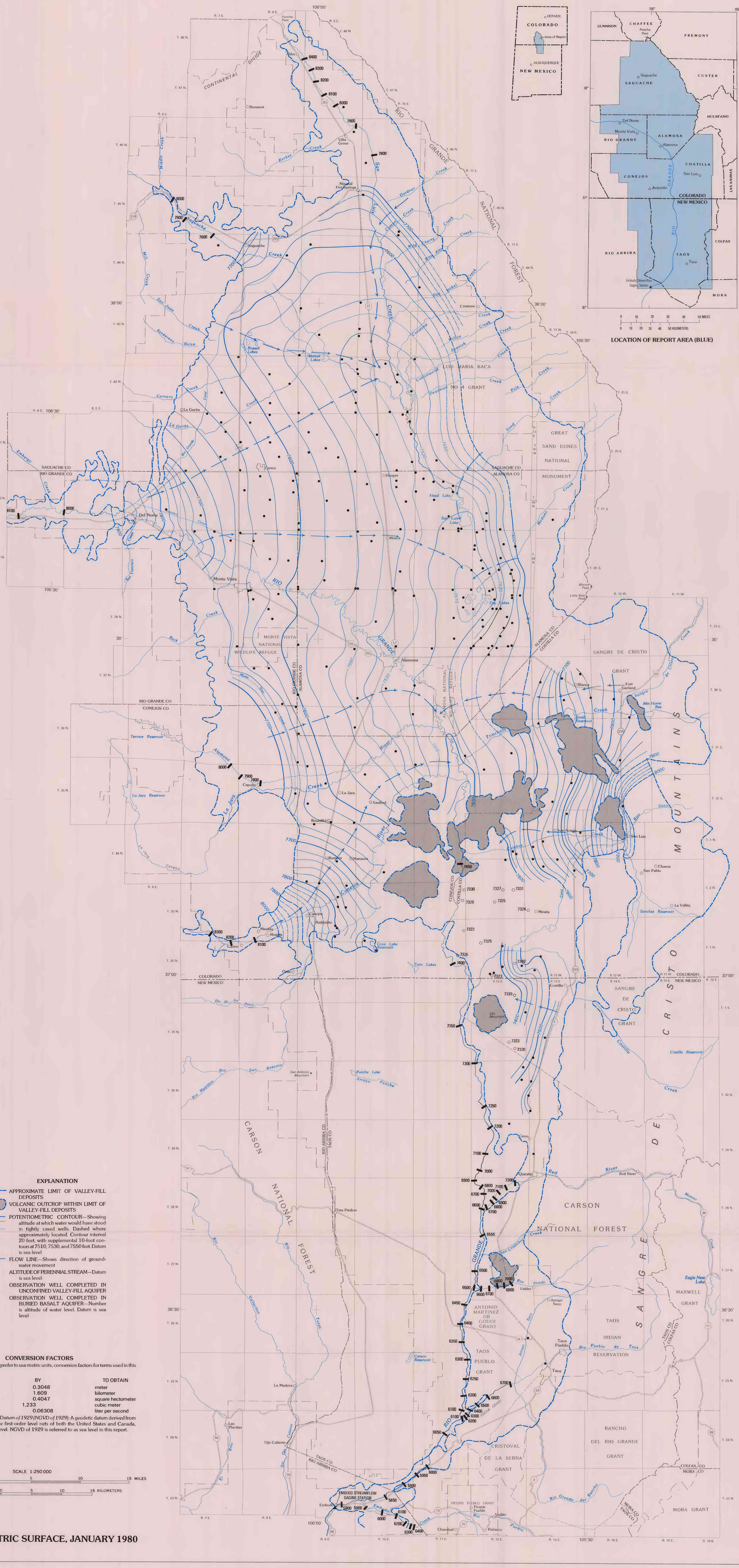


LOCATION OF REPORT AREA (BLUE)

POTENTIOMETRIC SURFACE, JANUARY 1980

EXPLANATION

- APPROXIMATE LIMIT OF VALLEY-FILL DEPOSITS
- VOLCANIC OUTCROP WITHIN LIMIT OF VALLEY-FILL DEPOSITS
- 7800 / 7530 POTENTIOMETRIC CONTOUR—Shows altitude at which water would have stood in tightly cased wells. Dashed where approximately located. Contour interval 20 feet, with supplemental 10-foot contours at 7510, 7530, and 7550 feet. Datum is sea level
- FLOW LINE—Shows direction of ground-water movement
- 7100 ALTITUDE OF PERENNIAL STREAM—Datum is sea level
- OBSERVATION WELL COMPLETED IN UNCONFINED VALLEY-FILL AQUIFER
- 7330 OBSERVATION WELL COMPLETED IN BURIED BASALT AQUIFER—Number is altitude of water level. Datum is sea level

CONVERSION FACTORS

For use of readers who prefer to use metric units, conversion factors for terms used in this report are listed below:

MULTIPLY	BY	TO OBTAIN
foot	0.3048	meter
mile	1.609	kilometer
acre	0.4047	square hectometer
acre-foot	1,233	cubic meter
gallon per minute	0.06308	liter per second

National Geodetic Vertical Datum of 1929 (NGVD of 1929): A geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called mean sea level. NGVD of 1929 is referred to as sea level in this report.

SCALE 1:250 000

5 0 5 10 15 MILES

5 0 5 10 15 KILOMETERS

INTRODUCTION

In 1978, the U.S. Geological Survey initiated a number of regional aquifer-systems analyses (RASA), one of which is a study of the Southwest alluvial basins (SWAB). The SWAB (east) area includes a series of basins in the Rio Grande drainage and adjacent closed basins in Colorado, New Mexico, and Texas. The planning report for the SWAB (east) study (Wilkins and others, 1980) sets forth the purpose and scope of the study and provides general information on the physiography, geohydrology, and other aspects of the area.

This report describes the 1980 potentiometric surface and the 1969–80 water-level changes in the unconfined valley-fill aquifer of the San Luis Basin in Colorado and New Mexico. Also included are some water levels from wells completed in buried basalt flows that, although not usually considered as valley fill, constitute unconfined aquifers in the southern part of the basin. The San Luis Basin is the northernmost alluvial basin of the Rio Grande drainage, extending from Poncha Pass in northeastern Saguache County, Colorado, to the Embudo constriction, about 20 miles southwest of Taos, New Mexico. At Embudo, the alluvial basin is less than 1 mile wide. The part of the basin in Colorado is known as the San Luis Valley, and the part in New Mexico is known as the Sunshine Valley.

Emery and others (1971; 1973) have described the geohydrologic system of the San Luis Valley, and Winograd (1959) has described that of the Sunshine Valley. The limits of the alluvial basin and volcanic outcrop areas shown on the maps in this report were compiled from the following geologic maps: for Colorado, Johnson (1969), Scott and others (1978), Steven and others (1974), and Tweto and others (1976); for New Mexico, Bingler (1968), Dane and Bachman (1965), Kelley (1978), Manley and Scott (1978), and McKinlay (1955; 1957).

Most water-level data used in compiling the maps of this report were collected by the U.S. Geological Survey. Some data for Colorado were collected by the Rio Grande Water Conservation District. A report by Emery and others (1972) presents well data and water levels for 1967–70. Most of these data are stored in the U.S. Geological Survey's Water Data Storage and Retrieval system (WATSTORE); inquiries may be directed to the U.S. Geological Survey, Water Resources Division, Mail Stop 415, Box 25046, Denver Federal Center, Lakewood, CO 80225. Some data for selected wells completed in basalts were reported by Zorich-Erker Engineering (1980).

POTENTIOMETRIC SURFACE

A potentiometric surface (Lohman and others, 1972, p. 11) represents the static head in an aquifer. The January 1980 potentiometric-surface map of the San Luis Basin (sheet 1) is based on water-level measurements in 258 wells. A similar map for the San Luis Valley was compiled by Emery and others (1973, pl. 1) for December 1969. Although they refer to the contoured surface as a "water table," current usage of that term is more restrictive. A water table is a particular potentiometric surface in an unconfined aquifer, at which the pressure is atmospheric. The wells in which water levels were measured in 1969 and 1980 are open to various depth intervals in the unconfined aquifer and thus define a potentiometric surface rather than a water table.

In compiling both the 1969 and 1980 maps, potentiometric contours were made to coincide with corresponding perennial-stream altitudes at stream-contour crossings. This method of contouring assumes that flow in the perennial streams is adequate to maintain water levels in the adjoining aquifer at the altitude of the streambed or that ground water from the aquifer is discharging to the stream. Perennial-stream altitudes are also shown, in areas not contoured, by means of short transverse bars. Areas where volcanic rocks are at land surface within the valley-fill aquifer area are not contoured due to lack of water-level data and unknown hydrologic relationships to the unconfined alluvial aquifer.

Ground-water movement is at right angles to the potentiometric contours in the direction of decreasing head. Near streams, flexures of contours indicate whether ground water is moving toward or away from the streams. Flexures in an upstream direction, such as along the Rio Grande 2 to 5 miles northwest of Alamosa, Colorado, indicate that ground water flows toward, and discharges into, streams. Flexures in a downstream direction, such as along the Rio Grande between Del Norte and Monte Vista, Colorado, indicate flow moving away from streams into the aquifer.

The general flow pattern in the unconfined aquifer of the San Luis Basin is from the basin perimeter along the mountains on the east and west toward the central north-south axis of the valley. In the northern part of the basin, north of the Rio Grande and the Alamosa-Costilla County line, ground water is discharged by withdrawals from wells and by evapotranspiration from crops and native vegetation. In the southern part of the basin, similar mechanisms account for part of ground-water losses, with the remainder discharging into streams.

The general pattern of ground-water flow in the unconfined aquifer has not changed since 1969. However, a significant change has occurred in the area of the Rio Grande fan, north of the Rio Grande between Del Norte and Monte Vista, Colorado. The December 1969 water-table map indicated that the area was a closed basin at that time and received no ground-water inflow. However, lowering of water levels in the fan from 1969 to 1980 has developed a gradient to the northeast from the Rio Grande, as indicated on the 1980 potentiometric-surface map by the downstream flexures of contours along the north side of the Rio Grande and the arrows showing flow direction. This change in flow pattern in the unconfined aquifer indicates that the closed basin of 1969 is no longer closed with respect to inflow, and that water is moving from the Rio Grande into the unconfined aquifer in the Rio Grande fan.

Buried basalt flows are a significant source of water to some wells in southern Costilla County, Colorado, and northern Taos County, New Mexico. Winograd (1959, p. 27) discussed the occurrence of water in volcanic flows and showed that hydraulic heads were lower than in the overlying alluvium. A few water levels in wells completed in the shallowest buried basalt aquifer in the area are shown on the 1980 potentiometric-surface map but these are not contoured. These water levels, measured during 1977–80, indicate that the potentiometric head in the basalt is lower than in the unconfined alluvium in surrounding areas, and is also lower than the nearby perennial streams.

WATER-LEVEL CHANGES

The water-level-change map shown on sheet 2 illustrates the approximate areal extent of water-level changes from December 1969 to January 1980 in the unconfined valley-fill aquifer of the San Luis Basin. This map was constructed using data from 138 wells in which water levels were measured at the beginning and end of the 10-year period.

The change in the volume of water stored in the unconfined aquifer, based on an estimated storage coefficient of 0.20 (Emery and others, 1973, p. 14), was a net decrease of about 880,000 acre-feet. In areas of water-level rise, the increase in water in storage was about 50,000 acre-feet. In areas of decline, the decrease was about 930,000 acre-feet. There was a decrease of water in storage of about 450,000 acre-feet in the Rio Grande fan and a decrease of about 140,000 acre-feet in northwestern Costilla County. In other areas where water-level declines of 5 to 10 feet occurred, there was a decrease in storage of about 110,000 acre-feet. The remaining 230,000 acre-feet of storage decrease was in areas where declines were less than 5 feet. The area of water-level rise in northern Taos County accounted for about 45,000 acre-feet of the increase in water storage.

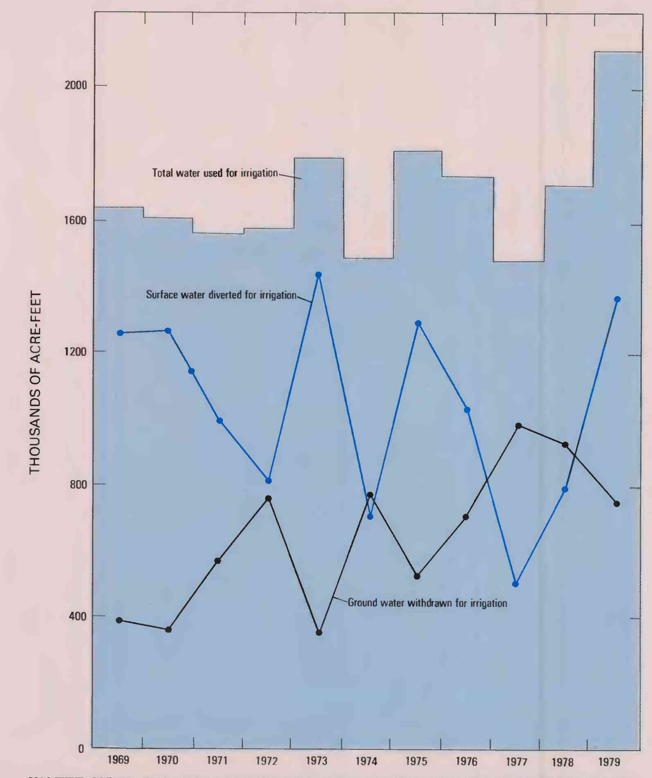
There are several factors that may have contributed to the general water-level decline in the San Luis Valley during the 1970's. These include an increase in ground-water withdrawals from the unconfined aquifer for irrigation of an expanded acreage and a decrease in surface-water diversion with a resultant decrease in ground-water recharge. The following discussion of these factors is limited to the San Luis Valley in Colorado; the pertinent data are not available for the Sunshine Valley.

The irrigated acreage for row crops, small grains, and cut hay in the San Luis Valley showed a net increase of 14 percent from 1970 through 1979 (Colorado Department of Agriculture, 1972; 1979; 1980). The acreage of irrigated pastureland, though significant, is unknown. Therefore, changes in total irrigated acreage in the valley are unknown.

Surface-water diversions, which correlate closely with surface-water inflow, showed a decreasing trend during the 1970's. Annual surface-water diversions were compiled from records of the Colorado Division of Water Resources, Department of Natural Resources.

Ground-water withdrawal for irrigation showed an increasing trend through the 1970's. Annual total ground-water withdrawal for the San Luis Valley was estimated from irrigation-well power-use data furnished by the San Luis Valley Rural Electric Cooperative and the Public Service Company of Colorado. Data were not available to determine withdrawal from the unconfined aquifer only. The number of large-capacity wells in the San Luis Valley increased during the 1970's. Emery and others (1971) reported that in 1967 there were about 2,800 wells in the valley that yielded more than 300 gallons per minute. A tabulation of "Colorado State Engineer Registered Wells—January, 1979" lists about 3,700 such wells.

The graph below illustrates the trends in surface-water diversions and ground-water withdrawal for irrigation in the San Luis Valley.



WATER USED FOR IRRIGATION IN THE SAN LUIS VALLEY, COLORADO—Blue and black dots represent annual surface- and ground-water use; connecting lines illustrate trends and do not imply intermediate values

In years of decreased surface-water diversion, ground-water withdrawal increased. However, during the 1970's, ground-water withdrawal increased more than surface-water diversion decreased, resulting in an increase in total water used for irrigation. The following are averages of water used annually for irrigation, in thousands of acre-feet:

Source	1969–74	1975–79
Surface water	1,076	997
Ground water	531	773
Total	1,607	1,770

In summary, there has been a general decline in water levels in the unconfined alluvial aquifer of the San Luis Valley. The probable causes for this decline are an increase in withdrawal from the unconfined aquifer, an increase in irrigated acreage, and a decrease in surface-water diversion.

The water-level rise that occurred in northeastern Taos County during the 1970's probably resulted primarily from increased runoff and recharge in the latter 1970's. Discharge records for streams in the vicinity of the rise show that average runoff for 1975–79 was about 19 percent greater than for 1969–74. Other factors may have contributed to the rise, but no pertinent data are available.

HYDROGRAPHS

Representative hydrographs are presented to show the rate of change of water levels in selected wells. These wells were selected from irrigated and non-irrigated areas, and recharge and discharge areas; they include wells completed at a wide range of depths. The water-level-change patterns and magnitudes vary greatly, but several trends are apparent. Most wells show an overall decline in water level during 1969–80, with greatest declines in areas most intensely irrigated. Well hydrographs for the Rio Grande fan and vicinity generally show rises in years of increased surface-water diversion and declines in years of decreased diversion, but have an overall downward trend as a result of increasing ground-water use. In the northwest corner of Costilla County, where a group of wells was installed in the mid-1970's, there was a steady decline of about 24 feet in one well from 1972 to 1980. There are no irrigation ditches in the area and seldom any surface runoff to provide recharge. Therefore, withdrawal for irrigation has lowered the potentiometric surface in the area, with no net recovery even in wet years.

Several hydrographs are presented for wells that are measured monthly or bi-monthly. These show various patterns and magnitudes of water-level changes that occur within a year in response to natural and man-induced recharges and withdrawals. The blue lines on two of the hydrographs show the annual hydrographs for comparison with the monthly hydrographs. The differences show that the lines connecting winter measurements on the annual hydrographs only illustrate water-level-change trends and patterns and do not indicate the actual water level at any time other than on the measurement date.

The downward water-level trend observed on most hydrographs during December 1969 to January 1980 will not necessarily continue. Changes in climate or irrigation practice may result in different trends than those measured during this period.

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Base modified from U.S. Forest Service
½"=1 mile series maps, Colorado and New Mexico

INTERIOR—GEOLOGICAL SURVEY, RESTON, VA—1985—W84195

POTENTIOMETRIC SURFACE, 1980, AND WATER-LEVEL CHANGES, 1969–80, IN THE UNCONFINED VALLEY-FILL AQUIFERS OF THE SAN LUIS BASIN, COLORADO AND NEW MEXICO

By
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1985

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