creek Dolomite		10–60	Dolomite, anhydrite, or gypsum.	Do.
		Sandstone of Whitehorse age		30–300	Buff to red fine-grained sandstone and red shale.	Do.

The Pierre Shale description is directly from Boettcher and Horr (1964), the Niobrara through Whitehorse strata is directly from Voegeli and Hershey (1965). Strata between the Whitehorse Sandstone and base of the Stone Corral Formation are not described here.

Shales interbedded in the Dakota aquifer are generally gray to black, but can be multicolored in places and, according to Voegeli and Hershey (1965), can be mistaken for shales of the Morrison Formation.

Robson and Banta (1987) discuss the Dakota-Cheyenne aquifer of eastern Colorado and refer to it as a member of the Great Plains aquifer system. In their report, Robson and Banta discuss region-wide stratigraphic characteristics and, to a limited extent, quality of water.

Except in outcrop areas where it may be drained, the Dakota aquifer is a reliable source of water for domestic, stock, and public supplies in much of southeastern Colorado. This property extends westward to outcrop areas along the Front Range of the Southern Rocky Mountains. Depth of existing water wells completed in the Dakota aquifer ranges from 100 to 200 feet along the Arkansas River to approximately 900 to 1,300 feet in the Brandon and Sheridan Lake area.

Depth to the top of the Dakota aquifer ranges from zero in outcrop areas along the Arkansas River to approximately 3,000 feet in the northwestern part of the project area. Plate 3 is a structure contour map of the top of the Dakota aquifer. The Las Animas Arch makes its presence known in the branched ridge which extends northeastward from the Las Animas and John Martin Reservoir area. Plate 4 is a structure contour map of the base of the Dakota aquifer (equivalent to the top of the Kiowa Shale). Plates 3 and 4 can be used to determine depth below land surface by subtracting the structure contour elevations at a specific site from the determined land surface elevation at that site. The Dakota aquifer is underlain by the Kiowa Shale.

Kiowa Shale - The Kiowa Shale consists of 30 to 140 feet of dark gray to black shale with interbeds of sandy shale and thin beds of sandstone. The geophysical logs of plates 1 and 2 show that when the Kiowa is generally 50 feet or more in thickness, a prominent sandy zone normally occurs about midway between the Dakota aquifer and underlying Cheyenne aquifer. Thickness frequently attained by sandstone beds in this zone is 20 to 30 feet. Voegeli and Hershey (1965) report that Kiowa shales are occasionally both calcareous and gypsiferous. The Kiowa Shale is important because it serves as an effective hydrologic barrier between the Dakota and Cheyenne aquifers.

Cheyenne Aquifer - The Cheyenne aquifer underlies the Kiowa Shale and overlies the Morrison Formation. The aquifer consists of from 30 to approximately 200 feet of light gray to white, fine to coarse grained, friable sandstone with thin interbeds of gray shale. Well cemented zones occur locally. The generally light color and friability are two basic characteristics distinguishing it from the usually tightly cemented sandstone of the Dakota aquifer (McLaughlin, 1954; Voegeli and Hershey, 1965). Haun (1959, 1963) reports that the interfingering relationship of the lower Dakota (Cheyenne aquifer included) and upper part of the Morrison Formation renders the Cheyenne-Morrison contact indistinct. Therefore, the base of the Cheyenne aquifer is chosen to be the base of the predominantly sandstone sequence regardless of the classic formational boundary.

The Cheyenne aquifer is a reliable source of water for domestic, stock, and public supplies throughout much of southeastern Colorado. This property extends westward to outcrop areas along the east slope of the Front Range. Depth to the Cheyenne aquifer ranges from 200 to 400 feet along the Arkansas River to approximately 3,300 feet in the northwestern

corner of the project area. Plates 5 and 6 are structure-contour maps of the top and base of the Cheyenne aquifer.

The Cheyenne aquifer is underlain by mudstone, shale, siltstone, and thin bedded sandstone and limestone of the Morrison Formation. Morrison colors are red, green, gray, and brown, with green predominating.

QUALITY OF WATER FROM THE DAKOTA AND CHEYENNE AQUIFERS

Most water quality analyses of Dakota and Cheyenne aquifer water have been obtained from wells located within 12 miles from the Arkansas River. Water is withdrawn from domestic, stock, irrigation, and public supply wells. Voegeli and Hershey (1965) obtained groundwater from 28 Dakota, Cheyenne, and Dakota/Cheyenne aquifers. All of the wells checked are located south of Township 20 South. They reported that the quality of water in the Dakota, Cheyenne, and Dakota/Cheyenne combination wells varies considerably from place to place, and that the chemical quality of water from the Dakota in many places does not meet recommended standards for public and domestic water supplies. However, people using such water have reported no adverse effects. Total dissolved solids (TDS) from seven wells range from 478 to 2,090 milligrams per liter (mg/l) from depths ranging from 59 to 1032 feet below land surface. Their table 3 details test results. Voegeli and Hershey report that the hardness of Dakota water ranges from 10-650 mg/l. Weist (1963) reports that in southern Crowley County Dakota and Cheyenne water of the sodium sulfate type is generally soft and that hardness decreases in a northern direction. Weist reports that the hardness of water obtained from 23 Dakota and Cheyenne wells ranged from 8 to 906 mg/l. Weist, Jenkins, and Horr (1965, p.53) graph average composition of groundwater with respect to aquifer.

With the exception of water quality analyses from four wells - one from the Brandon Water Association and three drill stem test results from oil and gas exploration holes - there are no readily available water quality analyses of Dakota and Cheyenne aquifer water between Township 19 South and the northern boundary of the project area.

Two documented methods for determining water quality from geophysical logs were investigated. The first relies on the resistivity log in conjunction with priority and density logs. The second relies on the SP logs. While both methods appear to be useful, overall absence of porosity and density logs of Dakota and Cheyenne intervals, and lack of sufficient chemical quality analyses led to the decision to utilize the spontaneous potential method or SP-method for formation water resistivity (Rw) estimations. Total dissolved solids and sodium chloride (NaCl) concentrations were estimated by the application of methods described by Jorgensen (1989, p.22). TDS and NaCl tolerances are briefly described in the Appendix.

SPONTANEOUS POTENTIAL METHOD

One technique used to estimate formation-water resistivity is the spontaneous potential or SP-method. The SP-method can be used to estimate the Rw of NaCl type water. The method is based on the equation.....

$$SP = -K \log \frac{Rmf}{Rw}$$

Simplifying and rearranging....

$$Rw = \frac{Rmf}{10^{-SSP/K}}$$

Where SSP is the static spontaneous potential in millivolts at formation temperature, K is a constant which is a function of temperature, Rmf is the resistivity of the mud filtrate in ohm-

meters, and Rw is the formation-water resistivity in ohm-meters. More detailed descriptions of the method are usually presented in most well-logging manuals and texts such as those by Collier (1992), Jorgensen (1989), Keys (1990), Schlumberger (1989), and Western Atlas International (1985).

Requirements for use of the SP-method in fresh-water formations are:

1) The water contains less than 10,000 (mg/l) dissolved solids.

2) The borehole fluid and formation water must be sodium chloride (NaCl) solutions.

3) The formation water must be distinctly saline.

4) The sand must be relatively clay-free, permeable, and thick enough for an SSP (static spontaneous potential) to be established.

Collier (p. 390) and Keys (p. 52) discuss complications in more detail. Jorgensen (p. 9,10) suggests that the SP-method should be used only if an estimated accuracy of plus or minus one-half order of magnitude is acceptable.

The SP-method is used in this report for three reasons:

1) In an over 3,000 square mile area north of Township 19 South, only three relatively complete Dakota water samples are available.

2) The overall absence of chemical data, and porosity/density data prevents application of various cross-plot methods for determining Rw.

3) The SP-method was tested by comparing SP-method estimations of Rw with the results of commercial/private lab analyses of four drill stem tests obtained from Dakota and Cheyenne water samples from deep oil and gas exploration activities. Results revealed that calculated Rw and TDS lie within 70 to 95 percent of the lab values.

It is believed that the SP-method can be used as a guide to water quality, provided the reader accepts the opinion of Jorgensen that the calculated results may be in error by as much as one-half order of magnitude. Specific conductance and NaCl and TDS concentrations were estimated using techniques described in Jorgensen (1989, p. 2). No corrections were attempted.

RESULTS OF SP-METHOD CALCULATIONS

Colorado State Department of Health data from two analyses indicates that Dakota water withdrawn from the Brandon Water Association has a sodium (Na) concentration of 500-700 mg/l and a TDS of approximately 1,800 mg/l. Drill stem test data from the #4 Grays State oil and gas exploration well in T.12S., R.51W., Section 36, indicates Dakota water at that site has a TDS averaging 8,258 mg/l from a depth of 2,672 feet. Drill stem test data from the #3 Navajo #32-3 well in T.17S., R.46W., Section 3, reveals a chloride (Cl) concentration of 7,800 mg/l and a TDS of 17,036 mg/l from a depth of 1,156 feet. Drill stem test data from the #2

Fallow 43-18 well in T.10S., R.54W., Section 18, reveals Cheyenne aquifer water with a TDS of 2,952 mg/l from a depth of 4,150 feet (table 2).

Results of the calculations for Rw, TDS, and NaCl are plotted on figures 3, 4, 5, and 6. Figures 3 and 4 are plots of estimated Rw versus estimated TDS for the Dakota and Cheyenne aquifers. A single line drawn through the plots of each diagram clearly show the interrelationship between Rw and TDS: low Rw - high TDS, high Rw - low TDS. More importantly, three background data plots for the Dakota aquifer (fig. 3) lie along the distinct lineation of the Rw/TDS plots. These three data points (Brandon W.A., Grays State, and Navajo #32-3) are 20 to 50 miles apart, serve as the basis for a distinct lineation, and the basis for using the SP-method for determining Rw and without applying a correction factor. The Cheyenne aquifer diagram (fig. 4) has the benefit of only one established data point (Fallow #43-18, in 10 South - 54 West - 18); nearly 10 miles north of the project area. It is believed that the Cheyenne plots lie well within the potential plus or minus one-half order of magnitude of error mentioned by Jorgensen (p. 6).

TABLE 2

Average concentrations, in mg/l of pertinent constituents in water obtained from three oil and gas exploration holes and from the Brandon Water Association. SO_4 = sulfate, Kd = Dakota aquifer, KC = Cheyenne aquifer.

Well Name	Location	Na	Cl	SO_4	TDS	Depth (ft)
#4 Grays State	12S-51W-36	2993	4048	175	8,258	2,672 (Kd)
#3 Navajo 32-3	17S-46W-3	-	7300	-	17,036	1,156 (Kd)
Fallow 43-18	10S-54W-18	-	-	-	2,952	4,150 (Kc)
Brandon W.	18S-45W-34	600	-	-	1,760	840 (Kd)

Calculated formation water Rw's for the Dakota aquifer range from 0.28 ohm-meters to 12.57 ohm-meters. Calculated TDS from the 0.28 ohm-meter water is 23,100 mg/l, whereas calculated TDS from the 12.57 ohm-meter water is 603 mg/l. Calculated formation - water Rw's for the Cheyenne aquifer range from 0.31 to 8.31 ohm-meters. Calculated TDS from the 0.31 ohm-meter water is 17,180 mg/l, whereas calculated TDS from the 8.31 ohm-meter water is 906 mg/l. Estimated NaCl concentrations (both aquifers represented) range from 431 to 25,760 mg/l.

Distribution of estimated Rw, and NaCl and TDS concentrations are plotted on figures 5 and 6. Depth to the top of each aquifer is included as a 500 foot contour interval. In general, Rw decreases with depth and NaCl and TDS increases. Since the Dakota and Cheyenne aquifers have an apparent northward dip, it follows that Rw decreases with distance from the outcrop/subcrop area, and NaCl and TDS increases.

On figures 5 and 6, approximate contours have been drawn on 4,000 and 10,000 mg/l TDS. Coincidentally, the position of the 4,000 and 10,000 mg/l NaCl contour is (for this report) identical. A concentration of 4,000 mg/l was chosen because many communities use 2,000-4,000 mg/l water when more suitable supplies are absent (McKee and Wolf, 1978). The 10,000 mg/l concentration is for reference purposes only. In utilizing the two figures the

reader will find that low Rw, high TDS, and high NaCl normally occur north and west of the 4,000 mg/l contour. On the opposite side, high Rw's, and lower TDS and NaCl are common. Figures 5 and 6, therefore, can be used to approximate the locations of low and high Rw, and low and high TDS and NaCl. Or, when used with reservation, as a general guide to water quality.

Figures 5 and 6 also show the current northern limit of Dakota and Cheyenne aquifer utilization within the project area. The limit does not represent water quality restrictions as much as it does well construction and pumping economics, and water quantity requirements.

Examination of figures 5 and 6 reveals that water quality trends of both Dakota and Cheyenne water are nearly parallel and that the chemical quality of Cheyenne water is generally poorer than Dakota water lying above it. The reader is advised to compare the positions of the Dakota and Cheyenne 4,000 and 10,000 TDS contours.

SUMMARY

Principal bedrock aquifers in the 5,200 square mile project area are the Dakota and Cheyenne aquifers. These aquifers supply water not only to domestic and stock wells, but also several public supply wells. Most of the useful water quality data within the project area has been obtained from wells south of Township 20 South. North of Township 20 South there are only four useful water quality analyses of Dakota and Cheyenne water; one analyses of Brandon Water Association water, analyses of water from drill stem tests on two widely-spaced oil and gas exploration holes, and the analyses of water from an oil and gas exploration hole 10 miles north of the project area.

The SP-method was used to estimate Rw in the area north of Township 19 South. Total solids and NaCl concentration were obtained by utilizing methods described in Jorgensen (p.22). Results of the calculations were plotted on four diagrams: two Rw vs. TDS diagrams and two Rw, TDS, NaCl vs. distance and depth diagrams. The diagrams support use of the SP-method as a viable means of estimating Rw within the project area, and that relative water quality can be determined by utilization of the four diagrams.

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APPENDIX A

TDS AND SODIUM CHLORIDE TOLERANCES

Information in the following two paragraphs has been obtained from McKee and Wolf (1978), Hemm (1959), and Colorado State Health Department (1993).

For domestic water supplies, 1962 U.S. Public Health Service recommends that TDS should not exceed 500 mg/l. Many communities, however, use water containing from 2,000-4,000 mg/l when no better water is available. Such waters are not palatable, may not quench thirst, and may have laxative action on new users. Waters containing 5,000 mg/l or more are reported to be bitter and act as bladder and intestinal irritants.

Sodium chloride can be tasted by most people at a concentration of 550 mg/l, although taste threshold values from 200 to 900 mg/l have been reported. Concentrations exceeding 500 mg/l may be unpalatable. Conversely concentrations of 1,400 mg/l have been used by some communities. It has been reported that 7,500 mg/l NaCl is harmless, but 10,000 mg/l causes vomiting. Colorado State Health Department reports the recommended tolerances for humans is 20 mg/l sodium and 250 mg/l chloride.

APPENDIX B

DATA FROM GEOPHYSICAL LOGS
DAKOTA/CHEYENNE AQUIFERS
EASTERN COLORADO
1994

TWN/RNG	SEC	QTR/QTR	WELL ID	ELEV. GS	ELEV MP	DEPTH TO TOP DAKOTA	DEPTH BASE DAKOTA	DEPTH TO TOP CHEY	DEPTH BASE CHEY	ELEV TOP DAKOTA	ELEV BASE DAKOTA	ELEV TOP CHEY	ELEV BASE CHEY	
12S 42W	7	NENW	#1 CARVILLA 21-7	4106	4114	2175	2350	2490	2650	1939	1764	1624	1464	
12S 42W	31	SESE	#1 DAVIS 44-31	4024	4034	1935	2140	2280	2460	2099	1894	1754	1574	
12S 43W	11	SWSW	#1 EIGER 14-11	4163	4172	2185	2340	2495	2705	1987	1832	1677	1467	
12S 43W	24	SWNW	#1 PRICE 12-24	4090	4106	2180	2270	2430	2585	1926	1836	1676	1521	
12S 43W	27	SWSE	#1 WEED 34-27	4116	4125	2137	2230	2370	2540	1988	1895	1755	1585	
12S 43W	32	SESE	1 WECO UPRC OK CORRAL 44H-32	4191	4202	2110	2300	2455	2590	2092	1902	1747	1612	
12S 43W	36	NESE	#1 STATE DURR 43-36	4039	4048	1985	2180	2320	2475	2063	1868	1728	1573	
12S 44W	7	SWSE	PJ GERGEN #1	4346	4355	2125	2325	2525	2665	2230	2030	1830	1690	
12S 44W	10	SWSW	PFEIFER #1	4291	4300	2235	2390	2535	2660	2065	1910	1765	1640	
12S 44W	28	NENW	ALVEY #1	4307	4317	2190	2360	2495	2665	2127	1957	1822	1652	
12S 44W	31	NENE	#1 PELTO 43-31	4353	4363	2175	2350	2500	2630	2188	2013	1863	1733	
12S 44W	34	SWSW	DICKEY No 43-13	4247	4257	2100	2390	2435	2555	2157	1867	1822	1702	
12S 44W	36	NWNW	No 11-36	4202	4212	2080	2280	2420	2580	2132	1932	1792	1632	
12S 45W	13	NENE	#1 CHAMPLIN-PELTON	4373	4383	2142	2348	2548	2730	2241	2035	1835	1653	
12S 45W	24	SWNE	GERGEN-BAINER 1-24	4384	4393	2270	2460	2585	2740	2123	1933	1808	1653	
12S 45W	27	SWSW	PELTON #1	4425	4437	2185	2395	2505	2755	2252	2042	1932	1682	
12S 46W	7	NWNW	#1 SCHUTTE 11-7	4473	4483	2290	2470	2690	2885	2193	2013	1793	1598	
12S 47W	20	NWSE	#1 LILLIE 33-20	4631	4641	2280	2435	2600	2825	2361	2206	2041	1816	? BASE Kc
12S 47W	26	SWNE	SMELKER FARMS A 1-X	4598	4610	2285	2475	2640	2855	2325	2135	1970	1755	
12S 47W	31	SESW	1-31 KELLEY	4463	4475	2105	2315	2425	2600	2370	2160	2050	1875	
12S 48W	6	SENE	BAKER A-1	4824	4829	2585	2785	2888	3195	2244	2044	1941	1634	
12S 48W	18	NESW	DAVID CURE 1-18	4730	4738	2440	2670	2788	2955	2298	2068	1950	1783	
12S 48W	23	SWSW	#1 BLODER	4593	4606	2355	2560	2675	2845	2251	2046	1931	1761	

DATA FROM GEOPHYSICAL LOGS
DAKOTA/CHEYENNE AQUIFERS
EASTERN COLORADO
1994

TWN/RNG	SEC	QTR/QTR	WELL ID	ELEV. GS	ELEV MP	DEPTH TO TOP DAKOTA	DEPTH BASE DAKOTA	DEPTH TO TOP CHEY	DEPTH BASE CHEY	ELEV TOP DAKOTA	ELEV BASE DAKOTA	ELEV TOP CHEY	ELEV BASE CHEY	
12S 48W	29	SESE	WECO-IPRR 1, JOLLY 44-29	4640	4650	2330	2560	2660	2840	2320	2090	1990	1810	
12S 49W	14	NESW	OLSEN A-1	4732	4743	2450	2670	2855	3035	2293	2073	1888	1708	
12S 49W	36	NWSE	WECO-UPRC 1, JOLLY-STATE	4599	4609	2250	2485	2585	2775	2359	2124	2024	1834	
12S 50W	24	NENE	TOTAL 1-24 STATE	4760	4768	2470	2690	2800	3045	2298	2078	1968	1723	
12S 50W	28	SENW	SHADE #1	4782	4792	2475	2695	2790	2930	2317	2097	2002	1862	
12S 50W	31	SWSE	10 BLESOE 34-31	4774	4784	2432	2650	2790	2940	2352	2134	1994	1844	
12S 51W	1	SWSW	#1 CHISTOPHER 14-1	5046	5058	2845	3030	3190	3305	2213	2028	1868	1753	
12S 51W	5	NWSE	S-S-M VP KITCHELIN 1-5	5126	5135	2980	3210	3300	3425	2155	1925	1835	1710	
12S 51W	14	SWNE	BLEDSOE 7-14	4931	4943	2695	2910	3030	3215	2248	2033	1913	1728	
12S 51W	20	SWSW	S-S-M BLEDSOE 1-20	5002	5012	2785	3020	3090	3340	2227	1992	1922	1672	
12S 51W	33	NWSW	#1 WECO-UPRC GRANITE RUN	4876	4886	2570	2790	2848	3015	2316	2096	2038	1871	? BAS Kc
12S 52W	2	SWNE	STEELE A-1	5090	5099	3050	3270	3355	3510	2049	1829	1744	1589	
12S 52W	6	NWNW	SOHIO-NEWBY 6-4	5066	5075	3125	3330	3420	3680	1950	1745	1655	1395	
12S 52W	9	SWSE	VICK 1	4959	4968	2928	3140	3230	3345	2040	1828	1738	1623	
12S 52W	19	NWNE	VICK #1	4843	4853	2820	3030	3125	3265	2033	1823	1728	1588	
12S 53W	3	SENE	#1 CLAY	4911	4923	3050	3260	3340	3540	1873	1663	1583	1383	
12S 53W	6	SENE	1-6 S-S-M MELLOTT	4902	4911	3090	3295	3445	3568	1821	1616	1466	1343	
12S 53W	17	NESW	#1 BRAUKMANN FARMS H	4857	4869	2960	3150	3325	3480	1909	1719	1544	1389	
13S 42W	1	NWNE	WECO UPRC #1, ROTHER 31-1	3983	3991	2010	2200	2360	2510	1981	1791	1631	1481	
13S 42W	7	SWNW	#2 LAZY A FARMS 12-7	4023	4033	1820	2030	2165	2350	2213	2003	1868	1683	
13S 42W	15	SWNW	#1 WECO PATRICK 12-15	3932	3942	1850	2065	2010	2370	2092	1877	1932	1572	
13S 42W	26	NW	1 BILL 12E-26	3883	3893	1755	1940	2085	2255	2138	1953	1808	1638	
13S 42W	32	NE	HOWARD C-1	3972	3984	1790	1920	2245	2310	2194	2064	1739	1674	

DATA FROM GEOPHYSICAL LOGS
DAKOTA/CHEYENNE AQUIFERS
EASTERN COLORADO
1994

TWN/RNG	SEC	QTR/QTR	WELL ID	ELEV. GS	ELEV MP	DEPTH TO TOP DAKOTA	DEPTH BASE DAKOTA	DEPTH TO TOP CHEY	DEPTH BASE CHEY	ELEV TOP DAKOTA	ELEV BASE DAKOTA	ELEV TOP CHEY	ELEV BASE CHEY	
13S 43W	3	SESE	#1 STEELE 44C-3	4129	4138	2100	2290	2435	2595	2038	1848	1703	1543	
13S 43W	13	NENE	#2 CAMPBELL 41-13	3998	4008	2113	1913	1773	1593	1895	2095	2235	2415	
13S 43W	17	SWSE	#1 SHOTGUN 34-17	4096	4106	1780	1970	2106	2280	2326	2136	2000	1826	
13S 43W	25	SWSE	#2 KLEMENT 34-25	3981	3991	1760	1955	2095	2185	2231	2036	1896	1806	
13S 43W	32	SWSW	#1 A S KERN	4098	4107	2372	2187	2057	1907	1735	1920	2050	2200	
13S 43W	35	NENE	#1 UPRC-ACKERMAN	4029	4038	1680	1785	1920	2095	2358	2253	2118	1943	
13S 44W	7	NESE	#1 CHAMPLIN-WEINS	4335	4343	2110	2265	2420	2550	2233	2078	1923	1793	
13S 44W	20	NESE	NELSON 1-20	4236	4245	2045	2225	2335	2480	2200	2020	1910	1765	
13S 44W	24	NWNW	#1 KNOTT	4160	4170	1840	2000	2135	2320	2330	2170	2035	1850	
13S 44W	35	NENE	NO 1 ROTH 41-35	4173	4184	1980	2165	2280	2390	2204	2019	1904	1794	
13S 45W	10	SWSW	BLOSSER 1	4341	4350	2140	2295	2430	2580	2210	2055	1920	1770	
13S 46W	2	NWSW	BENDIXON No. 1	4495	4506	2050	2270	2435	2550	2456	2236	2071	1956	
13S 46W	7	SWSW	CHAMPLIN-SMELKER FARMS 1	4479	4488	2010	2245	2330	2530	2478	2243	2158	1958	
13S 46W	26	NWSE	#1 MOCKELMAN	4430	4442	1915	2140	2235	2365	2527	2302	2207	2077	
13S 46W	30	SWNE	#1 KENNECREEK INC.	4415	4427	1865	2120	2205	2350	2562	2307	2222	2077	
13S 47W	14	NWSE	#1 ERVIN	4406	4418	1925	2145	2230	2415	2493	2273	2188	2003	BASE Kc DIFFICULT
13S 47W	18	SENW	1-18 MITCHELL	4425	4435	1920	2130	2290	2390	2515	2305	2145	2045	BASE Kc DIFFICULT
13S 47W	25	NENW	#1 P&P DECHANT 21-25	4368	4378	1835	2075	2200	2400	2543	2303	2178	1978	THICK BASAL Kc = Jm?
13S 47W	28	NWSE	WECO-UPRC #2P, DECHANT 33-28	4348	4358	1785	2020	2170	2330	2573	2338	2188	2028	
13S 47W	31	NWSW	NO 1 SAYLES	4326	4337	1780	2000	2075	2090	2557	2337	2262	2247	
13S 48W	19	NWSE	STATE W #1	4426	4437	1920	2125	2240	2400	2517	2312	2197	2037	
13S 48W	25	NWNE	#5 WHITE 31-25	4355	4365	1800	2020	2170	2320	2565	2345	2195	2045	
13S 48W	32	NENE	4-32 RHOADES 32	4395	4404	1825	2010	2110	2235	2579	2394	2294	2169	

DATA FROM GEOPHYSICAL LOGS
DAKOTA/CHEYENNE AQUIFERS
EASTERN COLORADO
1994

TWN/RNG	SEC	QTR/QTR	WELL ID	ELEV. GS	ELEV MP	DEPTH TO TOP DAKOTA	DEPTH BASE DAKOTA	DEPTH TO TOP CHEY	DEPTH BASE CHEY	ELEV TOP DAKOTA	ELEV BASE DAKOTA	ELEV TOP CHEY	ELEV BASE CHEY
13S 49W	4	NW	WECO-UPRC #1, HAGER 11-4	4628	4638	2225	2500	2605	2735	2413	2138	2033	1903
13S 49W	13	NWNE	UPRC LANG 1	4495	4502	2004	2210	2330	2525	2498	2292	2172	1977
13S 49W	18	NWNE	WECO-UPRC #1 , ALLEN	4545	4555	2145	2380	2485	2600	2410	2175	2070	1955
13S 49W	29	SESW	CHAMPLIN-PETERSON No. 1	4484	4491	1885	2120	2255	2420	2606	2371	2236	2071
13S 49W	35	SENE	5 RHOADES 42-35	4479	4489	1880	2035	2170	2320	2609	2454	2319	2169
13S 50W	4	SENW	WILD HORSE #1	4725	4735	2355	2570	2675	2875	2380	2165	2060	1860
13S 50W	14	SESE	S-S-M PFLAZGRAF 1-14	4574	4584	2155	2400	2500	2635	2429	2184	2084	1949
13S 50W	18	NWNE	#1 WECO-UPRC SANDERS RANCH 31C	4731	4741	2325	2555	2645	2755	2416	2186	2096	1986
13S 50W	33	SENE	UPRC-WECO #1, CAPITOL 42-33	4607	4617	2025	2265	2365	2535	2592	2352	2252	2082
13S 51W	2	NENE	BLEDSOE 1	4809	4817	2510	2725	2815	2990	2307	2092	2002	1827
13S 51W	18	SWSW	SCHAFER No. 18-13	4658	4669	2300	2515	2605	2730	2369	2154	2064	1939
13S 51W	21	SENE	1-21 H&L ENTERPRIZES	4712	4722	2330	2550	2605	2705	2392	2172	2117	2017
13S 51W	24	SE	SANDERS 16-24	4694	4704	2278	2510	2605	2700	2426	2194	2099	2004
13S 52W	24	SENW	OSBORNE 22-24	4736	4748	2385	2605	2640	2790	2363	2143	2108	1958
13S 52W	33	NWNW	UPRC No. 1	4652	4663	2350	2570	2680	2836	2313	2093	1983	1827
13S 53W	32	NWNW	MOSHER No. 32-11	4795	4806	2610	2825	2890	3020	2196	1981	1916	1786
13S 53W	36	NENE	STATE 1-36	4693	4701	2435	2670	2755	2880	2266	2031	1946	1821
14S 41W	19	SENE	3 SIMPSON 22E-19	3889	3901	1675	1830	1985	2150	2226	2071	1916	1751
14S 41W	31	NWSW	No 7 PURVIS FARMS 13-31	3890	3900	1675	1855	1970	2160	2225	2045	1930	1740
14S 42W	2	NWNE	MITCHEM 2-2	3935	3945	1825	2010	2160	2315	2120	1935	1785	1630
14S 42W	7	NENE	#1 WECO-UPRC, BIRD 41-7	4020	4030	1890	2065	2200	2345	2140	1965	1830	1685
14S 42W	14	SWSE	FUNK 'C' 1	3918	3928	1810	1985	2125	2285	2118	1943	1803	1643
14S 42W	20	NENW	#1 HAROLD	3964	3978	1680	1800	1975	2125	2298	2178	2003	1853

DATA FROM GEOPHYSICAL LOGS
DAKOTA/CHEYENNE AQUIFERS
EASTERN COLORADO
1994

TWN/RNG	SEC	QTR/QTR	WELL ID	ELEV. GS	ELEV MP	DEPTH TO TOP DAKOTA	DEPTH BASE DAKOTA	DEPTH TO TOP CHEY	DEPTH BASE CHEY	ELEV TOP DAKOTA	ELEV BASE DAKOTA	ELEV TOP CHEY	ELEV BASE CHEY	
14S 42W	34	NENE	#1 WILLIAMS	3915	3925	1465	1685	1760	1940	2460	2240	2165	1985	
14S 43W	2	SWSW	KEMPLER 1-2	4034	4046	1720	1890	2030	2165	2326	2156	2016	1881	
14S 43W	22	SENW	#1 MITCHELL	4095	4107	1645	1815	1935	2045	2462	2292	2172	2062	
14S 44W	6	NENE	SWARD 1	4294	4303	1795	1980	2080	2195	2508	2323	2223	2108	
14S 44W	17	NENW	TXO/UPRC KLIESEN 1	4250	4260	2010	2200	2320	2415	2250	2060	1940	1845	
14S 44W	30	NWSE	CARROLL & SON 1-30	4275	4285	1900	2095	2205	2340	2385	2190	2080	1945	
14S 45W	8	SWSW	McKELLIPS 1	4410	4420	1880	2125	2190	2265	2540	2295	2230	2155	? BASE Kc
14S 45W	24	SWSW	SCHRAMM 1	4317	4327	1870	2025	2125	2260	2457	2302	2202	2067	
14S 46W	6	NWNE	2 WECO-UPRC MOUSEL 31-06	4349	4359	1755	1930	2080	2155	2604	2429	2279	2204	Kc ?
14S 46W	9	SESE	U P RESOURCES CO. FEE 1-9	4472	4482	1830	2070	2170	2310	2652	2412	2312	2172	
14S 46W	21	NESW	GROUSE 21-1	4503	4513	1850	2030	2165	2290	2663	2483	2348	2223	DIFFICULT Kc
14S 46W	31	SESW	BOGENHAGEN 1	4357	4366	1650	1865	1980	2030	2716	2501	2386	2336	THINNING Kc
14S 47W	3	NESE	#1 GEORGE 43-3	4292	4302	1680	1925	2020	2245	2622	2377	2282	2057	
14S 47W	6	SESE	#1 M T RANDOLPH 44-6	4284	4294	1650	1840	1970	2155	2644	2454	2324	2139	
14S 47W	14	SENE	STORMIN NORMIN #1	4303	4314	1635	1830	1950	2100	2679	2484	2364	2214	BASE Kc ?
14S 47W	30	NENE	#1 WECO-UPRC DECHANT 41-30	4233	4243	1515	1710	1835	2010	2728	2533	2408	2233	
14S 48W	4	NWSW	#1 BETSCHART 13-4	4366	4376	1740	1900	2040	2225	2636	2476	2336	2151	
14S 48W	11	SWSW	SMIRNOFF-MITCHEK 14-11	4295	4304	1615	1830	1925	2115	2689	2474	2379	2189	
14S 48W	16	SESE	1-16 STATE CULLEN	4292	4301	1600	1755	1900	2075	2701	2546	2401	2226	
14S 48W	31	NWNE	10 MITCHEK 31-3	4329	4339	1715	1885	2030	2210	2624	2454	2309	2129	
14S 48W	35	NENE	1-36 STATE-COLLINS RANCH	4233	4242	1500	1690	1850	2080	2742	2552	2392	2162	
14S 49W	4	NWNW	#1 McCORMICK	4475	4484	1815	2070	2180	2380	2669	2414	2304	2104	
14S 49W	11	SENE	#1 RHOADES	4436	4445	1785	1985	2090	2315	2660	2460	2355	2130	

DATA FROM GEOPHYSICAL LOGS
DAKOTA/CHEYENNE AQUIFERS
EASTERN COLORADO
1994

TWN/RNG	SEC	QTR/QTR	WELL ID	ELEV. GS	ELEV MP	DEPTH TO TOP DAKOTA	DEPTH BASE DAKOTA	DEPTH TO TOP CHEY	DEPTH BASE CHEY	ELEV TOP DAKOTA	ELEV BASE DAKOTA	ELEV TOP CHEY	ELEV BASE CHEY	
14S 49W	20	NWSW	REED 20-11	4453	4461	1710	1905	2000	2260	2751	2556	2461	2201	
14S 50W	1	SENW	WILKERSON D-1	4532	4541	1865	2115	2265	2405	2676	2426	2276	2136	
14S 50W	13	SWSW	#1 SAYLES	4493	4502	1755	1960	2020	2175	2747	2542	2482	2327	
14S 51W	10	SESE	1-10 KUHN	4524	4534	1905	2130	2250	2380	2629	2404	2284	2154	
14S 51W	19	SWNW	#1 MAUER	4689	4698	2090	2325	2420	2520	2608	2373	2278	2178	
14S 51W	22	NWSE	#1 IBERG	4508	4520	1830	2070	2175	2320	2690	2450	2345	2200	
14S 51W	32	NESE	CAGE A-1	4656	4666	1945	2155	2265	2465	2721	2511	2401	2201	SOME Jm INC IN Kc
14S 52W	10	SWSW	1-10 HOC	4754	4763	2255	2465	2565	2780	2508	2298	2198	1983	
14S 52W	19	NESW	PALMER A-1	4761	4770	2260	2460			2510	2310			Kc OMITTED--DIFFICULT
14S 53W	12	NENE	ROSS #1	4783	4791	2485	2700	2790	2990	2306	2091	2001	1801	
15S 41W	6	NENE	STEELE B-2	3916	3926	1510	1710	1825	1915	2416	2216	2101	2011	
15S 41W	7	SESE	#2 ELMER AKERS 14-7	3946	3957	1530	1710	1865	1990	2427	2247	2092	1967	
15S 41W	19	SWNW	#5 WHITE 120-19	3938	3949	1475	1670	1820	1945	2474	2279	2129	2004	
15S 41W	30	NENE	PHEASANT TRAIL 30-1	3925	3936	1475	1665	1815	1875	2461	2271	2121	2061	
15S 42W	2	NENE	ALLEN 2-1	3933	3943	1530	1700	1835	2015	2413	2243	2108	1928	
15S 42W	4	SENE	MULL No. 1, ROTHER	3943	3955	1605	1795	1940	2105	2350	2160	2015	1850	
15S 42W	16	SESE	STATE-HULL No. 1	4019	4031	1520	1705	1855	1995	2511	2326	2176	2036	
15S 42W	24	NENW	#1 MAUL	3956	3967	1495	1700	1840	1995	2472	2267	2127	1972	
15S 42W	32	SWNE	32-1 KRISS	4037	4042	1475	1660	1810	1950	2567	2382	2232	2092	
15S 42W	34	SWNE	#1 FUNK	3982	3994	1435	1635	1775	1920	2559	2359	2219	2074	
15S 44W	6	NW	HOFFMAN-URBAN 6-3	4286	4296	1695	1915	2010	2110	2601	2381	2286	2186	
15S 44W	10	NENE	HEINZ #1	4198	4208	1665	1800	1925	1980	2543	2408	2283	2228	DIFFICULT Kc
15S 44W	17	SESE	No. 1 CHAMPLIN-HEINZ	4291	4299	1660	1860	1955	2085	2639	2439	2344	2214	

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TWN/RNG	SEC	QTR/QTR	WELL ID	ELEV. GS	ELEV MP	DEPTH TO TOP DAKOTA	DEPTH BASE DAKOTA	DEPTH TO TOP CHEY	DEPTH BASE CHEY	ELEV TOP DAKOTA	ELEV BASE DAKOTA	ELEV TOP CHEY	ELEV BASE CHEY	
15S 45W	1	SWSE	No. 1 YELTSIN	4304	4312	1765	1980	2095	2250	2547	2332	2217	2062	
15S 45W	14	SWSW	ARDREY 1	4354	4363	1720	1910	2010	2140	2643	2453	2353	2223	
15S 45W	20	NENE	SAMPSON 1	4386	4398	1695	1920	1995	2060	2703	2478	2403	2338	
15S 45W	26	SWNW	DOLFI-JONES 1	4352	4361	1645	1875	1975	2080	2716	2486	2386	2281	
15S 45W	33	NWNW	CHAMPLIN SS $ N. FARMS INC. #1	4289	4299	1495	1630	1745	1870	2804	2669	2554	2429	
15S 46W	6	SENW	STEVENS 1-6	4359	4370	1620	1845	1940	2060	2750	2525	2430	2310	
15S 46W	10	NW	BAIN 1	4525	4534	1860	2015	2130	2165	2674	2519	2404	2369	
15S 46W	17	SENW	2X ROTHER 22-17	4330	4340	1550	1750	1870	2025	2790	2590	2470	2315	
15S 46W	23	SESW	LARSON No. 1 RDD	4474	4484	1700	1930	2025	2135	2784	2554	2459	2349	
15S 47W	1	SENE	#1 IRENE 42-1	4359	4369	1625	1855	1940	2075	2744	2514	2429	2294	
15S 47W	6	SESE	SSM No 1-6 TXD DRAN	4204	4213	1415	1610	1760	1935	2798	2603	2453	2278	
15S 48W	5	SENE	SSM-UPRR 1-5	4294	4305	1520	1735	1875	2020	2785	2570	2430	2285	
15S 48W	14	NWSW	JELINEK 14-13	4233	4245	1385	1595	1745	1950	2860	2650	2500	2295	DIFFICULT Kc
15S 48W	34	SWSE	M. SELL 1	4235	4244	1275	1540	1675	1840	2969	2704	2569	2404	
15S 49W	1	NWSW	#1 WECO COLLINS RANCH 13-1	4338	4348	1550	1745	1880	2065	2798	2603	2468	2283	DIFFICULT Kc
15S 49W	12	NENW	COLLINS RANCH A-1	4293	4303	1465	1665	1780	1990	2838	2638	2523	2313	
15S 49W	26	SESE	COGC No. 1 LIESEN	4344	4352	1405	1620	1775	1920	2947	2732	2577	2432	
15S 49W	30	SENW	SSM KELLER 1-30	4454	4465	1520	1715	1725	2025	2945	2750	2740	2440	
15S 50W	1	NWNW	STEWART A-1	4392	4402	1580	1785	1965	2120	2822	2617	2437	2282	
15S 50W	4	NENE	#1 CSU MINPOOL A	4504	4516	1750	1955	2075	2255	2766	2561	2441	2261	
15S 50W	36	NWNW	#1 STATE-KELLER	4407	4419	1460	1645	1720	1920	2959	2774	2699	2499	
15S 51W	24	NESW	No. 1 CAGE RANCH	4489	4501	1560	1760	1850	1980	2941	2741	2651	2521	
15S 52W	8	NENE	HOC 1-8	4760	4770	2125	2320	2485	2630	2645	2450	2285	2140	DIFFICULT LOG

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TWN/RNG	SEC	QTR/QTR	WELL ID	ELEV. GS	ELEV MP	DEPTH TO TOP DAKOTA	DEPTH BASE DAKOTA	DEPTH TO TOP CHEY	DEPTH BASE CHEY	ELEV TOP DAKOTA	ELEV BASE DAKOTA	ELEV TOP CHEY	ELEV BASE CHEY	
15S 52W	14	NENE	HOC 1-14	4655	4665	1900	2095	2190	2430	2765	2570	2475	2235	
15S 52W	31	NWNW	KINZIE ET et al 1-31	4597	4607	1875	2060	2140	2260	2732	2547	2467	2347	
16S 41W	6	SESW	#1 JUNE EVANS	3954	3963	1480	1625	1790	1935	2483	2338	2173	2028	
16S 41W	18	NESW	KRISS A-3	3955	3963	1440	1585	1710	1880	2523	2378	2253	2083	
16S 42W	13	SWSE	#3 TEAGUE 34-13	3967	3977	1495	1590	1720	1880	2482	2387	2257	2097	
16S 42W	21	NENE	#1 WECO SCHNEIDER 41-21	4127	4137	1415	1630	1710	1815	2722	2507	2427	2322	DIFFICULT LOG
16S 42W	23	SESE	#1 CL EVANS 44-23	3969	3979	1390	1540	1670	1820	2589	2439	2309	2159	
16S 42W	26	SWSE	COX V No. 1	3962	3970	1365	1520	1645	1780	2605	2450	2325	2190	UPPER Jm VERY SANDY
16S 43W	9	NWNW	TEXACO-UPRR A-1	4151	4161	1450	1660	1780	1880	2711	2501	2381	2281	ASSUMED BASE FOR Kc
16S 43W	24	NWSE	#1 ROTHER 31-24	4051	4061	1415	1585	1705	1850	2646	2476	2356	2211	
16S 44W	24	NENE	#1 NEHRING 41-24	4208	4218	1455	1660	1750	1880	2763	2558	2468	2338	
16S 44W	30	SWSW	#1 ASHER	4289	4299	1465	1670	1875	1920	2834	2629	2424	2379	THIN Kc
16S 45W	1	SWSW	UPRR NININGER 14-1	4329	4338	1620	1855	1930	1980	2718	2483	2408	2358	THINING Kc IN THIS AREA
16S 45W	6	SESE	PAUL FORWARD 6-1	4324	4334	1560	1795	1865	1920	2774	2539	2469	2414	
16S 45W	18	NWNE	#2 KERN LAND 2A-18	4312	4322	1575	1755	1835	1890	2747	2567	2487	2432	
16S 45W	25	SENE	CPC 1 TALLMAN 42-25	4285	4294	1450	1680	1750	1815	2844	2614	2544	2479	THIN Kc
16S 45W	29	SENE	#1 PETE 42-29	4202	4213	1370	1610	1615	1710	2843	2603	2598	2503	Kc VERY THIN OR ABSENT
16S 46W	10	SWSW	MOCKELMANN 10-13	4208	4213	1390	1645	1680	1710	2823	2568	2533	2503	Kc VERY THIN OR ABSENT
16S 46W	13	NENE	31 penski 41-13	4266	4278	1465	1730	1770	1795	2813	2548	2508	2483	Kc VERY THIN OR ABSENT
16S 46W	28	SWSW	BAUGHMANN FARMS	4112	4125	1200	1395	1505	1525	2925	2730	2620	2600	Kc VERY THIN OR ABSENT
16S 47W	12	NWSE	#1 ILLMORE 33-12	4133	4143	1235	1475	1590	1620	2908	2668	2553	2523	Kc THIN
16S 47W	20	C	TEMPLE E-1	4179	4190	1185	1400	1490	1625	3005	2790	2700	2565	
16S 47W	26	NENE	#1 RHOADES 41-26	4080	4090	1115	1330	1390	1495	2975	2760	2700	2595	

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TWN/RNG	SEC	QTR/QTR	WELL ID	ELEV. GS	ELEV MP	DEPTH TO TOP DAKOTA	DEPTH BASE DAKOTA	DEPTH TO TOP CHEY	DEPTH BASE CHEY	ELEV TOP DAKOTA	ELEV BASE DAKOTA	ELEV TOP CHEY	ELEV BASE CHEY	
16S 47W	32	SESE	CLEAVES 16-32-26	4129	4137	1280	1505	1610	1760	2857	2632	2527	2377	
16S 48W	10	SESE	CUNNINGHAM 10-1	4216	4242	1260	1470	1590	1810	2982	2772	2652	2432	Kc INCLUDES SOME Jm
16S 48W	12	SENW	#1 CHEYENNE STATE	4216	4225	1260	1485	1630	1820	2965	2740	2595	2405	Kc INCLUDES SOME Jm
16S 48W	24	NENE	Mc EVENS # 1	4209	4220	1210	1425	1515	1725	3010	2795	2705	2495	
16S 48W	28	SENE	#1 KLEIBOEKER 1	4226	4235	1155	1370	1465	1635	3080	2865	2770	2600	
16S 48W	36	SWSE	TERND STATE MOBILE #1	4166	4176	1080	1245	1400	1650	3096	2931	2776	2526	
16S 49W	36	NWSE	#1 STATE Mc BRYDE	4320	4332	1190	1380	1480	1535	3142	2952	2852	2797	TIGHT Jm
16S 51W	22	SENW	#1 MORGAN	4543	4555	1505	1690	1790	1830	3050	2865	2765	2725	DIFFICULT KIOWA
16S 52W	24	NWNW	#1 BENZ 11-24	4653	4663	1730	2025	2070	2080	2933	2638	2593	2583	VERY THIN Kc
16S42 W	34	SESE	COX S No.1	3955	3963	1310	1480	1600	1765	2653	2483	2363	2198	
17S 41W	19	NWNW	#1 DAY 11-9	3871	3881	1215	1390	1510	1630	2666	2491	2371	2251	
17S 42W	1	SE	#2 MARGUERITE 44-1	3919	3930	1295	1490	1605	1770	2635	2440	2325	2160	
17S 42W	10	SWNW	#1 WECO CLIFF 12A-10	3960	3970	1280	1455	1570	1740	2690	2515	2400	2230	
17S 42W	17	NWNW	#1 ASH 11-17	3998	4008	1295	1480	1585	1735	2713	2528	2423	2273	
17S 42W	26	NWNW	#1 TRAVELERS	3920	3930	1240	1455	1555	1700	2690	2475	2375	2230	
17S 42W	30	NENW	CROCKETT #1	4005	4013	1265	1410	1545	1720	2748	2603	2468	2293	
17S 42W	35	NWSE	TUTTLE 33-35	3957	3967	1225	1410	1540	1690	2742	2557	2427	2277	
17S 43W	1	NWSW	1-1 LAKE ALBERT	4042	4052	1350	1515	1630	1695	2702	2537	2422	2357	POOR LOG Kc THIN
17S 43W	27	SESE	1-27 BELLER-FOLTZ	4051	4060	1225	1390	1520	1585	2835	2670	2540	2475	Kc THIN
17S 43W	32	NWNW	#1 LIBERA 11-32	4164	4174	1290	1520	1620	1720	2884	2654	2554	2454	Kc MAY INCLUDE SOME Jm
17S 45W	5	NENE	TRAIL 41H-5	4126	4136	1220	1430	1545	1680	2916	2706	2591	2456	
17S 45W	14	NENE	FRAZEE 1	4172	4179	1300	1550	1665	1770	2879	2629	2514	2409	DIFFICULT LOG
17S 45W	28	SESE	TENNELL #1	3971	3981	1060	1275	1370	1530	2921	2706	2611	2451	

DATA FROM GEOPHYSICAL LOGS
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TWN/RNG	SEC	QTR/QTR	WELL ID	ELEV. GS	ELEV MP	DEPTH TO TOP DAKOTA	DEPTH BASE DAKOTA	DEPTH TO TOP CHEY	DEPTH BASE CHEY	ELEV TOP DAKOTA	ELEV BASE DAKOTA	ELEV TOP CHEY	ELEV BASE CHEY	
17S 45W	36	SWSW	STATE 1-36	4026	4037	1080	1300	1400	1510	2957	2737	2637	2527	
17S 46W	2	SWSW	BETTY 2-1	4068	4078	1155	1370	1415	1445	2923	2708	2663	2633	THIN Kc
17S 46W	8	NWNW	GOLDEN RULE #1	4049	4059	1120	1330	1425	1525	2939	2729	2634	2534	BASE Kc ?
17S 46W	34	SESW	1-34 BUCKLEN	4040	4048	975	1200	1285	1415	3073	2848	2763	2633	
17S 47W	2	NENE	BOWEN #1	4085	4095	1130	1345	1405	1530	2965	2750	2690	2565	
17S 47W	24	NWNW	NEWSHAM HYBRIDS	4038	4038	1004	1210	1284	1394	3034	2828	2754	2644	
17S 47W	28	NWNE	#1 SPOILER 31-28	4125	4135	1040	1275	1335	1480	3095	2860	2800	2655	
17S 47W	31	NENW	HIGHTOWER #1	4158	4168	1150	1370	1470	1600	3018	2798	2698	2568	
17S 48W	2	SWSW	OWENS #1	4193	4203	1030	1250	1350	1580	3173	2953	2853	2623	
17S 48W	8	SWSW	THOMPSON #1	4280	4289	1065	1270	1430	1560	3224	3019	2859	2729	
17S 48W	13	SWNE	WILLIE Jr.1	4210	4220	1155	1360	1430	1530	3065	2860	2790	2690	
17S 49W	21	SWSE	No. 1 U P BERRY	4383	4393	1170	1360	1530	1655	3223	3033	2863	2738	
17S 49W	25	SESE	No. 1 CHAMPLIN-GREENWELL	4340	4350	1320	1520	1605	1710	3030	2830	2745	2640	
17S 49W	36	SESE	FERGUS-STATE 1-36	4301	4310	1250	1455	1540	1640	3060	2855	2770	2670	
17S 50W	14	SWSW	#1 UNITED BANK	4462	4474	1340	1530	1630	1770	3134	2944	2844	2704	
17S 50W	31	SWSE	#1 UPRC-RUST	4467	4479	1255	1435	1515	1595	3224	3044	2964	2884	
17S 50W	32	SWSW	#1 PECK	4453	4465	1230	1430	1515	1625	3235	3035	2950	2840	
17S 51W	18	NWNW	BLAKEMORE 11-18	4647	4657	1520	1680	1725	1855	3137	2977	2932	2802	
17S 52W	1	SWSE	BLAKEMORE 1-1	4662	4672	1530	1685	1800	1865	3142	2987	2872	2807	
17S 52W	12	NWNE	BLAKEMORE 1-12	4656	4667	1540	1705	1800	1845	3127	2962	2867	2822	THIN Kc
17S 53W	6	NWNW	FLB et al 6-1	4627	4636	1880	2000	2130	2215	2756	2636	2506	2421	FAULTED OR LOCATION ERROR
17S 53W	22	NWNW	D-4 RANCH 22-1	4527	4536	1585	1710	1785	1860	2951	2826	2751	2676	
18S 41W	6	SWSW	LAS ANIMAS 1	3958	3967	1210	1405	1520	1610	2757	2562	2447	2357	

DATA FROM GEOPHYSICAL LOGS
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TWN/RNG	SEC	QTR/QTR	WELL ID	ELEV. GS	ELEV MP	DEPTH TO TOP DAKOTA	DEPTH BASE DAKOTA	DEPTH TO TOP CHEY	DEPTH BASE CHEY	ELEV TOP DAKOTA	ELEV BASE DAKOTA	ELEV TOP CHEY	ELEV BASE CHEY	
18S 41W	17	NWNW	WILLIAMS # 1	3894	3904	1150	1325	1455	1525	2754	2579	2449	2379	
18S 41W	29	NESE	MAURINE # 1	3878	3890	1085	1230	1390	1445	2805	2660	2500	2445	
18S 42W	3	SENE	WEBER 1-3	3961	3971	1220	1410	1530	1655	2751	2561	2441	2316	
18S 42W	6	NESW	Mc DANIELS 1	4034	4046	1220	1445	1530	1665	2826	2601	2516	2381	
18S 42W	16	SWSE	#1 STATE	3978	3990	1165	1425	1480	1610	2825	2565	2510	2380	
18S 42W	25	SESE	TOWER 1-25	3916	3928	1085	1265	1380	1470	2843	2663	2548	2458	
18S 42W	31	NWNE	TAYLOR 1-31	4035	4040	1150	1380	1460	1570	2890	2660	2580	2470	
18S 43W	8	SENW	BOEKEN #1	4175	4184	1180	1385	1485	1600	3004	2799	2699	2584	
18S 43W	13	SW	Mc NEIL 1-13	4047	4056	1170	1370	1465	1565	2886	2686	2591	2491	
18S 43W	25	NENE	TAYLOR 1-25	4039	4047	1180	1350	1500	1620	2867	2697	2547	2427	
18S 43W	33	NWSW	BAUGHMAN FARMS 33-12	4080	4090	1210	1430	1490	1565	2880	2660	2600	2525	THIN Kc
18S 44W	5	NWNE	1 UPRC JAGEE	4067	4079	1090	1345	1405	1575	2989	2734	2674	2504	
18S 44W	17	NENE	JAMES GARVEY #1	4017	4029	1085	1320	1420	1575	2944	2709	2609	2454	
18S 44W	22	SESW	JAMES GARVEY 1-22	4065	4075	1190	1435	1480	1610	2885	2640	2595	2465	DIFFICULT LOG
18S 44W	33	NWNE	LAS ANIMAS MINERALS 1	4067	4077	1110	1225	1345	1440	2967	2852	2732	2637	
18S 45W	2	SWSW	1-2 TALLMAN	3980	3989	950	1100	1205	1305	3039	2889	2784	2684	
18S 45W	7	SWSW	#1 POLLIE ROY BURROWS	3968	3976	950	1180	1245	1355	3026	2796	2731	2621	
18S 45W	23	NWSE	TALLMAN 23-3	3939	3946	850	1020	1090	1180	3096	2926	2856	2766	
18S 45W	29	NWSW	FLUKE CGA No 1-29	3890	3901	750	975	1055	1185	3151	2926	2846	2716	
18S 45W	34	NENE	WEAR 1	3924	3929	800	1040	1105	1235	3129	2889	2824	2694	Jm SANDY, DIFFICULT
18S 46W	3	NWNW	BARLOW 1-3	4036	4044	965	1185	1240	1370	3079	2859	2804	2674	
18S 46W	12	NWSE	10-12 FEDERAL LAND BANK	4023	4033	970	1110	1265	1370	3063	2923	2768	2663	
18S 46W	14	NENW	BARLOW	3988	3988	895	1085	1190	1295	3093	2903	2798	2693	

DATA FROM GEOPHYSICAL LOGS
DAKOTA/CHEYENNE AQUIFERS
EASTERN COLORADO
1994

TWN/RNG	SEC	QTR/QTR	WELL ID	ELEV. GS	ELEV MP	DEPTH TO TOP DAKOTA	DEPTH BASE DAKOTA	DEPTH TO TOP CHEY	DEPTH BASE CHEY	ELEV TOP DAKOTA	ELEV BASE DAKOTA	ELEV TOP CHEY	ELEV BASE CHEY	
18S 46W	16	NWSE	WALTER STATE 1	3952	3961	830	1020	1125	1230	3131	2941	2836	2731	
18S 46W	25	NENW	CHIVINGTON GRAZING ASSOC, 1-25	3992	4001	875	1115	1185	1335	3126	2886	2816	2666	DIFFICULT
18S 47W	4	NENE	#1 RAYMOND 41-4	4123	4133	1035	1240	1325	1420	3098	2893	2808	2713	
18S 47W	17	SESW	#1 MARTIN 24-17	4166	4176	1085	1315	1395	1480	3091	2861	2781	2696	
18S 47W	23	NWSE	LEWIS #1	4083	4092	955	1160	1285	1485	3137	2932	2807	2607	
18S 47W	33	NENE	MERRICK E-1	4108	4117	895	1095	1185	1320	3222	3022	2932	2797	
18S 48W	28	SWSW	FILSON 1-28	4221	4231	1075	1298	1370	1510	3156	2933	2861	2721	
18S 48W	36	SESE	STATE-FERGUS #1	4144	4153	895	1090	1165	1220	3258	3063	2988	2933	
18S 49W	16	SWSE	#1 STATE-DAVIS	4330	4335	1050	1275	1325	1520	3285	3060	3010	2815	Kc MAY INCLUDE SOME Jm
18S 49W	27	NWNE	BLACK #1	4252	4262	940	1140	1210	1320	3322	3122	3052	2942	Kc MAY INCLUDE SOME Jm
18S 49W	31	NESE	LEMON #1	4321	4332	995	1145	1185	1230	3337	3187	3147	3102	DIFFICULT
18S 50W	5	NW	#1 UPRC ALDRICH	4438	4446	1210	1400	1485	1620	3236	3046	2961	2826	Kc MAY INCLUDE SOME Jm
18S 50W	23	NWSE	NEUFIELD #1	4283	4292	980	1170	1250	1380	3312	3122	3042	2912	Kc MAY INCLUDE SOME Jm
18S 50W	30	SENW	BAUGHMAN #1	4474	4484	1055	1225	1265	1380	3429	3259	3219	3104	Kc MAY INCLUDE SOME Jm
18S 51W	22	SESW	STOKER 1-22	4513	4524	1165	1340	1395	1535	3359	3184	3129	2989	
18S 51W	25	SWSW	SALISBURY 1-25	4493	4503	1100	1265	1305	1445	3403	3238	3198	3058	
18S 51W	35	NWNE	DEAR 1-35	4485	4495	1050	1225	1285	1385	3445	3270	3210	3110	LOG LOCATION WRONG
18S 52W	4	SESE	#1 WAGNOR F-X	4613	4618	1555	1690	1780	1960	3063	2928	2838	2658	FAULTED? THICK Kc/Jm
18S 52W	6	NWNW	FEDERAL 1-6	4618	4627	1520	1640	1785	1855	3107	2987	2842	2772	
18S 52W	32	NWSE	LUEKING 1-32	4430	4440	1265	1440	1515	1635	3175	3000	2925	2805	
18S 53W	22	NESW	23-22 JOHNSTON	4428	4437	1415	1585	1625	1755	3022	2852	2812	2682	
19S 41W	5	SWSW	MAVERICK 1-5	3895	3903	1060	1220	1350	1450	2843	2683	2553	2453	
19S 41W	31	NWSW	COGC 1-31-19-41 YOUNG	3855	3864	935	1160	1230	1315	2929	2704	2634	2549	DIFFICULT Kc

DATA FROM GEOPHYSICAL LOGS
DAKOTA/CHEYENNE AQUIFERS
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TWN/RNG	SEC	QTR/QTR	WELL ID	ELEV. GS	ELEV MP	DEPTH TO TOP DAKOTA	DEPTH BASE DAKOTA	DEPTH TO TOP CHEY	DEPTH BASE CHEY	ELEV TOP DAKOTA	ELEV BASE DAKOTA	ELEV TOP CHEY	ELEV BASE CHEY	
19S 42W	8	NENE	ANDREWS 1-8	3950	3960	1080	1310	1395	1480	2880	2650	2565	2480	DIFFICULT Kc
19S 42W	13	SWSW	T-LL #1-13X	3899	3904	1025	1250	1350	1405	2879	2654	2554	2499	
19S 42W	20	SENW	T-LL #1-20	3964	3974	1095	1295	1390	1470	2879	2679	2584	2504	
19S 42W	25	SE	POLTERA 1	3867	3879	1020	1220	1315	1390	2859	2659	2564	2489	
19S 44W	5	NENE	ANSCHUTZ 1-5	4053	4062	1050	1250	1360	1430	3012	2812	2702	2632	VERY DIFFICULT Kc
19S 44W	10	NWSW	MOBIL 1-10	4118	4128	1110	1330	1410	1500	3018	2798	2718	2628	
19S 44W	21	NWNW	1-21 LAS ANIMAS MINERALS	4084	4096	1000	1190	1665	1410	3096	2906	2431	2686	DIFFICULT Kd
19S 44W	26	SWSW	#1 MOBIL	4132	4142	1075	1260	1355	1430	3067	2882	2787	2712	
19S 45W	2	SWNE	#3 BAUGHMAN	3937	3947	870	1000	1075	1180	3077	2947	2872	2767	
19S 45W	9	NENE	HARRISON #2	3902	3910	730	1000	1070	1170	3180	2910	2840	2740	
19S 45W	19	NESE	#1 KIOWA GRAZING ASSOCIATION	3838	3844	670	855	905	980	3174	2989	2939	2864	DIFFICULT Kc
19S 45W	22	SWNW	BARBER FARMS 1-22	3980	3990	770	920	1000	1090	3220	3070	2990	2900	POOR LOG
19S 45W	34	SWSW	BAUGHMAN FARMS No. G-1	3939	3947	815	1065	1150	1205	3132	2882	2797	2742	
19S 46W	5	SENE	REINHARDT-MICHEL 1-5	3998	4008	885	1105	1180	1260	3123	2903	2828	2748	
19S 46W	21	SENW	PYLES 1-21	3964	3975	770	1010	1085	1210	3205	2965	2890	2765	
19S 46W	24	NWNE	BAXTER 1-24	3843	3850	610	830	910	1005	3240	3020	2940	2845	
19S 46W	32	SENW	STATE OF COLORADO 1-32	4029	4038	875	1125	1200	1300	3163	2913	2838	2738	
19S 46W	35	SWSE	KCGA #1	3790	3800	540	750	830	935	3260	3050	2970	2865	
19S 47W	4	NENE	C.D. NEESE No.1	4103	4113	875	1105	1180	1295	3238	3008	2933	2818	
19S 47W	7	NESW	ARNOLD BARTON 1	4041	4046	815	1010	1155	1300	3231	3036	2891	2746	
19S 47W	16	SWSE	HAWKS 2-16 STATE	4067	4076	825	1030	1100	1230	3251	3046	2976	2846	SANDY KIOWA
19S 47W	29	NENE	SPRING STATE 1-29	3988	3997	730	940	1030	1150	3267	3057	2967	2847	SANDY KIOWA
19S 47W	34	NWNW	1-34 LOUTHAN	3992	4003	635	870	980	1120	3368	3133	3023	2883	

DATA FROM GEOPHYSICAL LOGS
DAKOTA/CHEYENNE AQUIFERS
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TWN/RNG	SEC	QTR/QTR	WELL ID	ELEV. GS	ELEV MP	DEPTH TO TOP DAKOTA	DEPTH BASE DAKOTA	DEPTH TO TOP CHEY	DEPTH BASE CHEY	ELEV TOP DAKOTA	ELEV BASE DAKOTA	ELEV TOP CHEY	ELEV BASE CHEY	
19S 48W	8	SESE	La VELLE 1	4074	4086	895	1100	1160	1260	3191	2986	2926	2826	Kc MAY INCLUDE SOME Kk
19S 48W	13	SESE	#1 PYLES ESTATE "A"	3970	3980	845	1060	1105	1215	3135	2920	2875	2765	
19S 48W	28	NESW	STATE 475-S No. 2	4003	4013	610	815	895	1045	3403	3198	3118	2968	SANDY Jm
19S 48W	35	SESW	HULTEEN No. 1	3934	3944	690	890	960	1095	3254	3054	2984	2849	
19S 49W	5	SWNE	HASWELL FARMS 1-5	4248	4258	1010	1160	1250	1445	3248	3098	3008	2813	DIFFICULT
19S 49W	23	SENE	LARSON 1-A	4219	4229	905	1065	1130	1325	3324	3164	3099	2904	DIFFICULT, INCLU. SOME Jl
19S 49W	28	NWSE	28-10 FRANCES E. COX et al	4241	4250	940	1135	1230	1350	3310	3115	3020	2900	
19S 49W	31	NENE	COX L-1	4252	4262	835	1020	1145	1265	3427	3242	3117	2997	
19S 50W	3	SWSE	FRAZEE 1-3	4326	4336	945	1120	1205	1310	3391	3216	3131	3026	
19S 50W	6	NWNW	FRAZEE 2-6	4448	4459	1015	1180	1255	1355	3444	3279	3204	3104	
19S 50W	13	SWNE	KOONTZ "A" No.1	4338	4343	950	1145	1250	1330	3393	3198	3093	3013	
19S 50W	27	NENE	NELSON No.1	4405	4414	955	1140	1195	1260	3459	3274	3219	3154	
19S 50W	32	SESE	1-32 SHOTTON	4396	4406	1015	1260	1290	1370	3391	3146	3116	3036	
19S 51W	1	NWNE	LAS ANIMAS 1-1	4468	4478	1030	1195	1255	1365	3448	3283	3223	3113	
19S 51W	10	SENE	KIMCO 1	4491	4501	1035	1210	1285	1415	3466	3291	3216	3086	Kc INCLUDES SOME Jm
19S 51W	29	NWSW	1-29 WEBSTER	4278	4285	820	970	1010	1055	3465	3315	3275	3230	
19S 52W	8	NENE	P.L. REED 1	4382	4391	1080				3311				POOR LOG
19S 53W	33	NWNE	PHILIPY 1	4238	4248	930	1095	1120	1220	3318	3153	3128	3028	
20S 41W	19	NESW	01-19 BERNDT	3797	3806	965	1190	1265	1340	2841	2616	2541	2466	
20S 42W	16	SWSW	BUFFALO STATE 1-16	3857	3866	1050	1270	1380	1445	2816	2596	2486	2421	
20S 42W	20	SWSW	REINERT 2-20	3905	3917	1090	1330	1420	1495	2827	2587	2497	2422	
20S 42W	31	NWSW	FENTON 3-31	3862	3871	1050	1245	1305	1370	2821	2626	2566	2501	
20S 43W	4	NWSE	PREISSER RANCH UNIT 1	4065	4075	1025	1205	1262	1320	3050	2870	2813	2755	

DATA FROM GEOPHYSICAL LOGS
DAKOTA/CHEYENNE AQUIFERS
EASTERN COLORADO
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TWN/RNG	SEC	QTR/QTR	WELL ID	ELEV. GS	ELEV MP	DEPTH TO TOP DAKOTA	DEPTH BASE DAKOTA	DEPTH TO TOP CHEY	DEPTH BASE CHEY	ELEV TOP DAKOTA	ELEV BASE DAKOTA	ELEV TOP CHEY	ELEV BASE CHEY	
20S 43W	14	NWNW	SW INSTRUMENT CO.	4005	4015	1125	1370	1410	1510	2890	2645	2605	2505	
20S 43W	26	NWSE	PAULIN 1-26	3930	3940	1080	1315	1340	1385	2860	2625	2600	2555	? Kc, VERY DIFFICULT
20S 43W	35	SWSE	HALLOCK 1-35	3883	3892	1105	1325	1360	1460	2787	2567	2532	2432	
20S 44W	3	SESE	COFFMAN 1-3	4039	4051	975	1040	1210	1295	3076	3011	2841	2756	
20S 44W	11	NENE	W.E. LIERLEY etal 2-11	4033	4045	940	1115	1180	1325	3105	2930	2865	2720	Kc MAY INCLUDE SOME Jm
20S 44W	11	SWNW	DORSETT 3	4023	4035	905	1090	1155	1245	3130	2945	2880	2790	Kc BASE GOOD
20S 44W	15	NENE	TOOKE	3963	3974	820	990	1065	1155	3154	2984	2909	2819	Kc BASE GOOD
20S 44W	28	SENE	1-28 HOLMES	3853	3865	930	1180	1250	1380	2935	2685	2615	2485	
20S 45W	6	SENW	LAS ANIMAS MINERALS 1-6	3810	3815	600	785	855	940	3215	3030	2960	2875	
20S 45W	16	NENW	1-16 STATE	3847	3856	735	915	955	980	3121	2941	2901	2876	THIN Kc
20S 45W	30	SWNE	nO. 1 MARBLE	3781	3790	600	815	885	970	3190	2975	2905	2820	
20S 45W	31	SWNE	CORNELSON	3728	3740	655	895	955	1030	3085	2845	2785	2710	
20S 46W	9	NESW	HATCHER 1	3928	3937	615	820	895	975	3322	3117	3042	2962	
20S 46W	13	SESW	EDGAR 24-13	3745	3754	460	665	765	830	3294	3089	2989	2924	Kc THIN
20S 46W	25	NESW	FEDERAL 1	3747	3757	560	790	870	995	3197	2967	2887	2762	SALINE WATER?
20S 46W	32	SESE	GENTZ 1	3900	3910	505	730	785	865	3405	3180	3125	3045	
20S 46W	34	NWNW	THOMAS 1-34	3881	3890	515	720	800	950	3375	3170	3090	2940	
20S 47W	1	SESW	STATE 1-1	4070	4078	795	1020	1090	1210	3283	3058	2988	2868	DIFFICULT Kc
20S 47W	31	NWNW	STATE 1-A	4000	4009	770	970	1005	1150	3239	3039	3004	2859	
20S 48W	2	SESW	STATE MAYCUMBER 1	3924	3933	520	725	770	830	3413	3208	3163	3103	Kc INCLUDES 10' OF Kk
20S 48W	4	NWNE	IZARD-BARR	3960	3969	520	725	765	825	3449	3244	3204	3144	
20S 48W	16	SENW	STATE 1-16	3940	3947	660	875	930	1010	3287	3072	3017	2937	
20S 48W	25	NESW	#1 RICHARDS	3962	3972	705	895	940	1095	3267	3077	3032	2877	Kc INCLUDES 45' OF Jm

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TWN/RNG	SEC	QTR/QTR	WELL ID	ELEV. GS	ELEV MP	DEPTH TO TOP DAKOTA	DEPTH BASE DAKOTA	DEPTH TO TOP CHEY	DEPTH BASE CHEY	ELEV TOP DAKOTA	ELEV BASE DAKOTA	ELEV TOP CHEY	ELEV BASE CHEY	
20S 48W	29	SWNE	WHITTEMORE A-1	3993	3998	605	820	880	990	3393	3178	3118	3008	
20S 48W	34	SWNE	ERRAMUSPE A-1	3945	3946	490	710	750	800	3456	3236	3196	3146	
20S 49W	1	SWSE	PYLES 15-1	4002	4012	550	760	825	1100	3462	3252	3187	2912	Kc INCLUDES SOME Jm
20S 49W	3	NWSE	#1 C.P. COOP	4140	4149	760	960	1015	1185	3389	3189	3134	2964	
20S 49W	13	NWSE	ABRAMS #1	4023	4032	535	760	820	1060	3497	3272	3212	2972	Kc INCLUDES SOME Jm
20S 49W	19	SENW	FRAZEE 1-19	4324	4333	760	920	965	1040	3573	3413	3368	3293	
20S 49W	25	NWSE	STATE-ABRAMS C-1	4084	4094	685	885	945	1060	3409	3209	3149	3034	
20S 50W	12	NWSW	ROSE 11-12	4353	4363	800	955	970	1105	3563	3408	3393	3258	Kc INCLUDES SOME Jm
20S 50W	21	SWSW	#1 GRANDVIEW	4364	4374	785	930	965	1000	3589	3444	3409	3374	
20S 50W	24	NESW	WILLIAM ROSE #2	4322	4334	800	965			3534	3369	4334	4334	Kc ABSENT
20S 50W	27	NE	1-27 GARVEY	4350	4359	785	900	935	1020	3574	3459	3424	3339	
20S 51W	3	NESW	HAMBLETON FAMILY TRUST No. 1	4292	4302	785	920	955	1030	3517	3382	3347	3272	
20S 51W	14	SENE	WEAR 1	4351	4362	820	915	1125	1180	3542	3447	3237	3182	
20S 52W	6	SWSW	BOLTON 1-6	4320	4329	890	1050	1085	1130	3439	3279	3244	3199	
20S 52W	8	SW	BOLTON 1-8	4269	4277	790	980	1005	1105	3487	3297	3272	3172	Kc INCLUDES SOME Jm
20S 52W	26	NWNE	WEINMAN et al	4162	4172	700	865	900	940	3472	3307	3272	3232	
21S 41W	19	NWNW	HADSEN-CAMPBELL #4-19	3813	3822	740	960	1010	1140	3082	2862	2812	2682	
21S 41W	29	NESW	DOYLE A_1	3789	3800	645	870	930	1050	3155	2930	2870	2750	NO RESISTIVITY LOG
21S 43W	3	SWNE	#1 HALLOCK	3861	3873	990	1130	1195	1360	2883	2743	2678	2513	
21S 43W	6	NENE	LIEVRANCE 1-6	3830	3837	890	1165	1180	1310	2947	2672	2657	2527	
21S 43W	10	NENE	PAULIN 1	3813	3822	920	1030	1245	1350	2902	2792	2577	2472	
21S 44W	7	NENE	FLEENER #1	3797	3808	690	920	980	1180	3118	2888	2828	2628	BASE Kc ESTIMATED
21S 44W	12	NENE	STEIMEL #1	3767	3777	720	965	1065	1175	3057	2812	2712	2602	

DATA FROM GEOPHYSICAL LOGS
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TWN/RNG	SEC	QTR/QTR	WELL ID	ELEV. GS	ELEV MP	DEPTH TO TOP DAKOTA	DEPTH BASE DAKOTA	DEPTH TO TOP CHEY	DEPTH BASE CHEY	ELEV TOP DAKOTA	ELEV BASE DAKOTA	ELEV TOP CHEY	ELEV BASE CHEY	
21S 44W	19	NWNW	K.M. PARK 1-19	3773	3782	560	775	825	965	3222	3007	2957	2817	
21S 44W	27	NW	HOLMES 1-27	3759	3769	585	805	850	920	3184	2964	2919	2849	DIFFICULT LOG
21S 45W	2	NENE	BRUNING 1	3724	3733	472	700	770	815	3261	3033	2963	2918	THIN BEDDED Kc
21S 45W	7	NESW	PCGA 1-7	3816	3825	725	925	1000	1100	3100	2900	2825	2725	
21S 45W	22	SWSW	ROUSH 1-22	3667	3677	505	730	795	890	3172	2947	2882	2787	
21S 45W	27	NWNE	L.W. SCHMIDT #1	3665	3676	510	730	795	880	3166	2946	2881	2796	TOP Kd ESTIMATED
21S 45W	33	SWSE	15-33 KISSINGER-UNION	3616	3626	385	570	635	755	3241	3056	2991	2871	
21S 46W	3	SWSW	Mc ARTHUR STATE 1-X	3858	3868	740	935	1000	1170	3128	2933	2868	2698	Kc INCLUDES SOME Jm
21S 46W	9	NWNE	JOHN GENTZ 9-1	3881	3891	805	1000	1065	1140	3086	2891	2826	2751	
21S 46W	23	SESE	1-23 REIFSCNEIDER	3802	3811	610	800	865	950	3201	3011	2946	2861	
21S 46W	28	SWSW	1-28 HEINSON	3763	3768	485	680	750	865	3283	3088	3018	2903	
21S 46W	34	SWSW	1-34 REIFSCHNEIDER	3743	3748	390	595	660	755	3358	3153	3088	2993	
21S 47W	5	NWSW	RC No. 13-5	3955	3965	535	750	820	1020	3430	3215	3145	2945	Kc INCLUDES SOME Jm
21S 47W	15	SWNE	STATE 1	3977	3987	765	960	1020	1085	3222	3027	2967	2902	
21S 47W	19	SWSW	BURKE FARMS 1-1	3822	3831	490	630	690	820	3341	3201	3141	3011	
21S 47W	29	SWSW	DIETERLE 1	3818	3827	490	690	750	875	3337	3137	3077	2952	
21S 47W	31	NE	TEMPLE FASNACHT 1-31	3777	3787	455	640	700	805	3332	3147	3087	2982	
21S 48W	2	SE	WOLLERT C-1	3873	3879	520	705	755	895	3359	3174	3124	2984	
21S 48W	5	SWNE	STATE 881-S #1	3999	4009	585	760	820	925	3424	3249	3189	3084	
21S 48W	15	SWNW	KICKING BIRD 12-15	3956	3965	495	710	770	900	3470	3255	3195	3065	
21S 48W	18	SWSW	SMARTT 1-18	4110	4121	590	770	810	955	3531	3351	3311	3166	
21S 48W	25	NENE	ROWE A-1	3801	3811	520	660	720	845	3291	3151	3091	2966	
21S 48W	28	SWNE	HARDY 1	3975	3985	530	730	810	885	3455	3255	3175	3100	

DATA FROM GEOPHYSICAL LOGS
DAKOTA/CHEYENNE AQUIFERS
EASTERN COLORADO
1994

TWN/RNG	SEC	QTR/QTR	WELL ID	ELEV. GS	ELEV MP	DEPTH TO TOP DAKOTA	DEPTH BASE DAKOTA	DEPTH TO TOP CHEY	DEPTH BASE CHEY	ELEV TOP DAKOTA	ELEV BASE DAKOTA	ELEV TOP CHEY	ELEV BASE CHEY	
21S 48W	33	NENE	SNEIDER 1	3971	3980	355	575	655	700	3625	3405	3325	3280	STRONG Jm SANDSTONE
21S 48W	36	SESE	KEDING 1-36	3843	3853	470	655	715	800	3383	3198	3138	3053	
21S 49W	14	NENE	SMART 1	4158	4166	625	815	890	1070	3541	3351	3276	3096	Kc INCLUDES SOME Jm
21S 49W	16	SWSW	STATE 1	4174	4182	480	690	775	510	3702	3492	3407	3672	Kc THIN
21S 50W	3	NENE	STATE 1	4283	4288	630	820	880	930	3658	3468	3408	3358	
21S 50W	5	NWSE	STATE OF COLORADO 1-5	4175	4184	510	650	730	790	3674	3534	3454	3394	
21S 51W	13	NESW	HAM A-1	4161	4171	500	675	720	790	3671	3496	3451	3381	
21S 51W	19	NENE	1-19 SPADY	4274	4284	590	735	815	890	3694	3549	3469	3394	
21S 51W	28	NE	KIT CARSON 1	4227	4237	505	640	730	810	3732	3597	3507	3427	
21S 52W	15	NWSE	STATE 1	4193	4201	585	760	810	855	3616	3441	3391	3346	THIN Kc
21S 52W	18	NWNW	STATE OF COLORADO 1-18	4117	4126	565	665	720	830	3561	3461	3406	3296	Kc INCLUDES SOME Jm
21S 52W	33	NWSE	SHANNON FREMONT #1 STATE	4169	4179	490	610	665	760	3689	3569	3514	3419	
21S 53W	15	NESW	STATE 1-15	4139	4149	675	775	805	920	3474	3374	3344	3229	
22S 41W	7	NWSE	Mc ENTIRE 1-7	3674	3685	585	720	800	870	3100	2965	2885	2815	DIFFICULT TO CORRELATE
22S 42W	35	NENE	#1 KING	3505	3516	500	720	835	905	3016	2796	2681	2611	POOR LOG
22S 43W	34	SESW	KIRBY VER HOEFF 1-34	3531	3540	495	700	770	880	3045	2840	2770	2660	Kc INCLUDES SOME Jm
22S 44W	18	SWNE	WILSON 1-18	3656	3662	445	620	670	800	3217	3042	2992	2862	Kc DIFFICULT
22S 44W	31	SESE	CARLTON FARM 1	3516	3524	340	540	610	710	3184	2984	2914	2814	TOP Kd ESTIMATED
22S 45W	4	SWSW	STATE 13-4	3589	3596	295	505	565	745	3301	3091	3031	2851	TOP Kd ESTIMATED
22S 45W	12	SWNE	DUNCAN-WILSON 32-12	3662	3672	350	550	615	690	3322	3122	3057	2982	TOP Kd ESTIMATED
22S 45W	22	SENE	PRAIRIE DOG 1	3572	3582	180	380	445	530	3402	3202	3137	3052	Kd ESTIMATED
22S 45W	25	SW	#1 LINDA	3522	3531	290	490	555	690	3241	3041	2976	2841	TOP Kd ESTIMATED
22S 45W	26	SW	#2 JUDY	3535	3543	450	650	715	785	3093	2893	2828	2758	TOP Kd ESTIMATED

DATA FROM GEOPHYSICAL LOGS
DAKOTA/CHEYENNE AQUIFERS
EASTERN COLORADO
1994

TWN/RNG	SEC	QTR/QTR	WELL ID	ELEV. GS	ELEV MP	DEPTH TO TOP DAKOTA	DEPTH BASE DAKOTA	DEPTH TO TOP CHEY	DEPTH BASE CHEY	ELEV TOP DAKOTA	ELEV BASE DAKOTA	ELEV TOP CHEY	ELEV BASE CHEY	
22S 45W	31	SENE	1-31 JIM Mc MILLIN	3564	3574	225	425	500	635	3349	3149	3074	2939	TOP Kd ESTIMATED
22S 46W	2	NENE	ELLENBERGER BROTHERS 1	3707	3716	475	680	745	800	3241	3036	2971	2916	
22S 46W	5	SENE	SHINN 1-5	3724	3734	425	625	690	790	3309	3109	3044	2944	
22S 46W	10	NWNW	REIFSCHNEIDER 1-10	3741	3751	415	625	680	765	3336	3126	3071	2986	
22S 46W	20	SENW	PIERSON 1-20	3631	3640	260	465	525	605	3380	3175	3115	3035	THIN BEDDED Kc
22S 47W	3	NENW	CACTUS VIEW 32032-F	3872	3872	490	694	754	862	3382	3178	3118	3010	
22S 47W	21	NWNW	REED C 1-21	3690	3700	390	655	690	740	3310	3045	3010	2960	Kd/Kc DIFFICULT
22S 47W	24	SENW	MAUCH A-1X	3099	3104	425	580	595	640	2679	2524	2509	2464	Kc VERY THIN
22S 47W	27	SWSE	#1 HANAGAN	3637	3647	200	400	445	590	3447	3247	3202	3057	Kc DIFFICULT
22S 47W	29	NWNW	COLORADO BEEF 14255-F	3715	3715	185	392	435	548	3530	3323	3280	3167	
22S 47W	30	NENE	COLORADO BEEF	3700	3700	110	315	442	510	3590	3385	3258	3190	
22S 47W	32	NWNE	ILER B No. 2	3651	3661	150	350	390	485	3511	3311	3271	3176	Kd ESTIMATED
22S 47W	35	NWSW	NIKELSON 1	3636	3646	375				3271				Kd ESTIMATED
22S 48W	1	SWSW	1-1 HUDSON-PERSYN	3860	3870	225	425	465	560	3645	3445	3405	3310	Kc DIFFICULT
22S 48W	9	NWSE	SNYDER A-1	3846	3856	310	510	545	670	3546	3346	3311	3186	Kc DIFFICULT
22S 48W	19	SESE	SMARTT 1	3802	3810	150	350	385	520	3660	3460	3425	3290	
22S 48W	22		#1 CHEATUM	3789	3799	215	415	455	580	3584	3384	3344	3219	LOCATION UNCERTAIN
22S 48W	25	SWNE	#1 SCHWANZ	3737	3747	180	380	410	555	3567	3367	3337	3192	DIFFICULT Kd/Kc
22S 48W	29	NWSW	1-29 HOFFMAN	3777	3786	180	380	395	545	3606	3406	3391	3241	Kd ESTIMATED
22S 48W	35	NE	DOWNING 1-A	3690	3700	50	250	300	445	3650	3450	3400	3255	Kd/Kc ESTIMATED
22S 49W	14	SENW	KASZA 1-A	3863	3873	275	475	500	645	3598	3398	3373	3228	Kd TOP ESTIMATED
22S 49W	16	NWSE	EARL UNIT B-1	3871	3880	290	490	535	650	3590	3390	3345	3230	Kd TOP ESTIMATED
22S 49W	22	SE	#1 KASZA	3826	3836	225	425	495	580	3611	3411	3341	3256	Kd TOP ESTIMATED

DATA FROM GEOPHYSICAL LOGS
DAKOTA/CHEYENNE AQUIFERS
EASTERN COLORADO
1994

TWN/RNG	SEC	QTR/QTR	WELL ID	ELEV. GS	ELEV MP	DEPTH TO TOP DAKOTA	DEPTH BASE DAKOTA	DEPTH TO TOP CHEY	DEPTH BASE CHEY	ELEV TOP DAKOTA	ELEV BASE DAKOTA	ELEV TOP CHEY	ELEV BASE CHEY	
22S 49W	25	SESE	PIATT #1	3813	3823	185	385	440	575	3638	3438	3383	3248	Kd ESTIMATED
22S 49W	29	SWNE	BALDWIN 1-A	3834	3844	210	410	460	570	3634	3434	3384	3274	Kd ESTIMATED
22S 49W	35	NE	#1 Mc CLAVE	3760	3770	120	320	375	510	3650	3450	3395	3260	Kd TOP ESTIMATED
22S 50W	5	SWNE	A.B. HAM A-1	4199	4208	480	675	760	795	3728	3533	3448	3413	
22S 50W	10	NWNE	BALWIN 1	4204	4214	480	690	735	820	3734	3524	3479	3394	
22S 50W	12	NWSE	1-B HAM	3984	3994	250	450	535	720	3744	3544	3459	3274	TOP Kd ESTIMATED
22S 50W	26	NESE	1-GILL	3930	3941	365	565	600	680	3576	3376	3341	3261	TOP Kd ESTIMATED
22S 50W	36	SWSE	TROSTELL 1	3888	3898	220	420	460	555	3678	3478	3438	3343	TOP Kd ESTIMATED
22S 51W	11	NENE	POINTONS 41-11	3962	3974	250	450	505	560	3724	3524	3469	3414	TOP Kd ESTIMATED
22S 51W	17	SENW	MARSHALL S. DEAN 1	3987	3998	195	395	470	580	3803	3603	3528	3418	Kd ESTIMATED
22S 51W	25	NWNE	LOONEY #1	3860	3871	65	265	320	440	3806	3606	3551	3431	TOP Kd ESTIMATED
22S 51W	31	SESE	SHAW 1	3885	3897	60	260	310	430	3837	3637	3587	3467	ESTIMATED
22S 52W	9	SWNW	COLT 1	4111	4121	390	590	650	770	3731	3531	3471	3351	Kd ESTIMATED
22S 52W	12	SESE	#1 MARSHALL-DEAN	4063	4072	365	490	570	670	3707	3582	3502	3402	
22S 52W	21	SENE	WRIGHT-GRIFFITH #1	4110	4117	290	420	495	610	3827	3697	3622	3507	
22S 52W	28	SENE	8-28 CARVER	3981	3991	245	375	435	515	3746	3616	3556	3476	TOP Kd ESTIMATED
22S 53W	9	SENE	FREMINT-STATE 1	4114	4123	460	605	655	775	3663	3518	3468	3348	
22S 53W	21	SESW	STATE 1-21	4077	4087	445	595	635	710	3642	3492	3452	3377	Kd ESTIMATED
22S 53W	31	SESW	STATE 1-31	4136	4146	470	620	660	710	3676	3526	3486	3436	Kd ESTIMATED
23S 41W	18	SWNW	#1 ETTER	3354	3363	680	855	895	970	2683	2508	2468	2393	Kd/Kc ?
23S 42W	18	NESE	VAUGHN-ETTER #1	3408	3417	240	440	495	610	3177	2977	2922	2807	Kd ?
23S 43W	6	NESE	XY RANCH #1	3463	3473	480	675	730	805	2993	2798	2743	2668	
23S 43W	19	NESE	BARRETT 1-19	3544	3549	530	730	805	890	3019	2819	2744	2659	

DATA FROM GEOPHYSICAL LOGS
DAKOTA/CHEYENNE AQUIFERS
EASTERN COLORADO
1994

TWN/RNG	SEC	QTR/QTR	WELL ID	ELEV. GS	ELEV MP	DEPTH TO TOP DAKOTA	DEPTH BASE DAKOTA	DEPTH TO TOP CHEY	DEPTH BASE CHEY	ELEV TOP DAKOTA	ELEV BASE DAKOTA	ELEV TOP CHEY	ELEV BASE CHEY	
23S 43W	33	NWNW	ROWE 1-33	3557	3566	385	595	650	740	3181	2971	2916	2826	
23S 44W	8	NWSW	MERRITT 1-8	3617	3626	170	405	490	540	3456	3221	3136	3086	
23S 44W	18	SWNE	#3 JUDY	3661	3669	330	635	695	765	3339	3034	2974	2904	
23S 44W	20	NESW	BURNETT A-1	3634	3644	450	615	665	775	3194	3029	2979	2869	
23S 44W	30	NENE	E.F. OBLANDER 1	3612	3622	340	540	590	730	3282	3082	3032	2892	
23S 44W	35	NWNW	SWIFT 1	3700	3709	400	595	645	760	3309	3114	3064	2949	
23S 45W	3	SW	1-3 HIGBEE 1	3598	3608	450	690	730	795	3158	2918	2878	2813	
23S 45W	11	SWSW	Mc MILLAN 2-11	3659	3670	395	605	650	815	3275	3065	3020	2855	Kc INCLUDES SOME Jm
23S 45W	13	SWNE	CURD 1	3667	3677	350	620	380	745	3327	3057	3297	2932	
23S 45W	19	SWNE	WEIS A-1	3737	3747	280	480	550	650	3467	3267	3197	3097	TOP Kd ESTIMATED
23S 45W	25	SESE	Mc MILLAN 1-25	3673	3683	400	600	630	740	3283	3083	3053	2943	TOP Kd ESTIMATED
23S 46W	14	NENW	LOTUS 1	3668	3678	155	385	425	525	3523	3293	3253	3153	TOP Kd ESTIMATED
23S 46W	18	SWNW	JONESY 1	3705	3715	245	445	490	570	3470	3270	3225	3145	TOP Kd ESTIMATED
23S 46W	22	SESW	BARR 1	3690	3700	210	410	440	515	3490	3290	3260	3185	Kd ESTIMATED
23S 47W	3	NENW	#1 ABERCROMBIE	3645	3655	175	375	415	490	3480	3280	3240	3165	TOP Kd ESTIMATED
23S 47W	5	SW	IDLER "F" 1	3697	3707	165	365	400	515	3542	3342	3307	3192	Kd ESTIMATED
23S 47W	9	SENW	IDLER "G" 1	3687	3697	195	395	430	510	3502	3302	3267	3187	Kd ESTIMATED
23S 47W	20	SE	KISER "A" 1	3747	3757	175	375	410	520	3582	3382	3347	3237	Kd ESTIMATED
23S 47W	25	SE	HIXSON 1-25	3746	3755	170	370	430	500	3585	3385	3325	3255	ESTIMATED
23S 47W	25	SENW	OWEN Mc EWEN CNG 25-1	3770	3781	190	390	460	535	3591	3391	3321	3246	TOP Kd ESTIMATED
23S 48W	4	NESW	BROYLES "A" 1	3710	3719	20	220	270	390	3699	3499	3449	3329	Kd ESTIMATED
23S 48W	7	SWNE	SNIFF "D" 1	3801	3811	90	290	340	480	3721	3521	3471	3331	Kd ESTIMATED
23S 48W	11	NW	STONY POINT RANCH 1	3773	3783	130	330	390	480	3653	3453	3393	3303	Kd ESTIMATED

DATA FROM GEOPHYSICAL LOGS
DAKOTA/CHEYENNE AQUIFERS
EASTERN COLORADO
1994

TWN/RNG	SEC	QTR/QTR	WELL ID	ELEV. GS	ELEV MP	DEPTH TO TOP DAKOTA	DEPTH BASE DAKOTA	DEPTH TO TOP CHEY	DEPTH BASE CHEY	ELEV TOP DAKOTA	ELEV BASE DAKOTA	ELEV TOP CHEY	ELEV BASE CHEY	
23S 48W	20	NE	FAMILTON 1	3888	3898	205	405	460	595	3693	3493	3438	3303	TOP Kd ESTIMATED
23S 48W	24	SWSE	RUNDELL "A" 1	3864	3876	170	370	430	560	3706	3506	3446	3316	TOP Kd ESTIMATED
23S 48W	34	NWNW	ROHLMAN 1-34	3979	3989	120	320	380	480	3869	3669	3609	3509	Kd ESTIMATED
23S 49W	12	NE	SNIFF "H" 1	3751	3761	85	285	345	425	3676	3476	3416	3336	Kd/TOP Kc ESTIMATED
23S 49W	25	SESE	SNIFF RANCH 2-A	3843	3851	90	290	350	470	3761	3561	3501	3381	Kd/TOP Kc ESTIMATED
23S 49W	29	SWNW	TROSTEL 1-B	3845	3855	110	310	370	450	3745	3545	3485	3405	Kd/TOP Kc ESTIMATED
23S 49W	34	NWNW	SNIFF 1	3946	3956	45	245	295	395	3911	3711	3661	3561	Kd TOP ESTIMATED
23S 50W	16	SESE	1-16 USA	3916	3926	20	220	280	360	3906	3706	3646	3566	Kd/Kc TOP ESTIMATED
23S 50W	22	SENE	GOVERNMENT 1	3932	3940	10	210	270	340	3930	3730	3670	3600	Kd ESTIMATED
23S 50W	24	NENE	GOVERNMENT 2	3918	3928	50	250	305	475	3878	3678	3623	3453	Kd TOP ESTIMATED
23S 50W	27	SWNW	ELSTON-FED 1	3967	3976		160	220	330		3816	3756	3646	Kd TOP ABOVE LAND SURFACE
23S 51W	16	SWSW	# 1 HUSKY STATE	3924	3934	30	230	290	360	3904	3704	3644	3574	Kd/Kc ESTIMATED
23S 51W	24	SESE	SAPP 1	3947	3957		170	230	355		3787	3727	3602	Kd TOP ABOVE LAND SURFACE
23S 52W	14	SESW	#1 ALTA PAGE	3904	3914		200	260	340		3714	3654	3574	Kd TOP ABOVE LAND SURFACE
23S 52W	26	NENE	FEDERAL 1-26	4168	3914	190	390	450	530	3724	3524	3464	3384	Kd/Kc ESTIMATED
23S 53W	16	NWNW	STATE 1-16	3976	3986	120	320	380	460	3866	3666	3606	3526	Kd/Kc ESTIMATED
23S 53W	26	NWNW	FEDERAL 1-26	4168	4178	190	390	450	530	3988	3788	3728	3648	Kd/Kc ESTIMATED

K-E LOGARITHMIC • 2 X 3 CYCLES KEUFFEL & ESSER CO. MADE IN U.S.A. 46 7320

Figure 3

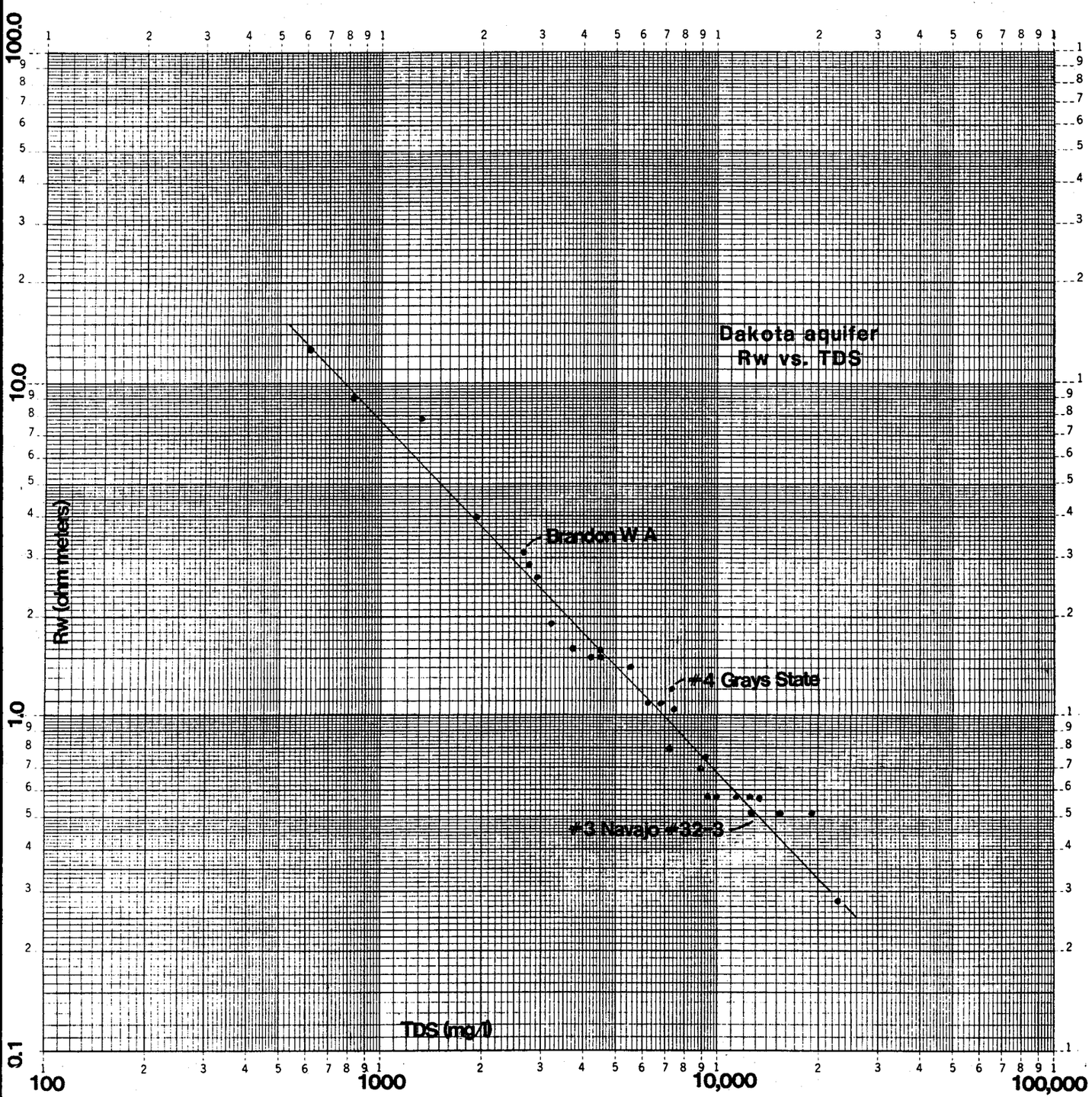
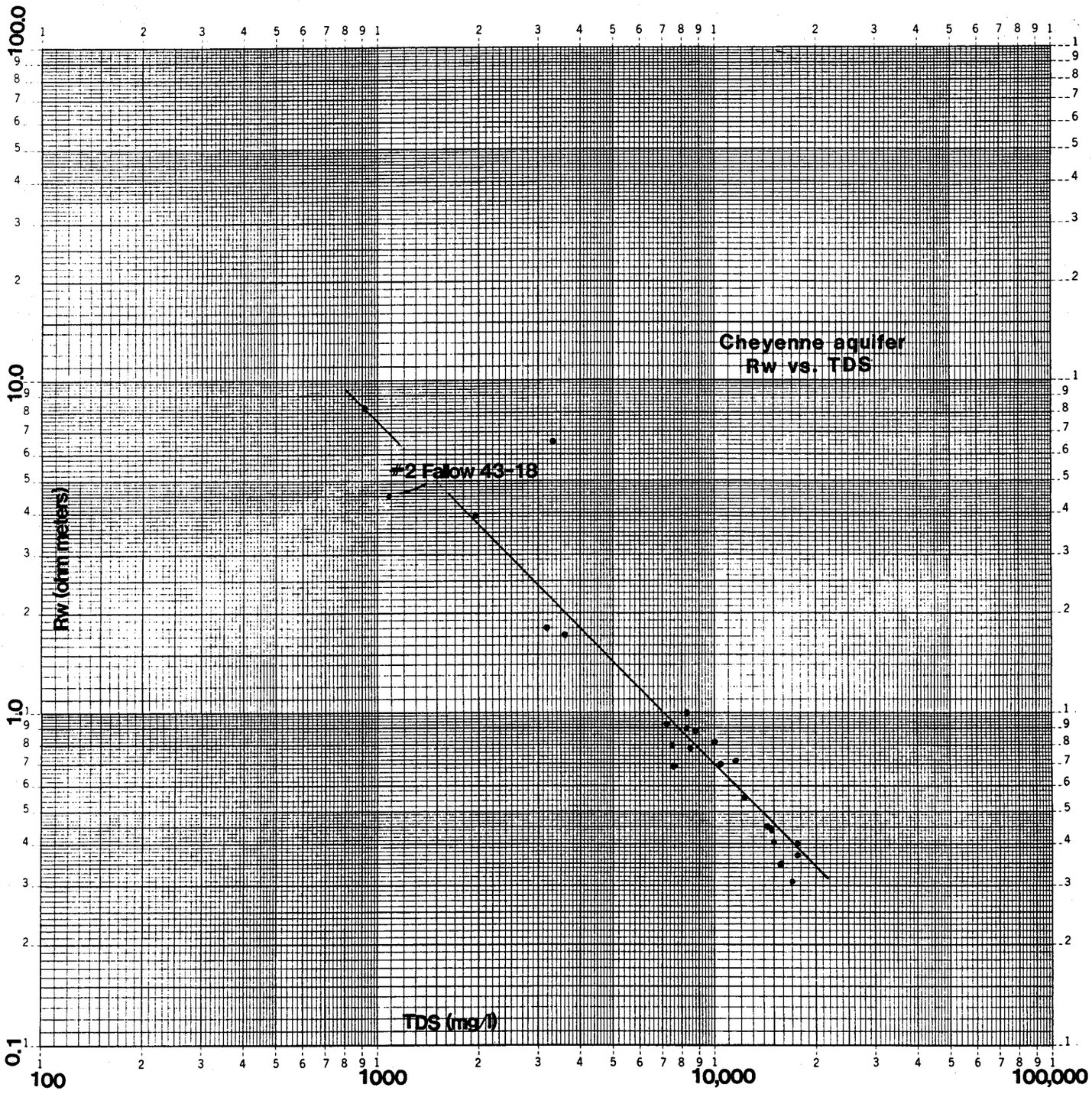


Figure 4


Cheyenne aquifer
Rw vs. TDS
#2 Fallow 43-18
Rw (ohm meters)
TDS (mg/l)
100.0
10.0
1.0
0.1
100
1000
10,000
100,000

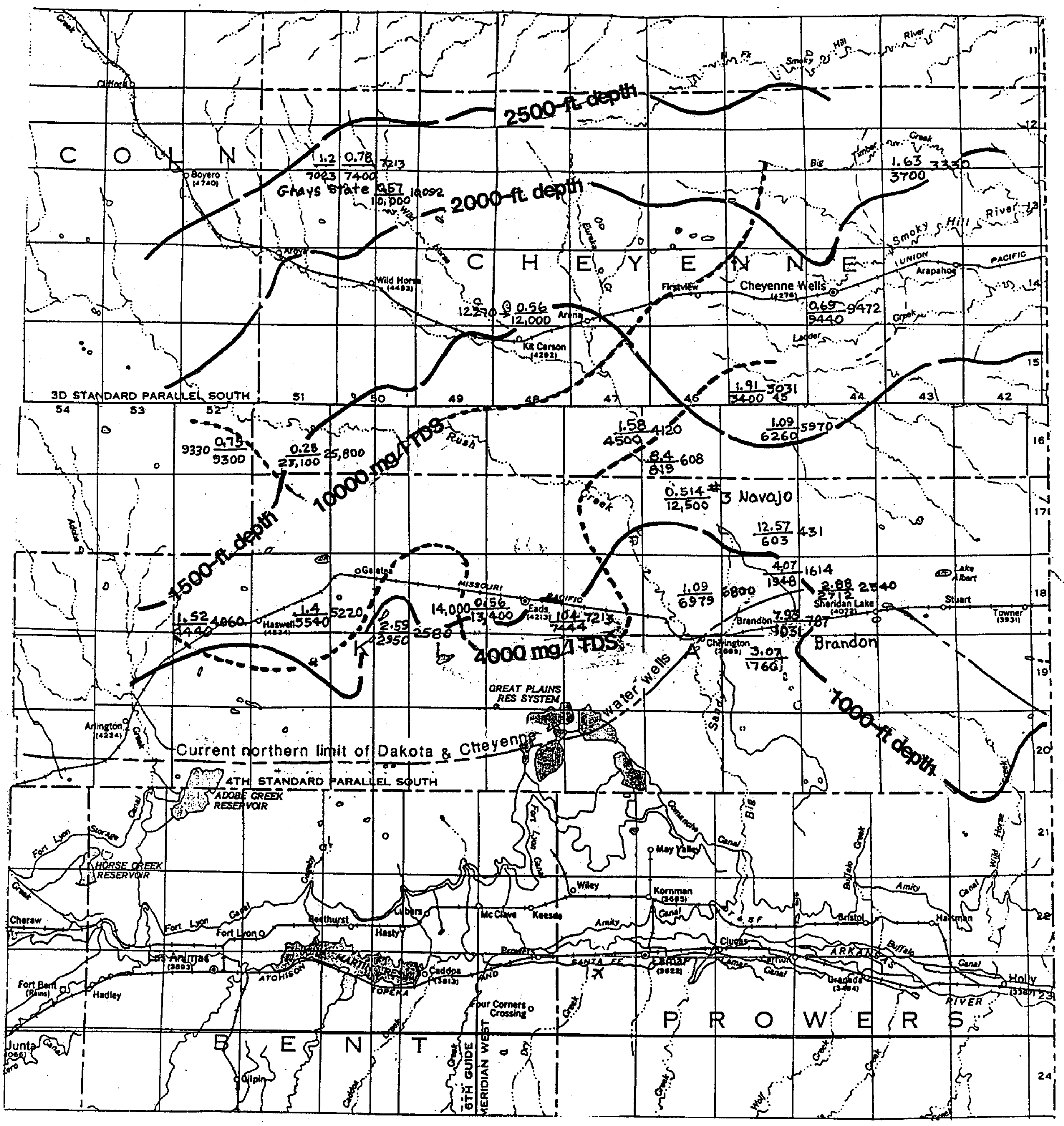


FIGURE 5. - Dakota aquifer Rw, TDS, and NaCl concentration sites, and TDS and depth to top of aquifer contours. Sites are approximately located. Rw in ohm-meters, TDS and NaCl in mg/l.

$$\frac{1.09}{6260}\ 5970 = \frac{Rw}{TDS}\ \text{NaCl}$$

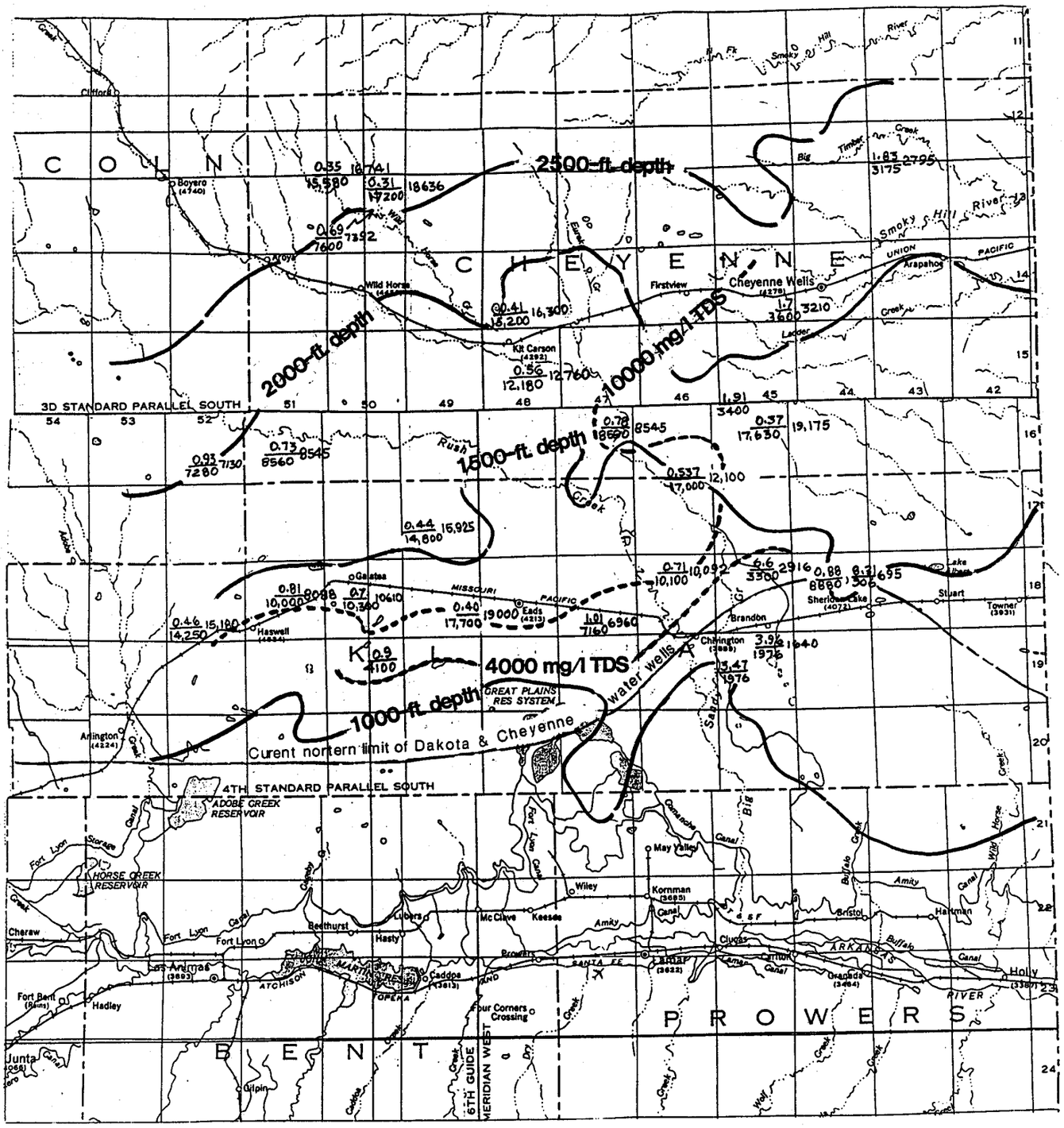


FIGURE 6. - Cheyenne aquifer Rw, TDS, and NaCl concentration sites, and TDS and depth to top of aquifer contours. Sites are approximately located. Rw in ohm-meters, TDS and NaCl in mg/l.

$$\frac{1.01}{7160}\ 6960 = \frac{Rw}{TDS}\ NaCl$$