TECHNICAL REPORT NO. 13

State of New Mexico
State Engineer Office
Santa Fe, N. Mex.

ANNUAL WATER-LEVEL MEASUREMENTS IN OBSERVATION WELLS, 1951-1955, AND ATLAS OF MAPS SHOWING CHANGES IN WATER LEVELS FOR VARIOUS PERIODS FROM BEGINNING OF RECORD THROUGH 1954, NEW MEXICO

PART C

SOUTH-CENTRAL CLOSED BASINS AND RIO GRANDE VALLEY

Estancia Valley, Torrance and Santa Fe Counties
Tularosa-Alamogordo area, Otero County
Hot Springs basin, Sierra County
Grants-Bluewater area, Valencia County

By

H. O. Reeder and Others

*Prepared in cooperation with
the United States Geological Survey*

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FOREWORD

After publication of 1950 data pertaining to annual measurements of water levels in observation wells in New Mexico, the U. S. Geological Survey suspended publication of such data in its water-supply papers, while continuing to publish bimonthly water-level and recorder-well measurements. With publication of the 1955 bimonthly water-level and recorder-well measurements, the Survey also suspended publication of these data for general distribution. However, the agency has continued its program of measuring and interpreting changes of water levels in wells in various parts of the State, and in order that the findings may again be made available to the general public the State Engineer Office has undertaken to publish the information in its technical reports series.

First of the State Engineer Office water-level papers, Technical Report No. 13 contains records of annual water-level measurements for the period 1951-1955, together with maps showing changes in water levels from the beginning of record through 1954 and brief text summaries of such changes. Inasmuch as records of bimonthly measurements of recorder wells through 1955 have already been published in the Geological Survey water-supply papers, such data are not included in this volume. Subsequent water-level papers will be published annually and will contain annual measurements, maps showing changes in water levels, seasonal water levels, data on recorder wells for the calendar year, and explanatory text material pertaining to the compilations.

The interest of most persons who use this work will be restricted to specific areas and, for the convenience of users as well as for economy in printing, the report is being published initially in four parts, with each part constituting a separate volume, as follows:

A. High Plains (House area, Clovis area, Portales Valley, and Tatum-Lovington-Hobbs area: Quay, Curry, Roosevelt, and Lea Counties)

B. Pecos River valley (Roswell basin and Carlsbad area: Chaves and Eddy Counties)

C. South-Central closed basins and Rio Grande Valley (Estancia Valley, Tularosa-Alamogordo area, Hot Springs basin, and Grants-Bluewater area: Torrance, Santa Fe, Otero, Sierra, and Valencia Counties)

D. Southwestern New Mexico (Animas, Playas, and Mimbres Valleys: Hidalgo and Luna Counties)

Preliminary distribution of the work will be by individual part, on the basis of locale of specific interest to the reader. The four parts will be combined in a single volume for distribution to libraries, agencies, and individuals requiring access to Statewide data.

The Abstract and the Introduction to the report will appear in each separately issued part, as well as in the complete compilation. Pages, illustrations, and tables are numbered consecutively throughout the work; consequently, gaps will appear in the numerical sequence of each in Parts B, C, and D. Part divisions will not appear in the final volume.

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ANNUAL WATER-LEVEL MEASUREMENTS IN OBSERVATION WELLS, 1951-1955, AND ATLAS OF MAPS SHOWING CHANGES IN WATER LEVELS FOR VARIOUS PERIODS FROM BEGINNING OF RECORD THROUGH 1954, NEW MEXICO

Part C - South-Central Closed Basins and Rio Grande Valley

Estancia Valley, Torrance and Santa Fe Counties
Tularosa-Alamogordo area, Otero County
Hot Springs basin, Sierra County
Grants-Bluewater area, Valencia County

By

H. O. Reeder, E. H. Herrick, J. W. Hood, and E. D. Gordon
U. S. Geological Survey

ABSTRACT

By

H. O. Reeder

This report tabulates the annual measurements of water level in the observation wells in the various irrigated areas, primarily from 1951 through 1955. It summarizes changes in water level by discussion and with an atlas of nearly all the maps of change of water level for the period of record to 1955 for each area in which observations are being made. Included also are hydrographs for the period of record through 1954 of several selected wells in the various areas irrigated from ground-water sources. The annual measurements of water level before 1951, seasonal measurements, and daily records of water levels in wells equipped with recording gages have been published in an annual series of U. S. Geological Survey Water-Supply Papers.

The areas of observation included in this report are the House area, Clovis area, Portales Valley, Tatum-Lovington-Hobbs area, Roswell basin, Carlsbad area, Estancia Valley, Tularosa-Alamogordo area, Hot Springs basin, Grants-Bluewater area, Animas Valley, Playas Valley, and Mimbres Valley.

Irrigation has been practiced for many years in semiarid New Mexico where precipitation is insufficient or too variable for most crops. Surface water from streams was first used for irrigation and more recently ground water from wells was also used. As the population has increased and irrigation of lands has expanded, water has been used in increasing amounts. And, as the supply of surface water was almost entirely appropriated at an early date and is somewhat fixed, the increased use of water for irrigation, as well as for domestic, stock, municipal, and industrial use, has been supplied mostly from ground-water sources. In New Mexico far more ground water is

being used for irrigation than for any other purpose.

The first wells for irrigation in New Mexico were constructed near the end of the nineteenth century; however, large-scale irrigation was not practiced except in areas of very shallow water or areas in which flowing artesian wells could be developed. The only major area of flowing wells in New Mexico has been in the Roswell basin where development of ground water for domestic use began in 1891 and for irrigation use began in 1902. Large-scale use of shallow water for irrigation began in the Mimbres Valley about 1908 and in the Portales Valley about 1910. Shallow-water development was expanded somewhat in these and other areas in the late 1920's, but the greatest expansion began about 1946 and has continued through 1954. The report describes each area briefly and gives a short history of its development.

A network of observation wells in which water levels are measured periodically is necessary to record changes in ground-water storage in areas where the ground-water resources are being developed. Such a network provides information on the capacity of the aquifer and the probable life of the supply.

The number of wells in which water levels have been measured annually has increased from 645 in 1938 to 1,450 in 1954. About 1,700 wells were included in the network of observation wells in January and February 1955, all of which, for various reasons, were not measured. The number of observation wells in which water levels are measured seasonally has increased from 86 in 1938 to 385 in 1954. The number of observation wells by years and for each area is given in the report under each area heading and shown graphically in the introduction.

In addition to measurements of water levels, other related data were collected in connection with the observation-well program. As changes in water level are related to the pumping of ground water, and as more ground water in New Mexico is used for irrigation than for any other purpose, data were obtained on acreage irrigated, quantity of water pumped, and other related factors. As the ground-water body is recharged primarily from precipitation, precipitation is an integral factor in the study of changes of water levels. Many of these data and a discussion of their relation to changes of water level are given under each area heading in the report.

Acreage irrigated with ground water in the report areas increased from about 128,000 acres in 1938 to about 420,000 acres in 1954, of which 35,000 acres received water from ground-water sources supplemental to surface water in 1954. The total acreage irrigated in New Mexico in 1954 is estimated at about 820,000, of which about 275,000 acres was irrigated entirely with surface water, 400,000 acres entirely with ground water, and 145,000 acres with a combination of ground water and surface water.

Although precipitation in most of New Mexico is rarely sufficient for the needs of most crops, it does supply part of the water requirement and, at such times, reduces the amount of water required for irrigation from surface- and ground-water supplies. Precipitation generally has been below

average in most years during the period of observation of water levels. Precipitation data are given for one station in each area discussed in the report.

The amount of water pumped is listed by years under each area heading. About 1,025,000 acre-feet of water was pumped for use on 420,000 acres of land in the report areas in 1954. A total of about 1,300,000 acre-feet of water was pumped for use on 545,000 acres of land, 145,000 acres of which received supplemental surface water, in New Mexico in 1954.

With the increased development of ground water it was recognized that some control over development was needed. In 1931 three basins were declared by the State Engineer. Other basins have been declared as the need arose since that time.

The trend in water levels from year to year generally has been downward in most areas in New Mexico, especially in the areas where ground water is pumped for irrigation. A notable exception was in 1941 when heavy precipitation greatly reduced the draft on ground-water reservoirs while providing unusually large recharge to them. Water levels rose generally, and by 1942 water levels in some areas were higher than any previously recorded. However, since 1941 the precipitation has been near or below average for most years, causing a new trend of declines in water levels from year to year as more ground water was required for crops, and by 1946-1948 water levels in many wells had reached record lows. In the following years, the increasing number of irrigation wells and, since 1949, the persistent drought have caused somewhat larger net annual declines and successive record-low water levels in general.

INTRODUCTION

By
H. O. Reeder

Water has been at a premium, even for domestic and stock use, in much of the area now known as New Mexico since man came to the region. Civilizations of the past and their progress have been governed in part by the available water. Large areas remain relatively undeveloped, in part either because of scarcity of water of usable quality or in places because of lack of knowledge of potential supplies of ground water. Even in areas where water is relatively plentiful the demand generally exceeds the supply, although the depletion of a ground-water reservoir may not be as apparent as that from a surface-water reservoir or a stream. Extensive periods of below normal rainfall in a normally semiarid climate have caused additional difficulties, amounting at times to catastrophe. For instance, in ancient times a flourishing Indian pueblo economy in this region is inferred to have been almost wiped out by a severe drought of long duration.

As New Mexico is a semiarid region where precipitation is insufficient for most crops or too variable for successful farming, irrigation has been practiced for many years -- first by use of surface water from streams and more recently by use of ground water from wells. As the population has increased and irrigation of lands has expanded, water has been used in increasing amounts; and, as the surface-water supply was almost entirely appropriated at an early date except for that in the San Juan River, and is somewhat fixed, the increased use of water for irrigation, as well as for domestic, stock, municipal, and industrial use, has been supplied mostly from ground-water sources. More water is used for irrigation than for any other purpose in New Mexico.

The development of ground water began early in the State's history with the construction of wells for domestic and stock use. The first wells for irrigation in New Mexico were constructed near the end of the nineteenth century. However, until more adequate pumping plants became available, large-scale irrigation was not practiced except in areas of very shallow water or areas in which flowing artesian wells could be drilled. The only major area of flowing wells in New Mexico has been the Roswell basin, where development for domestic use began in 1891. Drilling of wells for irrigation in the Roswell basin began about 1902 in Chaves County and about 1904 in Eddy County Large-scale use of shallow water for irrigation began in the Deming area in the Mimbres Valley about 1908 and in the Portales Valley about 1910. Shallow-water development was expanded somewhat in these and other areas in the late 1920's, but the greatest expansion began about 1946 and has continued through 1954. Development of ground water in the early years, with the exception of the Roswell basin, was limited essentially to areas where surface water was lacking, such as the Mimbres Valley; but in later years, beginning about 1947, irrigation wells have been utilized partly in response to the drought, in areas where irrigation had been usually by surface water,such as in Carlsbad.

Scope of the Program of Water-Level Measurements

Ground-water reservoirs, like surface-water reservoirs, may be depleted, although in places the ground-water reservoir may be so large that changes in storage are not generally apparent during brief periods. Nevertheless in some areas, notably the Roswell artesian basin, declines in water level, as shown by the decreased flow of artesian wells, were so marked after the drilling of many wells that the concept of an unlimited supply of ground water was quickly dispelled. The reduction in artesian pressure brought out the need for an investigation of the ground-water resources of the area. Beginning in 1925 with the study of the Roswell basin, the ground-water investigations in the State have been expanded to other areas and continued through the present, primarily in the areas in which large supplies have been developed for irrigation.

An important phase of investigation in areas where ground water is developed or where ground water is likely to be developed is the establishment of a network of observation wells. Periodic measurement of water levels in a number of wells over an area provide a good index to the status of the particular ground-water reservoir. A decline in water levels during an interval represents a decrease in the water stored in the reservoir. The decrease in storage may be related to discharge from the ground-water reservoir through natural avenues of escape of water or more commonly through discharge from wells. A rise in water levels indicates an increase in storage that may be related to above-normal recharge or, in a small area, be related to cessation of pumping. Because of the frictional resistance of the water-bearing bed (aquifer) to movement of ground water, the piezometric surface is not level, as in a surface reservoir, and an adequate portrayal of variations in underground storage necessitates measurements of water level at many locations. Thus a network of wells in an area where water levels are measured periodically provides a record of the change in storage in the ground-water reservoir and provides information as to the permanence of the supply and the characteristics of the aquifer.

Periodic measurements of water levels are part of the continuing program of investigations of ground water made in New Mexico by the U. S. Geological Survey in cooperation with the State Engineer. The observation-well program was begun in 1925 and has been expanded from time to time to obtain information on changes in water level in newly developed areas. Figure 1 shows the location and approximate extent of the areas observed as of January 1955 and included in this report. The areas of observation include most areas of major development of ground water, as of January 1955, except for a few areas, such as the Rincon and Mesilla Valleys of the Rio Grande.

Water levels are measured in many observation wells each January or February in the main areas in New Mexico where ground water is used for irrigation. The wells are measured at a time of the year when water levels have recovered from the major part of the effects of pumping from the previous irrigation season -- therefore, at a time when comparison with water levels of previous years can best be made. These winter measurements are significant because they indicate the amount of ground water in storage. A comparison of water-level measurements from year to year shows the changes of storage resulting from changes in recharge, which is primarily from precipitation, and in discharge, which is primarily by pumping for irrigation.

The number of wells in which water levels have been measured annually has increased from 645 in 1938 to 1,450 in 1954. About 1,700 wells were included in the observation-well network in January and February 1955. However, for various reasons, such as wells being pumped, only about 1,500 wells were measured in January and February 1955. Figure 2 shows graphically by years the number of wells in which annual and seasonal measurements were made in each of the observation areas. The height of the bars represents the total number of wells measured either annually or seasonally in the State. Figure 2 does not include observation wells which were not measured.

Water levels also are measured periodically in a number of observation wells to determine the seasonal fluctuation, if any, of the water table and the relation of this fluctuation to precipitation and to pumping of water for irrigation during the growing season. Seasonal measurements of water levels are made at 2-month intervals in most of the areas, but are made at 3-month intervals in the Estancia Valley. Most of the wells measured periodically exhibit seasonal fluctuations in response to pumping from irrigation wells. The number of observation wells in which water levels are measured seasonally has increased from 86 in 1938 to 385 in 1954. The seasonal water-level measurements have been published annually in the series of U. S. Geological Survey water-supply papers entitled, "Water Levels and Artesian Pressures in Observation Wells in the United States in (year)." Beginning with the records for 1956, seasonal measurements for a few of the wells will be published at 5-year intervals in a similar series of water-supply papers. Prior to 1951, the annual measurements were published in these water-supply papers but from 1951 through 1955 they were released to the open file and distributed in mimeographed form.

The total number of annual and seasonal measurements of water levels has increased from about 1,250 in 1938 to about 3,135 in 1954. Recording gages are maintained on a number of wells to determine detailed water-level fluctuations. The number of recording gages has ranged up to about 35. Daily records of water level in most of these wells have been published in the U. S. Geological Survey water-supply papers.

As changes in water level are related to the pumping of ground water, and as more ground water in New Mexico is used for irrigation than for any other purpose, it is important to know how much land is irrigated and how much water is pumped in the areas of water-level observation. Ground-water pumpage is computed or estimated on the basis of acreage irrigated, pump ratings, and records of electric power used, where available. As recharge to the ground-water body is derived primarily from precipitation, precipitation must be considered in the study of changes of water level.

Water levels and data related to the program of water-level measurements have been published annually since 1935 in the series of U. S. Geological Survey water-supply papers entitled, "Water Levels and Artesian Pressures in Observation Wells in the United States in (year)." Beginning in 1940, the water-level data in New Mexico are included in the "Part 6" volume for the Southwestern States and Territory of Hawaii. The following listed water-supply papers by years of observation include data for New Mexico on the pages indicated.

Year	Water-Supply Paper	Pages
1935	777	106-114
1936	817	194-197
1937	840	252-354
1938	845	242-300
1939	886	376-467
1940	911	150-240
1941	941	183-282
1942	949	255-344
1943	991	202-305
1944	1021	184-302
1945	1028	198-301
1946	1076	206-316
1947	1101	183-316
1948	1131	157-288
1949	1161	153-298
1950	1170	167-279
1951	1196	154-222
1952	1226	171-237
1953	1270	179-253
1954	1326	181-262

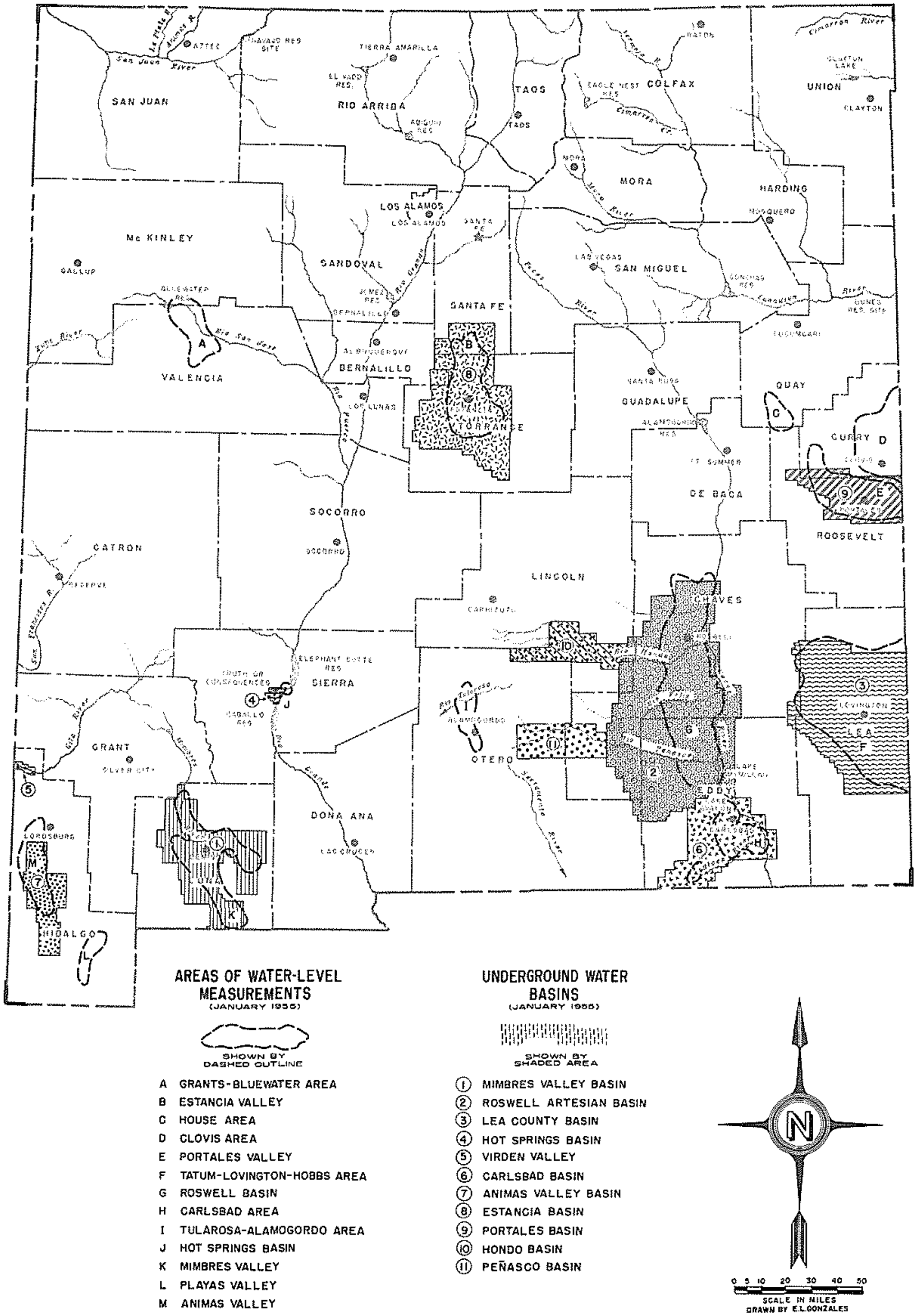

FIGURE 1. -- Areas in which water levels were being measured periodically in New Mexico, and underground water basins declared by the State Engineer, as of January 1955.

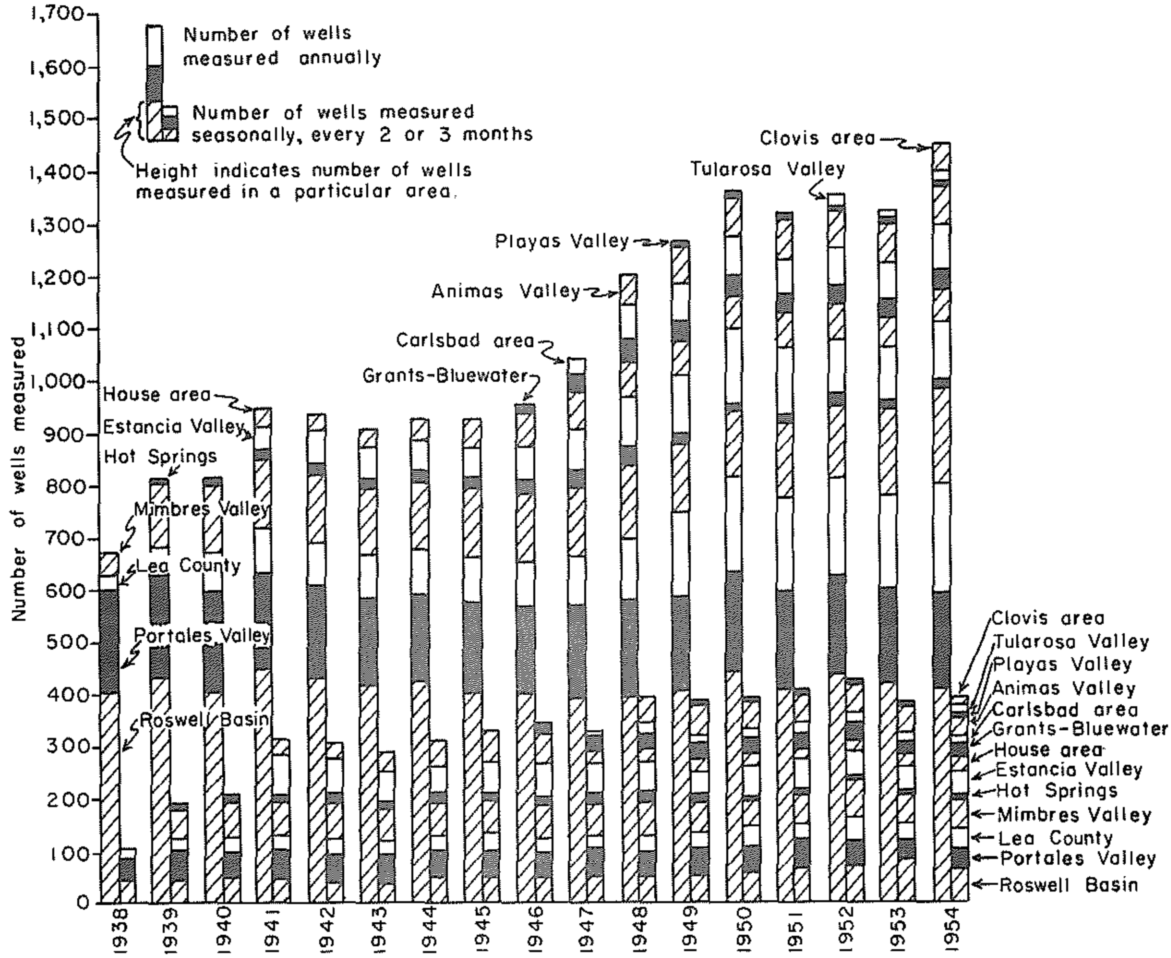

FIGURE 2. -- Number of observation wells in New Mexico in which water levels were measured annually and seasonally by the U. S. Geological Survey in cooperation with the State Engineer of New Mexico.

Scope and Organization of this Report

Seasonal measurements of water levels in observation wells in New Mexico and daily records of water levels in wells equipped with recording gages are published annually in the series of U. S. Geological Survey water-supply papers as mentioned. Since 1950, however, annual measurements of water levels have not been published in this series.

This report tabulates the annual measurements of water level in the observation wells in the various irrigated areas from 1951 to 1955. It summarizes changes in water level by discussion and an atlas of nearly all the maps of change in water level for the period of record to 1955 for each area in which observations are being made. Included also are hydrographs for the period of record through 1954 of several selected wells in the various areas irrigated principally or wholly from ground-water sources.

The areas of observation included in this volume (Part C of Technical Report 13) are as follows:

South-Central Closed Basins and Rio Grande Valley

Estancia Valley, Torrance and Santa Fe Counties
Tularosa-Alamogordo area, Otero County
Hot Springs basin, Sierra County
Grants-Bluewater area, Valencia County

Discussion and data of other areas of observation will be or have been issued as parts of the report, as follows:

Part A. High Plains

House area, Quay County
Clovis area, Curry County
Portales Valley, Roosevelt County
Tatum-Lovington-Hobbs area, Lea County

Part B. Pecos River Valley

Roswell basin, Chaves and Eddy Counties
Carlsbad area, Eddy County

Part D. Southwestern New Mexico

Animas Valley, Hidalgo County
Playas Valley, Hidalgo County
Mimbres Valley, Luna County

The report for each area includes a discussion, an atlas of maps of changes of water level, and records of water levels measured annually. The text and atlas of the maps of changes of water level for each area cover the period of record to January or February 1955. The tabulations of annual water-level measurements for each area cover the period January or February 1951 through January or February 1955 except in the Clovis area and the Tularosa Valley, where the water-level program was started after 1951. The seasonal measurements of water levels and daily records of water levels are not included in this report, but the water-level fluctuations in some wells are illustrated graphically and are discussed under the various area headings.

Water-Level Measurements and Tabulations

The tables of water-level measurements list the water levels in January or February of each year, the net change from year to year, a net long-term change, the highest and lowest annual levels recorded, the year of beginning of record, and the years of missing record, if any. The water levels listed are for January or February for all observation wells for the 5-year period

1951 to 1955. If any measurement other than for January or February is used, a footnote is added identifying the month. If, however, essentially all wells in an area were measured in a month other than January or February, the month is stated in the column heading. The annual change of water level listed is the net annual change since the preceding January or February measurement. The long-term change is the difference in water level for a period of several years, such as from January 1950 to January 1955. The highest and lowest levels in January or February during the period of record are listed for comparison. The lowest recorded level, as published for a well, is a static or nonpumping level, so far as can be determined, except in some wells on which windmills were pumping and the water level was not lowered appreciably by recent pumping. The first January or February measurement is considered the beginning of record except in a few areas, such as Animas Valley, where the wells were first measured after February -- but before large-scale pumping began and before the water levels were lowered appreciably. The years of missing record are years in which a January or February measurement was not made or, prior to 1950, when recent pumping of the well affected the measurement unduly.

The years of record are all in the present century, and the "19" of the year and the apostrophe commonly used to indicate omission of the "19" are omitted for the sake of brevity. The year 1952, for instance, is shown simply as 52.

All measurements, except the mean monthly and mean annual heads in seven artesian wells in the Roswell basin, are given in feet below land-surface datum, which approximates the land surface at the well. The mean artesian heads for the wells in the Roswell basin are given in feet above mean sea level.

Where notations are needed to add meaning to the measurements, such as to indicate pumping effects if determinable, footnotes have been used. The footnotes have been kept as brief and few in number as possible. Lower case letters are placed in the tabulation, where necessary, and their meanings are as follows:

a. Pumping.
b. Pumped recently.
c. Nearby well being pumped.
d. Nearby well pumped recently.
e. Estimated.
f. Dry.
g. Measured by State Engineer Office.
h. Well destroyed, filled, or caved.
i. Measurement discontinued.
j. Possible discrepancy of a few tenths of a foot between present and previous land-surface datum.
k. From recorder chart.
m. Measurement uncertain.
n. Water level above land-surface datum.
p. Well flowing in 1939, 1940, 1941, 1951, 1952, and 1953.
q. Discontinued observation well has been cleaned out and measurements resumed.

r. February.
s. March.
t. April.
u. Also 1942.
v. Also 1951.
w. Also 1953.
x. Also 1955.

All footnotes are not used in each tabulation, but the notations are standard in meaning throughout the tabulations. The tabulations provide a convenient and valuable historical summary of water levels in each area and each well. The latest measurement, for instance, can be compared with previously observed high or low levels and the level when records began. High or low levels may reflect, among other phenomena, additional or less recharge to the ground-water reservoir from increased precipitation or drought, respectively.

Maps of Changes of Water Level

Net changes in water level from year to year are shown graphically on maps for most of the areas of ground-water development. The magnitude and extent of the changes in water levels are shown by contours on maps, where control is adequate. Maps showing the net yearly changes, that is, the net changes between the winter measurements in January or February of one year to those of the next, are included for the period of record to 1955. In addition, several maps are included showing the changes in water level for longer periods of time. Together, the maps constitute an atlas showing the changes in water level as completely as possible. The maps give a three-dimensional picture of the changes in ground-water storage each year. Comparison of the maps of an area from year to year show the changes resulting from variations in pumping and recharge. The changes in water level are discussed in this report under the various area headings.

Personnel and Acknowledgments

Water levels have been measured and the maps showing changes in water levels, presented herein, have been prepared by personnel of the Geological Survey. The maps were redrawn and many of the hydrographs were prepared by personnel of the State Engineer Office under the supervision of J. C. Yates. The annual measurements of water levels as presented herein also were assembled and tabulated by personnel of the State Engineer Office from records of the Geological Survey. The work by personnel of the Geological Survey was done under the general direction of A. N. Sayre, Chief of the Ground Water Branch of the Geological Survey, under the immediate supervision of C. S. Conover, District Engineer, and W. E. Hale, Assistant District Engineer, and under the direct supervision of H. O. Reeder. The work by personnel of the State Engineer Office was under the general direction of John H. Bliss, John R. Erickson, and Stephen E. Reynolds, successively State Engineer of New Mexico, and under the immediate supervision of J. C. Yates, Chief, Water Resources and Development Section.

Acreage Irrigated

The acreage irrigated by ground water in each area is listed by year in the report for each area. In the report areas, acreage irrigated with ground water increased from about 128,000 acres in 1938 to about 420,000 acres in 1954, of which 35,000 acres received water from ground-water sources supplemental to surface water in 1954. However, this does not include all the acreage irrigated by ground water in the State. A total of about 820,000 acres was irrigated in New Mexico in 1954, of which about 275,000 acres was irrigated entirely with surface water, 400,000 acres entirely with ground water, and 145,000 acres with a combination of ground water and surface water. Within the ground-water basins declared by the State Engineer, an estimated 334,000 acres was irrigated entirely with ground water in 1954, and an additional 42,000 acres received ground water supplemental to surface water.

Figure 3, which shows by years the acreage irrigated in the areas of water-level observations, also shows the rapid rate of increase in irrigated acreage since World War II. The increase in acreage reflects to some extent the increase in number of areas of ground-water irrigation.

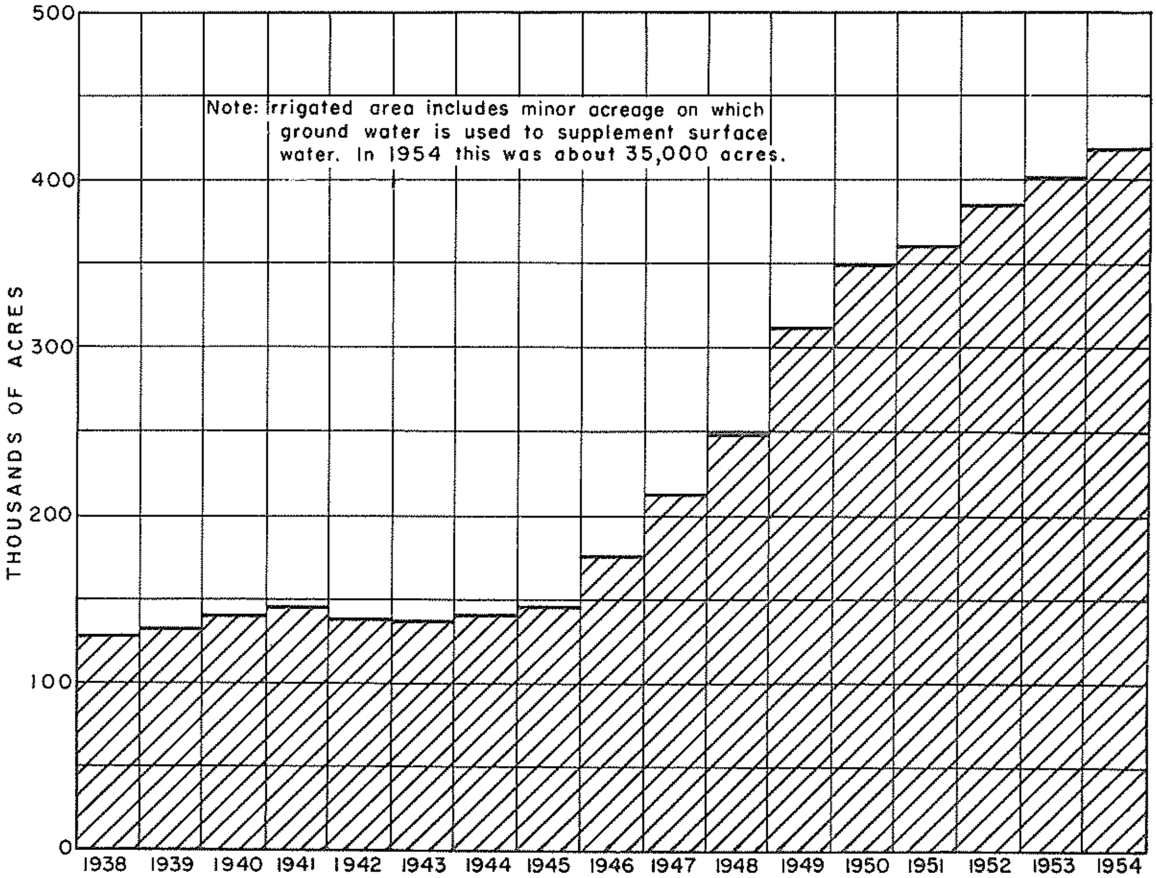

FIGURE 3. -- Acreage irrigated with ground water in New Mexico where water levels were measured, 1938 to 1954.

With the increased development of ground water, it was recognized that some control over development was needed. In 1931 three basins were declared by the State Engineer. Other basins have been declared as the need arose since that time. The basins declared by the State Engineer before 1955 include the following (see fig. 1):

Basin	County
Mimbres Valley Underground Water Basin	Luna
Roswell Artesian Basin	Chaves and Eddy
Lea County Underground Water Basin	Lea
Hot Springs Underground Water Basin	Sierra
Virden Valley Underground Water Basin	Hidalgo
Carlsbad Underground Water Basin	Eddy
Animas Valley Underground Water Basin	Hidalgo
Estancia Underground Water Basin	Torrance and Santa Fe
Portales Underground Water Basin	Roosevelt
Hondo Underground Water Basin	Lincoln
Penasco Underground Water Basin	Otero and Chaves

The Hondo and Penasco basins are not discussed in this report as the water-level program was not extended to include them by the end of 1954.

Other important but undeclared areas at the end of 1954 in which ground water was being used for irrigation include the developments in the following areas:

Area	County
Clovis area	Curry
House area	Quay
Grants-Bluewater area	Valencia
Playas Valley	Hidalgo
Tularosa-Alamogordo area	Otero
Crow Flats area	Otero
Causey-Lingo area	Roosevelt
Sunshine Valley	Taos
Areas in the middle and lower Rio Grande valley	

Several of these undeclared areas are of relatively new development. In 1954, an estimated 65,000 acres in these areas, 40,000 of which was in Curry County, was irrigated entirely with ground water. It is estimated that an additional 105,000 acres, mostly in the lower Rio Grande valley in New Mexico, received supplemental ground water in 1954.

Precipitation and Pumpage

Although precipitation over most of New Mexico is seldom sufficient for most crops, it supplies part of the water requirement, and consequently reduces the amount of water required for irrigation. Precipitation generally has been below average in most years during the period of record of water-level measurements. Most of the precipitation in New Mexico occurs during

July, August, and September accompanying local thunderstorms, which vary in intensity and areal extent. As a result, the amount of water from precipitation that may be available to crops is variable and unpredictable. Such factors necessitate a more certain source of water if farming is to flourish.

As more farm land and wells are developed, the amount of ground water pumped for irrigation increases. No estimates of the total amount of water pumped in New Mexico are available for earlier years; however, an idea of the increased usage of water may be inferred from the increase in a typical area. It is estimated that about 15,100 acre-feet of water was pumped and applied on 9,100 acres in the Mimbres Valley in 1938. It is estimated that about 74,000 acre-feet of water was used on about 32,000 acres of land in 1954. Most of the increased use of water is due to increased acreage irrigated; however, a part of the increased pumping is a result of the drought in later years. For example, the precipitation at Deming, in the Mimbres Valley, was 9.35 inches in 1938, 0.04 inch below average. The precipitation at Deming was 6.62 inches in 1954, 2.77 inches below average. Below-average precipitation has prevailed generally over the State since 1950.

The amount of water pumped is listed by years in the report under each area heading. It is estimated that about 1,025,000 acre-feet of water was used on 420,000 acres of land in 1954 in the report areas. A total of about 1,300,000 acre-feet of ground water was pumped to irrigate 545,000 acres, 145,000 acres of which received supplemental surface water, in the whole State in 1954.

Summary of Changes of Water Levels

The trend in water levels from year to year generally has been downward in most areas in New Mexico, especially in the areas where ground water is pumped for irrigation. As the amount of water pumped for irrigation in most areas exceeds recharge to the ground-water reservoir, and as the natural discharge has not diminished appreciably, a large part of the water is pumped from storage. Consequently, water levels decline in such areas, except in periods of normal or above normal precipitation when recharge is increased and pumping is decreased. One of the main effects of precipitation is to supply part or all the water required for crops, thus reducing the amount of ground water pumped and retarding the decline of water levels. During the rare periods of above normal precipitation, such as 1941, not only is the amount of ground water required for crops reduced but the ground-water reservoir is recharged, causing water levels to rise.

In 1941, heavy precipitation reduced greatly the ground water used for irrigation and provided unusually large recharge to the ground-water reservoir. Water levels rose generally, and by 1942 water levels in some areas were higher than any levels recorded previously. However, in 1942 a new trend of declines began in most areas. Since 1941, precipitation has been near or below average for most years, causing declines in water levels from year to year as more ground water was required for crops. Water levels in a number of wells reached record lows from 1946 to 1948. In succeeding years record-low levels were reached each year in an increasing number of wells. Since 1949, the persistent drought and the increasing number of irrigation wells have caused somewhat larger net annual declines and succeeding record-low water levels in general.

The maximum net declines of water levels from 1950 to 1955 were as much as 15 feet to 20 feet in most of the areas observed, but water levels declined as much as 30 feet in the Roswell basin and as much as 40 feet in the Carlsbad area. From 1940 to 1955, net declines as great as 50 feet occurred in the Roswell basin. From 1932 to 1955, net declines as great as 34 feet occurred in the Portales Valley. However, these are approximate maximum recorded declines, not widespread or average declines. In outlying areas where pumping is minor, net declines were generally small -- amounting to as little as a fraction of a foot from 1950 to 1955. Changes in water level are discussed in more detail under the various area headings.

Well-Numbering System

The system of numbering wells in New Mexico, used in all areas except for the thermal wells in Truth or Consequences (the Hot Springs area), Sierra County, is based on the common subdivisions of public lands into sections. The well number, in addition to designating the well, locates its position to the nearest 10-acre tract in the land network. The number is divided by periods into four segments. The first segment denotes the township north or south of the New Mexico base line; the second denotes the range east or west of the New Mexico principal meridian; and the third denotes the section. In a county such as Roosevelt County, where wells are situated both north and south of the base line, an N is added to the first segment of the well number if the well is north of the base line, but no letter is added if the well is south of the base line. Similarly, in a county where wells are located both east and west of the meridian, an E is added to the second segment of the well number of those wells east of the meridian. In counties lying entirely within one quadrant of the principal meridian and base line, the direction north or south of the base line or east or west of the meridian is not given. The fourth 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 fourth 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 12.36.24.342 in Lea County is located in the NE¼SE¼SW¼ 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 sections, the fourth segment of the well number is omitted. When it

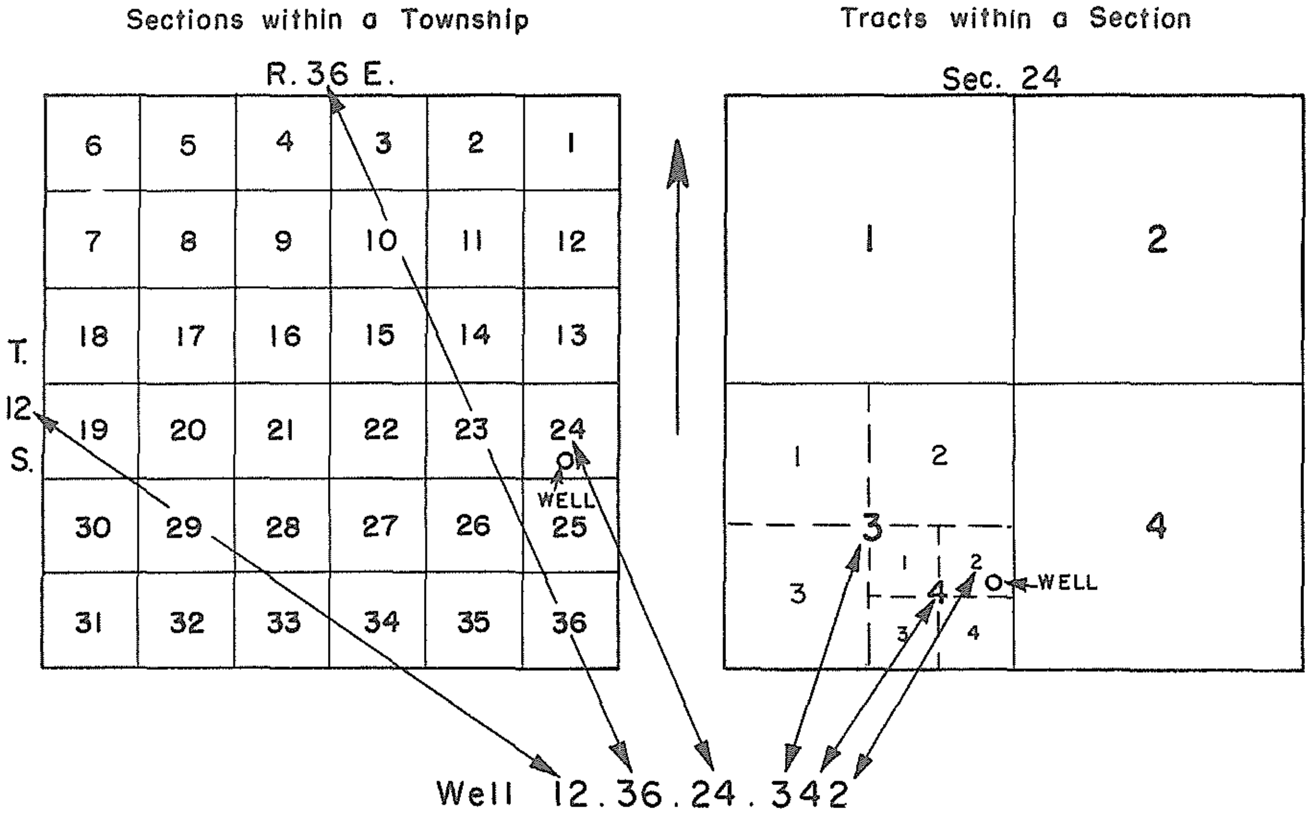

FIGURE 4. -- System of numbering wells in New Mexico.

becomes possible to locate more accurately a well in whose number zeros have been used, the proper digit or digits are substituted for the zeros. In U. S. Geological Survey Water-Supply Paper 911 and earlier reports, the digits corresponding to unknown 10-acre and 40-acre tracts were simply omitted, but this practice caused some confusion in cataloging the wells. In Water-Supply Paper 941 and subsequent reports, wells whose numbers end in one or two zeros correspond to wells whose numbers in earlier reports are the same except for the omission of the last one or two zeros. Letters a, b, c, etc., are added to the last segment to designate the second, third, fourth, and succeeding wells in the same 10-acre tract.

In some land subdivisions where a section is larger or smaller than a square mile, part of the section may be subdivided into lots of as much as 40 acres. For a well located in a lot, the fourth segment of the well number consists simply of an "L" followed by the number of the lot.

Figure 4 shows the method of numbering the tracts.

ESTANCIA VALLEY, TORRANCE AND SANTA FE COUNTIES

By

E. H. Herrick

Location and Description of Area

Estancia Valley is a closed drainage and ground-water basin extending from southern Santa Fe County into south-central Torrance County. The valley proper is about 50 miles long and ranges in width from about 12 miles near Moriarty to about 30 miles near Willard. The total area of the valley floor is about 900 square miles, of which about two-thirds is in Torrance County.

The floor of the basin is relatively flat. East of State Highway 41 are numerous playa lakes and associated dunes. Some well-defined arroyos extend from the higher surrounding lands to the playa lakes, but there are no perennial streams in the basin. A few small springs are in the eastern part of the basin.

Estancia Valley is underlain by valley fill of late Tertiary and Quaternary age, which overlies Pennsylvanian and Permian sandstone, limestone, silt, and gypsum. The thickness of the valley fill ranges from 0 at the margins of the basin to at least 400 feet about 2 miles southeast of Stanley.

The valley fill, consisting mainly of unconsolidated gravel, sand, and clay, is the principal aquifer in Estancia Valley, but the underlying bedrock yields large quantities of water to wells in some parts of the basin. The arkosic limestone member of the Madera limestone of Pennsylvanian age is the principal aquifer along the western margin of the basin north of Manzano. The Glorieta sandstone of Permian age is fractured and apparently yields water to several irrigation wells in the northeastern part of the basin. The Yeso formation of Permian age is the principal aquifer in the eastern part of the basin near Cerrito del Lobo and in the southwestern part of the basin in the vicinity of Mountainair.

The ground-water body of Estancia Valley is recharged by precipitation within the valley proper and on the slopes of the surrounding higher lands. The average rate of recharge in the area is estimated to be about one-half inch annually. Ground water in the basin moves generally toward the playa lakes, where it is discharged and lost by evaporation. Available data indicate that ground water does not move out of the basin.

Because of the rapid development of ground water for irrigation, the Estancia Underground Water Basin was declared by order of the State Engineer on January 31, 1950 (fig. 1). The declared basin, 1,482 square miles in area, includes part of southern Santa Fe County and extends almost to the south edge of Torrance County. The basin has not been closed to further appropriation of ground water.

Scope of the Water-Level Program

Ground water in Estancia Valley was studied by the New Mexico State Engineer from 1923 to 1930, but from 1930 to 1940 interest in irrigation in the area waned primarily because of the economic conditions at that time. Water levels have been measured in observation wells in the area since 1941. Water levels were measured in 50 wells in 1941. Observation wells have been added as irrigated acreage increased; in February 1955 water levels were measured in 115 wells. In addition, water levels were measured every 3 months during the year in about half of these wells. A recording gage has been maintained on well 7.8.27.221 about 3 miles northwest of Estancia since December 1945. Recording gages have been maintained for shorter periods of time on other wells in the area.

Development of Ground Water

Irrigation in Estancia Valley was attempted unsuccessfully many times early in the 20th century. About 160 acres was irrigated in 1941, but the acreage increased little until after World War II. About 725 acres was irrigated in 1946 and 5,000 acres was irrigated in 1947. About 10,000 acres was irrigated with about 8,000 acre-feet of water in 1949. In 1950, the irrigated area almost doubled, reaching about 19,000 acres. Irrigated acreage continued to increase until 1954 when about 23,000 acres was irrigated. Table 14 shows the estimated irrigated acreage and pumpage by years. Annual measurements of water level from 1951 through 1955 are given in table 15.

Changes in Water Level

The Estancia area was irrigated extensively for the first time in 1947, and in that year water levels declined for the first time since measurements were begun in 1941. The largest net annual declines of water level from 1947 through 1949 occurred in the area of initial development and greatest pumpage, about 7 miles southwest of Estancia. The development of irrigation spread to the area about 7 miles northwest of Estancia in 1950 and thence northward in subsequent years. The largest net annual declines since 1950, about 3 to 8 feet, occurred in the area from about 3 to 5 miles northwest to about 10 miles north of Estancia. Net annual declines since 1950, ranging from about 1 to 5 feet, occurred in the area about 7 miles southwest of Estancia. Table 14 shows the number of square miles in which the water level declined more than 1, 2, 3, and 4 feet, respectively, by year, from 1947 to 1954. The accompanying maps, figures 117 through 124, show the locations of areas and magnitudes of net declines of water level in the Estancia Valley. The maps also show the location and magnitude of the maximum net decline recorded for the particular period.

Withdrawal of large quantities of water from the ground-water reservoir causes seasonal fluctuations of the water level. As the pumping season begins in early spring, the water level in the vicinity of pumping wells begins to decline and continues to decline until the pumping season ends in late summer or fall. As pumps are stopped, the water level in the vicinity of the pumped wells begins to rise and continues to rise gradually until the next pumping season begins. However, water levels in heavily pumped areas, such as those southwest and north of Estancia, rarely return to the levels of the previous year, indicating that water is removed from storage. Seasonal fluctuations that result from pumping water for irrigation are demonstrated graphically by hydrographs of water levels in wells 6.8.3.221 and 7.8.27.221, shown in figure 116. The primary effect of precipitation on the seasonal fluctuations of water level is to regulate the pumpage of ground water required for crops. In periods of normal or above normal precipitation, pumpage is less than during periods of below normal precipitation; consequently, the declines of water levels are smaller.

Summary and Conclusions

The amount of ground water pumped for irrigation depends to a large extent upon the amount and distribution of precipitation during the growing season. The deficient precipitation in Estancia Valley during most of the period of record and the development of additional land for irrigation have resulted in net declines in ground-water levels from year to year since 1947. As pumpage for irrigation in the area is largely from storage, it is anticipated that water levels will continue to decline. Declines should become progressively less in ensuing years if development does not increase significantly and if precipitation returns to normal.

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Year of observation	Year of publication	Water-Supply Paper	Pages
1941	1943	941	275-282
1942	1944	949	340-344
1943	1945	991	299-305
1944	1947	1021	294-302
1945	1949	1028	295-301
1946	1949	1076	305-311
1947	1951	1101	297-306
1948	1951	1131	270-280
1949	1952	1161	278-289
1950	1953	1170	265-274
1951	1954	1196	210-217
1952	1955	1226	226-232
1953	1956	1270	243-249
1954	1957	1326	252-258

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TABLES AND HYDROGRAPHS

TABLES

HYDROGRAPHS

TABLE 14. -- Precipitation, irrigated acreage, pumpage, number of measurements of water level, and areas of water-level decline, 1941 to 1954, in the Estancia Valley, Torrance and Santa Fe Counties, N. Mex.

Year	Estancia		Estimated acres irrigated	Estimated irrigation pumpage (ac-ft)	Annual measurements	Area in square miles in which water level declined more than			
	Precip. (in.)	Depart. (in.)				1 ft	2 ft	3 ft	4 ft
1941	23.63	+11.04	160	500	50	Rises	-	-	-
1942	13.50	+ .91	100	75	64	0	0	0	0
1943	10.56	- 2.03	150	150	60	-	0	0	0
1944	11.37	- 1.22	200	150	58	0	0	0	0
1945	6.93	- 5.66	250	500	58	-	0	0	0
1946	12.24	- .35	725	1,000	63	-	0	0	0
1947	e7.0	- 5.6	5,000	5,000	78	17	0	0	0
1948	7.14	- 5.45	6,000	5,400	100	72	4	0	0
1949	13.27	+ .68	10,000	8,000	113	80	0	0	0
1950	13.94	+ 1.35	19,000	19,000	139	100	15	2.4	0
1951	5.98	- 6.61	20,000	40,000	130	200	66	23	6
1952	9.86	- 2.73	21,000	30,000	116	104	25	11	-
1953	11.01	- 1.58	21,000	36,500	102	222	57	26	3
1954	9.61	- 2.98	23,000	33,000	115	180	77	37	17

e Estimated.

TABLE 15. -- Annual water levels in Estancia Valley, Torrance and Santa Fe Counties, in February 1951 through February 1955, highest and lowest recorded annual levels, in feet below land-surface datum; and annual changes, and change from February 1950 to February 1955, in feet.

Location Number	Name	Source	1951 February Level	1951 February Day	Change 1950-51	1952 February Level	1952 February Day	Change 1951-52	1953 February Level	1953 February Day	Change 1952-53	1954 February Level	1954 February Day	Change 1953-54	1955 February Level	1955 February Day	Change 1954-55	Change 1950-55	Highest Level	Highest Year	Lowest Level	Lowest Year	Record Began	Record Years Missing
4. 8.11.233	R. B. Slease		81.31	15	-	81.81	7	- .50	81.66	9	+ .15	81.93	16	- .27	82.50	3	- .57	-	81.31	51	82.50	55	51	
11.433	do.		82.94	15	+ .29	83.43	7	- .49	83.33	19	+ .10	83.49	16	- .16	84.14	3	- .65	- .91	82.94	51	84.14	55	50	
12.330	do.		(i)															-	-	-	-	-	50	
12.333	do.		70.85	15	+ .39	71.35	7	- .50	71.17	9	+ .18	71.43	16	- .26	72.62	3	- 1.19	- 1.38	70.85	51	72.62	55	50	
13.133	do.		79.37	15	+ 1.21	79.97	7	- .60	79.80	9	+ .17	79.80	16	.00	80.59	3	- .79	- .01	79.37	51	80.59	55	50	
13.233	do.		70.82	15	+ .32	71.50	7	- .68	71.23	9	+ .27	71.36	16	- .13	72.03	3	- .67	- .89	70.82	51	72.03	55	50	
13.333	do.		79.67	15	+ .11	80.28	7	- .61	80.13	19	+ .15	80.14	16	- .01	80.95	3	- .81	- 1.17	79.67	51	80.95	55	50	
13.412	do.		(i)															-	-	-	-	-	50	
14.140	do.		(h,i)															-	-	-	-	-	50	
14.233	do.		91.96	15	-	92.47	7	- .51	92.42	19	+ .05	92.45	16	- .03	93.19	3	- .74	-	91.96	51	93.19	55	51	
14.433	do.		93.89	15	+ .01	94.39	7	- .50	94.35	19	+ .04	94.32	16	+ .03	95.06	3	- .74	- 1.16	93.89	51	95.06	55	50	
24.133	do.		84.79	15	+ .01	85.38	7	- .59	85.28	19	+ .10	85.22	16	+ .06	86.00	3	- .78	- 1.20	84.79	51	86.00	55	50	
24.222	M. E. Ottoson		55.87	15	+ .21	56.64	7	- .77	56.34	19	+ .30	56.44	16	- .10	57.17	3	- .73	- 1.09	55.87	48	57.23	41	41	49
4. 9. 5.344	Morris Ottoson		-	-	-	31.34	28	-	31.23	11	+ .11	31.53	16	- .30	32.02	3	- .49	- 1.94	30.08	50	32.02	55	47	51
10.133	Homer Arnn		a32.30	15	-15.11	17.46	8	-	am18.69	9	- 1.23	17.49	16	-	17.87	3	- .38	- .68	17.15	47	18.22	41	41	49
5. 7.11.411	O. H. Brown		89.54	12	- 1.10	-	-	-	-	-	-	-	-	-	96.15	3	-	- 7.71	86.81	48	96.15	55	48	52-54
15.212	Ewing School		118.20	12	- .63	119.45	19	- 1.25	120.55	18	- 1.10	122.38	17	- 1.83	(i)			-	115.33	46	122.38	54	41	
5. 8. 4.343	Carter Bowden		37.90	12	- 2.03	41.57	19	- 3.67	41.78	25	- .21	43.21	18	- 1.43	47.60	4	- 4.39	-11.73	30.24	42	47.60	55	42	48
5.311	Glenn Gustin		68.63	12	- 2.20	72.62	19	- 3.99	73.13	25	- .51	74.82	18	- 1.69	79.57	4	- 4.75	-13.14	64.98	49	79.57	55	49	
5.344	O. R. Ethridge		58.38	12	- 2.22	62.49	19	- 4.11	62.65	25	- .16	64.16	18	- 1.51	69.12	4	- 4.96	-12.96	51.14	47	69.12	55	47	
6.431	W. M. Hibner		88.68	12	- 2.10	92.68	19	- 4.00	f86.00	-	-	95.35	18	-	-	-	-	-	85.10	49	95.35	54	49	55
7.431	John Ingle		77.34	12	- 1.97	81.51	22	- 4.17	77.30	25	+ 4.21	83.73	17	- 6.43	87.56	3	- 3.83	-12.19	70.21	47	87.56	55	47	
8.331	Madison Davis		61.68	12	- 2.12	65.99	20	- 4.31	66.59	18	- .60	68.46	17	- 1.87	72.92	3	- 4.46	-13.36	54.24	47	72.92	55	47	
8.424	Arlington Austin		68.10	14	- 2.47	72.27	20	- 4.17	72.39	25	- .12	73.94	18	- 1.55	79.13	4	- 5.19	-13.50	62.03	48	79.13	55	48	
9.423	Carter Bowden		59.40	14	- 2.32	63.76	20	- 4.36	-	-	-	65.60	17	-	69.08	4	- 3.48	-12.00	52.52	47	69.08	55	47	49,53
10.331	Frank Craven		24.12	14	- 2.03	a42.17	20	-	-	-	-	31.18	17	-	33.76	4	- 2.58	-11.67	18.25	47	33.76	55	47	53
10.331a	do.		24.98	14	- 2.05	b33.87	20	-	29.37	16	-	32.16	17	- 2.79	34.64	4	- 2.48	-11.71	19.79	48	34.64	55	48	
10.333	do.		24.03	14	- 2.12	28.70	20	- 4.67	28.33	16	+ .37	30.74	17	- 2.41	33.59	4	- 2.85	-11.68	17.32	47	33.59	55	47	
11.221a	J. V. Chamberlin		11.90	14	.	11.86	7	+ .04	12.42	16	- .56	11.49	17	+ .07	11.38	4	+ .11	-	9.78	45	12.42	53	45	50
11.221b	do.		(h,i)															-	-	-	-	-	50	
12.111	do.		(h,i)															-	12.04	43	20.91	50	41	
15.113	D. S. Bailey		24.63	14	- 2.30	28.51	20	- 3.88	28.40	18	+ .11	31.09	17	- 2.69	34.13	4	- 3.04	-11.80	17.91	47	34.13	55	47	
15.131	Joe Begley		20.71	14	- 2.26	24.76	20	- 4.05	24.79	18	- .03	26.90	17	- 2.11	30.09	4	- 3.19	-11.64	14.45	47	30.09	55	46	
15.131a	do.		23.05	14	- 2.31	-	-	-	26.64	18	-	28.77	17	- 2.13	31.89	4	- 3.12	-11.15	16.29	47	31.89	55	47	52
15.311	Charles Rattan		25.51	14	- 2.34	28.82	20	- 3.31	32.76	18	- 3.94	34.78	17	- 2.02	37.79	5	- 3.01	-14.62	19.44	47	37.79	55	47	
15.313	do.		26.72	14	- 2.14	29.86	20	- 3.14	30.05	18	- .19	31.88	17	- 1.83	34.84	4	- 2.96	-10.26	20.33	47	34.84	55	46	
16.111	Adolph Autry		60.33	14	- 2.47	64.58	20	- 4.25	65.01	16	- .43	66.36	18	- 1.35	71.00	3	- 4.64	-13.14	54.17	48	71.00	55	48	
16.211	Ben Mullen		52.14	14	- 2.53	56.19	20	- 4.05	56.54	16	- .35	58.75	18	- 2.21	62.05	3	- 3.30	-12.44	45.96	48	62.05	55	48	
16.421	Joe Begley		32.74	14	- 2.50	36.42	20	- 3.68	36.60	18	- .18	38.45	17	- 1.85	41.81	4	- 3.36	-11.57	28.78	49	41.81	55	49	
17.113	Madison Davis		52.33	12	- 1.87	56.15	22	- 3.82	56.76	25	- .61	57.98	18	- 1.22	62.47	4	- 4.49	-12.01	45.01	46	62.47	55	46	
17.212	Virgel Garland		b58.16	14	- 2.45	62.31	20	- 4.15	62.54	18	- .23	64.00	18	- 1.46	69.15	3	- 5.15	-13.44	51.99	48	69.15	55	48	
17.311a	Ray Brown		34.87	14	- 1.76	b41.07	19	-	40.00	25	+ 1.07	41.19	17	- 1.19	b45.03	4	- 3.84	-11.92	29.50	48	b45.03	55	48	
17.323	do.		34.42	14	- 1.91	38.82	19	- 4.40	39.59	25	- .77	40.00	17	- .41	b44.51	4	- 3.51	-12.00	26.05	42	b44.51	55	41	
18.233	S. W. Hodgson		45.35	12	- 1.55	49.18	22	- 3.83	49.98	27	- .80	48.25	17	+ 1.73	54.86	4	- 6.61	-11.06	38.69	47	54.86	55	47	
18.312	Willard Hodgson		44.67	12	- 1.49	48.20	22	- 3.53	49.24	27	- 1.04	50.63	17	- .39	53.73	3	- 3.13	-10.55	38.57	47	53.73	55	47	
18.421	F. H. Ayres		33.47	12	- 1.07	37.61	22	- 4.14	39.23	25	- 1.62	40.55	17	- 1.32	44.19	4	- 3.64	-11.79	26.89	47	44.19	55	47	
21.111	R. B. Ford		34.13	14	- 2.18	38.49	7	- 4.36	39.17	25	- .68	40.26	17	- 1.09	43.56	4	- 3.30	-11.61	27.23	47	43.56	55	46	
24.311	E. B. Wallace		22.68	14	+ .30	22.92	7	- .24	23.26	11	- .34	23.63	17	- .37	23.99	3	- .36	- 1.01	21.93	46	23.99	55	46	
25.212	Homer Arnn		25.20	15	+ .79	f125.80	7	-										-	22.45	42	25.99	50	42	
28.122			j19.49	14	- 1.01	21.37	29	- 1.88	a19.90	25	+ 1.47	a19.15	17	+ .75	24.54	3	- 5.39	- 6.06	18.48	50	24.54	55	50	
30.121a			30.07	14	- .22	-	-	-	-	-	-	(f)	-	-	f35.27	3	-	-	29.85	50	30.07	51	50	52-54
36.341	Mrs. Iva Moe		45.18	15	+ .22	45.70	7	- .52	a48.58	25	- 2.88	a64.13	16	-15.55	46.36	3	-	- .96	45.11	47	46.69	41	41	
5. 9.29.111			-	-	-	-	-	-	-	-	-	(i)						-	-	-	-	-	50	51-53
31.331	Homer Arnn		32.32	15	+ .52	32.78	7	- .46	32.82	25	- .04	33.51	16	- .69	33.63	3	- .12	- .79	32.32	51	34.10	41	41	
5.10.27.444			40.82	15	- .38	41.28	22	- .46	41.87	26	- .59	41.88	16	- .01	42.14	3	- .26	- 1.70	40.32	49	42.14	55	41	
6. 7.11.222			132.45	12	- .40	133.34	19	- .89	133.87	27	- .53	135.25	18	- 1.38	137.76	3	- 2.51	- 5.71	h132.05	50	137.76	55	50	
25.133	C. E. Clark		69.54	12	- .27	-	-	-	-	-	-	78.99	18	-	80.15	4	- 1.16	-10.88	69.27	50	80.15	55	48	52,53
6. 8. 1.111	Pat Homan		24.05	13	- 2.10	24.28	18	- .23	24.77	19	- .49	25.23	25	- .46	25.63	7	- .40	- 3.68	21.95	50	25.63	55	49	
1.244	J. H. Wiggins		20.16	14	-	20.00	18	+ .16	-	-	-	20.51	25	-	20.79	2	- .28	-	20.00	52	21.62	45	42	49,53
2.111	Ellison Timmins		19.19	13	- .52	21.35	18	- 2.16	22.65	19	- 1.30	33.97	25	-11.32	39.40	7	- 5.43	-20.73	16.06	48	39.40	55	48	
3.221	do.		31.19	13	- 1.72	32.33	18	- 1.14	29.83	19	+ 2.50	37.92	25	- 8.09	43.52	7	- 5.60	-14.05	26.18	42	43.52	55	41	
9.112	I. P. Johnson		j97.90	13	- 2.58	j99.97	19	- 2.07	f86.10	-	-	105.01	18	-	106.60	4	- 1.59	-11.28	93.62	49	106.60	55	49	

See footnotes at end of table.

TABLE 15.-- continued

Location Number	Name	Source	WATER LEVELS 1951 February Level	Day	Change 1950-51	1952 February Level	Day	Change 1951-52	1953 February Level	Day	Change 1952-53	1954 February Level	Day	Change 1953-54	1955 February Level	Day	Change 1954-55	Change 1950-55	Highest Level	Year	Lowest Level	Year	Record Began	Years Missing
6. 8.15.444	Estancia Cemetery		30.85	12	+ .31	31.90	19	- 1.05	32.96	25	- 1.06	33.87	18	- .91	35.29	4	- 1.42	- 4.13	29.99	43	35.29	55	41	
16.222	H. L. Lovelace		60.11	12	- .21	j61.43	19	- 1.32	62.84	16	- 1.41	64.26	18	- 1.42	66.10	4	- 1.84	- 6.20	58.66	44	66.10	55	41	
24.111	Aurileo Brito		8.46	14	+ 2.19	a14.30	22	- 5.84	11.35	11	-	a14.50	17	- 3.15	a12.58	4	+ 1.92	-	6.22	42	a14.50	54	41	49
27.134	R. M. Spruill		22.32	12	- .44	23.75	19	- 1.43	24.55	25	- .80	26.10	18	- 1.55	27.96	4	- 1.86	- 6.08	19.59	43	27.96	55	42	45
30.434	J. W. Langley		a45.70	12	- 2.03	a45.74	19	- .04	a44.88	25	-	47.47	18	- 2.59	m59.60	4	-12.13	-	25.63	42	47.47	54	41	48
32.212	O. R. Ethridge		27.16	12	- 1.09	29.45	19	- 2.29	30.24	25	- .79	-	-	-	34.62	4	-	- 8.55	23.22	47	34.62	55	47	54
6. 9.11.211	H. E. Means		7.15	14	- 1.35	7.62	18	- .47	7.45	19	+ .17	7.65	16	- .20	7.78	2	- .13	- 1.98	5.80	50	7.78	55	50	
33.333			17.16	14	+ .01	16.80	20	+ .36	-	-	-	-	-	-	16.69	4	-	+ .48	16.69	55	17.17	50	50	53,54
6.10. 5.312	Berkshire Brothers		jm10.50	14	+ .85	10.25	18	+ .25	f10.90	-	-	10.53	16	-	f11.00	2	-	-	10.25	52	j11.35	50	49	
5.312a	do.		12.98	14	- 1.44	13.77	18	- .79	13.32	26	+ .45	13.46	16	- .14	13.62	2	- .16	- 2.08	11.54	50	13.77	52	50	
7.112			7.81	14	- 1.56	(a)	-	-	a8.25	19	-	a8.46	16	- .21	a8.40	2	+ .06	-	5.74	49	a8.46	54	49	52
8.112	J. M. Milburn and Son		10.60	14	- 1.56	11.38	18	- .78	10.99	19	+ .39	11.07	16	- .08	11.19	2	- .12	- 2.15	9.04	50	11.38	52	50	
25.344	C. A. Blackwell		42.43	14	- .49	42.79	22	- .36	-	-	-	b43.43	16	-	43.41	3	+ .02	- 1.47	41.74	49	b43.43	54	42	53
27.444	Major Dean		21.78	14	- 1.08	a23.55	22	- 1.77	a24.17	26	- .62	a24.81	16	- .64	a23.26	3	+ 1.55	-	20.20	48	a24.81	54	41	
7. 7.12.444	C. B. Roland		44.47	13	+ .25	46.23	18	- 1.76	46.78	26	- .55	47.78	25	- 1.00	48.21	7	- .43	- 3.49	41.37	47	48.21	55	41	
7. 8. 1.231	Myrtle Homan Estate		26.41	16	+ 1.06	29.03	20	- 2.62	-	-	-	31.74	26	-	32.93	2	- 1.19	- 5.46	25.10	47	32.93	55	42	53
1.423	Floyd Stump		24.91	13	+ 1.70	-	-	-	27.96	26	-	30.36	26	- 2.40	29.84	2	+ .52	- 3.23	23.93	47	30.36	54	41	52
3.300	Neal Jenson		9.73	13	- 2.99	13.36	22	- 3.63	14.41	27	- 1.05	c20.87	26	- 6.46	(Incorrect designation used previously for well 7.8.3.423, which see.)									
3.300a	do.		14.86	13	- 2.94	-	-	-	-	-	-	c26.08	26	-	(Incorrect designation used previously for well 7.8.3.423a, which see.)									
3.423	do.														26.34	7	- 5.46	-19.60	3.27	48	26.34	55	48	
3.423a	do.														31.55	7	- 5.47	-19.63	9.95	49	31.55	55	49	52,53
7.121	C. T. Norman		-	-	-	f50.00	18	-	-	-	-	(i)						-	75.40	48	77.27	49	48	51,53
8.311	do.		-	-	-	117.73	15	-	116.90	26	+ .87	118.26	25	- 1.36	120.49	7	- 2.23	- 8.05	111.00	49	120.49	55	49	51
9.431	Knox and Barron		63.91	13	- 9.51	j69.19	15	- 5.28	-	-	-	82.20	25	-	90.27	7	- 8.07	-35.87	46.37	49	90.27	55	49	53
10.221	Neal Jenson		(i)															-	15.66	48	17.86	50	42	
10.244	Ted Maxfield		20.95	13	- 2.12	-	-	-	-	-	-	32.67	25	-	35.57	7	- 2.90	-16.74	17.13	47	35.57	55	42	48,52,53
11.132	Neal Jenson		10.78	13	- 1.40	13.45	29	- 2.67	14.33	26	- .88	-	-	-	-	-	-	-	7.48	48	14.33	53	48	54,55
12.433	Arthur Schmidt		21.06	15	+ 1.82	-	-	-	(h,i)									-	21.06	51	23.53	41	41	52
12.433a	do.		21.09	15	+ 1.74	22.50	15	- 1.41	23.80	11	- 1.30	27.07	26	- 3.27	27.70	2	- .63	- 4.87	21.09	51	27.70	55	48	
13.212	H. J. Austin														27.72	2	-	-	-	-	-	-	55	
16.142	J. J. Thomas		56.49	13	-10.55	62.68	15	- 6.19	-	-	-	76.67	25	-	84.88	7	- 8.21	-38.94	10.92	48	84.88	55	47	53
16.422	Jim Ergood		-	-	-	(h,i)												-	43.88	46	45.73	50	41	45,51
19.422	Bruce Grimes		129.03	13	+ 2.59	(h,i)												-	129.03	51	131.62	50	49	
20.240	C. A. Burns		89.49	13	- .85	90.57	18	- 1.08	-	-	-	-	-	-	(i)			-	86.70	48	90.57	52	48	53,54
20.334	Marion Gates		113.96	13	- 1.32	115.56	18	- 1.60	117.29	20	- 1.73	119.17	25	- 1.88	120.63	7	- 1.46	- 7.99	110.20	48	120.63	55	48	
23.311	O. L. Austin		20.06	13	- .21	21.47	29	- 1.41	22.05	20	- .58	-	-	-	28.04	7	-	- 8.19	17.80	47	28.04	55	41	54
23.324	do.		2.51	13	- .27	(f,i)												-	1.74	48	2.51	51	41	
24.431	R. T. Floyd		22.43	15	+ .65	22.69	18	- .26	23.77	11	- 1.08	25.09	25	- 1.32	25.65	2	- .56	- 2.57	22.34	48	25.65	55	48	
24.433	do.		24.15	15	+ .50	24.10	18	+ .05	25.17	26	- 1.07	26.31	25	- 1.14	26.80	2	- .49	- 2.15	23.68	42	26.80	55	41	
26.141	Mr. Richter		9.55	13	+ 1.20	12.47	29	- 2.92	-	-	-	-	-	-	-	-	-	-	4.10	47	12.47	52	46	53-55
27.221	F. C. Pace		21.37	13	- .11	22.89	28	- 1.52	24.42	9	- 1.53	25.91	14	- 1.49	28.48	1	- 2.57	- 7.22	k19.21	47	28.48	55	41	
33.424	E. C. Hayes Estate		-	-	-	-	-	-	-	-	-	(i)						-	52.44	48	53.93	50	41	51-53
34.222	Lilburn Homan		21.64	13	+ .63	25.36	18	- 3.72	27.72	19	- 2.36	38.93	25	-11.21	(i)			-	18.68	48	38.93	54	48	49
7. 9. 5.211			19.20	13	- .15	19.35	15	- .15	19.07	24	+ .28	19.18	26	- .11	19.70	2	- .52	- .65	18.80	48	19.70	55	42	
10.333	Mr. Price		15.03	13	- .26	15.68	20	- .65	16.21	27	- .53	16.74	26	- .53	17.35	2	- .61	- 2.58	14.77	50	17.35	55	42	43,44
17.221			16.23	13	-	16.40	20	- .17	16.98	27	- .58	18.22	26	- 1.24	18.86	2	- .64	-	16.23	51	18.86	55	51	
30.412	W. L. Davidson		11.53	14	+ .12	12.28	20	- .75	-	-	-	14.21	25	-	15.16	2	- .95	- 3.51	11.34	48	15.16	55	48	53
8. 8. 1.434	Bennie Moore		(i)															-	29.12	48	31.21	50	48	
10.111	W. H. Woodman		112.85	13	- 2.12	j116.16	12	- 3.31	-	-	-	-	-	-	-	-	-	-	108.05	48	j116.16	52	48	53-55
12.212	Lawrence Groff		32.94	15	- 1.60	35.62	12	- 2.68	38.56	16	- 2.94	41.33	27	- 2.77	43.67	2	- 2.34	-12.33	30.21	49	43.67	55	49	
13.311	B. M. Maxwell		26.55	13	- 1.25	29.57	12	- 3.02	31.46	24	- 1.89	38.41	27	- 6.95	40.32	5	- 1.91	-15.02	21.87	48	40.32	55	48	
15.343	Ed. W. Davis		-	-	-	99.80	12	-	101.98	24	- 2.18	104.52	27	- 2.54	107.25	5	- 2.73	-10.25	97.00	50	107.25	55	50	51
24.131	Buck and Cunningham		15.08	13	- .58	18.49	12	- 3.41	22.74	24	- 4.25	25.68	26	- 2.94	29.10	5	- 3.42	-14.60	10.55	48	29.10	55	48	
26.222			10.62	13	- 1.77	12.94	20	- 2.32	a16.19	24	- 3.25	a27.57	26	-	20.97	5	-	-12.12	6.64	47	20.97	55	42	48
28.311	Cecil Thomas					134.53	13	-	137.56	24	- 3.03	141.34	26	- 3.78	143.41	5	- 2.07	-	134.53	52	143.41	55	52	
29.144	do.		122.77	16	- 1.54	-	-	-	-	-	-	-	-	-	127.71	5	-	- 6.48	121.23	50	127.71	55	50	52-54
34.111	Mr. Sowel		-	-	-	(i)												-	-	-	-	-	50	51
35.322	A. C. Hibner		58.00	13	- 3.07	61.93	13	- 3.93	65.38	24	- 3.45	69.26	26	- 3.88	74.22	5	- 4.96	-19.29	51.08	48	74.22	55	48	
8. 9.29.111	Mr. Mills		21.68	13	+ 1.46	b22.80	14	- 1.12	a24.13	24	- 1.33	23.47	26	+ .56	-	-	-	-	20.89	42	23.47	54	42	55
29.111a	do.		21.12	13	+ 3.92	-	-	-	m21.45	24	-	22.57	26	- 1.12	22.98	2	- .41	+ 2.06	20.93	46	25.04	50	44	52
34.444			15.70	13	-	-	-	-	a19.20	24	-	18.32	26	+ .88	-	-	-	-	15.70	51	18.32	54	51	52,55

See footnotes at end of table.

TABLE 15. -- continued

Location Number	Name	Source	WATER LEVELS 1951 February Level	1951 Day	Change 1950-51	1952 February Level	1952 Day	Change 1951-52	1953 February Level	1953 Day	Change 1952-53	1954 February Level	1954 Day	Change 1953-54	1955 February Level	1955 Day	Change 1954-55	Change 1950-55	Highest Level	Highest Year	Lowest Level	Lowest Year	Record Began	Record Years Missing
9. 8. 2.112	Valley Irrigation Company		61.58	16	- 1.27	62.83	14	- 1.25	-	-	-	-	-	-	-	-	-	-	b59.12	49	62.83	52	49	53-55
11.233	Mr. Lujan		-	-	-	59.42	14	-	60.19	28	- .77	62.26	27	- 2.07	-	-	-	-	57.26	49	62.26	54	49	51,55
16.444			36.57	21	+ .55	c38.24	14	- 1.67	38.69	24	- .45	c36.44	27	+ 2.25	38.90	5	- 2.46	- 1.78	c36.44	54	38.90	55	50	
24.330	Valley Irrigation Company		41.85	15	+ .57	43.35	12	- 1.50	44.46	24	- 1.11	45.96	27	- 1.50	b49.15	2	- 3.19	- 6.73	40.10	49	b49.15	55	48	
26.433	Everett Shockey		-	-	-	-	-	-	-	-	-	(i)						-	45.10	49	46.01	50	49	51-53
28.244			80.04	21	- 1.17	81.87	12	- 1.83	82.02	24	- .15	85.88	27	- 3.86	87.68	5	- 1.80	- 8.81	78.87	50	87.68	55	50	
9. 9.11.341	Captain Bill Ehert								38.01	28	-	39.40	27	- 1.39	40.62	5	- 1.22	-	38.01	53	40.62	55	53	
16.233						22.70	20	-	22.99	28	- .29	23.85	27	- .86	a24.60	5	- .75	-	22.70	52	a24.60	55	52	
32.131	G. L. Dean		6.39	15	+ .28	f5.20	12	-	(i)									-	5.64	47	6.88	41	41	44
32.131a	do.		6.61	15	+ .06	7.43	12	- .82	8.35	24	- .92	9.67	27	- 1.32	10.35	2	- .68	- 3.68	5.70	47	10.35	55	44	
10. 7.23.212	G. F. Mosley		(a)	-	-	140.30	14	-	c142.40	28	- 2.10	m140.25	28	-	146.20	6	-	-	137.18	49	146.20	55	49	51
23.234	Ray Bassett		144.93	21	- 1.31	146.14	14	- 1.21	-	-	-	149.84	28	-	152.13	6	- 2.29	- 8.51	143.00	49	152.13	55	49	53
10. 8. 3.333			(i)															-	-	-	-	-	50	
11.331	Ruben Cavasas		121.69	21	- .76	122.38	14	- .69	123.01	28	- .63	123.69	28	- .68	124.20	6	- .51	- 3.27	120.93	50	124.20	55	50	
13.133	Mr. Irby		88.14	21	- 1.39	89.50	14	- 1.36	90.63	28	- 1.13	92.05	28	- 1.42	93.45	6	- 1.40	- 6.70	86.75	50	93.45	55	50	
17.424	Kenneth Martin		136.48	21	- .73	137.12	14	- .64	a137.80	28	- .68	138.35	28	- .55	138.68	6	- .33	- 2.93	135.49	49	138.68	55	49	
20.444	Alice M. Martin		(i)															-	-	-	-	-	50	
25.311	Floyd Irvin		75.36	16	- 1.30	76.61	14	- 1.25	77.92	20	- 1.31	80.08	27	- 2.16	80.71	5	- .63	- 6.65	72.85	49	80.71	55	49	
34.413	Lloyd Smith		77.34	16	-	78.47	14	- 1.13	79.89	20	- 1.42	81.70	27	- 1.81	-	-	-	-	72.92	49	81.70	54	49	50,55
35.211	Valley Irrigation Company		50.02	16	- 1.26	51.27	14	- 1.25	52.58	20	- 1.31	54.62	27	- 2.04	55.39	5	- .77	- 6.63	47.50	49	55.39	55	49	
35.312	do.		67.14	16	- 1.25	68.38	14	- 1.24	68.67	20	- .29	71.67	27	- 3.00	72.47	5	- .80	- 6.58	65.89	50	72.47	55	50	
35.331	do.		66.38	16	- 1.26	67.61	14	- 1.23	68.93	20	- 1.32	70.92	27	- 1.99	71.70	5	- .78	- 6.58	c64.04	49	71.70	55	49	
35.411	do.		64.49	16	- 1.21	-	-	-	-	-	-	(i)						-	c62.00	49	64.49	51	49	52,53
36.111	do.		38.73	16	- 1.22	39.98	14	- 1.25	41.31	20	- 1.33	42.16	27	- .85	44.07	5	- 1.91	- 6.56	34.91	48	44.07	55	48	
10. 9. 5.111	Bill King		c75.77	21	- 2.22	75.88	13	- .11	76.30	28	- .42	78.20	28	- 1.90	80.47	6	- 2.27	- 6.92	72.89	49	80.47	55	49	
18.131	W. E. Dollahow		72.29	21	- 1.33	-	-	-	-	-	-	76.22	28	-	78.63	6	- 2.41	- 7.67	69.45	49	78.63	54	49	52,53
21.431	Everett Shockey		27.48	16	- .48	27.95	13	- .47	-	-	-	-	-	-	(i)			-	24.63	47	27.95	52	47	53,54
29.130	Mr. Terry		57.96	16	- 1.33	59.22	13	- 1.26	60.37	28	- 1.15	61.80	28	- 1.43	62.98	6	- 1.18	- 6.35	55.13	49	62.98	55	49	

a. Pumping. b. Pumped recently. c. Nearby well being pumped. f. Dry. h. Well destroyed, filled, or caved. i. Measurement discontinued. j. Possible discrepancy of a few tenths of a foot between present and previous land-surface datum. k. From recorder chart. m. Measurement uncertain.

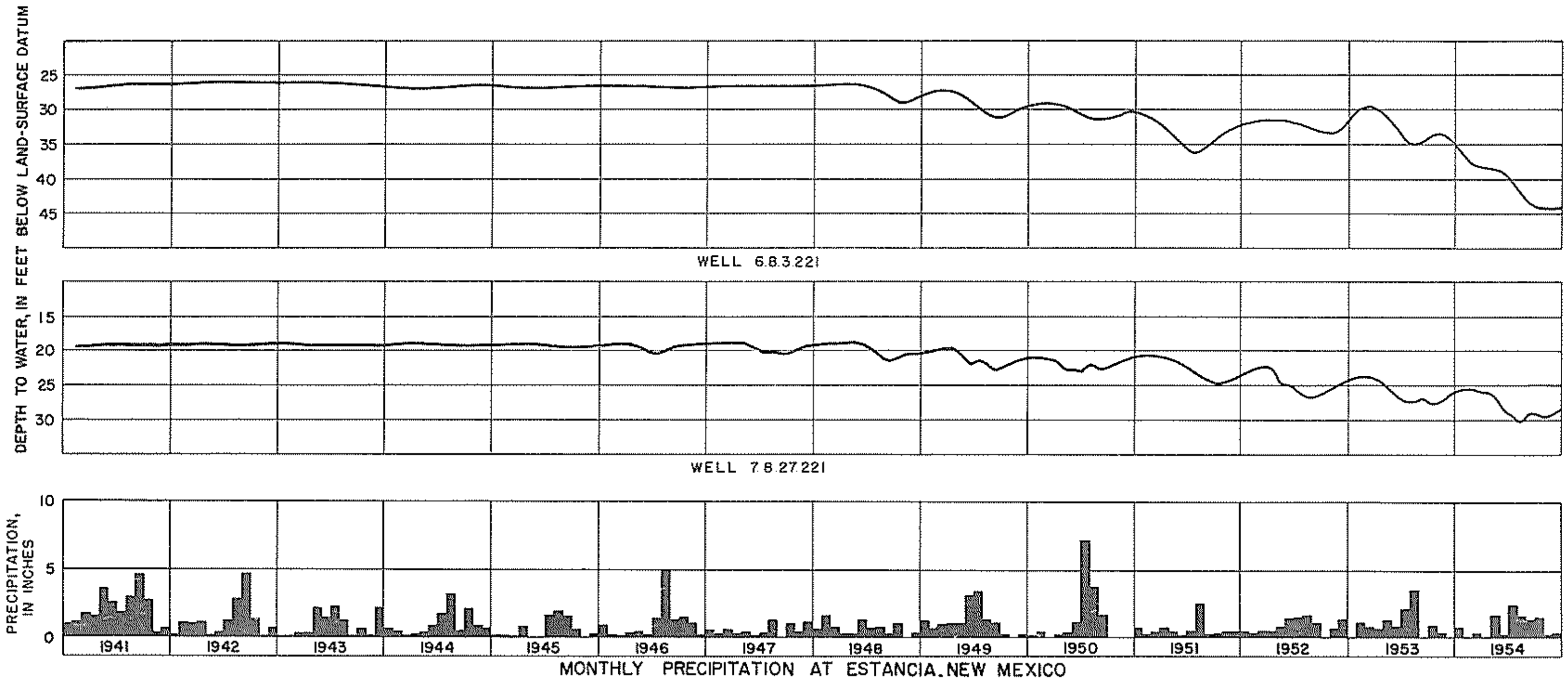

FIGURE 116. -- Graphs showing fluctuations of water levels in two wells, and precipitation in Torrance County, N. Mex.

ATLAS OF MAPS OF CHANGES OF WATER LEVEL

LIST OF MAPS

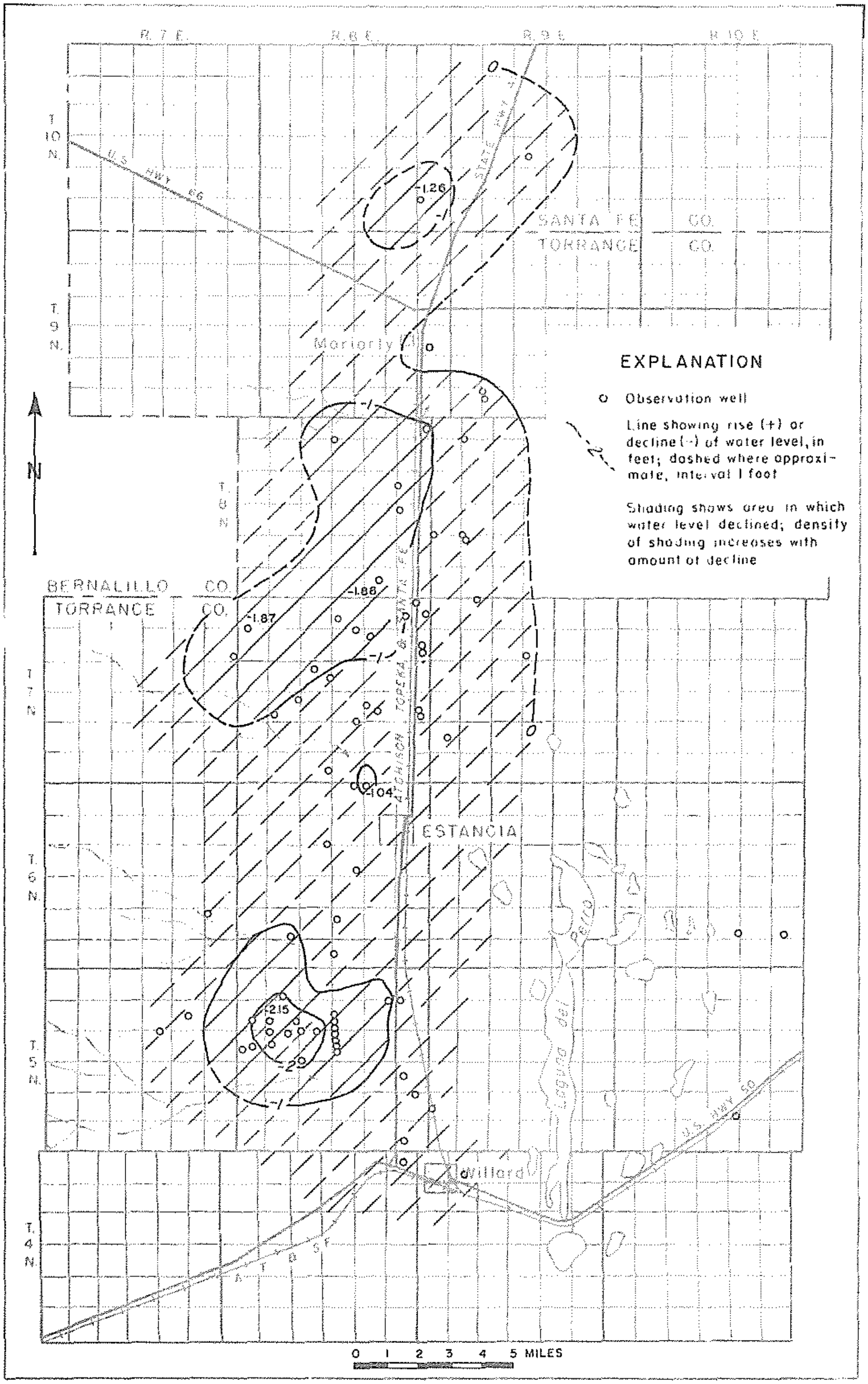

FIGURE 117. -- Change of ground-water level in Estancia Valley, Torrance and Santa Fe Counties, N. Mex., from March 1948 to February 1949.

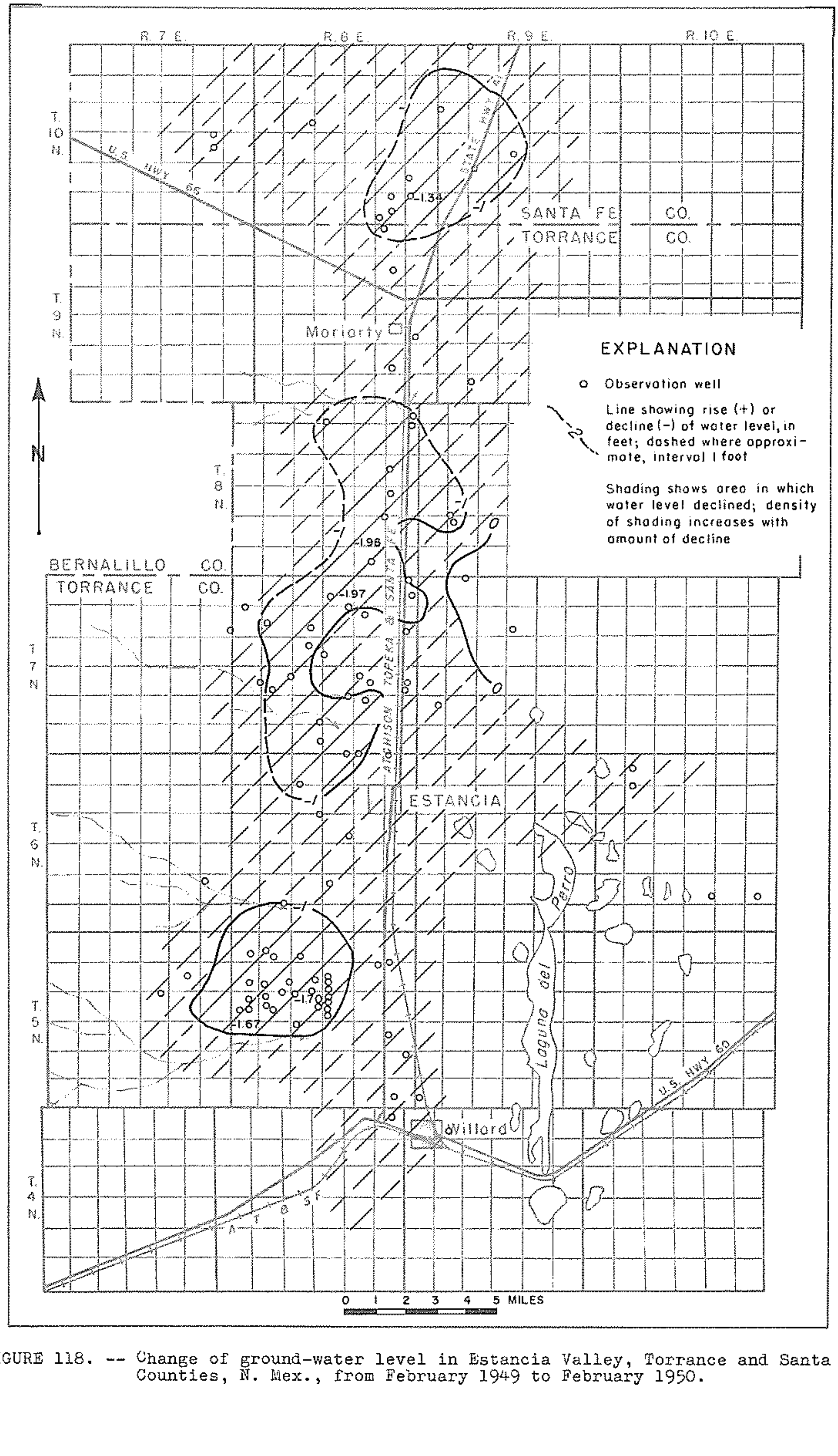

FIGURE 118. -- Change of ground-water level in Estancia Valley, Torrance and Santa Fe Counties, N. Mex., from February 1949 to February 1950.

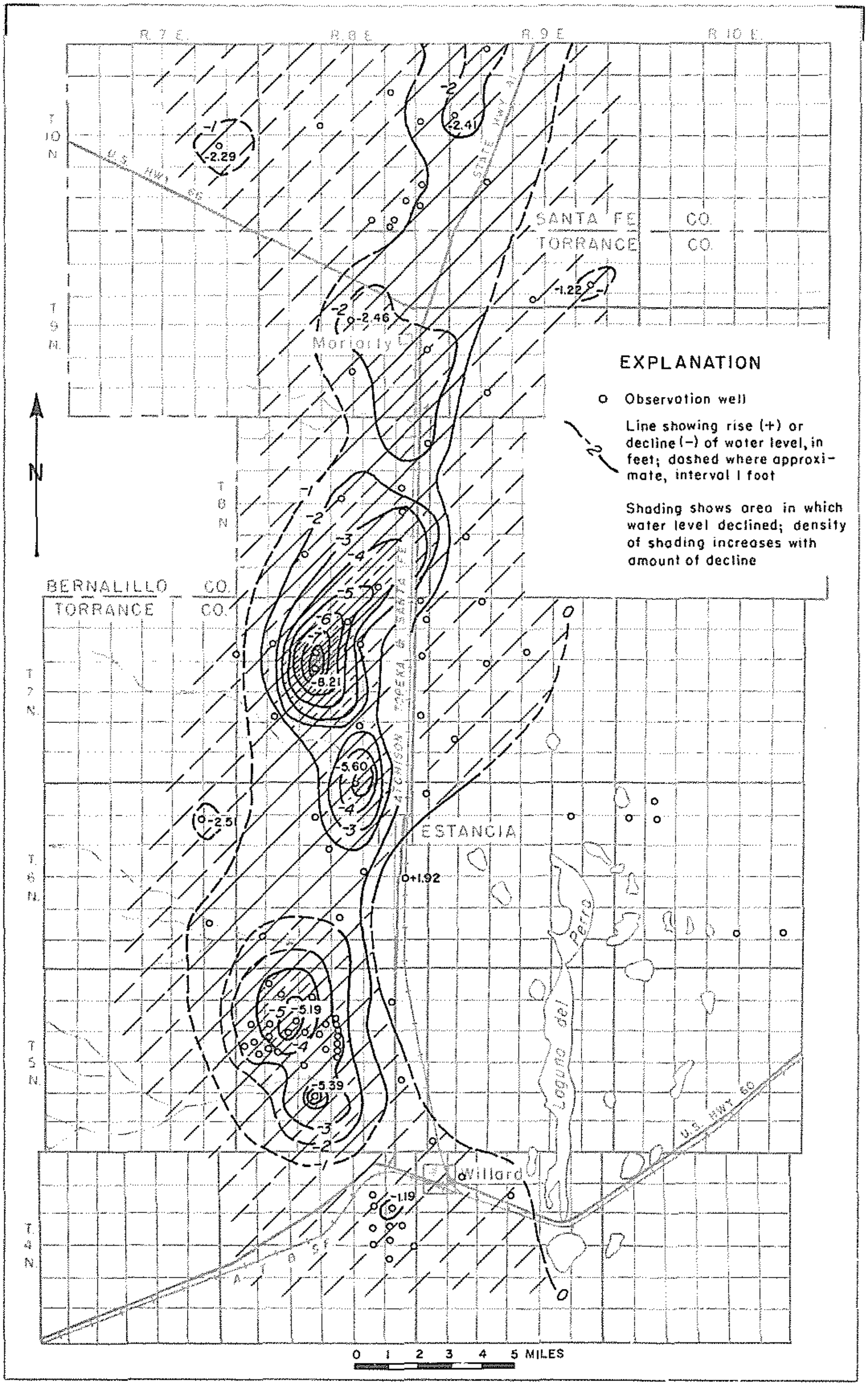

FIGURE 123. -- Change of ground-water level in Estancia Valley, Torrance and Santa Fe Counties, N. Mex., from February 1954 to February 1955.

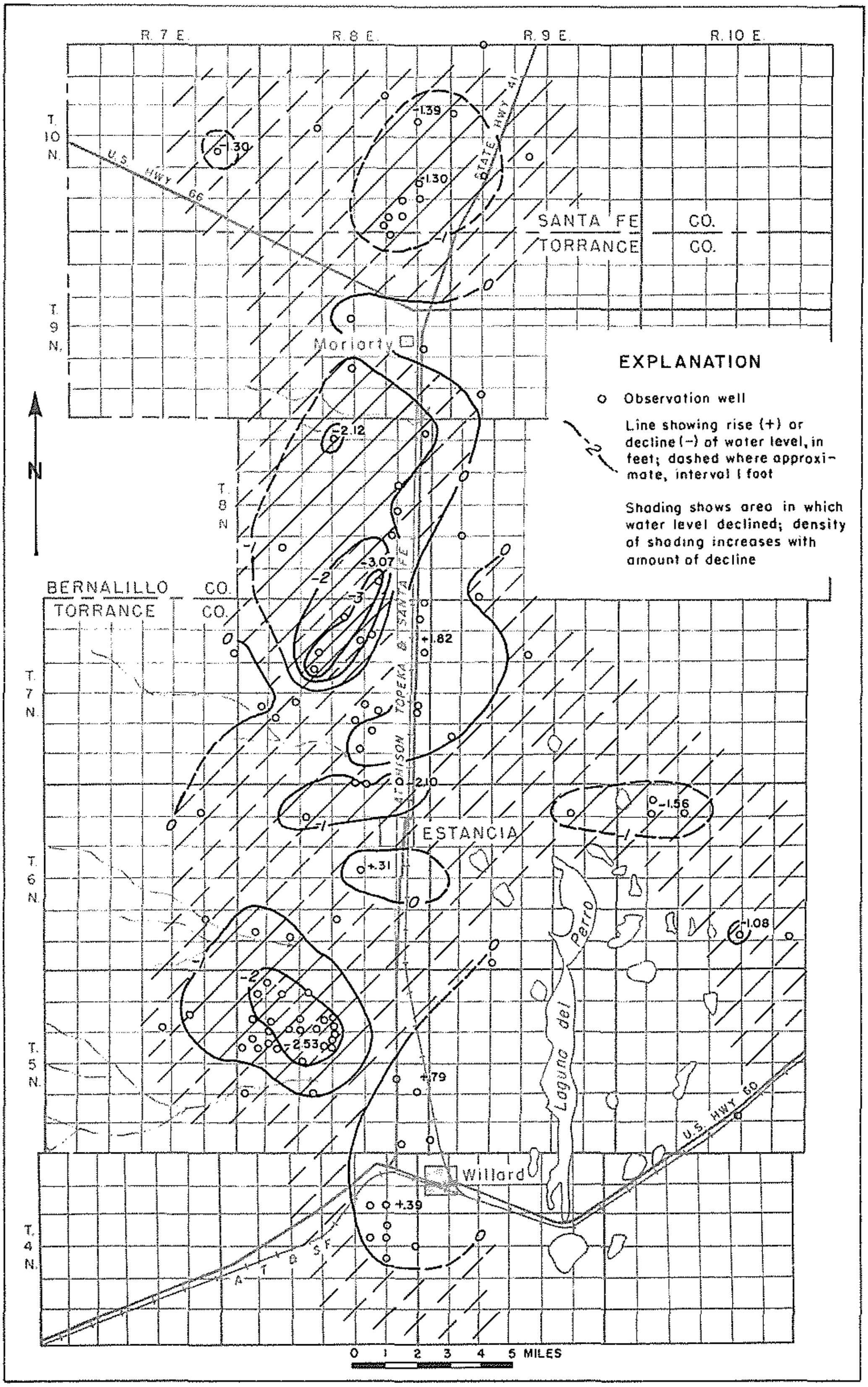

FIGURE 119. -- Change of ground-water level in Estancia Valley, Torrance and Santa Fe Counties, N. Mex., from February 1950 to February 1951.

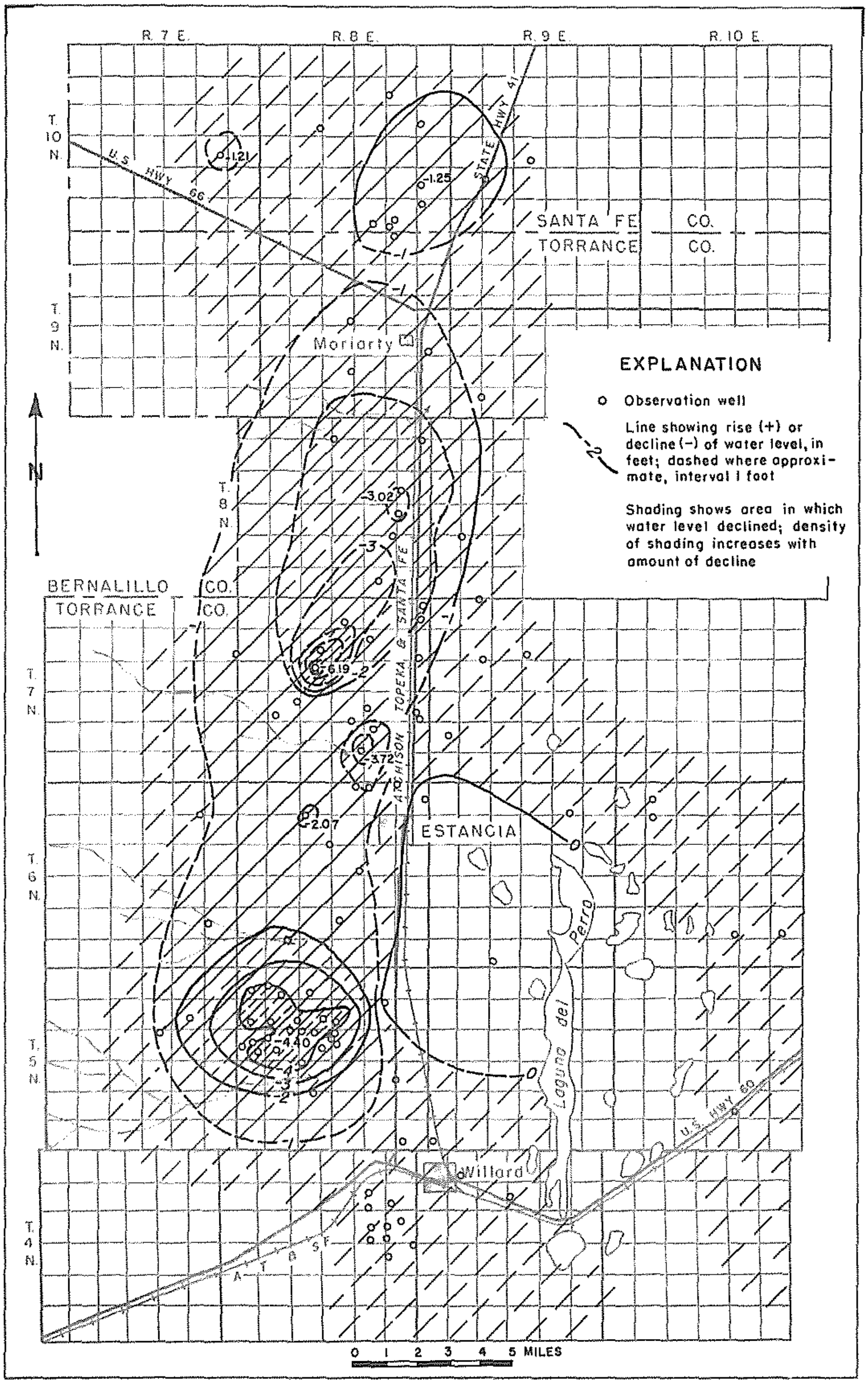

FIGURE 120. -- Change of ground-water level in Estancia Valley, Torrance and Santa Fe Counties, N. Mex., from February 1951 to February 1952.

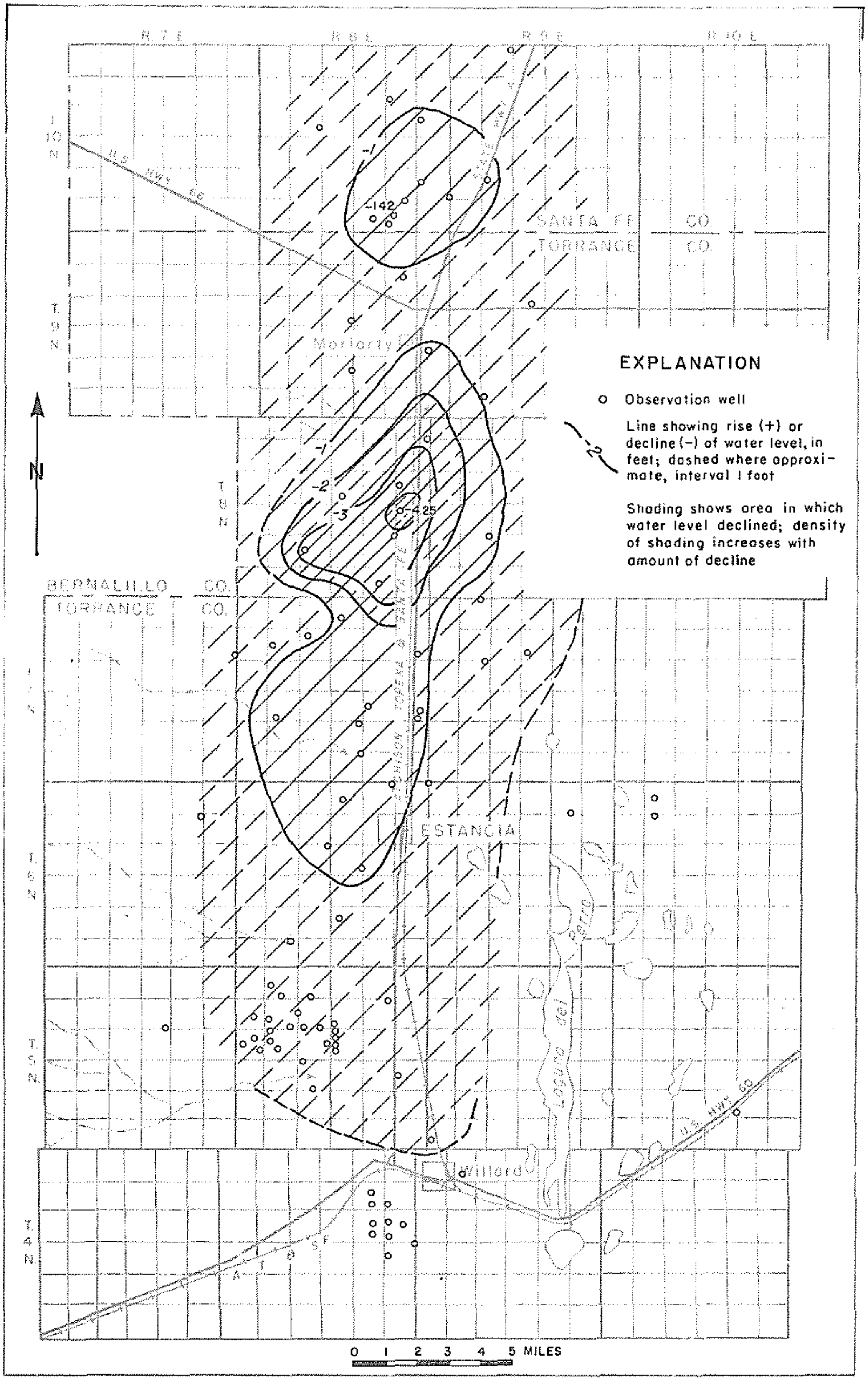

FIGURE 121. -- Change of ground-water level in Estancia Valley, Torrance and Santa Fe Counties, N. Mex., from February 1952 to February 1953.

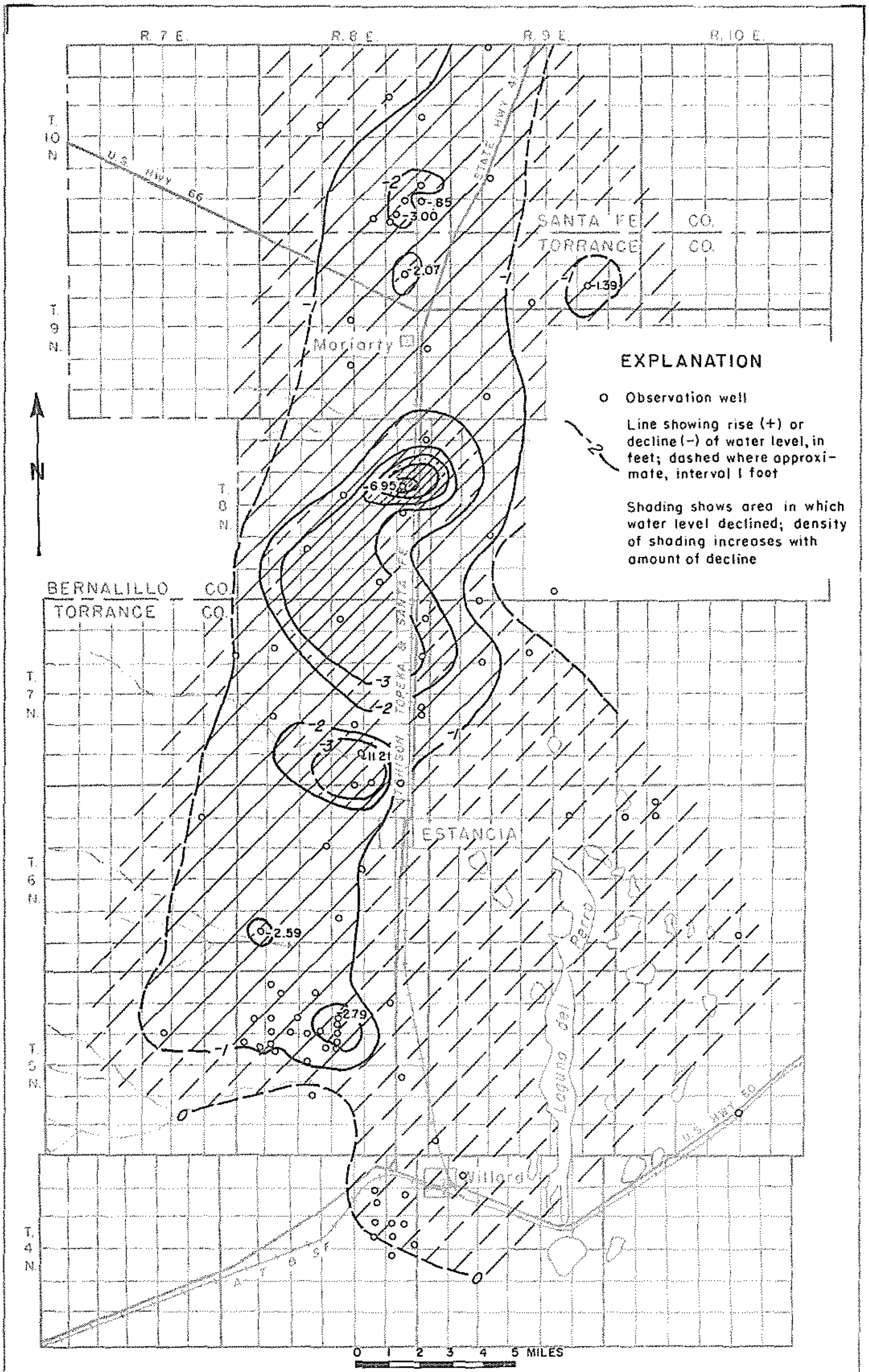

FIGURE 122. -- Change of ground-water level in Estancia Valley, Torrance and Santa Fe Counties., N. Mex., from February 1953 to February 1954.

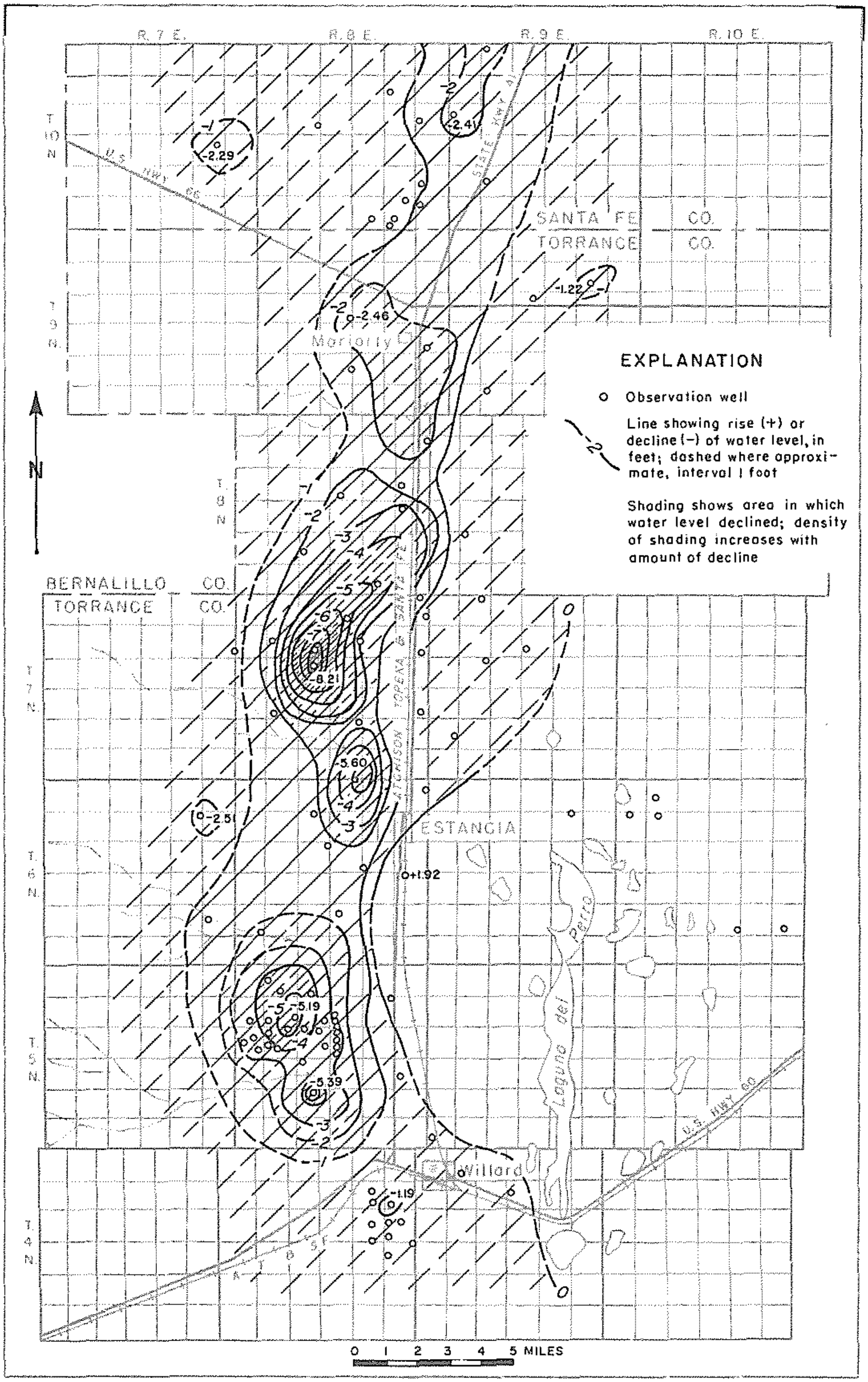

FIGURE 123. -- Change of ground-water level in Estancia Valley, Torrance and Santa Fe Counties, N. Mex., from February 1954 to February 1955.

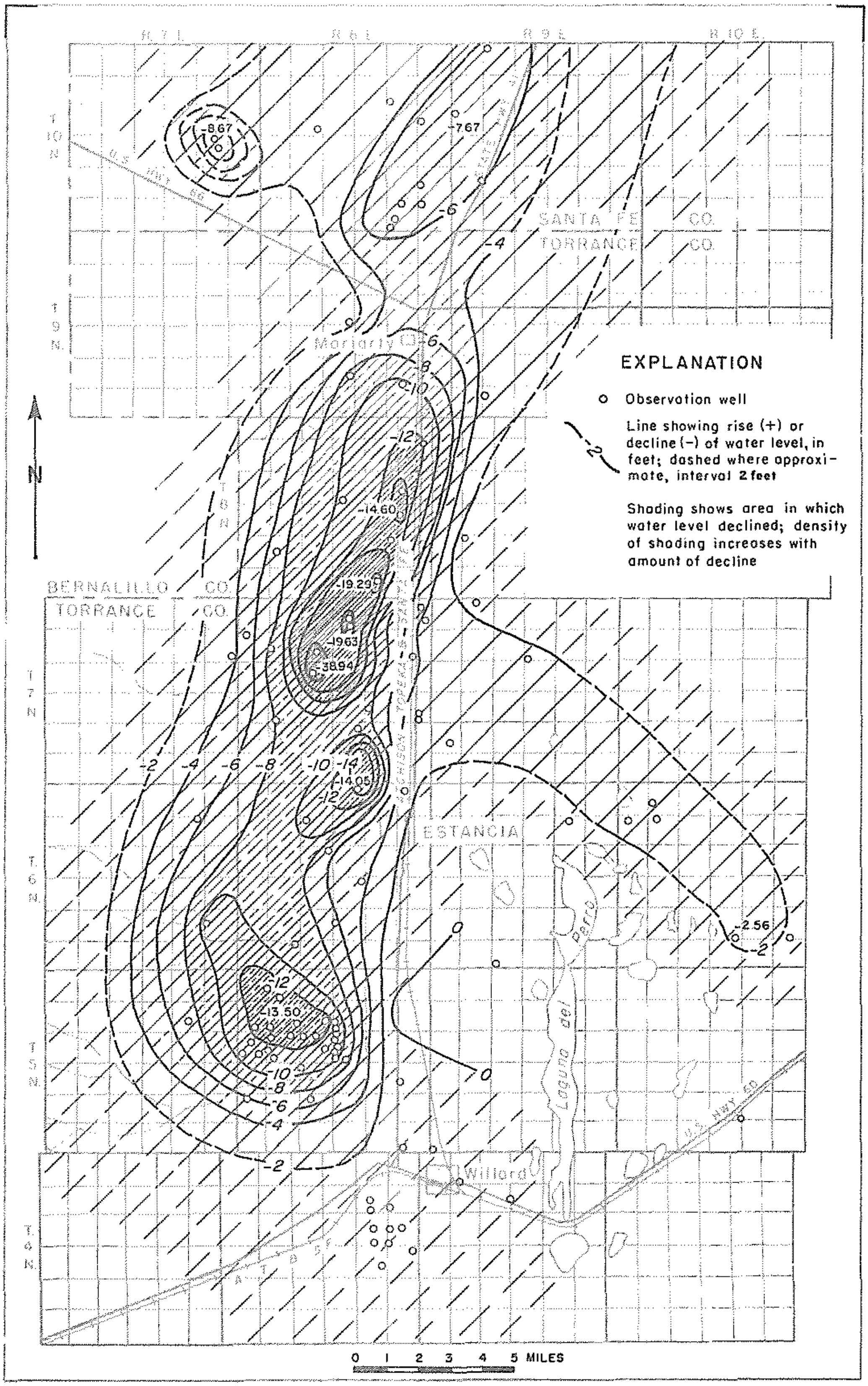

FIGURE 124. -- Change of ground-water level in Estancia Valley, Torrance and Santa Fe Counties, N. Mex., from February 1950 to February 1955.

TULAROSA-ALAMOGORDO AREA, OTERO COUNTY

By

J. W. Hood

Location and Description of Area

One of the principal irrigated areas in Otero County is in the vicinity of Tularosa and Alamogordo, in northwest-central Otero County, extending southward from T. 14 S., Rs. 9 and 10 E., into T. 17 S., R. 10 E. Most farms are in the vicinity of Tularosa; however, some are scattered throughout the area.

The Tularosa-Alamogordo area is on the east side of the Tularosa Basin, at the west base of the Sacramento Mountains. The land surface in the farming area consists of the lower slope of alluvial fans that slope downward from the mountains toward the plain to the west. Altitudes in the area range from about 4,200 to about 4,600 feet.

The area in the vicinity of Alamogordo and Tularosa may be divided into two geologic and topographic subdivisions. The farming area is included in one, the Tularosa Basin, a bolson valley filled with lensing deposits of clay, sand, and gravel. The mountains east of the Tularosa Basin, which are underlain by consolidated rocks, compose the other subdivision. Runoff from precipitation in the mountains recharges the bolson fill and maintains the flow of springs in the Rio Tularosa. Springflow is used to irrigate a part of the Tularosa area.

Irrigation wells tap beds of water-saturated sand and gravel. Although the bolson fill is more than 1,000 feet thick in several places, only the first few hundred feet are sufficiently permeable to yield adequate amounts of water to wells. The principal area of recharge to the bolson fill apparently is a strip of coarse-grained fill adjoining the base of the mountains, particularly at the mouths of canyons. The amount of recharge is small, however, and water is pumped almost entirely from storage. Ground water is semiconfined in the bolson fill. Although wells may exhibit artesian characteristics when pumped, the bolson fill more nearly resembles a water-table aquifer over long periods of time, owing to the discontinuity of its beds of clay. Water recharging the aquifer moves west-southwestward toward distant discharge areas along the west side and the southern end of the basin.

The Tularosa-Alamogordo area has not been declared an underground-water basin by the State Engineer.

Scope of Water-Level Program

Although ground water in the Tularosa Basin has been investigated several times, water levels were not measured systematically until 1952, when it became apparent that the irrigated area was expanding and withdrawals of ground water were becoming significantly large. Water levels were measured in 21 wells in April 1952. Seventeen of these wells were measured again in March 1953 and at this time one other well was added to the network of observation wells. Water levels were measured in 19 of the 22 wells in the network in February 1954, and another new observation well was added. Nine of the observation wells were measured bimonthly in 1954. The observation-well program in the Tularosa-Alamogordo area was expanded in February and March 1955, when eight new wells were added to the network. Recording gages have been operated for a few months in observation wells in the southern part of the area.

Development of Ground Water

Some land in the Tularosa-Alamogordo area has been irrigated for many years with surface water from the Rio Tularosa, and a small amount of land has been irrigated with ground water at times for nearly 50 years. Large-scale pumping of ground water for irrigation, however, did not begin until the end of World War II. Much of the early ground water used undoubtedly was pumped to supplement supplies of surface water, but exact records for that period are not available. According to the U. S. Soil Conservation Service, about 25 wells were drilled by 1950. About 60 wells had been drilled by February 1952, and about 90 wells had been drilled by February 1955.

The acreage irrigated with ground water in the Tularosa-Alamogordo area cannot be estimated accurately because several wells are used to supplement supplies of surface water and the amount of supplemental ground water pumped varies inversely with the amount of surface water available. An estimate of acreage irrigated from wells from 1952 through 1954 is shown in table 16. Although data given are not exact, they should be in the right order of magnitude. Amounts of ground water shown as being pumped during the same period, also in table 16, are based on the acreage estimated for various crops and the amount of water required per acre for those crops. The average amount of water pumped is about 2.5 acre-feet per acre, which compares closely with the amount of water used in other irrigated areas of New Mexico.

Changes in Water Level

In general, water levels in the Tularosa-Alamogordo area tend to decline, largely as a result of pumping. In a natural hydrologic system, discharge from the ground-water reservoir tends to equal recharge over a period of years, and the effects of dry and wet years on ground-water storage tend to balance. Where pumping for irrigation is superimposed on a natural hydrologic system, such as has occurred in the Tularosa-Alamogordo area, heavy precipitation can reduce drastically the amount of ground water pumped for irrigation, and drought can increase the amount. Water levels in observation wells in the area decline mainly in response to pumping, and the amount of decline depends upon the distance of the observation well from the pumping. Table 17 indicates that the water level rose appreciably from 1952 to 1953 in well 14.10.18.424 (R. D. Champion). This apparent rise may be attributed to the fact that the observation well was pumped shortly before being measured in 1952, or that nearby wells were pumped while the observation wells were being measured. On the other hand, several large declines in water level were recorded from 1952 to 1953 -- particularly 1) in well 15.9.24.242a (Fred Dale), because a nearby well was being pumped during the 1953 measurement; 2) in well 15.10.7.412 (Jim Lackey), because a nearby well probably was being pumped at the time of the 1953 measurement or had been pumped shortly before; and 3) in well 16.9.3.422 (Wade Maupin), because the well was being pumped during the 1953 measurement. The influence of pumping on the Dale and Lackey wells is indicated by the apparent rise in the water levels indicated by the 1954 measurements. These measurements indicated declines of water level in most wells in the same areas. Throughout the period of record, most rises in water level in observation wells probably can be attributed to pumping which may have affected previous measurements.

In general, water levels in table 17 appear to indicate that where the levels apparently were unaffected by pumping, the declines during 1953 were significantly less than those in either the preceding or the following years. Examples are the water-level measurements in wells 14.10.19.130 (J. C. Johnson) and 15.9.1.122 (G. V. Clayton). The small declines in 1953 might be attributed to the greater amount of precipitation and consequent reduction in pumpage that year. Figure 125 shows the depth to ground-water level in February 1955 and change in water level from 1954 to 1955.

Nine wells were measured bimonthly or seasonally in the Tularosa-Alamogordo area in 1954. The bimonthly measurements indicate that the ground-water levels in the area rise to their highest stages in late February, and that when the pumping season begins the water levels decline at rates depending primarily on the nearness of the observation well to pumped wells. Water levels decline slowly at uniform rates during the irrigation season in observation wells somewhat removed from heavy pumping. Seasonal declines are rather abrupt in observation wells in the vicinity of Tularosa, and water levels fluctuate throughout the pumping season, depending on pumpage in the immediate vicinity of the observation well. Water levels rise rather uniformly following the end of the pumping season, in September or October, until the next pumping season begins.

Summary and Conclusions

Changes in water level in the Tularosa-Alamogordo area have not yet developed an integrated pattern. Declines in most outlying irrigation wells apparently reflect drawdowns near the wells and not those in the general area. However, even when measurements in wells obviously influenced by pumping are eliminated, it is inferred that pumping for irrigation in the area since the beginning of record has lowered water levels a minimum of nearly 1 foot. In the vicinity of the heavily pumped area at the southwest corner of Tularosa, the maximum measured net decline of water levels was 9 feet during the 3-year period of record. Water levels have declined very little in the outlying parts of the Tularosa-Alamogordo area. Declines in water level in excess of 1 foot are believed to be restricted for the most part to the vicinity of the well in which they were measured.

Development of irrigation continues in the heavily pumped area; also, declines of water levels probably will continue and the area of decline probably will expand. Declines probably will continue to be small in outlying areas except in the Boles well field south of Alamogordo.

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TABLES AND MAP

TABLES

MAP

TABLE 16. -- Precipitation, irrigated acreage, pumpage, and number of measurements of water level, 1952 to 1954, in the Tularosa-Alamogordo area, Otero County, N. Mex.

Year	Tularosa		Alamogordo		Estimated acres irrigated with ground water	Estimated irrigation pumpage (ac-ft)	Annual measurements
	Precip. (in.)	Depart. (in.)	Precip. (in.)	Depart. (in.)			
1952	9.19	-0.38	4.85	-5.31	1,700	4,300	21
1953	9.73	+0.16	e10.45	+0.29	2,000	5,100	18
1954	4.50	-5.07	6.43	-3.73	2,500	5,900	20

e Estimated.

TABLE 17. -- Annual water levels in Tularosa-Alamogordo area, Otero County, April 1952, March 1953, and February 1954 and 1955, highest and lowest recorded annual levels, in feet below land-surface datum; and annual changes, in feet.

Location Number	Name	Source	WATER LEVELS 1951 January Level	Day	Change 1950-51	1952 April Level	Day	Change 1951-52	1953 March Level	Day	Change 1952-53	1954 February Level	Day	Change 1953-54	1955 February Level	Day	Change 1954-55	Change 1950-55	Highest Level	Highest Year	Lowest Level	Lowest Year	Record Began	Record Years Missing
13. 9.20.234															4.34	s8	-	-	-	-	-	-	55	
34.430	Spencer								19.48	26	-	-	-	-	28.26	s8	-	-	19.48	53	28.26	55	53	54
13.10. 6.334	A. F. Stover														271.58	s8	-	-	-	-	-	-	55	
14. 9.12.220	W. T. Bookout					116.14	10	-	117.81	27	- 1.61	121.60	2	- 3.79	120.99	21	+ .61	-	116.14	52	121.60	54	52	
13.200	Thomas Potter					134.55	10	-	-	-	-	134.05	2	-	132.46	21	+ 1.59	-	132.46	55	134.55	52	52	53
24.343	W. H. Cook					154.29	8	-	159.23	27	- 4.94	(a)	-	-	(i)			-	154.29	52	159.23	53	52	54
25.140	C. W. Trammel											155.92	20	-	-	-	-	-	-	-	-	-	54	55
26.412	L. R. Case					102.02	8	-	107.89	27	- 5.87	110.62	4	- 2.73	b110.13	23	+ .49	-	102.02	52	110.62	54	52	
28.121	Montie Gardenhire					33.32	8	-	35.76	27	- 2.44	-	-	-	39.69	23	-	-	33.32	52	39.69	55	52	54
14.10.18.424	R. D. Champion					184.59	8	-	c172.38	27	+12.21	173.37	2	- .99	c177.49	21	- 4.12	-	c172.38	53	184.59	52	52	
19.130	J. C. Johnson					113.44	8	-	115.38	27	- 1.94	115.83	2	- .45	119.60	21	- 3.77	-	113.44	52	119.60	55	52	
19.230	R. D. Champion					151.48	8	-	152.67	27	- 1.19	155.60	3	- 2.93	(a)	-	-	-	151.48	52	155.60	54	52	55
20.221	Julian Martinez														241.87	s9	-	-	-	-	-	-	55	
29.312	H. B. Shaw					153.53	8	-	(a)	-	-	161.25	5	-	158.69	21	+ 2.56	-	153.53	52	161.25	54	52	53
31.144	Luther Watson					73.75	8	-	a109.50	27	-	b106.10	4	-	80.56	21	-	-	73.75	52	80.56	55	52	
15. 9. 1.122	G. V. Clayton					56.74	9	-	59.43	27	- 2.69	61.22	5	- 1.79	c65.41	23	- 4.19	-	56.74	52	61.22	54	52	
24.242a	Fred Dale					107.89	9	-	c114.76	27	- 6.87	111.12	5	+ 3.64	111.50	23	- .38	-	107.89	52	c114.76	53	52	
35.333	Osie Danley and Tom Jones														29.00	s9	-	-	-	-	-	-	55	
15.10. 6.312	E. E. Rhodes					49.61	9	-	54.15	27	- 4.54	56.92	4	- 2.77	c58.76	23	- 1.84	-	49.61	52	c58.76	55	52	
7.412	Jim Lackey					63.57	9	-	79.45	27	-15.88	69.41	4	+10.04	79.31	23	- 9.90	-	63.57	52	79.45	53	52	
22.430	J. D. Jackson														268.15	s10	-	-	-	-	-	-	55	
29.120															133.05	s10	-	-	-	-	-	-	55	
30.320	Osie Danley					99.81	12	-	100.47	26	- .66	100.83	5	- .36	101.49	21	- .66	-	99.81	52	101.49	55	52	
16. 9. 3.422	Wade Maupin					124.38	12	-	a153.10	26	-28.62	b132.88	8	-	(a)	-	-	-	124.38	52	b132.88	54	52	55
5.244	Charlie Nichols					55.40	7	-	55.93	26	- .53	55.43	8	+ .50	57.22	21	- 1.79	-	55.40	52	57.22	55	52	
13.320	E. A. Steinhoff					90.85	14	-	92.60	26	- 1.75	91.63	8	+ .97	95.29	21	- 3.66	-	90.85	52	95.29	55	52	
26.341	R. J. Turner					26.33	14	-	(a)	-	-	27.38	8	-	b27.20	21	+ .18	-	26.33	52	27.38	54	52	53
17. 9.24.342	W. L. McCammon					56.18	14	-	-	-	-	58.65	8	-	59.74	15	- 1.09	-	56.18	52	59.74	55	52	53
17.10. 6.114	Walter Ray					121.86	14	-	122.74	28	- .88	127.14	8	- 4.40	bc124.84	21	+ 2.30	-	121.86	52	127.14	54	52	
18.432	Harold Striker														105.91	8	-	-	-	-	-	-	55	
19.323	W. E. Groom and others														74.91	17	-	-	-	-	-	-	55	

a. Pumping.
b. Pumped recently.
c. Nearby well being pumped.
i. Measurement discontinued.
s. March.

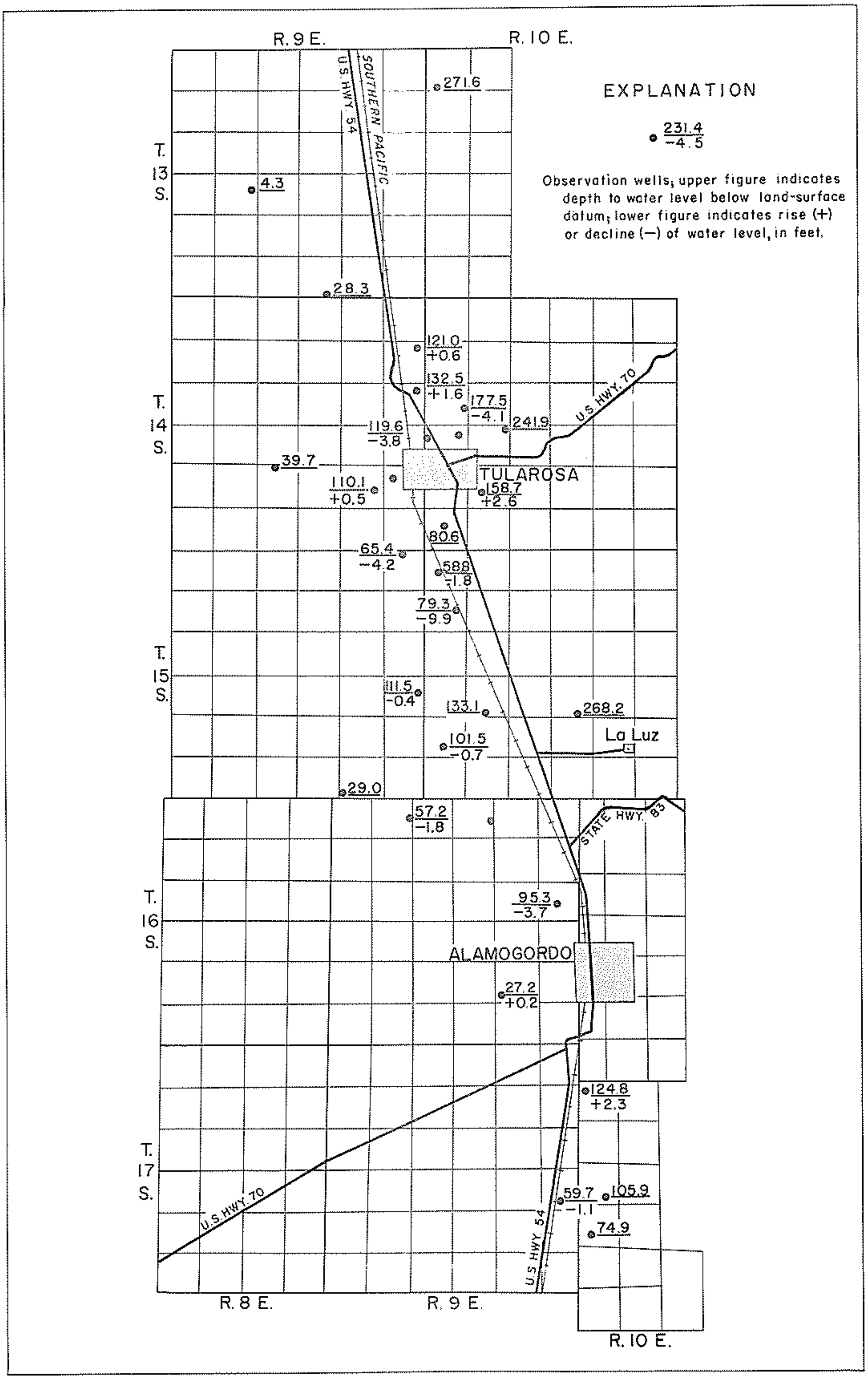

FIGURE 125. -- Depth to ground-water level in February 1955 and change of ground-water level from February 1954 to February 1955 in the Tularosa-Alamogordo area, Otero County, N. Mex.

HOT SPRINGS BASIN, SIERRA COUNTY

By

H. O. Reeder

Location and Description of Area

The Hot Springs basin includes the area in the vicinity of and southwest of Truth or Consequences (formerly Hot Springs) near the center of Sierra County. The area is on the west side of the Rio Grande about 5 miles southwest of Elephant Butte Reservoir and is in the semiarid to arid Basin and Range province. Ground water is under artesian pressure on the west side of the Rio Grande from the vicinity of Truth or Consequences southward about 18 miles to Arrey. However, only the area of thermal water in the vicinity of Truth or Consequences and the area of nonthermal water about a mile southwest of Truth or Consequences in the vicinity of Mud Springs Draw are considered in this report.

Truth or Consequences is a health resort utilizing hot mineral waters from artesian wells drilled into rocks of the Magdalena group or wells which discharge from the overlying alluvium. The hot mineral water is limited to an area of about 130 acres in the town of Truth or Consequences, where the water ranges in temperature from 98° to 114°F. Nonthermal fresh water for irrigation and municipal supply is pumped from artesian wells in the Tertiary and Quaternary deposits in Mud Springs Draw, about a mile southwest of Truth or Consequences. Artesian pressures in Mud Springs Draw are believed to be caused by confinement of ground water by beds of clay. The valley-fill material becomes coarser toward the west and becomes a fairly well-cemented conglomerate. Recharge water is believed to enter the aquifers west of the area of artesian development, to move toward the Rio Grande, and to be discharged by upward percolation through imperfectly confining beds to the overlying shallow-water aquifers and thence to the river.

Some of the wells in Mud Springs Draw originally flowed a few hundred gallons a minute; but, in general, the wells flow only a few tens of gallons a minute. Most of the wells are now equipped with pumps.

An area of about 38 square miles was included in the Hot Springs Underground Water Basin as declared by order of the State Engineer on April 15, 1935. The basin was closed to further appropriation of mineral (thermal) artesian water on July 1, 1937, and to further appropriation of fresh (nonthermal) artesian water on August 26, 1947. Also on August 26, 1947, and again on July 17, 1950, parts of the basin, totaling about 1.5 square miles, were reopened for the appropriation of mineral water. Appropriation of shallow nonthermal water is permitted along Palomas Creek, principally to supplement surface-water irrigation rights.

Scope of Water-Level Program

Water levels at Truth or Consequences have been measured periodically since 1939 in thermal wells and since 1948 in nonthermal wells. From 10 to 15 thermal wells have been measured annually in January, February, or March. Water levels measured annually from 1951 through 1955 are given in table 18. Water levels were measured seasonally in 10 to 15 thermal wells from 1939 through 1949 in two or three thermal wells since 1949. In the earlier years, 1939 to 1944, the seasonal measurements were irregular, ranging from three to six measurements during the year. Since 1944 the seasonal measurements in the thermal wells generally have been at 2-month intervals. Recording gages were installed in 1940 on well 6, a deep artesian thermal well, and in 1941 on well 6a, a shallow dug thermal well in the alluvium. A recording gage was installed in May 1939 and was maintained through May 1953 on well 25, a dug well tapping the limestone near the upper edge of the spring area.

Four nonthermal wells were measured annually in 1948, 1949, and 1950, two in 1951, and one annually after 1951. Few seasonal measurements have been made in the nonthermal wells.

Changes in Water Level

Water levels in wells in the area of thermal water fluctuate both daily and seasonally. The water table in the alluvium and the pressure in lower beds of the alluvium and in the Magdalena limestone decline during the day as a result of the withdrawal of thermal water for bathing. Daily declines in unused artesian wells range from about 0.1 foot to 0.4 foot. Water levels recover during the night. Water levels and artesian heads fluctuate seasonally with the stage of the Rio Grande at Truth or Consequences. Water is impounded at Elephant Butte Reservoir above Truth or Consequences during the winter, and the stage of the river at Truth or Consequences is low. During this period, water levels and artesian heads are low also. When water is discharged from the reservoir during the irrigation season and the stage of the river is high, the water levels and artesian heads rise.

Figure 126 shows graphs of fluctuations of water levels in three wells equipped with recorders in the Hot Springs basin. Well 6, a deep artesian well, and well 25, dug into limestone near the upper edge of the spring area, fluctuate daily (not shown on figure 126) in response to withdrawal of mineral water for bathing. These two wells, and well 6a, a shallow dug well in the alluvium, fluctuate seasonally, as shown on figure 126. Generally, water levels fluctuated seasonally about half a foot until 1951, except for 1942. Precipitation was considerably above normal in 1941 and the stage of the Rio Grande was high because of release of water from Elephant Butte Reservoir. Beginning in 1951, seasonal fluctuations of water levels have been greater because of decreasing amounts of surface water available for release from Elephant Butte Reservoir and continued withdrawal of thermal ground water. The sharp fluctuations of water level in well 6a in 1953 are due largely to heavy local rains, which affect water levels in the shallow aquifer.

Thermal water pumped from wells is balanced somewhat by a decrease in the natural discharge of ground water into the river. However, the slight downward trend in the graph of water levels, figure 126, indicates that the withdrawal of thermal water has exceeded the decrease in natural discharge somewhat since about 1947.

Artesian heads and yields of wells in the area of nonthermal water have been greater than in the area of thermal water; hence the fluctuations of water levels due to withdrawal of water have been greater in the nonthermal wells. As a result of the greater withdrawal of nonthermal water for municipal, domestic, and irrigation uses, the decline of artesian head in Mud Springs Draw has been greater than in the area of thermal water. Declines in head cannot be measured accurately because of great interference between wells resulting from withdrawal of the water.

Summary and Conclusions

Daily changes in artesian head are caused primarily by pumping wells. Seasonal changes in artesian head in the thermal wells are caused primarily by the stage of water in the Rio Grande, into which most of the thermal waters discharge. Generally, artesian head fluctuated seasonally about half a foot from 1943 through 1950. Seasonal fluctuations have been greater since 1950 because of continued withdrawal of thermal water and decreasing amounts of surface water available for release from Elephant Butte Reservoir, causing the river stage to be low for longer periods each year.

The thermal water pumped from wells is somewhat balanced by a decrease in natural discharge into the river. However, water levels have trended downward slightly since about 1947, indicating that withdrawal of thermal water has somewhat exceeded the decrease in discharge to the river.

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Year of observation	Year of publication	Water-Supply Paper	Pages
1939-40	1941	911	235-240
1941	1943	941	270-274
1942	1944	949	336-340
1943	1945	991	295-299
1944	1947	1021	290-294
1945	1949	1028	290-295
1946	1949	1076	300-304
1947	1951	1101	292-297
1948	1951	1131	264-270
1949	1952	1161	274-278
1950	1953	1170	262-265
1951	1954	1196	217-218
1952	1955	1226	232-234
1953	1956	1270	241-243
1954	1957	1326	250-252

TABLE AND HYDROGRAPHS

TABLE

HYDROGRAPHS

TABLE 18. -- Annual water levels in Hot Springs area, Sierra County, in January 1951 through January 1955, highest and lowest recorded annual levels, in feet below land-surface datum; and annual changes, and change from January 1950 to January 1955, in feet.

Location: Field Number	Location: Lot	Location: Block	Name	Source	WATER LEVELS: 1951 January Level	1951 Day	Change 1950-51	1952 January Level	1952 Day	Change 1951-52	1953 January Level	1953 Day	Change 1952-53	1954 January Level	1954 Day	Change 1953-54	1955 January Level	1955 Day	Change 1954-55	Change 1950-55	Highest Level	Highest Year	Lowest Level	Lowest Year	Record: Began	Record: Years Missing
											THERMAL WELLS															
2	17	1	H. L. Lockhart		j- .14	29	-	- .58	31	- .44	- .79	5	- .21	- 1.23	5	- .44	- .54	14	+ .69	-	+1.20	42	- 1.23	54	41	46,50
3	17	1	do.		j- .11	29	- .11	- .58	31	- .47	- .75	5	- .17	- 1.23	5	- .48	- .58	14	+ .65	- .58	+1.23	42	- 1.23	54	41	46
5	12	9	J. E. Malone		- 1.00	29	-	b- 1.76	31	- .76	- 1.61	5	+ 15	- 1.97	5	- .36	- 1.39	14	+ .58	- .07	+ .13	42	- 1.97	54	39	
6	4	8	Harry Dakos		+ .25	29	- .03	- .10	31	- .35	- .22	5	- .12	- .67	5	- .45	- .22	14	+ .45	- .50	k+1.57	42	- .67	54	41	
6a	4	8	do.		- 1.91	29	- .04	- 2.23	31	- .32	- 2.38	5	- .15	- 2.62	5	- .24	- 2.25	14	+ .37	- .38	k-1.24	42	- 2.62	54	42	
12	8	40	Mr. Mathis		+ 3.39	29	- .02	+ 2.95	31	- .44	+ 3.07	r1	+ .12	+ 2.42	5	- .65	+ 2.98	14	+ .56	- .43	+4.53	42	+ 2.42	54	39	
18	7	105	W. R. Whitehead		- 2.09	29	- .09	- 2.41	31	- .32	- 2.57	5	- .16	- 2.96	5	- .39	- 2.43	14	+ .53	- .49	-1.19	42	- 2.96	54	39	
19	12	105	Bill Green		- 1.21	29	+ .07	- 1.50	31	- .29	- 1.61	5	- .11	- 2.13	5	- .52	-	-	-	-	- .20	42	- 2.13	54	39	55
25	4	93	Jim Knox		- 8.10	29	+ .01	- 8.49	31	- .39	- 8.72	5	- .23	(f)	-	-	- 8.55	14	-	- .44	k-6.95	42	- 8.72	53	39	54
27	4	42	Mr. Gideon		-	-	-	-	-	-	-	-	-	(i)						-	+2.97	42	+ 1.85	50	39	49,51-53
30	1	102	G. L. Mills		- 1.78	29	- .02	b- 2.26	31	- .48	- 2.72	5	- .46	- 3.27	5	- .55	- 2.70	14	+ .57	- .94	- .63	42	- 3.27	54	39	
33	2	106	C. E. James		- .81	29	- .02	- 1.45	31	- .64	- 1.48	r1	- .03	-	-	-	(i)			-	+ .28	42	- 1.48	53	41	54
											NONTHERMAL WELLS															
Location Number																										
14. 4. 6.110a			Dave Gray		-99.93	29	+ .49	-99.38	31	+ .55	-95.10	5	+ 4.28	-100.34	5	- 5.24	-99.47	14	+ .87	+ .95	-95.10	53	-100.66	r49	47	
6.441			Roy Howe		+40.35	30	+ 9.13	-	-	-	-	-	-	-	-	-	-	-	-	-	+58.30	47	+ 40.35	51	47	52-55
6.442			Mrs. Arnold		-	-	-	-	-	-	-	-	-	(i)						-	+55.57	48	+ 54.94	47	47	49,51-53
7.311			J. A. Slater		-	-	-	-	-	-	-	-	-	(i)						-	+17.55	50	+ 16.61	48	48	49,51-53

b. Pumped recently.
f. Dry.
i. Measurement discontinued.
j. Possible discrepancy of a few tenths of a foot between present and previous land-surface datum.
k. From recorder chart.
r. February.

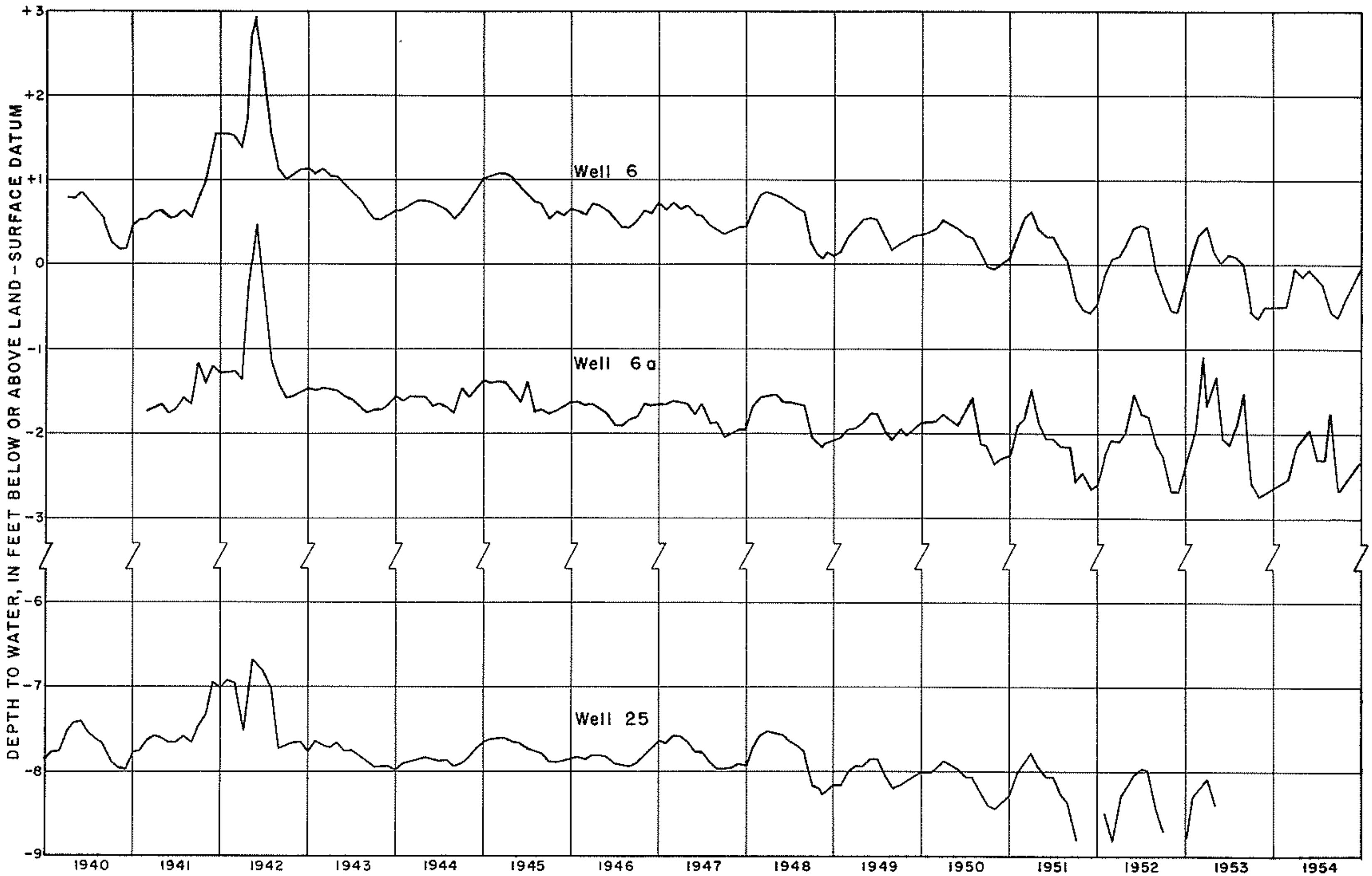

FIGURE 126. -- Graphs showing fluctuations of water levels in three wells in Hot Springs basin, Sierra County, N. Mex.

GRANTS-BLUEWATER AREA, VALENCIA COUNTY

By

E. D. Gordon

Location and Description of Area

The Grants-Bluewater area is in north-central Valencia County, about 80 miles west of Albuquerque along U. S. Highway 66. The area is in a broad valley adjacent to the northeast flank of the Zuni Mountains. The altitude of the land surface ranges from about 6,300 feet to about 6,800 feet above sea level. The principal towns are Grants, Bluewater, and San Rafael.

Much of the irrigated area lies within the boundaries of the Bluewater-Toltec Irrigation District which was formed to distribute surface water from storage in Bluewater Lake. Unfortunately, the supply of surface water generally has been insufficient for irrigation needs, and in only three seasons since 1945 has any surface water been available for irrigation. Consequently, several irrigation wells have been drilled, and in recent years these wells have become the only reliable source of water for irrigation in the area.

The Grants-Bluewater area is semiarid to arid. The average annual precipitation at Bluewater, based on a 38-year record, is 10.10 inches, about 70 percent of which usually occurs during the growing season, from April through September. From 1944 through 1954, however, precipitation averaged only about 8.2 inches per year. Complete precipitation records for Grants are not available, but precipitation at Grants is usually slightly less than at Bluewater. Precipitation records for Bluewater from 1945 through 1954 are shown in table 19.

Irrigation wells in the Grants-Bluewater area obtain water principally from the San Andres formation and the Glorieta sandstone of Permian age; however, several irrigation wells tap sandstones of the Chinle formation of Triassic age, and many wells also obtain supplies of water from the alluvium or from associated basaltic lava flows of Quaternary age in some parts of the valley. Many stock and domestic wells also obtain water from the deposits of Quaternary age.

The Glorieta sandstone, formerly designated as a member of the San Andres formation, is now considered to be a separate formation in this region. However, the San Andres formation and the Glorieta sandstone constitute a single aquifer in the Grants-Bluewater area. The two formations are, together, about 250 to 300 feet thick. The formations crop out along the northeastern flank of the Zuni Mountains, along the southwest side of the area, and dip northeastward toward the San Juan Basin. Therefore, the depth of the formations beneath the surface gradually increases northeastward. In many localities, however, the depth is difficult to predict because of dislocation of beds along numerous faults in the area. The top of the San

Andres formation is about 800 feet below land surface 6 to 7 miles north of Grants, and is more than 3,000 feet beneath the surface in the Ambrosia Lake area, about 20 miles north of Grants. The formations are recharged principally from precipitation on the area of outcrop along the northeast flank of the Zuni Mountains, from precipitation in the alluvium and the basalt flows underlying parts of the area, and from surface-water seepage from Bluewater Lake, Bluewater Creek, and the irrigation-canal system. They are recharged also to some extent by return flow from irrigation.

Ground water moves generally southeastward in the vicinity of Bluewater and Grants. South of Grants and east of San Rafael, however, ground water moves generally eastward. Ground water is discharged in the swampy area south of Grants and east of San Rafael, and in the Horace Springs area about 10 miles southeast of Grants, near McCartys.

Scope of Water-Level Program

The program of measuring water levels periodically and the gathering of other data pertaining to ground water in the area began in February 1946. Water levels have been measured in about 35 wells in February of each year since 1947. Water levels were measured bimonthly in about 28 wells during 1954. A recording gage has been maintained since November 1946 on well 12.11.9.222, about 2.5 miles north-northwest of Bluewater.

The net changes in ground-water storage from year to year are determined by comparing the water levels measured each February. Seasonal fluctuations of water levels due to pumping and recharge are reflected in the bimonthly measurements of water levels. Water levels measured annually from 1951 to 1955 are given in table 20.

Development of Ground Water

Early settlers in the Grants-Bluewater area irrigated by diverting a part of the flow of Bluewater Creek into community ditches. The Bluewater-Toltec Irrigation District was organized in 1923. In 1927 the District built Bluewater Dam, which was intended to impound surface water to irrigate about 9,000 acres of land from the mouth of Bluewater Canyon to near Grants. Unfortunately, the supply of surface water has been inadequate to meet the needs of the project. For example, in the past 10 years, surface water for irrigation has been available only in 1948, 1949, and 1952. Moreover, during these 3 years, surface water was available in amounts sufficient to irrigate only 1,500 to 2,000 acres.

Because of the generally deficient supply of surface water for irrigation in most years, interest was aroused in ground water. The first successful irrigation well was drilled in August 1944. The number of irrigation wells had increased to 16 by the end of 1946. A few additional wells were drilled in succeeding years. A total of 28 irrigation wells had been drilled in the area by the end of 1954. Twenty-three irrigation wells were in use during the 1954 irrigation season. In addition to the irrigation wells, three industrial wells and four municipal wells were in use in 1954. The total number of irrigation wells in use in the area each year from 1945 to 1954 are shown in table 19.

Although the quantity of ground water pumped annually for irrigation is dependent on the precipitation, and to some extent on the amount of surface water available, the total annual pumpage has been fairly constant. In 1945, when only seven irrigation wells were in use, 3,500 acre-feet of ground water was pumped. The number of irrigation wells was increased to 16 in 1946, and 9,000 acre-feet of ground water was pumped that year. Since 1946, with the exception of 1949 when only 6,900 acre-feet of ground water was used, pumpage of ground water to the end of 1954 has varied between 9,000 and 12,600 acre-feet per year. Annual pumpage of water, number of wells pumped, and irrigated acreage are shown in table 19.

Changes in Water Level

The Grants-Bluewater area may be divided into two general areas where water levels fluctuate differently because of differences in hydrologic characteristics of the aquifer. In the upper part of the area, from the mouth of Bluewater Canyon to north of Bluewater, water levels decline rapidly in response to pumping and rise rapidly when surface water is released into the distribution canals of the Bluewater-Toltec Irrigation District. The irrigation area southeastward from Bluewater to south of Grants, however, is characterized by less pronounced pumping effects, smaller seasonal fluctuations in ground-water levels, and slower responses to discharge and recharge, even though most of the pumpage is from this area.

In years when surface water is not available for irrigation, water levels in the irrigated area usually are highest in March or April, before the beginning of the pumping season. Water levels usually decline steadily during the pumping season, rising only slightly during interruptions of pumping, and are lowest generally from July to October, at the end of the pumping season. Water levels begin to rise again with cessation of pumping.

North of Bluewater, water levels have declined 40 to 45 feet since 1946, the first year of record, whereas, from Bluewater southeast to near Grants, the levels have declined only about 18 to 20 feet. The large decline north of Bluewater may be due, in part at least, to abnormally high water levels in the vicinity at the beginning of the period of record. The aquifer undoubtedly was recharged greatly by irrigation-canal seepage in 1941, 1942, and 1943, when flow past the gage in Bluewater Canyon during the growing season was 26,260, 16,720, and 16,880 acre-feet, respectively. The flow past the gage near the mouth of the canyon was 8,020 acre-feet for the entire year in 1944. Since 1944, the flow past the gage during the growing season has averaged only 2,885 acre-feet per year.

The hydrograph of well 12.11.9.222 (fig. 127) illustrates the rapid response of water levels in the upper part of the area to pumping and recharge. It indicates that, with the exception of 1948, 1949, and 1952, when surface water was available for irrigation, water levels declined rapidly during the height of the growing season (May, June, and July) and began a gradual rise about July or August that continued until the beginning of the following pumping season. In years when surface water is available for irrigation, water levels are affected by quantity and demand, as well as by the time of year when such water becomes available.

Summary and Conclusions

As pumping of ground water in the area is a new discharge imposed upon a more or less stable ground-water system, water levels may be expected to decline as long as large-scale pumping continues. If enough water is available in Bluewater Reservoir in some years to provide adequate surface water for irrigation in the area, the ground-water reservoir will be replenished temporarily to some extent, and pumping will be reduced unless additional acreage is irrigated. Additional use of ground water in the area will accelerate the rate of decline of the water table.

Pumping ground water in the Grants-Bluewater area probably will result in an eventual reduction of the natural discharge of ground water in the area south and southeast of Grants and near McCartys.

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Year of observation	Year of publication	Water-Supply Paper	Pages
1946	1949	1076	311-316
1947	1951	1101	306-316
1948	1951	1131	280-288
1949	1952	1161	290-298
1950	1953	1170	275-279
1951	1954	1196	219-222
1952	1955	1226	234-237
1953	1956	1270	249-253
1954	1957	1326	258-262

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TABLES AND HYDROGRAPHS

TABLES

HYDROGRAPHS

TABLE 19. -- Precipitation, irrigated acreage, ground- and surface-water use, number of used wells, and number of measurements of water level, 1945 to 1954, in the Grants-Bluewater area, Valencia County, N. Mex.

Year	Bluewater Precip. (in.)	Bluewater Depart. (in.)	Estimated acres irrigated: Ground water	Estimated acres irrigated: Surface water	Estimated ground water pumpage (ac-ft)	Estimated surface water diversion (ac-ft)	Number of irrigation wells used	Annual measurements
1945	8.82	-1.28	1,500	1,200?	3,500	2,400?	7	0
1946	10.76	+0.66	4,500	0	9,000	0	16	16
1947	-	-	4,500	0	10,300	0	15	35
1948	9.36	-0.74	4,000	1,500	9,300	4,630	19	38
1949	11.05	+0.95	4,000	1,700	6,900	4,630	19	41
1950	-	-	6,000	0	11,800	0	22	39
1951	-	-	6,000	0	12,300	0	23	38
1952	7.71	-2.39	5,000	2,000	10,400	4,500?	23	34
1953	5.41	-4.69	6,000	0	12,000	0	23	34
1954	8.43	-1.67	5,000	0	12,600	0	23	35

TABLE 20. -- Annual water levels in Grants-Bluewater area, Valencia County, in February 1951 through February 1955, highest and lowest recorded annual levels, in feet below land-surface datum; and annual changes, and change from February 1950 to February 1955, in feet.

Location Number	Name	Source	WATER LEVELS 1951 February Level	Day	Change 1950-51	1952 February Level	Day	Change 1951-52	1953 February Level	Day	Change 1952-53	1954 February Level	Day	Change 1953-54	1955 February Level	Day	Change 1954-55	Change 1950-55	Highest Level	Year	Lowest Level	Year	Record Began	Years Missing
10. 9.26.224	Robert Gottlieb		b8.72	12	+ .20	8.95	19	- .23	a9.04	17	- .09	8.90	8	+ .14	9.00	9	- .10	- .08	b8.72	51	a9.04	53	47	
10.10.10.200	Joe Padilla		12.05	12	- 1.15	12.19	26	- .14	10.18	20	+ 2.01	13.53	9	- 2.35	14.60	12	- 1.07	- 3.70	9.83	47	14.60	55	47	
22.421	Monico Mirabal					22.07	21	-	24.81	20	- 2.74	(f)	-	-	f23.00	10	-	-	22.07	52	24.81	53	52	54
26.331	do.					22.18	21	-	23.03	20	- .85	23.57	9	- .54	b24.25	10	- .68	-	22.18	52	b24.25	55	52	
11.10. 4.111	Buford Yarbo		76.61	12	- 3.88	79.72	26	- 3.11	80.08	17	- .36	83.34	11	- 3.26	83.77	10	- .43	-11.04	69.25	47	83.77	55	47	
4.211	J. C. Church Company		71.54	12	- 3.75	75.50	26	- 3.96	76.03	17	- .53	79.21	11	- 3.18	79.79	10	- .58	-12.00	57.97	46	79.79	55	46	
4.222	do.		67.89	12	- 1.97	70.78	26	- 2.89	b72.40	17	- 1.62	73.13	11	- .73	74.20	10	- 1.07	- 8.28	60.85	47	74.20	55	47	
5.214	V. M. Vidal		76.60	12	- 4.42	80.20	26	- 3.60	(i)									-	68.99	47	80.20	52	47	
8.111	Salvador Milan		81.36	12	- 3.96	j84.13	26	- 2.77	-	-	-	88.12	9	-	88.85	10	- .73	-11.45	73.75	47	88.85	55	47	53
8.122	do.		66.67	13	- 3.93	69.94	26	- 3.27	70.50	19	- .56	73.83	9	- 3.33	74.64	10	- .81	-11.90	62.74	50	74.64	55	49	
8.222	do.		70.43	13	- 3.88	73.66	26	- 3.23	74.25	19	- .59	77.53	9	- 3.28	78.20	10	- .67	-11.65	57.85	46	78.20	55	46	
8.344	do.		60.45	13	- 3.76	(i)												-	53.42	47	60.45	51	47	
9.222	A. R. Card		66.04	12	- 3.16	69.39	26	- 3.35	69.85	17	- .46	72.57	11	- 2.77	73.04	11	- .47	-10.16	54.49	46	73.04	55	46	
9.242	do.		64.42	12	- 3.58	67.44	26	- 3.02	(i)									-	52.24	46	67.44	52	46	
16.121	Frank Wilson		58.47	13	- 3.49	61.36	26	- 2.89	62.01	19	- .65	64.30	9	- 2.29	64.71	10	- .41	- 9.73	46.47	46	64.71	55	46	
16.142	do.		-	-	-	(i)												-	45.50	46	54.25	49	46	51
17.222	Salvador Milan		54.97	13	- 3.60	57.97	26	- 3.00	58.58	19	- .61	61.67	9	- 3.09	62.09	10	- .42	-10.72	47.84	47	62.09	55	47	48
26.131	Ice Plant (?)								19.86	20	-	21.85	9	- 1.99	22.28	10	- .43	-	19.86	53	22.28	55	53	
26.411	City of Grants Well No. 3		9.70	12	- .38	13.19	26	- 3.49	c16.30	20	- 3.11	bc19.55	11	-	b18.24	12	-	- 8.92	7.95	47	13.19	52	47	48
27.410	Mr. McMain - 1954		38.45	12	- 1.28	39.73	26	- 1.28	40.09	18	- .36	41.88	9	- 1.79	42.16	10	- .28	- 4.99	35.59	47	42.16	55	47	
34.400			15.55	12	- .95	(Incorrect designation used previously for well 11.10.34.420, which see.)																		
34.420	Manual Ortiz					f16.03	26	-	(f)	-	-	(f,i)						-	14.41	48	15.55	51	48	53
12.10.23.233	T. A. Morris & Son - 1952		126.83	12	- 3.33	-	-	-	-	-	-	133.08	11	-	b143.53	11	-10.45	-20.03	115.59	46	133.08	54	46	52,53
29.434	A. R. Card		82.75	15	- 6.03	c97.97	26	-15.22	86.16	17	-	90.17	11	- 4.01	91.33	10	- 1.16	-14.61	69.23	46	91.33	55	46	
30.111	E. E. Harden		115.85	15	- 4.40	-	-	-	120.03	18	-	123.80	11	- 3.77	a125.09	11	- 1.29	-	107.98	47	a125.09	55	47	52
30.242	Jack Freas - 1955		98.16	15	- 3.52	101.33	26	- 3.17	102.30	17	- .97	105.57	11	- 3.27	106.72	11	- 1.15	-12.08	90.78	47	106.72	55	47	
30.412	Fred Freas		103.34	15	- 4.20	106.94	26	- 3.60	107.61	17	- .67	111.08	11	- 3.47	112.13	10	- 1.05	-12.99	90.04	46	112.13	55	46	
30.421	Milton Harding		101.63	15	- 4.16	(c)	-	-	105.84	17	-	b111.58	11	- 5.74	110.32	10	+ 1.26	-12.85	88.38	46	b111.58	54	46	52
32.111	J. C. Church Company		m94.95	15	- 4.14	98.70	26	- 3.75	99.68	17	- .98	103.09	11	- 3.41	-	-	-	-	82.09	46	103.09	54	46	55
12.11. 5.413	do.		201.02	15	-14.22	213.50	20	-12.48	208.79	18	+ 4.71	219.64	10	-10.85	225.65	11	- 6.01	-38.85	186.80	50	225.65	55	49	
9.114a	do.		146.36	15	-14.30	157.52	20	-11.16	153.27	18	+ 4.25	160.97	10	- 7.70	163.95	11	- 2.98	-31.89	132.06	50	163.95	55	49	
9.222	do.		137.42	15	-13.90	149.34	20	-11.92	145.20	18	+ 4.14	154.79	9	- 9.59	160.03	14	- 5.24	-36.51	115.70	46	160.03	55	46	
9.424	George Rowley		106.39	15	- 7.38	114.10	20	- 7.71	112.60	18	+ 1.50	j118.30	10	- 5.70	123.81	11	- 5.51	-24.80	99.01	50	123.81	55	47	
14.213	Dyan Berryhill		99.82	15	- 1.56	100.99	20	- 1.17	100.77	20	+ .22	101.16	10	- .39	101.16	11	.00	- 2.90	98.26	50	101.16	x54	50	
15.341	Edward Freas		115.49	15	-13.15	126.75	20	-11.26	123.00	19	+ 3.75	132.62	10	- 9.62	137.05	11	- 4.43	-34.73	102.34	50	137.07	55	47	
16.223	E. E. Harden		-	-	-	(i)												-	119.87	50	131.49	48	47	51
20.424	J. F. Nielson		252.07	15	-11.53	259.35	20	- 7.28	258.11	20	+ 1.24	261.05	10	- 2.94	b265.59	11	- 4.54	-25.05	240.54	50	261.05	54	47	
22.414	Mr. Hassell		132.38	15	-13.26	140.82	21	- 8.44	140.51	19	+ .31	-	-	-	-	-	-	-	110.59	46	140.82	52	46	54,55
23.233	Harmon and Read		m70.34	15	- 1.54	70.27	26	+ .07	-	-	-	71.21	10	-	-	-	-	-	68.80	50	71.21	54	47	53,55
24.411	Anaconda Copper Mining Co.								149.31	18	-	152.65	10	- 3.34	a155.32	11	- 2.67	-	149.31	53	152.65	54	53	
25.223	J. C. Church Company		116.85	15	- 7.50	-	-	-	118.36	17	-	121.88	10	- 3.52	123.28	11	- 1.40	-13.93	100.18	46	123.28	55	46	52
25.223a	do.		-	-	-	118.86	26	-	119.42	17	- .56	123.02	10	- 3.60	124.41	11	- 1.39	-13.72	106.82	47	124.41	55	47	51
25.311	Harmon and Read		131.86	15	- 4.61	135.70	26	- 3.84	136.18	19	- .48	139.99	10	- 3.81	141.18	11	- 1.19	-13.93	124.50	47	141.18	55	47	
27.222	Harold Prewitt		160.56	15	- 8.35	166.52	26	- 5.96	a166.50	19	+ .02	b172.16	11	- 5.66	b173.93	11	- 1.77	-21.72	152.21	50	b173.93	55	48	

a. Pumping.
b. Pumped recently.
c. Nearby well being pumped.
f. Dry.
i. Measurement discontinued.
j. Possible discrepancy of a few tenths of a foot between present and previous land-surface datum.
m. Measurement uncertain.
x. Also 1955.

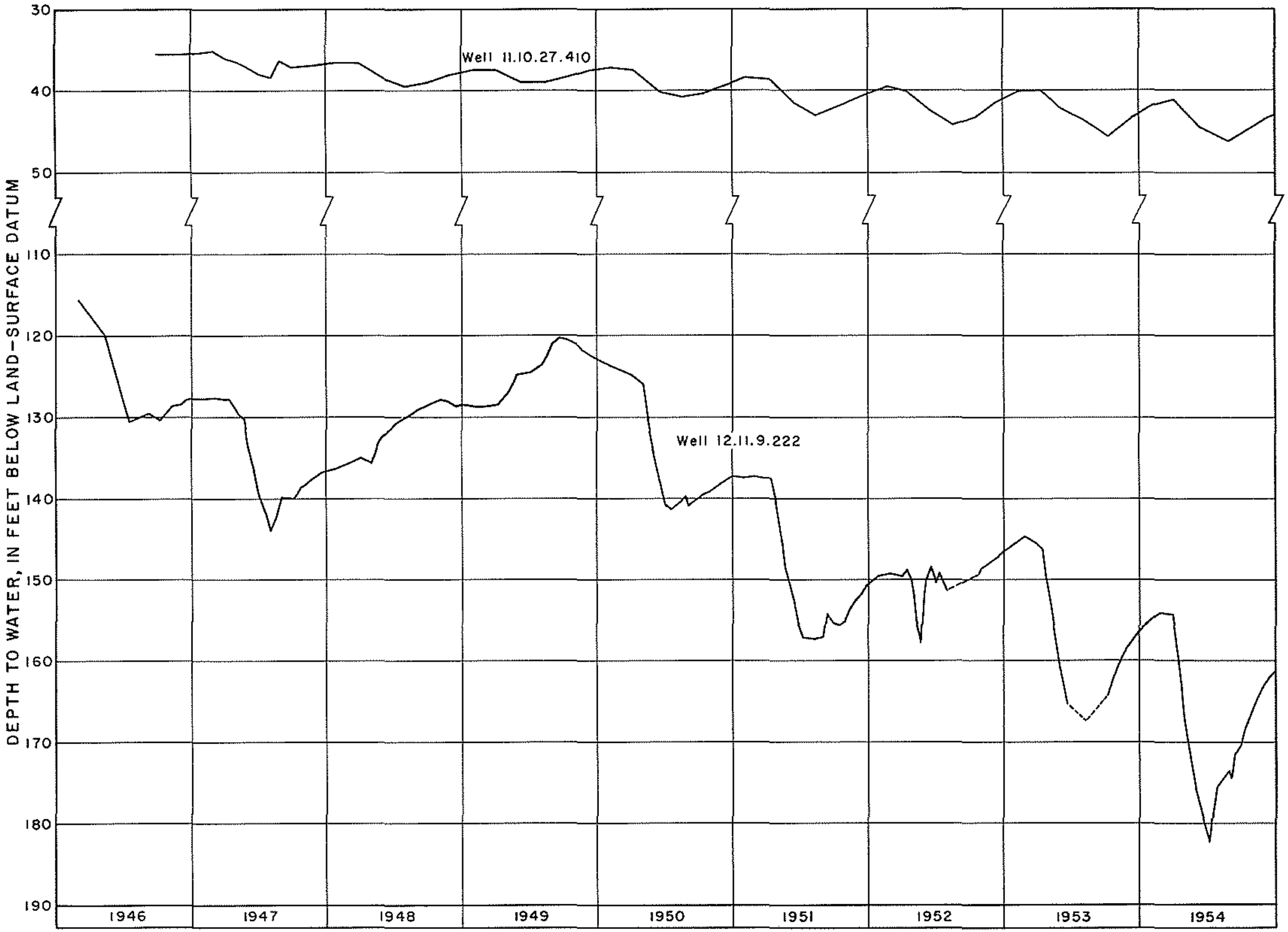

FIGURE 127. -- Graphs showing fluctuations of water levels in two wells in Grants-Bluewater area, Valencia County, N. Mex.