

ADMINISTRATION OF WATER RIGHTS
PORTALES VALLEY UNDERGROUND WATER BASIN
NEW MEXICO

by

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July 1968

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INTRODUCTION

The development of ground water for irrigation in the Portales Valley is an important part of the history of the agricultural development of the Llano Estacado of eastern New Mexico and western Texas, for it was in this valley that the present extensive irrigation development of the region had its beginning. Large-scale irrigation farming using water derived entirely from wells, was initiated in the vicinity of the City of Portales about 60 years ago and has since spread to include practically all of the irrigable land in the valley. Over the years the economy of the valley has developed progressively with the expansion of irrigation, and the major part of the income of the valley is now derived either directly or indirectly from irrigation farming and related industries.

Most of the water presently used in the valley is pumped from shallow wells constructed in valley fill of Pleistocene and Recent age and to a minor extent in the Ogallala formation of Pliocene age. Ground water also occurs in rocks of Triassic and Permian age which underlie the valley fill and the Ogallala formation. Ordinarily the Triassic rocks yield water to wells at only relatively small rates and generally the water is of such poor chemical quality that it is unfit for other than limited stock and domestic use. In general, it is used only in areas where ground water is not available from the valley fill. No attempt has been made in the

area to obtain water from rocks of Permian age, however, data obtained from oil-well records, indicate that the water present in these rocks is of such poor chemical quality that it is unfit for either stock, domestic, or irrigation use. The poor water-producing characteristics of the Permian and Triassic rocks and the poor chemical quality of the water which they contain preclude any foreseeable extensive development of ground-water supplies from them, particularly for irrigation; consequently, the valley fill and the Ogallala formation are the only formations in the valley capable of producing water of good chemical quality in quantities sufficient to be of importance to the present economy of the area. Because of the obvious importance of irrigation farming and related industries to the valley it follows that the water available from these formations, in conjunction with the soil and climatic conditions, is at present the valley's most valuable natural resource.

Unfortunately, the supply of water available from the valley fill and the Ogallala formation for irrigation and other major water uses in the Portales Valley, like that of the whole Llano Estacado, is limited largely to stored water that has accumulated during the past several thousand years. Some water, originating in areas outside the hydrologic limits of the valley, may leak upward to the valley's shallow aquifer system from underlying rocks of Triassic or Cretaceous age or spill laterally into the valley from relatively thin zones of saturation that extend beyond its general hydrologic boundaries. The general geologic and hydrologic setting of the valley, however, precludes the inflow of any significant quantity of water from any outside source; consequently, recharge to the ground-water supply of the valley must be derived almost entirely from the downward percolation of precipitation that falls within the valley's hydrologic limits.

In general, the increasing use of water for irrigation farming and the accompanying increased use of water for other purposes in the Portales Valley have resulted in a general decline of the water table in all of the irrigated area. The water table has declined almost continuously since the initiation of irrigation development near the turn of the century, but it has declined at an accelerated rate during the past twenty years. From the middle part of the 1940's (1943-44) to the middle part of the 1950's (1955-56) the valley experienced one of the worst drouths in its history, which undoubtedly reduced the recharge to the shallow ground-water reservoir and increased, to some extent, the irrigation water demand of crops grown in the valley. Most of the accelerated rate of water-level decline appears to be attributable, however, to an expansion of irrigation development that began immediately following World War II and has continued to date. The drouth appears only to have amplified the effects of the additional pumpage from the shallow ground-water reservoir. The magnitude of current rates of water-level decline and the successive all-time water-level lows measured in most of the observation wells in the valley in recent years have clearly indicated that the shallow ground-water supply has been overdeveloped in parts of the valley and have resulted in a general recognition and acceptance of the fact that the water pumped for irrigation and other purposes in the valley, as in other areas of the Llano Estacado, is derived chiefly from ground-water storage and is essentially a mined resource. Inasmuch as the future economy of the valley depends almost entirely on the future of its ground-water resources, the continued progressive lowering of the water table and the impending reduction of available ground-water supplies to the extent that irrigation is no longer feasible, is a subject of grave concern to both the irrigators and businessmen

in the valley, and to the New Mexico State Engineer who is responsible for the administration of this vital resource.

BASIC INVESTIGATIONS

A number of the early reports on the High Plains area of eastern New Mexico and western Texas (Hill, 1893; Johnson, 1901, 1902; et al.) describe the general geology and the occurrence of underground water in this region; however, the earliest investigation to deal specifically with the Portales Valley was by O. E. Meinzer, then assistant geologist of the U. S. Geological Survey, who spent a short time in the valley in 1909. His limited study resulted in two reports (Meinzer, 1909a, 1909b) in which he outlined the sand-dune areas of the valley and the belt in which ground water occurred within 25 feet of the land surface. He concluded from his study that the Portales Valley was a part of an ancient stream system whose headwaters were captured by the Pecos River.

In 1914, C. L. Baker of the Texas Bureau of Economic Geology made a study of the geology and hydrology of the northern Llano Estacado. His report (1915) includes a discussion of regional geology and the origin of the Portales Valley, data relative to irrigation and the depth to water, and tables containing chemical analyses of water and drillers logs that pertain to the area covered by this report.

The first detailed investigation of ground-water conditions in the Portales Valley was made by C. V. Theis, geologist, U. S. Geological Survey, in 1931. This investigation covered both Roosevelt and Curry Counties, but most of the data collected during the investigation pertain to the Portales Valley. Theis (1932) describes the geology, geologic

history, and hydrology of the valley and recommends the formation of a "ground-water district." Records for about 500 wells are given in his report.

Records of water-level measurements, annual pumpage, and other pertinent hydrologic data, collected by the U. S. Geological Survey since the completion of the basic investigation by Theis, are given in progress reports by Theis (1934 and 1939) and Conover and Akin (1942), and in the water-level and artesian-pressure reports of this federal agency. A discussion of the quantity of ground-water recharge in the southern High Plains by Theis (1938) gives an estimate of the annual recharge to the shallow ground-water supply in the valley.

The most comprehensive study of the valley fill was made by H. W. Robbins in 1939, 1940, and 1941. His unpublished report (1941) divides these sediments into several stratigraphic units and correlates the development of the valley with regional geologic history during Pleistocene time.

The most recent detailed report on ground-water conditions in the Portales Valley was prepared by S. E. Galloway of the State Engineer office in 1956. This report, which was based on studies initiated by the State Engineer in 1954, discusses, in considerable detail, the lithologic characteristics and areal distribution of the various stratigraphic units underlying the valley and their relation to the occurrence of ground water; relates climatic conditions, on a qualitative basis, to the availability of ground-water recharge and the use of water in the valley; reviews the history and effects of ground-water development in the area; describes the chemical quality of ground-water supplies in the region; and presents maps showing

the general configuration of the land surface, the altitude and configuration of the water table, and the altitude and configuration of the base of the shallow ground-water reservoir in the parts of the valley where the required basic data for such maps had been collected as of the spring of 1956. Upon completion of this report a determination was made of the quantity and areal distribution of ground-water in storage in the part of the valley covered by the maps of the water table and the base of the shallow ground-water reservoir. In 1957 a series of standard topographic quadrangles, that included coverage for most of the valley, were prepared by the Topographic Division of the U. S. Geological Survey. The collection of basic water resources data was also expanded by the State Engineer in 1957 to obtain additional water-level records, well logs, and other needed records, particularly in parts of the valley not covered by the maps prepared by Galloway in 1956. Work was also initiated at this time to obtain elevations at wells for which water levels and well logs were available that were outside the area covered by topographic quadrangles. Other studies initiated as part of the continuing investigation included determining the hydraulic coefficients of the shallow aquifer, the extent and distribution of water rights, the quantities of water pumped for various uses, the irrigation-water requirements for the principal crops, changes and potential changes in the chemical quality of produced water, and the change in ground-water levels in undeveloped areas on the perimeter of the valley between January 1956 and January 1961. The change in ground-water levels within and immediately adjacent to the irrigated area of the valley is determined annually by the U. S. Geological Survey as part of its cooperative program with the State Engineer.

In 1964 an investigation was begun by the U. S. Bureau of Reclamation to determine the amount of water that might be available from the relatively undeveloped sand dunes area northeast of the City of Portales and the feasibility of drilling wells in this area to provide supplemental water to owners of valid water rights in the Portales Valley who were experiencing or were expected to experience water shortages. This investigation was initiated at the request of residents of the valley following completion of preliminary studies by the State Engineer. To facilitate the determination of the quantity and life expectancy of the water available for the project an electric analog model was developed by the Bureau's Denver office from basic data supplied by the State Engineer, the High Plains Underground Water Conservation District No. 1 at Lubbock, Texas, and other cooperating agencies. The modeled area included contiguous areas of pumping in New Mexico and Texas as well as the project area.

An analog model such as the one developed for this project is an electrical system representing the shape, size, and characteristics of a given aquifer system. It is based on the theory that the flow of water in a ground-water system is analogous to the flow of electricity in an electrical circuit. In practice, the thickness of the aquifer and the properties of water storage and transmittal of the ground-water system are simulated by joining "junctions" composed of combinations of electrical resistors, representing rates of ground-water flow, and electrical capacitors, representing quantities of water in storage, on a small-scale map in a shape similar to that of the actual aquifer system. Each of these junctions represents, at some predetermined scale, the conditions extant at a particular point in the aquifer system. The changes that occur in the electrical properties of the model when all or part of the

"junctions" are stimulated by the withdrawal of electricity from the model provide data from which the hydraulic performance of an aquifer under an analogous set of pumping conditions can be predicted. For example, the withdrawal of electricity from a given point in the model causes a decline in voltage in the vicinity of that point that is analogous to the decline of the water table that will occur in the vicinity of a pumping well located at that point in the corresponding aquifer system. The extent to which the voltage declines in response to a given stimulus is a measure of the decline to be expected in the water table if the well represented by the point is pumped at a rate corresponding to the magnitude of the stimulus.

The model developed for the Portales project, as finally completed, reflected, within reasonable limits, the historical effects of pumping in the modeled area. The combined effects of initiating pumping in the sand dunes area and continuing pumping in contiguous areas of New Mexico and Texas were then determined, with appropriate adjustments for expected reductions in ground-water storage and total irrigated acreage at the end of 10, 20, 30 and 40-year periods of pumping, to determine the quantity and life expectancy of water that might be available for the proposed project. This study indicated that enough water could be developed in the dunes area to meet the needs of the proposed project. The investigation was then extended to include a preliminary determination of the economic feasibility of the project. Upon completion of this phase of the investigation, the project was discontinued at the request of its local sponsors.

The most recent study of the quantity of water in storage in the valley's shallow aquifer system and the effects of continuing the withdrawal of water from this aquifer for irrigation, municipal, and industrial

use was completed by the State Engineer in October 1967. This study included the preparation of maps showing the altitude and configuration of the water table in January 1962, the altitude and configuration of the base of post-Mesozoic sediments, and the thickness of saturated post-Mesozoic sediments as of January 1962; and the determination of the location and extent of existing rights to water in the Portales Basin as of October 1, 1967. Studies were also made to determine the average thickness of saturated post-Mesozoic sediments, the average annual change of groundwater levels from January 1956 to January 1961, and the average reduction in the thickness of saturated sediments to be expected if withdrawals of water to satisfy rights to water that existed on October 1, 1967 are continued until 1996. Each township lying wholly or partially within the declared boundaries of the Portales Basin was divided into nine essentially square units of 4 sections each to facilitate the determination of these averages. The maps prepared in connection with this study were based on measured depths to water in about 500 wells and drillers logs of more than 4,500 wells and seismic shotholes. The map of saturated sediments approved by the Internal Revenue Service for use in calculating water depletion allowances in northern Roosevelt County was adapted from the map of saturated sediments developed during this study.

In addition to these cited works there are a number of reports, both published and unpublished, that deal with the region in which the Portales Valley is located. They deal, for the most part, with the regional stratigraphy and geologic structure of the subsurface Paleozoic and Mesozoic strata, extremely detailed geology at sites of archeological interest, soils, climatology, and farm economics.

GENERAL DESCRIPTION OF VALLEY

The Portales Valley includes most of northern Roosevelt County and a part of southwestern Curry County. It is bounded on the west by the western limit of the Llano Estacado, on the south by a poorly defined break in slope that is believed to be associated with the northern limit of the "caprock" along the locally truncated edge of the generally south-eastward sloping surface of the Llano Estacado, and on the east by the Texas-New Mexico state line. The northern boundary of the valley is considered to roughly follow a line that might be drawn just north of, and parallel to, Blackwater Draw from the Texas-New Mexico state line to the western limit of the Llano Estacado.

Although small quantities of water of relatively poor chemical quality are produced from sandstones in the Triassic "red beds" in local areas of the Portales Valley, and a part of the water pumped for irrigation along the extreme northern margin of the valley is produced from the Ogallala formation, most of the water produced for irrigation is obtained from valley-fill deposits of Quaternary age. These deposits occupy an erosional trough that was incised through the Ogallala formation and into the Triassic "red beds" in late Pliocene or early Pleistocene time. This trough is believed to have been cut by a major ancient stream that followed the present course of the Pecos River to the vicinity of Fort Sumner and then continued southeastward across what is now the Southern High Plains to the area in the vicinity of the present course of the Double Mountain Fork of the Brazos River in Texas. The headwaters of this stream were probably pirated by a northward extension of the present lower reach of the Pecos River in late Pleistocene time. Theis (1932) concluded that the valley

of this ancient stream must have had a topography similar to that of the present "Breaks in the Plains," with steep side slopes facing a broad flat valley on either side. He further concluded that at least the lower part of the valley fill, which consists largely of sand and gravel, was the result of stream deposition on the ancient valley floor. The remainder of the fill, which consists largely of silt and fine-grained sand, was considered by Theis to consist of an accumulation of waste and slump from the side slopes of the valley that the beheaded stream was unable to carry away. The accumulation of this waste and slumpage and subsequent smoothing by runoff and wind have been postulated as the principal factors in the development of the present valley form.

The shallow aquifer system that is present in the valley fill of the Portales Valley is bounded on the west by a ground-water divide located near the western limit of the Llano Estacado, and on the south by a definite hydraulic boundary that is defined by a line of approximate intersection of the water table with rocks of Triassic and perhaps Cretaceous age. The northern boundary of this aquifer system is essentially coincident with the northern physiographic boundary of the Portales Valley and between the northwestern part of Township 1 North, Range 34 East and the Texas-New Mexico state line is considered to very nearly coincide with the poorly defined crest of a ground-water divide that lies beneath the belt of sand dunes along and on either side of Blackwater Draw between the northern margin of extensive irrigation development in the Portales Valley and the southern boundary of extensive irrigation development in Curry County and the extreme northeastern part of Roosevelt County. The crest of this ground-water divide, in turn, is considered by the writers to be the

practical northern limit of the area in which water is produced wholly or in part from valley fill. Neither the position of this ground-water divide nor the position of the northern wedge edge of the valley fill is considered, however, to have any real hydraulic significance for the ground-water reservoir in the valley fill extends northward without interruption into contiguous sediments of the Ogallala formation in Curry County. The ground-water reservoir in the valley fill also extends eastward without interruption into Bailey County, Texas, where the hydraulic connection between the valley fill of the Texas portion of the ancient Portales Valley and the adjacent Ogallala formation is comparable to that existing in New Mexico. The part of the northern boundary of this aquifer system between the northwestern part of Township 1 North, Range 34 East and the approximate western limit of the Llano Estacado, in contrast, consists of a definite hydraulic boundary that is defined by a line of approximate intersection of the water table with rocks of Triassic age along the south side of an elongated, locally discontinuous, west-northwest to east-southeast trending "red bed high." This "red bed high" lies between nearly adjacent areas of irrigation development and locally divides the regional shallow ground-water reservoir into two separate and distinct aquifer systems. The water produced south of this "red bed high" is considered to be produced from valley fill and that produced north of this "red bed high" is considered to be produced from the Ogallala formation.

The eroded surface of rocks of Triassic or Cretaceous age that immediately underlie the valley fill in most of the Portales Valley and the Ogallala formation along the north side of the Portales Valley and in Curry County is considered to be the practical lower limit of permeable

sediments from which significant quantities of water can be produced for irrigation, municipal and industrial purposes.

Theis (1932, p. 143) considered the area of contributory drainage to the Portales Valley to cover an area of about 850 square miles and concluded (p. 144) that annual recharge to the valley's shallow aquifer system "may amount to 24,000 acre feet but is probably less." If his estimates are correct the recharge to this aquifer system can be considered to be in order of 0.5 inch per year or less. The average annual flow of ground water across the Texas-New Mexico state line approximately equals the average annual recharge to this aquifer system in New Mexico; therefore, virtually all of the water withdrawn for beneficial use in New Mexico is derived from ground-water storage.

The depth to the water table in the Portales Valley ranges from less than 10 feet to more than 140 feet and averages about 60 feet in most of the irrigated area. The depth to the top of the Triassic "red beds" ranges from 0 to more than 200 feet. Existing irrigation wells normally have specific capacities ranging from 10 to 50 gallons per minute per foot of drawdown and production capacities ranging from 50 to 1,500 gallons per minute. The average irrigation well in the valley has a specific capacity of about 20 gallons per minute per foot of drawdown and a production capacity of about 450 gallons per minute. Pumping lifts in existing irrigation wells ranged from 50 feet to 115 feet in 1960 and averaged about 84 feet. The average annual water-level decline in the irrigated area was 0.59 feet for the period of January 1956 through January 1961. The average annual water-level decline since January 1961 has not been determined.

The major part of the irrigation development in the valley is located in Township 1 North, Ranges 31, 32, and 33 East; Township 1 South, Ranges 32, 33, 34, and 35 East; Township 2 South, Ranges 33, 34, 35, 36, and 37

East; and Township 3 South, Range 35 East.

DEVELOPMENT OF IRRIGATION

Large scale irrigation farming had its beginning in the Portales Valley in about 1910 and, for all practical purposes, has continued to expand to the present time. Prior to 1910 many farmers irrigated small tracts with water pumped by windmills or in a few cases, by centrifugal pumps powered by gasoline engines, but it was not until the organization of the Portales Irrigation Company in 1910 that irrigation on a large scale is considered to have begun.

The Portales Irrigation Company was composed of local irrigators and was financed with bonds secured by mortgages on the irrigated lands. Following the organization of this company a centrally-located electric-power plant was constructed at Portales and 69 individual pumping plants were served in the present irrigated area. The power plant was designed to produce sufficient electricity to pump 30,000 acre feet during the growing season for the 10,000 acres that were included in the project, but the capacity of the plant was never reached and the planned acreage was never irrigated (Theis, 1932, p. 124). It is reported that an average of 4,000 acre feet of water per year was pumped from 1910 to 1914 (Baker, 1915, p. 90).

This initial attempt to irrigate on a large scale in the Portales Valley was unsuccessful. Few of the people involved in the project had had previous experience with irrigation -- attempts were made to irrigate too much land with one well and crops suitable to soil and climatic conditions were not ascertained -- and no ready markets for the produce were

available. The necessity of restricting individual irrigators as to the time when they could use power in order that the load on the central power station might be distributed also caused a great deal of dissatisfaction among the people involved in the project. As the result of these and other factors the project failed. The entire electric plant was dismantled and sold during World War I.

In 1919 the pumping plants in the valley were too few in number to be reported separately by the U. S. Census, but after a period of quiescence the practice of irrigation revived and began to expand in about 1925. The growth from this date was more normal, and by 1929 the U. S. Census reported that 166 pumping plants were in operation and 4,823 acres of land were irrigated. About 300 irrigation wells were in use in 1931 and about 8,850 acres were under irrigation. Approximately 22,000 acre-feet of water was pumped during the 1931 irrigation season.

The extent of irrigation development and irrigation pumpage in the valley each year from 1932 through 1966 has been estimated by the U. S. Geological Survey as follows:

<u>Year</u>	<u>Acres Irrigated^a</u>	<u>Irrigation Pumpage (acre-feet)</u>
1932	7,400	17,000
1933	5,650	13,000
1934	9,000	18,000
1935	10,000	20,000
1936	11,000	22,000
1937	11,000	22,000
1938	11,000	16,500
1939	13,000	19,500
1940	13,700	25,800
1941	15,000	9,750
1942	15,700	23,500
1943	17,000	45,000
1944	20,500	23,500
1945	22,000	37,500

<u>Year</u>	<u>Acres Irrigated</u> ^a	<u>Irrigation Pumpage</u> <u>(acre-feet)</u>
1946	24,500	37,000
1947	28,000	45,000
1948	32,000	37,000
1949	37,000	37,000
1950	43,000	52,000
1951	47,000	84,000
1952	48,000	82,000
1953	49,000	101,000
1954	50,000	108,000
1955	50,750	95,000
1956	51,250	100,000
1957	51,000	89,000
1958	51,000	70,000
1959	56,000	90,000
1960	56,000	75,000
1961	58,000 ^b	
1962	58,700 ^b	
1963	60,000 ^b	
1964	62,000 ^b	
1965	63,000 ^b	
1966	64,000 ^b	

a Estimate by U. S. Geological Survey unless otherwise indicated.

b Estimate by New Mexico State Engineer Office.

Approximately 66,000 acres of land were irrigated with water produced from about 1,626 wells in 1967.

DECLARATION AND EXTENSION OF BASIN

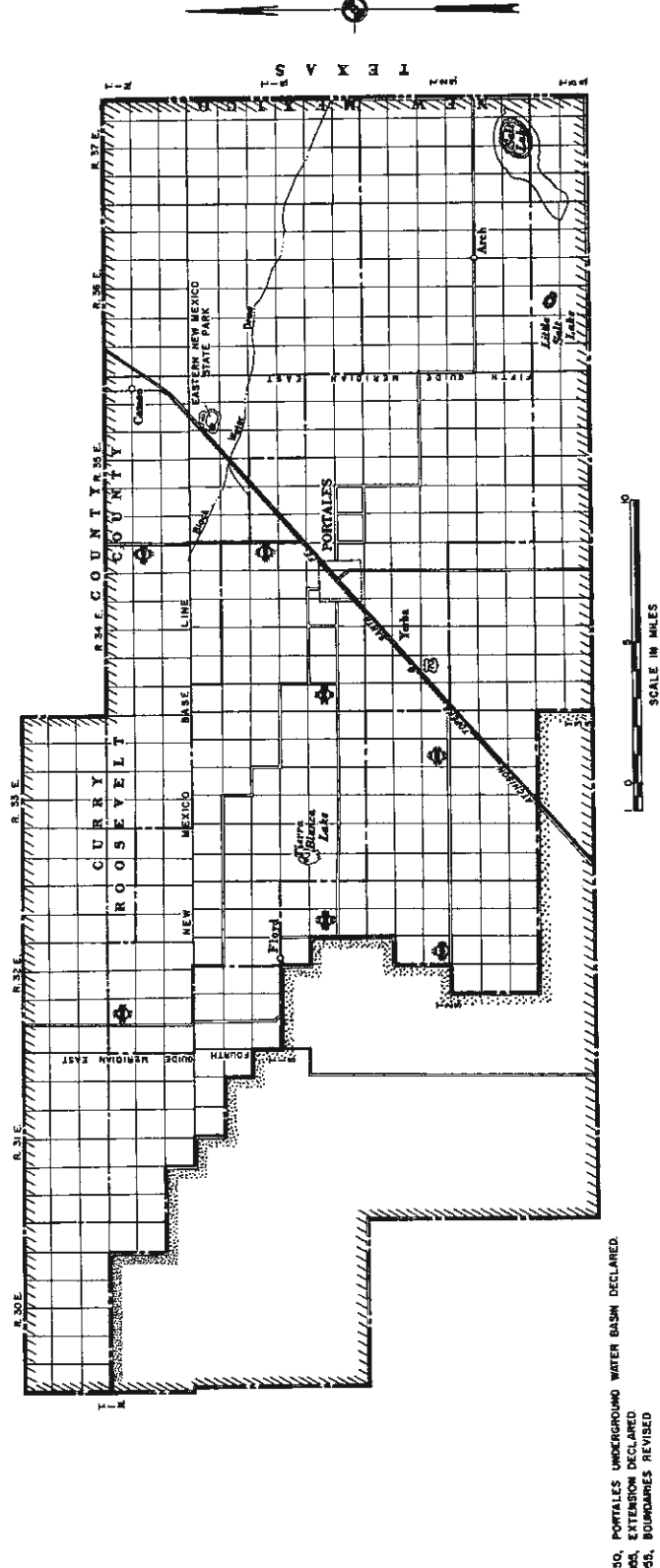
The Portales Valley Underground Water Basin was originally declared and bounded by Order No. 28 of the State Engineer dated May 1, 1950 and extended by Order No. 51, dated July 18, 1955, to include certain areas adjacent to the north and south boundaries of the previously declared basin. A subsequent State Engineer Order, No. 52, dated November 3, 1955, revised the boundaries of the southward extension of the basin to exclude an area southwest of the community of Floyd where the geological condi-

tions were such as to make it impractical to produce water from wells for other than stock and domestic use. Figure 1 shows the original boundaries, the extended boundaries, and the revised boundaries of the basin.

WATER-RIGHTS ADMINISTRATION

The supply of water available from the shallow aquifer system of the Portales Valley, as has been previously noted, is limited largely to stored water that has accumulated in this aquifer system over a period of several thousand years. It has also been noted that the large-scale pumping extant in the valley is essentially a mining operation that will ultimately reduce the available ground-water supply to the extent that irrigation will no longer be feasible. In attempting to find an equitable solution to the problems inherent to the administration of water rights under these conditions considerable effort has been devoted by the State Engineer to the development of a system of administration that provides a reasonable measure of protection to existing rights to water without unduly restricting the full economical utilization of existing water supplies in the basin. At the time of its declaration in 1950 no detailed quantitative data were available for the basin and applications to appropriate water were approved or denied solely on the basis of recorded historical changes in ground-water levels. Information was developed for the basin's shallow aquifer system from 1954 through 1956, however, that permitted the determination of the probable "life expectancy" of the ground-water supply in the central heavily developed part of the basin, and in 1967 investigations were completed that permitted the determination of either the "life expectancy" or the "life expectancy index" for the ground-water supply in all parts of the basin. The "life expectancy" or "life expectancy index" expresses the expected years of

MAP SHOWING DECLARED AREA PORTALES UNDERGROUND WATER BASIN



1950, PORTALES UNDERGROUND WATER BASIN DECLARED.
1955, EXTENSION DECLARED.
1955, BOUNDARIES REVISED.

- LEGEND**
- STATE LINE
 - COUNTY BOUNDARY
 - ORIGINAL BASIN BOUNDARY
 - EXTENDED BASIN BOUNDARY
 - REVISED BASIN BOUNDARY

Figure 1

continued large-scale pumping in established unit areas of the basin, and is the basis upon which applications for new appropriations of water are approved or denied by the State Engineer at the present time. The essential elements of the principal steps in the development of this system of water-rights administration are described in subsequent paragraphs.

Administration Based on Historical Changes in Water Levels

The store of available data pertaining to the ground-water supply of the Portales Valley at the time of its declaration in 1950 consisted principally of the conclusions and supporting records given by Theis (1932 and 1938), and the records collected by the U. S. Geological Survey subsequent to 1931 that are given in progress reports by Theis (1934 and 1939) and Conover and Akin (1942), and in the annual water-level reports of this federal agency. Although lacking in specific information on the quantity of water available from the valley's shallow aquifer system these reports provided ample evidence that a substantial part of the water pumped for irrigation and other purposes was being mined from ground-water storage. In recognition of this fact the State Engineer, upon designating a part of the valley as a declared ground-water basin, established definite administration criteria to prevent further expansion of irrigation development in areas where the rate of storage depletion was considered to be excessive. Inasmuch as measured changes in water levels constituted the only specific basin-wide records upon which a more or less localized control of rates of storage depletion could be based, the net recorded change in water levels from January 1940 to January 1950 was adopted by the State Engineer as being representative of the rate of storage depletion by existing pumping and

excessive rate of storage depletion was defined as a net water level decline of more than 2 feet during this period. Water was considered to be available for appropriation under this system of basin administration if the water-level decline experienced at the location of a proposed well between January 1940 and January 1950 was 2 feet or less. In cases, however, where a decline in water level of more than 2 feet had been experienced during this period the water supply was considered to be fully appropriated and the application to appropriate water from a well at that location was denied.

Initial System of Administration
Based on Life Expectancy of Water Supply

It was evident upon completion of the studies by Galloway (1956) and the subsequent determination of the quantity and areal distribution of ground water in storage that the extent to which water was available for continued pumping varied widely, and often abruptly, within the area in which subsurface and water-level data were then available. It was further evident that a recognition of these variations in actions on applications to appropriate water would provide a more reasonable and equitable basis for water-rights administration. In order that he might incorporate a consideration of these variations into a set of criteria for determining the quantities of water available for appropriation, the State Engineer replaced his heretofore described policy of approving or denying applications to appropriate water on the basis of change in water levels from 1940 to 1950 with a system of administration based on the concept of "life expectancy" of continued large-scale pumping in unit areas of the basin. This change in administrative criteria became effective on March 24, 1958.

The concept of "life expectancy" as adopted for use in this system of water-rights administration was based on the following assumptions:

(1) that the change in the water level at any particular point in the basin over a period of several years represents the total net effect of all natural and man-made forces acting upon the hydraulic system of the ground-water reservoir at that point during that period;

(2) that the average specific yield of the ground-water reservoir remains unchanged with depth and that the average rate of decline experienced at a point over a period of several years of pumping is comparable to the rate of decline that can be expected to continue at that point if the rate and distribution of pumping remain unchanged; and

(3) that the period over which large-scale pumping can be expected to be continued in an area of ground-water mining is largely a function of the rate of water-level decline and the extent to which the ground-water reservoir can be dewatered without substantial reductions in pumping rates.

It was apparent, upon consideration of the limitations of available data and the practicality of possible systems of administration, that any determination of "life expectancy" of continued large-scale pumping should be based upon average conditions within specified unit areas of the basin rather than upon conditions at sites of proposed wells. Although it was desirable to adopt a unit area as large as practicable for purposes of administration, it was also apparent, in consideration of the wide and often abrupt variations in the thickness of saturated sediments, that the area selected should be small enough to permit action on applications for

water on the basis of conditions in the general vicinity of proposed wells. It was further apparent that the boundaries of the selected area should coincide with established section lines of the New Mexico Rectangular Coordinate System so that the areas might be readily and explicitly defined for purposes of administration. To meet the need for a unit of area that met these requirements each township lying wholly or partially within the declared boundaries of the Portales Basin was divided into nine essentially square units of four sections each. The system of letter designations assigned to "administrative blocks" in each township in the basin is shown on Figure 2.

Upon establishing a workable system of administrative blocks, work was immediately initiated to determine, insofar as possible, the average annual water-level change, the average thickness of saturated sediments, and the extent of irrigated lands served from wells within the boundaries of each block. The period over which then existing large-scale pumping could be expected to continue was then computed for each individual block by the equation

$$LE = \frac{EST}{\Delta}$$

in which "LE" represents years of life expectancy of available water supply for the block as of January 1956; "EST" represents "average effective saturated thickness" of water-bearing sediments beneath the block, in feet, as of January 1956; and " Δ " represents the average annual historical water-level change beneath the block, in feet, between January 1950 and January 1956. The "average effective saturated thickness", as used in this equation, is equal to the "average saturated thickness" less 20 feet and is considered to be the maximum thickness of saturated sediments that can be effectively dewatered by continued large-scale pumping without substantial reductions

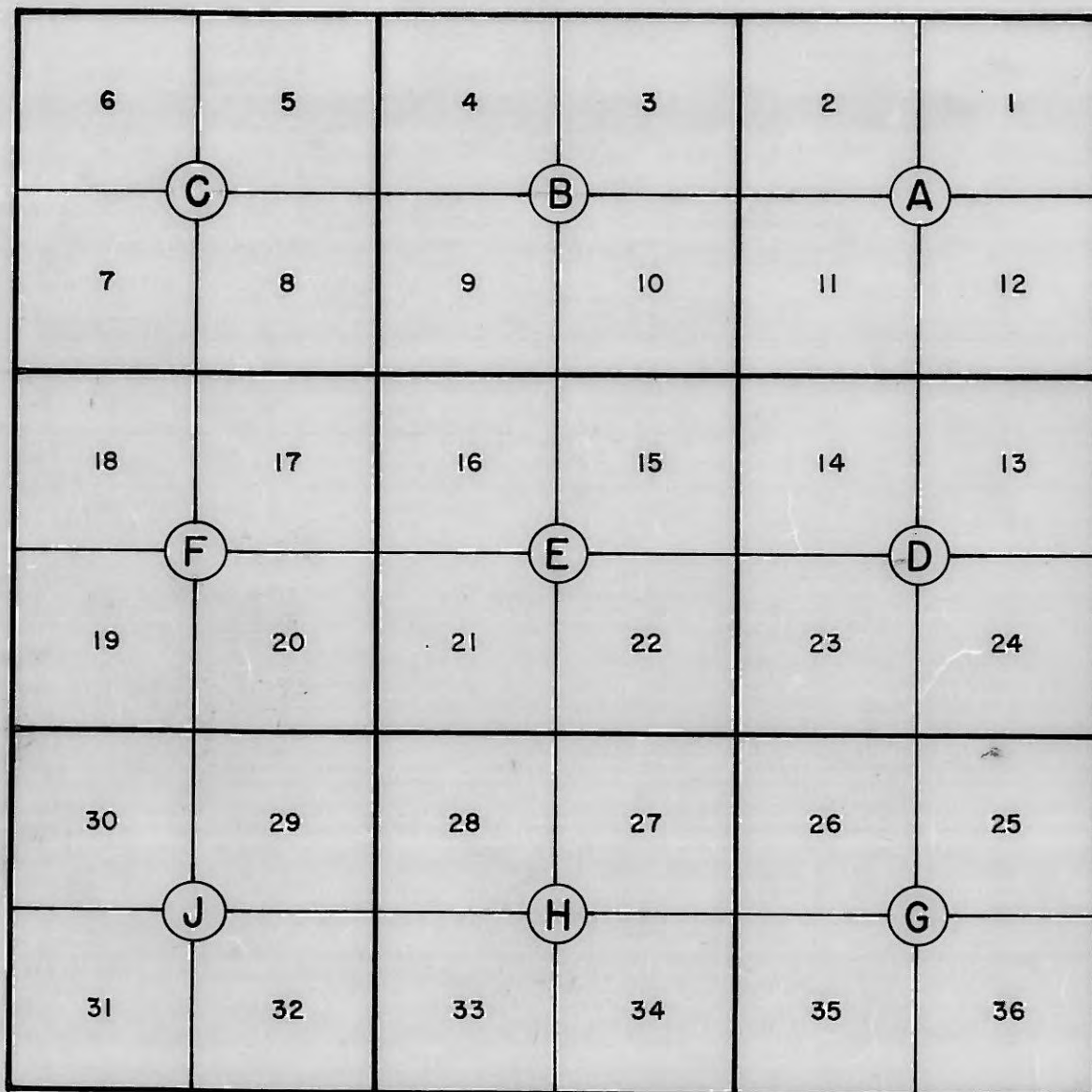


FIGURE 2. METHOD OF DESIGNATING ADMINISTRATIVE BLOCKS IN A TOWNSHIP, PORTALES VALLEY UNDERGROUND WATER BASIN.

in pumping rates. The average annual change in water levels from January 1950 to January 1956 was selected for use in this equation because of the relatively close correspondence of the average total irrigated acreage during this period with the total irrigated acreage at the close of the 1955 irrigation season. The average annual water-level change during this period was thus considered to be representative of the average annual water-level change to be expected in the future if the irrigation development in the basin as of the close of the 1955 irrigation season continued unchanged.

Upon adopting the concept of life expectancy of water supply in established administrative blocks actions were taken on applications to appropriate water in accordance with the following criterion:

The supply of water available to an administrative block was considered to be fully appropriated if the life expectancy for the administrative block or any of the four administrative blocks adjacent to its north, south, east and west boundaries was less than 40 years from 1956.

To reflect the effects of pumping for rights granted or developed subsequent to 1955 the life expectancy for each of the 5 blocks was adjusted by the equation

$$LE_a = \frac{(\text{Irrigated Acreage in 1955}) (LE)}{(\text{Existing Vested Rights}) + (0.90 \times \text{Existing Inchoate Rights})} \quad **$$

In this equation the term "LE" is the apparent life expectancy of the water supply available to an administrative block and the term "LE_a" is the probable

**For a time life expectancies were adjusted by the equation

$$LE_a = \frac{(\text{Irrigated Acreage in 1955}) (LE)}{(\text{Irrigated Acreage in 1955}) + (0.90 \times \text{Existing Inchoate Rights})}$$

The fact that considerable acreage with water rights was fallow in 1955 in some administrative blocks made it desirable to revise the denominator of this equation to reflect total rights in 1955 rather than acreage irrigated in 1955.

life expectancy as adjusted to reflect the effects of expected demands for water by all existing vested and inchoate rights in that block as of the date of filing of the application in question. These adjustments were made for each permit granted until a permit was granted that reduced the life expectancy of the water considered to be available to pumping in the block to less than 40 years. When this point was reached subsequently filed applications to appropriate water from that administrative block generally were denied.

Although the limitations of the above criterion provided the basis for action on most applications, exceptions were deemed necessary in some cases, particularly in cases of applications in areas of the basin where the life expectancy of the available water supply was relatively short because of a limited thickness of saturated sediments rather than an appreciable water-level decline. The fact that the subject administrative block or any of the four adjacent blocks had a life expectancy of less than 40 years was not considered cause for denial if there were no existing rights in the block having a life of less than 40 years. In such cases, however, the applicant was advised by reference to maps and other data of the probable shortness of life of the available water supply and the probable inefficiency of the proposed appropriation.

Interim System of Administration Based
On Life Expectancy of Water Supply

Following adoption of the concept of life expectancy of water supply as the basis upon which water rights would be administered, irrigation spread slowly throughout most of the administrative blocks in which water had been found to be available for appropriation, and by 1962 much of the

available water had been appropriated in the part of the basin for which historical water-level changes and other needed quantitative data were available. Applications were also being filed at this time to appropriate water in areas known to be underlain by sufficient water to permit the development of irrigation wells for which no water-level change data were available, and an increasing number of applications were being filed to appropriate water in areas where neither the volume of ground water in storage nor the historical rate of water-level decline was known. To facilitate action on applications for water in areas where the thickness of saturated sediments was unknown work was initiated in 1962 to extend, insofar as possible, the quantitative studies conducted in 1956 and 1957. Work was also initiated in 1962 to develop a more reasonable method for synthesizing the anticipated future effects of pumping that were not reflected in the then available records of water-level change. It became apparent during the course of these studies that the previously described criterion and the computations made in its application should be revised. To meet this need the State Engineer incorporated the following changes into his system of water-rights administration in August 1964:

(1) The total number of administrative blocks in which life expectancies would be considered in actions on applications to appropriate water was expanded from 5 to 9 by adding the blocks located northwest, northeast, southwest and southeast of the block in which the proposed well was to be located to the cross-like pattern of 5 blocks used in the previously described system of administration;

(2) January 1956 to January 1961 was adopted as the period on which average annual water-level changes would be based;

(3) Average annual water-level changes and average thicknesses of saturated sediments were determined on the basis of areas underlain by saturated sediments rather than total areas within the boundaries of administrative blocks;

(4) The projected total annual water-level change (Δ_T) in an administrative block was determined by calculating the average annual water-level decline to be expected in that block from pumping to satisfy rights granted subsequent to 1955 in that block and all of the 8 surrounding blocks, considering the local transmissibility of the shallow aquifer system, and adding the result to the average annual historical water-level change in the block;

(5) The term "life expectancy index" (LEI) was adopted to designate a life expectancy calculated by using a projected total average annual water-level change (Δ_T) rather than an average annual historical water-level change; and

(6) The "life expectancy" or "life expectancy index" for each administrative block was revised after each permit was granted to reflect the expected probable effects of all rights in that block and the 8 surrounding blocks as of the date of revision.

The concepts of "effective saturated thickness" (EST), "average annual water-level change" (Δ), and "life expectancy" (LE) of water supply available to pumping in a given administrative block in this system of administration were the same as has been defined in the discussion of the previously described system of administration. The size and method of designating

administrative blocks within each township in the basin was unchanged.

The group of administrative blocks in which life expectancies were considered in new applications for water was expanded from a total of 5 blocks to a total of 9 blocks to assess the effects of pumping in a given administrative block in a manner more reasonably consistent with the actual distribution of water-level declines in the vicinity of a discharging well.

January 1956 to January 1961 was adopted as the period on which average annual water-level changes would be based because (1) the average annual water-level changes in this period were believed to reflect, within reasonable limits, the average annual water-level changes to be expected in the future if irrigation development as of the close of the 1960 irrigation season continued unchanged; and (2) the mean annual precipitation at the climatological stations in the Portales Valley during this period was within 0.2 percent of a composite long-term mean obtained by averaging records of annual precipitation at all of these stations from the beginning of record through 1961.

The average annual water-level declines to be expected from pumping to satisfy rights granted subsequent to 1955 were computed with an equation developed by Theis (1935). This equation is based on the assumption that the flow of water in a porous medium is analogous to the flow of heat by conduction and that the mathematical theory of heat conduction is largely applicable to hydraulic theory. It is generally accepted and widely used by ground-water hydrologists and can be derived using hydraulic concepts directly.

In general, the rate at which the water table declines at any point within the cone of water-table depression that surrounds a pumping well

is dependent on the distance to the pumping well, the rate of discharge from the pumping well, the length of the period of pumping, the areal extent of the aquifer system, and the ability of the aquifer system to store and transmit water. The "coefficient of storage" expresses the quantity of water that can be removed from or placed into storage in a saturated material under field conditions and is defined as the volume of water that an aquifer releases from or takes into storage per unit of surface area of the aquifer per unit of change in the component of head normal to that surface. The ability of the aquifer to transmit water is expressed in terms of the "coefficient of transmissibility" which is defined as the number of gallons of water per day, at the prevailing temperature of the water, that are transmitted laterally through a section of the aquifer one mile in width when the hydraulic gradient is one foot per mile.

For purposes of computing future effects of pumping for this system of administration Theis' equation was expressed as

$$s = \frac{71.05}{T} Q W(u)$$

in which "s" is the lowering of the water table at a specified point in feet, "Q" is the anticipated discharge of the well in acre feet per year, "T" is the "coefficient of transmissibility" and "W(u)" is the "well function of u" that is determined from a type curve or published tables of the function "u". The value of "u" for a particular set of conditions was computed by the equation

$$u = \frac{142,830}{Tt} r^2 S$$

in which "r" is the distance to the pumping well in miles, "S" is the "coefficient of storage", "T" is the "coefficient of transmissibility", and "t" is the anticipated time the well will be pumped in years.

Data pertinent to the application of this equation that were available to the State Engineer as of 1964 indicated that:

(1) The average irrigation water requirement for crops grown in the valley was about 2.0 acre feet per acre;

(2) Approximately 25 percent of the water used for irrigation purposes was being lost to deep percolation;

(3) The "coefficient of storage" of the shallow aquifer system ranged from about 0.10 to about 0.20 but was usually in the order of 0.15 in most of the then irrigated area of the valley; and

(4) The "coefficient of transmissibility" of the shallow aquifer system varied widely in response to changes in the lithology and thickness of the sediments comprising the ground-water reservoir and ranged from as little as 30,000 in the northwestern, western, and extreme southern parts of the basin to as much as 125,000 near the Texas-New Mexico state line.

It was assumed for purposes of computing the required water-level declines that:

(1) All water pumped to satisfy rights granted subsequent to 1955 in a given administrative block would be derived from a single well located at the center of that block;

(2) The net average annual depletion of ground-water storage by pumping for irrigation purposes was 1.5 acre feet per acre irrigated;

(3) The "coefficient of storage" for the shallow aquifer system was 0.15; and

(4) The "coefficient of transmissibility" varied from area to area with changes in thickness of saturated sediments.

It was further assumed that pumping to satisfy rights granted subsequent to 1955 began in 1956 and would continue until 1996.

Upon establishing the probable "coefficient of transmissibility" of the shallow aquifer system in the vicinity of a given administrative block that contained rights granted subsequent to 1955, computations were made to determine the water-level declines that would be caused by pumping to satisfy those rights for 40 years at a point located 0.25 miles from the center of the subject block, at the corners of the subject block, and at the remaining corners of the eight surrounding blocks. The average water-level decline to be expected in the subject block as a result of the subject pumping was obtained by averaging the computed declines at its corners and the computed decline at a point 0.25 miles from its center. The average water-level decline to be expected in each of the eight surrounding blocks as a result of the subject pumping was obtained by averaging the computed declines at the corners of that block. Inasmuch as the computed average water-level decline in each of the nine blocks represented the effects of satisfying the cited rights for 40 years each average decline was divided by 40 to obtain a computed average annual water-level decline.

When the foregoing computations had been made for all rights granted subsequent to 1955 in all administrative blocks in the basin the total computed average annual water-level decline in any given block was determined by adding the average annual water-level decline produced in that block by pumping in each of the eight surrounding blocks to the average

annual water-level decline produced by pumping in the block itself. The resulting value was added to the average annual historical water-level change in the block to obtain " Δ_T ", which has been previously defined. " Δ_T " was then divided into the average effective thickness of saturated sediments (EST) in the subject administrative block to determine its "life expectancy index" (LEI).

Except for adopting the parameter "life expectancy index" (LEI) and increasing from 4 to 8 the number of adjacent administrative blocks in which "life expectancy" (LE) or "life expectancy index" (LEI) was considered in determining the availability of water for appropriation in any given block the basic criterion for determining the availability of water for appropriation was unchanged from the previous system of water-rights administration.

Present System of Administration Based On Life Expectancy of Water Supply

The adoption of January 1956 to January 1961 as the period upon which average annual historical water-level changes (Δ) would be based in August 1964, and the continued extension of quantitative studies in the basin as additional basic data became available facilitated action on most applications for water filed prior to July 1964. Beginning in July 1964, however, the number of applications seeking water from the sand dunes area east and northeast of the City of Portales began to increase and by the end of December 1964 applications had been filed to appropriate water for about 30,000 acres of previously undeveloped land in this area. Applications were also filed during this period to appropriate supplemental water from this area for 35,000 acres of existing irrigated land located outside the sand dunes area. Additional applications were also filed during and immediately

following this period to appropriate water from areas in the extreme western part of the basin into which quantitative studies had not been extended. To facilitate action on these applications work was initiated to develop detailed quantitative data for areas not covered by previous quantitative studies. Work was also initiated to update and revise the findings of all previously conducted quantitative studies to the extent of the then known available basic data. The Bureau of Reclamation's investigation of the availability of supplemental water for existing rights in the basin was conducted concurrently with this work. Upon completion of these studies the State Engineer incorporated the following modifications into his system of water-rights administration in November 1967.

(1) The basin, for purposes of determining the quantity of water available for appropriation, was divided into three areas: (a) the "Western Area", consisting of that part of the basin lying in Range 30 East and the western one-third of Range 31 East; (b) the "Central Area", consisting of that part of the basin lying in the eastern two-thirds of Range 31 East and Ranges 32, 33 and 34 East; and (c) the "Eastern Area", consisting of that part of the basin lying in Ranges 35, 36 and 37 East.

(2) In the "Western Area" the water-level declines to be expected from pumping to satisfy rights existing as of October 1, 1967 were computed with the Theis equation to provide a substitute for historical water-level change records;

(3) In the "Eastern Area" the number of administrative blocks to which the 40-year life expectancy criterion is applied was increased from 9 to 25;

(4) The "coefficient of storage" was increased from 0.15 to 0.20;

(5) The "coefficient of transmissibility" was considered to be 40,000 gpd/ft in the "Western" and "Central" areas and 100,000 gpd/ft in the "Eastern Area";

(6) The net average annual depletion of ground-water storage by pumping for irrigation purposes was decreased from 1.5 to 1.29 acre feet per acre irrigated; and

(7) In the "Eastern Area" the water-level declines to be expected from pumping to satisfy rights existing as of December 31, 1961 were calculated from analog data developed by the Bureau of Reclamation.

No changes were made in the concepts of "effective saturated thickness" (EST); "average annual historical water-level change" (Δ); "life expectancy" (LE); "life expectancy index" (LEI); or the size or method of designating administrative blocks within each township of the basin. The method of computing the water-level declines to be expected from pumping to satisfy rights granted subsequent to 1955, and the period of record upon which average annual historical water-level changes (Δ) were based were also unchanged.

The basin was divided into three separate areas under this system of administration to provide a reasonably consistent and equitable basis for determining quantities of water available for appropriation in all areas of the basin.

The revised average values assigned to the storage coefficient and the net average annual depletion of ground-water storage by pumping for irrigation

purposes were developed by the Bureau of Reclamation during their investigation of the availability of supplemental water for existing rights in the valley.

It was assumed for purposes of computing the average annual water-level declines to be expected from 1956 to 1996 in the "Western Area" that the average coefficient of transmissibility (T) of the ground-water reservoir in this part of the basin was 40,000 gpd/ft, that the average coefficient of storage (S) was 0.20, and that the net average annual depletion of ground-water storage by pumping for irrigation was 1.29 acre feet per acre irrigated. It was further assumed that the average annual water-level decline computed for any given administrative block (Δ_C) would be equal to the sum of the average annual decline produced in that block by pumping to satisfy existing rights in the 48 surrounding blocks and the average annual decline produced by pumping to satisfy existing rights in the block itself. With the aquifer coefficients characteristic of the western part of the valley 86 percent of the water pumped from an administrative block in a period of 40 years is taken from storage beneath that block and the 48 surrounding blocks. A lack of water-level change data, upon which projections of future effects of pumping to satisfy then existing rights could be based, made it necessary to compute these average annual water-level declines. The method employed to compute the average annual decline in each administrative block (Δ_C) was similar in all other respects to the method employed to compute the average annual declines for the previously discussed 9-block system of administration.

The method used to compute total average annual water-level changes in the "Central Area" caused by pumping to satisfy existing rights (Δ_T) was identical to the method employed in the previously used system of

administration. All previously used water-level declines were recalculated to reflect the adopted change in the coefficient of storage and the adopted change in the net average annual depletion of ground-water storage by pumping for irrigation purposes. It was assumed, for purposes of computing the latter declines, that the average value of the coefficient of transmissibility in this part of the basin was 40,000 gpd/ft.

The water-level declines that would occur in the "Eastern Area" from pumping to satisfy recently granted rights were computed with the Theis equation. It was assumed for purposes of computing these declines that the average coefficient of transmissibility (T) of the ground-water reservoir in this part of the basin was 100,000 gpd/ft, that the average coefficient of storage (S) was 0.20, and that the net average annual depletion of ground-water storage was 1.29 acre feet per acre irrigated. It was further assumed that the average annual water-level decline to be expected from this pumpage in any given administrative block would be equal to the sum of the average annual decline produced in that block by pumping to satisfy recently granted rights in the 24 surrounding blocks and the average annual decline produced by pumping to satisfy recently granted rights in the block itself. A group of 25 administrative blocks was adopted for these computations to provide an area in which the volume of saturated sediments expected to be dewatered under a given set of pumping conditions would duplicate, within reasonable limits, the volume of saturated sediments that would be expected to be dewatered under a similar set of pumping conditions in a group of 9 blocks in the "Central and Western Areas" of the basin where the coefficient of transmissibility is in the order of 40,000 gpd/ft rather than 100,000 gpd/ft.

The method used to compute the total average annual water-level changes that would occur in the southern and western parts of the "Eastern Area"

where representative historical water-level change data were available (Δ_T) was identical to the method employed in the previously used 9-block system of water-rights administration. All previously used water-level declines resulting from pumping to satisfy rights granted subsequent to 1955 were recalculated to reflect the effects of pumping in the increased number of surrounding administrative blocks, the adopted changes in the hydraulic coefficients of the shallow aquifer system, and the adopted change in the net average annual depletion of ground-water storage by pumping for irrigation purposes.

The remainder of the "Eastern Area" consists largely of the essentially undeveloped "sand dunes area" in the northeastern part of the basin. In this area the total average annual water-level declines (Δ_{aT}) were determined by adding the computed average annual water-level declines resulting from pumping to satisfy rights granted subsequent to 1961 to an average annual water-level change derived from electric analog data developed by the U. S. Bureau of Reclamation. The Bureau data represented the distribution and magnitudes of the total water-level declines to be expected to the year 2000 from pumping to satisfy rights existing as of December 31, 1961 in parts of the Portales Valley and contiguous areas of Parmer and Bailey Counties, Texas and Curry County, New Mexico. The parameters employed in the computation of average annual water-level declines to be expected in this area from pumping to satisfy rights granted subsequent to 1961 were identical to those used to compute such effects in the part of the "Eastern Area" where representative historical water-level changes were available.

The "life expectancy index" (LEI) for administrative blocks in the "Western", "Central", and "Eastern" areas of the basin were determined by

dividing the "average effective thickness of saturated sediments" (EST) by " Δ_C ", " Δ_T ", and " Δ_T " or " Δ_{gT} ", respectively.

The basic criteria for determining the availability of water for appropriation in a given administrative block under this system of water-rights administration is as follows:

(1) In all areas of the basin the supply of water available to an administrative block with less than 40 years of life expectancy from the year 1956 is considered to be fully appropriated;

(2) The supply of water available to an administrative block with more than 40 years of life expectancy in the "Western" or "Central" areas of the basin is considered to be fully appropriated if the life expectancy for any of the 8 surrounding administrative blocks is less than 40 years; and

(3) The supply of water available to an administrative block with more than 40 years of life expectancy in the "Eastern Area" of the basin is considered to be fully appropriated if the life expectancy for any of the 24 surrounding administrative blocks is less than 40 years.

Applications to appropriate water from administrative blocks in any of these categories are generally denied. The cited criteria for denial may be waived, however, if the block (or blocks) that might otherwise constitute a basis for denying an application for water contains no rights.

The changes in ground-water levels that occurred in the basin from January 1956 to January 1961 and the thickness and distribution of saturated post-Mesozoic sediments that existed in the basin as of January 1962 are shown on Figures 3 and 4, respectively. Figure 5 shows the probable life

expectancy of continued large-scale pumping ("LE" or "LEI") in years from 1962 as well as other specific data for each administrative block. Figure 6 shows the locations of large-capacity wells and the distribution and status of irrigation development in the part of the basin lying in Ranges 31 through 37 East as of 1967.

Two wells had been drilled and approximately 260 acres of land had been placed under irrigation as of 1967 in the part of the basin not covered by Figure 6. The latter development is located in the NW $\frac{1}{4}$ of Section 5 and the NE $\frac{1}{4}$ of Section 6, Township 1 North, Range 30 East.

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Map

Figure 3

Change in ground-water levels
in Patales Valley

Roswell - Curry Counties
New Mexico

January 1956 to
January 1961

Map

Figure 1-

Saturated thickness of
Post-Mesozoic deposits in the
Portales underground-water basin
Roosevelt and Curry Counties
New Mexico

January 1962

Map
Figure 5

Life expectancy and Life expectancy
indices for administrative blocks
in the Pinalos underground
water basin

Roosevelt - Curry Counties

1962

Map

Figure 6

Well in irrigated land in
Parts Curry, Quay + Roosevelt
Counties, New Mexico

1967