Saline-Water Resources of New Mexico

By JAMES W. HOOD and LESTER R. KISTER

GEOLOGICAL SURVEY WATER-SUPPLY PAPER 1601

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1962

UNITED STATES DEPARTMENT OF THE INTERIOR

STEWART L. UDALL, *Secretary*

GEOLOGICAL SURVEY

Thomas B. Nolan, *Director*

The U.S. Geological Survey Library has catalogued this publication as follows:

Hood, James Warren, 1925–

Saline-water resources of New Mexico, by James W. Hood and Lester R. Kister. Washington, U.S. Govt. Print. Off., 1962.

iv. 70 p. maps, diagrs., tables. 24 cm. (U.S. Geological Survey. Water-supply paper 1601)

Part of illustrative matter folded in pocket. Bibliography: p. 34–38.

1. Saline waters—New Mexico. 2. Water-supply—New Mexico. 3. Water, Underground—New Mexico. I. Kister, Lester Ray, 1923– joint author. (Series)

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington 25, D.C.

CONTENTS

ILLUSTRATIONS

[Plates are in pocket]

TABLES

SALINE-WATER RESOURCES OF NEW MEXICO

By JAMES W. HOOD and LESTER R. KISTER

ABSTRACT

Use of fresh water in the United States is increasing markedly. To add to the future supply, work is being done to develop economically feasible methods of converting saline water into fresh water. The supplies of saline water must be studied to determine the quantity and quality of water and the areas in which it is available.

Water is classified herein as saline if it contains more than 1,000 ppm (parts per million) of dissolved solids. The degree of water salinity in terms of dissolved solids is defined as slightly saline (1,000 to 3,000 ppm), moderately saline (3,000 to 10,000 ppm), very saline (10,000 to 35,000 ppm), and brine (more than 35,000 ppm).

Parts of most aquifers in New Mexico contain saline water, and some of the aquifers can yield large quantities of saline water to wells. The aquifers considered herein range from Pennsylvanian to Recent in age. The Pennsylvanian rocks generally yield small to moderate quantities of saline water.

The Yeso formation and the San Andres and Capitan limestones of Permian age yield large quantities of water to wells mainly in or near the Pecos Valley. The Yeso and some other Permian rocks contain large amounts of evaporites, the solution of which contributes to the salinity of water in much of the State.

Most of the Triassic and Jurassic rocks in New Mexico are fine grained or well cemented and are poor aquifers. In many areas they yield only small quantities of saline water.

Rocks of Cretaceous age crop out in, or underlie, about 30 percent of New Mexico. A relatively thin section of them, belonging mainly to the Dakota sandstone, yields small to moderate quantities of saline water. The Upper Cretaceous series is 3,000 to more than 5,000 feet thick and generally yields small to moderate quantities of fresh to moderately saline water.

Tertiary aquifers include the Nacimiento formation in the San Juan basin, which probably can yield moderate quantities of saline water, and the Ogallala formation on the High Plains, which contains some saline water in southern Lea County.

In central and southwestern New Mexico, several thousand feet of Tertiary and Quaternary rocks partly fill intermontane basins. The fill forms some of the largest saline-water reservoirs and in many parts of the State it can yield large quantities of saline water.

Quaternary rocks mantle most of New Mexico, but yield large quantities of saline water only in the valleys of the Pecos River and the Rio Grande.

Saline surface waters are important irrigation supplies in New Mexico, especially in the Pecos Valley. The Pecos River is slightly saline at Puerto de Luna and moderately saline at Red Bluff, N. Mex.

The Rio Grande, Canadian, and San Juan Rivers generally are fresh, but they receive saline water occasionally from intermittent tributaries and possibly from a few perennial tributaries.

Saline reservoirs in New Mexico are Alamogordo Reservoir and Lakes McMillan and Avalon, all on the Pecos River. Many small permanent and ephemeral lakes in New Mexico also contain saline water.

INTRODUCTION

Use of fresh water for domestic, industrial, and irrigation purposes is increasing rapidly in the United States. In most areas in New Mexico the total available supply of fresh water is now utilized, and in some places the demand for fresh water already exceeds the supply. In a few places only saline-water supplies are available. Because a shortage or lack of fresh water is a deterrent to economic expansion, serious consideration now is being given to augmenting fresh-water supplies by converting saline water into fresh water.

PURPOSE AND SCOPE

Since about 1952 the U.S. Department of the Interior has been investigating economically feasible processes for converting saline water into fresh water. An integral part of the Saline-Water Conversion Program is the acquisition of information of the saline-water resources of the Nation. Such knowledge is required for two purposes. First, the development of a demineralizing process requires that the chemical quality of the water to be processed be known in advance. Second, should an economical process of conversion for the water be developed, the location and extent of areas containing sufficient suitable water for processing must be known.

Heretofore, water-resources investigations have dealt mainly with supplies of water that are naturally suitable for domestic, industrial, and agricultural uses. Although considerable quantities of saline water are known to exist in the United States, those waters have not been studied as possible sources for conversion to fresh water. In order to implement the Saline-Water Conversion Program, reconnaissance reports describing the saline-water conditions in the United States as a whole and several individual States have been prepared. This report is a part of that series and is based on a reconnaissance of the occurrence, quantity, and quality of saline waters in New Mexico. It describes areas where considerable quantities of saline ground and surface waters are available, points out areas where little or no fresh water is available, describes the physical characteristics of the saline aquifers and streams, and describes the quality of the saline water from the various sources in New Mexico.

SOURCE OF DATA

The chemical analyses listed in this report were made by the U.S. Geological Survey, and most are on file in the Albuquerque, N. Mex., office. The analyses selected for presentation are those which not only give the best areal coverage but also indicate the known maximum range in chemical quality of the saline water.

The outcrop maps are based principally on the geologic map of New Mexico prepared by Darton (1928b). For use in this report, many parts of Darton's map were modified using the results of more recently published and unpublished reports and the work copies and preliminary editions of the forthcoming revision of the geologic map of New Mexico (Dane and Bachman, 1957, 1958). Most sources of data are listed in the selected references which are part of this report. These sources have been consulted freely and their use is acknowledged, with the authors' thanks.

WELL-NUMBERING SYSTEM

The system of numbering wells in New Mexico, as used in this report is based on the common subdivisions in sectionized land. The well number, in addition to designating the well, locates its position to the nearest 10-acre tract in the land net. The number is divided by periods into five segments. The first segment denotes the quarter of the State with respect to the New Mexico base line and principal meridian. The quarters of the State are numbered 1, 2, 3, and 4, in the normal reading order, for the northwest, northeast, southwest, and southeast quarters, respectively. The second segment denotes the township; the third denotes the range; and the fourth denotes the section.

The fifth segment of the number, which consists of three digits, denotes the particular 10-acre tract in which the well is situated. For this purpose, the section is divided into four quarters, numbered 1, 2, 3, and 4, in the normal reading order, for the northwest, northeast, southwest, and southeast quarters, respectively. The first digit of the fifth segment gives the quarter section, which is a tract of 160 acres. Similarly, the quarter section is divided into four 40-acre tracts numbered in the same manner, and the second digit denotes the 40-acre tract. Finally, the 40-acre tract is divided into four 10-acre tracts, and the third digit denotes the 10-acre tract. Thus, well 4.12.36.24.123 is in the southeastern quarter of the State in Lea County and is in the SW¼NE¼NW¼ sec. 24, T. 12 S., R. 36 E. If a well cannot be located accurately within a 10-acre tract, a zero is used as the third digit, and if it cannot be located accurately within a 40-acre tract, zeros are used for both the second and third digits.

If the well cannot be located more closely than the section, the fifth segment of the well number is omitted. Letters a, b, c, . . . are added to the last segment to designate the second, third, fourth, and succeeding wells in the same 10-acre tract.

The following diagram (fig. 1) shows the method of numbering the tracts within a section.

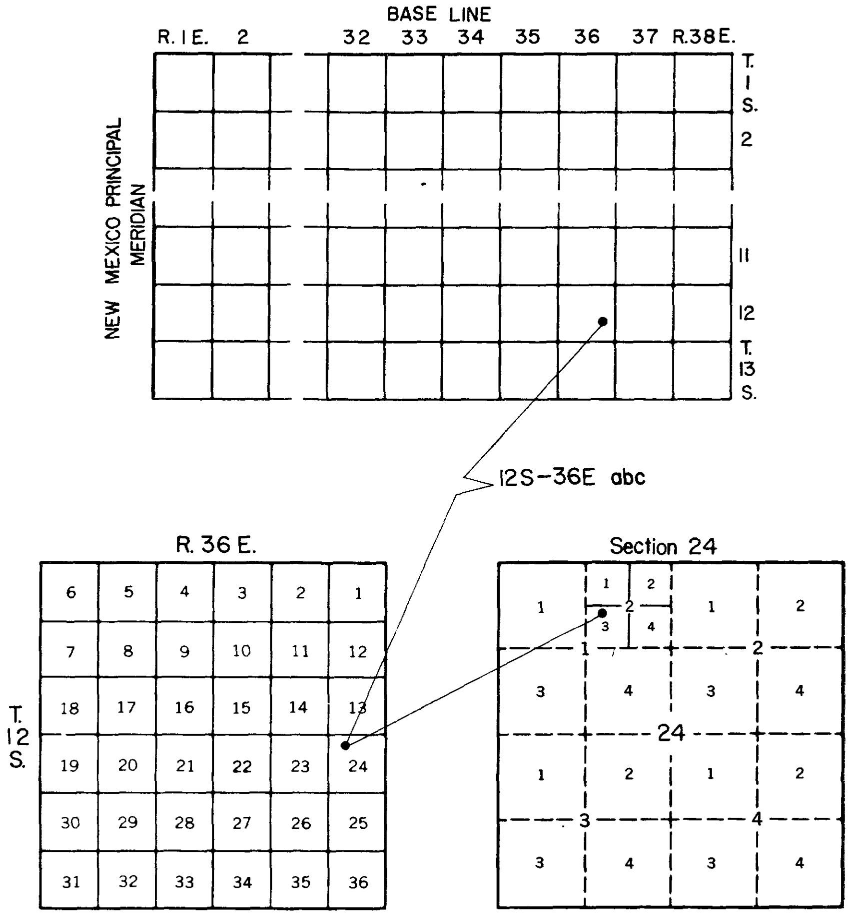

FIGURE 1.—Well-numbering system.

CHEMICAL ANALYSES OF WATER

The chemical analyses reported herein show the concentrations of most of the major water-soluble constituents. Concentrations of the individual constituents are expressed in parts per million. A part per million is a unit weight of the dissolved substance in 1 million unit weights of solution. Concentrations of the individual constituents also may be expressed for purposes of computation in equivalents per million. An equivalent per million is 1 equivalent weight in 1 million weights of water. The equivalent is the weight with reference to some standard (such as the combining weight—either of oxygen, 8, or of hydrogen, 1.008) of that quantity of an element, radical, or compound, that will react with another element, radical, or compound to complete a definite chemical reaction. An equivalent of an element or ion is exactly equal in combining power to an equivalent of another element or ion.

A comphrehensive discussion of the individual mineral constituents is not included in this report. Definitions, however, are given for specific conductance, dissolved solids, and percent sodium because they are considered to be the most important criteria in classifying water as fresh or saline.

Specific conductance is a measure of the ability of an aqueous solution to conduct an electric current under standardized conditions and is expressed in micromhos per centimeter at 25° C. It serves as a general indication of the amount of dissolved mineral matter in the water.

The dissolved-solids concentration, in parts per million, is the weight of dissolved material in water and is determined either as the residue after evaporation of water and drying of residue at 180° C or as the arithmetical sum of the weights of the individually determined constituents, the bicarbonate being computed as carbonate. The residue from some water containing more than 1,000 ppm (parts per million) of dissolved solids may include organic matter and water of crystallization in sufficient quantities to cause considerable variation in the reporting of dissolved solids. For this reason, most of the values for dissolved solids in the tables of chemical analyses in this report are the sums of the individually determined constituents, but a few are the weights of the residue after evaporation because the number of determined constituents was insufficient for computing a sum.

The percent sodium is a computed quantity obtained by dividing the equivalents per million of sodium, multiplied by 100, by the sum of the equivalents per million of calcium, magnesium, sodium, and potassium. An excessive proportion of sodium in the water applied to land may cause the soil structure to break down and the soil to become relatively impermeable. The percent sodium, therefore, is important to the prospective user of water for irrigation. The usefulness of water for irrigation purposes also may be indicated by the sodium-adsorption-ratio (SAR) described by the U.S. Department of Agriculture Salinity Laboratory Staff (1954). However, percent sodium is used in this report, because most of the available analyses express the sodium hazard to soil as percent sodium.

DEFINITION OF SALINE WATER

Saline water generally is considered to be water containing large quantities of dissolved solids. The tolerable limit of dissolved solids, or of any individual constituent, depends largely on the intended use of the water. For example, water too mineralized for drinking may be suitable for irrigation, and water too mineralized for irrigation may be satisfactory for some industrial processes. Because standards for quality of water can be based on different criteria, the term "saline water" is defined so that its use in this report will be understood.

The U.S. Public Health Service (1946) permits no more than 1,000 ppm of dissolved solids in drinking water used on interstate carriers subject to Federal quarantine regulations. In this report, water containing more than 1,000 ppm of dissolved solids is termed "saline," although in many parts of New Mexico the only water available has higher concentrations and is consumed by local residents without apparent ill effect. The degree of the salinity of the waters discussed in this report is the same as in the system of classification used by Winslow and Kister (1956) in their report on the saline-water resources of Texas. This system of classification is as follows:

Description	*Dissolved solids, in parts per million*
Slightly saline	1,000–3,000
Moderately saline	3,000–10,000
Very saline	10,000–35,000
Brine	More than 35,000

Slightly saline water is used on many farms and ranches and in many small communities. It is unsatisfactory for some domestic purposes, but generally this class of water is not harmful to health. Water containing as much as 3,000 ppm of dissolved solids may be used for irrigation, although under some conditions it is unsatisfactory.

Moderately saline water is unsatisfactory for most uses and is seldom used for domestic supply. However, moderately saline water has been used for irrigation for years in parts of the Pecos River valley in New Mexico. This is possible because of favorable natural drainage and suitable texture of the soil. Experiments have shown that 10,000 ppm is about the upper limit of salinity that can be tolerated by livestock (Smith, Dott, and Warkentin, 1942, p. 15).

The upper limit of concentration of very saline water is about equal to the average concentration of sea water. Very saline water may be obtained from some aquifers and some closed drainage basins in New Mexico.

Water containing more than 35,000 ppm dissolved solids is called brine. Brines are present in a few aquifers in New Mexico, notably in the southern Pecos Valley, where inflow of brine adds to the mineral load of the Pecos River. At the present time, brines cannot be economically demineralized.

CAUSES OF MINERALIZATION

Nearly all ground water in New Mexico, both fresh and saline, is derived from infiltration of precipitation and seepage from streams. All water in an aquifer is at least slightly mineralized because it has dissolved minerals from the soil and rock with which it has come into contact. Some strata, especially those of Permian age in New Mexico, include beds of evaporites such as common salt and gypsum, and water passing through these easily dissolved minerals becomes saline within a comparatively short distance. Other strata, although they do not include evaporites, contain other types of soluble minerals. Some additional factors governing the degree to which water becomes mineralized are the rate of water movement, the temperature of the water, and the hydrostatic pressure.

In areas where the water table is at or near the surface, evapotranspiration of ground water causes the dissolved minerals to become more concentrated in the remaining water. Evapotranspiration is greatest in the summer when high temperatures are coupled with low relative humidity. Evaporation from playa lakes also may result in an increase in the salinity of ground water, because, when the lake dries up, the salts remain on the former lake floor and later may be dissolved by infiltrating water. Irrigation exposes large amounts of water to the atmosphere, and even though fresh water is applied, the return water from irrigated areas may be saline. In the river valleys where return flow from irrigation is used and reused several times, the water becomes more and more saline. In the valleys of the Pecos River, Rio Grande, and some of the smaller streams, the numerous phreatophytes transpire large quantities of ground water, thereby causing the remaining ground water to become increasingly mineralized.

Water in aquifers where structural or stratigraphic traps have prevented flushing is termed "connate water." Such water is commonly saline. No large reserves of connate water are known to be present in New Mexico.

The mineral content in nearly all the saline stream waters in New Mexico can be traced to one or more of the following causes: (a) inflow of saline ground water into surface-water channels; (b) solution of minerals from rocks and soil over which the water flows; (c) evaporation which tends to concentrate the minerals in the remaining water; (d) growth of phreatophytes, especially those that exude salts from their leaves; and (e) inflow of drainage from irrigated lands. Evaporation is the most important factor in increasing the salinity of water in lakes and reservoirs in the State.

In the perennial streams, such as characterized humid regions, the concentration of dissolved solids usually is least during periods of large discharge and is greatest during periods of small discharge.

This relation of dissolved solids concentration to discharge exists because the overland runoff contributing to the large discharge is less mineralized than the ground water that maintains the small discharge. The reverse is true of many intermittent streams draining arid areas. In the channels of such streams evaporation may cause salts to accumulate when the stream has a small discharge or no discharge, and later, when a rainstorm causes a large discharge, the salts are dissolved and add to the concentration of dissolved solids in the water. Thus the initial flow from a stream in flood may be saline and the latter part fresh, and the later flow following the flood also may be fresh.

Evaporation and inflow from saline streams, springs, or seeps causes the water in reservoirs and natural lakes to become more mineralized. Generally water in the reservoirs is less mineralized than the saline flows of the streams and more mineralized than the fresh flows.

GENERAL GEOLOGY AND SALINE-WATER AQUIFERS

The rock strata in New Mexico have undergone widely different changes in attitude. In the Great Plains province (fig. 2) and part of the Colorado Plateau, for example, most of the rocks retain their original position or have been warped only slightly, whereas the pre-Tertiary strata in the Southern Rocky Mountains, Basin and Range province, and parts of the Colorado Plateau have been complexly folded and faulted and have been intruded by igneous rock. In these latter areas, only the rocks of Tertiary and Quaternary age are relatively undisturbed. Owing to differing attitudes, rocks of different geologic ages are exposed within relatively small areas, and rocks of the same age are exposed in widely separated areas in the State.

Rocks cropping out in New Mexico range in age from Precambrian to Recent. In the southern part of the State, Paleozoic rocks of Cambrian to Devonian age directly overlie the Precambrian basement, whereas available data for the remainder of the State indicate that in most areas rocks of Pennsylvanian age rest on the Precambrian rocks. Intrusive and extrusive igneous rocks of Tertiary age crop out in extensive areas in the State. Because the Precambrian rocks generally yield little or no water, because the Paleozoic rocks older than Pennsylvanian yield only small supplies and generally are deeply buried, and because the Tertiary igneous rocks generally yield fresh water, the water in these rocks is not considered further in this report.

Few of the aquifers in New Mexico contain exclusively fresh or saline water. Most aquifers that contain fresh water at one locality contain saline water at another. Considerable study of the fresh-

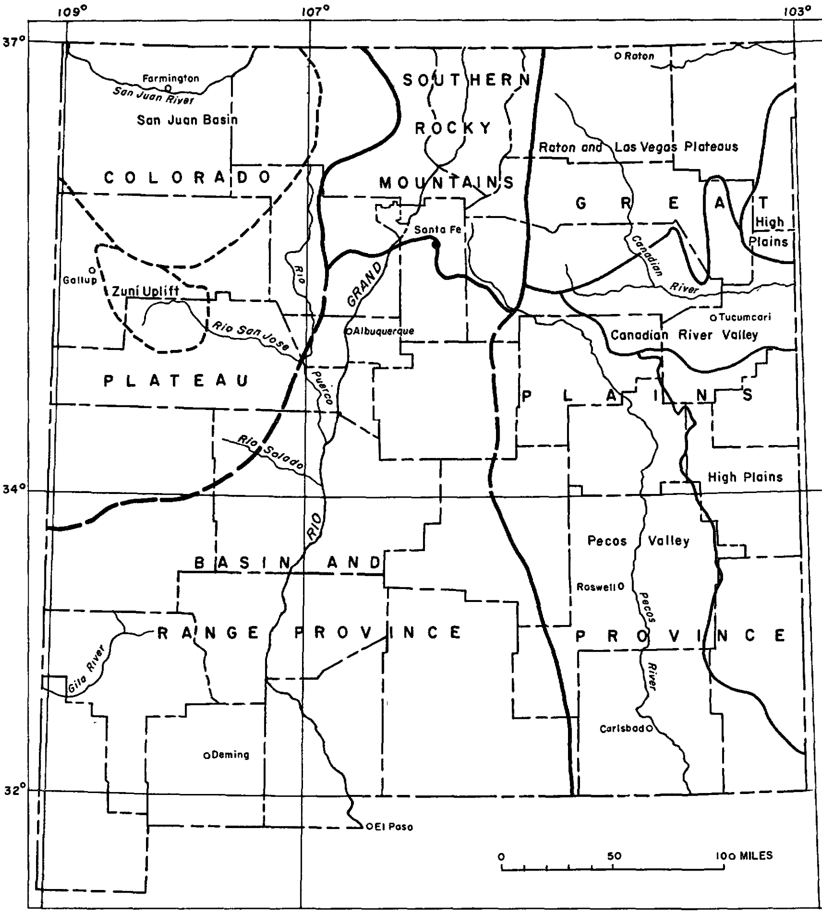

FIGURE 2.—Map of New Mexico showing physiographic, structural, and geographic features referred to in text. After Fenneman (1931).

water areas have been made, but the saline-water areas usually have been neglected. In some parts of New Mexico all ground water is saline, and in some of these areas all the aquifers yield comparatively small amounts of water. For this reason, data have been included in this report on some aquifers that yield only small amounts of water. For the purposes of discussion, yield of 100 gpm (gallons per minute) or less are considered small, 100 to 300 gpm, moderate, and more than 300 gpm, large. The saline-water aquifers are described on following pages and are listed with a brief description of their characteristics in the following table. Chemical analyses of samples of saline ground water are given in table 1 and on the maps showing the outcrops of saline-water aquifers. Data relating to the sources of water for which analyses are given are listed in table 2.

Saline-water aquifers in New Mexico

System	Series	Formation or group	Character of rocks	Saline-water supply
Quaternary	Recent and Pleistocene.	Alluvial and eolian deposits	Gravel, sand, silt, and clay.	Large supplies in Pecos and Rio Grande Valleys. Moderate to large supplies from alluvial fans in mountain areas in the Basin and Range provinces. Small to moderate supplies from terrace deposits and small stream valleys.
Tertiary and Quaternary	Middle Miocene(?) to Pleistocene(?)	Santa Fe group and related bolson fill.	Unconsolidated, or slightly consolidated gravel, sand, silt, clay, and tuffaceous rocks, some interbedded volcanic rocks.	Small to large supplies in intermontane basins of Basin and Range province.
Tertiary	Pliocene.	Ogallala formation.	Gravel, sand, and clay.	Moderate to large supplies in southern High Plains.
	Paleocene.	Nacimiento formation.	Sandstone, shale, and conglomerate.	Small to possibly moderate supplies in San Juan Basin.
Cretaceous	Upper Cretaceous.	Undifferentiated.	Shale, sandstone, limestone, and conglomerate.	Small supplies in the area of the Raton and Las Vegas Plateaus and in small areas of Basin and Range province. Small to moderate supplies in Colorado Plateau.
	Lower(?) and Upper Cretaceous.	Dakota sandstone.	Sandstone with some shale, conglomerate, and coal.	Small to moderate supplies in the areas of the Raton and Las Vegas Plateaus, the eastern edge of the Basin and Range province, and the Colorado Plateau.
Jurassic	Undifferentiated.	Undifferentiated.	Sandstone, siltstone, and shale, with some limestone and conglomerate.	Generally yields small to moderate supplies in the northern half of the State.
Triassic	Upper Triassic.	Dockum group.	Sandstone, siltstone, red shale, and some conglomerate.	Small to moderate supplies in the Canadian River valley, northern Pecos Valley, and Colorado Plateau; possible large supplies locally.

Permian	Ochoa.	Rustler formation.	Dolomite, anhydrite, and red shale.	Small to large supplies in southern Pecos Valley.
		Castile formation.	Anhydrite or gypsum, lesser amounts of salt and limestone.	Small supplies in southern Pecos Valley.
	Guadalupe.	Capitan limestone.	Reef limestone.	Moderate to large supplies in vicinity of Carlsbad.
		Undifferentiated.	Red beds, gypsum, limestone, dolomite, siltstone, and sandstone.	Small to large supplies in the Pecos Valley.
		San Andres limestone.	Limestone and dolomitic limestone with some gypsum and sandstone.	Large supplies in the Pecos Valley and in the vicinity of the Zuni uplift.
	Leonard.	Glorieta sandstone.	Sandstone and some limestone.	Generally yields small supplies, but locally yields large supplies, where fractured.
		Yeso formation.	Pink and yellow to white shales, siltstone, gypsum, limestone, and sandstone.	Small to moderate supplies in eastern Basin and Range province from Otero County northward to Southern Rocky Mountains and eastward to Canadian River valley. Capable of yielding large supplies locally, particularly in thick limestone section in southeastern Otero County.
		Abo formation.	Red shale, siltstone, sandstone, and conglomerate.	Small supplies in Basin and Range province.
	Wolfcamp.			
Pennsylvanian	Undifferentiated.	Undifferentiated.	Limestone, shale, and sandstone.	Small to moderate supplies in Basin and Range province and on flanks of Southern Rocky Mountains. Capable of yielding large supplies locally.

PENNSYLVANIAN SYSTEM

According to available data rocks of Pennsylvanian age are the oldest strata in New Mexico capable of yielding more than small quantities of water to wells. In most of the State these rocks are included in the Magdalena group. In the central part of the State the group includes three units. In ascending order these are the Sandia formation of Devonian(?), Mississippian, and Pennsylvanian age, the Madera limestone of Pennsylvanian age, and the Bursum formation of Permian age. Read and others (1944) report that the Magdalena group in the northeastern Basin and Range province and the Southern Rocky Mountains province ranges in thickness from 1,000 to about 1,600 feet. The thickness of Pennsylvanian rocks increases from the central part of the State to the southeastern part of the Basin and Range province, where Pray[1] measured approximately 3,000 feet of rocks belonging to the group, but excluded the Bursum formation. The Bursum formation now is considered to be early Permian in age (Dane and Bachman, 1957). Along the southern State line and in trans-Pecos Texas the Pennsylvanian rocks are called the Magdalena limestone (King, King, and Knight, 1945).

Pennsylvanian rocks crop out in the Southern Rocky Mountains and in the Basin and Range province (fig. 2 and pl. 1), and are present beneath the surface in most of the State. The principal types of rocks in the Pennsylvanian are limestone, shale, and sandstone; some of the sandstone is arkosic and some of the limestone consists of bioherms.

Smith (1957) reports that several irrigation wells tapping Pennsylvanian rocks in Torrance County discharge from 350 to 850 gpm of fresh water. Spring 1.1.2.7.100, in northwestern Socorro County, discharges about 500 gpm of moderately saline ground water and reportedly sustains the low flow of the Rio Salado below that point. The group of springs utilized by health resorts at Truth or Consequences, in Sierra County, issue from Pennsyvanian rocks and discharge hot saline water. Although the discharge from individual springs is small, the aggregate discharge of water from them and from wells near the springs was nearly 1,600 gpm in 1940 (Theis, Taylor, and Murray, 1941).

The observed quality of water from rocks of Pennsylvanian age varied from slightly saline to very saline. (See table 1.) On the basis of the available chemical analyses, it appears that the quality of saline water in the Pennsylvanian rocks is far from uniform from one part of the State to another and that several types of water may be obtained from the rocks. The location of wells and springs sampled and the areas of outcrop of rocks of Pennsylvanian age are shown on plate 1.

[1] Pray, L. C., 1952, Stratigraphy of the escarpment of the Sacramento Mountains, Otero County, New Mexico: Ph. D. thesis, California Inst. Technology. On file at New Mexico Inst. Mining and Technology, State Bur. Mines and Min. Resources Div., Socorro, N. Mex.

PERMIAN SYSTEM

The Permian rocks are among the most important reservoirs of saline water in New Mexico. The Permian system not only contains some of the most productive aquifers, but also is the source of the salts in much of the saline water in the State. Permian rocks crop out extensively in the eastern part of the Basin and Range province and in the Pecos Valley; they crop out also on the flanks of the Southern Rocky Mountains and in the Zuni uplift. They underlie the Great Plains province, most of the Basin and Range province, and part, if not all, of the Colorado Plateau. Generally, the Permian rocks are relatively thin in the western part of the State and thicken toward the southeast.

In most parts of New Mexico, the saline-water aquifers in the Permian system are the Abo and Yeso formations, the Glorieta sandstone, the San Andres limestone, and rocks in the Guadalupe series other than the San Andres. Although the San Andres limestone is partly of Guadalupe age, it is discussed separately, owing to its importance as an aquifer. For the sake of simplicity in this report, the term Guadalupe series is used in place of the names of the Bernal and Chalk Bluff formations, which crop out in the northern and central Pecos Valley and eastern Basin and Range province, and the Grayburg, Queen, Seven Rivers, Yates, and Tansill formations in the southern Pecos Valley of New Mexico, which are of the same age as the Chalk Bluff formation, but differ lithologically. The Capitan limestone also is approximately equivalent in age to the Chalk Bluff formation but is described separately herein because it is an important aquifer in the vicinity of Carlsbad.

Rocks of late Permian age bear water only in the southernmost part of the Pecos Valley. Owing to the large amounts of included evaporites the Castile and Rustler formations contain brine.

In parts of Socorro, Torrance, Lincoln, Guadalupe, and DeBaca Counties one of the principal aquifers is the Yeso formation which, in most of these areas, contains slightly to moderately saline water. In much of this region water of suitable quality for public and domestic use is scarce. Water of good quality is also scarce in southern Eddy County in the area where the Rustler and Castile formations crop out.

Saline water from most of the Permian rocks in New Mexico is predominately of the calcium sulfate type. However, some of the brines from the San Andres limestone and the Castile and Rustler formations are of the sodium chloride type. The Salado formation underlying the Rustler is the principal source of mineralization of water pumped from the Rustler formation.

634404—62——2

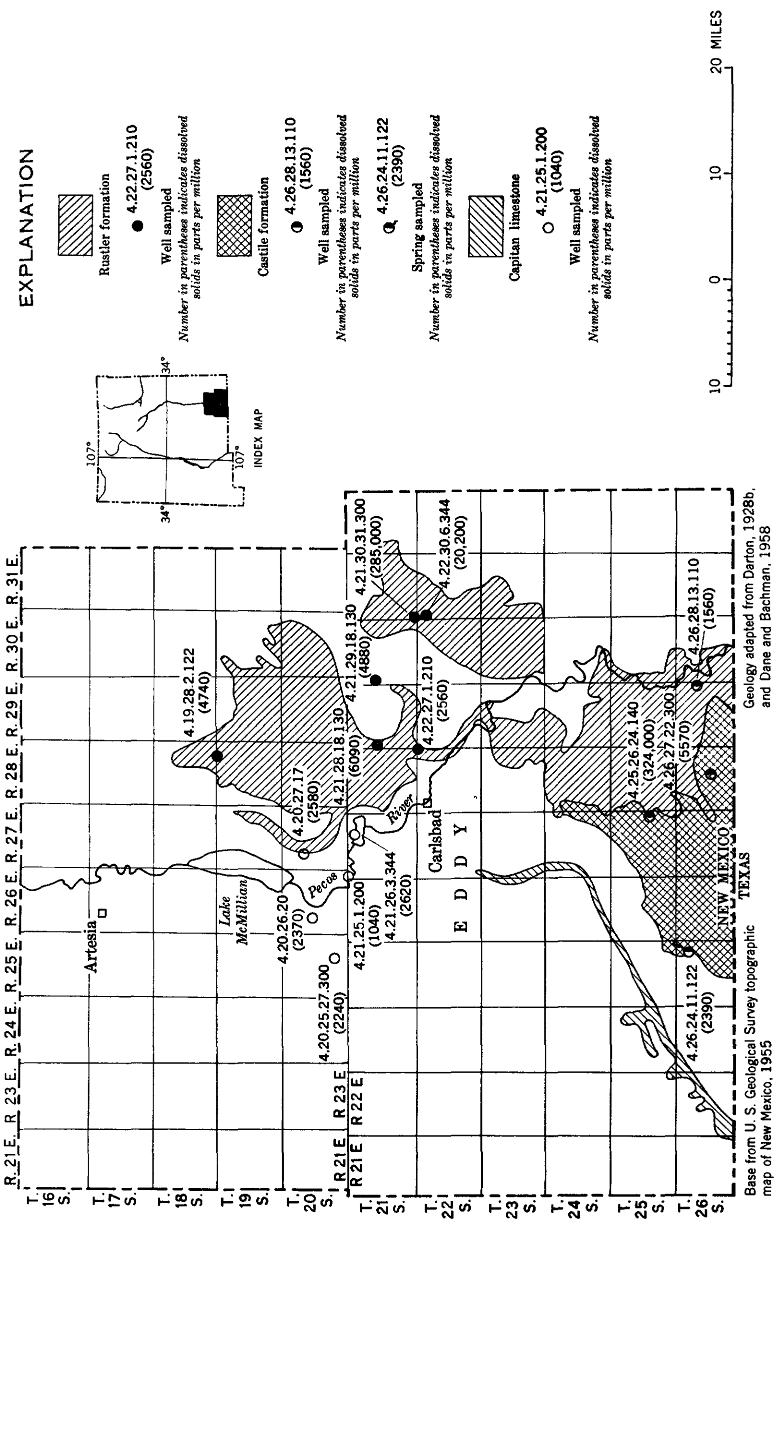

FIGURE 3.—Map of Eddy County, N. Mex., showing location of wells and springs sampled and areas of outcrop of the Capitan limestone, Castile formation, and Rustler formation of Permian age.

Analyses of saline water from aquifers of Permian age are given in table 1. Location of wells and springs sampled and areas of outcrop of Permian formations are shown on plates 2 and 3 and in figure 3.

ABO FORMATION

The oldest Permian rocks in New Mexico are those of the Abo formation; for simplicity this report does not differentiate the older Bursum formation nor the top of the Sangre de Cristo formation of Pennsylvanian and Permian age in the vicinity of the Southern Rocky Mountains. The Abo formation consists mainly of red shale, sandstone, arkose, and conglomerate. In the southeastern Basin and Range province there is also a limestone tongue—the Pendejo Tongue of Pray (1954)—which thickens southward, to the exclusion of the red bed and sandstone facies.

The Abo formation crops out principally around the flanks of the Southern Rocky Mountains and in the Basin and Range province (pl. 2). It crops out also in small areas in the Zuni uplift. Bates and others (1947) measured 810 feet of the Abo in Abo Canyon, in and near the southwestern part of Torrance County. In central Otero County, Pray[2] found the maximum thickness to be approximately 550 feet. The Bursum formation in about the same area has a maximum thickness of about 350 feet. The Abo formation underlies most of the Great Plains province and is approximately 1,500 feet thick in the vicinity of Artesia (Roswell Geol. Soc., 1956). The formation also underlies most of the Basin and Range province and at least part of the Colorado Plateau.

The sandstone and conglomerate of the Abo formation are the water-bearing units of the formation, but yield only small quantities of water. Smith (1957) reports that a test well drilled for the Punta de Agua community in Torrance County (T. 4 N., R. 6 E.) was drilled to a depth of 400 feet and penetrated the Abo formation. Upon testing, it had a yield of about 3 gpm. In other parts of the Basin and Range province, the sandstone, where fractured, yields moderate amounts of slightly to very saline water, predominately of the calcium sulfate type.

YESO FORMATION

In much of central and south-central New Mexico the Yeso formation affects the quality of ground water because it yields salt to the water within it and it also discharges this mineral-laden water to the Tertiary-Quaternary bolson fill in some areas. The Yeso formation crops out principally in the Basin and Range province, from central Santa Fe County southward to the State line. Where it does not

---

[2] See footnote, p. 12.

crop out, the Yeso formation underlies much of the eastern Basin and Range province and has been penetrated by deep wells throughout much of the Great Plains province. In the north-central and central parts of the State, the Yeso consists of gypsum, limestone, sandstone, siltstone, and shale ranging in color from orange and red through yellow and pink to white. In the southeastern Basin and Range province the formation grades southward into a section composed mainly of limestone with some shale. The limestone of the Yeso near the New Mexico–Texas line is part of a sequence of limestone which has been called the Bone Spring limestone (King, 1944; Scalapino, 1950).

Smith (1957) reports that the Yeso formation in Torrance County ranges in thickness from about 680 to 1,000 feet. In the east-central part of the Basin and Range province, the thickness ranges from less than 500 feet to more than 1,800 feet. Beneath the Pecos Valley the formation is approximately 2,000 feet thick. The Bone Spring limestone is several thousand feet thick in the area of the intersection of the eastern edge of the Basin and Range province with the New Mexico–Texas line.

The Yeso formation generally yields small to moderate quantities of slightly to moderately saline water, but it yields large quantities of water where the rock is cavernous or fractured. A group of springs in the mountains in central Otero County yields fresh water at an average rate of about 700 gpm, and an irrigation test well in Torrance County reportedly yields about 600 gpm. The limestone near the New Mexico–Texas line is one of the most productive aquifers in New Mexico. The yields are due to the high permeability of the limestone where solution of the rocks has produced cavernous zones. The cavernous zones characteristically are not limited to any specific horizon, nor are they uniformly distributed throughout the area. Consequently, some wells do not discharge sufficient water for irrigation, the principal use of ground water in the area. Irrigation well 4.26.18.28.113, in southeastern Otero County had a measured yield of 3,620 gpm and a drawdown of 10 feet on April 12, 1956 (Bjorklund, 1957). However, the average yield of wells in the area probably is on the order of 1,500 gpm.

Most of the water samples from the Yeso formation were slightly to moderately saline and characteristically were calcium magnesium sulfate water with low concentrations of chloride (pl. 2). Several samples, however, had relatively high concentrations of chloride, and were from wells which penetrate the Yeso formation where it is deeply buried. Examples, are wells 2.11.28.30.232 and 4.18.8.5.430 (tables 1 and 2).

GLORIETA SANDSTONE

Overlying the Yeso formation is the white to yellow Glorieta sandstone. It crops out in several areas in the eastern part of the Basin and Range province, in the western part of the Pecos Valley, and in the Zuni uplift. The Glorieta sandstone, as discussed here, includes limestone in some areas; at places limestone of the Yeso grades upward into limestone of the Glorieta, and the two formations are difficult to distinguish. The Glorieta sandstone also crops out in small areas around the east and west edges of the San Juan basin (Dane and Bachman, 1957) and apparently underlies much of the basin. The formation underlies much of the Basin and Range province, and from the highlands along the east edge of that province it dips eastward beneath younger strata in the Great Plains province.

The thickness of the sandstone differs from place to place. Its thickness is about 100 feet in the Zuni uplift, 150 to 300 feet in Torrance County, and 250 to 400 feet in Guadalupe County. Southward, in Lincoln and Otero Counties, the Glorieta sandstone generally is much thinner, being only a few feet thick in some places; it is absent in some areas.

Generally, the sandstone is rather tightly cemented and yields only small amounts of water to wells, but locally it yields moderate to large amounts. Smith (1957) reports an irrigation well tapping the Glorieta sandstone in Torrance County was pumped at rates exceeding 3,000 gpm, with a drawdown of 6 feet.

Analyses indicate that the water from the Glorieta sandstone is slightly to moderate saline and is of the calcium sulfate type (pl. 3).

SAN ANDRES LIMESTONE

Among the economically important aquifers in New Mexico is the San Andres limestone, which overlies the Glorieta sandstone. The San Andres crops out in the Zuni uplift, caps several of the mountain ranges and upland plateaus in the Basin and Range province, and dips eastward beneath younger rocks in the Pecos Valley. In the southern half of the Basin and Range province and in the Pecos Valley the San Andres is mainly limestone and dolomitic limestone. In this general area the formation ranges in thickness from about 500 feet to more than 1,000 feet. From the latitude of Roswell northward, and from the vicinity of the Pecos River, west to the eastern edge of the Colorado Plateau, the San Andres includes beds of gypsum as well as limestone. Sandstone is interbedded with the limestone in the Zuni uplift. In these latter areas, the formation generally is less than 500 feet thick.

In most areas where the San Andres limestone is water-bearing it yields moderate to large amounts of ground water to wells. The aquifer is most important in the Pecos Valley, where more than a thousand irrigation wells have been completed in the formation. In this area the limestone contains cavernous zones, and at many wells it is capable of yielding 1,000 to 2,000 gpm of slightly to moderately saline water. An example of extremely large yield is that from well 4.11.25.22.210, which in 1926 discharged 5,710 gpm by natural flow (Fiedler and Nye, 1933). The San Andres is a source of ground water for irrigation and other uses on the eastern and northern parts of the Zuni uplift. Some wells in that area yield 500 to 2,000 gpm of slightly to very saline water.

In DeBaca and adjacent parts of northern Chaves, northeastern Lincoln, eastern Torrance, and Guadalupe Counties, the San Andres limestone, the underlying Yeso formation, and the overlying rocks of Guadalupe age all reportedly certain saline water. Moderate to large supplies of saline water probably can be obtained throughout the region, however, water chemically suitable for domestic and other purposes generally is difficult to obtain and the lack of adequate supplies of usable—slightly saline, or better—water has retarded the economic development of the area considerably. The lack of water suitable for locomotive boilers is an example. In order to supply suitable boiler water at stops along its road from Carrizozo northeastward to Santa Rosa, the Southern Pacific Co. found it necessary to lay more than 100 miles of pipeline from the mountains in west-central Lincoln County, along the railroad to the area of Vaughn.

GUADALUPE SERIES

Overlying the San Andres limestone are red beds, gypsum, siltstone, sandstone, limestone, and dolomite belonging to the Guadalupe series. The principal area of outcrop is in the Pecos Valley from San Miguel County southward to the Texas State line. North of Eddy County rocks of the series have been referred to the Chalk Bluff formation in most areas. Small outcrops have been recognized in the eastern Basin and Range province, where these rocks of Guadalupe age have been called the Bernal formation.

In the vicinity of Guadalupe County, the Chalk Bluff formation generally is less than 300 feet thick and consists of beds of siltstone, fine-grained sandstone, gypsum, and dolomite. The formation thickens southward, exceeding 1,000 feet in Chaves County, where it includes red beds, siltstone, gypsum, limestone, and dolomite. Southward, in Eddy County, the Chalk Bluff grades laterally into 5 separate units which, in ascending order, are the Grayburg, Queen, Seven Rivers, Yates, and Tansill formations. The section consists of sandstone, dolomitic limestone, red beds, and evaporites, and has a maximum thickness of about 1,800 feet in the Guadalupe Mountains (W. S. Motts, oral communication). The rocks described above are designated by some authors as the Whitehorse group. Rocks of Guadalupe age underlie a large part of the Great Plains, east of the Pecos River.

In some areas the rocks of Guadalupe age are not aquifers. In Guadalupe County, however, yields of slightly to moderately saline water are obtained from the Chalk Bluff formation. In the Roswell Basin beds of clay and shale in the Chalk Bluff formation are the aquicludes which cause artesian conditions in the underlying San Andres formation, but locally the Chalk Bluff yields slightly to moderately saline water to irrigation wells. In Eddy County, the Guadalupe series yields small to large amounts of water to wells. One well northwest of Carlsbad is pumped at a rate of about 500 gpm and reportedly yields slightly saline water.

Water from rocks of the Guadalupe series generally is of the calcium sulfate type and has a low concentration of chloride, but several samples from Chaves and Lea Counties, which had dissolved-solids concentrations in excess of 5,000 ppm, also contained large quantities of sodium and chloride.

CAPITAN LIMESTONE

Another formation which is considered to be a part of the upper Guadalupe series is the Capitan limestone. This formation is a reef limestone that lies between the Permian back-reef or shelf facies, occurring in most of New Mexico, and the fore-reef or basin facies in the southeastern corner of the State and in Western Texas. It crops out (fig. 3) in a narrow belt from the New Mexico-Texas line northeastward to near Carlsbad, and ranges in thickness from 1,000 to 1,500 feet. From the State line to Carlsbad much of the formation contains fresh water; however, north of Carlsbad and at some depths beneath Carlsbad the formation contains saline water.

Ground water in the Capitan limestone is largely in cavernous zones. Yields from the Capitan vary widely, depending on the character and number of solution channels penetrated by the individual well. Maximum yields are 2,000 gpm or more. Water from the formation is used for a municipal supply by the city of Carlsbad, for industrial purposes, and for irrigation from more than 50 wells in the area. Water from the Capitan limestone is slightly saline and generally is of the calcium sulfate type.

CASTILE FORMATION

Southeast of and adjacent to the Capitan limestone a thick section of evaporite rocks overlies the Guadalupe series. The lower part of the evaporite section, the Castile formation, consists mainly of anhydrite and gypsum with thick beds and lenses of salt and thin beds of limestone and sandstone. The formation is as much as 2,500 feet or more thick in the subsurface east of the Pecos River, but where it crops out south of Carlsbad, in the southernmost part of the Pecos Valley (fig. 3), it is considerably thinner. The upper part of the evaporite section, the Salado formation, consists mainly of halite with beds of anhydrite and other evaporite rocks. The formation is about 800 feet thick in the Pecos Valley, and, although not an aquifer, it considerably modifies the quality of water in the overlying Rustler formation.

The Castile formation yields water to stock and domestic wells in an area west of the Pecos River. The depth to water generally is less than 100 feet, and the water occurs under artesian conditions in some places. One such place is a few miles west of the Pecos River where the formation contains a supersaturated sodium and magnesium sulfate brine, which is processed for sodium sulfate. Generally the Castile yields only small amounts of slightly to moderately saline water, although sufficient for needs in the area where it is an aquifer. However, because the formation consists in such large part of highly soluble rock, moderate to large yields of calcium sulfate water might be obtained locally.

RUSTLER FORMATION

The Rustler formation, the youngest of the Permian water-bearing rocks in New Mexico, is 200 to 500 feet thick and contains anhydrite, red beds, and two distinct dolomite beds. It crops out in Eddy County, in the southern Pecos Valley (fig. 3), and is present in the subsurface in much of the southeastern part of the State. The lower of the dolomite beds, which is the principal aquifer in the formation, yields large quantities of ground water. A potash company near Carlsbad reports that the combined discharge from 3 wells in the dolomite bed is 2,400 gpm. The second water-bearing zone, porous gypsum at the base of the Rustler, contains a supersaturated brine under artesian pressure, and the zone is permeable enough to yield moderate to large quantities of water. Springs and seeps issuing from this aquifer near the State line contribute to the salinity of water in the Pecos River. The discharge of about 200 gpm of brine into the river, adds about 420 tons per day of dissolved minerals to the river (Hale, Hughes, and Cox, 1954).

TRIASSIC SYSTEM

DOCKUM GROUP

Rocks of Triassic age are exposed in many places in northern and eastern New Mexico. The largest areas of outcrop are in the Colorado Plateau, the northern Pecos Valley, and the Canadian River valley; Smaller areas of outcrop are along the flanks of the Southern Rocky Mountains, at widely separated points in the Basin and Range province, and east of the river in the central and southern Pecos Valley. In some areas in the eastern part of the State the Triassic has been separated into two formations, the Santa Rosa sandstone below and the Chinle formation above, which comprise the Dockum group; but in most areas, the two formations are difficult to distinguish. In the Colorado Plateau, in the vicinity of Gallup, most of the Triassic rocks are assigned to the Chinle formation. Throughout the State, Triassic rocks consist of sandstone, siltstone, red shale, and conglomerate. The thickness of the system is about 1,600 feet in the vicinity of Gallup and from 1,000 to 2,000 feet in the eastern part of the State. Because most of the sandstones are relatively fine grained and tightly cemented, they yield only small amounts of water to wells. In most areas where wells tap the Triassic rocks they do not discharge more than 50 gpm.

The quality of water from rocks of the Dockum group is governed by the lithology In general the water is slightly to moderately saline, but one sample, from well 4.9.29.22, was a brine. Most of the samples analyzed were sodium sulfate waters with dissolved-solids concentrations ranging from 1,000 to about 5,000 ppm, but several were calcium magnesium sulfate waters. In Roosevelt and Chaves Counties several samples show the water to be of the sodium chloride type with dissolved solids in concentrations from about 6,000 to about 36,000 ppm. A sample from well 4.3.31.30.300, also in Roosevelt County, contained 6.4 ppm of fluoride. Water from the rocks of the Dockum group, if applied to the soil, probably would produce black alkali conditions because it contains so much residual sodium carbonate.

The location of wells and springs and the areas of outcrop of rocks belonging to the Dockum group are shown on plate 4, and the analyses of saline water are given in table 1.

JURASSIC SYSTEM

Rocks of Jurassic age crop out in the Colorado Plateau, on the flanks of the Southern Rocky Mountains, in the northern Pecos Valley, and in the Canadian River Valley (fig. 2), and underlie the Colorado, Raton, and Las Vegas Plateaus. The various formations of the Jurassic system in New Mexico have been assigned different names in different areas. There are, in ascending order, the Carmel formation, Entrada sandstone, Todilto limestone, and Morrison formation, together with a number of correlative units and other formations of intermediate age. The rocks consist mainly of sandstone, siltstone, and shale with lesser amounts of limestone and conglomerate. In the Pecos Valley and the Canadian River valley the Morrison and

Entrada generally are less than 800 feet thick. In the vicinity of Gallup the Morrison formation and a partial correlative, the Zuni sandstone, have an aggregate thickness of about 700 feet.

In most areas the Jurassic rocks are predominantly fine grained and not very permeable, and therefore yield only small quantities of water. Locally, however, they yield moderate or even large quantities, as at spring 1.8.3.10.222 and well 1.15.19.29.300.

The Entrada sandstone and Morrison formation mostly contain slightly saline water. A sample of very saline sodium chloride water was obtained from well 1.7.2.6.434, in Valencia County. Waters sampled from other wells were predominantly of the sodium sulfate type, and some contained undesirable amounts of residual sodium carbonate. Location of wells and springs sampled and outcrops of rocks of Jurassic age are shown on plate 4, and analyses of the saline water are given in table 1.

CRETACEOUS SYSTEM

Rocks of Cretaceous age crop out in or underlie about 30 percent of the surface area of New Mexico. The two principal areas of Cretaceous rocks are the Raton and Las Vegas Plateaus and the Colorado Plateau. In the former area, the Great Plains stratigraphic nomenclature generally is used. The section, in ascending order, includes the Purgatoire formation, Dakota sandstone, Graneros shale, Greenhorn limestone, Carlile shale, Niobrara formation, Pierre shale, Trinidad sandstone and Vermejo formation (Griggs, 1948; Griggs and Hendrickson, 1951; and Woods, Northrup, and Griggs, 1953), and has a thickness of about 3,200 feet in Colfax County. In the Colorado Plateau and in most of the minor outcrops in the State, the lithology of the Cretaceous rocks is different and other formation names are used. In these latter areas the name Dakota has been retained for the Lower(?) and Upper Cretaceous, and the Upper Cretaceous rocks are divided into a large number of formations, many of which are partly or entirely correlative, one to another. The Cretaceous rocks are thickest in the San Juan basin where they are more than 5,000 feet thick. Owing to the complex stratigraphic relations of the Upper Cretaceous in the Colorado Plateau, these rocks are discussed as a unit with reference to the availability of saline water.

DAKOTA SANDSTONE

Rocks of Lower(?) and lowermost Upper Cretaceous age in New Mexico belong mainly to the Dakota sandstone. Prior to 1951, the Dakota sandstone in all areas was considered to be in the Upper Cretaceous series; however, investigations in western Colorado by Cobban and Reeside (1951) and in southeastern Colorado by McLaughlin (1954) indicate that the Dakota sandstone in those areas is partly, if not entirely, Lower Cretaceous. In New Mexico, the Cretaceous is correlated, to some degree, with formations in Colorado.

In the Colorado Plateau, the Dakota shows complex facies changes. It consists of lenses of sandstone, shale, and some conglomerate and coal. In the Raton and Las Vegas Plateaus, the lower part of the Dakota sandstone includes some beds of shale which may correlate with the Purgatoire formation (Griggs, 1948). In Colfax County the sandstones generally are tightly cemented, here the formation is about 200 feet thick. In the vicinity of Gallup in western New Mexico, the thickness of the formation ranges from 50 to 250 feet.

Because the Dakota differs in lithology from place to place, the permeability differs also. The tight sandstones of the formation in the vicinity of Colfax County generally yield less than 50 gpm to individual wells. The sandstone in the Colorado Plateau generally yields small to moderate quantities of water, although large yields of saline water might be possible locally.

According to Griggs (1948) the salinity of water in the Dakota sandstone in southern Colfax County probably is related to igneous activity during Quaternary time. The principal constituents of the water are calcium, sodium, sulfate, and chloride. Some of the water also contains large amounts of bicarbonate and relatively large amounts of fluoride. The sodium bicarbonate and sodium chloride, and possibly the fluoride, probably have been added to the water from igneous emanations rising along the boundaries of dikes and plugs. Griggs also says, in effect, that the permeability of the sandstone in the area is such that the salinity of the water probably is not due, primarily, to the presence of connate water. Dikes of Quaternary age are not known to be present in eastern Colfax County, and the Dakota sandstone contains fresh water in much of that area.

The salinity of one sample of moderately saline water obtained from the Dakota in Sandoval County probably is due to the depth of burial of the formation at well 1.18.3.21.210, which is an oil test.

Ground water sampled from the Dakota sandstone was slightly to moderately saline, and most contained more than 60 percent sodium. The location of wells sampled and the areas of outcrop of the Dakota sandstone are shown on plate 5. Analyses of saline water from the formation are given in table 1.

UPPER CRETACEOUS SERIES

Rocks of Upper Cretaceous age that crop out in the Raton and Las Vegas Plateaus in northeastern New Mexico consist principally of shale and marl with some intercalated limestone. Some sandstone and coal are present in the upper part of the series. The series is about 3,000 feet thick in Colfax County and yields only small amounts of water to wells.

On the Colorado Plateau in northwestern New Mexico the Upper Cretaceous consists of sandstone, much of which is thick and massive, shale, conglomerate, and some coal in the lower half of the series. Many of these rocks can be traced from one part of the San Juan Basin to another, but the series is complex owing to the numerous lithologic changes in the form of tongues and lenses. The series differs in thickness from place to place, but generally the thickness increases toward the center of the basin, where it exceeds 5,000 feet.

The ground-water conditions in much of the Colorado Plateau have not been investigated. In areas where data are available, the sandstone and conglomerate yield small to moderate quantities of slightly to moderately saline water to wells. An example is the Gallup sandstone which is from 150 to 250 feet thick in the vicinity of Gallup and consists chiefly of fine-grained sandstone with interbedded shale and coal. The yields of wells drilled into the sandstone range from 30 to about 200 gpm.

If used for irrigation on poorly drained soil, the water from some of the rocks of Lake Cretaceous age contain sufficient residual sodium carbonate to cause black alkali conditions. One well in Colfax County (2.24.24.15.111), 130 feet deep in Graneros shale, yielded water containing approximately 40 epm of residual sodium carbonate. According to Eaton (1950) water containing more than 2.5 epm of residual sodium carbonate is not suitable for irrigation use under normal conditions.

Spring 1.8.2.30.430, in Valencia County, yielded very saline water containing 4.3 ppm of fluoride. The analyzed water samples from Upper Cretaceous rocks (were from) slightly to very saline. The chemical analyses in table 1 indicate that several types of water are obtained from Upper Cretaceous rocks. Among these are waters of the calcium magnesium sulfate, sodium sulfate, sodium bicarbonate, and sodium chloride types.

The location of wells and springs sampled and the areas of outcrop of the Upper Cretaceous series are shown on plate 5.

TERTIARY SYSTEM

PALEOCENE SERIES

NACIMIENTO FORMATION

The oldest Tertiary rocks containing saline water in New Mexico are the sandstones of the Nacimiento formation which crops out in a roughly circular band around the central part of the San Juan basin (fig. 4). The Nacimiento formation has been mapped as a unit around the southeast, south, and west sides of the basin (Dane and Bachman, 1957), but at the east side of the basin, the formation grades into the upper part of the Animas formation. In the same area the Ojo Alamo sandstone of Upper Cretaceous age, which underlies the Nacimiento formation, grades into the lower part of the Animas formation. The Nacimiento formation herein includes that part of the Animas in the San Juan basin which is correlative to the Nacimiento. The beds consist of sandstone, shale, and conglomerate, and represent a continuation of the complex intertonguing and other facies changes that are typical of the underlying Upper Cretaceous series (Baltz, 1953).

The Nacimiento crops out in a comparatively undeveloped part of the State, and only a few domestic and stock wells have been drilled into the formation. On the basis of lithology, however, the authors believe that the formation would yield small to moderate quantities of water to wells.

Water from the Nacimiento formation is of the calcium and sodium sulfate type and is slightly saline. Location of wells sampled and analyses of saline water from the formation are shown in figure 4, and table 1, respectively.

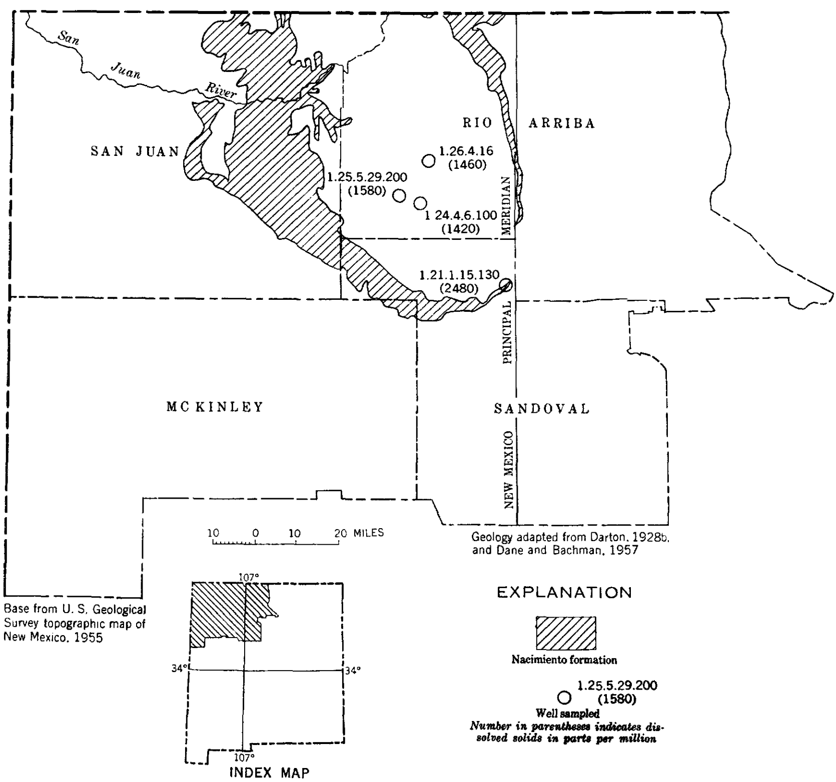

FIGURE 4.—Map showing location of wells sampled and areas of outcrop of the Nacimiento formation of Paleocene age in New Mexico.

PLIOCENE SERIES

OGALLALA FORMATION

Unconsolidated gravel, sand, clay, and caliche of the Ogallala formation of Pliocene age underlie the High Plains in the eastern part of New Mexico (fig. 5), and cap a few erosional remnants in the Pecos Valley and the Raton and Las Vegas Plateaus. In the High Plains the Ogallala ranges in thickness from a veneer to about 250 feet and lies upon the eroded surface of Triassic rocks and erosional remnants of Lower Cretaceous rocks.

In most areas on the High Plains the Ogallala yields moderate to large quantities of fresh water to irrigation and public-supply wells. However, water yielded by wells 4.18.38.30.223 and 4.21.33.2.422a in southern Lea County (fig. 5 and table 1) was slightly saline. Water from well 4.18.38.30.223 also contained fluoride in excess of 1.5 ppm which seems to be typical of saline water from the Ogallala formation on the High Plains of Texas. Although specific data are meager, saline water reportedly occurs in the Ogallala north of the wells described.

TERTIARY AND QUATERNARY SYSTEMS

SANTA FE GROUP AND RELATED BOLSON FILL

Most of the rocks filling the structural troughs or basins of the Basin and Range province in New Mexico belong to the Santa Fe group and to other bolson fill of equivalent or nearly equivalent age. The rocks consist of caliche, clay, silt, sand, gravel, and larger particles of erosional debris. The Santa Fe group also includes some interbedded volcanic flow and tuffaceous rocks. The various rock types are irregularly distributed, and within a short distance the lithology may differ considerably. Consequently, individual beds generally cannot be traced very far. They are unconsolidated or slightly consolidated, and in most areas have been slightly deformed by structural movements of the underlying or adjacent consolidated rocks (Bryan, 1938). In some areas, as in Torrance County, the thickness of the fill ranges from less than 1 foot to 300 feet or a little more. However, much greater thicknesses of erosional debris have accumulated in several of the deeper structural troughs. An oil test near the State line in El Paso County, Texas, was drilled through more than 4,000 feet of fill (Sayre and Livingston, 1945). More than 5,000 feet of upper Tertiary rocks were deposited in the vicinity of the present Rio Grande valley in northern Socorro County (Spiegel, 1955). Elsewhere, recorded data show that the fill in the several basins ranges from a veneer to more than 1,000 feet in thickness (Meinzer and Hare, 1915; Murray, 1942; Conover, 1954). Although the fill contains fresh water in many areas, large quantities of saline water

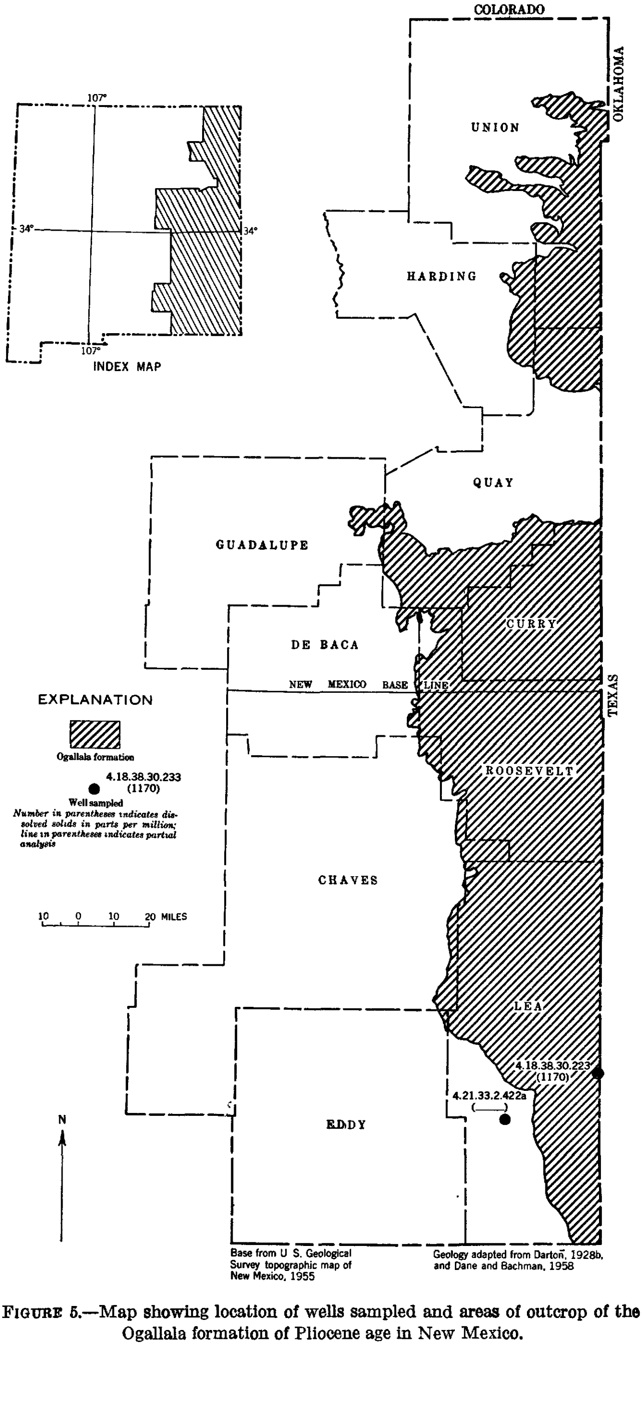

FIGURE 5.—Map showing location of wells sampled and areas of outcrop of the Ogallala formation of Pliocene age in New Mexico.

are stored in the several basins. The fill has a wide range of permeability, and therefore has a wide range of yields. In Torrance County yields of wells penetrating the Tertiary and Quaternary fill is as much as about 2,000 gpm. Southward and westward, in eastern Valencia and Socorro Counties, parts of Lincoln, Sierra, Otero, and Dona Ana Counties, the bolson fill yields 500 to 1,000 gpm to individual wells. In the southwestern Basin and Range province, near Deming, in Luna County, the fill yields as much as 1,500 gpm, and in Hidalgo County it yields as much as 1,800 gpm to wells.

The bolson deposits were derived from a variety of consolidated rocks of different ages, and the quality of the ground water in the fill differs from place to place as a result of the differing source rocks. Most of the water samples analyzed were of the sodium chloride and calcium and sodium sulfate types and were slightly to moderately saline. One sample, from well 4.17.8.13.231, was a sodium chloride brine. Several samples contained relatively large quantities of minor constituents, such as 11 ppm of fluoride from well 3.28.7.9.411 and 24 ppm of nitrate from well 4.17.9.23.333.

Several areas in New Mexico contain bolson deposits in which little or no fresh water is stored. The Tularosa Basin and the Jornado del Muerto are the largest of those areas. The bolson deposits there consist largely of debris from limestone and evaporites. Recharge consists mainly of floodwater from the adjoining mountains, and as a result of the method of recharge and of the chemical nature of the deposits, the only fresh water that has been found is stored at the bases of the adjoining mountains. Thus, in an area of about 3,000 square miles in the Tularosa Basin, it is doubtful that more than 200 square miles are underlain by aquifers that contain fresh water. Elsewhere in the State, as in the Rio Grande Valley, large supplies of saline water are available from the bolson deposits, but fresh-water supplies are more abundant than in the Tularosa Basin and Jornado del Muerto.

Analyses of saline water from the Santa Fe group and related bolson fill are shown in table 1. Location of wells and springs sampled are shown on plate 6. Outcrops of these rocks are not shown on plate 6, mainly because they underlie Quaternary deposits in many areas and because they are difficult to distinguish from the overlying Quaternary rocks.

QUATERNARY SYSTEM

PLEISTOCENE AND RECENT ALLUVIAL AND EOLIAN DEPOSITS

Much of the land surface of New Mexico is underlain by a veneer of Pleistocene and Recent alluvial deposits and, locally, dune sand. Generally, these deposits are either thin or not saturated and thus yield little or no water, but, in a few areas, they are water-bearing and thick enough to be important aquifers. Among the important alluvial aquifers of the State are the sands and gravels beneath the flood plains of the Pecos River and the Rio Grande.

In the Pecos Valley the alluvial deposits are most important in Chaves and Eddy Counties. There, the alluvium ranges in thickness from less than a few feet to a little more than 300 feet. The alluvium yields as much as 1,500 gpm of slightly to moderately saline water (Morgan, 1938).

The relatively narrow Rio Grande flood plain is underlain by alluvium that averages about 100 feet and reaches a maximum thickness of about 200 feet. The river flows through several sub-basins from Sandoval County to El Paso, at the southern State line. In this reach of the river valley, the alluvial deposits yield large quantities of fresh to moderately saline water to irrigation and some public-supply wells. Yields of irrigation wells are as much as 2,000 gpm.

In the Basin and Range province alluvial fans at the mouths of mountain canyons also are sources of water. In central Otero County, alluvial fans yield as much as 500 gpm of slightly to moderately saline water to irrigation wells.

Throughout the State, alluvium along minor streams yields small to moderate quantities of water to stock, domestic, and irrigation wells. In addition, terrace gravels, such as those in Colfax County, yield small quantities of water.

Dune sand is rarely water bearing in New Mexico, but the dunes are important recharge areas. However, dune sand is water-bearing in western Otero County, but because the sand there is composed principally of gypsum, the ground water is highly mineralized and is not utilized at present.

The analyzed samples of saline water from Quaternary rocks (table 1), were slightly to moderately saline, and generally calcium, sodium, chloride, and sulfate were the predominant ions. In a few samples magnesium was the predominant cation. Like the bolson fill, the alluvium is derived from rocks of differing lithology and, therefore, the quality of water in the alluvium differs from place to place. Unlike that in most of the older rocks, water in the alluvium is subject to changes in quality owing to changes of surface conditions. Increased or decreased recharge, evapotranspiration, and other factors can cause fluctuations in the quality of water from wells in the alluvium or from springs issuing from it. The location of wells and springs sampled is shown on plate 7.

SALINE SURFACE WATER

Several areas in New Mexico depend upon moderately saline surface water for irrigation. Most of these areas are in the Pecos River

634404—62——3

Valley below Santa Rosa, a town that utilizes saline surface water in part for a public supply. Slightly saline water is frequently used for irrigation in the Rio Grande basin both above and below Elephant Butte Reservoir.

The U.S. Geological Survey has studied the chemical quality of the surface waters in New Mexico for many years. The studies have been partly under the Federal program for collection of basic data and partly in cooperation with the New Mexico Interstate Stream Commission and the Pecos River Commission, and for the most part have been limited to the main stems of the most important streams; therefore, few or no data are available for most of the less important tributaries. Analyses of samples containing maximum, minimum, and modal concentrations of dissolved solids for the period of record and weighted averages of analyses of surface water for representative years are shown in table 3. A modal concentration of dissolved solids is that concentration which recurs most frequently during the period of record. A weighted average of analyses represents the approximate chemical composition of the water passing a point during a period of 1 year if all the water were impounded and thoroughly mixed, and there were no losses by evaporation. Records and stream data of saline surface water in New Mexico are shown in table 4.

In this report the occurrence of saline surface waters is discussed by river basins. The approximate boundaries of the river basins in New Mexico and location of sampling points are shown on plate 8. For simplicity of illustration several closed basins which may or may not be hydraulically connected with the rivers are included in the river basins. These closed basins are: San Augustine Plains, Mimbres Valley, Estancia Valley, Jornada del Muerto, and Tularosa Valley in the Rio Grande drainage area, and Salt Basin in the Pecos drainage area.

CANADIAN RIVER BASIN

The Canadian River, one of the principal tributaries of the Arkansas River, rises in northern Colfax County, flows southward through Conchas Reservoir, then turns eastward and leaves the State about 40 miles northeast of Tucumcari. The Canadian River drains approximately 12,500 square miles in New Mexico.

The concentration of dissolved minerals in the water in the Canadian River fluctuates widely. Although low flows in the Canadian River near Taylor Springs and Sanchez (pl. 8) often are slightly saline, the weighted average of analyses indicates the impounded river water would be fresh near Sanchez. The water is the calcium and magnesium sulfate type.

While impounded in Conchas Reservoir the saline low flows and the fresh high flows become mixed, and the resulting water is fresh. Probably the water in the Canadian River in New Mexico below the dam also is fresh.

Chicorica Creek and Cimarron River are fresh-water streams in their upper reaches. However, available data show that they contain slightly saline water at times.

The flow of the Cimarrron River near Springer is partly controlled by Eagle Nest Lake and by diversions for irrigation above the station. The saline-water, low flow of the Cimarron River is the calcium and magnesium sulfate type. The salinity of the water probably is due to irrigation return flows entering the river and to the dissolving action of the river on gypsiferous rocks in the Niobrara formation and Pierre shale both of which crop out in the river channel.

Water from Chicorica Creek and Una de Gato Creek, which are both near Hebron, is at times slightly saline and is the calcium and magnesium sulfate type. These creeks also traverse gypsiferous rocks.

Location of sampling points and chemical analyses of saline water in the Canadian River basin are shown on plate 8 and in table 3, respectively.

RIO GRANDE BASIN

The Rio Grande heads in southwestern Colorado, flows in a southerly direction through central New Mexico, and leaves the State at El Paso, Texas. The drainage area in New Mexico is approximately 24,500 square miles.

For most years of record the weighted average of dissolved solids in water in the main stem of the Rio Grande in New Mexico is less than 1,000 ppm.

Generally the day-to-day base flow in the Rio Grande is fresh; however, the concentration of dissolved solids in the water varies considerably from time to time in the summer, owing to rapid changes in flow caused by flash floods. Occasionally the main stem of the Rio Grande is saline below Bernardo because of flow from the major tributaries upstream from San Acacia. Irrigation drains also contribute saline water to the Rio Grande. Saline flows in the main stem of the Rio Grande probably are of short duration.

Because most of the saline surface water in the basin is in the tributaries of the Rio Grande, the occurrence of saline water in the basin is discussed by sub-basins.

RIO PUERCO AND RIO SALADO

The Rio Puerco and Rio Salado are important tributaries of the Rio Grande that contribute saline water. Both intermittently yield the same type of saline water because both flow across beds of gypsum and shale that contain large quantities of soluble salts. Usually, the first flows of summer floods are highly mineralized and cause an increase in dissolved-solids concentration of the water in the main stem of the Rio Grande at San Acacia.

Recent data seem to indicate that the storm runoff in the Rio Puerco is usually saline whereas the storm runoff in the Rio Salado is saline only about half the time. The salts carried by these streams consist largely of sulfates of calcium, magnesium, and sodium.

RIO SAN JOSE

The Rio San Jose rises in northwestern Valencia County, flows southeastward, and enters the Rio Puerco approximately 40 miles southwest of Albuquerque.

Chemical analyses show that water in the Rio San Jose during intermittent high flows is slightly saline but that water during sustained flows of about 3 to 6 cfs (cubic feet per second) generally is fresh. The saline water is of the calcium sulfate type.

Analyses of saline surface water from regular stations on the Rio Grande and of miscellaneous samples on the major tributaries in the basin are shown in table 3. Sampling points are shown on plate 8.

PECOS RIVER BASIN

The Pecos River heads in the Southern Rocky Mountains in northern New Mexico and flows in a generally southeastward direction, leaving the State south of Carlsbad. The drainage area in New Mexico is approximately 19,600 square miles.

Samples for chemical analyses have been collected regularly at many sampling stations on the Pecos River and infrequently from the major tributaries and from reservoirs on the river. Records of the U.S. Geological Survey indicate that most of the saline water in the Pecos River in New Mexico is below Santa Rosa in central Guadalupe County. It is in this reach of the river that considerable quantities of water are diverted for irrigation.

According to the weighted average of the chemical analyses, water from the Pecos River ranges from slightly saline at Puerto de Luna to moderately saline near Red Bluff (table 3). Analyses of composites of daily samples taken during periods of low flow near Acme show the water to be very saline.

The concentration of dissolved solids increases and the chemical composition of the water changes between Puerto de Luna and Red Bluff. In the reach of the river from Puerto de Luna to Malaga the river traverses deposits of gypsum, thus enabling the water to leach out considerable calcium sulfate. In the Malaga Bend area, however, numerous springs and seeps discharge enough sodium chloride brine into the river channel to change the chemical composition of the water from predominantly calcium sulfate to predominantly sodium chloride.

Location of sampling points and analyses of saline water from the Pecos River basin are shown in plate 8 and table 3.

SAN JUAN RIVER BASIN

The San Juan River rises on the western slope of the Continental Divide in southwestern Colorado and northwestern New Mexico. Where it enters the State it forms the boundary between Rio Arriba and San Juan Counties and flows in a southwesterly direction. It then swings to the west and northwest and reenters Colorado near the four corners of New Mexico, Colorado, Utah, and Arizona. Its drainage area in New Mexico is approximately 10,000 square miles. Nearly all the surface water in the San Juan basin is fresh. Although La Plata River discharges saline water into the San Juan River at Farmington, the San Juan below Farmington is fresh, owing to the dilution effect of the larger flow of the main stem.

Records of chemical analyses at approximately monthly intervals show La Plata River near Farmington to be slightly to moderately saline. From low concentrations to as much as about 2,000 ppm of dissolved solids, the water is of the calcium and magnesium sulfate type. At greater concentrations, the water is predominantly the sodium sulfate type.

The location of the sampling point and chemical analysis of saline water in the San Juan basin is given in plate 8 and table 3, respectively.

SALINE LAKES AND RESERVOIRS

Severel natural lakes in New Mexico are saline. Some of these may have been fresh originally, but the concentration of dissolved solids has increased more or less progressively because all the inflowing water is mineralized to some extent, however small, and none of the minerals are removed with the water that evaporates from the surface of the lakes. A lake with no outlet may be freshened temporarily by precipitation on its surface and by inflowing water that is less mineralized than the lake water, but eventually it is even more mineralized than it was before it was freshened.

The water in a reservoir generally contains dissolved solids in amounts somewhat lower than the saline flows of the river and somewhat higher than the fresh flows. In many instances the quality oi the water in the reach of a stream below a dam is better than that upstream from the reservoir because the saline low flows are mixed in the reservoir with the fresh high flows. Evaporation from reservoirs results in some increase in the concentration of dissolved solids in the impounded water. The most significant amount of saline water in reservoirs in New Mexico is in the Pecos River below Puerto de Luna.

Saline lakes and reservoirs in the Pecos River basin in New Mexico for which chemical analyses are available are Alamogordo Reservoir near Fort Sumner, Lakes McMillan and Avalon near Carlsbad, all on the Pecos River, and several lakes in the Bottomless Lakes State Park east of Roswell.

Several spot samples taken from Alamogordo Reservoir show the water to be slightly saline and of the calcium sulfate type.

Samples taken from Lake McMillan at different stages show that the water is commonly slightly saline and of the calcium sulfate type at high elevations (gage height 24.4 feet) and very saline and of the sodium chloride type at low elevations (gage height 13.6 feet). The reason for this apparent relation of quality of water to stage of Lake McMillan is that at high stages the reservoir storage is usually made up primarily of flood waters or water of good quality released from Alamogordo reservoir whereas at low stages the water entering Lake McMillan is primarily base flow derived from ground-water discharge to the Pecos from the Roswell Basin. This base flow is highly mineralized. Lakes in the Bottomless Lakes State Park contain waters that probably are moderately saline to very saline. Specific conductances of these waters range from 5,250 to 20,400 micromhos. Analyses of surface samples from several of these lakes show the water to be of the calcium sulfate type. However, the highly concentrated water from one lake (20,400 micromhos specific conductance) is of the sodium chloride type.

Many small lakes scattered throughout New Mexico have become saline because of evaporation. However, the volume of water in these lakes is probably not sufficient for the establishment of a demineralization project.

SELECTED REFERENCES

Bachman, G. O., 1953, Geology of a part of northwestern Mora County, New Mexico: U.S. Geol. Survey Oil and Gas Inv. Map OM 137.

Baltz, E. H., Jr., 1953, Stratigraphic relationships of Cretaceous and early Tertiary rocks of a part of northwestern San Juan Basin, New Mexico: U.S. Geol. Survey open-file rept., Albuquerque, N. Mex.

Bates, R. L., Wilpolt, R. H., MacAlpin, A. J., and Vorbes, Georges, 1947, Geology of the Gran Quivira quadrangle, New Mexico: New Mexico Inst. Mining and Technology, State Bur. Mines and Mineral Resources Div. Bull. 26, 52 p., 9 pls., 4 figs.

Beaumont, E. C., 1954, Preliminary geologic map of the Beautiful Mountain anticline, San Juan County, New Mexico: U.S. Geol. Survey Oil and Gas Inv. Map OM 147.

Bjorklund, L. J., 1957, Reconnaissance of ground-water conditions in the Crow Flats area, Otero County, New Mexico: New Mexico State Engineer Office Tech. Rept. 8, 26 p., 1 pl., 4 figs.

Bryan, Kirk, 1938, Geology and ground-water conditions of the Rio Grande depression in Colorado and New Mexico, *in* [U.S.] Natl. Resources Planning Board, Rio Grande Joint Investigation in the Upper Rio Grande basin, v. 1, pt. 2, p. 197–225, 8 figs., map.

Cobban, W. A., and Reeside, J. B., Jr., 1951, Lower Cretaceous ammonites in Colorado, Wyoming, and Montana: Am. Assoc. Petroleum Geologists Bull., v. 35, no. 8, p. 1892–1893.

——— 1952, Correlation of the Cretaceous formations of the Western Interior of the United States: Geol. Soc. America Bull., v. 63, no. 10, p. 1011–1043.

Conover, C. S., 1954, Ground-water conditions in the Rincon and Mesilla Valleys and adjacent areas in New Mexico: U.S. Geol. Survey Water-Supply Paper 1230, 200 p., 9 pls., 15 figs.

Dane, C. H., 1946, Stratigraphic relations of Eocene, Paleocene, and latest Cretaceous formations of the eastern side of San Juan Basin, New Mexico: U.S. Geol. Survey Oil and Gas Inv. Prelim. Chart 24.

Dane, C. H., and Bachman, G. O., 1957, Preliminary geologic map of the northwestern part of New Mexico: U.S. Geol. Survey Misc. Geol. Inv. Map 1–224.

——— 1958, Preliminary geologic map of the southeastern part of New Mexico: U.S. Geol. Survey Misc. Geol. Inv. Map 1–256.

Dane, C. H., and others, 1948, Geologic map of part of eastern San Juan Basin, Rio Arriba County, New Mexico: U.S. Geol. Survey Oil and Gas Inv. Prelim. Map 78.

Darton, N. H., 1928a, "Red Beds" and associated formations in New Mexico, with an outline of the geology of the State: U.S. Geol. Survey Bull. 794, 356 p., 62 pls., 173 figs.

——— 1928b, Geologic map of New Mexico: U.S. Geological Survey.

Dobrovolny, Ernest, Summerson, C. H., and Bates, R. L., 1946, Geology of northwestern Quay County, New Mexico: U.S. Geol. Survey Oil and Gas Inv. Prelim. Map 62, 2 sheets.

Eaton, F. M., 1950, Significance of carbonates in irrigation waters: Soil Sci., v. 69, no. 2, p. 123–133.

Fenneman, N. M., 1931, Physiography of the Western United States: New York, McGraw-Hill Book Co., 533 p., 1 pl., 173 figs.

Fiedler, A. G., and Nye, S. S., 1933, Geology and ground-water resources of the Roswell artesian basin, New Mexico: U.S. Geol. Survey Water-Supply Paper 639, 372 p., 46 pls., 37 figs.

Gorman, J. M., and Robeck, R. C., 1946, Geology and asphalt deposits of north-central Guadalupe County, New Mexico: U.S. Geol. Survey Oil and Gas Inv. Prelim. Map 44.

Gregory, H. E., 1916, The Navajo country—a geographic and hydrographic reconnaissance of parts of Arizona, New Mexico, and Utah: U.S. Geol. Survey Water-Supply Paper 380, 219 p., 29 pls.

Griggs, R. L., 1948, Geology and ground-water resources of the eastern part of Colfax County, New Mexico: New Mexico Inst. Mining and Technology, State Bur. Mines and Mineral Resources Div. Ground-Water Rept. 1, 187 p., 8 pls., 10 figs.

Griggs, R. L., and Hendrickson, G. E., 1951, Geology and ground-water resources of San Miguel County, New Mexico: New Mexico Inst. Mining and Technology, State Bur. Mines and Mineral Resources Div. Ground-Water Rept. 2, 121 p., 6 pls., 2 figs.

Hale, W. E., Hughes, L. S., and Cox, E. R., 1954, Possible improvement of quality of water of the Pecos River by diversion of brine at Malaga Bend, Eddy County, New Mexico: Pecos River Comm., New Mexico and Texas, 60 p., 8 pls., 5 figs.

Hayes, P. T., and Zapp, A. D., 1955, Geology and fuel resources of the Upper Cretaceous rocks of the Barker dome-Fruitland area, San Juan County, New Mexico: U.S. Geol. Survey Oil and Gas Inv. Map OM 144, 2 sheets.

Hendrickson, G. E., 1949, Ground-water resources of the Carrizozo area, Lincoln County, New Mexico: U.S. Geol. Survey open-file rept., Albuquerque, N. Mex., 14 p., 1 fig.

Hendrickson, G. E., and Jones, R. S., 1952, Geology and ground-water resources of Eddy County, New Mexico: New Mexico Inst. Mining and Technology, State Bur. Mines and Mineral Resources Div. Ground-Water Rept. 3, 276 p., 8 pls., 11 figs.

Kelley, V. C., and Wood, G. H., Jr., 1946, Geology of the Lucero uplift, Valencia, Socorro, and Bernalillo Counties, New Mexico: U.S. Geol. Survey Oil and Gas Inv. Prelim. Map 47.

Kelley, V. C., and Silver, Caswell, 1952, Geology of the Caballo Mountains: New Mexico Univ. Pub. Geology no. 4, 286 p., 19 pls., 26 figs.

King, P. B., 1944, Geologic map of the southern Guadalupe Mountains, Hudspeth and Culberson Counties, Texas: U.S. Geol. Survey Oil and Gas Inv. Prelim. Map 18.

——— 1949, Regional geologic map of parts of Culberson and Hudspeth Counties, Texas: U.S. Geol. Survey Oil and Gas Inv. Prelim. Map 90.

King, P. B., King, R. E., and Knight, J. B., 1945, Geology of Hueco Mountains, El Paso and Hudspeth Counties, Texas: U.S. Geol. Survey Oil and Gas Inv. Prelim. Map 36, 2 sheets.

Kottlowski, F. E., and others, 1956, Stratigraphic studies in the San Andres Mountains, New Mexico: New Mexico Inst. Mining and Technology, State Bur. Mines and Mineral Resources Div. Mem. 1, 132 p., 5 pls., 15 figs.

McLaughlin, T. G., 1954, Geology and ground-water resources of Baca County, Colorado: U.S. Geol. Survey Water-Supply Paper 1256, 232 p., 2 pls., 54 figs.

Meinzer, O. E., and Hare, R. F., 1915, Geology and water resources of Tularosa Basin, New Mexico: U.S. Geol. Survey Water-Supply Paper 343, 317 p., 19 pls.

Morgan, A. M., 1938, Geology and shallow-water resources of the Roswell artesian basin, New Mexico: New Mexico State Engineer Office 12th–13th Bienn. Repts., p. 155–251.

Murray, C. R., 1942, Preliminary report on completion of the Deming test well: New Mexico State Engineer Office 14th–15th Bienn. Repts., p. 181–219.

——— 1949, Ground-water conditions in the non-thermal artesian basin south of Hot Springs, Sierra County, New Mexico: U.S. Geol. Survey open-file rept., Albuquerque, N. Mex., 93 p., 1 pl., 12 figs.

New Mexico Geological Society, 1950, Guidebook of the north and east sides of the San Juan Basin, New Mexico and Colorado, 1st field conference: 153 p.

——— 1951, Guidebook of the south and west sides of the San Juan Basin, New Mexico and Arizona, 2nd field conference: 163 p., 26 pls., 22 figs.

——— 1952, Guidebook of the Rio Grande country, central New Mexico, 3rd field conference: 126 p.

——— 1953, Guidebook of southwestern New Mexico, 4th field conference: 153 p., 37 figs.

——— 1954, Guidebook of southeastern New Mexico, 5th field conference: 209 p., 33 figs.

New Mexico Geological Society, 1955, Guidebook of south-central New Mexico, 6th field conference: 193 p.

Northrup, S. A., and others, 1946, Geologic maps of a part of the Las Vegas Basin and of the foothills of the Sangre de Cristo Mountains, San Miguel and Mora Counties, New Mexico: U.S. Geol. Survey Oil and Gas Inv. Prelim. Map 54.

Pray, L. C., 1954, Outline of the stratigraphy and structure of the Sacramento Mountain escarpment, *in* New Mexico Geol. Soc. Guidebook to Southeastern New Mexico, 5th field conference: p. 92–107.

Rankama, Kalervo, and Sahama, T. G., 1950, Geochemistry: Chicago, University of Chicago Press.

Read, C. B., and others, 1944, Geologic map and stratigraphic sections of Permian and Pennsylvanian rocks of parts of San Miguel, Santa Fe, Sandoval, Bernalillo, Torrance, and Valencia Counties, New Mexico: U.S. Geol. Survey Oil and Gas Inv. Prelim. Map 21.

Renick, B. C., 1931, Geology and ground-water resources of western Sandoval County, New Mexico: U.S. Geol. Survey Water-Supply Paper 620, 117 p., 10 pls.

Robinson, T. W., and Lang, W. B., 1938, Geology and ground-water conditions of the Pecos River valley in the vicinity of Laguna Grande de la Sal, New Mexico, with special reference to the salt content of the river: New Mexico State Engineer Office 12th–13th Bienn. Repts., p. 77–100.

Roswell Geological Society, 1956, West-east correlation section, San Andres Mountains to New Mexico-Texas line, southeastern New Mexico.

Sayre, A. N., and Livingston, Penn, 1945, Ground-water resources of the El Paso area, Texas: U.S. Geol. Survey Water-Supply Paper 919, 190 p., 16 pls., 11 figs.

Scalapino, R. A., 1950, Development of ground water for irrigation in the Dell City area, Hudspeth County, Texas: Texas Board of Water Engineers Bull. 5004, 38 p., 1 pl., 1 fig.

Schwennesen, A. T., 1918, Ground water in the Animas, Playas, Hachita, and San Luis basins, New Mexico: U.S. Geol. Survey Water-Supply Paper 422, 152 p., 3 pls.

Slichter, C. S., 1905, Observations on the Ground waters of Rio Grande Valley [U.S.]: U.S. Geol. Survey Water-Supply Paper 141, 83 p., 5 pls.

Smith, O. M., Dott, R. H., and Warkentin, E. C., 1942, The chemical analyses of the waters of Oklahoma: Oklahoma Agricultural and Mech. Coll. Eng. Exp. Sta. Pub. 52, Stillwater, Okla., v. 12, no. 1, p. 15.

Smith, R. E., 1957, Geology and ground-water resources of Torrance County, New Mexico: New Mexico Inst. Mining and Technology, State Bur. Mines and Mineral Resources Div. Ground-Water Rept. 5, 181 p., 5 pls., 7 figs.

Spiegel, Zane, 1955, Geology and ground-water resources of northeastern Socorro County, New Mexico: New Mexico Inst. Mining and Technology, State Bur. Mines and Mineral Resources Div. Ground-Water Rept. 4, 99 p., 2 pls., 8 figs.

Spiegel, Zane, and Baldwin, Brewster, 1958, Geology and water resources of the Santa Fe area, New Mexico, with contributions by F. E. Kottlowski and E. L. Barrows and a section on Geophysics by H. A. Winkler: U.S. Geol. Survey open-file rept., 403 p., 13 pls., 49 figs.

Theis, C. V., 1932, Ground water in Curry and Roosevelt Counties, New Mexico: New Mexico State Engineer Office 10th Bienn. Rept., p. 98–160.

Theis, C. V., Taylor, G. C., Jr., and Murray, C. R., 1941, Thermal waters of the Hot Springs artesian basin, Sierra County, New Mexico, *in* New Mexico State Engineer Office 14th-15th Bienn. Repts., 1938–42: p. 419–492.

U.S. National Resources Planning Board, 1942, Pecos River joint investigation; reports of the participating agencies: 407 p., 34 pls.

U.S. Public Health Service, 1946, Drinking-water standards: Public Health Service Repts., v. 61, no. 11, p. 371–384.

U.S. Department of Agriculture, Salinity Laboratory Staff, 1954, Diagnosis and improvement of saline and alkali soils: U.S. Dept. Agriculture, Agriculture Handb. 60, 160 p.

Wilpolt, R. H., and Wanek, A. A., 1951, Geology of the region from Socorro and San Antonio east to Chupadera Mesa, Socorro County, New Mexico: U.S. Geol. Survey Oil and Gas Inv. Map OM–121.

Winslow, A. G., and Kister, L. R., 1956, Saline-water resources of Texas: U.S. Geol. Survey Water-Supply Paper 1365, 105 p., 9 pls., 12 figs.

Wood, G. H., Jr., and Northrop, S. A., 1946, Geology of Nacimiento Mountains, San Pedro Mountains, and adjacent plateaus in parts of Sandoval and Rio Arriba Counties, New Mexico: U.S. Geol. Survey Oil and Gas Inv. Prelim. Map 57.

Wood, G. H., Jr., Northrop, S. A., and Griggs, R. L., 1953, Geology and stratigraphy of Koehler and Mount Laughlin quadrangles and parts of Abbott and Springer quadrangles, eastern Colfax County, New Mexico: U.S. Geol. Survey Oil and Gas Inv. Map OM–141, 2 sheets.

BASIC DATA

TABLE 1.—*Chemical analyses of saline ground water in New Mexico*

[Analyses in parts per million, except as indicated]

Well No.	County	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids	Calcium, magnesium hardness as $CaCO_3$	Percent sodium	Specific conductance (micromhos at 25° C)	pH
PENNSYLVANIAN SYSTEM																		
1.1.2.7.100	Socorro			189	59	877		420	611	1,160		4.9		3,110	714	73	5,020	
1.5.3.29.400	Valencia	5.9	0.80	284	245	10,400	225	2,700	4,510	12,500	1.6			29,500	1,720	92		
1.6.3.35.430	do	15	.57	704	356	4,570	79	2,050	2,660	6,240	.0			15,600	3,220	75		
2.2.4.12.210	Socorro	25		178	58	86		236	612	20	1.5	10		1,110	682	22	1,440	
2.11.15.14.300	San Miguel							[1] 916		386					54		3,210	9.3
3.13.4.34.310	Sierra	21		472	102	645		161	1,230	1,120	2.6	.9		3,670	1,600	47	5,280	
3.17.4.29.340	do			52	19	303		370	309	160	5.8	2.0		1,030	208	76	1,650	
4.9.6.2.400	Lincoln	19	.01	145	115	45		409	516	41	1.0	.4		1,080	835	11	1,520	7.5
PERMIAN SYSTEM																		
Abo formation																		
1.7.2.31.140	Valencia	20	0.18	603	271	5,230	118	1,620	5,380	5,120	1.2			17,500	2,620	80		
2.1.4.14.113	Socorro	25		408	114	241		212	1,710	36	.8	4.1		2,640	1,490	26	2,860	
2.2.5.20.244	do			468	184	98		175	1,830	48		26		2,740	1,920	10	3,010	
2.10.14.20.400	San Miguel	24		169	66	65		205	629	6.0	.7	1.7		1,060	693	17	1,400	
4.7.7.9.222	Socorro	16		176	93	322		306	1,100	86	1.0	1.9		1,950	822	46	2,430	
Yeso formation																		
1.4.4.30.223	Socorro	10				19		68	1,780	35	1.0	0.2			1,920	2	2,740	7.0
2.1.2.15.223	do	24		184	49	53		135	521	24	.5	108		1,030	660	15	1,360	
2.1.10.11.412	Torrance	27		562	174	11		497	1,630	23	1.7	.2		2,670	2,140	1	2,940	
2.1.15.5.111	do	10		530	198	304		70	2,530	75		.3		3,680	2,140	24	3,990	7.4
2.2.6.9.233	do	26		586	136	26		186	1,790	25	.5	30		2,710	2,020	3	2,840	
2.2.20.10	De Baca			656	139	730		294	1,790	1,200		.5		4,660	2,210	42	6,300	
2.3.8.16.222	Torrance	10		548	154	2.3		121	1,800	21	1.4	.2		2,600	2,000	0	2,750	
2.3.13.33.413	do	21		484	198	55		279	1,750	61	1.0	1.6		2,710	2,020	6	2,970	
2.5.14.32.300	do			542	230	85		100	2,210	69	1.2	.2		3,190	2,300	7	3,410	
2.7.11.34.311	do	22		332	147	93		337	1,180	89	1.8	1.0		2,030	1,430	12	2,460	
2.8.13.22.130	do	27		180	64	80		177	656	37	2.3	.2		1,130	712	20	1,470	
2.9.10.18.233	do	20		42	13	708		439	789	365	.6	.6		2,150	158	91	3,350	

2.9.12.16.213	do			412	149	65		151	1,570	15	.5	1.1		2,290	1,640	8	2,540	
2.10.16.5.120	Guadalupe	14		436	90	37		238	1,270	14	.4	.0		1,980	1,460	5	2,200	7.7
2.11.28.30.232	Quay			890	102	1,510		994	1,840	2,270				7,100	2,640	55	10,000	
2.12.12.4.110	San Miguel	23		486	135	18		152	1,610	4	.3	.2		2,350	1,770	2	2,550	
4.1.5.33.	Socorro	18				1,610		418	5,670	62	1.6	254			3,040	54	9,080	
4.1.8.1.433	do	21		340	171	13		278	1,250	34	.2	3.6		1,970	1,550	2	2,270	
4.2.13.18.300	Lincoln	17		588	114	9.7		175	1,710	21	.5	2.7		2,550	1,940	1	2,680	
4.2.18.30.330	do	19		632	100	19		165	1,740	54	.7	5.9		2,650	1,990	2	2,820	
4.5.5.19.231	Socorro							135	1,980	76				[2] 3,180	2,130		3,210	
4.6.1.36.233	do							204	1,800	127				[2] 3,020	1,400		3,490	
4.7.8.14.320	do	10		536	225	146		92	2,310	67	1.9	.2		3,340	2,260	12	3,720	
4.8.2.17.200	do							107	3,080	26				[2] 4,650	2,980		4,320	
4.9.15.15.331	Lincoln							158	617	98					830		1,570	7.7
4.11.14.28.321	do	18		240	84	11		266	649	52	.1	.8		1,190	944	2	1,570	7.1
4.11.17.20.212a	do							204	973	91					1,120		2,070	7.6
4.18.8.5.430	Otero							128		2,670			0.30				11,700	
4.23.18.30.340	do			220	95	6.2		222	698	19	1.1	18	.29	1,170	940	1	1,530	7.2
4.26.18.29.113	do			230	92	17		242	672	57	1.1	11	.05	1,200	952	4	1,610	7.1
Glorieta sandstone																		
2.1.16.27.444	Lincoln	23		426	71	10		107	1,140	47	0.6	8.9		1,780	1,360	2	2,020	
2.2.18.22.422	Guadalupe							127	1,510	19		13			1,730		2,440	7.4
2.7.10.35.111	Torrance	41		702	350	586		1,990	2,300	310	.1	2.0		5,270	3,190	29	6,040	
2.10.10.32.333	Santa Fe	26		312	71	432		184	1,020	558	2.0	5.0		2,520	1,070	47	3,630	
2.11.17.36.420	Guadalupe							230	1,310	11					1,490		2,240	7.4
4.3.17.7.110	Lincoln	23		382	80	16		174	1,030	69	.5	3.2		1,690	1,280	3	2,020	
San Andres limestone																		
1.7.2.18.310	Valencia	34	1.8	918	220	11,000	283	2,840	8,910	11,100	3.4			33,900	3,200	87		
1.12.10.23.233	do			254	88	379		702	829	270	.4	.6	.3	2,170	996	45	3,040	
1.12.11.10.431	do			178	47	155		429	462	98	.3	3.6		1,160	638	35	1,700	
1.15.17.30.340	McKinley	10	.02	148	80	61	4.6	220	620	7.2	.1	.3		1,040	698	16	1,360	7.5
2.1.2.34.130	Socorro	21		562	130	21		142	1,770	10	.6	10		2,590	1,940	2	2,760	
2.6.17.15.122	Guadalupe					.2		102	1,710	49		10			1,940	0	2,730	7.3
2.10.19.18.420	do							200	947	54					1,100		1,930	7.4
2.10.21.32.230	do	17		318	47	34		168	872	10	.2	1.4		1,380	987	7	1,630	7.4
3.10.2.25.100	Sierra							136	1,660	22					1,850		2,600	7.2
4.7.22.26.311	Chaves	20		272	84	81		149	854	132	0.7	2.4		1,520	1,020	15	2,000	
4.8.23.33	do			138	46	317		184	350	502				1,440	534	56	2,410	
4.9.23.20.140	do	15	2.5	183	99	111	5.2	172	618	196		42		1,350	863	22		
4.9.24.11.300	do	18		344	91	228		174	940	425	.9	5.8		2,140	1,230	29	3,010	
4.10.24.24.300	do	14		282	91	332		226	818	535	.7	7.2		2,190	1,080	40	3,230	
4.12.23.5.300	do			256	68	35		243	677	56		15		1,230	918	8	1,620	
4.13.25.10.400	do	16	54.	358	91	27	1.1	224	1,040	37		.0		1,680	1,270	4		
4.15.25.35.213	do					28		182	1,460	29		.3			1,650	4	2,430	7.9

See footnotes at end of table.

TABLE 1.—*Chemical analyses of saline ground water in New Mexico*—Continued

[Analyses in parts per million, except as indicated]

Well No.	County	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids	Calcium, magnesium hardness as $CaCO_3$	Percent sodium	Specific conductance (micromhos at 25° C)	pH
Guadalupe series																		
2.3.22.24.300	De Baca			480	167	21		96	1,700	62		0.25		2,470	1,880	2	2,660	
2.6.21.29.130	Guadalupe			520	149	20		106	1,730	42		3.4		2,520	1,910	2	2,700	
2.7.19.23.111	do							159	2,220	95					2,510		3,480	7.3
2.8.22.19.234	do			627	145	83		188	1,900	137		23		3,010	2,160	8	3,350	
2.9.21.35.131	do	18		528	81	27		190	1,440	37	0.3	2.5		2,230	1,650	3	2,430	
2.10.20.25.243	do			554	46	29		92	1,490	6.0				2,170	1,570	4	2,280	
4.1.23.12	De Baca			582	169	94		132	1,980	132				3,020	2,150	9	3,290	
4.2.25.18	do			570	183	23		153	1,960	38				2,850	2,170	2	2,980	
4.8.24.15.111	Chaves	10		598	233	1,360		145	3,050	1,500	1.4	5.5		6,830	2,450	55	8,840	
4.9.25.33	do	34		825	239	2,140		175	2,740	3,330	2.0			9,400	3,040	60	13,300	
4.11.26.2.442	do					161		112	2,560	215					2,710		4,160	
4.20.25.16.	Eddy			524	133	222		162	1,600	380		3.2		2,940	1,850	21	3,680	
4.21.24.20.410	do			232	93	19		283	716	16		2.6		1,220	962	4	1,570	
4.21.27.9.330	do	31		275	38	.5		229	608	5	.7	17		1,090	842	0	1,370	
4.21.33.1.114	Lea							1,320		4,460							15,900	
4.24.36.26.400	do							1,080		1,860							8,460	
Capitan limestone																		
4.20.25.27.300	Eddy			166	270	165		132	1,210	365		0.7		2,240	1,520	19	3,120	
4.20.26.20	do			499	146	6.9		206	1,580	34		4.0		2,370	1,850	1	2,670	
4.20.27.17	do			610	96	41		233	1,600	85		38		2,580	1,920	4	2,900	
4.21.25.1.200	do			167	98	16		196	620	24		17		1,040	820	4	1,430	
4.21.26.3.344	do			560	119	57		92	1,780	58				2,620	1,890	6	2,810	
Castile formation																		
4.25.26.24.140	Eddy			97	38,300	43,900	2,090	1,380	222,000	16,800				324,000	158,000	37		
4.26.24.11.122	do			640	56	3.0		238	1,560	10		1.1		2,390	1,830	1	2,540	
4.26.27.22.300	do			580	339	735		240	2,930	814		54		5,570	2,840	36	6,640	
4.26.28.13.110	do			428	27	8.5		179	982	10		18		1,560	1,180	2	1,820	

Rustler formation

4.19.28.2.122	Eddy			412	195	987		142	1,300	1,770		11		4,740	1,830	54	7,280	
4.21.28.18.130	do	34		574	423	747		237	3,530	642	3.2	15		6,090	3,170	34	6,930	
4.21.29.18.130	do	28		694	230	571		110	2,220	1,060	2.6	20		4,880	2,680	32	6,220	
4.21.30.31.300	do			254	5,090	102,000		72	20,000	158,000				285,000	21,600	91		
4.22.27.1.210	do	39		670	41	35		165	1,510	93	1.7	92		2,560	1,840	4	2,790	
4.22.30.6.344	do			1,020	395	5,950		149	2,880	9,920				20,200	4,170	76	29,600	

TRIASSIC SYSTEM

Dockum group

1.3.6.4.200	Socorro	12				788		268	1,260	175	0.7	7.4			72	96	3,430	
1.5.6.25.100	Valencia	15				651		1,410	240	27	1.4	.0			30	98	2,480	
1.7.4.11.430	do	20	1.4	640	177	301	26	625	1,960	326	1.0			3,760	2,320	22		
1.12.10.23.233a	do			40	11	458		392	733	37	.4	4.4	3.0	1,480	145	87	2,130	
1.13.11.8.210	McKinley	16		160	69	452		322	1,260	60	.4	5.5		2,180	682	59	2,860	7.9
2.4.24.1	DeBaca			217	32	78		153	607	60				1,070	673	20	1,420	
2.7.30.17.244	Quay							257	1,090	745					200		4,610	8.0
2.8.21.1.333	Guadalupe			616	64	29		187	1,570	53		.0		2,420	1,800	3	2,650	
2.9.28.17.244	Quay							825	849	570					33		4,470	8.2
2.9.32.1.433	do	5.7		46	15	1,620		593	2,540	390	3.1	2.6		4,910	176	95	6,670	
2.10.15.27.330	San Miguel			286	34	14		264	620	15	.7	.1		1,100	854	4	1,420	
2.10.25.23.333	Guadalupe	7.2	.01	5.0	1.7	582	2.6	499	620	170	2.5	.2	1.28	1,640	19	98		
2.10.35.29.222	Quay					1,940		[3] 464	2,150	1,190		2.1			73	98	7,920	8.7
2.11.31.20.442	do			9.5	4.5	1,370		924	1,760	300		2.9		3,900	42	99	5,520	
2.12.22.22.110	San Miguel			125	184	379		880	1,030	70	.5	.0	.72	2,220	1,070	44	2,970	
2.12.25.17.400	do	18		34	18	348		351	409	142	1.0	.0	.4	1,140	159	83	1,820	7.8
2.12.32.1.422b	Quay							438	240	146							1,580	
2.15.24.27.210	San Miguel	12		5.2	4.3	513		[4] 759	416	62	1.2	.4	.40	1,380	30	97	2,090	
2.15.30.11.300	Harding							1,200	846	178							3,730	
2.32.31.34.133	Union					545		(5)	957	17	.8	.5			27	98	2,670	10.7
4.3.31.30.300	Roosevelt	28		338	545	1,020		298	3,350	1,080	6.4	46		6,560	3,080	42	8,280	
4.3.36.13.244	do	9.2		99	36	2,900		138	1,860	3,290	.5	1.1		8,260	395	94	12,700	6.8
4.6.9.1.200	Lincoln	27		135	78	324		388	823	130	.6	3.3		1,710	658	52	2,360	
4.9.29.22	Chaves			1,480	625	11,300		155	3,550	19,100				36,100	6,260	80	52,600	
4.15.28.31	do			548	306	196		188	2,460	240				3,840	2,630	14	4,360	
4.19.31.33.110b	Eddy	40		504	303	46		191	2,160	60	2.0	136		3,340	2,500	39	3,530	
4.21.37.33.210	Lea	16	0.23	50	31	555	7.6	360	855	208	1.8	.5		1,900	252	82	2,850	
4.24.37.10.123	do	13		121	93	402		277	934	252	1.6	1.2		1,950	684	56	2,840	
4.26.31.1	Eddy			410	121	366		109	1,500	470		2.1		2,920	1,520	34	3,810	

See footnotes at end of table.

TABLE 1.—*Chemical analyses of saline ground water in New Mexico*—Continued

[Analyses in parts per million, except as indicated]

Well No.	County	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids	Calcium, magnesium hardness as $CaCO_3$	Percent sodium	Specific conductance (micromhos at 25° C)	pH
JURASSIC SYSTEM																		
1.7.2.6.434	Valencia			92	126			2,440	6,300	9,400					748		35,200	7.7
1.8.3.10.222	do			264	118	504		226	1,520	330	.8	5.1		2,850	1,140	49	3,810	
1.10.6.33.100	do	13		131	31	532		423	1,160	37	1.4	1.4		2,110	454	72	2,810	
1.10.7.18.331	do			36	27	596		572	924	43	2.1	.6		1,910	201	87	2,750	
1.15.19.29.300	McKinley	13		18	4.2	914		407	1,290	256	4.1	.9		2,700	62	97	3,940	
2.11.30.20.444	Quay							276	806	160							2,310	
2.28.3.19.300	Rio Arriba	10	.02	222	48	141		241	815	8.5	.4	.2		1,370	752	29	1,740	7.0
CRETACEOUS SYSTEM																		
Dakota sandstone																		
1.10.8.27.	Valencia			143	107	567		408	1,280	255	1.2	0.9		2,560	797	61	3,330	7.9
1.18.3.21.210	Sandoval			30	9.6	3,170		255	4,650	1,390		3.4		9,380	114	98	12,100	
2.16.17.22.400	San Miguel			21	6.6	499		583	627	23	.7	.8		1,470	80	93	2,150	
2.17.18.17.400	do			359	171	414		358	1,990	88	.1	11		3,210	1,600	36	3,820	
2.22.33.1.422	Union	16				403		336	866	79	1.6	4.7			420	68	2,330	
2.22.35.32.342	do	16				425		408	651	95	.7	.1			224	80	2,140	
2.23.24.10.100	Colfax			293	69	200		305	739	130	.6	303		1,880	1,010	30	2,470	
2.25.22.19.	do	11	.02	20	7.9	1,110		872	112	1,170	5.6	.2	2.8	2,870	82	97	4,860	7.4
2.25.24.5.300	do			24	14	2,200		2,120	11	2,240	.9	.7		5,530	118	98	9,100	
Upper Cretaceous series																		
1.2.21.2.	Catron		240	1,540	832	1,110		[6]0	644	6,760				11,100	7,250	25		
1.3.18.30.	do			14		491		568	175	340	0.0	1.8		[2]1,260	62	95		
1.6.20.14.	Valencia			312	87	323		520	1,330	18	.2	3.1		2,330	1,140	38	2,860	
1.8.2.30.430	do	20	.09	516	163	6,630	194	1,340	6,540	6,170	4.3			20,900	1,960	87		
1.9.8.3.300	do	17		76	39	246		362	519	32	1.1	.0		1,110	350	60	1,580	
1.15.9.6.200	McKinley	12		630	245	299		288	2,480	47	.5	427		4,280	2,580	20	4,480	
1.17.8.25.144	do			40	28	2,240		519	421	3,000				5,980	215	96	10,200	
1.18.12.12.400	do			5		776		446	1,070	160	1.6	.0		[2]2,130	20	99		

1.18.15.5.300	do	----	----	46	28	709		490	1,160	115	.4	.1	----	2,300	230	87	----	----
1.20.10.30.300	do	----	----	9	----	662	----	[7]260	1,090	76	.6	.0	----	[2]1,860	16	97	----	----
1.21.6.3.200	Sandoval	----	----	----	----	----		308	----	78	----	----	----	----	33	----	3,050	----
1.28.18.28.200	San Juan	15	----	64	29	707		230	1,370	142	.3	.1	----	2,440	278	85	3,480	----
2.13.9.3.200	Santa Fe	11	----	171	65	95		209	677	15	1.2	.8	----	1,140	694	23	1,490	----
2.17.17.31.100	San Miguel	----	----	9.0	5.9	534		1,360	34	36	----	.5	1.0	1,290	47	96	2,120	----
2.24.20.4.224	Colfax	----	----	484	92	221		183	1,720	49	0.2	69	----	2,730	1,590	23	3,040	----
2.24.24.15.111	do	----	----	36	30	1,180		2,690	446	82	.8	.0	0.7	3,100	214	92	4,420	----
2.25.19.6.434	do	----	----	244	215	489		512	2,030	16	.3	.2	----	3,250	1,490	42	3,850	----
2.25.25.31.240	do	----	----	267	98	787		835	1,890	90	.3	.0	.2	3,540	1,070	62	4,530	----
2.26.21.36.300	do	11	----	504	450	281		518	3,130	26	.0	.4	----	4,660	3,110	16	4,820	----
2.28.26.8.200	do	----	----	246	70	75		271	699	66	.2	26	----	1,320	902	15	1,760	----
2.28.26.14.200	do	----	----	11	7.9	616		[8]1,640	9.1	33	----	.0	----	1,450	60	96	2,110	----
4 4.2.23.344	Socorro	22	----	101	57	148		317	491	18	.1	15	----	1,010	486	40	1,440	8.0
4.9.9.32.211	Lincoln	----	----	209	70	129		196	526	270	----	2.2	----	1,300	810	26	2,000	7.7
4.9.14.10.132	do	12	0.13	500	171	121		411	1,220	428	.4	1.7	----	2,660	1,950	12	3,470	6.7

TERTIARY SYSTEM

Nacimiento formation

1.21.1.15.130	Sandoval	14	----	456	70	228		418	1,460	40	0.9	0.2	----	2,480	1,430	26	2,860	----
1.24.4.6.100	Rio Arriba	8.0	.06	8.3	1.1	489	5.0	429	667	32	.9	.4	----	1,420	25	97	2,090	----
1.25.5.29.200	do	12	.17	69	10	442	6.1	298	882	12	.6	.2	----	1,580	214	81	2,230	----
1.26.4.16.	do	12	.13	17	2.6	470	5.0	367	763	14	.2	.2	----	1,460	53	94	2,170	----

Ogallala formation

4.18.38.30.223	Lea	45	----	77	28	297		312	293	270	3.6	3.5	----	1,170	307	68	1,940	7.6
4.21.33.2.422a	do	----	----	----	----		2.5	115	20	1,170	----	13	----	----	1,770	.3	3,730	7.3

TERTIARY AND QUATERNARY SYSTEMS

Santa Fe group and related bolson fill

1.2.1.30.330	Socorro	----	----	462	91	2,240		147	5,820	156	----	1.9	----	8,840	1,530	76	9,970	----
1.3.1.25.444	do	----	----	110	50	622		279	711	610	----	3.8	----	2,240	480	74	3,520	----
1.4.2.11.211	Valencia	53	----	41	18	823		644	640	538	3.1	5.3	----	2,440	176	91	3,820	7.8
1.5.3.34.200	do	----	----	401	305	----		1,230	----	6,760	----	----	----	----	2,280	----	23,100	----
1.6.2.31.400	do	25	----	278	118	1,080		275	1,090	1,540	----	3.8	----	4,270	1,180	67	6,520	7.7
1.13.1.11.220	Sandoval	12	----	17	7.9	545		612	654	54	.9	.1	----	1,590	75	94	2,290	8.1
2.1.2.34.130a	Socorro	18	----	586	144	15		130	1,880	13	.7	4.3	----	2,720	2,050	2	2,850	----
2.3.9.3.122	Torrance	24	----	520	162	13		159	1,720	44	.9	7.5	----	2,570	1,960	1	2,780	----
2.4.10.2.143	do	24	----	624	125	505		570	1,660	685	.9	7.1	----	3,910	2,070	35	5,050	----
2.5.1.28.114	Valencia	24	----	322	119	221		166	1,230	252	.2	1.3	----	2,250	1,290	27	2,960	7.2
2.6.9.1.300	Torrance	24	----	228	107	226		252	780	336	1.1	5.4	----	1,830	1,010	33	2,640	----

See footnotes at end of table.

634404—62——4

TABLE 1.—*Chemical analyses of saline ground water in New Mexico*—Continued

[Analyses in parts per million, except as indicated]

Well No.	County	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids	Calcium, magnesium hardness as $CaCO_3$	Percent sodium	Specific conductance (micromhos at 25° C)	pH
Santa Fe group and related bolson fill—Continued																		
2.6.11.19.234	Torrance							223		386							4,060	
2.7.9.3.300	do	28		294	134	211		186	1,040	358		3.2		2,160	1,280	26	3,090	
2.10.9.34.311	Santa Fe	21		276	108	158		205	854	290	.6	11		1,820	1,130	23	2,550	
2.23.6.14.	Rio Arriba		.33	170	40	334		313	749	188	4.6	1.8		1,640	588	55	2,320	
3.1.1.2.120	Socorro	24		318	121	539		179	869	1,000	.2	1.6		2,960	1,290	48	4,700	
3.5.14.33.110	Catron	19				1,080		276	92	1,660	1.2	0.4			320	88	5,630	
3.14.4.5.240	Sierra			143	18	790		218	94	1,320	3.6	.0		2,480	431	80	4,510	
3.19.4.11.221	Dona Ana			267	53	259		295	615	400	.3	1.5		1,740	884	39	2,640	
3.21.1.11.431	do			216	52	962		506	286	1,510		2.3		3,280	753	74	5,760	
3.22.21.3.312	Hidalgo							431		102					128		1,590	7.8
3.23.1.31.400	Dona Ana	19	0.02	110	1.1	928		[9] 55	927	910		3.3		2,930	279	88	4,640	8.6
3.25.7.12.321	Luna	42		54	17	279		270	242	230	3.6	6.3		1,010	204	75	1,630	
3.25.19.7.234	Hidalgo	141		19	1.2	329		181	460	78	11	.9	0.45	1,130	52	93	1,540	
3.28.7.9.411	Luna	66		4	2.3	425		468	235	203	11	1.6		1,180	20	98	1,850	
4.5.3.28.320	Socorro			540	110	349		38	2,340	59		12		3,430	1,800	30	3,790	7.6
4.7.4.23.312	do							32	2,290	32				[2] 3,520	2,020		3,480	7.1
4.9.4.4.134	do	11	.03	474	202	639		82	3,160	32	.5	.0		4,560	2,010	41	5,030	
4.9.7.25.200	Lincoln	24	.01	668	152	339		142	1,910	650	1.0	5.0		3,820	2,290	24	4,730	7.2
4.10.5.17.432	Sierra							295	528	128				[2] 1,290	920		1,690	7.4
4.10.6.23.200	Lincoln							151	1,950	710				4,170	2,450		4,850	7.6
4.14.10.18.424	Otero					195		130	991	87					836		2,120	
4.15.10.29.100	do			196	77	175		227	624	245		5.4		1,430	806	32	2,090	7.8
4.17.8.13.231	do			965	3,360	12,600		208	9,280	24,000				50,300	16,200	63	61,700	6.7
4.17.9.23.333	do	22		540	253	362		244	2,100	545	.3	24		3,970	2,390	25	4,720	
4.18.8.12.113	do					550		86	2,070	865					2,250		5,510	
4.22.5.17.200	Dona Ana	13		471	81	2,110		123	539	3,850	.9			7,120	1,510	75	11,900	7.2
4.23.5.34.300	do	32	.00	630	57	421	14	54	541	1,550	.1	1.5	.40	3,270	1,830	33	5,440	7.0
4.23.6.35.100	Otero							41	1,410	6,710					7,950		19,000	6.5
4.24.5.32.	Dona Ana	25	.02	1,480	77	531		22	201	3,500	.0			5,820	4,010	22	10,200	6.8
4.25.4.35.122	do	30	.02	578	88	1,370		57	273	3,150	.2			5,520	1,800	62	9,560	7.0
4.25.6.4.100	Otero	24	.00	1,250	282	824		36	1,210	3,390	.0			7,000	4,280	30	11,000	6.7
4.26.3.9.100	Dona Ana			142	45	386		663	211	436	.1	.6		1,550	540	61	2,580	
4.26.7.32.122	Otero	21	.00	90	5.5	541	5.6	47	44	950	1.0	.0	.36	1,680	247	82	3,220	7.3
4.26.8.32.111	do	17	.02	534	61	2,850		62	611	5,030	.3			9,130	1,580	80	15,100	7.3

QUATERNARY SYSTEM

Alluvial and eolian deposits

1.1.2.1.330	Socorro	18		154	68	861	303	838	1,000	1.0	1.5		3,090	664	74	4,830	
1.1.21.16.	Catron			129	108	167	400	649	69	1.2	30		1,350	765	32		
1.4.3.25.334	Socorro	24		138	67	887	354	471	1,250	.8	4.3		3,020	620	76	5,200	
1.7.1.31.122	Valencia	27		110	55	1,940	910	2,440	1,010	.4	2.3		6,030	500	38	8,540	7.7
1.10.7.23.243	Valencia	20		183	108	229	303	1,020	57	1.2	5.9		1,770	900	36	2,310	
1.10.9.17.113	do	30		330	380	931	469	2,840	754	.7	3.1		5,500	2,390	46	6,840	
1.25.16.26	San Jaun			200	39	927	536	2,090	38	2.2	.7		3,560	660	75	4,580	
1.29.12.6.130a	do	17		425	66	22	304	1,050	25	.8	.0		1,750	1,330	3	2,120	
1.30.18.25	do			158	32	208	290	649	46	.1	.2		1,240	526	46		
2.1.32.20.111	Roosevelt	67		111	67	277	303	607	184	4.7	2.0		1,470	552	52	2,060	7.5
2.2.26.10	De Baca			408	80	154	175	1,170	226				2,130	1,350	20	2,700	
2.3.6.34.431	Torrance	21		592	92	8.6	125	1,640	10	.4	14		2,440	1,860	1	2,530	
2.7.2.11.210	Valencia	30		203	32	139	465	441	70	.3	.3		1,140	638	32	1,620	7.6
2.8.21.10.444	Guadalupe			524	94	140	154	1,520	206				2,560	1,690	15	3,020	
2.8.21.36.224	do			576	141	164	29	1,870	284				3,050	2,020	15	3,560	
2.9.28.23.212	Quay						917	576	85					64		2,660	7.5
2.10.18.15.400	Guadalupe			359	63	93	188	1,060	66		3		1,740	1,150	15	2,120	
2.11.30.8.411	Quay						353	391	60							1,520	
2.13.4.1.240	Sandoval	42		281	55	123	187	887	71	.4	20		1,570	927	22	1,940	7.7
2.13.33.11.312	Quay						468	713	760		722					5,010	
2.15.2.36.411	Sandoval	2.5		92	17	310	298	347	258	1.7	.7		1,180	300	69	1,910	
2.15.27.17	San Miguel	30		97	46	241	498	398	92	.4	2.1	.6	1,150	431	55	1,680	
2.22.33.29.422	Union	23				370	490	742	161	4.7	38			640	56	2,520	
2.24.22.3.200	Colfax			346	152	128	332	1,390	30	.5	3.8	.04	2,210	1,490	16	2,600	
2.26.20.28.444	do			108	109	152	410	625	37	1.5	8.3	.1	1,240	718	32	1,770	
2.29.22.18	do			188	65	211	293	866	32	.4	9.6		1,520	736	38	2,010	
2.29.24.9	do			180	139	210	284	1,140	36	.6	7.1	.04	1,850	1,020	31	2,320	
3.1.1.23.300	Socorro	38		156	49	339	232	329	562	.4	1.1		1,590	590	56	2,630	
3.14.4.4.211	Sierra	39	0.01	174	25	692	221	98	1,240	2.8	2.7		2,380	537	74	4,430	7.2
3.17.4.31.111	do	20		157	21	296	316	666	119	.0	.9		1,440	478	57	1,400	
3.19.3.10.330	Dona Ana			200	29	140	354	399	153	.2	.8		1,100	618	33	1,650	
3.27.16.8.111	Grant						292	741	102					740		2,040	7.2
4.1.2.29.340	Socorro	28		458	779	765	530	5,150	151	.2	.7		7,590	4,350	28	7,640	
4.1.33.28.433	Roosevelt	50		97	84	217	179	591	200	4.7	2.9		1,330	588	44	1,920	7.2
4.1.34.35.344	do	53		167	55	139	194	528	160	1.9	7.4		1,210	642	32	1,670	7.2
4.2.24.21	De Baca			607	94	18	154	1,690	34		12		2,530	1,900	2	2,850	
4.2.35.11.313	Roosevelt	71		139	69	109	246	510	87	1.5	11		1,120	630	27	1,510	7.0
4.3.25.28	De Baca			603	140	9.5	244	1,780	32				2,690	2,080	1	2,910	
4.4.1.20.430	Socorro	46		98	36	743	290	642	780	.5	.7		2,490	392	80	4,000	
4.7.10.26.420	Lincoln			339	64	230	224	1,080	210	1.0	2.9		2,040	1,110	31	2,350	
4.8.9.29.113	do						150	1,140	470				[2] 2,560	1,420		3,340	7.4
4.10.8.18.131	do						379	2,340	840				[2] 5,260	2,980		6,030	7.6
4.10.24.22.441	Chaves					855	256	1,810	1,280					2,040	48	6,550	
4.10.25.31.100	do	15		304	90	333	226	748	626	.5	6.2		2,230	1,130	39	3,350	
4.12.7.8.244	Otero						57	1,910	1,200				65,100	2,520		6,170	7.5
4.12.26.31.133	Chaves					158	209	1,820	306		8.1			2,160	14	3,690	6.8

See footnotes at end of table.

TABLE 1.—*Chemical analyses of saline ground water in New Mexico*—Continued

[Analyses in parts per million, except as indicated]

Well No.	County	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids	Calcium, magnesium hardness as $CaCO_3$	Percent sodium	Specific conductance (micromhos at 25° C)	pH
Alluvial and eolian deposits—Continued																		
4.15.26.7.111	Chaves			284	102	130		126	867	285		4.3		1,730	1,130	20	2,430	
4.16.25.11.133	Eddy					44		187	1,380	53		15			1,580	6	2,440	8.2
4.17.7.23	Otero					224		183	1,970	224					2,030		3,710	
4.17.26.14.210	Eddy			620	201	112		170	1,260	815		19		3,110	2,370	9	4,330	
4.22.1.28.310	Dona Ana			302	44	309		508	747	289	0.1	4.7		1,950	934	42	2,740	
4.22.23.26.413	Eddy			600	184	113		152	2,100	129		7.7		3,210	2,250	10	3,540	
4.22.37.24.311	Lea	82		218	131	254		187	482	675	2.5	26		1,960	1,080	34	3,200	
4.23.27.2.122	Eddy			502	322	585		225	2,070	1,060		16		4,670	2,580	33	6,100	
4.24.19.18.344	Otero							186	727	26					980		1,590	7.2
4.24.27.8.430	Eddy			574	125	79		190	1,710	126		5.8		2,710	1,950	8	3,030	
4.24.28.36.144	do			729	135	520		233	1,960	900	.2	5.7		4,360	2,370	32	5,410	
4.25.18.26.111	Otero			556	264	65		202	2,230	82	3.2	2.4	.48	3,300	2,470	5	3,530	7.1
4.26.3.34.111	Dona Ana	49		118	48	526		518	536	462		1.5	.42	2,000	492	70	3,110	7.5
4.26.24.3.341	Eddy	16		473	42	3.9		230	1,110	9.0	.6	3.9		1,770	1,350	1	2,010	

1 Includes equivalent of 183 ppm of carbonate (CO_3).
2 Residue on evaporation at 180° C.
3 Includes equivalent of 19 ppm of carbonate (CO_3).
4 Includes equivalent of 30 ppm of carbonate (CO_3).
5 Hydroxide 27; carbonate 66.
6 Contains equivalent of 19 ppm of free sulfuric acid (H_2SO_4).
7 Includes equivalent of 16 ppm of carbonate (CO_3).
8 Includes equivalent of 69 ppm of cabronate (CO_3).
9 Includes equivalent of 14 ppm of carbonate (CO_3).

TABLE 2.—*Records of saline water wells and springs in New Mexico for which chemical analyses are listed in table 1*

[Use of water: D, domestic; S, stock; Ind, industrial; Irr, irrigation; P, public supply; N, none. Depth of well, water level, and yield: E, estimated; R, reported; all others measured]

Well No.	County	Owner	Depth of well (feet)	Diameter of well (inches)	Water level: Depth below land-surface datum (feet)	Water level: Date of measurement	Yield (gpm)	Use of water	Date of collection of sample	Temperature (°F)	Remarks
PENNSYLVANIAN SYSTEM											
1.1.2.7.100	Socorro	Campbell Farming Corporation.	Spring		Flows		500	N	Nov. 30, 1949	70	Sample from Madera limestone of the Magdalena group. Source of perennial flow of Rio Salado.
1.5.3.29.400	Valencia	Lee Auchsur	do		do		.3	N	Aug. 17, 1941	64	Sample from arkosic limestone member of Madera limestone.
1.6.3.35.430	do	New Mexico and Arizona Land Company.	do		do		5	N	do	71	Do.
2.2.4.12.210	Socorro	R. E. Miller	do		do		.75	D	Aug. 22, 1949	63	Dripping Springs. Sample from Madera limestone.
2.11.15.14.300	San Miguel	I. V. Lucero	4,295		do		.15		Nov. 13, 1952		Oil test.
3.13.4.34.310	Sierra	Mrs. Lula Howard Fincher.	120	6	do		2		Apr. 13, 1949	70	Casing: Steel to 120 ft. Bottled for medicinal purposes.
3.17.4.29.340	do		Spring		do				Apr. 17, 1947	93	Sample from Magdalena group.
4.9.6.2.400	Lincoln		24	48 x 48	13.8	Mar. 31, 1955		N	Mar. 31, 1955	59	Dug well. Sample from arkosic limestone member of Madera limestone from zone between 14 and 24 ft.

TABLE 2.—*Records of saline water wells and springs in New Mexico for which chemical analyses are listed in table 1*—Continued

Well No.	County	Owner	Depth of well (feet)	Diameter of well (inches)	Water level: Depth below land-surface datum (feet)	Water level: Date of measurement	Yield (gpm)	Use of water	Date of collection of sample	Temperature (°F)	Remarks
PERMIAN SYSTEM											
Abo formation											
1.7.2.31.140	Valencia	New Mexico and Arizona Land Company.	Spring		Flows		0.05	N	Sept. 2, 1941	80	
2.1.4.14.113	Socorro	Ed Bryan			163	Aug. 31, 1949		S	Aug. 31, 1949		
2.2.5.20.244	do	J. J. Contreras	58	8	39.8	July 28, 1949	2E	S	Dec. 19, 1949	57	
2.10.14.20.400	San Miguel	Frank Ortiz	670	6	325R	Aug. 12, 1947		D, S	Aug. 12, 1947		Water occurred at 630 ft. and rose to about 325 ft Cased to 660 ft.
4.7.7.9.222	Socorro	H. O. Bursum		6	68.5	May 19, 1955		N	Feb. 25, 1954		
Yeso formation											
1.4.4.30.223	Sorocco	Yriart Ranch		4			2E	S	Dec. 8, 1954		
2.1.2.15.223	do	T. D. Campbell						S	Jan. 24, 1950	64.5	
2.1.10.11.412	Torrance	Atkinson Ranch	295		284.5	Jan. 26, 1951	3E	S	Jan. 26, 1951		
2.1.15.5.111	do	A. Hindi	550	7	500		7E	S	Aug. 15, 1948		
2.2.6.9.233	do	R. L. Chilton	26		7.7	Aug. 11, 1950	5	S	Aug. 11, 1950		Dug well.
2.2.20.10	De Baca	Perez Ranch	1,065		980	July 30, 1940			July 30, 1940		
2.3.8.16.222	Torrance	Hodgins	210		184.2	Aug. 1, 1950		D, S	Aug. 1, 1950		
2.3.13.33.413	do	Juan Garcia	98	6	26.9	July 20, 1950		S	July 20, 1950		
2.5.14.32.300	do	Noble Dunlap							July 24, 1945		
2.7.11.34.311	do	Roy Dean	200	6	93	July 26, 1950		S	July 26, 1950		
2.8.13.22.130	do	Charlie Waller	600R		550R			S	May 26, 1951		East well.
2.9.10.18.233	do	Bill Ehret	358R		208R		8R	D	Sept. 27, 1950		
2.9.12.16.213	do	J. L. Smith	1,038					D	May 13, 1946		
2.10.16.5.120	Guadalupe	Dahlia Community	506	8				S	July 11, 1947	59	
2.11.28.30.232	Quay	Dr. Hoover	2,420	8	Flows		1,000E		Dec. 11, 1951		Oil test. Sample from zone between 2,167 to 2,420 ft.
2.12.12.4.110	San Miguel	P. G. Huddleston	470	5	300+E	1947		S	Aug. 4, 1947		

4.1.5.33.	Socorro	Riss Bishop	126	6	28R		2E	S	Jan. 1954		
4.1.8.1.433	do	James Wells	670R		650R			S	Aug. 3, 1950		
4.2.13.18.300	Lincoln							S	Mar. 17, 1950		
4.2.18.30.330	do	C. C. Hays	640E		560±E	Mar. 16, 1950		S	Mar. 16, 1950		
4.5.5.19.231	Socorro	H. O. Bursum	190E	6	172.8	Feb. 15, 1955	2	S	Feb. 15, 1955	67	
4.6.1.36.233	do	Dean Fite	300	6	256.4	Feb. 8, 1955	2	S	Feb. 8, 1955	70	
4.7.8.14.320	do	Rentfrow	810		600R	Feb. 26, 1954	12		Feb. 26, 1954		
4.8.2.17.200	do	Dean Fite		6			4	S	Feb. 9, 1954	70	
4.9.15.15.331	Lincoln	Bert Pfingsten	120	12			800E	Irr	May 23, 1955	54	Cased to 70 ft.
4.11.14.28.321	do	B. Griffith	Spring				240E	P	Apr. 27, 1955	54	Hale Spring.
4.11.17.20.212a	do	Joe Salcido	56	7	41	May 18, 1955	5E	D, S	May 18, 1955	61	
4.18.8.5.430	Otero	U.S. National Park Service.	989	10	Flows		50R		Mar. 30, 1954		Garton well. Flows from zone between 882 and 892 ft. Warm water.
4.23.18.30.340	do	U.S. Air Force	300	8	260		12E	D	Apr. 18, 1956		From zone between 260 and 300 ft.
4.26.18.29.113	do	Frank Gentry	333	18	52.8	Feb. 11, 1956	2,180	Irr	Apr. 11, 1956	68	
					Glorieta sandstone						
2.1.16.27.444	Lincoln	M. Nalda	460		435R			S	Apr. 6, 1950		
2.2.18.22.422	Guadalupe	Timoteo Garde	930	6				S	Feb. 14, 1955	65	
2.7.10.35.111	Torrance	Milton and Homer Berkshire.	173		62.0	July 6, 1950		S	July 14, 1950		
2.10.10.32.333	Santa Fe		158R		139.5	Mar. 2, 1951	5	D, S	Mar. 2, 1951		
2.11.17.36.420	Guadalupe		480						June 15, 1955	77	
4.3.17.7.110	Lincoln	Clark and Treat	400+	5				S	Mar. 31, 1950		Cased to 380 ft.
					San Andres limestone						
1.7.2.18.310	Valencia	U.S. Bureau of Indian Affairs.	Spring		Flows		0.02	N	Aug. 25, 1941	82	
1.12.10.23.233	do	John Jacobs	865	20	118	July 12, 1946	2,500	Irr	July 12, 1946		
1.12.11.10.431	do	Burton Johns	500	16	105	Feb. 27, 1946	1,500	Irr	May 10, 1946	59	
1.15.17.30.340	McKinley	U.S. Army	910	18, 7	Flows		40	D	May 18, 1953	68	Wingate Ordnance Depot
2.1.2.34.130	Socorro	Campbell Farming Corporation.	33		25.0	Jan. 24, 1950		D, S	Jan. 24, 1950	65	
2.6.17.15.122	Guadalupe	Julian Martinez	122R	6	108R		2E	S	Mar. 28, 1955		
2.10.19.18.420	do	Elliot F. Cowden	550					S	June 13, 1955	64	
2.10.21.32.230	do	Shaw and Craig	96	12	55.3	Apr. 7, 1955	2,000R	Irr	Apr. 7, 1955		
3.10.2.25.100	Sierra	Victoria Land and Cattle Company.	6,044	8	Flows		900E		July 8, 1955	94	Oil test. Sample from zone between 1,318 and 1,347 ft.
4.7.22.26.311	Chaves	T. Corn			625R			D, S	Feb. 7, 1950		
4.8.23.33.	do	Oscar White	215					S	July 26, 1947		
4.9.23.20.140	do	C. A. Morley	364					S	Jan. 26, 1927		
4.9.24.11.300	do	J. C. Wiggins			32			S	May 23, 1950		

TABLE 2.—*Records of saline water wells and springs in New Mexico for which chemical analyses are listed in table 1*—Continued

Well No.	County	Owner	Depth of well (feet)	Diameter of well (inches)	Water level: Depth below land-surface datum (feet)	Water level: Date of measurement	Yield (gpm)	Use of water	Date of collection of sample	Temperature (°F)	Remarks
San Andres limestone—Continued											
4.10.24.24.300	Chaves	Pecos Valley Artesian Conservancy District.	413	7, 5			400		Nov. 28, 1950		Test hole. Sample from zone between 258 and 403 ft. Cased to 235 ft.
4.12.23.5.300	do	Mrs. J. E. Bloom						D, S	July 19, 1947		
4.13.25.10.400	do	Loyd S. Walters	923	8	23.5	May 10, 1928	720		May 10, 1928	71	Cased to 763 ft.
4.15.25.35.213	do				Flows		765	Irr	Sept. 15, 1955	73	
Guadalupe series											
2.3.22.24.300	De Baca	Henry Long	152						July 29, 1940		
2.6.21.29.130	Guadalupe	Ernest Mullens	75	6	66.0	Jan. 10, 1956		S	July 25, 1940		
2.7.19.23.111	do	David Glass	250	4	208.6	Apr. 14, 1955	3	S	Apr. 14, 1955	66	Has odor of hydrogen sulfide.
2.8.22.19.234	do								Aug. 20, 1940		
2.9.21.35.131	do	Town of Santa Rosa	Spring		Flows				Dec. 16, 1954		Municipal emergency supply.
2.10.20.25.243	do		do		do		30E		Sept. 19, 1940		
4.1.23.12	De Baca	Walker Bros. Ranch					8–10		Dec. 11, 1939		
4.2.25.18	do		Spring		Flows				Dec. 12, 1939		Blanco Spring.
4.8.24.15.111	Chaves	J. Corn	215	14	24	May 17, 1950		N	May 17, 1950		
4.9.25.33	do	U.S. Dept. of Interior			5.3	Feb. 14, 1950			Feb. 14, 1950		Sinkhole.
4.11.26.2.442	do		Spring		Flows		10–15E	S	July 31, 1952		Comanche Springs.
4.20.25.16	Eddy		do		do				Apr. 30, 1951		Flat Rock Spring.
4.21.24.20.410	do	U.S. Army							Feb. 4, 1949		
4.21.27.9.330	do			6			2E	S	Jan. 25, 1950		
4.21.33.1.114	Lea								Mar. 1953		Discharge from oil-treating tower. Sample from Yates formation.
4.24.36.26.400	do	Magnolia Oil Co.							Mar. 11, 1953		Discharge from oil-treating tower. Sample from Yates-Seven Rivers formations.

Capitan limestone

4.20.25.27.300	Eddy		150		100E	Nov. 21, 1951			Nov. 21, 1951	68	Hardesty Well.
4.20.26.20	do								June 25, 1942		
4.20.27.17	do	John Fannin	180		130R	May 3, 1944			May 3, 1944		
4.21.25.1.200	do	U.S. Army							Dec. 7, 1948		Henry's Well. Damsite number 3.
4.21.26.3.344	do								Sept. 29, 1953		Harris Well.

Castile formation

4.25.26.24.140	Eddy	Roy Forehand	195		Flows				Feb. 7, 1939		Sodium sulfate test well.
4.26.24.11.122	do	A. M. Leeman	Spring		do		1		Jan. 22, 1948	64	Sample from middle of spring pond.
4.26.27.22.300	do	R. G. Ozley							Jan. 31, 1946		
4.26.28.13.110	do			6	56.0	Dec. 15, 1948	3	S	Dec. 15, 1948		Coad tank well.

Rustler formation

4.19.28.2.122	Eddy	H. A. Lindsey	160	6	128.3	Dec. 13, 1948	1E	S	Dec. 13, 1948	68	
4.21.28.18.130	do	Bybee		7	18.9	Jan. 21, 1950		S	Jan. 30, 1950		
4.21.29.18.130	do		160	6	135.1	Dec. 30, 1948	4	S	May 3, 1950	65	Lusk east well.
4.21.30.31.300	do	Union Potash and Chemical Co.	328						Aug. 21, 1939		Sample from base of Rustler formation.
4.22.27.1.210	do	Bond Ranch		6	39.9	Dec. 23, 1948	6	D, S	Apr. 30, 1950		
4.22.30.6.344	do	Inter. M. and C. Corporation.			110.3	May 20, 1949	700	Ind	May 20, 1949		

TRIASSIC SYSTEM

Dockum group

1.3.6.4.200	Socorro	Field Ranch	250R					D, S	Aug. 4, 1953		Sample from Chinle formation.
1.5.6.25.100	Valencia	Seis Wilson Ranch	600	4			2E	S	Apr. 15, 1954		Do.
1.7.4.11.430	do	Virgil P. Harrington	Spring		Flows		20	S	Sept. 4, 1941	62	Spring.
1.12.10.23233a	do	Henry Elkins	500	10	75	July 12, 1946	300	D, S	July 12, 1946		Sample from Chinle formation.
1.13.11.8.210	McKinley	Tom Elkins	200E	6	37.2	July 23, 1948	3E	S	July 23, 1948	55	Do.
2.4.21.1.	De Baca		147						Oct. 24, 1939		At old C.C.C. Camp.
2.7.30.17.244	Quay	Tom Lawson	525	6	275		4	S	Apr. 25, 1955	66	Sample from Chinle formation.
2.8.21.1.333	Guadalupe		80R		Flows		3,000R		Apr. 30, 1951		Blue Hole.
2.9.28.17.244	Quay	Louis Kinkead	171.5	6	do		.38	S	Apr. 28, 1955	63	

TABLE 2.—*Records of saline water wells and springs in New Mexico for which chemical analyses are listed in table 1*—Continued

Well No.	County	Owner	Depth of well (feet)	Diameter of well (inches)	Water level: Depth below land-surface datum (feet)	Water level: Date of measurement	Yield (gpm)	Use of water	Date of collection of sample	Temperature (°F)	Remarks
Dockum group—Continued											
2.9.32.1.433	Quay	Mrs. Will Wallace	198	5	170R		1.5	S	Sept. 1951		Sample from Chinle formation.
2.10.15.27.330	San Miguel	W. A. Thompson	180	6	143.5	Aug. 11, 1947		S	Aug. 11, 1947		Sample from Santa Rosa sandstone.
2.10.25.23.333	Guadalupe		187	6			4.5	N	May 27, 1936		Sample from Chinle formation. Steel casing to 187 ft.
2.10.35.29.222	Quay	Charlie White	128	6	51.3	May 11, 1956	1.5R	N	July 1955		Cased to 127 feet.
2.11.31.20.442	do	Louis Buth	170	8	167R			D, S	Oct. 12, 1948		
2.12.22.22.110	San Miguel	Cabra Springs Ranch	185	6	165			S	May 21, 1947		Sample from Santa Rosa sandstone.
2.12.25.17.400	do	Henry Priddy	355	6	155R			S	Nov. 14, 1947		Sample from Santa Rosa sandstone from zone between 325 and 355 ft.
2.12.32.1.422b	Quay	M. G. Cottingham	278	6	183.8	Sept. 25, 1953	2.5	S	June 10, 1954	64	
2.15.24.27.210	San Miguel	Pete Gonzales	115	6	23.8	Oct. 3, 1947		S	Oct. 3, 1947		Sample from Santa Rosa sandstone.
2.15.30.11.300	Harding	Owen Williams	485	4	290+E	Sept. 23, 1953		S	Sept. 23, 1953		Sample from Chinle formation.
2.32.31.34.133	Union	E. C. Hopkinson	302	8	101	Dec. 5, 1955	30	N	Dec. 5, 1955		Gas test well. Sample Chinle formation from zone between 228 and 302 ft. Cased to 103 ft.
4.3.31.30.300	Roosevelt	M. G. Vinther	150	8	22	June 26, 1950	15+E	D, S, Irr	June 26, 1950	62	
4.3.36.13.244	do	H. C. Nickels	46OR	6			3E	S	Oct. 26, 1955	65	Sample from Chinle formation.
4.6.9.1.200	Lincoln	W. R. Lovelace Livestock Co.	172	16			1,000R	Irr	Oct. 29, 1951	62	
4.9.29.22	Chaves	Jess Beadle	258						June 19, 1940		
4.15.28.31	do							S	May 3, 1939		
4.19.31.33.110b	Eddy	John Lusk		6			3E	S	May 1, 1950	65	
4.21.37.33.210	Lea		35OR	6			10E	P	Aug. 1, 1942		
4.24.37.10.123	do	Trinity Production Company.	747R		120	Mar. 11, 1953	50E	N	Mar. 11, 1953		
4.26.31.1	Eddy	Ross Ranch	340		287.7	Mar. 10, 1949		S	May 1, 1949		

JURASSIC SYSTEM

1.7.2.6.434	Valencia	U.S. Bureau of Indian Affairs.	Spring		Flows		3E	N	Feb. 20, 1956	58	Sample from Morrison formation.
1.8.3.10.222	do		do		do		200		Oct. 12, 1948		Suwaunee Springs.
1.10.6.33.100	do	U.S. Bureau of Indian Affairs.	581	8, 6				D	Oct. 20, 1952		Sample from Entrada sandstone from zone between 216 and 498 ft. Cased to 581 ft.
1.10.7.18.331	do	Turner Bros.	430					S	Oct. 10, 1948	60	
1.15.19.29.300	McKinley	A.T. and S.F. Ry. Co.	1,155	14	Flows		480	D, S	Dec. 6, 1949		
2.11.30.20.444	Quay	A. J. Cothern	50	48 x 48	45.5	Mar. 15, 1944			Dec. 15, 1952		Dug well. Sample from Entrada sandstone.
2.28.3.19.300	Rio Arriba	U.S. Air Force	802	8	220	Nov. 1954	100		Nov. 1954	46	Cased to 300 ft.

CRETACEOUS SYSTEM

Dakota sandstone

1.10.8.27.	Valencia	U.S. Bureau of Indian Affairs.	100	6					June 27, 1949		
1.18.3.21.210	Sandoval		3,445						Oct. 23, 1948		Oil test. Sample from zone between 3,440 and 3,445 ft.
2.16.17.22.400	San Miguel	J. H. Leatherwood	210	6	35			D, S, Irr	Aug. 18, 1947		
2.17.18.17.400	San Miguel	J. W. Shoemaker		6				S	Sept. 30, 1947		
2.22.33.1.422	Union	J. Park					1E	D, Irr	May 19, 1954	66	
2.22.35.32.342	do	Johnny Cain	75	5	30	Oct. 2, 1953	2	D, S	Oct. 2, 1953	63	
2.23.24.10.100	Colfax	Ben Floersheim	85					D, S	May 14, 1946		
2.25.22.19.	do	Clayton Ranch	889	8	Flows		25R	S	Jan. 23, 1946	68	Drilled to 928 ft. Plugged back to 889 ft. Dakota sandstone from 840 to 889 ft.
2.25.24.5.300	do	Frank Suable	450	6	61.8	Apr. 3, 1946		S	Feb. 10, 1947		Sample from zone between 430 and 450 ft.

Upper Cretaceous Series

1.2.21.2.	Catron	O. C. Kiehne	150	6	37			N	Dec. 22, 1933		Steel casing to 125 ft.
1.3.18.30.	do	State of New Mexico	Spring		Flows		3	D, S	do	55	
1.6.20.14.	Valencia	Jacob Barth	200	6	122			N	July 14, 1946	58	
1.8.2.30.430	do	U.S. Bureau of Indian Affairs.	Spring		Flows		0.3	N	Sept. 3, 1941	72	Sample from Mancos shale.
1.9.8.3.300	do							D, S	Sept. 19, 1952		Do.
1.15.9.6.200	McKinley	Pablo Pena	120	6					Aug. 1951		Sample from Dalton sandstone member of Crevasse Canyon formation of Mesaverde group from zone between 8 and 120 ft.

TABLE 2.—*Records of saline water wells and springs in New Mexico for which chemical analyses are listed in table 1*—Continued

Well No.	County	Owner	Depth of well (feet)	Diameter of well (inches)	Water level		Yield (gpm)	Use of water	Date of collection of sample	Temperature (°F)	Remarks
					Depth below land-surface datum (feet)	Date of measurement					
					Upper Cretaceous Series—Continued						
1.17.8.25.144	McKinley								May 18, 1950		Sample from Gallup sandstone of Mesaverde group from 1,760 ft.
1.18.12.12.400	do	Presley	800	12	Flows		45	D, S	Dec. 15, 1933		Sample from Point Lookout sandstone of Mesaverde group.
1.18.15.5.300	do	Chas. Damon	141					D, S	Dec. 11, 1933		Do.
1.20.10.30.300	do	Smith Bros.	3,275		Flows		120	S	Nov. 26, 1933		Sample from Dalton sandstone member of Crevasse Canyon formation of Mesaverde group.
1.21.6.3.200	Sandoval	U.S. Bureau of Indian Affairs.	465	8	200	Aug. 25, 1953	2	D	Aug. 25, 1953		Sample from Ojo Alamo sandstone from zone between 420 and 465 ft.
1.28.18.28.200	San Juan	J. W. McMillen	652E	12	Flows		20E		Dec. 28, 1953		Sample from Gallup sandstone of Mesaverde group.
2.13.9.3.200	Santa Fe	Wm. Pratt	30	16			580		Sept. 24, 1948		Sample from Mancos shale.
2.17.17.31.100	San Miguel	W. T. Bookout	134	6	72.4	Oct. 23, 1947		S	Nov. 3, 1947		Sample from Greenhorn limestone. Drawdown: 48 ft while pumping 2 gpm.
2.24.20.4.224	Colfax	Harley Coppock	17		14.2	Mar. 21, 1946		D	May 29, 1946	52.5	Dug well. Sample from Pierre shale.
2.24.24.15.111	do	Ben Floersheim	130	6	45			S	June 8, 1946	68	Sample from Graneros shale.
2.25.19.6.434	do	Philmont Scout Ranch.	119	5	51.9	May 31, 1946		S	May 31, 1946	55	Sample from Pierre shale.
2.25.25.31.240	do	G. D. Gillespie	49	5	24.4	Apr. 3, 1946		S	June 8, 1946	55	Sample from Greenhorn limestone.

2.26.21.36.300	do	N. E. Worley	39		12	Nov. 26, 1953	30R	D, S	Nov. 26, 1953	51	Sample from Niobrara formation.
2.28.26.8.200	do	Joe Cunico	52	6				D, S	May 16, 1946	51	Sample from Fort Hays limestone member of Niobrara *formation*.
2.28.26.14.200	do	Oscar Harris	135		86.3	May 17, 1946		S	July 3, 1946	58	Sample from Carlisle shale.
4.4.2.23.344	Socorro	F. Fernandez	90	6	17.5	Feb. 10, 1955	6	S	Feb. 10, 1955		Mancos shale.
4.9.9.32.211	Lincoln	Kiel Bonnell	Spring		Flows			N	Feb. 26, 1953		Milagro Spring. Sample from Mesaverde group.
4.9.14.10.132	do	Village of Capitan	320	6			70E	P	Apr. 27, 1955	59	

TERTIARY SYSTEM

Nacimiento formation

1.21.1.15.130	Sandoval	Village of Cuba	125				2.3	P	Oct. 24, 1952		
1.24.4.6.100	Rio Arriba	U.S. Bureau of Indian Affairs.	290	5	100	Nov. 10, 1938			Nov. 10, 1938		
1.25.5.29.200	do	do	225						do		
1.26.4.16.	do	do	100	5					do		

Ogallala formation

4.18.38.30.223	Lea	G. W. Goins	70	6	26	Mar. 22, 1955		D	Mar. 22, 1955	51	
4.21.33.2.422a	do	D. C. Berry	120		107.2	June 22, 1955		N	June 22, 1955		

TERTIARY AND QUATERNARY SYSTEMS

Santa Fe group and related bolson fill

1.2.1.30.330	Socorro	Campbell Farming Corporation.	90		7.0	Nov. 30, 1949		S	Nov. 30, 1949		
1.3.1.25.444	do	Bryan and Mumford	85		36.2	Nov. 21, 1949		S	May 1944	62	
1.4.2.11.211	Valencia	Huning Ranch	439	10, 5	401.2	Dec. 27, 1949	2	S	May 24, 1956	74	
1.5.3.34.200	do	Henry Garley	80	6	25	March 1954	20E	S	March 1954	60	Cased to 40 ft.
1.6.2.31.400	do	Malcolm Major							Sept. 13, 1950		
1.13.1.11.220	Sandoval	O. F. Sandoval	200	8	80	May 7, 1950	5		May 7, 1950		
2.1.2.34.130a	Socorro	Campbell Farming Corporation.	120	16	31.6	Jan. 27, 1950	1,250	Irr	Feb. 3, 1950	50	Sample from zone between 80 and 100 ft. Drawdown: 28 ft while pumping 1,250 gpm.
2.3.9.3.122	Torrance	Jack Dean	90		37.0	Aug. 3, 1950		S	Aug. 3, 1950		
2.4.10.2.143	do		100		92.4	Aug. 1, 1950		S	Aug. 1, 1950		
2.5.1.28.114	Valencia	B. C. Ringer		6			4E	S	Apr. 24, 1956	72	

TABLE 2.—*Records of saline water wells and springs in New Mexico for which chemical analyses are listed in table 1*—Continued

Well No.	County	Owner	Depth of well (feet)	Diameter of well (inches)	Water level: Depth below land-surface datum (feet)	Water level: Date of measurement	Yield (gpm)	Use of water	Date of collection of sample	Temperature (°F)	Remarks
Santa Fe group and related bolson fill—Continued											
2.6.9.1.300	Torrance	Huling Means, Jr.							Apr. 26, 1950		
2.6.11.19.234	do	Jones Land and Cattle Co.	56	6	31.0	July 28, 1950		S	July 28, 1950		
2.7.9.3.300	do	Huling Means							June 1, 1950		
2.10.9.34.311	Santa Fe								July 7, 1950		
2.23.6.14	Rio Arriba	Winfiled Morten	624	5	40	Sept. 30, 1945	10		Sept. 30, 1945	56	Sample from zone between 400 and 420 ft. Cased to 530 ft.
3.1.1.2.120	Socorro	E. Chavez	98	7	29.0	Jan. 15, 1950		D,S	Jan. 18, 1950		
3.5.14.33.110	Catron	M. Rael	290	6	83	Dec. 3, 1952	4	D,S	Dec. 3, 1952	60	
3.14.4.5.240	Sierra	Russell Free	138	8, 7	74.3	Jan. 24, 1948			Jan. 24, 1948		Sample from zone between 112 and 138 ft. Casing: 8-inch to 121 ft. Perforated 90 to 121 ft. 7-inch perforated from 121 to 138 ft.
3.19.4.11.221	Dona Ana	Clyde Cowan	74	10	11.9	Nov. 23, 1946	700	Irr	Apr. 17, 1947	66	Cased to 74 ft.
3.21.1.11.431	do	C. C. Rice	150	12	64.0	Mar. 26, 1948		Irr	Mar. 26, 1948		
3.22.21.3.312	Hidalgo	Frank Clayton		6	445.6	June 14, 1955	5E	S	July 8, 1955	88	"Blowing Well"
3.23.1.31.400	Dona Ana		1,200	8	597	Feb. 19, 1955	13.2		Feb. 19, 1955	90	Sample from zone between 1,030 and 1,197 ft. to 1,200 ft.
3.25.7.12.321	Luna	Robt. Milligen	230	16			70	LIrr	May 12, 1952	69	Cased to 230 ft; perforated 134 to 230 ft.
3.25.19.7.234	Hidalgo	D. A. Vannoy	95	18	31.6	Nov. 21, 1948		Irr	Apr. 28, 1949	210	Sample from zone between 70 and 87 ft. Cased to 90 ft.
3.28.7.9.411	Luna	Paul Gavme	615	14	23	Aug. 8, 1952	220	Irr	Aug. 8, 1952	88	Sample from zone between 361 and 431 ft and from basalt from zone between 431 to 586 ft. Cased to 615 ft. Drawdown: 137 ft.

4.5.3.28.320	Socorro	H. O. Bursum	180	6	154.9	Feb. 2, 1955	4E	S	June 29, 1953		Padilla Well.
4.7.4.23.312	do	C. Story	130		12	May 20, 1955	5E	N	May 20, 1955	66	
4.9.4.4.134	do	Ross McDonald		14				N	Sept. 13, 1945		
4.9.7.25.200	Lincoln		100	6	90	Oct. 27, 1952	140E	D	Oct. 27, 1952		
4.10.5.17.432	Sierra	B. Burris	50	6	37.3	May 31, 1955	5E	N	May 31, 1955	68	
4.10.6.23.200	Lincoln	do	Spring		Flows		3E	S	June 2, 1955	61	Mound Springs.
4.14.10.18.424	Otero	R. D. Champion	440	16	184.6	Apr. 8, 1952	400	Irr	June 25, 1954		Cased to 336 ft.
4.15.10.29.100	do	J. F. Cadwallader	407	16, 12	133.1	Mar. 10, 1955	820R	Irr	Jan. 17, 1954		Casing: 16-inch to 238 ft; 12-inch from 238 to 418 ft.
4.17.8.13.231	do	U.S. Air Force	110	6	9.1	Sept. 16, 1954			Mar. 1, 1949		Well is used for grounding at electrical substation.
4.17.9.23.333	do		208	8	38.7	Oct. 19, 1954	6		Oct. 18, 1954		Test well. Drill stem sample from zone between 107 and 208 ft.
4.18.8.12.113	do	G. B. Oliver	40	76 x 42	24.0	Apr. 8, 1954		S	Apr. 8, 1954		Dug well. Harrington Well.
4.22.5.17.200	Dona Ana	U.S. Army	1,006	6					June 10, 1953		Test well. Drill stem sample from zone between 956 and 1,003 ft.
4.23.5.34.300	do						8.7		May 6, 1953		Test well. Drill stem sample from zone between 1,162 and 1,216 ft.
4.23.6.35.100	Otero		650		287.5	Mar. 29, 1953			Mar. 30, 1953		Test well. Drill stem sample from zone between 423 and 450 ft.
4.24.5.32.	Dona Ana						12		Apr. 5, 1953		Test well. Drill stem sample from zone between 505 and 521 ft.
4.25.4.35.122	do						10.4		May 12, 1953		Test well. Drill stem sample from zone between 1,009 and 1,055 ft.
4.25.6.4.100	Otero		1,208		300.3	Mar. 31, 1953	18		Mar. 31, 1953		Test well. Drill stem sample from zone between 489 and 514 ft.
4.26.3.9.100	Dona Ana	Berino Cotton Gin Company.	148	2.5	3.6	Aug. 12, 1947	15	D, Ind	Aug. 12, 1947	72	Cased to 148 ft.
4.26.7.32.122	Otero		1,200	3	348		16+		Mar. 22, 1953		Test well. Drill stem sample from zone between 852 and 880 ft.
4.26.8.32.111	do		824		447.3	June 21, 1953			June 22, 1953		Test well. Drill stem sample from zone 775 and 820 ft.

TABLE 2.—*Records of saline water wells and springs in New Mexico for which chemical analyses are listed in table 1*—Continued

Well No.	County	Owner	Depth of well (feet)	Diameter of well (inches)	Water level: Depth below land-surface datum (feet)	Water level: Date of measurement	Yield (gpm)	Use of water	Date of collection of sample	Temperature (°F)	Remarks
QUATERNARY SYSTEM											
Alluvial and eolian deposits											
1.1.2.1.330	Socorro	Campbell Farming Corporation.	44		10.9	Nov. 30, 1949		S	Aug. 23, 1949		
1.1.21.16.	Catron	T. A. Summers	15						Dec. 22, 1933		
1.4.3.25.334	Socorro		Spring		Flows		100	S	Jan. 5, 1950		
1.7.1.31.122	Valencia	Huning	97	6			2E	S	Apr. 26, 1956	64	
1.10.7.23.243	do	Bobby Gottlieb	160	6	39.3	Dec. 15, 1950	50R	D	Dec. 15, 1950		Cased to 160 ft.
1.10.9.17.113	do	do	77	6	44.2	Dec. 8, 1950	5E	S	Dec. 8, 1950	57	Cased to 77 ft.
1.25.16.26.	San Juan	B. McGee						S	Nov. 17, 1948	50	
1.29.12.6.130a	do	G. L. McColm	6						Nov. 24, 1953		
1.30.18.25.	do	U.S. Bureau of Indian Affairs.	30	180				D	Nov. 1, 1933		Dug well.
2.1.32.20.111	Roosevelt	A. E. Lee		6			3E	D, S	Nov. 1, 1955	61	
2.2.26.10.	De Baca	H. S. Fuller	40						Feb. 27, 1940		
2.3.6.34.431	Torrance		22		11.3	Aug. 10, 1950		N	Aug. 10, 1950		
2.7.2.11.210	Valencia	Edgar Murry	64	16	8.4	Mar. 8, 1956	1,326	Irr	Aug. 14, 1951		
2.8.21.10.444	Guadalupe		Spring		Flows		225E		June 11, 1940		
2.8.21.36.224	do		45	10					Oct. 18, 1940		Cased to 44 ft.
2.9.28.23.212	Quay	Parker Cattle Co.	44	5	36.9	May 16, 1955	2	S	May 16, 1955	62	
2.10.18.15.400	Guadalupe		34		16.7	July 25, 1940			July 25, 1940		
2.11.30.8.411	Quay	L. V. Morris	82	5	20.0	Jan. 5, 1953		D, S	Jan. 5, 1953	65	
2.13.4.1.240	Sandoval	El Yeso Liquor Store	55	4				D	July 26, 1952		
2.13.33.11.312	Quay	Mrs. Ann Bigelow	50	6	30		3R	D	June 10, 1954		
2.15.2.36.411	Sandoval	Jose La Cruce Galvan.	18		10.6	Dec. 19, 1951		D, S	Dec. 19, 1951		
2.15.27.17	San Miguel	Bell Ranch	20		15.9	Oct. 29, 1947		D	Oct. 29, 1947		Dug well.
2.22.33.29.422	Union	M. D. Smithson	35		26	May 27, 1954	2E	S, Irr	May 27, 1954		
2.24.22.3.200	Colfax	P. M. Bowen	Spring		Flows		12E	S	Mar. 8, 1946	47	
2.26.20.28.444	do	E. W. Swope	38+					D	Feb. 25, 1946		Do.
2.29.22.18	do	Town of Koehler	35	144 x 144				P	Feb. 11, 1947		Do.
2.29.24.9	do	L. K. Moore	17.5		10.8	Feb. 14, 1946			Feb. 14, 1946		Do.
3.1.1.23.300	Socorro	G. H. Hilderbrand	112	16	12E	Dec. 1, 1951	1,000E	Irr	Dec. 1, 1951		Cased to 112 ft.
3.14.4.4.211	Sierra	T. B. Speight	15		Flows		2		Mar. 31, 1952	110	Driven well.

3.17.4.31.111	do	Ben Luchini	71	14	8.9	Feb. 20, 1947	1,000	Irr	July 14, 1947	67	Drawdown 11.2 ft after pumping 1,000 gpm for 9 hours.
4.19.3.10.330	Dona Ana	E. L. Cooks	69	12	5.0	Aug. 11, 1947	600E	Irr	Aug. 11, 1947	65	Cased to 69 ft. Drawdown 10 ft after pumping 600 gpm for 15 minutes.
3.27.16.8.111	Grant	Victoria Land and Cattle Co.	56	6	40.3	Feb. 25, 1955		S	Feb. 25, 1955	65	
4.1.2.29.340	Socorro	Bland and McDonald	13		4.7	Jan. 27, 1950		S	Feb. 22, 1950		
4.1.33.28.433	Roosevelt	C. J. Bennett	100	6			15E	D	Nov. 1, 1955	58	
4.1.34.35.344	do	City of Portales	120	16			900E	P	do	59	
4.2.24.21	De Baca	Tom Deck	63						Oct. 19, 1940		
4.2.35.11.313	Roosevelt	Wm. Brown	47	6			3E	D, S	Nov. 1, 1955	61	
4.3.25.28	De Baca	Strickland	15						Jan. 31, 1940		Old Hewitt well.
4.4.1.20.430	Socorro	Walter Duncan	89	16	6	Sept. 12, 1951	2,000E	D, S, Irr	Sept. 12, 1951		Sample from zone between 65 and 89 ft.
4.7.10.26.420	Lincoln		Spring		Flows		100	S	Oct. 2, 1948		Carrizozo Spring.
4.8.9.29.113	do	Geo MacDonald	do		do		4.8	S	May 18, 1955	62	Willow Spring.
4.10.8.18.131	do				63.1	May 26, 1955		S	June 2, 1955	66	Dug well.
4.10.24.22.441	Chaves	Roswell Country Club.	Spring		Flows		150E	Irr	Aug. 15, 1952		
4.10.25.31.100	do	James A. Bird	70	5			5E	D	Oct. 27, 1954		Cased to 70 ft.
4.12.7.8.244	Otero		Spring		Flows		300E		June 2, 1955	60	Malpais Spring.
4.12.26.31.133	Chaves	C. A. Nicholas			35	Sept. 1, 1955	215	Irr	Sept. 1, 1955	63	
4.15.26.7.111	do							Irr	July 23, 1943		
4.16.25.11.133	Eddy	J. J. Jerry	235	12, 10	52	Sept. 1, 1955		Irr	Sept. 1, 1955	65	Casing: 12-inch to 150 ft; 10-inch from 150 to 230 ft.
4.17.7.23	Otero	U.S. National Park Service.	10	60 x 120	8.6	Apr. 13, 1954			Apr. 13, 1954		Old Walters Ranch. Dug well.
4.17.26.14.210	Eddy	Emil P. Bach							July 1951		
4.22.1.28.310	Dona Ana	T. L. Simpson	42	4	5	Aug. 13, 1947	15E	D, S	Aug. 13, 1947		
4.22.23.26.413	Eddy	C. D. Fuller			10.7	Feb. 4, 1948	8	S	Feb. 4, 1948	62	
4.22.37.24.311	Lea	George Sims	82					D	Oct. 14, 1953		
4.23.27.2.122	Eddy	Jim Derrick	186	18, 16	70.2	Sept. 26, 1947	500	Irr	Oct. 16, 1946	66	Sample from zone between 127 and 180 ft, Casing: 18-inch to 65 ft; 16-inch from 65 to 150 ft.
4.24.19.18.344	Otero	Richard Lewis	138	6	117R		12R	D, S	Apr. 18, 1956	65	Sample from zone between 117 and 138 ft.
4.24.27.8.430	Eddy	V. J. Reeves					500	Irr	July 11, 1945		
4.24.28.36.144	do	G. Reed			36.7	Oct. 21, 1947		S	Oct. 21, 1947		
4.25.18.26.111	Otero	Ed Prather	140	16	56.5	Apr. 13, 1956	840	Irr	Apr. 16, 1956	61	Drawdown: 41 ft while pumping 840 gpm.
4.26.3.34.111	Dona Ana	Dairy Farms Co.	141				1,800E		June 18, 1952	66	
4.26.24.3.341	Eddy	Arthur Mayes	121	8	30.1	Apr. 4, 1952		Irr	June 18, 1952		

634404—62——5

TABLE 3.—*Chemical analyses of saline surface water in New Mexico*

[Analyses in parts per million, except as noted. Significance of analysis: Max, maximum concentration observed; Min, minimum concentration observed; Mod, modal concentration; WA, weighted average; P, for period of record; R, for representative year. Maximum, minimum, and modal refer only to dissolved solids; weighted average refers to all constituents. The mode is that approximate concentration that recurs most frequently. The weighted average of analyses represents the approximate chemical composition of the water passing a point during a year, if all the water were impounded and thoroughly mixed and no evaporation occurred. See table 4 for additional station data]

No. given on plate 8	Source and range of samples	Significance of analyses	Date	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids	Calcium, magnesium hardness as $CaCO_3$	Percent sodium	Specific conductance (micromhos at 25° C)	pH
1	Chicorica Creek near Hebron.	Max, P.	Nov. 22, 1949	10	----	175	111	193		277	995	32	0.2	4.4	----	1,660	893	32	2,150	----
		Min, P.	Sept. 25, 1945	----	----	27	10	10		135	13	4.0	----	1.4	----	132	108	17	231	----
2	Una de Gato Creek near Hebron.	Max, P.	Feb. 1, 8, 14, 22, 1946.	----	----	196	118	141		252	990	28	.3	4.3	----	1,600	974	24	2,030	----
		Min, P.	Apr. 5, 1946	----	----	58	31	60		181	228	8.0	----	6.2	----	480	272	32	706	----
3	Cimarron River at Springer.	Mod, P.	Apr. 5, 1950	6.9	----	357	188	228		292	1,750	68	.6	.1	----	2,740	1,660	23	3,150	----
4	Canadian River near Taylor Springs	do	Oct. 7, 1948	----	----	300	143	206		253	1,430	62	----	.4	----	2,270	1,340	25	2,740	----
5	Canadian River near Sanchez.	Max	Nov. 21–30, 1947.	8.6	0.02	184	93	168		193	940	47	.3	.4	0.4	1,540	842	30	1,980	7.8
		Min	Aug. 5–8, 1948	20	.03	56	13	22		173	84	6.0	1.2	.4	----	288	193	20	420	8.2
		WA, R.	Oct. 1, 1947 to Sept. 30, 1948.	14	.04	93	37	59		179	326	15	.3	2.1	----	635	384	25	906	----
6	Rio San Jose near Grants.	Max, P.	Aug. 5, 1943	----	----	367	66	213		137	1,380	70	----	1.0	----	2,170	1,190	28	2,620	----
		Min, P.	July 20, 1945	----	----	79	37	107		250	266	68	----	4.1	----	684	349	40	1,080	----
7	Rio Puerco at Rio Puerco.	Mod, P.	Jan. 16, 1956	21	.00	226	115	700	16	249	1,590	505	.8	2.1	1.3	3,300	1,040	59	4,460	7.8
8	Rio Salado near San Acacia.	do	Aug. 26, 1957	21	.08	156	33	162	6.9	337	491	70	.0	1.0	.11	1,110	525	40	1,580	----
9	Rio Grande at San Acacia.	Max	July 13–20, 1951	24	----	218	59	254	----	360	821	136	----	2.6	----	1,690	786	41	2,300	7.8
		Min	Feb. 21–28, 1951	26	----	68	12	35	----	196	114	18	----	2.2	----	372	219	26	585	7.7
		WA, R.	Oct. 1, 1950 to Sept. 30, 1951.	27	----	89	18	73	----	226	214	36	----	1.8	----	570	296	35	856	----
10	Rio Grande at San Marcial.	Max	Aug. 24, 1951	----	----	219	51	156	----	315	746	50	----	1.5	----	1,380	756	31	1,870	7.4
		Min	Feb. 21–28, 1951.	20	----	62	12	46		172	127	22	----	1.5	----	376	204	33	584	8.2
		WA, R.	Oct. 1, 1950 to Sept. 30, 1951.	24	----	83	16	83	----	206	212	46	----	1.6	----	567	273	40	861	----
11	Salt Creek in Sierra County:																			
	12.6.16.100	Mod, P.	June 2, 1955	----	----	----	----	----	----	[1] 78	4,590	8,440	----	----	----	[2]20,500	4,840	----	26,800	8.4
	12.6.15.100	do	do	----	----	----	----	----	----	90	4,250	7,660	----	----	----	[2]18,800	4,430	----	24,800	8.1

12	Pecos River near Puerto de Luna.	Max	Mar. 11-12, 1952.	19	----	604	79	103	178	1,620	158	----	1.5	----	2,670	1,830	11	3,000	7.3
		Min	Aug. 11-15, 1952.	18	----	152	17	25	222	278	22	----	1.1	----	622	449	11	892	7.5
		WA, R	Oct. 1, 1951 to Sept. 30, 1952.	17	----	362	46	48	174	911	76	----	1.0	----	1,550	1,090	9	1,860	----
13	Alamogordo Reservoir near Ft. Sumner.	Mod, P	Feb. 1, 1944	----	----	440	63	79	114	1,230	109	----	.5	----	1,980	1,360	11	2,360	----
14	Pecos River near Acme.	Max	Mar. 3-8, 1952	17	----	921	356	2,850	203	2,900	4,810	----	----	----	12,000	3,760	62	16,600	7.4
		Min	Aug. 21-28, 1952	15	----	211	34	40	127	551	52	----	1.7	----	968	666	11	1,310	7.8
		WA, R	Oct. 1, 1951 to Sept. 19, 1952.	16	----	376	60	97	136	1,040	137	----	3.3	----	1,800	1,180	15	2,200	----
15	Rio Hondo at Diamond "A" Ranch near Roswell.	Mod, P	Jan. 1, 1941	----	----	252	78	28	120	799	56	----	2.2	----	[2] 1,350	950	6	1,630	----
16	Rio Hondo near Roswell.	do	Mar. 15, 1939	----	----	320	128	616	245	978	1,020	----	----	----	3,180	1,330	50	4,830	----
17	Bottomless Lakes State Park:																		
	Ink Well Lake	Mod	Aug. 2, 1952	----	----	----	----	396	127	2,120	745	----	----	----	----	2,500	26	5,250	----
	Pasture Lake	do	do	----	----	----	----	686	199	2,210	1,240	----	----	----	----	2,720	35	6,690	----
	Cottonwood Lake.	do	do	----	----	----	----	885	113	2,420	1,690	----	----	----	----	3,070	39	8,100	----
	Figure "8" Lake.	do	do	----	----	----	----	1,850	113	4,620	2,810	----	----	----	----	4,850	45	13,100	----
	Mirror Lake	do	do	----	----	----	----	3,970	142	4,370	5,870	----	----	----	----	4,310	67	20,400	----
18	Rio Felix at old highway bridge near Hagerman.	Max, P	Jan. 7, 1948	----	----	594	233	530	248	1,610	1,210	----	7.5	----	4,310	2,440	32	5,940	----
		Min, P	July 24, 1950	----	----	52	11	17	203	13	21	----	2.1	----	216	174	17	400	----
19	Pecos River near Artesia.	Max	June 14 to 24, 1952.	20	----	703	301	1,990	147	2,580	3,280	----	----	----	8,950	2,990	59	12,400	7.4
		Min	Aug. 21-29, 1952.	15	----	283	38	101	130	761	130	----	2.8	----	1,390	862	20	1,810	7.7
		WA, R	Oct. 1, 1951 to Sept. 30, 1952	16	----	473	108	438	158	1,430	675	----	3.6	----	3,220	1,620	37	4,250	----
20	McMillan Reservoir near Lakewood.	Max, P	June 12, 1947	----	----	1,270	439	2,330	164	4,490	3,710	----	----	----	12,300	4,970	50	15,500	----
		Min, P	June 25, 1942	----	----	354	84	243	95	1,100	374	----	1.0	----	2,200	1,230	30	3,060	----
21	Lake Avalon near Carlsbad.	Mod, P	Aug. 1-10, 1951	17	----	592	127	409	137	1,750	675	----	2.3	----	3,640	2,000	31	4,670	7.6
22	Pecos River near Malaga.	Max	Sept. 11-20, 1952.	28	----	628	227	1,130	153	2,180	1,820	----	3.6	----	6,090	2,500	50	8,280	7.5
		Min	July 15, 1952	18	----	390	125	400	132	1,290	640	----	5.2	----	2,930	1,490	37	4,000	7.3
		WA, R	Oct. 1, 1951 to Sept. 30, 1952.	19	----	515	188	659	187	1,730	1,090	----	6.2	----	4,300	2,060	41	5,860	----

See footnotes at end of table.

TABLE 3.—*Chemical analyses of saline surface water in New Mexico*—Continued

No. given on plate 8	Source and range of samples	Significance of analyses	Date	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Boron (B)	Dissolved solids	Calcium, magnesium hardness as $CaCO_3$	Percent sodium	Specific conductance (micromhos at 25° C)	pH
23	Pecos River near Red Bluff.	Max	Aug. 21-31, 1952	20	----	675	340	4,220		93	2,760	6,600	----	----	----	14,700	3,080	75	20,700	7.1
		Min	Feb. 1-10, 1952	16	----	508	171	1,080		199	1,660	1,720	----	8.5	----	5,260	1,970	54	7,750	7.5
		WA, R.	Oct. 1, 1951 to Sept. 30, 1952	16	----	530	223	1,600		173	1,900	2,550	----	----	----	6,900	2,240	61	10,000	----
24	La Plata River near Farmington.	Max, P.	Sept. 10, 1945	----	----	372	110	777		164	2,250	420	----	.4	----	4,010	1,380	55	5,020	----
		Min, P.	May 22, 1944	----	----	106	41	63		174	384	19	----	1.0	----	700	433	24	1,010	----
25	Salt Lake in Catron County.	(3)	Feb. 1954	15	----	----	----	92,300		324	13,400	139,000	----	----	----	----	9,450	95	186,000	----

[1] Includes equivalent of 6 ppm carbonate (CO_3).
[2] Residue on evaporation at 180° C.
[3] One analysis from source.

TABLE 4.—*Records and stream data of saline surface water in New Mexico*

[Frequency of sampling: D, daily; M, monthly; I, intermittent. Number of analyses: P, for period of record; R, for representative water year. Date, discharge, and temperature are data that apply to single or composite samples for which analyses are given in table 3]

No. given on plate 8	Source	Drainage area (sq mi)	Frequency of sampling	Number of analyses	Date	Discharge (cfs)	Temperature (°F)	Remarks
1	Chicorica Creek near Hebron	381	I	14P				Sampled weekly during part of 1946.
					Nov. 22, 1949	3.1	32	
					Sept. 25, 1945	2.1		
2	Una de Gato Creek near Hebron		I	11P				Sampled weekly during part of 1946.
					Feb. 1, 8, 14, 22, 1946			
					Apr. 5, 1946			
3	Cimarron River at Springer	1,032	M	60P				Records available: June 1945 to September 1950.
					Apr. 5, 1950	4.9		
4	Canadian River near Taylor Springs.	2,853	M	64P				Records available: June 1945 to September 1950.
					Oct. 7, 1948	4.61		
5	Canadian River near Sanchez	[1] 6,015			Nov. 21–30, 1947	26.7		Records available: October 1940 to June 1949.
					Aug. 5–8, 1948	398		
			D	42R	Oct. 1, 1947 to Sept. 30, 1948	191		
6	Rio San Jose near Grants	[2] 1,070	I	7P				
					Aug. 5, 1943	940		
					July 20, 1945	4.9		
7	Rio Puerco at Rio Puerco	[2] 5,160	I	18P				Sampled monthly basis during 1937. Infrequent basis since 1937.
					Jan. 16, 1956		40	
8	Rio Salado near San Acacia	[2] 1,380	I	6P				
					Aug. 26, 1937	[3] 100		
9	Rio Grande at San Acacia	[2, 4] 26,770			July 13–20, 1951	1.02		Records available: July to December 1937, March 1939 to September 1956. Monthly since September 1956.
					Feb. 21–28, 1951	1,451		
			D	40R	Oct. 1, 1950 to Sept. 30, 1951	249		
10	Rio Grande at San Marcial	[2, 4] 27,700			Aug. 24, 1951		72	Records available: July 1946 to January 1959.
					Feb. 21–28, 1951	1,159		
			D	31R	Oct. 1, 1950 to Sept. 30, 1951	163		
11	Salt Creek in Sierra County:							
	12.6.16.100		I	3P	June 2, 1955	[2] 1.5	72	
	12.6.15.100		I		do	[2] 1	74	

See footnotes at end of table.

TABLE 4.—*Records and stream data of saline surface water in New Mexico*—Continued

No. given on plate 8	Source	Drainage area (sq mi)	Frequency of sampling	Number of analyses	Date	Discharge (cfs)	Temper-ature (°F)	Remarks
12	Pecos River near Puerto de Luna	[2,5] 3,970			Mar. 11–12, 1952	81.9		Records available: July 1939 to September 1941, November 1946 to January 1959.
					Aug. 11–15, 1952	894		
			D	45R	Oct. 1, 1951 to Sept. 30, 1952	177		
13	Alamogordo Reservoir on Pecos River near Ft. Sumner.		I	40P				Contents: Approximately 48,120 acre-feet on Jan. 31, 1944.
					Feb. 1, 1944			
14	Pecos River near Acme	[2,5] 11,380			Mar. 3–8, 1952	.28		Records available: July 1937 to January 1959.
					Aug. 21–28, 1952	720		
			D	39R	Oct. 1, 1951 to Sept. 30, 1952	178		
15	Rio Hondo at Diamond "A" Ranch near Roswell.	[5] 947	I	9P				
					Jan. 1, 1941	[3] 2.3		
16	Rio Hondo near Roswell		I	35P				
					Mar. 15, 1939			
17	Bottomless Lakes State Park			67P				
	Ink Well Lake		I		Aug. 2, 1952			
	Pasture Lake		I		do			
	Cottonwood Lake		I		do			
	Figure "8" Lake		I		do			
	Mirror Lake		I		do			
18	Rio Felix at old highway bridge near Hagerman.	[5] 932	I	102P				Sampled monthly from 1938 to 1940; approximately weekly during 1940; infrequent after 1940.
					Jan. 7, 1948			
					July 24, 1950			
19	Pecos River near Artesia	[2,5] 15,300			June 14–24, 1952	19.7		Records available: July 1937 to January 1959.
					Aug. 21–29, 1952	659		
			D	41R	Oct. 1, 1951, to Sept. 30, 1952	152		
20	McMillan Reservoir on Pecos River near Lakewood.		I	170P				
					June 12, 1947			Lake contained probably less than 400 acre-feet when sampled.
					June 25, 1942			Lake contained about 28,000 acre-feet when sampled.
21	Lake Avalon on Pecos River near Carlsbad.		D		Aug. 1–10, 1951			Daily station directly below dam, represents approximate quality of the water in Lake Avalon.
22	Pecos River near Malaga	[2,5] 19,190			Sept. 11–20, 1952	19.8		Records available: July 1937 to January 1959.
					July 15, 1952	148		
			D	38R	Oct. 1, 1951, to Sept. 30, 1952	50.1		

23	Pecos River near Red Bluff	[2] [5] 19,540			Aug. 21-31, 1952	14.6		Records available: October 1937 to January 1959.
					Feb. 1-10, 1952	88.4		
			D	38R	Oct. 1, 1951, to Sept. 30, 1952	56.5		
24	La Plata River near Farmington	583	I	28P				Records available: February 1944 to February 1949.
					Sept. 10, 1945	0		
					May 22, 1944	179		
25	Salt Lake in Catron County		I	4P				
					February 1954			

[1] 303 square miles is probably noncontributing.
[2] Approximate.
[3] Estimated.
[4] Includes 2,940 square miles in northern part of San Luis valley, Colorado.
[5] Contributing area.

INDEX

U.S. GOVERNMENT PRINTING OFFICE: 1962