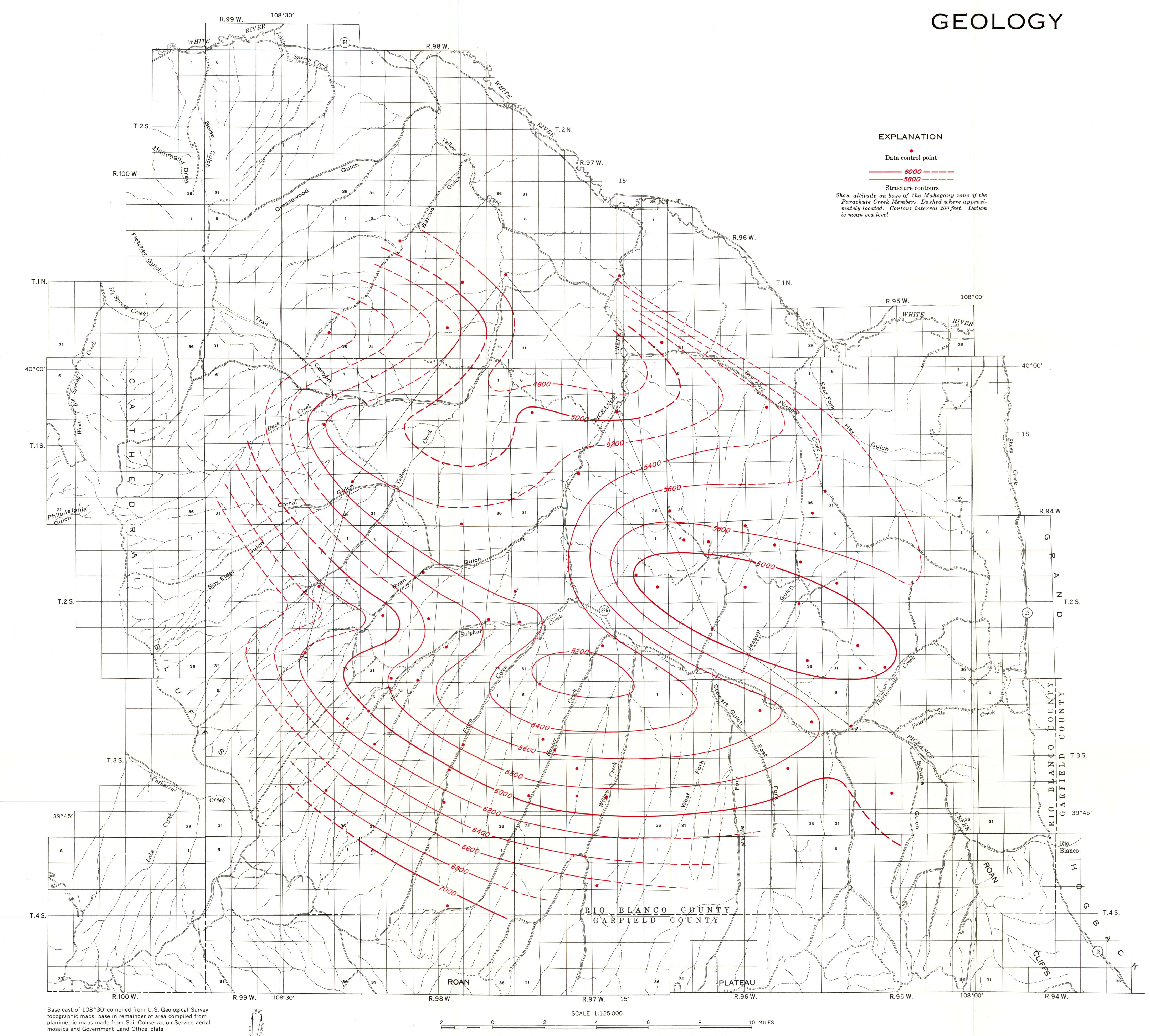
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
WILLIAM T. PECORA, DIRECTOR

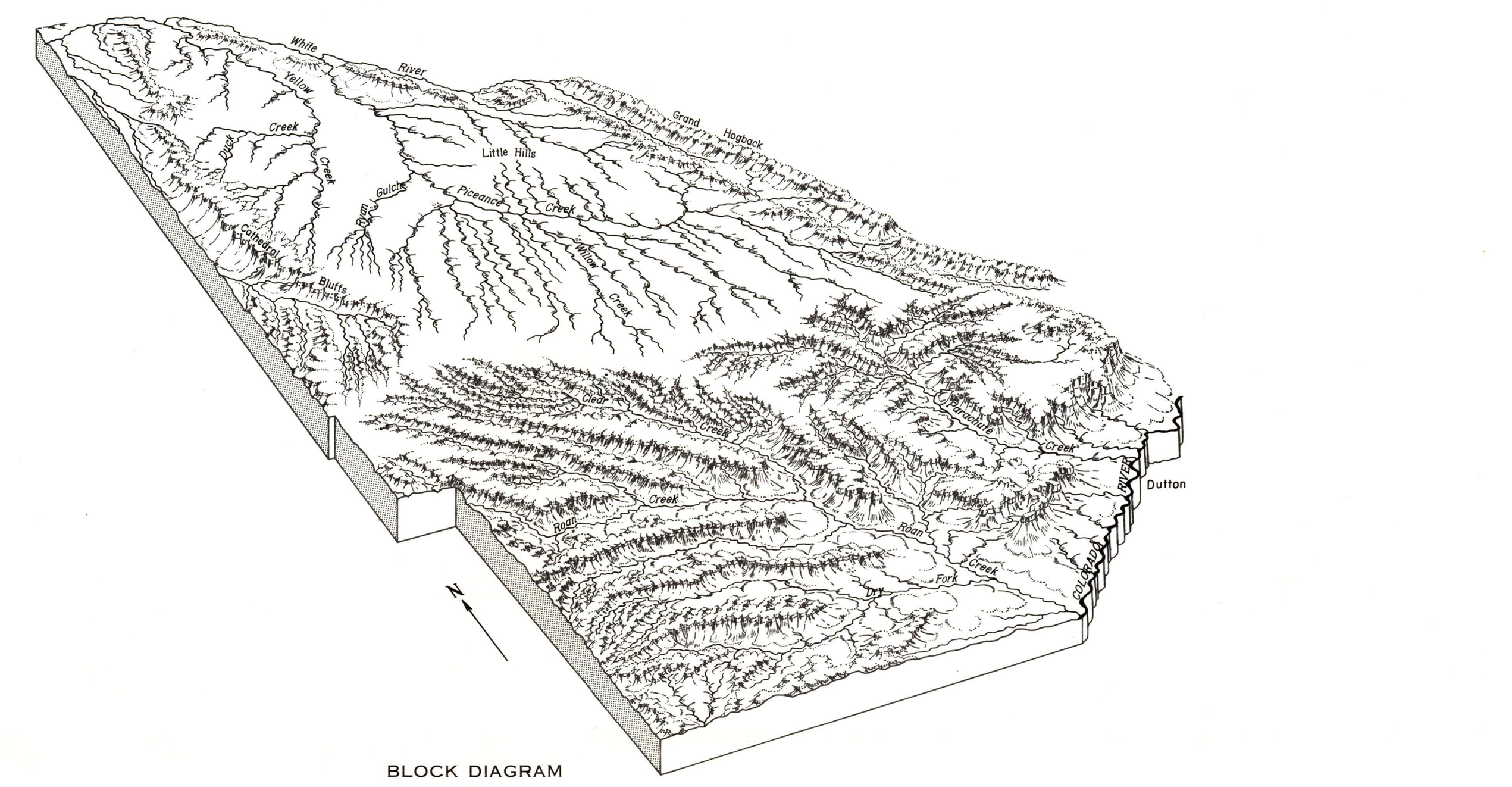
PREPARED IN COOPERATION WITH THE
COLORADO WATER CONSERVATION BOARD
FELIX L. SPARKS, DIRECTOR

HYDROLOGIC INVESTIGATIONS
ATLAS HA-370 (SHEET 1 OF 2)

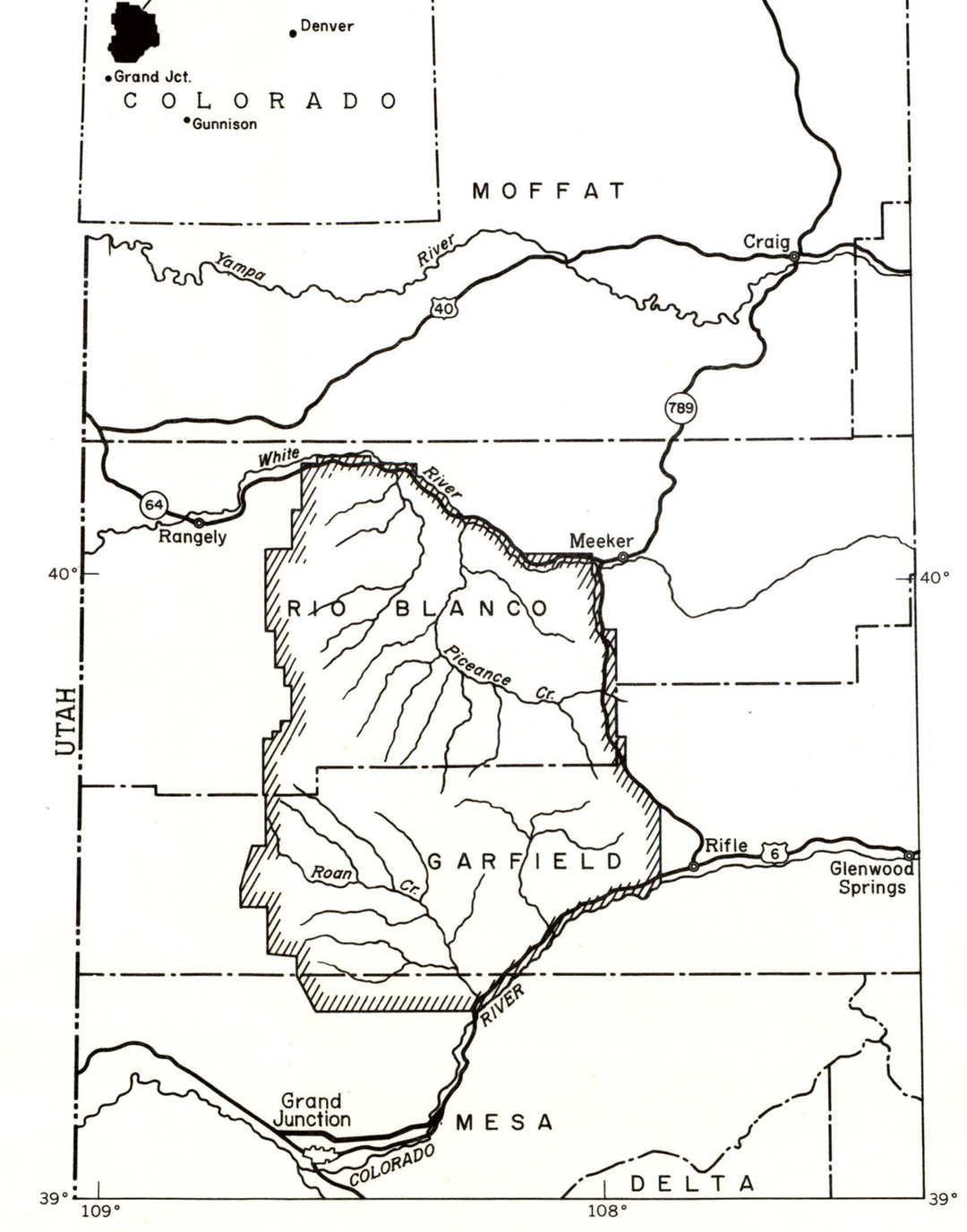
GEOLOGY



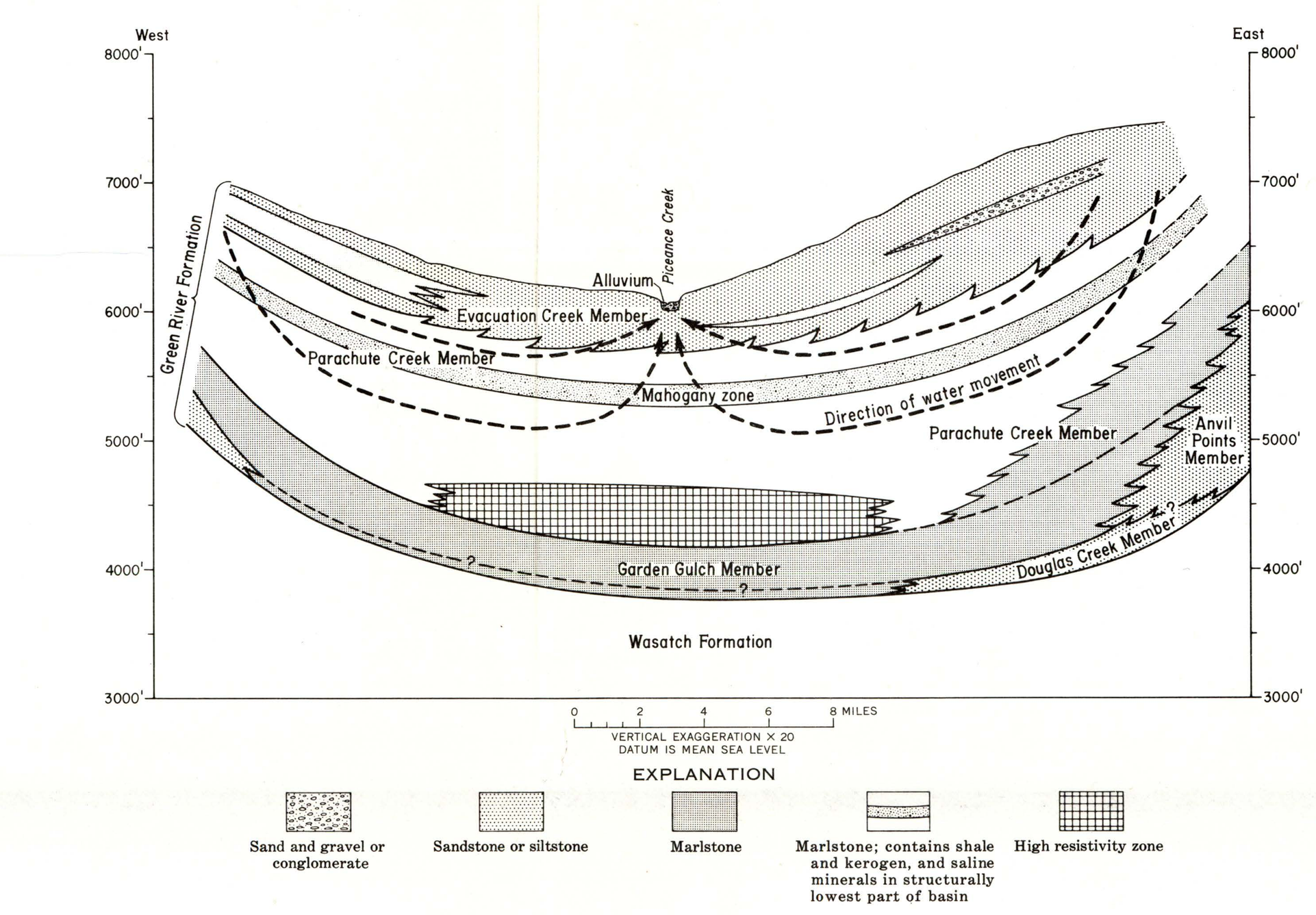
STRUCTURE CONTOUR MAP OF THE BASE OF THE MAHOGANY ZONE OF THE PARACHUTE CREEK MEMBER



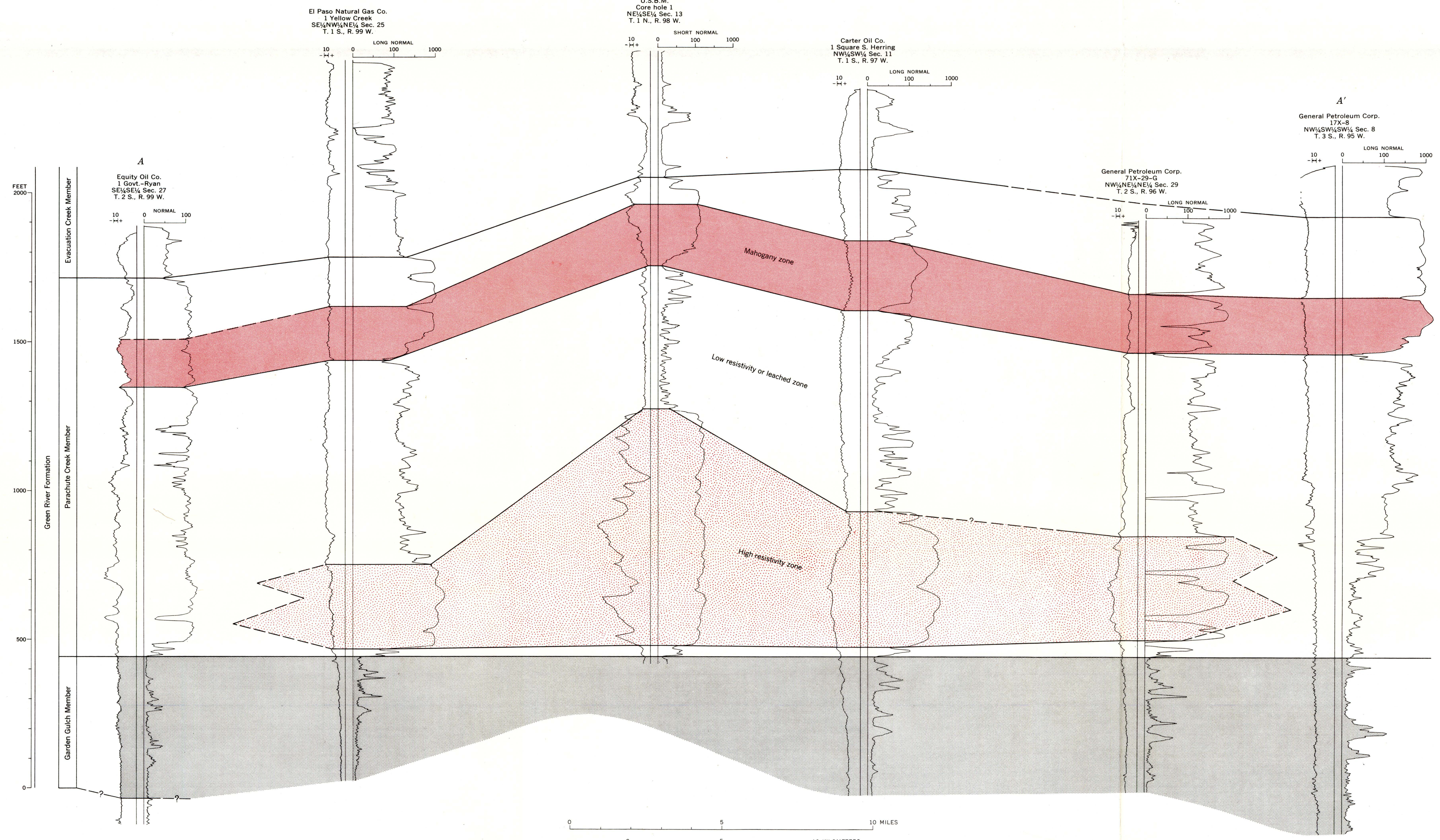
BLOCK DIAGRAM



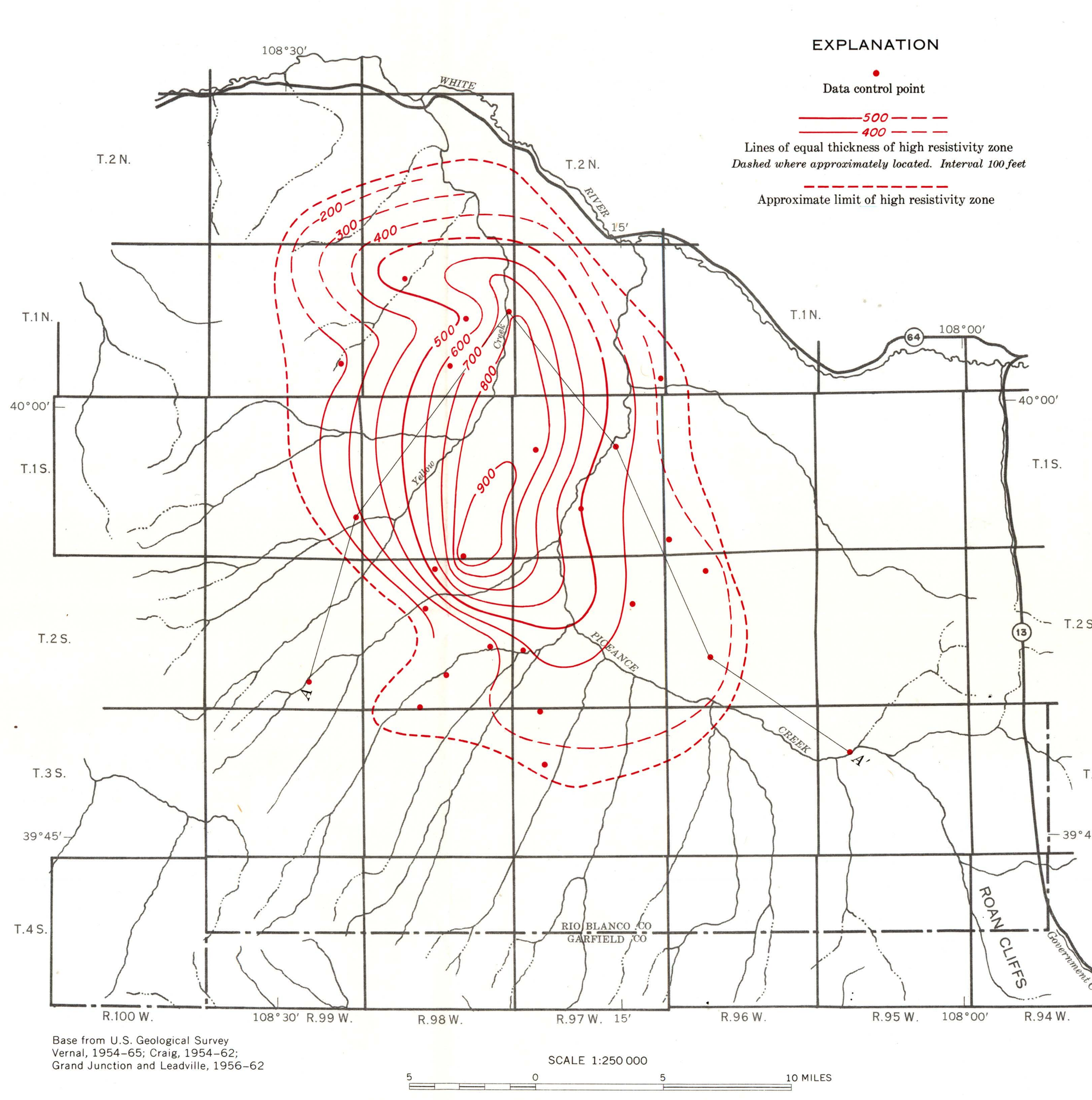
MAP SHOWING REPORT AREA



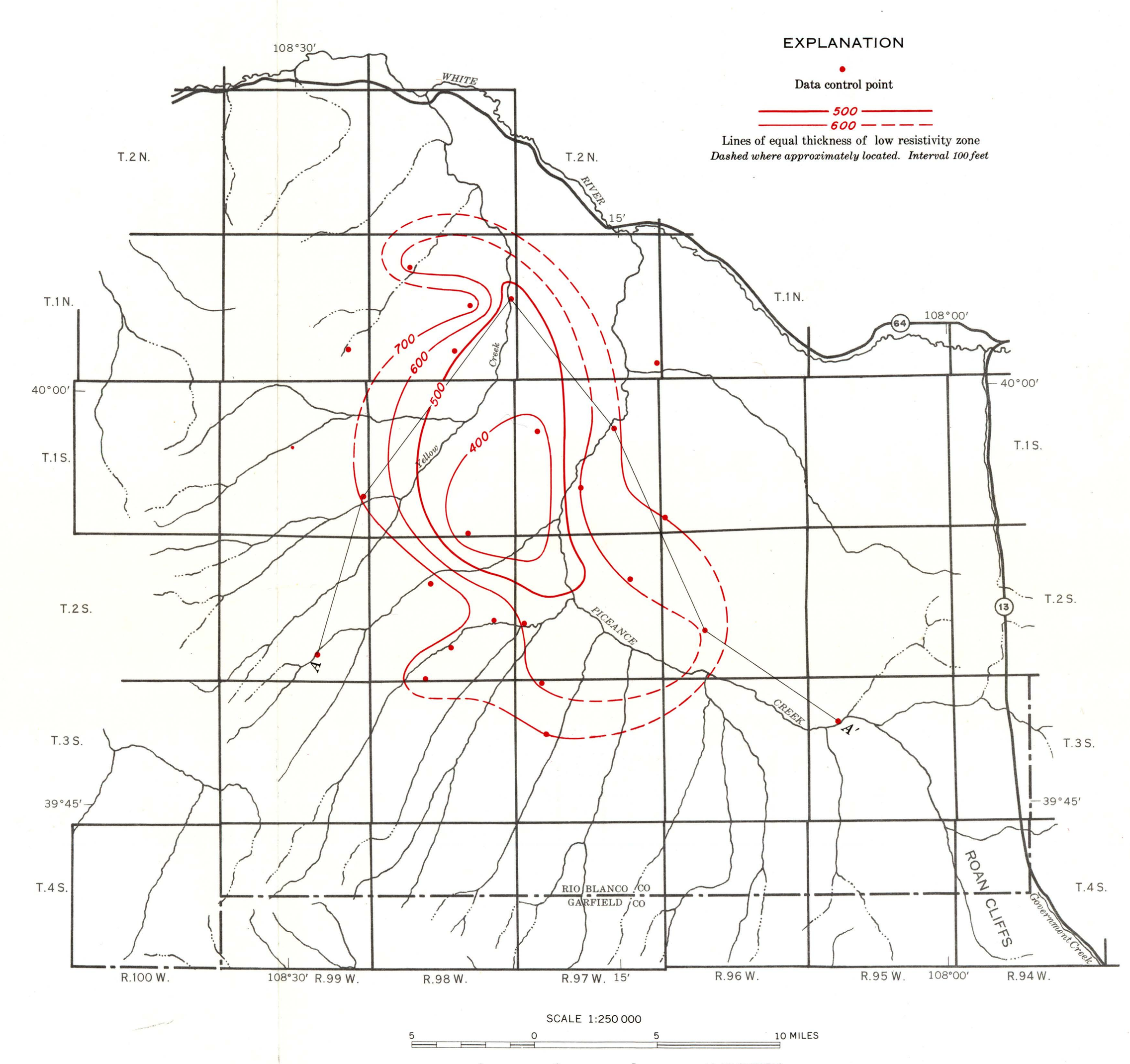
DIAGRAMMATIC SECTION ACROSS THE BASIN



STRATIGRAPHIC SECTION



THICKNESS MAP OF HIGH RESISTIVITY ZONE



THICKNESS MAP OF LOW RESISTIVITY OR LEACHED ZONE

SUMMARY OF GEOLOGIC UNITS AND THEIR WATER-BEARING CHARACTERISTICS

System	Series	Geologic unit		Thickness (feet)	Physical character	Water quality	Hydrologic character
Quaternary	Holocene and Pleistocene(?)	Alluvium		0–140	Sand, gravel, and clay partly fill major valleys as much as 140 feet; generally less than half a mile wide. Beds of clay may be as thick as 70 feet; generally thickest near the center of valleys. Sand and gravel contain stringers of clay near mouths of small tributaries to major streams.	Near the headwaters of the major streams, dissolved-solids concentrations range from 250 to 700 mg/l. Dominant ions in the water are generally calcium, magnesium, and bicarbonate. In most of the area, dissolved solids range from 700 to as much as 25,000 mg/l. Above 3,000 mg/l the dominant ions are sodium and bicarbonate.	Water is under artesian pressure where sand and gravel are overlain by beds of clay. Reported yields as much as 1,500 gpm. Well yields will decrease with time because valleys are narrow and the valley walls act as relatively impermeable boundaries. Transmissivity ranges from 20,000 to 150,000 gpd per ft. The storage coefficient averages 0.20.
Tertiary	Eocene	Green River Formation	Evacuation Creek Member	0–1,250	Intertonguing and gradational beds of sandstone, siltstone, and marlstone; contains pyroclastic rocks and a few conglomerate lenses. Forms surface rock over most of the area; thins appreciably westward.	Water ranges from 250 to 1,800 mg/l dissolved solids.	Beds of sandstone are predominantly fine grained and have low permeability. Water moves primarily through fractures. The part of the member higher than valley floors is mostly drained. Reported to yield as much as 100 gpm where tested in the north-central part of the basin. Member has not been thoroughly tested, and larger yields may be possible.
			Parachute Creek Member	500–1,800	Kerogenaceous dolomitic marlstone (oil shale) and shale; contains thin pyroclastic beds; fractured to depths of at least 1,800 feet. Abundant saline minerals in deeper part of the basin. The member can be divided into three zones—high resistivity, low resistivity or leached, and Mahogany (oldest to youngest), which can be correlated throughout basin by use of geophysical logs.	Water ranges in dissolved-solids content from 250 to about 63,000 mg/l. Below 500 mg/l, calcium is the dominant cation; above 500 mg/l, sodium is generally dominant. Bicarbonate is generally the dominant anion regardless of concentration. Fluoride ranges from 0.0 to 54 mg/l.	High resistivity zone and Mahogany zone are relatively impermeable. The leached zone (middle unit) contains water in solution openings and is under sufficient artesian pressure to cause flowing wells. Transmissivity ranges from less than 3,000 gpd per ft in the margins of the basin to 20,000 gpd per ft in the center of the basin. Estimated yields as much as 1,000 gpm. Total water in storage in leached zone 2.5 million acre-feet, or more.
			Garden Gulch Member	0–900	Papery and flaky marlstone and shale; contains some beds of oil shale and, locally, thin beds of sandstone.	One water analysis indicates dissolved-solids concentration of 12,000 mg/l.	Relatively impermeable and probably contains few fractures. Prevents downward movement of water. In the Parachute and Roan Creeks drainages, springs are found along contact with overlying rocks. Not known to yield water to wells.
			Douglas Creek Member	0–800	Sandstone, shale, and limestone; contains oölites and ostracods.	The few analyses available indicate that dissolved-solids content ranges from 3,000 to 12,000 mg/l. Dominant ions are sodium and bicarbonate, or sodium and chloride.	Relatively low permeability and probably little fractured. Maximum yield is unknown, but probably less than 50 gpm.
			Anvil Points Member	0–1,870	Shale, sandstone, and marlstone grade within a short distance westward into the Douglas Creek, Garden Gulch, and lower part of the Parachute Creek Member. Beds of sandstone are fine grained.	The principal ions in the water are generally magnesium and sulfate. The dissolved-solids content ranges from about 1,200 to 1,800 mg/l.	Sandstone beds have low permeability. A few wells tapping sandstone beds yield less than 10 gpm. Springs issuing from fractures yield as much as 100 gpm.
		Wasatch Formation		300–5,000	Clay, shale, lenticular sandstone; locally, beds of conglomerate and limestone. Beds of clay and shale are the main constituents of the formation. Contains gypsum.	Gypsum contributes sulfate to both surface-water and ground-water supplies.	Beds of clay and shale are relatively impermeable. Beds of sandstone are poorly permeable. Not known to yield water to wells.

INTRODUCTION

This atlas presents the results of an investigation of the water resources of part of the Piceance Creek structural basin in northwestern Colorado. The area of investigation is between the White and Colorado Rivers (see index map), an area of about 1,600 square miles in parts of Rio Blanco, Garfield, and Mesa Counties.

The U.S. Geological Survey's study of the water resources in the basin was begun in 1964 and completed in 1966. The study was made in cooperation with the Colorado Water Conservation Board. The basic hydrologic data collected during this study are published in a report by Coffin, Welder, Glanzman, and Dutton (1968). Additional basic data collected after publication of the Coffin, Welder, Glanzman, and Dutton report are in the files of the Geological Survey. The data include results of aquifer tests, logs of wells and test holes, hydrographs of streams, and chemical analyses of both ground water and surface water in the basin.

The objective of the investigation was to describe availability, occurrence, and chemical properties of the water resources of the basin. This description will be useful for developing water supplies and for coping with water problems associated with the development of the oil shale resources. The Piceance Creek basin contains some of the richest oil shale deposits in North America. These deposits represent a huge potential source of petroleum and efforts are currently being made to develop the resource. Some of the problems associated with the mining and retorting of oil shale are: removal of water from mines, supplying water for mining and retorting operations, supplying additional domestic water for an increase in population, effect of mining operations on present users of ground water and surface water, and water-quality problems created by mining operations.

The population of the basin is sparse, possibly less than 200. The major use of water is for irrigation and is supplied mostly by surface water. Hay meadows and feed crops are irrigated in the valleys of the four major streams (Piceance, Yellow, Roan, and Parachute Creeks). The surface water supply is adequate during the early part of the growing season and inadequate during the late summer months.

Ground-water resources of the basin are relatively undeveloped at the present because of sparse population and lack of arable land. The three irrigation wells in the basin are in the alluvium of Roan Creek. Four wells tapping the Green River Formation (originally drilled for oil) are occasionally used for irrigation along Piceance Creek. There are 65 small diameter wells, some of them flowing, and about 250 springs tapping the alluvium and the Green River Formation that supply water for domestic and stock use throughout the basin.

The Piceance Creek structural basin is a northwest-trending downwarp lying between the White River uplift on the east and the Douglas Creek arch on the west. The topography of the basin between the White and Colorado Rivers is illustrated by the block diagram. The edges of the basin are formed by cliffs of oil shale, which act as hydrologic boundaries separating the basin from adjacent areas. A major east-west topographic divide separates the structural basin into two drainage basins: the northern drainage basin contains Piceance and Yellow Creeks, which are tributary to the White River; the southern drainage basin contains Roan and Parachute Creeks, which are tributary to the Colorado River.

GEOLOGY

A brief description of the geologic units in the Piceance Creek basin and their water-bearing characteristics is given in the table. A geologic map and summary of the geology and oil resources of the basin is given in a report by Donnell (1961). The general shape of the basin and the relation of geologic units are shown on the structure contour map and the diagrammatic section.

Surface rocks exposed in the basin are sedimentary and range in age from the Cretaceous to the Quaternary (Donnell, 1961). Discussion of the geologic units in this report will be limited to the Green River Formation and younger rocks because these sediments are of greatest economic interest and contain the principal aquifers in the basin.

The Green River Formation of Eocene age rests conformably on the Wasatch Formation and is the bedrock in the area (see diagrammatic section). The formation is divided into five members: Anvil Points, Douglas Creek, Garden Gulch, Parachute Creek, and Evacuation Creek.

The Anvil Points, Douglas Creek, and Garden Gulch Members are composed of marlstone, shale, and sandstone. These units are relatively impermeable. In general, they impede the movement of ground water between the Green River Formation and the underlying rocks.

The Parachute Creek Member overlies the Garden Gulch Memberand is composed principally of oil shale. This member contains the principal bedrock aquifer in the basin. The member can be divided into three zones (high resistivity, low resistivity or leached, and Mahogany) based on differences in both geologic and hydrologic character. These zones can be correlated throughout the central part of the basin based on their characteristic appearance on electric logs as shown on the stratigraphic section. The lowermost zone in the Parachute Creek Member is called the high resistivity zone. This zone contains oil shale and beds of saline minerals, is relatively impermeable, and probably is little fractured. The high resistivity zone is confined to the center of the northern part of the Piceance Creek basin (see diagrammatic section) and ranges from less than 200 to more than 900 feet thick, as indicated on the thickness map of the zone. The absence of this zone elsewhere may be due to low concentration of kerogen or to removal of the saline minerals by solution. Apparently, some saline minerals were deposited throughout the basin in the Parachute Creek Member. Deposition in vugs and beds is undoubtedly most common near the center of the basin and less common on the edges of the basin. The zone overlying the high resistivity zone is characterized by low resistivity on electric logs (see stratigraphic section). In the center of the basin, where saline minerals make up a greater percentage of the member, the removal of minerals from the upper part has resulted in voids, fracturing, collapse, and irregular bedding. The low resistivity zone which corresponds to the leached zone is more porous and permeable than either the underlying or overlying zones. Because of its high porosity and permeability, the leached zone is the principal bedrock aquifer in the Piceance Creek basin. The low resistivity zone is best defined near the center of the northern part of the basin and ranges from less than 400 to 700 feet thick as shown on the thickness map of the zone. The low resistivity zone thickens outward, but cannot be distinguished on electric logs outside of the 700-foot thickness line (see stratigraphic section). Core recovery from the leached zone is generally poor, but when core is recovered, it is highly fractured and contains vugs. Drillers often report lost circulation in this zone.

Overlying the leached zone is the Mahogany zone, or as it is called on the outcrop, the Mahogany ledge (see stratigraphic section). The zone contains a relatively thick section of oil shale. Saline minerals are sparse in this zone and apparently were never thickly deposited.

The Evacuation Creek Member, consisting of marlstone and fine-grained sandstone, overlies the Parachute Creek Member and forms the surface rock throughout most of the basin. That part of the member topographically higher than the level of the streams is mostly drained. The Evacuation Creek Member is more permeable than the Mahogany zone but is less permeable than the leached zone. The Evacuation Creek Member ranges from 0 to 1,250 feet thick.

Alluvium of Quaternary age contains sand, gravel, and clay and partly fills the stream valleys of Piceance, Yellow, Roan, and Parachute Creeks. The permeable alluvium is an aquifer in the Piceance Creek basin. The saturated thickness is as great as 100 feet. However, the areal extent of the alluvium is small and is usually confined to belts less than 1 mile wide. Because of this limited width, the alluvium is not capable of supplying large quantities of water to wells for more than a few months. The alluvium ranges from 0 to 140 feet thick.

STRUCTURE

The Green River Formation is cut by a very extensive joint or fracture system. The orientation of many of the streams and their tributaries appears to be controlled by these fractures. Streamflow along joints or fractures provides avenues for recharge to both the Evacuation and Parachute Creek Members. The joints are parallel to major structural features in the basin, but the primary trend is towards the northwest.

GEOHYDROLOGY OF THE PICEANCE CREEK STRUCTURAL BASIN BETWEEN THE WHITE AND COLORADO RIVERS, NORTHWESTERN COLORADO

By
Donald L. Coffin, Frank A. Welder and Richard K. Glanzman

1971