STATE OF UTAH
DEPARTMENT OF NATURAL RESOURCES

Technical Publication No. 103

HYDROLOGY OF THE SEVIER-SIGURD GROUND-WATER BASIN AND OTHER GROUND-WATER BASINS, CENTRAL SEVIER VALLEY, UTAH

By P.M. Lambert, J.L. Mason, and R.W. Puchta

Prepared by the
United States Geological Survey
in cooperation with the
Utah Department of Natural Resources
Division of Water Rights
1995

CONTENTS

Abstract. 1
Introduction 1
Purpose and scope 3
Previous investigations 3
Description of study area 5
Geology 5
Surface-water hydrology of the Sevier-Sigurd basin 7
Sevier River and its tributaries 7
Canals and ditches 9
Ground-water hydrology of the Sevier-Sigurd basin 9
Occurrence 9
Unconfined zones 15
Confined zones 15
Aquifer characteristics and storage 15
Recharge 20
Infiltration of precipitation 20
Seepage from canals 20
Seepage from the Sevier River and other perennial and ephemeral streams 21
Inflow from consolidated rock and seepage from irrigated fields 23
Subsurface inflow from basin fill 24
Movement 25
Water-level fluctuations 25
Seasonal fluctuations 26
Long-term fluctuations 29
Discharge 29
Seepage to the Sevier River 29
Evapotranspiration 33
Alluvial springs 35
Wells 35
Drains 36
Subsurface outflow 37
Hydrologic budget of the ground-water system 37
Water quality in the Sevier-Sigurd basin 37
Surface-water quality 37
Chemical composition 37
Ground-water effects 39
Changes in surface-water quality with time 43
Ground-water quality 44
Chemical composition 44
Changes in ground-water quality with time 49
Isotopic data and interpretations 50
Hydrology of other basins in the central Sevier Valley 52
Junction-Marysvale basin 53
Northern basins 54
Surface water 54
Ground water 55
Water quality 58
Simulation of the ground-water system, Sevier-Sigurd basin 60

CONTENTS—Continued

Design and development of the computer model 60
Discretization of ground-water system 60
Boundary conditions and data requirements 60
No flow 63
Recharge 63
Discharge 65
Hydraulic properties 70
Model calibration 72
Steady-state calibration 72
Method 72
Results of calibration 72
Transient calibration 75
Transient calibration using annual recharge rates for 1957-88 75
Method 75
Results of 1957-88 annual calibration 83
Transient calibration using monthly recharge rates for 1958-59 87
Method 87
Results of 1958-59 monthly transient calibration 89
Particle-tracking analysis 96
Sensitivity analysis 97
Limitations of model 100
Predictive simulations 100
Need for future study 101
Conclusions 104
References cited 107

PLATE

[Plate is in pocket]

Plate 1. Map showing potentiometric surface of the principal ground-water reservoir for the shallow confined zone for September 1988, location of geohydrologic-data sites, areal extent of basin fill, and outcrop of Arapien Shale, central Sevier Valley, Utah

FIGURES

1. Map showing location and physiographic setting of the study area 2
2. Diagram showing numbering system for data sites in Utah 4
3. Map showing streams and canals in the Sevier-Sigurd basin 8
4. Map showing approximate area of confined zones and primary recharge areas in the Sevier-Sigurd basin 16

5-7. Lithologic diagrams showing correlation of zones in the basin-fill aquifer:
5. From northwest to southeast in the northern part of the Sevier-Sigurd basin 17
6. From northwest to southeast in the north-central part of the Sevier-Sigurd basin 18
7. From south to north along the axis of the Sevier-Sigurd basin 19

8. Map showing gaining and losing reaches of the Sevier River in the Sevier-Sigurd basin 22
9. Generalized section showing ground-water movement in the confined zones, Sevier-Sigurd basin.. 26
10. Generalized section showing ground-water movement in the shallow water-table zone, Sevier-Sigurd basin 27

FIGURES—Continued

11. Graph showing relation between monthly diversions from the Sevier River and Clear Creek, and departure from average water levels in wells (C-24-3)34cdb-1 and (C-24-2)7bac-1 27

12-15. Hydrographs showing:

12. Seasonal water-level fluctuations in wells completed in the unconfined zones of the ground-water system, Sevier-Sigurd basin 28

13. Seasonal water-level fluctuations in wells completed in the shallow and deep confined zones of the ground-water system, Sevier-Sigurd basin 30

14. Seasonal water-level fluctuations for 1958-60 in a well completed in the shallow confined zone, and for 1987-89 in a well completed in the same zone, Sevier-Sigurd basin 30

15. Long-term water-level fluctuations in wells completed in the deep and shallow confined zones of the ground-water system, Sevier-Sigurd basin 31

16. Graphs showing relation of annual diversions from the Sevier River and Clear Creek to water level in well (C-23-2)31dcb-3 and annual precipitation at Richfield, Utah, 1966-88 32

17. Map showing location of phreatophyte areas, Sevier-Sigurd basin 34

18-20. Diagrams showing:

18. Chemical composition of water from the Sevier River and tributary inflows in the Sevier-Sigurd basin 38

19. Dissolved-solids and calculated loads for the Sevier River, tributary inflows, and diversions in the Sevier-Sigurd basin during August 1988 40

20. Dissolved-solids and calculated loads for the Sevier River, tributary inflows, and diversions in the Sevier-Sigurd basin during October 1988 41

21. Map showing sampling sites and calculated dissolved-solids concentration of water gained in the Sevier-Sigurd basin during August and October 1988. 42

22-24. Diagrams showing:

22. Variation in specific conductance at gage 10194000 on the Sevier River upstream from Clear Creek, 1971-89 43

23. Variation in specific conductance at gage 10205000 on the Sevier River near Sigurd, 1971-89 44

24. Chemical composition of water from representative wells and springs in the Sevier-Sigurd basin 45

25-27. Maps showing:

25. Approximate distribution of bicarbonate, in percent equivalence, Sevier-Sigurd basin 46

26. Approximate distribution of sulfate, in percent equivalence, Sevier-Sigurd basin 47

27. Approximate distribution of chloride, in percent equivalence, Sevier-Sigurd basin 48

28-31. Graphs showing:

28. Variation in specific conductance of water from well (C-24-2)6abc-1 and water level in well (C-23-2)31dcb-3, 1962-89 49

29. Variation in specific conductance of water from well (C-23-2)15dcb-4, 1957-89 50

30. Variation in specific conductance of water from well (C-23-2)19dab-1, 1957-89 51

31. Relation of deuterium to oxygen-18 in surface and ground water in the Sevier-Sigurd basin 52

32. Hydrographs showing water-level fluctuations in observation wells in the Junction-Marysvale basin 53

33. Diagram showing chemical composition of water from wells in the Junction-Marysvale basin 54

34. Hydrograph showing water-level fluctuations in observation wells in the northern basins, 1935-89 57

35. Diagram showing chemical composition of water from the Sevier River and tributary inflows in the northern basins 59

36. Diagram showing dissolved-solids and calculated loads for the Sevier River, tributary inflows, and diversions in the northern basins during August 1988 61

FIGURES—Continued

37. Map showing sampling sites and calculated dissolved-solids concentration of water gained along the Sevier River in the northern basins during August 1988 62
38. Diagram showing chemical composition of water from selected wells and springs in the northern basins 63
39-52. Maps showing:
    39. Computer model grid and location of inactive nodes in the simulated area 64
    40. Location of specified-flux nodes simulating recharge from irrigated fields in layer 1 66
    41. Location of specified-flux nodes simulating recharge from streams and canals in layer 1 and head-dependent flux nodes simulating recharge from consolidated rock 67
    42. Location of head-dependent drain nodes and head-dependent river nodes and node conductance, and location of constant-head nodes simulating discharge to springs in layer 1 68
    43. Location of head-dependent evapotranspiration nodes and head-dependent flux nodes simulating discharge by subsurface outflow in layer 1 69
    44. Location of head-dependent drain nodes simulating discharge by flowing wells in layer 2 and node conductance 71
    45. Potentiometric contours based on measured water levels for 1957 and computed water levels in layer 2 73
    46. Final distribution of hydraulic-conductivity values for layer 1 76
    47. Final distribution of transmissivity values for layer 2 77
    48. Final distribution of transmissivity values for layer 3 78
    49. Final distribution of vertical-leakance values between layers 1 and 2 79
    50. Final distribution of vertical-leakance values between layers 2 and 3 80
    51. Final distribution of storage-coefficient values used during transient simulations for layer 2 81
    52. Final distribution of storage-coefficient values used during transient simulations for layer 3 82
53. Graph showing simulated recharge at specified-flux boundaries for the 1957-88 transient simulation 84
54. Hydrographs showing computed and measured water-level changes for five observation wells 85
55. Map showing potentiometric contours based on measured water levels for 1988 and computed water levels in layer 2 86
56-62. Graphs showing:
    56. Computed and estimated net gains in the Sevier River resulting from direct seepage and discharge by drains 87
    57. Variations in computed discharge to springs, by evapotranspiration, to flowing wells, and by subsurface outflow, and simulated recharge at specified-flux boundaries for the 1957-88 transient simulation 88
    58. Simulated recharge at specified-flux boundaries for irrigated fields, streams, and canals for the 1958-59 transient simulation 89
    59. Computed and measured water-level changes from February 1958 to December 1959 for 12 wells completed in the shallow confined zone 90
    60. Computed and measured water-level changes from February 1958 to December 1959 for three wells completed in the deep confined zone 93
    61. Computed and measured water-level changes from February 1958 to December 1959 for eight wells completed in the unconfined zones 94
    62. Variations in computed discharge to the Sevier River, to springs, by evapotranspiration, and to flowing wells, and simulated recharge at specified-flux boundaries for the 1958-59 transient simulation 97
63. Map showing flow paths for particles simulating discharge from the ground-water system to the Sevier River in layer 1 98

FIGURES—Continued

64. Map showing flow paths for particles simulating discharge from confined zones to alluvial springs in layer 1 99

65-68. Maps showing simulated declines in water levels in layer 2 during a 20-year period as a result of:

65. A reduction in seepage from irrigated fields to 32,400 acre-feet per year (a 25-percent reduction from steady-state conditions) 102

66. A reduction in seepage from irrigated fields to 21,600 acre-feet per year (a 50-percent reduction from steady-state conditions) 103

67. An increase in withdrawals from pumped wells by 15,000 acre-feet per year from estimates for 1988 105

68. An increase in withdrawals from pumped wells by 25,000 acre-feet per year from estimates for 1988 106

TABLES

1. Estimated mean annual flow in ephemeral streams using an empirical equation 9
2. Total annual flow in the Sevier River, diversions from the river, and estimated gains to the river within the Sevier-Sigurd basin for calendar years 1957-86 10
3. Summary of recharge to the ground-water system 20
4. Estimated annual inflow and outflow of water, Sevier-Sigurd basin 23
5. Irrigation water-use analysis for the Sevier-Sigurd basin 24
6. Summary of discharge from the ground-water system, Sevier-Sigurd basin 24
7. Analysis of inflow and outflow for the Sevier River in the Sevier-Sigurd basin 33
8. Summary of estimates for annual discharge by evapotranspiration for various classifications of phreatophytes 35
9. Use and estimated number of wells 35
10. Estimated average annual discharge from active flowing wells of various casing diameters in the Sevier-Sigurd basin 36
11 Use of wells and estimated annual discharge from wells in the Sevier-Sigurd basin 36
12. Hydrologic budget for the ground-water system, Sevier-Sigurd basin 37
13. Isotope analyses from surface and ground water in the Sevier-Sigurd basin 51
14. Estimated mean annual flow in ungaged streams in the Junction-Marysvale basin 53
15. Total annual flow in the Sevier River, diversions from the river, and estimated gains to the river in the northern basins for water years 1970-82 56
16. Estimated mean annual flow in ungaged streams in the northern basins 58
17. Ground-water budget for steady-state calibration, computed by the model compared with independent estimate on the basis of field data 74
18. Computed steady-state flow rates at river and drain nodes in layer 1 and measured gains and losses in August and October 1988 75
19. Computed flow rates at river and drain nodes in layer 1 for stress periods representing August and October 1958 and measured gains and losses in August and October 1988 96
20. Ground-water budget for steady-state and predictive transient simulations 104
21. Records of selected wells 110
22. Records of selected springs 122
23. Drillers' logs of selected wells 123
24. Water levels in selected wells 127
25. Temperature, specific conductance, and chloride concentration of water in selected wells 157
26. Chemical analyses of water from selected wells 168
27. Chemical analyses of water from selected springs 176
28. Chemical analyses of surface water collected during seepage study 178

CONVERSION FACTORS, VERTICAL DATUM, AND ABBREVIATED WATER-QUALITY UNITS

Multiply	By	To obtain
acre	0.4047	hectare
	4,047	square meter
acre-foot (acre-ft)	0.001233	cubic hectometer
	1,233	cubic meter
acre-foot per year (acre-ft/yr)	0.001233	cubic hectometer per year
cubic foot per second (ft^3/s)	0.02832	cubic meter per second
cubic foot per second per mile ($ft^3/s/mi$)	0.0176	cubic meter per second per kilometer
cubic foot per year (ft^3/yr)	0.02832	cubic meter per year
foot (ft)	0.3048	meter
foot per day (ft/d)	0.3048	meter per day
foot per second (ft/s)	0.3048	meter per second
foot per mile (ft/mi)	0.1894	meter per kilometer
foot per year (ft/yr)	0.3048	meter per year
foot squared (ft^2)	0.0929	meter squared
foot squared per day (ft^2/d)	0.0929	meter squared per day
gallon per minute (gal/min)	0.0631	liter per second
inch (in.)	25.4	millimeter
	0.0254	meter
inch per year (in/yr)	25.4	millimeter per year
	0.0254	meter per year
mile (mi)	1.609	kilometer
mile squared (mi^2)	2.59	kilometer squared

Water temperature is given in degrees Celsius (°C), which can be converted to degrees Fahrenheit (°F) by the following equation:

$$°F = 1.8\ (°C) + 32.$$

Sea level: In this report "sea level" refers to the National Geodetic Vertical Datum of 1929—a geodetic datum derived from a general adjustment of the first-order level nets of the United States and Canada, formerly called Sea Level Datum of 1929.

Chemical concentration and water temperature are given only in metric units. Chemical concentration is given in milligrams per liter (mg/L) or micrograms per liter (µg/L). Milligrams per liter is a unit expressing the solute per unit volume (liter) of water. One thousand micrograms per liter is equivalent to 1 milligram per liter. For concentrations less than 7,000 milligrams per liter, the numerical value is about the same as for concentrations in parts per million. Specific conductance is given in microsiemens per centimeter (µS/cm) at 25 degrees Celsius. The load of a constituent in a given volume of water is reported as grams per second (g/s).

Hydrology of the Sevier-Sigurd ground-water basin and other ground-water basins, central Sevier Valley, Utah

By P.M. Lambert, J.L. Mason, *and* R.W. Puchta

Abstract

The hydrologic system in the central Sevier Valley, and more specifically the Sevier-Sigurd basin, is a complex system in which surface- and ground-water systems are interrelated. Seepage from an extensive irrigation system is the primary source of recharge to the basin-fill aquifer in the Sevier-Sigurd basin.

Water-quality data indicate that inflow from streams and subsurface inflow that intersect evaporite deposits in the Arapien Shale does not adversely affect ground-water quality in the Sevier-Sigurd basin. Stable-isotope data indicate that large sulfate concentrations in water from wells are from the dissolution of gypsum within the basin fill rather than inflow from the Arapien Shale.

A ground-water-flow model of the basin-fill aquifer in the Sevier-Sigurd basin was calibrated to steady-state conditions and transient conditions using yearly water-level changes from 1957-88 and monthly water-level changes from 1958-59. Predictive simulations were made to test the effects of reduced recharge from irrigation and increased well discharge. To simulate the effects of conversion from flood to sprinkler irrigation, recharge from irrigated fields was reduced by 50 percent. After twenty years, this reduction resulted in water-level declines of 1 to 8 feet in most of the basin, and a reduction in ground-water discharge to the Sevier River of 4,800 acre-ft/yr. Water-level declines of as much as 12 feet and a reduction in recharge to the Sevier River of 4,800 acre-ft/yr were the result of increasing well discharge near Richfield and Monroe by 25,000 acre-ft/yr.

INTRODUCTION

The study area, which comprises five alluvial ground-water basins in the central Sevier Valley (fig. 1), is located in central Utah, about 160 miles south of Salt Lake City. These ground-water basins, which form the valley floor, include the Junction-Marysvale basin, Sevier-Sigurd basin, Aurora-Redmond basin, Redmond-Gunnison basin, and Gunnison-Sevier Bridge Reservoir basin. Although these basins make up only a fraction of the entire drainage area in the central Sevier Valley, they form the area of detailed study within the central Sevier Valley.

In the five ground-water basins, primarily surface water and some ground water have been developed for irrigation. Of these basins, the Sevier-Sigurd basin is probably the most developed. Similarly, the Sevier River probably is the most intensively used stream in Utah. Water is diverted for irrigation from the town of Sevier north to Gunnison. Some diverted irrigation water returns to the river as surface runoff, surface and subsurface drains, and seepage from shallow ground water. The reuse of water from the Sevier River contributes to an increase in dissolved solids downstream. The Arapien Shale of Jurassic age crops out in several places on the eastern margin of the valley and probably underlies the unconsolidated basin fill. The formation contains evaporite deposits that might contribute dissolved solids to the Sevier River and the unconsolidated basin fill.

Ground water makes up a small fraction of the total quantity of water used for irrigation. Additional ground-water development has been limited because of possible decreases in upward leakage to the Sevier River that might decrease flows in the river for downstream users. For this reason, State and local water-management agencies have indicated the need for a better understanding of the hydrologic system in the central Sevier valley in order to make decisions on further ground-water development. To meet this need, the water resources of the five ground-water basins in the central Sevier Valley, Utah, were studied by the U.S. Geological Survey during 1986-90, in cooperation with the Utah Department of Natural Resources, Division of Water Rights.

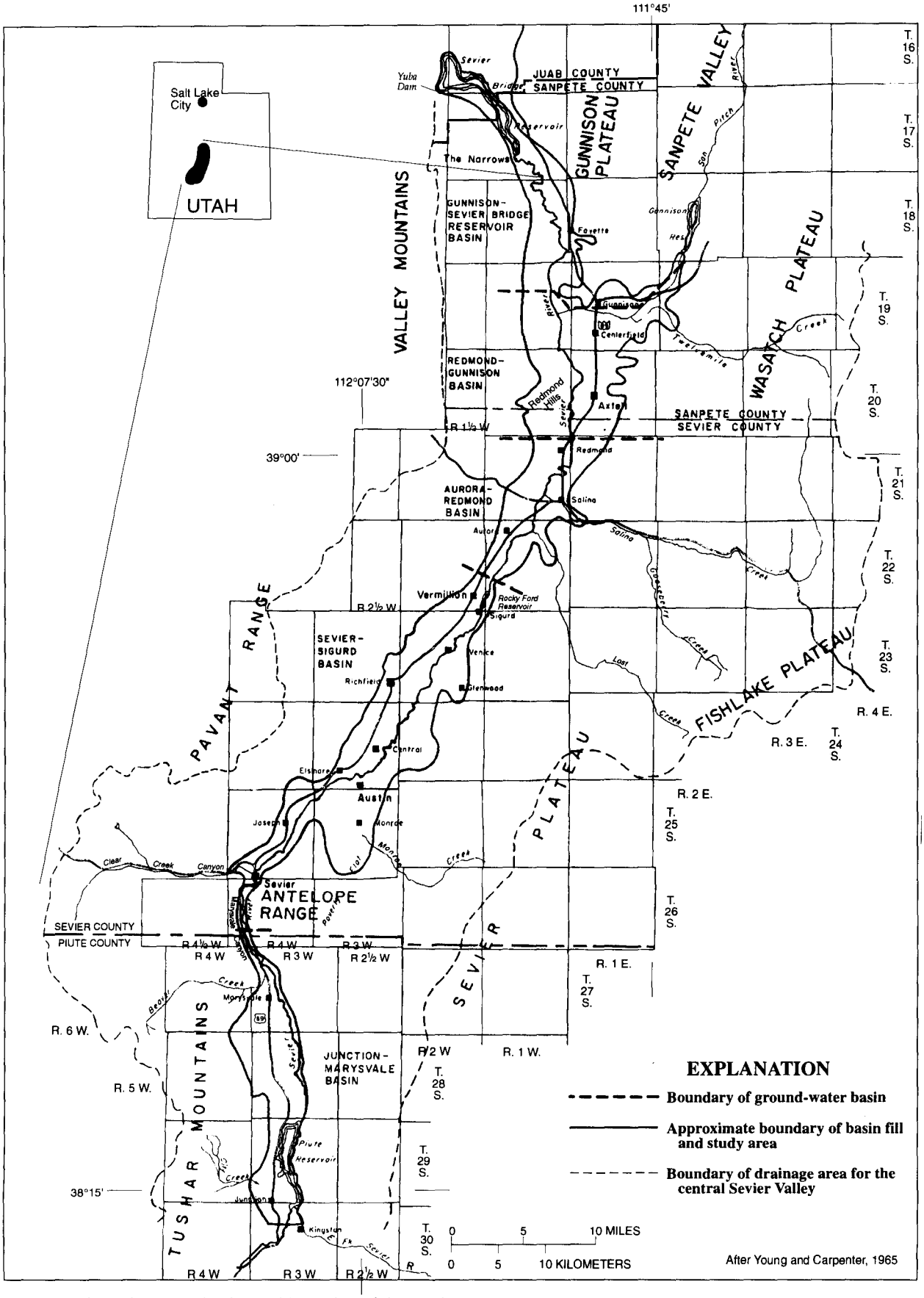


Figure 1. Location and physiographic setting of the study area.

Purpose and Scope

This report describes the current state of the hydrologic system of the Sevier-Sigurd ground-water basin and four other ground-water basins in the central Sevier Valley. The assessment of the current state of the hydrologic system in these basins emphasizes (1) the relation between surface and ground water, and (2) the increase in dissolved solids in surface and ground water from the upstream to the downstream ends of the study area. Alternate management practices considered are increased ground-water withdrawal and reduced recharge resulting from more efficient irrigation practices on surface-water flow and ground-water levels. The study concentrated on the hydrologic processes in the Sevier-Sigurd basin where the ground-water system is more developed than the other ground-water basins, thus providing the opportunity for more data acquisition. This concentrated effort included numerical simulations of the ground-water system and extensive surface- and ground-water sampling for chemical and isotopic analyses. Knowledge gained by studying the hydrologic processes of the Sevier-Sigurd basin subsequently can be applied to the other ground-water basins.

The hydrologic system in the Sevier-Sigurd basin is complex, with interaction between surface and ground water. The ground-water system receives most of its recharge from streams, canals, ditches, and irrigated fields. An explanation of the ground-water system, therefore, does not seem complete without explaining the interaction with the surface-water system. This report pertains primarily to the ground-water system; gains and losses to and from streams and canals will be described in the sections dealing with recharge and discharge to the ground-water system. Only a description of the surface-water distribution system and appropriate data are presented in the surface-water section.

The interpretations and conclusions in this report are based primarily on data presented in the tables at the end of the report. Data for wells, including well completions, depth, and discharge of flowing wells, are listed in table 21. Data for springs, including source of springs, are listed in table 22. Drillers' logs of selected wells are listed in table 23. Multiple water-level measurements from selected wells are listed in table 24. Temperature, specific conductance, and chloride concentrations that were determined for water collected on a monthly basis from selected wells are listed in table 25. Chemical-quality data for water collected from selected wells are listed in table 26. Chemical-quality data for water from selected springs are listed in table 27. Chemical-quality data for water collected from surface-water sites during the seepage study on the Sevier River are listed in table 28. Numbering system for data sites is explained in figure 2.

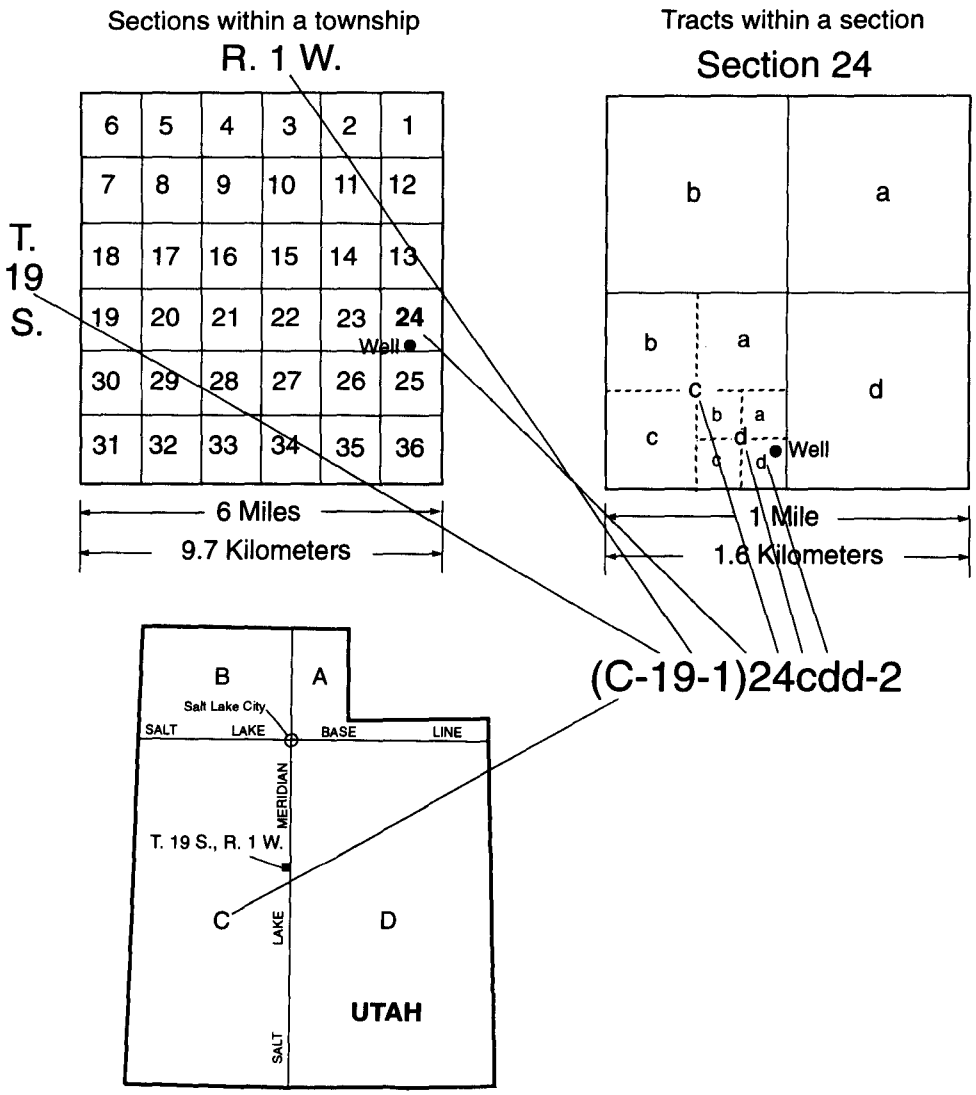
Previous Investigations

Several studies have been made of the hydrology of all or part of the central Sevier Valley. A reconnaissance of the ground-water resources in the central Sevier Valley and Sanpete Valley, a tributary valley to the northern part of the central Sevier Valley, was completed by Richardson (1907). Woolley (1947) studied the surface-water resources of the entire Sevier River system. The first detailed hydrologic study of the central Sevier Valley was completed by Young and Carpenter (1965). The study, done in 1961-63, emphasized the relations between surface and ground water. The report included a general water budget for the five ground-water basins in the study area. Data collected during the project, which included well, water-level, and water-quality data, and ground-water withdrawal estimates, were published in a separate data report by Carpenter and Young (1963). A report detailing the changes in chemical composition of water for the entire Sevier River and its tributaries was completed by Hahl and Mundorff (1968). During the study, numerous samples were collected and results of the analyses are published in a data report by Hahl and Cabell (1965). Seepage studies to determine gains or losses in several canals in the central Sevier Valley were completed by Cruff (1977) and Herbert and Smith (1989).

A study of water quality in the complex stream-aquifer system of the Sevier-Sigurd basin was completed by Mansour Sepehr (1984). This investigation used ground-water flow and solute-transport models to evaluate possible salinity sources to the Sevier River between Clear Creek and the town of Sigurd.

Numerous geologic studies have described the structure and stratigraphy of the central Sevier Valley and surrounding area. The studies that pertain the most to the central Sevier Valley and the Arapien Shale include Spieker (1946, 1949), Gilliland (1951, 1963), Hardy (1952), and more recently Picard (1980) and Picard and Kadir (1982).

The system of numbering wells in Utah is based on the cadastral land-survey system of the U.S. Government. The number, in addition to designating the well, describes its position in the land net. The land-survey system divides the State into four quadrants by the Salt Lake Base Line and the Salt Lake Meridian. These quadrants are designated by the upper case letters A, B, C, and D, indicating respectively, the northeast, northwest, southwest, and southeast quadrants. Numbers designating the township and range, in that order, follow the quadrant letter, and the three are enclosed in parentheses. The number after the parentheses indicates the section, and is followed by three letters indicating the quarter section, the quarter-quarter section, and the quarter-quarter-quarter section—generally 10 acres for regular sections[1]; the letters a, b, c, and d indicate, respectively, the northeast, northwest, southwest, and southeast quarters of each subdivision. The number after the letters is the serial number of the wells or springs within the 10-acre tract. The letter 'S' preceding the serial nunber denotes a spring. A number having all three quarter designations, but without the letter S and serial number indicates a miscellaneous data site other than a well or spring, such as surface outflow from a group of springs. Thus, (C-19-1)24cdd-2 designates the second well constructed or visited in the SE1/4, SE1/4, SW1/4, sec. 24, T. 19 S., R. 1 W.



[1]Although the basic land unit, the section, is theoretically 1 square mile, many sections are irregular. Such sections are subdivided into 10-acre tracts, generally beginning at the southeast corner, and the surplus or shortage is taken up in the tracts along the north and west sides of the section.

Figure 2. Numbering system for data sites in Utah.

Description of Study Area

The central Sevier Valley is defined as the valley through which the Sevier River flows from the town of Kingston at the south end to the Sevier Bridge Reservoir at the north end (fig. 1). Along this reach, the entire drainage basin occupies an area of about 2,800 mi^2 (Young and Carpenter, 1965, p. 3). The valley is located in the High Plateaus of the Utah section of the Colorado Plateaus physiographic province (Fenneman, 1931, p. 295). The elongate, alluvial-filled valley is surrounded by the Sevier, Fishlake, Wasatch, and Gunnison Plateaus to the east and the Tushar and Valley Mountains and the Pavant Range to the west. Altitudes range from 5,100 feet on the valley floor at the north end near Gunnison to about 12,000 feet in the Tushar Mountains.

The valley floor, which is divided into five ground-water basins, was formed by the Sevier River flood plain and laterally, is virtually flat. The valley floor has an areal extent of about 300 mi^2 (Young and Carpenter, 1965, p. 3). Alluvial fans slope into the valley from both sides and in many areas overlap the flood plain. In some ground-water basins, such as in the Sevier-Sigurd basin, alluvial fans are not present on the east side and the virtually flat flood plain is adjacent to the mountains.

The climate in the central Sevier Valley varies from semiarid on the valley floor to humid on the adjacent mountains and plateaus. The 1931-60 normal annual precipitation ranges from 8 inches on the valley floor to about 30 inches on the adjacent mountains (U.S. Weather Bureau, 1963). Precipitation during the summer commonly falls as intense local thunderstorms of short duration, whereas precipitation during the winter generally falls as snow from storms of moderate intensity that last from one to several days over extensive areas.

Most of the land in the central Sevier Valley is used for agriculture, which forms the largest part of the economic base. Mining of evaporite deposits associated with the Arapien Shale in and adjacent to the valley also is important to the economy of the region. Most of the drainage area for the central Sevier Valley consists of mountains where logging, grazing, and mining are important activities.

Geology

Consolidated rocks exposed in the mountains surrounding the central Sevier Valley range in age from Jurassic to Pleistocene. Thick sequences of primarily marine sediments were deposited east of the Sevier orogenic belt from Jurassic through Cretaceous time, with a hiatus in deposition between the Jurassic and Cretaceous. During this time, a broad arch developed in western Utah, and the basin to the east was downwarped and filled with evaporite deposits, fine-grained clastic rocks, carbonate rocks, and sandstone. Prior to deposition of Tertiary rocks, the Jurassic and Cretaceous rocks were deformed during the early Laramide orogeny. The post-early Laramide sequence, therefore, generally overlies, with an angular unconformity, folded Jurassic and Cretaceous rocks. This sequence consists of predominantly clastic marine and continental deposits that include thick units of limestone and volcanic rocks. These rocks vary in thickness with location and might have unconformable surfaces between formations.

The central Sevier Valley is a graben that was formed by the normal faulting of a synclinal trough. The two main faults are the Sevier on the east and the Elsinore on the west (Young and Carpenter, 1965, pl. 1). The Sevier fault extends from east of Piute Reservoir north to Monroe. The Elsinore fault extends from Elsinore to just north of Richfield. Both faults coincide with the basin margins where the basin-fill deposits are in contact with consolidated rock. Additional faulting, volcanism, intrusive activity, and stream erosion have combined to form five basins in the main graben. The basins are alluvial filled with constrictions generally formed by Tertiary volcanic rocks at each end of a basin. Constrictions might be at land surface or in the subsurface.

The Junction-Marysvale basin, the southernmost segment of the central Sevier Valley, extends from Kingston in the south to the head of Marysvale Canyon to the north. A volcanic constriction of Tertiary age is present near Piute Reservoir that effectively divides this basin into two subbasins. In the smaller southern subbasin, alluvial deposits have a maximum thickness of about 80 ft (Young and Carpenter, 1965, p. 16). Although the thickness of the alluvial deposits is unknown in the larger northern subbasin, lithologic logs indicate that the thickness is larger than the southern subbasin (Carpenter and Young, 1963, p. 28).

The Sevier-Sigurd basin extends from the mouth of Marysvale Canyon in the south to a constriction in the valley at Rocky Ford Reservoir just north of Sigurd. This constriction is formed by Tertiary volcanic rocks on the east and by an uplifted block of Tertiary sedimentary rocks covered with alluvium on the west. In

the southwest, a small subbasin is formed by a constriction of Tertiary volcanic rocks (Young and Carpenter, 1965, pl. 1) northeast of Joseph.

The Aurora-Redmond basin extends from Rocky Ford Reservoir to the southernmost extension of the Redmond Hills anticline (Young and Carpenter, 1965, pl. 1). This north-trending structure probably extends from west of Salina to the Gunnison Plateau (Gilliland, 1963, p. 121). The Arapien Shale is exposed in the Redmond Hills at the core of the anticline. The Arapien Shale outcrops at this locality consist primarily of bedded salt deposits. Young and Carpenter (1965, p. 17) reported a maximum thickness of 660 feet for the alluvial deposits in this basin. They attributed the formation of three clay layers in the alluvial deposits to ponding behind the Redmond Hills anticline.

The Redmond-Gunnison basin extends from the south end of the Redmond Hills to Gunnison where the basin branches to the north and northeast. The Sevier River flows through the main segment to the north. No geologic constriction divides this basin, but Young and Carpenter (1965, p. 18) defined the northern boundary as the farthest north outcrop of the Arapien Shale. The northeast segment extends about 7 miles up the San Pitch River from Gunnison to Gunnison Reservoir. Near the Gunnison Reservoir, the segment becomes constricted by the consolidated rocks in the Gunnison and Wasatch Plateaus. Young and Carpenter (1965, p. 18) reported that the alluvial deposits range in thickness from about 50 feet along the San Pitch River to 320 feet west of Gunnison.

The northernmost basin in the central Sevier Valley extends from Gunnison to Yuba Dam on the Sevier River and is known as the Gunnison-Sevier Bridge Reservoir basin. This basin is divided into two subbasins by a consolidated-rock constriction at the southern end of Sevier Bridge Reservoir. The thickness of the alluvial deposits is 500 feet near Fayette and consists of fine-grained material that was deposited in a lake upstream from the consolidated-rock constriction (Young and Carpenter, 1965, p. 18). The thickness of the alluvial deposits of the lower subbasin is unknown because this part of the valley is covered by the reservoir, but the alluvial deposits are assumed to be thin because of their close proximity to consolidated rock outcrops.

Lithologic descriptions, known thicknesses, and water-yielding properties of the consolidated-rock units in the study area are reported by Young and Carpenter (1965, p. 13-15, 18-21), and only the formations that have hydrologic significance are discussed in this report. The Jurassic Arapien Shale is extremely important not because of its water-yielding properties, but because of its areal extent and mineral content. The Arapien Shale is exposed along the eastern margin of the valley from near Glenwood north to near Gunnison and in the Redmond Hills, north of Salina (pl. 1). The shale has extensive beds of gypsum with some halite that can be dissolved readily, thus contributing to the mineralization of ground water. Sepehr (1984, p. 14-16) completed solubility tests on powdered samples of the Arapien Shale. Specific-conductance data, collected during a 550-hour period, indicate that most of the dissolution of gypsum and halite occurs in the first 50 hours. The dissolved salts, therefore, can be transported by runoff from precipitation in addition to transport by ground water.

The Flagstaff Limestone of late Paleocene age and the volcanic rocks (Dry Hollow Formation and some undifferentiated basalt flows) of Miocene (?) and Pliocene (?) age, in contrast, are important to the hydrologic system because of their water-resource potential. The Flagstaff Limestone, which is exposed northwest of Richfield and at the north end of the study area (Young and Carpenter, 1965, pl. 1), consists of limestone, siltstone, and sandstone. This formation is known to yield large quantities of water where it contains solution fractures. The Flagstaff Limestone is the source for Fayette Spring, (D-18-1)19dab-S1, and Richfield Spring, (C-23-3)26aca-S1 (pl. 1). Young and Carpenter (1965, p. 19) originally reported that the Crazy Hollow Formation was the source for Richfield Spring. A report by Liddle (1967, p. 2), however, indicates that the Flagstaff Limestone is the actual source for Richfield Spring, which is located on the Elsinore fault. Water-level data and core samples from test drilling and seismic profiles indicate that the Elsinore fault restricts lateral movement of ground water and forces water from the Flagstaff Limestone to move vertically to the land surface.

The Tertiary volcanic rocks are composed of latitic, basaltic, and rhyolitic flows, tuffs, and agglomerates. Several formation names have been applied to the different types of volcanic rocks, but Young and Carpenter (1965, pl. 1) did not differentiate each type on their geologic map. Generally, the volcanic rocks have low permeability except for the Dry Hollow Formation and some undifferentiated basalt flows that are a source for many springs. This is especially apparent in the Glenwood area where the volcanic rocks overlie the Arapien Shale, thus producing contact springs.

SURFACE-WATER HYDROLOGY OF THE SEVIER-SIGURD BASIN

Flow in the Sevier River through the Sevier-Sigurd basin is dependent on the quantity of water released upstream from Piute Reservoir, inflow from several tributary streams, diversions to canals, surface return flow from irrigation, and seepage to and from the ground-water system. The surface-water system of the Sevier-Sigurd basin is very complex, with surface return flow and seepage to and from the ground-water system, the two components that are the most difficult to determine.

Sevier River and Its Tributaries

The Sevier River in the Sevier-Sigurd basin flows northward from the mouth of Marysvale Canyon in the south to Rocky Ford Reservoir, north of Sigurd. The mean annual flow at the U.S. Geological Survey gaging station 10194000, Sevier River above Clear Creek, near Sevier, Utah (pl. 1), is 249 ft^3/s (180,400 acre-ft/yr) for the period of record--water years 1912-16, 1939-55, and 1960-88. Clear Creek is the largest tributary of the Sevier River in the Sevier-Sigurd basin. The mean annual flow at the U.S. Geological Survey gaging station 10194200, Clear Creek above diversions, near Sevier, Utah, is 38.8 ft^3/s (28,110 acre-ft/yr) for the period of record—water years 1957-88. Downstream from Rocky Ford Reservoir, the mean annual flow at the U.S. Geological Survey gaging station 10205000, Sevier River near Sigurd, Utah, is 112 ft^3/s (81,140 acre-ft/yr) for the period of record—water years 1914-88 (U.S. Geological Survey, 1989, p. 290-292). The difference in flow from the Sevier River and Clear Creek near Sevier and the Sevier River near Sigurd reflects the quantity of water used for irrigation or is transported north, out of the basin by irrigation canals.

Other perennial, tributary streams in the Sevier-Sigurd basin include Monroe Creek, Water Creek, and Brine Creek (also named Peterson Creek in Young and Carpenter, 1965)(fig. 3). Of these ungaged streams, only water from Brine Creek reaches the Sevier River on a regular basis. During the irrigation season, practically all of the water in the Brine Creek drainage east of the Arapien Shale outcrops is diverted for irrigation. During the year, water reaching the Sevier River in the Brine Creek channel is derived from base flow and springs downstream from diversions for irrigation. The flow in Brine Creek at its mouth might be greater than base flow only during short periods of high runoff from snowmelt or thunderstorms. From a limited number of discharge measurements, base flow is estimated to be about 0.2 ft^3/s (about 150 acre-ft/yr).

Monroe Creek and Water Creek are perennial streams that have several diversions along their entire course. If water reaches the mouths of each canyon, it is diverted into a canal. Only during periods of high spring runoff would water flow in the natural stream channels toward the Sevier River where most or all of the water seeps into the alluvial fans at the mouths of the canyons. Young and Carpenter (1965, p. 64) estimated that Monroe Creek contributes about 14 ft^3/s (10,000 acre-ft/yr) of water to the basin during most years. Young and Carpenter (1965, p. 28) estimated the average base flow in Water Creek upstream from diversions to be about 1 ft^3/s (700 acre-ft/yr).

Mill Creek, an ephemeral stream adjacent to Water Creek near Glenwood (fig. 3), is controlled by a small reservoir and the water is diverted for irrigation. Because the stream is controlled, the average annual flow was assumed to be equal to that of Water Creek (700 acre-ft/yr).

Several other ephemeral streams drain into the Sevier-Sigurd basin from both sides. During previous studies, no estimates of mean annual flow have been made for these streams. The drainage-basin characteristics of ephemeral streams are considerably different as compared with gaged perennial streams in the central Sevier Valley and, therefore, estimates of mean annual flow can not be made by comparing drainage area with mean basin altitude. Although the central Sevier Valley is not in the Colorado River Basin, the eastern drainage divide of the valley coincides with the western boundary of the basin. Because of the close proximity of the central Sevier Valley to the Colorado River Basin, the empirical equation derived by Christensen and others (1986, p. 8) for mountainous regions of the Colorado River Basin was considered to be applicable. The estimates listed in table 1 were determined by using the following equation:

$$(Q = 1.39 \times 10^{-5})\, A^{1.06} E^{4.67} \qquad (1)$$

where Q = mean annual flow, in cubic feet per second
A = contributing drainage area, in square miles, and
E = mean basin altitude, in thousands of feet.

Most of the water from the ephemeral streams listed in table 1 is diverted for irrigation or seeps into

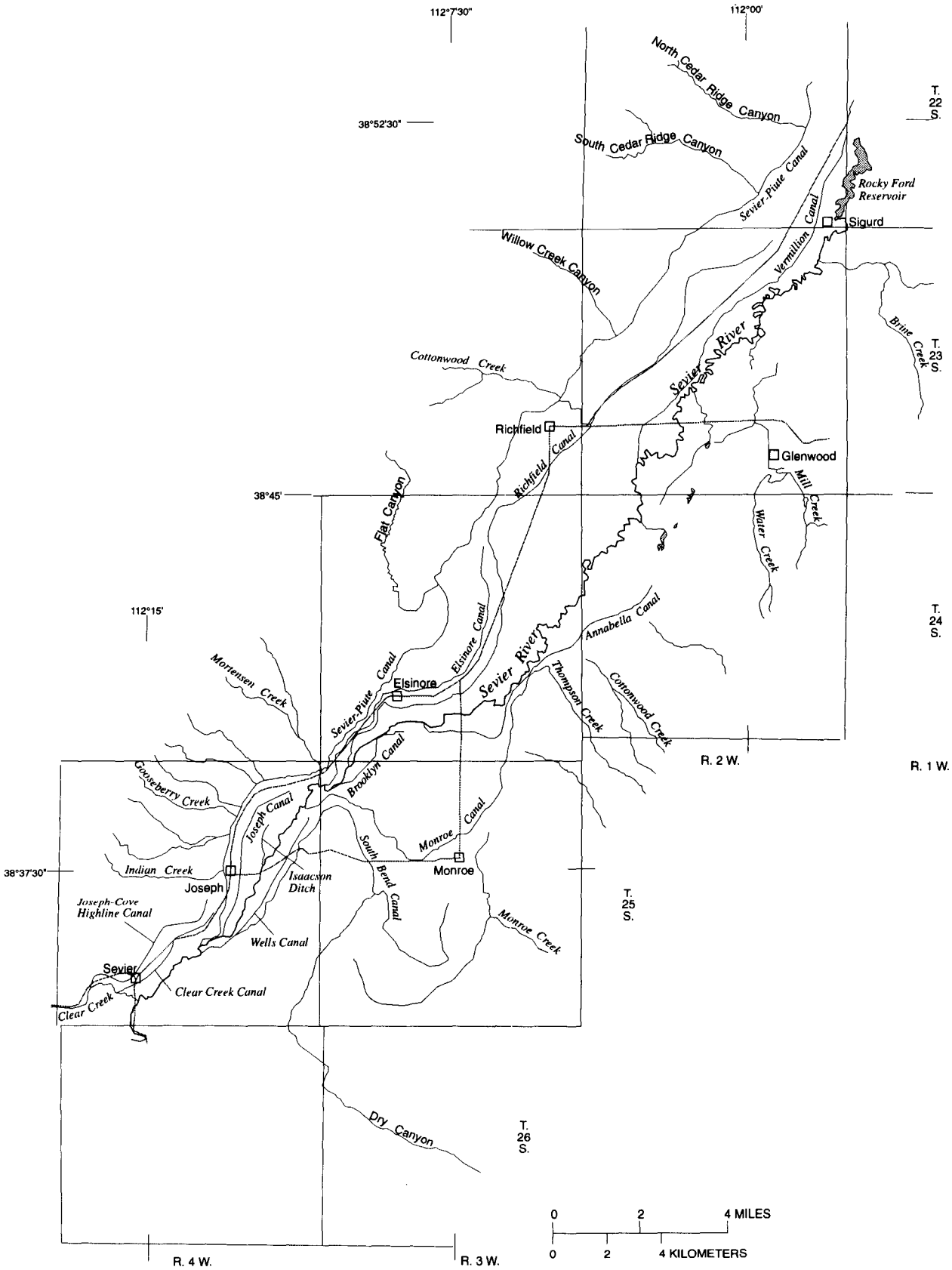


Figure 3. Streams and canals in the Sevier-Sigurd basin.

the basin fill at the margins of the basin. Most of the remaining water flows into the major canals on either side of the basin. Only during periods of high spring runoff does any of the water reach the Sevier River.

Table 1. Estimated mean annual flow in ephemeral streams using an empirical equation

Ungaged stream	Estimated mean annual flow: Cubic feet per second	Estimated mean annual flow: Acre-feet per year
Indian Creek	1.4	1,000
Gooseberry Creek	2.6	1,900
Mortensen Creek	1.4	1,000
Flat Canyon	2.1	1,500
Thompson-Cottonwood Creeks	6.5	4,700
Cottonwood Creek	4.8	3,500
Willow Creek Canyon	3.7	2,700
South Cedar Ridge Canyon	5.8	4,200
North Cedar Ridge Canyon	4.8	3,500

Canals and Ditches

Between the mouth of Clear Creek and Rocky Ford Reservoir, about 85 percent of the water in the Sevier River is diverted into a complex system of canals and ditches. Most of the water is diverted into the canals at the south end of the basin, between Sevier and Elsinore (fig. 3). The canals diverge from both sides of the river with the longest canals on the west side of the basin. The Sevier Valley Canal flows along most of the length of the Sevier-Sigurd basin and becomes the Piute Canal north of Richfield; both canals are referred to collectively as the Sevier-Piute Canal. A gage at this point, operated by the canal companies, measures the quantity of water exported from the Sevier-Sigurd basin.

The quantity of water diverted into the major canals in the Sevier-Sigurd basin for the calendar years 1957-86 is listed in table 2. Diversion data were obtained from the annual reports for the Sevier River Water Distribution System (Utah Division of Water Rights, 1956-87). For each year, the total inflow as measured at the U.S. Geological Survey gaging station 10194000, Sevier River above Clear Creek, and at the U.S. Geological Survey gaging station 10194200, Clear Creek above diversions, is listed. Total outflow in the Sevier River from the Sevier-Sigurd basin is computed by adding the quantity of water diverted into canals and the flow in the Sevier River measured at the U.S. Geological Survey gaging station 10205000, Sevier River near Sigurd, where the river flows from the basin. By subtracting total inflow from total outflow, total gain in the Sevier River from Sevier to Sigurd can be determined. The estimated gains to the Sevier River can come from several sources, but ground-water inflow might be the largest. Ground-water inflow might include seepage directly to the river and seepage to drains that discharge to the river. Other sources might include direct surface runoff from irrigated fields and undiverted water from ungaged tributaries and springs. The quantity of water from each source could not be determined from available data.

Total diversion is the actual quantity of water diverted for use in the Sevier-Sigurd basin. This quantity of water can be determined by subtracting from total outflow the quantity of water exported from the basin by canals and in the Sevier River as measured at the gage near Sigurd. Water exported by canals includes all the water in the Piute and Rocky Ford-Willow Bend Canals and 75 percent of the water in the Vermillion Canal. The estimate of water exported in the Vermillion Canal is based mainly on the length of canal and the number of diversions in the Sevier-Sigurd basin.

GROUND-WATER HYDROLOGY OF THE SEVIER-SIGURD BASIN

Occurrence

The principal ground-water system in the Sevier-Sigurd basin is in the unconsolidated basin fill where ground water is under unconfined and confined conditions. The ground-water system is interconnected with multiple layers consisting mainly of interbedded clay, silt, sand, and gravel. The consolidated rock bounding the basin contains water in some areas. Ground water discharges from the Flagstaff Limestone west of Richfield, and from the contact between the Arapien Shale and Tertiary volcanic rocks east of Glenwood. Several municipalities obtain water for public supply from springs issuing from consolidated rock in the adjacent mountains. Consolidated rock, however, generally is either a ground-water barrier or a localized source of recharge to the ground-water system. A description of general water-yielding properties of consolidated rock in the study area is presented by Young and Carpenter (1965, table 1).

Table 2. Total annual flow in the Sevier River, diversions from the river, and estimated gains to the river within the Sevier-Sigurd basin for calendar years 1957-86

[Data in acre-feet (rounded); —, no data available; Segment, station number following segment name is U.S. Geological Survey gaging station number. Total diversion, total diverted for use in the Sevier-Sigurd basin. Computed by subtracting from total outflow all water flowing from the Sevier-Sigurd basin. This would include all the water in the Piute and Rocky Ford Canals, 75 percent of the water in the Vermillion Canal, and all the water in the Sevier River as measured at the gage near Sigurd]

Segment	1957 Inflow	1957 Outflow	1958 Inflow	1958 Outflow	1959 Inflow	1959 Outflow
Sevier River above Clear Creek (10194000)	[1]91,500		[1]198,000		136,000	
Clear Creek (10194200)	[2]33,200		[2]25,300		[2]5,440	
Joseph-Cove Highline Canal		167		435		237
Clear Creek Canal		3,190		3,470		3,650
Monroe-South Bend Canal		14,900		19,700		14,700
Sevier Valley Canal		21,700		25,900		14,400
Piute Canal		12,100		50,600		32,800
Joseph Canal		4,770		7,850		3,150
Wells Canal		1,820		2,540		1,440
Isaacson Ditch		370		382		257
Monroe Canal		9,520		14,500		8,960
Elsinore Canal		3,510		5,040		3,220
Brooklyn Canal		6,430		9,680		4,970
Richfield Canal		21,200		29,300		15,100
Annabella Canal		5,850		7,720		4,140
Vermillion Canal		12,800		14,400		6,960
Rocky Ford-Willow Bend Canal		15,500		19,100		16,200
Sevier River near Sigurd (10205000)		43,600		58,800		49,400
Totals	125,000	177,000	223,000	269,000	141,000	180,000
Gains	52,000		46,000		39,000	
Total diversion	96,000		130,000		76,000	

Segment	1960 Inflow	1960 Outflow	1961 Inflow	1961 Outflow	1962 Inflow	1962 Outflow
Sevier River above Clear Creek (10194000)	[1]99,800		89,700		136,000	
Clear Creek (10194200)	[2]10,000		13,000		21,500	
Joseph-Cove Highline Canal		144		160		209
Clear Creek Canal		3,520		3,710		4,260
Monroe-South Bend Canal		13,100		13,700		16,600
Sevier Valley Canal		13,800		14,000		20,000
Piute Canal		18,300		13,700		19,700
Joseph Canal		3,480		3,700		5,500
Wells Canal		1,420		1,240		1,980
Isaacson Ditch		237		0		0
Monroe Canal		7,130		6,720		11,900
Elsinore Canal		2,910		2,530		4,520
Brooklyn Canal		4,650		4,820		7,510
Richfield Canal		14,200		13,700		23,200
Annabella Canal		4,130		4,360		6,480
Vermillion Canal		6,960		8,460		12,800
Rocky Ford-Willow Bend Canal		15,600		14,100		17,500
Sevier River near Sigurd (10205000)		40,400		32,900		44,300
Totals	110,000	150,000	103,000	138,000	158,000	196,000
Gains	40,000		35,000		38,000	
Total diversion	70,000		71,000		105,000	

Table 2. Total annual flow in the Sevier River, diversions from the river, and estimated gains to the river within the Sevier-Sigurd basin for calendar years 1957-86—Continued

Segment	1963 Inflow	1963 Outflow	1964 Inflow	1964 Outflow	1965 Inflow	1965 Outflow
Sevier River above Clear Creek (10194000)	91,000		92,300		126,000	
Clear Creek (10194200)	9,320		19,200		26,800	
Joseph-Cove Highline Canal		138		184		407
Clear Creek Canal		3,980		3,500		4,050
Monroe-South Bend Canal		15,400		12,400		16,800
Sevier Valley Canal		10,400		14,500		21,700
Piute Canal		16,500		13,800		13,800
Joseph Canal		2,850		4,180		6,150
Wells Canal		1,140		1,430		2,210
Isaacson Ditch		0		0		0
Monroe Canal		6,020		8,370		11,100
Elsinore Canal		2,470		3,410		4,210
Brooklyn Canal		4,490		5,450		6,850
Richfield Canal		11,600		16,600		21,300
Annabella Canal		3,220		4,790		6,310
Vermillion Canal		6,290		7,620		11,600
Rocky Ford-Willow Bend Canal		17,500		17,400		20,500
Sevier River near Sigurd (10205000)		35,200		33,000		45,800
Totals	100,000	137,000	112,000	147,000	153,000	193,000
Gains	37,000		35,000		40,000	
Total diversion	63,000		77,000		104,000	

Segment	1966 Inflow	1966 Outflow	1967 Inflow	1967 Outflow	1968 Inflow	1968 Outflow
Sevier River above Clear Creek (10194000)	122,000		133,000		159,000	
Clear Creek (10194200)	15,700		24,100		34,500	
Joseph-Cove Highline Canal		368		427		535
Clear Creek Canal		4,070		4,430		3,100
Monroe-South Bend Canal		15,100		16,600		17,000
Sevier Valley Canal		14,500		20,300		22,500
Piute Canal		34,900		22,700		31,600
Joseph Canal		4,510		4,940		6,380
Wells Canal		1,860		1,950		3,290
Isaacson Ditch		0		0		0
Monroe Canal		9,690		9,340		13,900
Elsinore Canal		3,820		3,420		4,070
Brooklyn Canal		6,360		6,550		7,590
Richfield Canal		21,200		16,300		20,800
Annabella Canal		5,120		5,250		6,290
Vermillion Canal		8,840		8,210		13,300
Rocky Ford-Willow Bend Canal		21,100		19,000		21,700
Sevier River near Sigurd (10205000)		25,200		56,600		63,900
Totals	138,000	177,000	157,000	196,000	194,000	236,000
Gains	39,000		39,000		42,000	
Total diversion	89,000		92,000		109,000	

Table 2. Total annual flow in the Sevier River, diversions from the river, and estimated gains to the river within the Sevier-Sigurd basin for calendar years 1957-86—Continued

Segment	1969 Inflow	1969 Outflow	1970 Inflow	1970 Outflow	1971 Inflow	1971 Outflow
Sevier River above Clear Creek (10194000)	238,000		184,000		129,000	
Clear Creek (10194200)	38,900		26,800		22,900	
Joseph-Cove Highline Canal		568		646		862
Clear Creek Canal		2,760		2,520		2,930
Monroe-South Bend Canal		23,400		16,200		12,600
Sevier Valley Canal		29,200		23,200		19,900
Piute Canal		31,100		49,000		40,800
Joseph Canal		8,650		6,630		5,150
Wells Canal		2,550		1,790		1,430
Isaacson Ditch		0		0		0
Monroe Canal		16,300		13,100		9,850
Elsinore Canal		5,510		4,690		4,330
Brooklyn Canal		11,600		8,920		6,620
Richfield Canal		24,600		22,000		17,800
Annabella Canal		6,900		5,360		4,670
Vermillion Canal		15,700		11,000		8,980
Rocky Ford-Willow Bend Canal		23,500		24,700		24,000
Sevier River near Sigurd (10205000)		128,000		96,700		47,900
Totals	277,000	330,000	211,000	286,000	152,000	208,000
Gains	53,000		75,000		56,000	
Total diversion	136,000		107,000		88,000	

Segment	1972 Inflow	1972 Outflow	1973 Inflow	1973 Outflow	1974 Inflow	1974 Outflow
Sevier River above Clear Creek (10194000)	128,000		223,000		158,000	
Clear Creek (10194200)		10,900		53,700		19,400
Joseph-Cove Highline Canal		304		496		563
Clear Creek Canal		2,790		2,990		2,910
Monroe-South Bend Canal		13,200		17,700		14,900
Sevier Valley Canal		12,500		28,800		23,300
Piute Canal		42,800		49,400		41,000
Joseph Canal		3,520		7,480		5,290
Wells Canal		1,160		2,450		1,820
Isaacson Ditch		0		0		0
Monroe Canal		7,640		14,200		12,600
Elsinore Canal		3,560		3,590		4,180
Brooklyn Canal		4,940		9,360		7,370
Richfield Canal		18,800		22,500		20,900
Annabella Canal		4,040		6,120		3,810
Vermillion Canal		7,700		15,200		11,400
Rocky Ford-Willow Bend Canal		22,700		24,300		23,200
Sevier River near Sigurd (10205000)		39,100		125,000		69,200
Totals	139,000	185,000	277,000	330,000	177,000	242,000
Gains	46,000		53,000		65,000	
Total diversion	75,000		120,000		100,000	

Table 2. Total annual flow in the Sevier River, diversions from the river, and estimated gains to the river within the Sevier-Sigurd basin for calendar years 1957-86—Continued

Segment	1975 Inflow	1975 Outflow	1976 Inflow	1976 Outflow	1977 Inflow	1977 Outflow
Sevier River above Clear Creek (10194000)	123,000		121,000		92,500	
Clear Creek (10194200)	32,500		17,700		8,370	
Joseph-Cove Highline Canal		441		—		—
Clear Creek Canal		2,320		—		—
Monroe-South Bend Canal		15,100		14,100		8,420
Sevier Valley Canal		24,700		[3]28,800		8,960
Piute Canal		34,800		[3]28,800		21,500
Joseph Canal		6,010		4,780		5,580
Wells Canal		2,460		2,080		753
Isaacson Ditch		0		0		81
Monroe Canal		10,300		8,650		9,090
Elsinore Canal		4,110		3,320		3,890
Brooklyn Canal		7,030		5,620		7,100
Richfield Canal		19,300		17,400		9,090
Annabella Canal		4,160		4,710		2,900
Vermillion Canal		11,500		9,940		5,970
Rocky Ford-Willow Bend Canal		23,600		22,300		20,100
Sevier River near Sigurd (10205000)		45,400		39,400		30,300
Totals	156,000	211,000	139,000	190,000	101,000	134,000
Gains	55,000		51,000		33,000	
Total diversion	99,000		92,000		58,000	

Segment	1978 Inflow	1978 Outflow	1979 Inflow	1979 Outflow	1980 Inflow	1980 Outflow
Sevier River above Clear Creek (10194000)	115,000		207,000		274,000	
Clear Creek (10194200)	29,400		38,700		36,100	
Joseph-Cove Highline Canal		864		1,100		1,520
Clear Creek Canal		3,910		3,660		5,570
Monroe-South Bend Canal		13,800		17,500		19,300
Sevier Valley Canal		18,700		30,000		35,300
Piute Canal		14,300		35,200		44,200
Joseph Canal		5,920		7,620		7,860
Wells Canal		1,430		2,130		2,110
Isaacson Ditch		353		516		238
Monroe Canal		9,620		13,900		13,000
Elsinore Canal		3,550		5,120		5,100
Brooklyn Canal		5,890		10,700		11,000
Richfield Canal		17,200		24,900		24,600
Annabella Canal		4,840		7,920		6,420
Vermillion Canal		10,500		13,600		17,400
Rocky Ford-Willow Bend Canal		19,900		22,000		23,400
Sevier River near Sigurd (10205000)		52,600		103,000		190,000
Totals	144,000	183,000	246,000	299,000	310,000	407,000
Gains	39,000		53,000		97,000	
Total diversion	88,000		129,000		136,000	

Table 2. Total annual flow in the Sevier River, diversions from the river, and estimated gains to the river within the Sevier-Sigurd basin for calendar years 1957-86—Continued

Segment	1981 Inflow	1981 Outflow	1982 Inflow	1982 Outflow	1983 Inflow	1983 Outflow
Sevier River above Clear Creek (10194000)	153,000		166,000		413,000	
Clear Creek (10194200)	17,400		24,300		58,100	
Joseph-Cove Highline Canal		982		1,400		362
Clear Creek Canal		5,410		4,170		5,320
Monroe-South Bend Canal		15,300		14,300		13,400
Sevier Valley Canal		31,000		27,500		[3]43,300
Piute Canal		47,800		45,700		[3]43,300
Joseph Canal		6,740		7,460		7,320
Wells Canal		1,860		2,300		2,850
Isaacson Ditch		149		329		50
Monroe Canal		11,400		12,400		13,800
Elsinore Canal		4,430		4,740		5,520
Brooklyn Canal		8,440		8,800		10,900
Richfield Canal		22,000		21,900		24,600
Annabella Canal		6,880		5,670		3,950
Vermillion Canal		14,800		13,500		22,800
Rocky Ford-Willow Bend Canal		21,800		22,200		23,200
Sevier River near Sigurd (10205000)		63,600		90,700		370,000
Totals	170,000	262,000	190,000	283,000	471,000	591,000
Gains	92,000		93,000		120,000	
Total diversion	118,000		114,000		137,000	

Segment	1984 Inflow	1984 Outflow	1985 Inflow	1985 Outflow	1986 Inflow	1986 Outflow
Sevier River above Clear Creek (10194000)	301,000		265,000		174,000	
Clear Creek (10194200)	70,400		47,000		53,400	
Joseph-Cove Highline Canal		0		708		0
Clear Creek Canal		4,080		4,790		5,220
Monroe-South Bend Canal		14,100		13,600		17,500
Sevier Valley Canal		31,300		33,800		29,300
Piute Canal		33,900		41,000		46,100
Joseph Canal		6,730		7,520		8,660
Wells Canal		2,410		2,490		2,810
Isaacson Ditch		0		0		0
Monroe Canal		10,100		11,000		12,300
Elsinore Canal		4,980		4,870		4,890
Brooklyn Canal		9,470		10,600		11,300
Richfield Canal		22,600		23,400		25,200
Annabella Canal		4,880		6,230		5,800
Vermillion Canal		10,400		15,400		18,300
Rocky Ford-Willow Bend Canal		25,100		21,600		22,400
Sevier River near Sigurd (10205000)		333,000		216,000		113,000
Totals	371,000	513,000	312,000	413,000	227,000	323,000
Gains	142,000		101,000		96,000	
Total diversion	113,000		123,000		128,000	

[1] Estimated flow based on regression correlation to flow from Piute Reservoir.

[2] Estimated flow reported by Young and Carpenter, 1965, p. 32.

[3] One value for total flow was reported for Sevier Valley and Piute Canals. Fifty percent was assumed to be used in the Sevier-Sigurd basin and 50 percent was exported in the Piute Canal.

Unconfined Zones

Ground water is under unconfined conditions primarily in a zone in the south end and along the west margin of the basin where confining layers are thin or absent. Coarse-grained sand and gravel deposits make up most of the unconfined zone. These deposits correlate laterally with the water-yielding units that make up the confined zones in the north one-half of the basin.

Unconfined ground water also is present in the basin fill in fine-grained deposits in the north one-half of the basin. These clay and silt deposits also function as an upper confining layer for underlying confined zones. This confining layer ranges in thickness from 20 to 100 feet and is thickest in the northern end of the basin. For the purpose of discussion, saturated deposits in the upper confining layer are referred to in this report as the shallow water-table zone. Most discharge from the ground-water system is from this zone by seepage to streams and drains, and by evapotranspiration.

Confined Zones

Ground water is under confined conditions in the north one-half of the basin away from the west margin of the basin where deposits grade into finer grained and more stratified units forming confining layers (fig. 4). The extension of the unconfined zones of the aquifer system laterally into confined zones is shown in figures 5 to 7. Lithologic descriptions used to create figures 5 to 7 were determined from drillers' logs presented by Young (1960), Carpenter and Young (1963, table 4) or in table 23 of this report. At least two confined zones can be identified in each correlation diagram. For the purpose of discussion, these zones have been labeled the shallow confined zone and the deep confined zone.

The shallow confined zone underlies the shallow water-table zone and ranges in thickness from 20 to 150 feet. In general, the thickness of the coarse-grained deposits that make up the zone is greatest along the east margin of the basin. The zone thins to the north where fine-grained deposits predominate.

The deep confined zone is separated from the shallow confined zone by a layer of fine-grained deposits ranging in thickness from 20 to 100 feet. The deep confined zone generally includes more than one water-yielding layer separated by fine-grained clay and silt layers. Available well-log data, however, were not sufficient to define the zone in greater detail. Results from the drilling of test wells indicate that the thickness of water-yielding strata in the deep confined zone ranges from 6 to 381 feet and has its largest thickness east of Highway 89 in the center of the basin (Young, 1960, p. 3).

Ground water also is under confined conditions at the north end of the small subbasin near Joseph where deposits grade to fine-grained clay and silt toward the shallow consolidated rock that forms the northern boundary of the subbasin.

Aquifer Characteristics and Storage

Hydraulic properties of the basin fill were determined from (1) aquifer tests done prior to this study, (2) specific capacity data and lithologic data from drillers' logs, and (3) slug tests in shallow observation wells drilled during this study.

Young and Carpenter (1965, p. 38) reported transmissivity values determined from aquifer-test data at six wells in the Sevier-Sigurd basin. The values ranged from 535 ft^2/d at a water-table well near Sevier to 120,300 ft^2/d at two artesian wells in the center of the basin. Original data available from test well (C-24-3)12bad-1 were reanalyzed using the Hantush modified method (Lohman, 1972, p. 32). The new analysis yielded a value of 28,500 ft^2/d instead of 120,300 ft^2/d. The original analysis did not account for leaky aquifer conditions.

Specific capacity data obtained from drillers' logs for seven wells were used to estimate transmissivity values as described by Lohman (1972, p. 52). The estimated transmissivity values were divided by the total perforated interval for their respective wells to obtain hydraulic conductivity for coarse-grained basin fill. Values of hydraulic conductivity derived from these data ranged from 50 to 1,000 ft/d. Including the values estimated from aquifer tests, the average horizontal hydraulic conductivity for coarse-grained basin fill was computed to be 370 ft/d. Assuming this estimate to be reasonably accurate, transmissivity values could be as much as 160,000 ft^2/d in the center of the basin where thick sand and gravel beds are present (based on a saturated thickness of 444 feet encountered in test well (C-23-2)10ddc-1 (Young, 1960, p. 11)).

The horizontal hydraulic conductivity for fine-grained basin fill was determined from slug-test data that were collected at an observation well completed in the shallow water-table zone near Venice. The data were analyzed using the method described by Bouwer and Rice (1976) and Bouwer (1989). The horizontal hydraulic conductivity was calculated to be 8 ft/d.

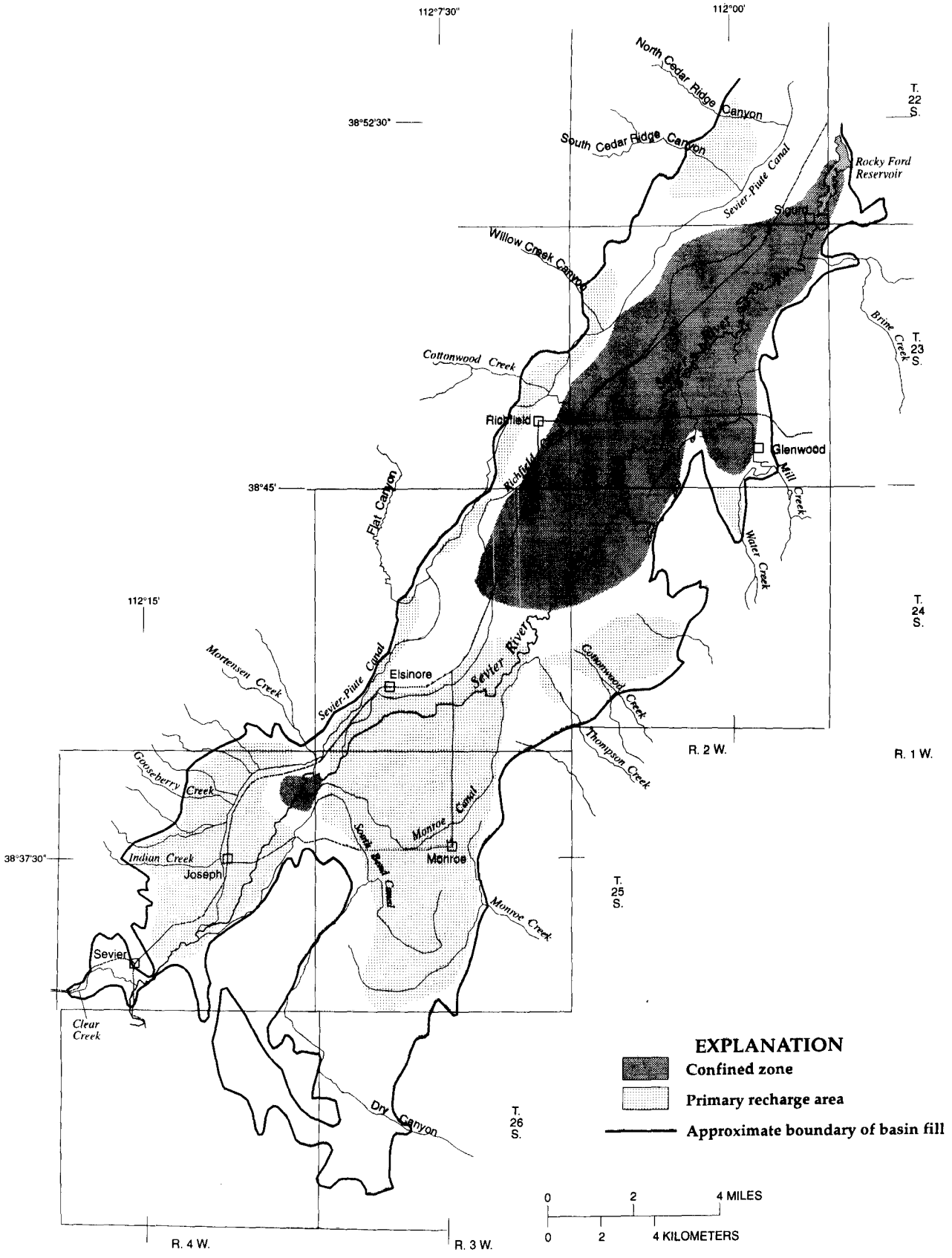


Figure 4. Approximate area of confined zones and primary recharge areas in the Sevier-Sigurd basin.

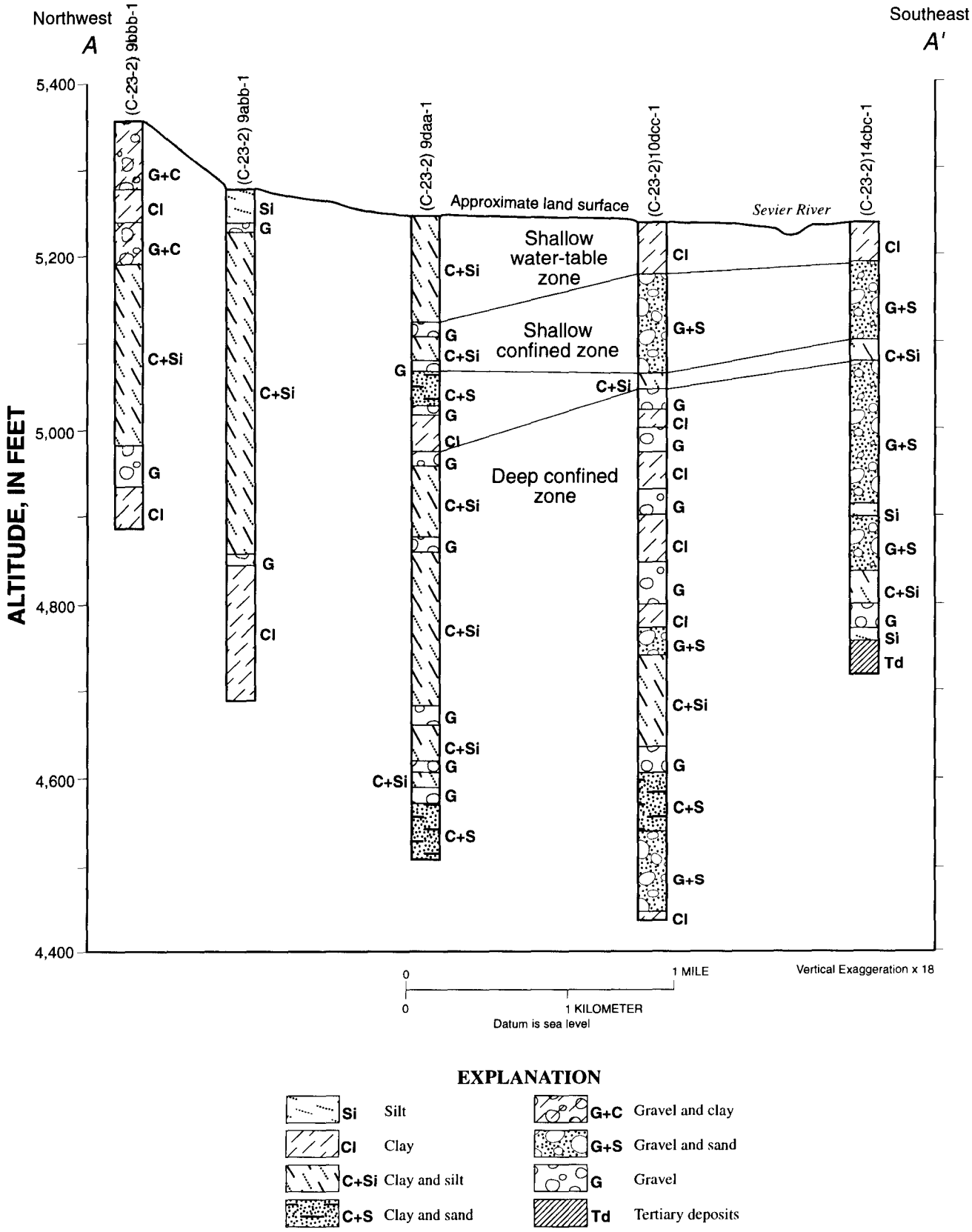


Figure 5. Correlation of zones in the basin-fill aquifer from northwest to southeast in the northern part of the Sevier-Sigurd basin. (The location of the section is shown on plate 1.)

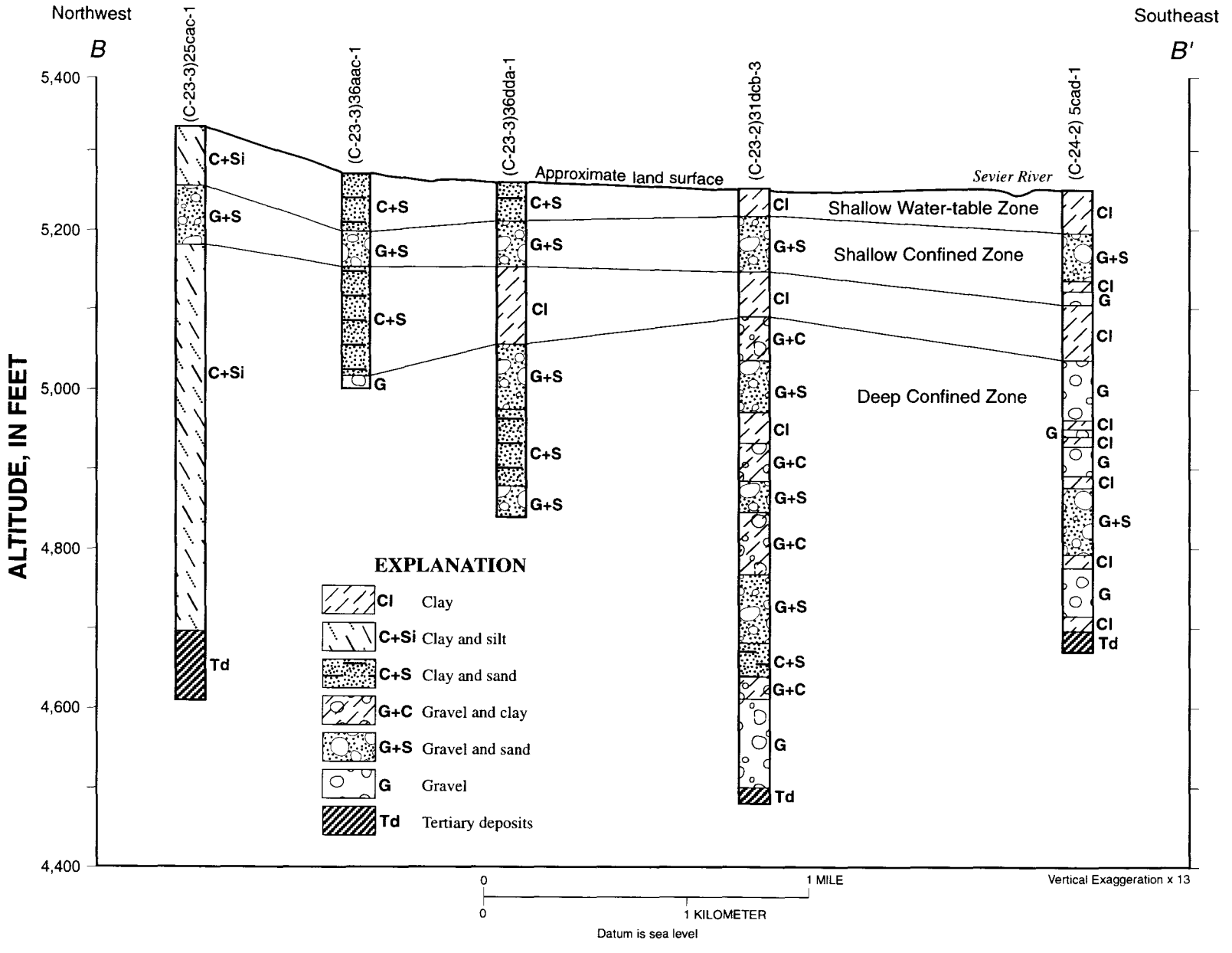


Figure 6. Correlation of zones in the basin-fill aquifer from northwest to southeast in the north-central part of the Sevier-Sigurd basin. (The location of the section is shown on plate 1.)

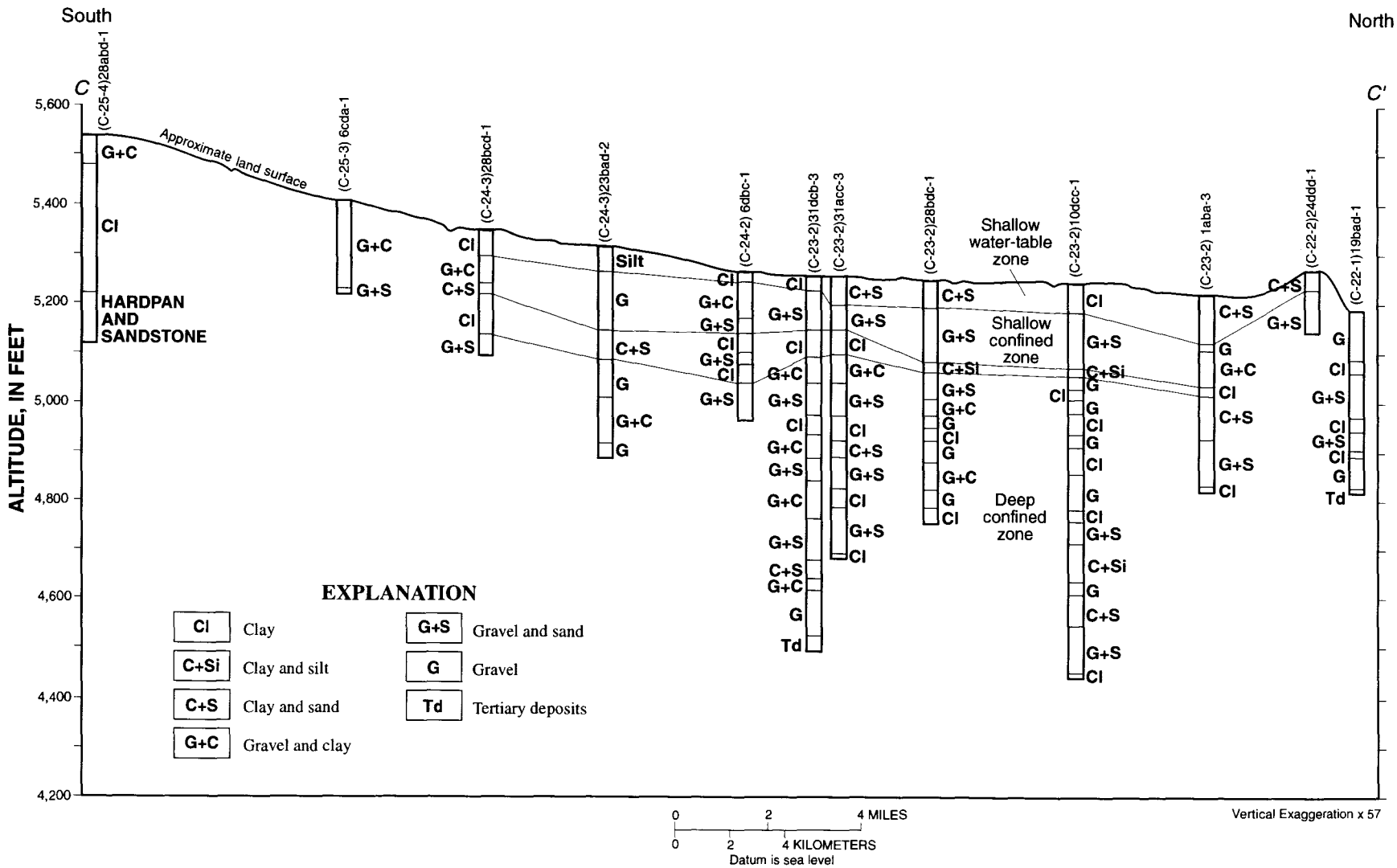


Figure 7. Correlation of zones in the basin-fill aquifer from south to north along the axis of the Sevier-Sigurd basin. (The location of the section is shown on plate1.)

Young and Carpenter (1965, p. 38) reported storage-coefficient values, which were derived from four aquifer tests in the Sevier-Sigurd basin, ranging from 0.0001 to 0.2. Generally, values for storage coefficient vary, depending on the material making up the aquifer, and whether the aquifer is confined or unconfined. In confined aquifers, values for storage coefficient typically range from 0.005 to 0.00005 (Freeze and Cherry, 1979, p. 60). Johnson (1967, table 29) reported, in a compilation of specific yields for various materials in unconfined aquifers, average specific yields ranging from 0.02 for clay to 0.27 for coarse-grained sand.

The volume of recoverable water stored in the principal ground-water system in the Sevier-Sigurd basin was calculated by estimating the extent and thickness of water-yielding zones in the basin fill, and by assuming an average specific yield. The areal extent of the basin fill was estimated to be about 62,000 acres. An average thickness of water-yielding material of 240 feet was determined from test holes and drillers' logs for irrigation and public supply wells (table 23). An average specific yield of 0.2 was assumed for coarse-grained material making up the principal water-yielding zones. An estimate for total recoverable water of about 3 million acre-ft was obtained by multiplying these three factors. This value for recoverable water represents only a part of the total quantity of water stored in the basin fill. A large quantity of water is stored in the saturated silt and clay deposits of the basin. Fine-grained deposits, however, yield a much smaller percentage of the contained water than do sand and gravel deposits.

Recharge

Recharge to the ground-water system occurs by infiltration of precipitation; seepage from canals, the Sevier River, other perennial and ephemeral streams, and irrigated fields; and by inflow from consolidated rock. Recharge to the ground-water system occurs mainly in recharge areas in the south end and along the west margin of the basin (fig. 4) where coarse-grained deposits predominate and ground water is under unconfined conditions. Seepage from an extensive irrigation system is the primary source of recharge to the basin-fill aquifer in the Sevier-Sigurd basin, with the largest quantity probably coming from applied irrigation water. The average annual recharge to the ground-water system from all sources is estimated to be 112,700 acre-ft/yr. The estimates for the various components of recharge are summarized in table 3.

Table 3. Summary of recharge to the ground-water system

Source	Estimated annual recharge (acre-feet per year)
Infiltration of precipitation	2,100
Seepage from canals	8,900
Seepage from the Sevier River	10,100
Seepage from other perennial and ephemeral streams	19,200
Inflow from consolidated rock and seepage from irrigated fields[1]	72,400
Total	112,700

[1]Estimate was derived indirectly by computing the differences between estimated recharge from other components and the total estimated discharge from the ground-water system (table 6).

Infiltration of Precipitation

Recharge from precipitation makes up a small percentage of the total recharge to the ground-water system of the Sevier-Sigurd basin. The annual average precipitation at the weather station in Richfield is 8.16 inches (Huber and others, 1982, table 2). Annual precipitation on the basin floor is estimated to be 42,200 acre-ft based on about 62,000 acres of unconsolidated basin fill (Young and Carpenter, 1965, p. 60). The percentage of precipitation that recharges the ground-water system was not measured during this study. Studies of other alluvial basins in Utah, however, indicate that recharge may range from 1 to 20 percent of the total precipitation (Razem and Steiger, 1981, p. 13; Hood and Waddell, 1968, p. 24; and Feth and others, 1966, p. 43). Assuming that 5 percent of precipitation recharges the ground-water system, on the basis of reported values in other alluvial basins, recharge from precipitation is estimated to be 2,100 acre-ft/yr.

Seepage from Canals

Recharge to the ground-water system from canals occurs where canals cross coarse-grained deposits in the south end of the basin and near the mouths of canyons. Seepage studies have been made by the U.S. Geological Survey on four of the canals in the Sevier-Sigurd basin (Cruff, 1977, and Herbert and Smith, 1989). Diversions to these four canals make up about

70 percent of the total quantity of water diverted to canals in the basin. A study of 29.6 miles of the Sevier-Piute Canal from Sevier to Aurora indicated that gains or losses amounted to a 6.6 percent net loss of available water. Seepage studies of the South Bend and Richfield canals indicated that small gains or losses were taking place.

Canal reaches in the Sevier-Sigurd basin showing substantial losses were identified from the seepage studies, and average percent losses of available water for those reaches were computed. Average flow in canals where losses were measured (for 1957-1986) was multiplied by the respective percent losses to obtain an estimate for average annual losses to ground water from the studied canals. Although the Monroe Canal was not studied, losses similar to those computed for the South Bend Canal were assumed because the two canals run parallel to each other along the identified losing reach of the South Bend Canal. Estimated recharge from the studied canals showing substantial losses and from the Monroe Canal are as follows:

	Average annual flow (acre-feet)	Percent loss	Estimated annual recharge to ground water (acre-feet)
Sevier-Piute	55,400	12	6,600
Richfield	20,100	5	1,000
South Bend	15,300	5	800
Monroe	10,900	5	500
Total	101,700		8,900

Seepage to ground water from smaller, unstudied canals, other than the Monroe Canal, was not estimated. The estimate for total seepage to ground water from canals of 8,900 acre-ft/yr, however, is probably reasonable for two reasons: (1) Annual flow in canals on which the estimate is based constitutes most of the water diverted from the Sevier River and Clear Creek in the Sevier-Sigurd basin, and (2) the seepage studies on which the estimate is based included most major canals carrying water across primary recharge areas in the basin where losses to ground water were assumed most likely to occur.

Seepage from the Sevier River and other Perennial and Ephemeral Streams

Recharge to the ground-water system by seepage from the Sevier River occurs in the south end of the basin primarily along two reaches of the river where the water table is below the level of the water in the river. Losing reaches of the river were defined and seepage rates quantified in seepage studies made on the river during August and October of 1988. The results of these seepage studies were summarized by G.W. Sandberg (U.S. Geological Survey, written commun., 1989).

The seepage study on the Sevier River in August indicated two losing reaches in the south end of the basin (fig. 8). An average rate of loss of 2.1 $ft^3/s/mi$ was measured along a 3.9-mile reach of the river near Sevier where the river enters the basin. An average loss of 1.9 $ft^3/s/mi$ was measured along a 3.2-mile reach north of Monroe, just north of the shallow consolidated-rock constriction bounding the subbasin near Joseph.

About 10,100 acre-ft/yr of water is estimated to recharge the ground-water system by seepage from the Sevier River on the basis of data collected during the August 1988 seepage study. Water levels in the basin usually peak in October, and losses from the river measured in August were assumed to be representative of average conditions for that year because ground-water levels are generally nearer to average in August than in October. Seepage to ground water from the river probably is greatest during the winter and early spring when the water table is lowest.

The accuracy with which the estimated 10,100 acre-ft/yr represents long-term average losses from the river is not known. Water levels measured in the basin during 1988 were above long-term average altitudes. Above average altitudes for aquifer zones discharging to the Sevier River might have reduced the length of losing reaches of the river, resulting in below average losses from the river during 1988. Locations of losing reaches along the river, however, cannot be defined, nor can losses by seepage from the river be quantified from available long-term flow data. Data from the 1988 seepage studies are the only field measurements available on which to base an estimate of ground-water recharge from the Sevier River.

Recharge to the ground-water system by seepage from perennial and ephemeral streams, other than the Sevier River, occurs mainly where the streams enter the basin. Here the streambeds are mainly composed of coarse-grained, unsaturated deposits. Much of the water in these streams is diverted for irrigation of fields in the spring, or seeps from natural channels to the ground-water system before reaching the Sevier River. Only during periods of high runoff does any appreciable quantity of streamflow reach the Sevier River. An

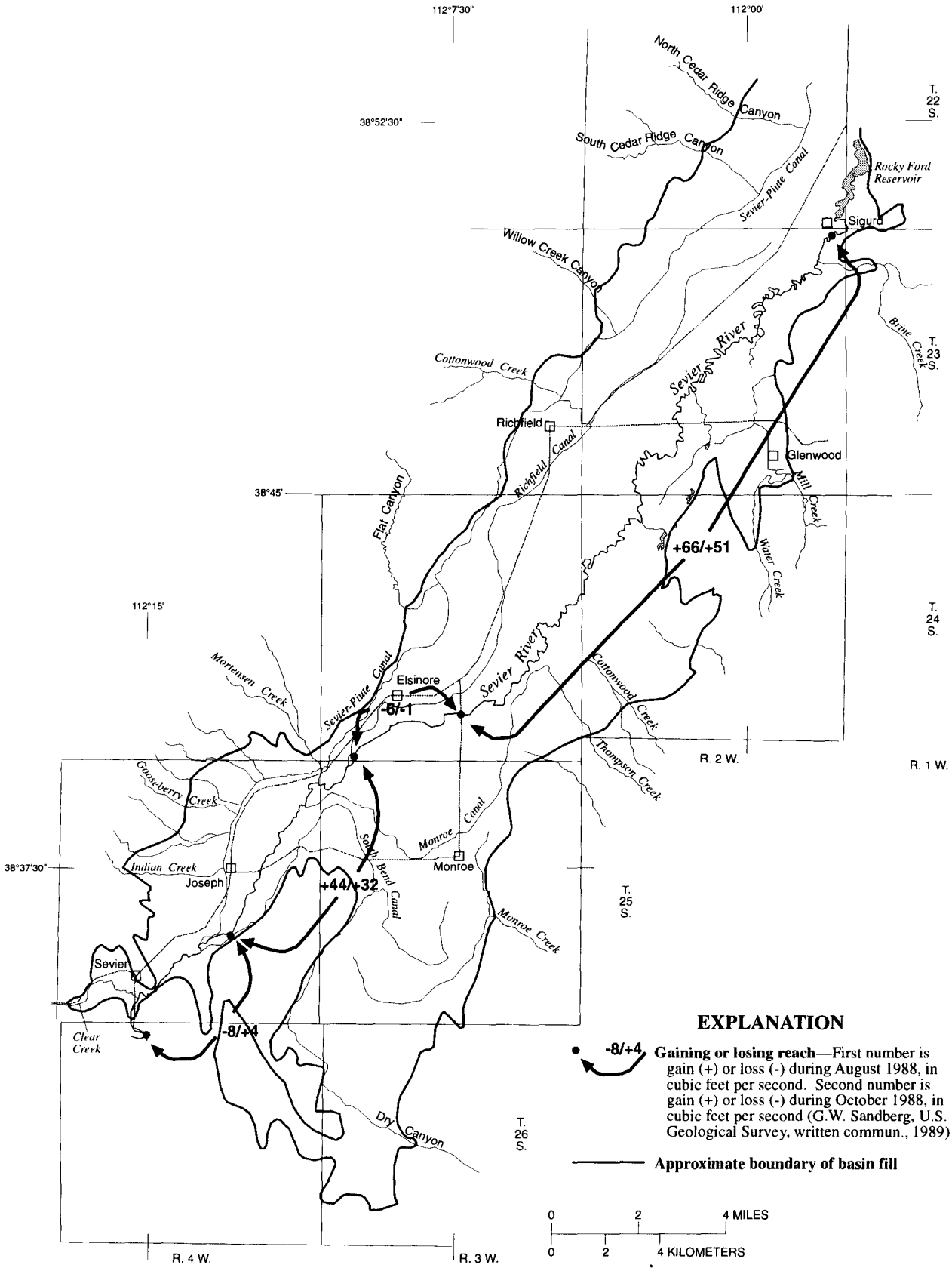


Figure 8. Gaining and losing reaches of the Sevier River in the Sevier-Sigurd basin.

estimated 19,200 acre-ft of water recharges the ground-water system annually by seepage from the natural channels of perennial and ephemeral streams. Estimates of losses from streams to the ground-water system were based on estimates of annual discharge in ungaged streams (table 1); information on irrigation practices obtained from records at the Richfield office of the Utah Department of Natural Resources, Division of Water Rights; information obtained from irrigation companies; and from field measurements.

Clear Creek is the largest tributary to the Sevier River in the Sevier-Sigurd basin. Clear Creek, however, discharges into the Sevier River as it enters the basin and the reach in which there could be seepage to the ground-water system from the creek channel is short. Recharge to the ground-water system by seepage from Clear Creak, therefore, is assumed to be negligible.

Inflow from Consolidated Rock and Seepage from Irrigated Fields

Relatively few data are available on which to base estimates for recharge to the ground-water system from consolidated rock. Evidence of some recharge from consolidated rock is indicated in water-level and water-chemistry data collected along the west margin of the basin near Richfield. The potentiometric surface near Richfield (pl. 1) indicates a steep hydraulic gradient and possible recharge from the west. Also, the chemical composition of water collected from wells just east of Richfield is indicative of water from fractured limestone such as the Flagstaff Limestone west of Richfield.

Recharge to the basin fill from consolidated rock also might occur along the east margin of the valley north of Glenwood. Springs issue along the contact between Tertiary volcanic rocks and the underlying Arapien Shale. The contact between the formation is buried to the north and south and might discharge water directly to alluvium in these areas.

An inflow-outflow analysis for the basin was made to determine the relative magnitude of recharge to ground water from consolidated rock compared with other recharge components. Estimated average inflow to the system, not including inflow from consolidated rock, was compared with the total estimated outflow (table 4). The cumulative error in the estimated inflow and total estimated outflow was estimated to be less than 15 percent. It was assumed that a large negative difference between estimated inflow and total estimated outflow would indicate a substantial contribution of water from consolidated rock. The difference between the totals is positive; however, about 7 percent of the estimated inflow, indicating only that inflow from consolidated rock is probably less than the cumulative error for other flows in table 4.

Table 4. Estimated annual inflow and outflow of water, Sevier-Sigurd basin

Source of inflow	Inflow (acre-feet per year)	Source of outflow	Outflow (acre-feet per year)
Sevier River	[1]164,600	Sevier River	[1]89,400
Precipitation	42,200	Canal export	[1]67,000
Clear Creek	[1]28,100	Crop consumptive use	[2]59,500
Other ephemeral and perennial streams	35,550	Evapotranspiration, wetlands	[2]29,500
Consolidated-rock springs	10,000	Evapotranspiration, non-cultivated	12,200
Subsurface consolidated rock	unknown	Discharge from public supply, industrial, stock, and domestic wells	2,700
		Evaporation, open water	[2]1,300
Total inflow	280,450	Total outflow	261,600
(total known inflow - total outflow) = 18,850 acre-feet/year			

[1]Estimate based on data for 1957-86, presented in table 2 of this report.
[2]From Department of Natural Resources, Water Resources Division, written commun., 1988.

The quantity of seepage from irrigated fields depends largely on the quantity of water applied. An estimated average 101,400 acre-ft of water is diverted annually from the Sevier River into canals and ditches to be used mainly for irrigation in the Sevier-Sigurd basin, based on yearly total diversions reported in table 2. An additional 40,600 acre-ft is estimated to be pumped from wells, and diverted annually from streams, springs, and drains for irrigation (table 5).

Table 5. Irrigation water-use analysis for the Sevier-Sigurd basin

Source of irrigation water	Average water applied for irrigation (acre-feet per year)
Diversions from the Sevier River and Clear Creek for irrigation in the Sevier-Sigurd basin minus estimated canal loses (8,900 acre-ft/yr) (Averaged for the period 1957-1986)	92,500
Diverted from other perennial and ephemeral streams	12,900
Diverted from alluvial and consolidated rock springs	12,300
Diverted from drains	6,000
Direct precipitation used by crops	[1]18,500
From pumped and flowing irrigation wells	9,400
Total water applied	151,600
Crop consumptive use	[1]-59,500
Unconsumed irrigation water	92,100

[1]From Department of Natural Resources, Water Resources Division, 1988, written commun.

The average quantity of unconsumed irrigation water is estimated to be 92,100 acre-ft/yr (table 5). No detailed studies have been done to determine what happens to unconsumed irrigation water in the basin, and the percentage of this water that recharges the principal ground-water system is unknown. Irrigated fields in the primary recharge areas of the basin (fig. 4) probably transmit a greater percentage of irrigation water to the ground-water system than do fields underlain by fine-grained silt and clay in the center and north end of the basin. Some unconsumed water runs off of fields to small ditches, canals, or directly to the Sevier River. Where fine-grained deposits are near land surface, unconsumed irrigation water could move downgradient along perched zones discharging into ditches, canals, or the Sevier River without reaching the principal ground-water reservoir. Available data are insufficient to quantify and differentiate between unconsumed irrigation water that recharges the ground-water system, and water that discharges into ditches, canals, or the Sevier River as surface runoff or discharges from shallow perched layers.

Because of the lack of available field data, recharge from consolidated rock and from seepage from irrigated fields was not estimated separately. The estimate for the combined recharge to the ground-water system from these two components of 72,400 acre-ft/yr (table 3) was derived indirectly by computing the difference between estimated recharge from other components (table 3) and the total estimated discharge from the ground-water system (table 6).

Table 6. Summary of discharge from the ground-water system, Sevier-Sigurd basin

Source	Ground-water discharge (acre-feet per year)
Seepage to the Sevier River	47,400
Evapotranspiration	23,200
Discharge from springs	18,000
Discharge from pumped and flowing wells	12,100
Seepage to drains	10,000
Subsurface outflow	2,000
Total discharge from the system	112,700

Subsurface Inflow from Basin Fill

Ground-water inflow at the south end of the basin is assumed to be negligible. Saturated fill material at the downstream ends of Marysvale Canyon and Clear Creek Canyon is very thin and does not transmit substantial quantities of water to the Sevier-Sigurd basin.

Subsurface inflow within the fill material was calculated near the mouth of the canyon containing Brine Creek. Two shallow test wells were installed to determine the horizontal gradient. Slug-test data obtained from the test wells were analyzed to determine horizontal hydraulic conductivity. Although the estimated horizontal hydraulic conductivity is representative of the upper part of the fill material, it is assumed

that this value is representative of the entire thickness of fill material. The maximum depth to the consolidated rock in the vicinity of the test wells of 100 ft was determined from a seismic refraction profile completed along the axis of the canyon. Seismic methods were not used to determine the depth to the consolidated rock perpendicular to the axis of the canyon because of the close proximity of the canyon walls. An elliptical-shaped cross section, therefore, was assumed to calculate the area of the fill material. The subsurface inflow was calculated using a form of Darcy's Law:

$$Q = KIA \qquad (2)$$

where Q = ground-water inflow, in cubic feet per second;
K = horizontal hydraulic conductivity, in feet per second;
I = horizontal hydraulic gradient, dimensionless; and
A = cross-sectional area, in square feet.

The calculated ground-water inflow is 0.1 ft^3/s (about 75 acre-ft/yr) using 5.8 ft/d (6.7×10^{-5} ft/s) for horizontal hydraulic conductivity, 0.026 for horizontal hydraulic gradient, and 62,000 ft^2 for cross-sectional area. This inflow is minimal compared with the overall ground-water budget for the Sevier-Sigurd basin.

Movement

In general, ground water in the Sevier-Sigurd basin moves from recharge areas in the south end and along the western margin of the basin (fig. 4) to the northeast, where it discharges from the ground-water system. Contours depicting the potentiometric surface for the principal ground-water reservoir in September 1988, are shown on plate 1. Ground water generally moves perpendicular to potentiometric surface contours. Water-level data for the thin, shallow water-table zone in the north end of the basin are few and the water-table surface for that zone is not shown.

Ground-water flow is impeded at the northern basin boundary by thick clay layers and by shallow consolidated rock of low permeability. Shallow consolidated rock and overlying fine-grained deposits also create an impediment to ground-water flow at the northern end of the subbasin near Joseph.

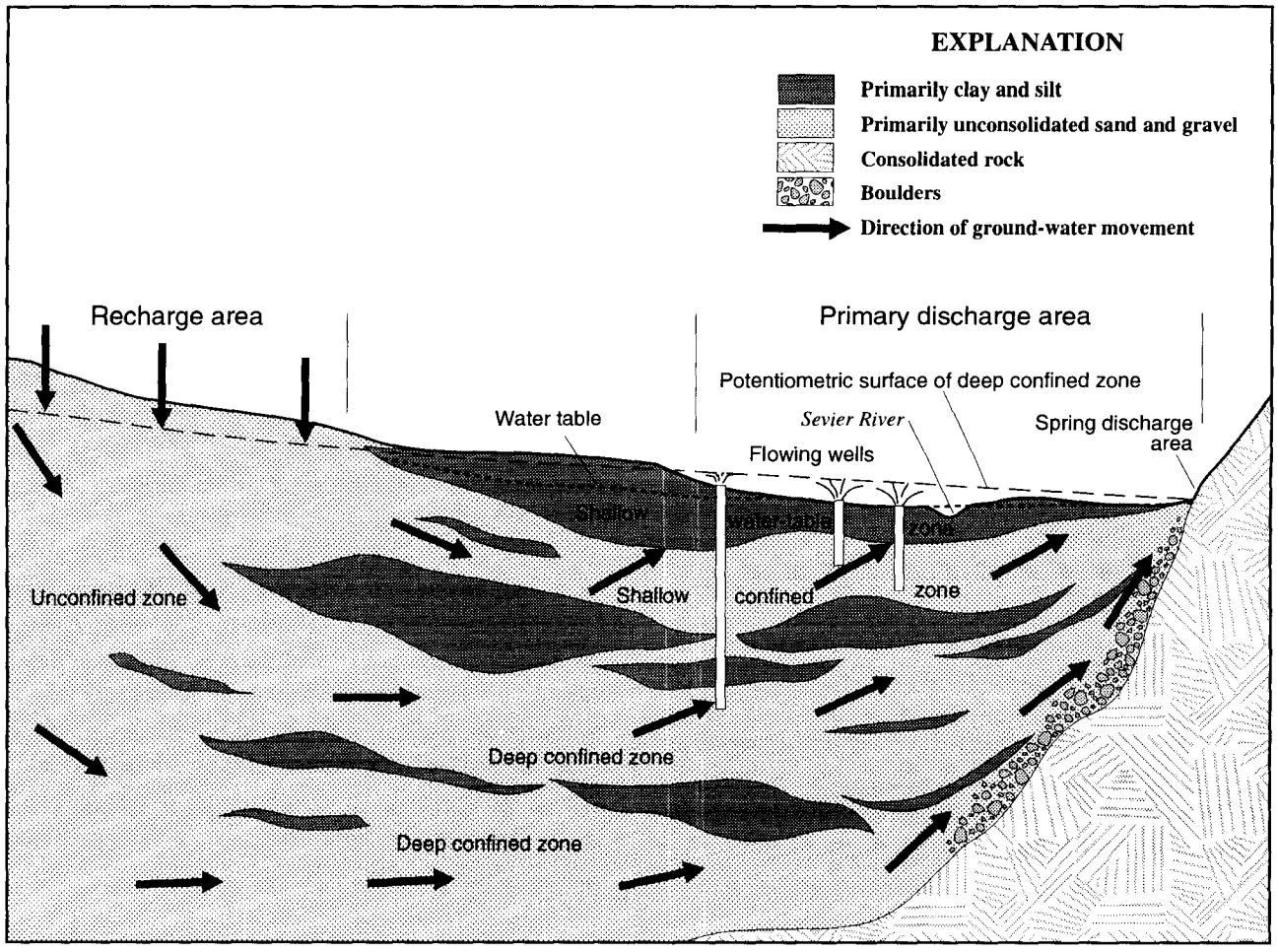
As ground water moves from the primary recharge areas of the basin into the confined zones, an upward vertical gradient is established. In these areas, ground water moves upward from the shallow confined zone to the shallow water-table zone where it is discharged to the Sevier River, to drains, and by evapotranspiration. Ground water also moves upward at the contact between basin fill and consolidated rock along the east margin of the basin and is discharged by springs. A generalized section showing ground-water movement in the confined zones of the aquifer system is shown in figure 9.

During the study, shallow wells (C-23-2)29cdb-2 and (C-23-2)29dcd-1 were completed in the fine-grained deposits constituting the shallow water-table zone east of Richfield near the Sevier River. These shallow wells were near wells completed in the underlying shallow confined zone. The wells were used to determine the horizontal hydraulic gradient of the shallow water-table zone and to determine the vertical hydraulic gradient between the shallow water-table zone and the shallow confined zone. The horizontal hydraulic gradient in the shallow water-table zone between the well sites was computed to be about 0.003 (about 16 ft/mi). The vertical hydraulic gradient between the shallow water-table zone and the shallow confined zone was estimated to range from 0 to 0.2. A generalized section showing ground-water movement in the shallow water-table zone in the Sevier-Sigurd basin is shown in figure 10.

Ground water moves upward from the deep confined zone to the shallow confined zone through clay-silt confining layers (fig. 9). Drillers' logs for wells on the east side of the basin indicate that the clay-silt layers separating the deep and shallow confined zones, and clay-silt layers within the deep confined zone, are thin or do not exist along the east margin of the basin where ground water from these zones discharges to springs. The vertical hydraulic gradient between the two confined zones was estimated from available data to range from 0 to about 0.03.

Water-Level Fluctuations

Water levels in the Sevier-Sigurd basin fluctuate seasonally and over long periods of time in response to changes in withdrawals or additions of water. Water levels have been measured intermittently in the Sevier-Sigurd basin at eight wells since 1935, and annually at eight wells since 1959 (table 24). During this study, water levels at 25 wells have been measured monthly from 1987 to 1989 (table 24).



Not to scale

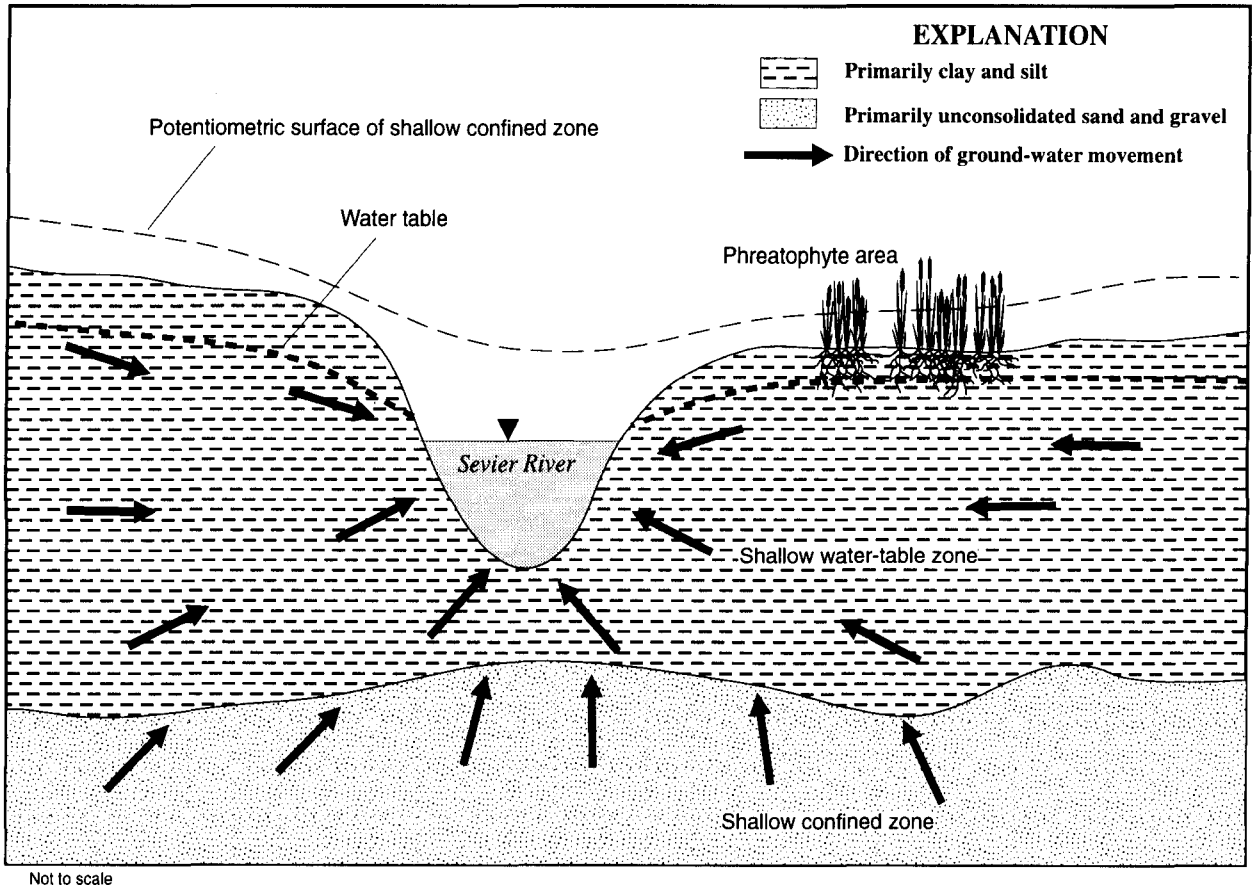
Figure 9. Ground-water movement in the confined zones, Sevier-Sigurd basin.

Seasonal Fluctuations

Seasonal fluctuations in water levels are caused mainly by changes in recharge from seepage of irrigation water from fields and canals, and by seepage from ephemeral streams during spring months. Water-level data collected during this study indicate that seasonal water-level trends are generally similar throughout the basin. Water levels begin to rise in May in response to spring runoff and early-season application of irrigation water and continue to rise in most areas of the basin throughout the summer and early fall. Water levels generally decline from October to March when recharge from unconsumed irrigation water ceases and water discharges mainly to drains, to springs, and to the Sevier River. The departure from average water levels in two wells and the quantity of water diverted from the Sevier River for use in the Sevier-Sigurd basin are shown in figure 11.

Water-level fluctuations in wells penetrating the confined zones are generally less than water-level fluctuations in wells finished in the unconfined zone underlying the primary recharge areas of the basin. Water levels in both zones reached their highest levels several months after diversions for irrigation were at a maximum.

Seasonal fluctuations in water levels from 1987 to 1989 (table 24) ranged from 1 to 6 feet in wells finished in the shallow and deep confined zones and from 2 to 12 feet in wells finished in unconfined zones in the south one-half and along the west margin of the basin. Seasonal water-level fluctuations in selected wells completed in the unconfined zones of the aquifer system are shown in figure 12. The highest water levels generally occurred from August through October and the lowest water levels generally occurred prior to the irrigation season in March through May.



Not to scale

Figure 10. Ground-water movement in the shallow water-table zone, Sevier-Sigurd basin.

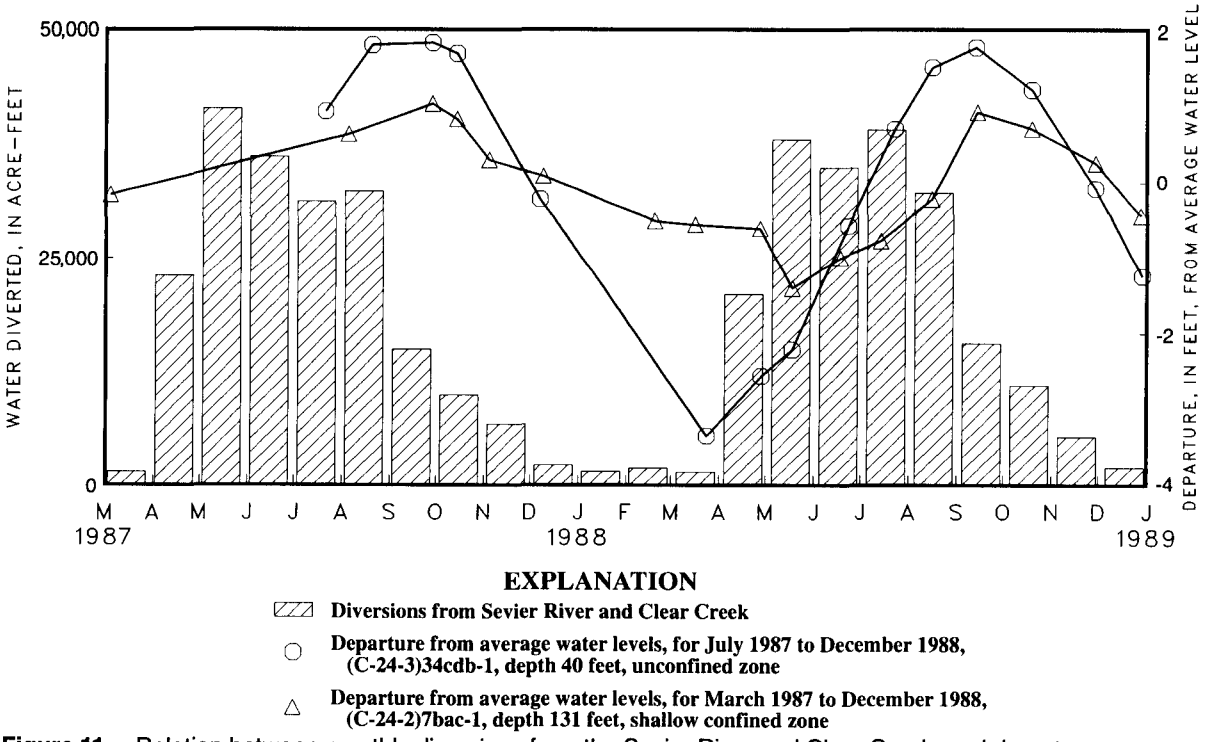


Figure 11. Relation between monthly diversions from the Sevier River and Clear Creek, and departure from average water levels in wells (C-24-3)34cdb-1 and (C-24-2)7bac-1.

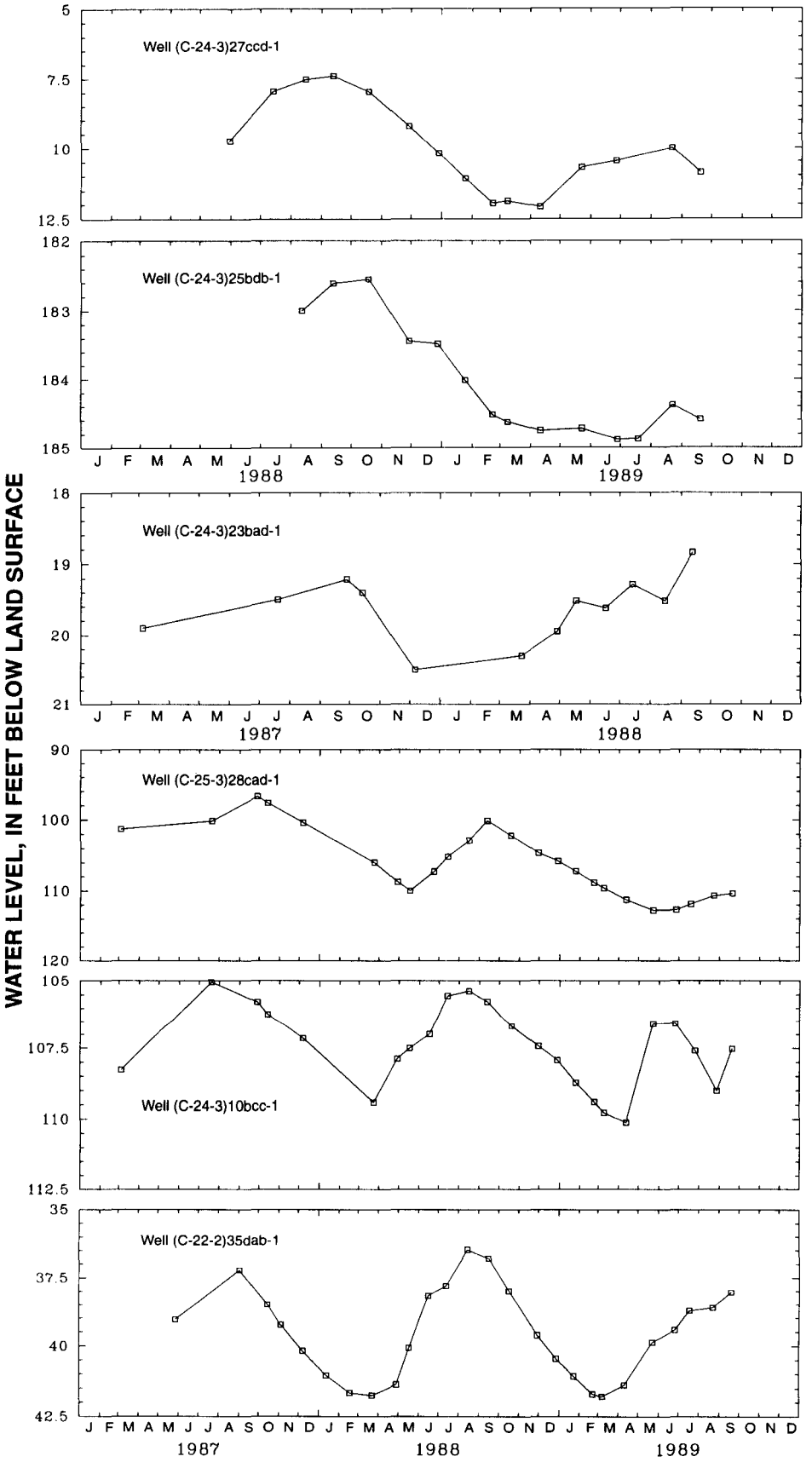


Figure 12. Seasonal water-level fluctuations in wells completed in the unconfined zones of the ground-water system, Sevier-Sigurd basin.

Water-level data collected from 1957 to 1960 (Carpenter and Young, 1963, p. 20-23) indicate that water levels in some wells finished in confined zones declined during spring and summer months as the result of increased discharge from flowing wells that were uncapped during the irrigation season. Similar water-level fluctuations, however, are not present in water-level data from selected wells completed in confined zones from 1987 to 1989 shown in figure 13.

The water-level fluctuations at a well completed in the shallow confined zone for 1958-60, and at a nearby well completed in the same zone for 1987-89 are shown in figure 14. From 1958 to 1960, water levels in well (C-23-2)10bdd-1 were highest during winter months and lowest during summer months when discharge from flowing wells was at its maximum. Water levels in well (C-23-2)10bdb-1 for 1987 to 1989 do not indicate a similar decline during the summer months. The apparent decreased effect of discharge from flowing wells on water levels in the confined zones of the ground-water system from 1958-60 to 1987-89 might indicate that (1) fewer flowing wells are used now than during 1958-60, and (2) a smaller percentage of wells now are capped during the winter months than during 1958-60.

Long-Term Fluctuations

Long-term trends in precipitation affect long-term, water-level fluctuations in the basin. Although infiltration from basin precipitation is only a minor contribution to recharge of the ground-water system, trends in precipitation in the entire drainage area determine the quantity of water available for recharge to the ground-water system from irrigated fields, and from streams and canals.

Periods of low ground-water levels reflect periods of below average precipitation, and subsequently, below average diversion of water for irrigation. Hydrographs showing long-term water-level fluctuations in wells completed in the deep and shallow confined zones are shown in figure 15. The relation of water-level fluctuations and fluctuations in annual precipitation and annual diversions for irrigation in the Sevier-Sigurd basin is shown in figure 16.

Discharge

Discharge from the ground-water system in the Sevier-Sigurd basin is by seepage to the Sevier River, by evapotranspiration, from springs and pumped and flowing wells, by seepage to drains, and by subsurface outflow (table 6). With the exception of evapotranspiration and discharge from pumped wells, most discharge from the ground-water system occurs in the north one-half of the basin.

Seepage to the Sevier River

About 47,400 acre-ft of water is estimated to discharge from the ground-water system to the Sevier River annually. The estimate was derived from an analysis of measured flow in the Sevier River at the U.S. Geological Survey gaging station 10194000, Sevier River above Clear Creek; measured and estimated inflow to the river in the basin; measured outflows to canals and by seepage to ground water; and measured flow in the Sevier River at the U.S. Geological Survey gaging station 10205000, Sevier River near Sigurd. A summary of the analysis is presented in table 7. Values for flow in the river and diversions to canals were computed from data listed in table 2 and represent averages for calendar years 1957-86.

By including inflow to the river from ungaged surface-water sources and outflow from the river by seepage in the analysis, it was assumed that the difference between total outflow and inflow would represent gains to the river coming primarily from the ground-water system.

A source of discharge to the river that is not accounted for in the above analysis is irrigation return flow in the form of surface runoff from fields, and shallow ground-water flow in perched layers. Water discharging to the river from these sources cannot be differentiated from discharge to the river from the ground-water system. It is possible that a substantial percentage of gains in the Sevier River indicated in streamflow data recorded at permanent gaging station on the river comes from surface runoff and discharge from shallow perched zones of unconsumed irrigation water.

Seepage rates to the Sevier River that were obtained from seepage studies done in August and October of 1988 were not used to estimate annual average ground-water discharge to the river because they might not represent long-term average conditions in the area. Results of the seepage studies indicated total gains in the river in the Sevier-Sigurd basin to be 110 ft^3/s for August and 87 ft^3/s for October (fig. 8).

If the average of the rates for ground-water gains to the Sevier River measured during August and October of 1988 is assumed to represent an annual average

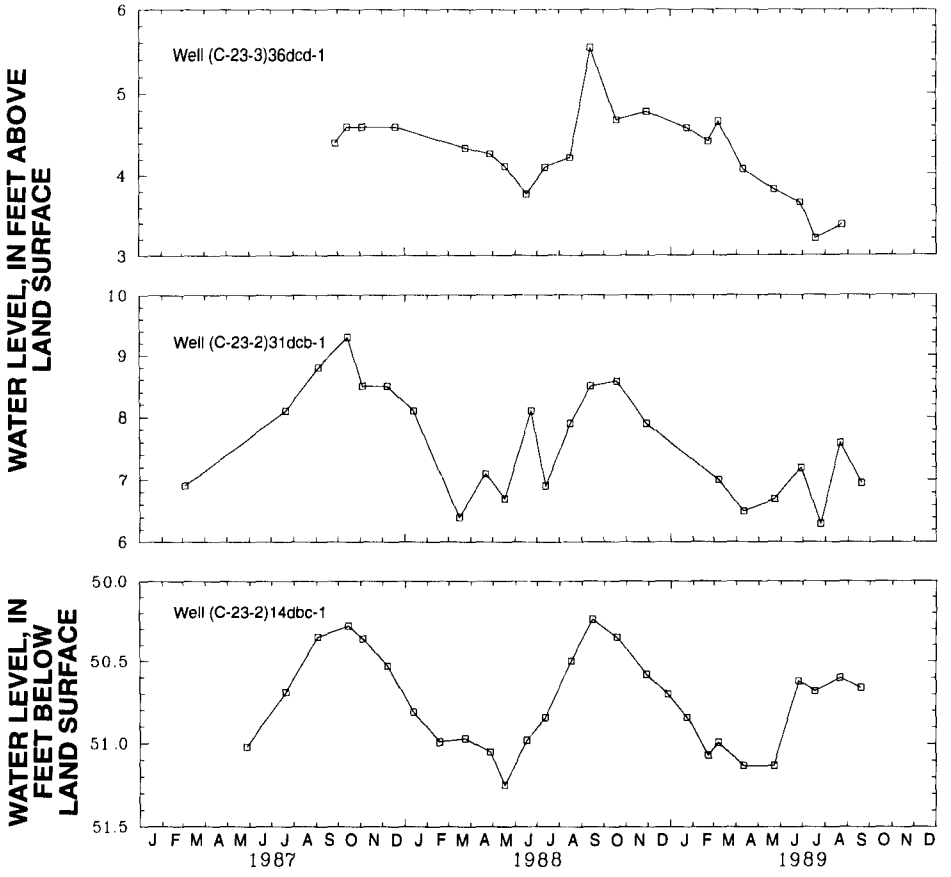


Figure 13. Seasonal water-level fluctuations in wells completed in the shallow and deep confined zones of the ground-water system, Sevier-Sigurd basin.

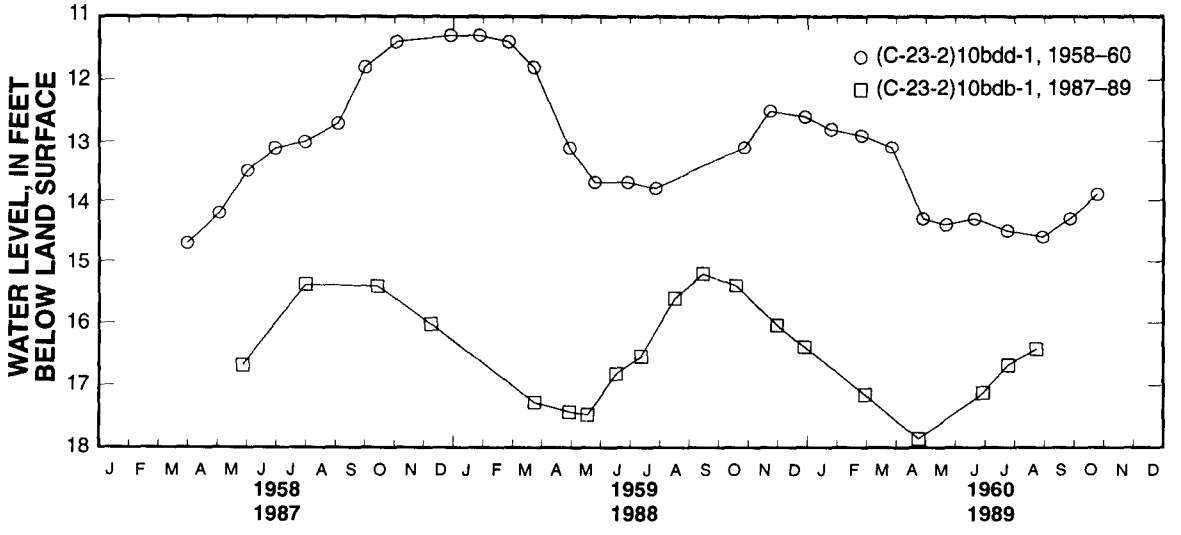


Figure 14. Seasonal water-level fluctuations for 1958-60 in a well completed in the shallow confined zone, and for 1987-89 in a well completed in the same zone, Sevier-Sigurd basin.

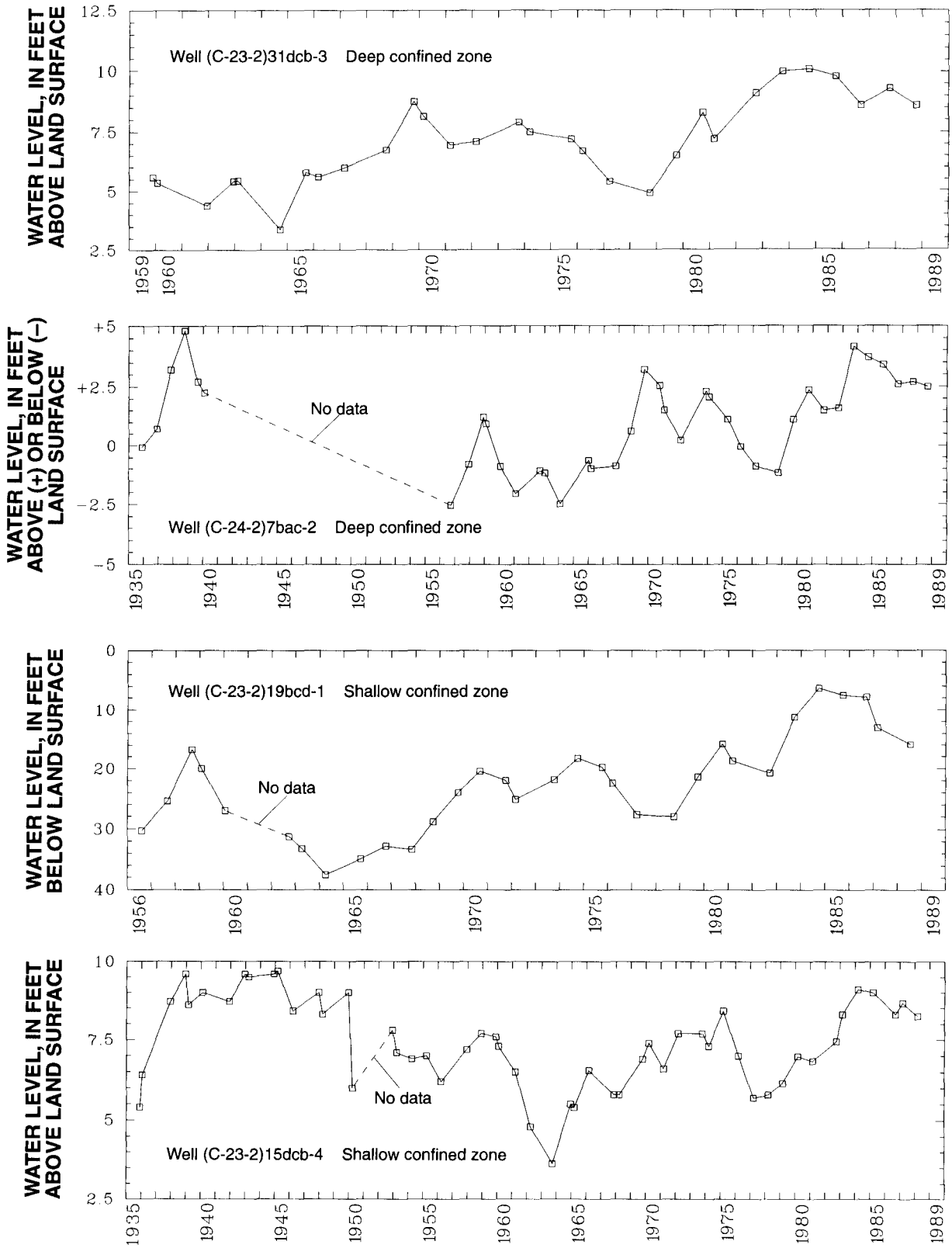


Figure 15. Long-term water-level fluctuations in wells completed in the deep and shallow confined zones of the ground-water system, Sevier-Sigurd basin.

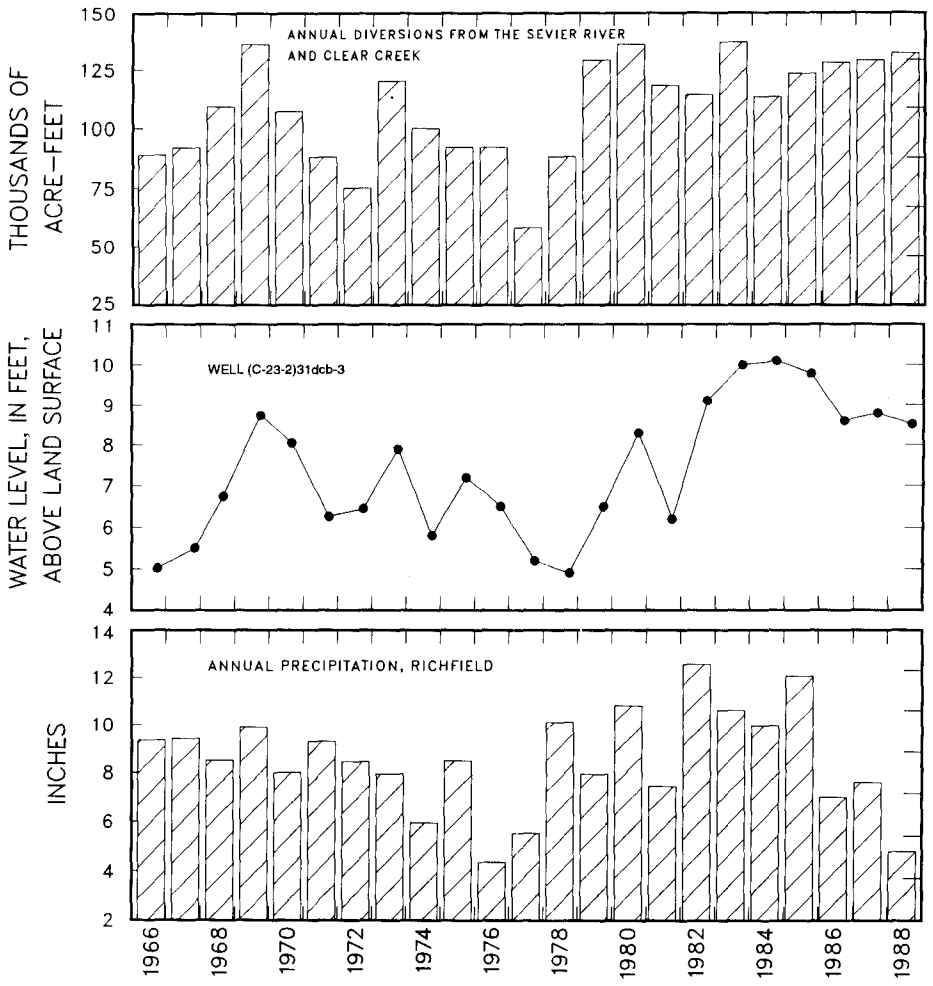


Figure 16. Relation of annual diversions from the Sevier River and Clear Creek to water level in well (C-23-2)31dcb-3 and annual precipitation at Richfield, Utah, 1966-88.

rate, the result is a calculated gain from ground water of about 71,000 acre-ft/yr. The substantial discrepancy between gains measured in August and October of 1988 and the calculated long-term average ground-water discharge to the river of 47,400 acre-ft/yr, based on long-term streamflow and diversion data, might be the result of above average ground-water levels and contributions from above average irrigation return flow during 1988. Ground-water discharge to the river varies with changes in the hydrostatic pressure in adjacent aquifers. Discharge to the river during 1988 would be expected to be above the long-term average because water levels and the quantity of water diverted for irrigation for the year were greater than average (fig. 16). The discrepancy might also be the result of the cumulative error in the estimates of inflow and outflow for the Sevier River, estimated to be about 10 percent.

Ground water discharges to the Sevier River primarily along two reaches located at the north end of the subbasin near Joseph, and at the north end of the Sevier-Sigurd basin (fig. 8). In these areas, the river probably receives ground water mainly from the shallow water-table zones.

Flow of ground water horizontally in the shallow water-table zone to the Sevier River on the west side of the river near Richfield was calculated using data collected at observation wells (C-23-2)29cdb-2 and (C-23-2)29dcd-1 completed in the shallow water-table zone. The quantity of water moving downgradient through this zone toward the river was calculated by using the following form of Darcy's law:

$$Q = K\,I\,A \qquad (3)$$

where Q = ground-water flow, in cubic feet per second;

K = hydraulic conductivity, in feet per second;

I = hydraulic gradient, dimensionless; and

A = cross-sectional area, in square feet per mile of river.

The saturated thickness of the shallow water-table zone was estimated to be 50 feet and the hydraulic conductivity was assumed to be 8 ft/d (9.3×10^{-5} ft/s). In order to relate discharge as a rate per length of river, one mile was used for the length of the cross section. The hydraulic gradient between the observation wells was calculated to be 0.003. Using these data, ground-water movement toward the river on the west side was calculated to be 0.073 $ft^3/s/mi$. If the calculated rate of 0.073 $ft^3/s/mi$ is doubled to represent ground-water flow toward the river from the west and the east, a rate of 0.15 $ft^3/s/mi$ is obtained. Although the gradient on the east side of the river was not measured, it was assumed to be similar because water levels in the shallow confined zone are similar on both sides of the river.

Table 7. Analysis of inflow and outflow for the Sevier River in the Sevier-Sigurd basin

Source	Flow (acre-feet per year) Inflow	Outflow
Sevier River at gage 10194000 above Clear Creek	164,600	
Clear Creek at gage 10194200	28,100	
Inflow from alluvial springs	10,700	
Inflow from consolidated-rock springs	5,000	
Discharge to the river from drains	4,000	
Discharge from ungaged tributaries	3,200	
Outflow to canals		163,500
Losses from seepage		10,100
Sevier River at gage 10205000 near Sigurd		89,400
Total inflow	215,600	
Total outflow		263,000
Total average gain in the Sevier River from ground water (Outflow - Inflow)	47,400	

An average rate of discharge to the river from ground water of about 2.0 $ft^3/s/mi$ for the same area was calculated from the results of seepage studies made in 1988. This value is over 10 times larger than the estimate for discharge to the river from horizontal ground-water flow in the shallow water-table zone. The discrepancy between the two values may indicate that a relatively large percentage of the gains from ground water are the result of vertical seepage from the underlying shallow confined zone through the thin confining layer beneath the river bed. The August measurement period of the seepage study was conducted during the irrigation season, and therefore, it also is possible that some of the gains measured in the river may be from unmeasured surface runoff of unused irrigation water.

Evapotranspiration

Ground-water is discharged by evapotranspiration in the north and central sections of the basin. Locally some evapotranspiration occurs along the Sevier River in the south end of the basin (fig. 17). The total discharge of water by evapotranspiration from about 8,800 acres of phreatophytes in the Sevier-Sigurd basin is estimated to be about 29,500 acre-ft/yr, 6,300 acre-ft of which is estimated to be supplied by direct precipitation (Utah Department of Natural Resources, Water Resources Division, written commun., 1988). Most of the remaining 23,200 acre-ft of annual discharge is assumed to come from ground water. Water supply to phreatophytes, other than directly from ground water, might come from springs and flowing wells, and water applied for irrigation. The percentage of the total annual discharge by phreatophytes supplied by these sources, however, could not be estimated.

Annual discharge by evapotranspiration for different phreatophytes is summarized in table 8. Reported values were obtained from the Utah Department of Natural Resources, Water Resources Division (written commun., 1988).

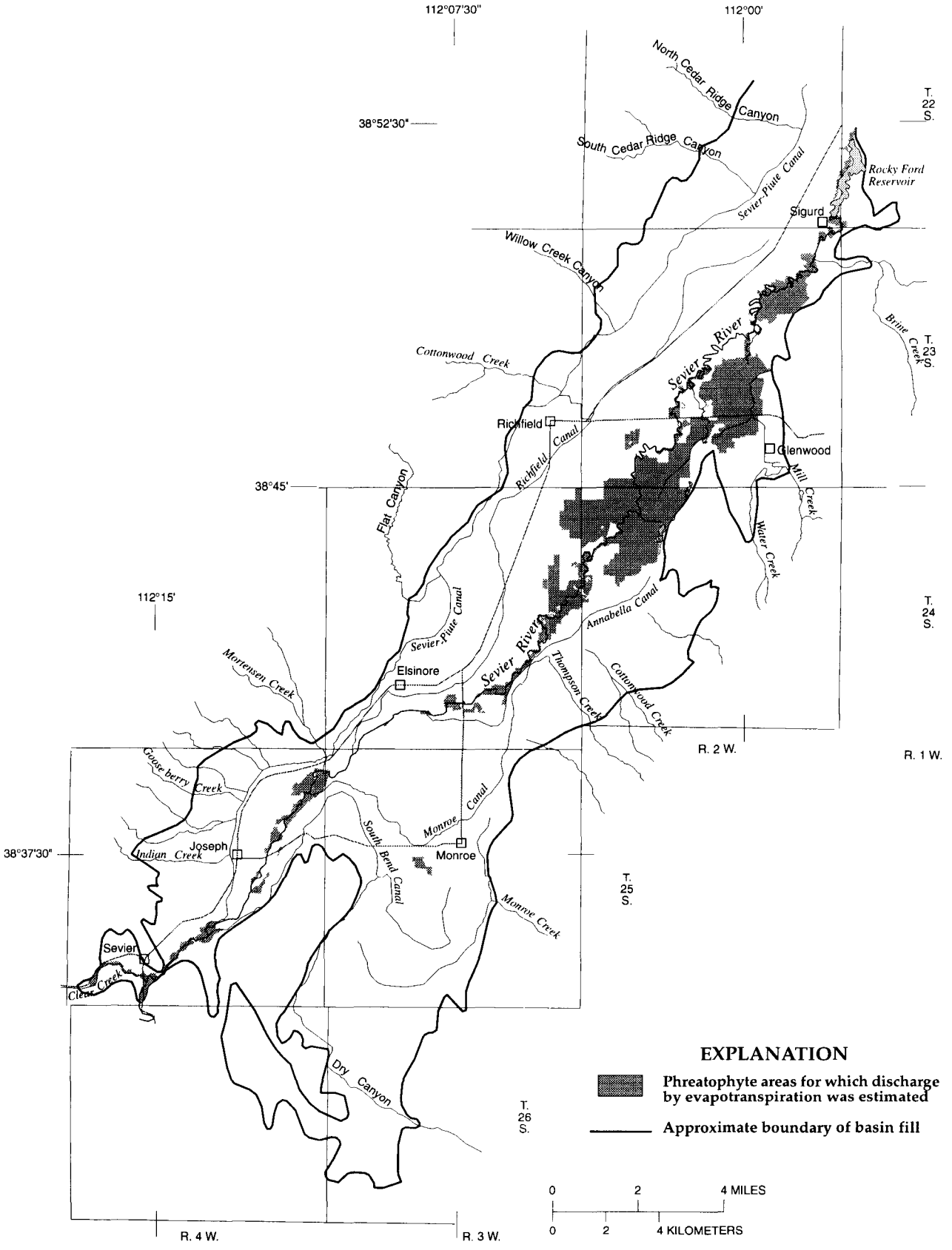


Figure 17. Location of phreatophyte areas, Sevier-Sigurd basin.

Table 8. Summary of estimates for annual discharge by evapotranspiration for various classifications of phreatophytes

Classification of phreatophytes from ground water (feet per year)	Evapotranspiration rate	Area (acres)	Evapotranspiration (acre-feet per year)
Saltgrass (12-24 inch depth to water)	1.91	339	647
Saltgrass (1-12 inch depth to water)	3.00	6,186	18,558
Cattail	4.88	1,667	8,135
Cottonwood	3.59	589	2,114
Total		8,781	29,454

Alluvial Springs

Ground water under confined conditions discharges to springs along the east margin of the basin at the contact between coarse-grained basin fill and Tertiary volcanic rocks. This contact forms a zone of relatively large hydraulic conductivity in which confined ground water moves upward to the surface. The confining layer thins along the east margin of the basin against talus from the volcanic hills to the east, and ground water discharges to springs through the talus (fig. 9). Young and Carpenter (1965, p. 67) estimated that about 18,000 acre-ft/yr is discharged to alluvial springs primarily in sec. 4, T. 24 S., R. 2 W.; in the spring areas in secs. 23, 27, 28, and 33, T. 23 S., R. 2 W.; and at (C-23-2)12bab-S1 (Black Knoll Spring).

The alluvial spring areas coincide with the location of the buried contact between Tertiary volcanic rocks and the underlying Arapien Shale. Springs issue from this contact above the basin fill east of Glenwood. It is possible, therefore, that some of the discharge from the alluvial springs comes from water discharged in the subsurface from consolidated rock.

Wells

Young and Carpenter (1965, table 7) reported obtaining drillers' records for 666 wells in the Sevier-Sigurd basin. Drillers' records for 375 wells drilled since 1963 were obtained during this study. The use and estimated number of wells drilled through 1988 are summarized in table 9.

Ground-water withdrawals from wells in 1988 were estimated to be 12,100 acre-ft. Most discharge from wells in the Sevier-Sigurd basin is from flowing wells used for domestic, stock, and irrigation purposes. Flowing wells are typically less than 200 feet deep and are drilled just deep enough to penetrate the shallow confined zone. Their casings are usually open at the bottom with no screened intervals or perforations. Few wells fully penetrate the shallow confined zone. Young and Carpenter (1965, table 7) reported 505 flowing wells, and drillers' records indicate that 99 flowing wells have been drilled since 1963.

Annual discharge from flowing wells was estimated on the basis of results from a field study of flowing wells in various areas within the central Sevier Valley. Most of the flowing wells used in the study are in the Sevier-Sigurd basin. All flowing wells known to be in the selected areas were visited. The diameter of the well casing was recorded and discharge was measured or estimated where possible.

Table 9. Use and estimated number of wells

Use of well	[1]Pre-1963	Estimated number of wells constructed from 1964-1988	Total
Irrigation and public supply	250	21	271
Industrial	6	9	15
Stock and domestic	410	345	775
Total	666	375	1,041

[1]From Young and Carpenter (1965, table 7, and p. 68)

A total of 112 wells were visited. The total discharge for flowing wells was estimated by averaging discharge measurements for each casing size (table 10).

Table 10. Estimated average annual discharge from active flowing wells of various casing diameters in the Sevier-Sigurd basin

Diameter of well casing (inches)	Range of measured discharge (gallons per minute)	Average discharge per well (gallons per well)	Number of active flowing wells with discharge per diameter	Total average discharge (acre-feet per year, rounded)
2	0.4 - 12	8	104	800
3	(one discharge measurement)	43	60	2,400
4	5 - 150	49	82	3,700
6	28 - 89	58	28	1,500
Total		274		[1]8,400

[1]An estimated 7,100 acre-feet of the annual discharge from flowing wells is used for irrigation.

Discharge was measured or estimated at 30 of the 112 wells visited. Many wells have valves and are normally shut off or plugged during the winter months. Average annual discharge per well, therefore, was estimated assuming that the wells flow 210 days of the year. The number of wells of each casing diameter was estimated by assuming that the percentage of wells of each diameter of the 112 wells visited could be applied to the total number of active flowing wells. About 55 percent of the wells visited no longer flowed, were capped and were no longer used, or were destroyed; therefore, 55 percent of the estimated total number of flowing wells were assumed to have no discharge. Ranges of measured discharge, average annual discharge measurements per well, the estimated number of active flowing wells of a certain casing diameter, and the total estimated average annual discharge are listed in table 10. The number of discharge measurements made at flowing wells is small compared with the estimated number of active flowing wells in the basin. Also, measured discharge varies considerably for wells of each casing size. The accuracy with which this estimate of discharge for flowing wells represents actual discharge, therefore, is unknown. More discharge measurements would have to be made to improve the accuracy of the estimate.

Discharge from pumped wells is relatively small compared with discharge by other means in the Sevier-Sigurd basin. Discharge from pumped wells in 1988 was estimated to be 3,700 acre-ft/yr. The estimate was derived from field measurements, records supplied by municipalities and industries, and from previously reported estimates that were updated to take into account wells constructed after 1963. Estimates made for the various uses of wells are listed in table 11.

Table 11. Use of wells and estimated annual discharge from wells in the Sevier-Sigurd basin

Use of well	Estimated discharge (acre-feet per year)
Flowing wells	
Irrigation	7,100
Stock and domestic	1,300
Subtotal	8,400
Pumped wells	
Irrigation	2,300
Industrial	100
Public supply	600
Stock and domestic	700
Subtotal	3,700
Total	12,100

Drains

Ground water discharges from the shallow water-table zone to buried and surface drains constructed in some residential and agricultural areas where the water table is near the land surface. Drains are prevalent in the north one-half of the Sevier-Sigurd basin and at the north end of the subbasin near Joseph. Young and Carpenter (1965, p. 68) estimated that about 10,000 acre-ft/yr of ground water is discharged to drains. Some

ground-water discharge to drains is diverted into canals for irrigation of crops and pasture with the remainder discharging into the Sevier River for use downstream.

Fine-grained deposits in which the drains are constructed yield ground water to drains slowly. Therefore, water levels are lowered only in the vicinity of the drain. The drain network is more important as a source of unused irrigation water from surface runoff and seepage from ground water than as a device for lowering ground-water levels regionally.

Subsurface Outflow

The Sevier-Sigurd basin is partially constricted at its north end by shallow consolidated rock, and fine-grained basin-fill deposits. It is estimated that about 2,000 acre-ft/yr of ground water flows out of the north end of the basin through the basin fill (Young and Carpenter, 1965, table 9).

Hydrologic Budget of the Ground-Water System

The hydrologic budget for the ground-water system in the Sevier-Sigurd basin is summarized in table 12. Estimates for total recharge and total discharge are identical because of the method used to estimate recharge from irrigated fields and consolidated rock (see section "Inflow from Consolidated Rock and Seepage from Irrigated Fields").

Estimates for components of recharge and discharge other than discharge to wells were derived from available data for 1957-86 and are assumed to represent long-term averages. Discharge from wells was estimated for 1988.

Table 12. Hydrologic budget for the ground-water system, Sevier-Sigurd basin

Budget component	Acre-feet per year
Recharge	
Inflow from consolidated rock and seepage from irrigated fields[1]	72,400
Seepage from the Sevier River	10,100
Seepage from other perennial and ephemeral streams (Sevier River)	19,200
Seepage from canals	8,900
Infiltration of precipitation	2,100
Total	112,700
Discharge	
Seepage to the Sevier River	47,400
Evapotranspiration	23,200
Springs	18,000
Pumped and flowing wells	12,100
Seepage to drains	10,000
Subsurface outflow	2,000
Total	112,700

[1]Estimate was derived indirectly by computing the differences between estimated recharge from other components and the total estimated discharge from the ground-water system (table 6).

WATER QUALITY IN THE SEVIER-SIGURD BASIN

The quality of surface and ground water has continued to be of vital interest to water users throughout the central Sevier Valley. The increasing dissolved-solids concentration in the Sevier River as the water moves downstream has been documented by Hahl and Mundorff (1968). Also, ground water from localized areas has a concentration of dissolved solids that is larger than that of most of the water from the ground-water system. The sources or causes for the larger dissolved-solids concentration in surface and ground water are not precisely known. Furthermore, the extent of possible change in water quality since the studies of Young and Carpenter (1965) and Hahl and Mundorff (1968) is unknown.

Surface-Water Quality

Chemical Composition

The predominant ions in the water from the Sevier River as it enters the Sevier-Sigurd basin are calcium, magnesium, and bicarbonate (fig. 18). Most of the water is diverted into the major canals and applied to irrigated fields throughout the basin. As the Sevier River flows northward, the percent equivalence of sodium increases until at Sigurd it becomes nearly equal to that of magnesium. Similarly, sulfate and chloride increases, but bicarbonate remains the predominant anion. The increases in sodium, sulfate, and chloride may be due to tributary inflow, seepage from ground water, and surface runoff from irrigated fields. Hahl and Mundorff (1968, p. 18) also attributed this increase to inflow from saline springs. Sepehr (1984, p.

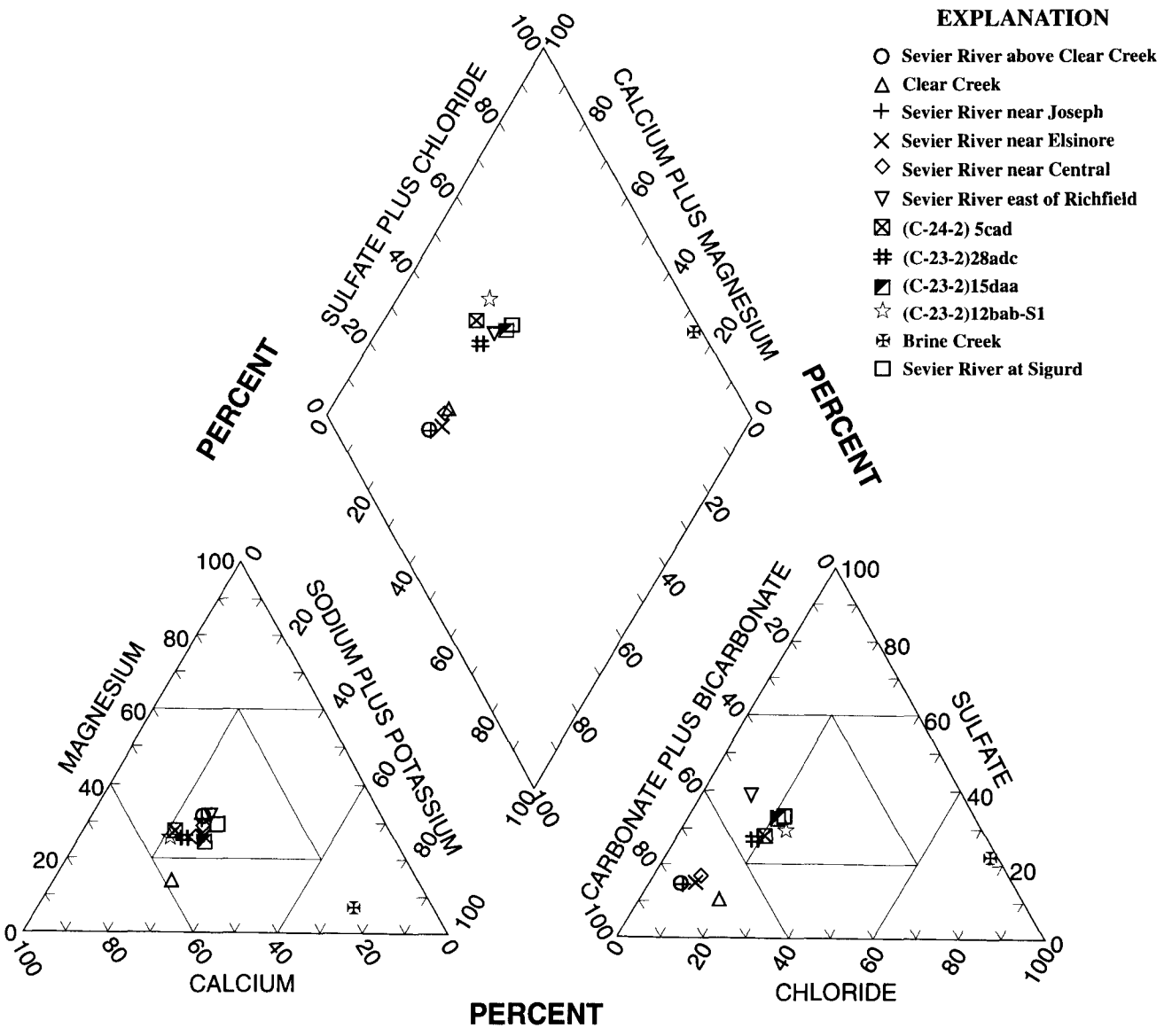


Figure 18. Chemical composition of water from the Sevier River and tributary inflows in the Sevier-Sigurd basin.

35) stated that the increased concentration of dissolved ions is too large to be attributed to tributary inflow or the concentrating effect of consumptive use.

Within the Sevier-Sigurd basin, Clear Creek and Brine Creek are the only tributary streams that continually flow into the Sevier River. The predominant ions in water from Clear Creek are calcium, sodium, and bicarbonate. The specific conductance in water from Clear Creek is generally smaller than the specific conductance in water from the Sevier River upstream from Clear Creek. Hahl and Mundorff (1968, p. 16) reported that during periods of high runoff, the dissolved-solids concentration in Clear Creek is less than one-half the dissolved-solids concentration in the Sevier River; therefore, the dissolved-solids concentration in the Sevier River is reduced. During the remainder of the year, when the flow in Clear Creek is small, the dissolved-solids concentration is similar in both streams. Although the sodium concentration is generally larger in water from Clear Creek, the flow and concentration is not sufficient to affect the composition of water in the Sevier River downstream from the confluence with Clear Creek.

The predominant ions in the water from Brine Creek are sodium and chloride, which are a result of the dissolution of halite in the Arapien Shale. As mentioned previously, most of the water in Brine Creek is diverted for irrigation prior to its contact with the shale outcrop. The water in Brine Creek reaching the Sevier River, therefore, is derived from base flow and spring

discharge downstream from the diversions. This water is concentrated in sodium and chloride with the specific conductance generally greater than 10,000 µS/cm. The discharge from Brine Creek into the Sevier River, however, is generally small (about 0.2 ft^3/s); thus, the overall increases in sodium and chloride concentrations in the Sevier River are small.

Inflows to the Sevier River from areas with large springs have several prevalent ions that include calcium, magnesium, sodium, bicarbonate, and sulfate. Concentrations are low with the specific-conductance values less than 1,000 µS/cm.

Ground-Water Effects

Ground-water gains to the Sevier River are a major contribution to its flow, as discussed earlier. Using this conclusion, Hahl and Mundorff (1968, p. 16) compared the water quality of the river with the quality of the ground water. Their data indicated that as streamflow is reduced by diversions and decreased runoff, the ratio of ground water to surface water is increased. With this process, the quality of the water in the river approaches the quality of the ground water.

As part of a seepage study on the Sevier River, water samples were collected for chemical analysis to evaluate the conclusions of Hahl and Mundorff (1968). The seepage study included stream measurements and sample collection during (August 9-11, 1988) and after (October 25-27, 1988) the irrigation season. Samples were collected from six river sites and six inflow sites within the Sevier-Sigurd basin. Not all inflow sites were sampled during each measurement period. River inflow from Black Knoll Spring, (C-23-2)12bab-S1, was sampled during August, and the river inflow near Venice, (C-23-2)15daa, was sampled during October.

The salt load was calculated for specific reaches of the Sevier River in order to determine the total dissolved-solids concentration in the water gained within the Sevier-Sigurd basin. The salt load, which is the quantity of salt carried by the river per unit of time (g/s), is calculated by multiplying the total dissolved-solids concentration (mg/L), measured discharge (ft^3/s), and the appropriate conversion factor. Salt loads were calculated at all sampling sites. The dissolved-solids concentration at the nearest upstream sampling site was used to compute the salt load of the water at a diversion for irrigation. If there is tributary inflow between the nearest upstream sampling site and the diversion, then the salt load of the inflow is added to the salt load of the water at the upstream site. From this combined salt load, a calculated value for dissolved solids is determined for use at the diversion. By subtracting the salt load of the water diverted from the salt load of the water at the nearest upstream sampling site or diversion, an adjusted value for salt load is obtained. This adjusted value is then subtracted from the salt load of the water at the next downstream sampling site. This difference is the salt load of the ungaged water gained between the two river sampling sites. To determine the dissolved-solids concentration of the ungaged inflow, the salt load is divided by the average gain for that particular reach of river and then multiplied by the appropriate conversion factor.

Unaccountable increases in the salt load between river sampling sites is assumed to be the result of ungaged inflow that may be from ground water or runoff from irrigation. Ground water, however, probably is the primary source. By not sampling the water at each point of diversion, it is necessary to assume that the water being diverted has the same dissolved-solids concentration as the water at the nearest upstream sampling site. All ground-water inflow, therefore, must be assumed to enter the river below all diversions for a particular reach. This accounting procedure is diagrammed in figures 19 and 20. The sampling sites and the calculated value for the dissolved-solids concentration in ungaged inflow for a particular reach during periods of measurement are shown in figure 21.

Calculated values for the dissolved-solids concentration in ungaged inflow to the river are different for three of the five reaches between the two measurement periods, thus indicating different hydrologic conditions. During the irrigation season, there is a net loss in the reach from Clear Creek to Joseph, whereas after the irrigation season, there is a net gain with calculated dissolved-solids concentration for ground-water inflow being greater than that of the river. For the reaches from Joseph to Elsinore (R2 to R3, fig. 21) and from Elsinore to Central (R3 to R4, fig. 21), the calculated values for dissolved solids are virtually the same for both measurement periods.

Calculated dissolved-solids concentration for gains from Central to Richfield (R4 to R5, fig. 21) are markedly different. The calculated value for August 1988 is less than one-half the value for October 1988. The smaller value is representative of the irrigation water diverted from the river near Sevier, whereas the larger value is representative of the ground water in that area. During the irrigation season, therefore, most gains in the river in this reach are probably from irrigation return flow rather than ground-water inflow.

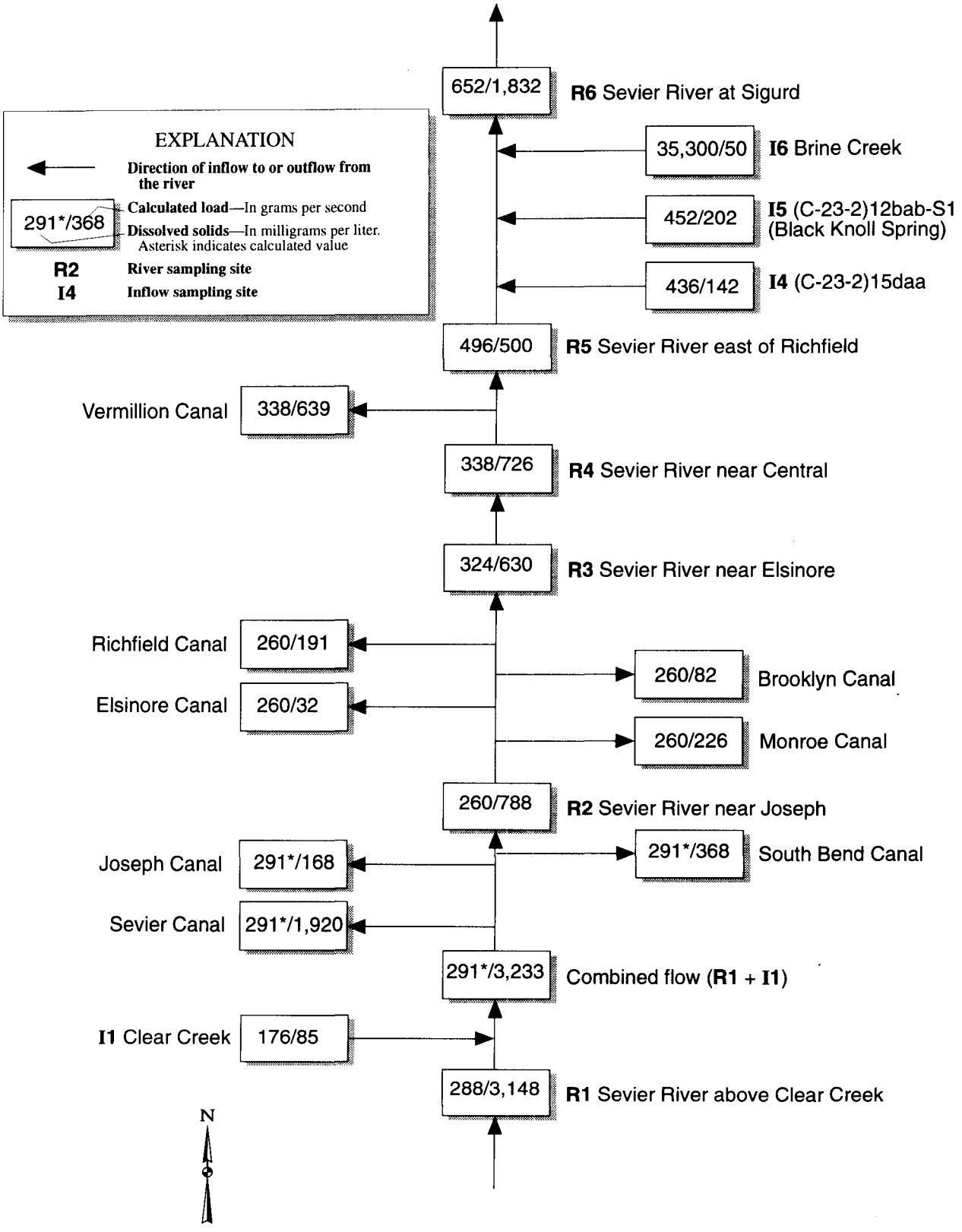


Figure 19. Dissolved-solids and calculated loads for the Sevier River, tributary inflows, and diversions in the Sevier-Sigurd basin during August 1988.

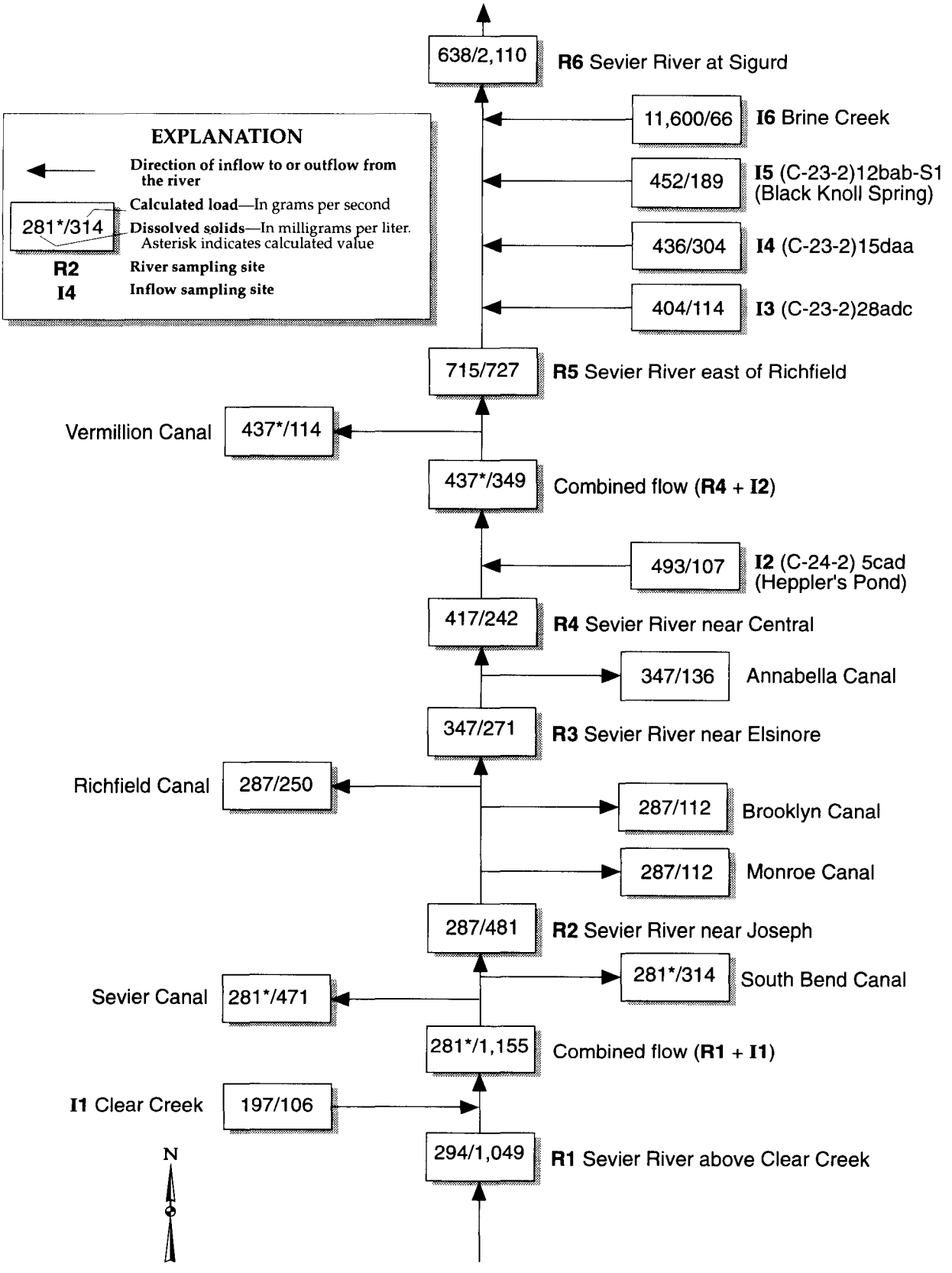


Figure 20. Dissolved-solids and calculated loads for the Sevier River, tributary inflows, and diversions in the Sevier-Sigurd basin during October 1988.

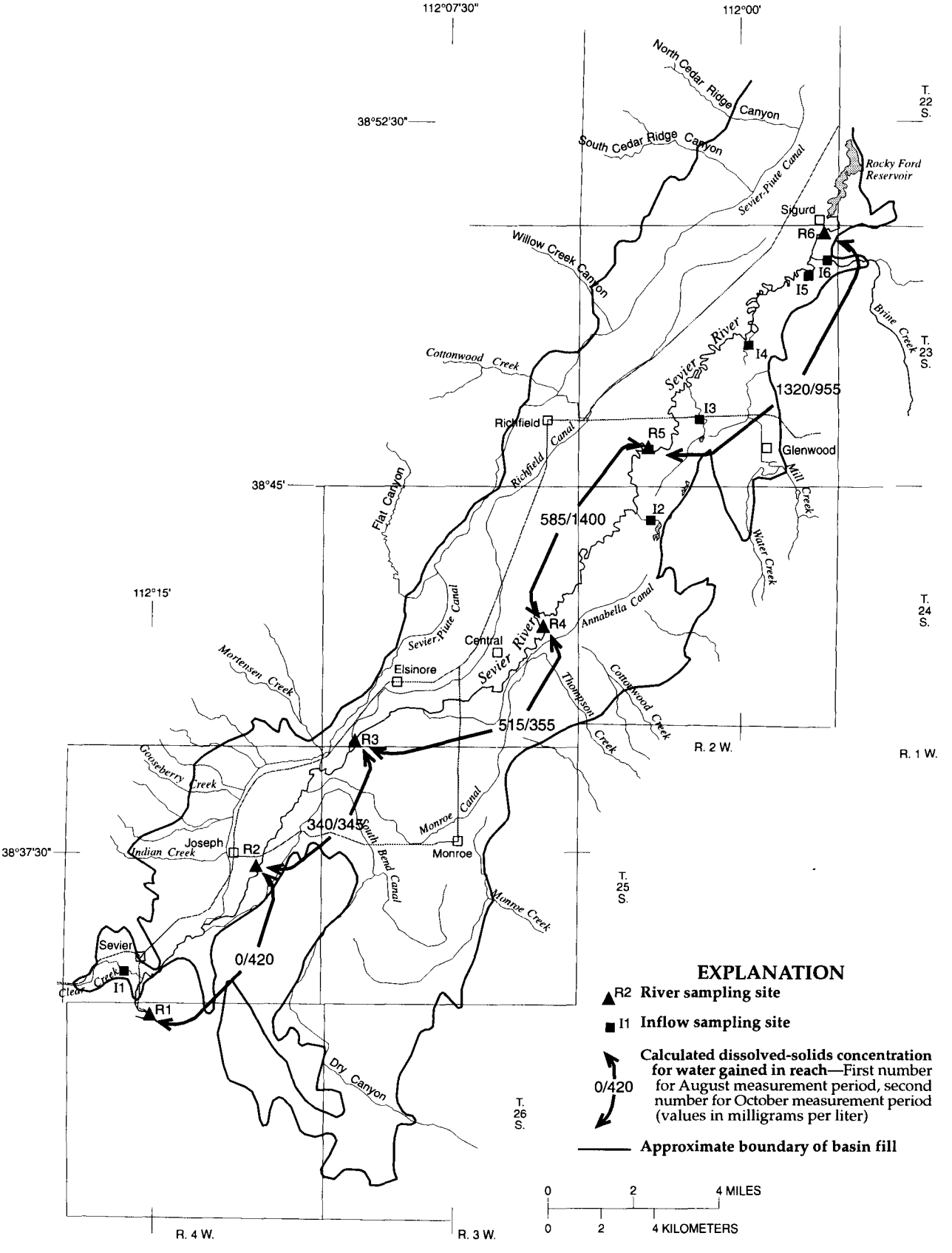


Figure 21. Sampling sites and calculated dissolved-solids concentration of water gained in the Sevier-Sigurd basin during August and October 1988.

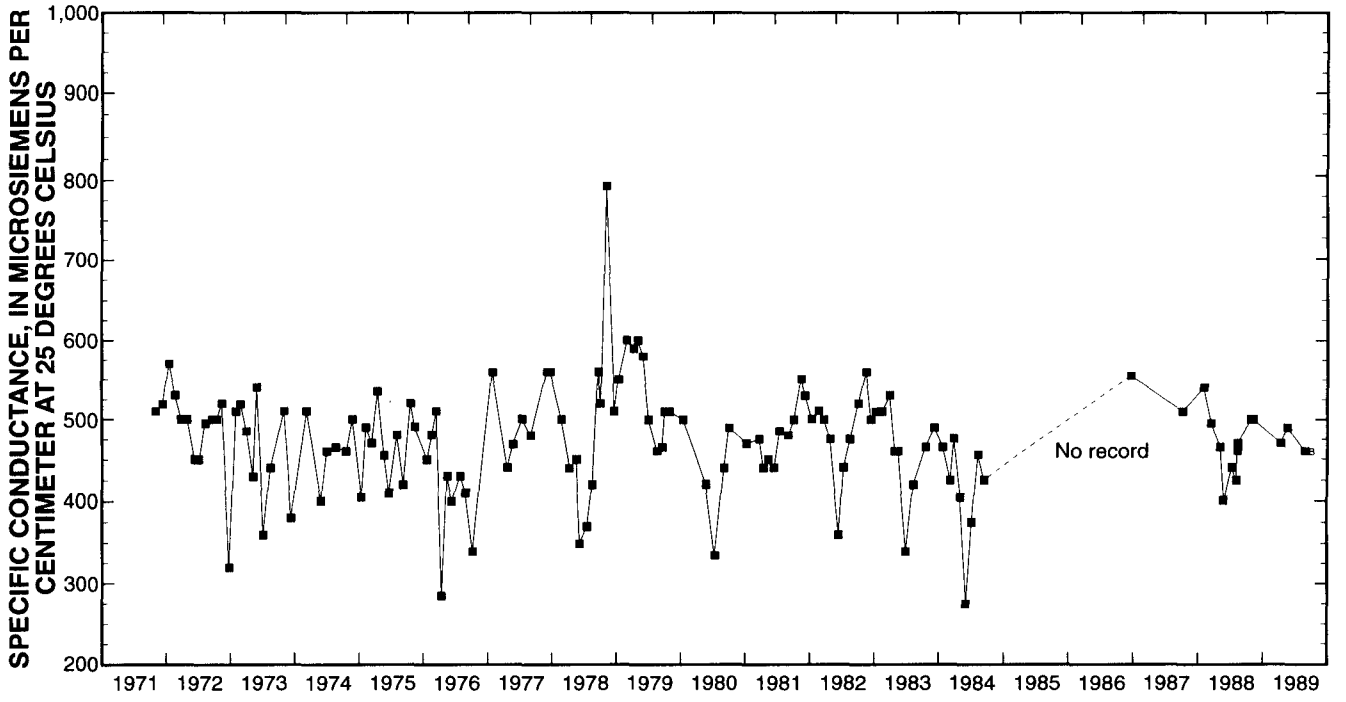


Figure 22. Variation in specific conductance at gage 10194000 on the Sevier River upstream from Clear Creek, 1971-89.

Unlike the reach from Central to Richfield, the calculated dissolved-solids concentrations for gains from Richfield to Sigurd are larger during August than October 1988. Both values are probably representative of ground-water inflow because they are considerably larger than what is representative of irrigation water. During the August 1988 measurements, most of the surface-water inflow that had a low dissolved-solids concentration was diverted for irrigation, thus increasing the ratio of ground water to surface water in the Sevier River.

The dissolved-solids concentration for ground-water inflow of each reach is an average value and, therefore, can represent several sources of ground water over a range of values. Water from the shallow water-table zone and the shallow confined zone have a dissolved-solids concentration that would be within a reasonable range of the calculated value. As a result, the zone from which the water is derived can not be determined.

Changes in Surface-Water Quality with Time

Specific-conductance data from the gaging stations on the Sevier River at the upstream and downstream ends of the Sevier-Sigurd basin do not show any deterioration of water quality from 1971 to the present (1989). As shown in figure 22, the specific conductance upstream from Clear Creek ranges from 285 to 790 µS/cm. The average specific conductance for this period of record is 477 µS/cm with a standard deviation of 65.7. As shown in figure 23, the specific conductance of water at the gaging station near Sigurd ranges from 510 to 1,480 µS/cm. The average specific conductance is 1,018 µS/cm with a standard deviation of 208.6.

The monthly variation in salt entering and leaving the Sevier-Sigurd basin in the Sevier River for the 1972-83 water years was calculated by Sepehr (1984, p. 25-35). To calculate the salt load on a monthly basis, Sepehr determined an empirical relation by regressing specific conductance against the dissolved-solids concentration at the upstream and downstream ends of the Sevier-Sigurd basin. Using this relation, he calculated the salt load using monthly specific conductance and discharge measurements. During years with near-normal flow, the salt inflow was almost equal to the salt outflow during the irrigation season, whereas the salt inflow was much less than the salt outflow in the nonirrigation season. The larger salt outflow during the nonirrigation seasons is the result of ground-water seepage to the river making up a larger percentage of the outflow, whereas salt inflow being nearly equal to outflow is the result of larger quantities of surface water enter-

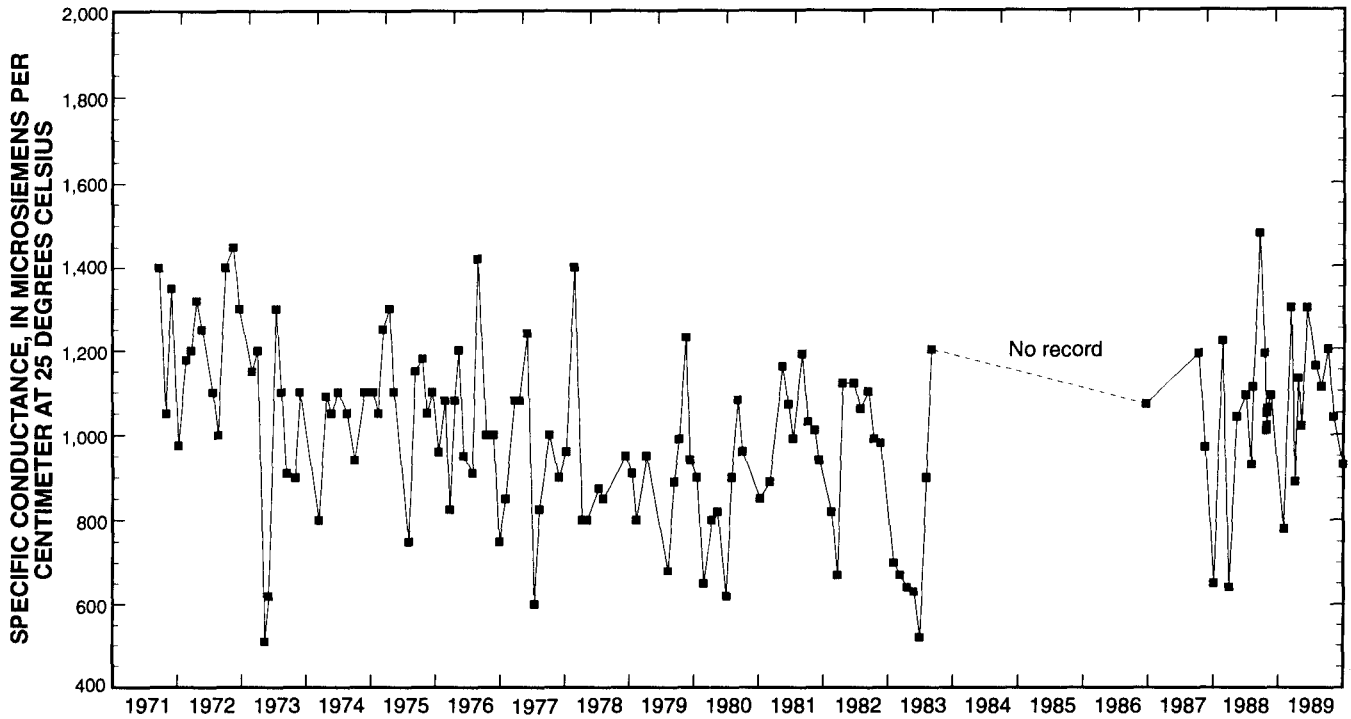


Figure 23. Variation in specific conductance at gage 10205000 on the Sevier River near Sigurd, 1971-89.

ing the basin and ground-water seepage making up a smaller percentage of the outflow. During wet years, salt outflow was generally greater than salt inflow throughout the year.

Ground-Water Quality

Chemical Composition

The chemical composition of ground water in the Sevier-Sigurd basin can be differentiated areally with respect to anions, whereas the cations generally do not show areal trends. Variations in chemical composition for water from selected wells and springs are shown in the trilinear diagram (fig. 24). The most common cations are calcium and magnesium, generally a nearly equal mixture of both. Sodium predominates in a few samples. Anions generally are divided into three groups with bicarbonate being the most common, followed by sulfate and a mixture of bicarbonate, sulfate, and chloride. Chloride was found to predominate in only a few samples, not all of which are shown in figure 24.

Trends in the areal distribution of anions can be recognized in the Sevier-Sigurd basin. Bicarbonate predominates in the south one-half of the basin and along most of the west margin, from Richfield north to Sigurd (fig. 25). Cations associated with the bicarbonates in these areas are calcium and magnesium. The difference in cation composition is indicative of the source of recharge. The bicarbonate water in the south one-half of the basin is derived from seepage of Sevier River irrigation water in which calcium is the predominant ion. The bicarbonate water along the western margin of the basin is derived from consolidated-rock inflow where magnesium is more prevalent. The source of this water is from the Flagstaff Limestone, which is composed of limestone ($CaCO_3$) and dolomite ($CaMgCO_3$). The areal distribution of the magnesium, calcium, and bicarbonate water coincides with the recharge mound west of Richfield as shown by the potentiometric surface on plate 1.

Bicarbonate also is the prevalent anion in the area west and north of Glenwood. Calcium is the cation generally associated with bicarbonate in this area, but sodium is associated with bicarbonate in water from spring (C-23-2)25bac-S1, Indian Spring, northeast of Glenwood on the east side of the basin. This water discharges from the Tertiary volcanic rocks overlying the Arapien Shale, and the type of water is indicative of water reacting with sodium plagioclase present in the volcanic rocks. Water from well (C-23-2)22dcc-2 has a similar chemical composition to the spring but the ion

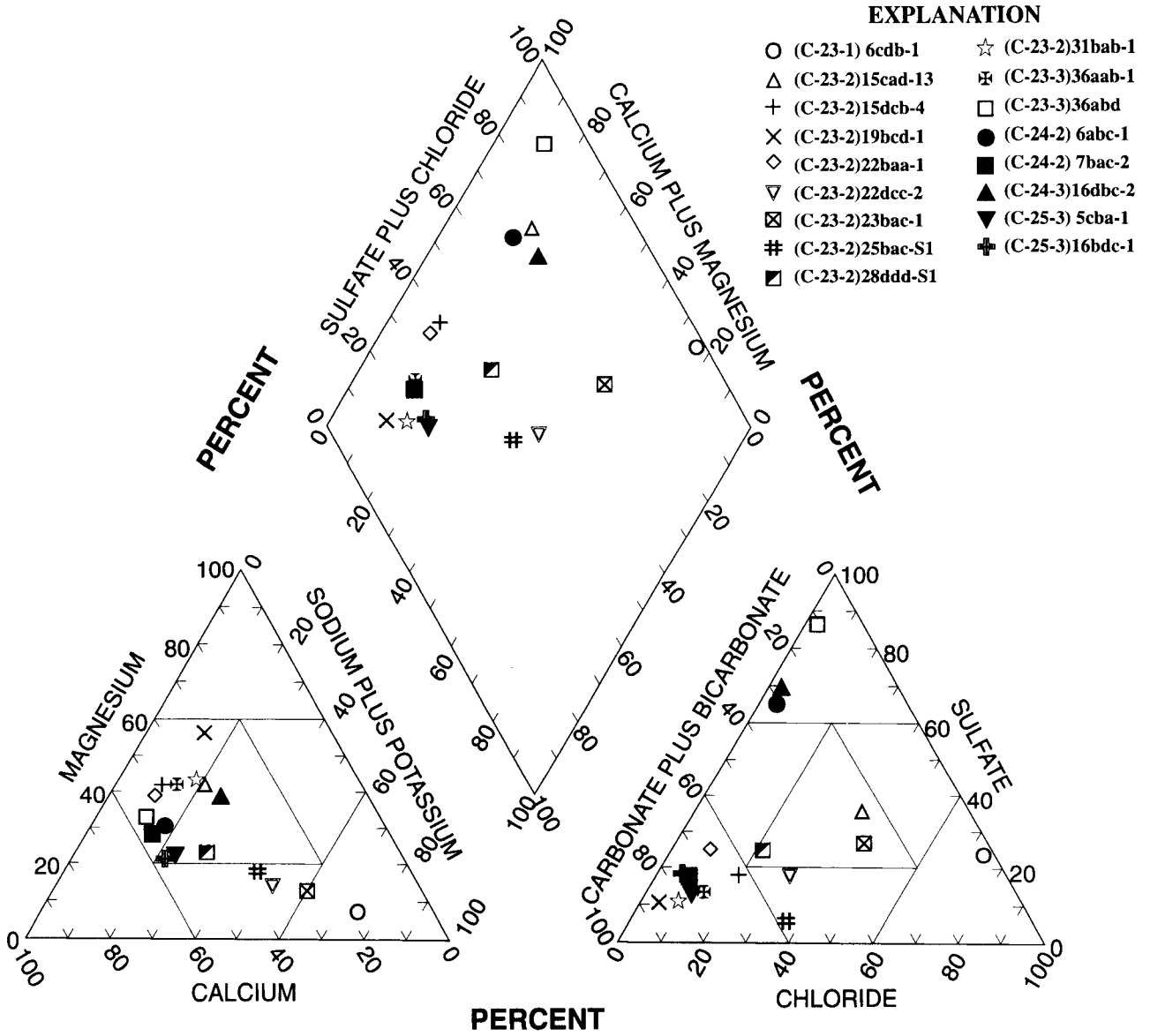


Figure 24. Chemical composition of water from representative wells and springs in the Sevier-Sigurd basin.

concentration is generally two times larger (tables 26 and 27).

Sulfate is the predominant anion in water southeast of Richfield and south of Sigurd (fig. 26). Along with the increase in sulfate, the specific conductance of this water is generally two to four times larger than the water in which bicarbonate predominates.

Chloride is the predominant anion in water from well (C-23-1)6cdb-1, adjacent to Brine Creek, and well (C-23-2)23bac-1, north of Glenwood at the edge of the basin (fig. 27). Sodium is the most prevalent cation in the water from both wells. The water in the well adjacent to Brine Creek has a specific conductance of more than 16,000 µS/cm (table 26). The large concentrations of sodium and chloride are from the dissolution of halite within the Arapien Shale. As mentioned previously, underflow entering the basin fill from the Brine Creek drainage was calculated to be about 0.1 ft^3/s. Although this water is concentrated, it does not appear to be affecting the quality of the ground water in the basin. Water from wells (C-23-2)1bdc-1 and 3, downgradient from the mouth of Brine Creek, does not show an appreciable increase in the concentration of sodium, chloride, or sulfate as compared with water from other wells in the basin. The water from wells that may be near the mouth of the canyon, however, could encounter water with concentrations of sodium, chloride, and sulfate that make it unsuitable for domestic use.

Compositionally, calcium and bicarbonate are more prevalent in water from well (C-23-2)23bac-1

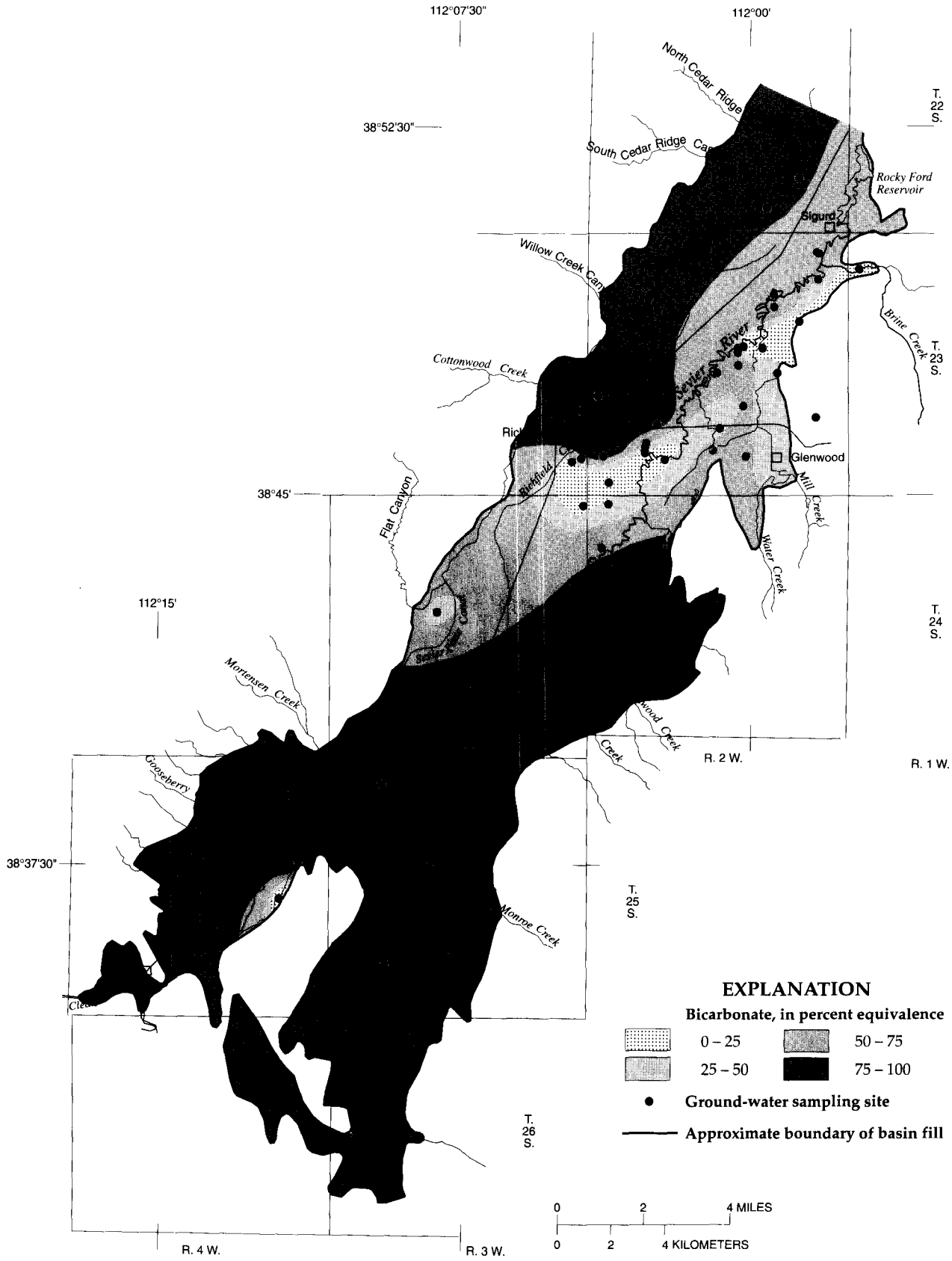


Figure 25. Approximate distribution of bicarbonate, in percent equivalence, Sevier-Sigurd basin.

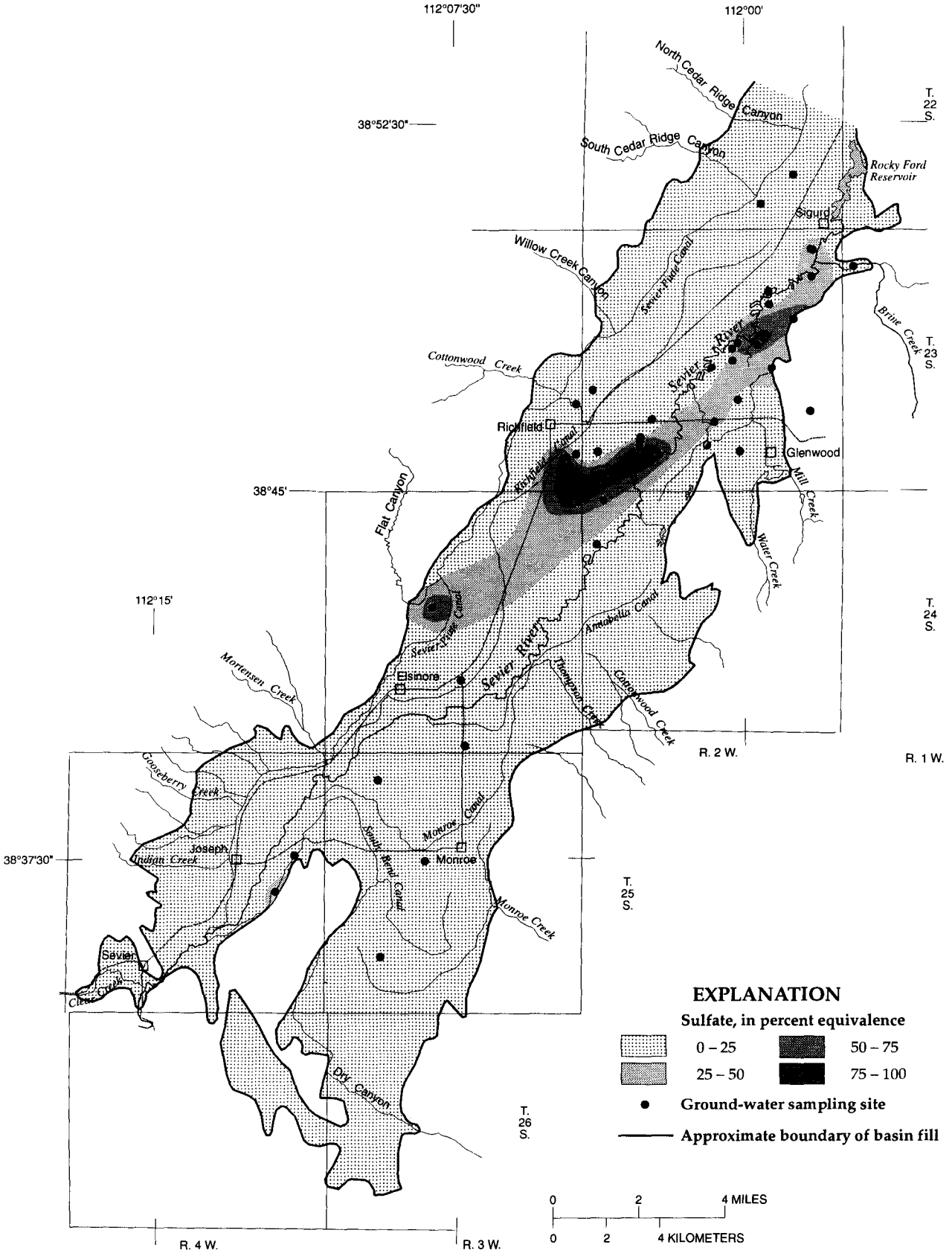


Figure 26. Approximate distribution of sulfate, in percent equivalence, Sevier-Sigurd basin.

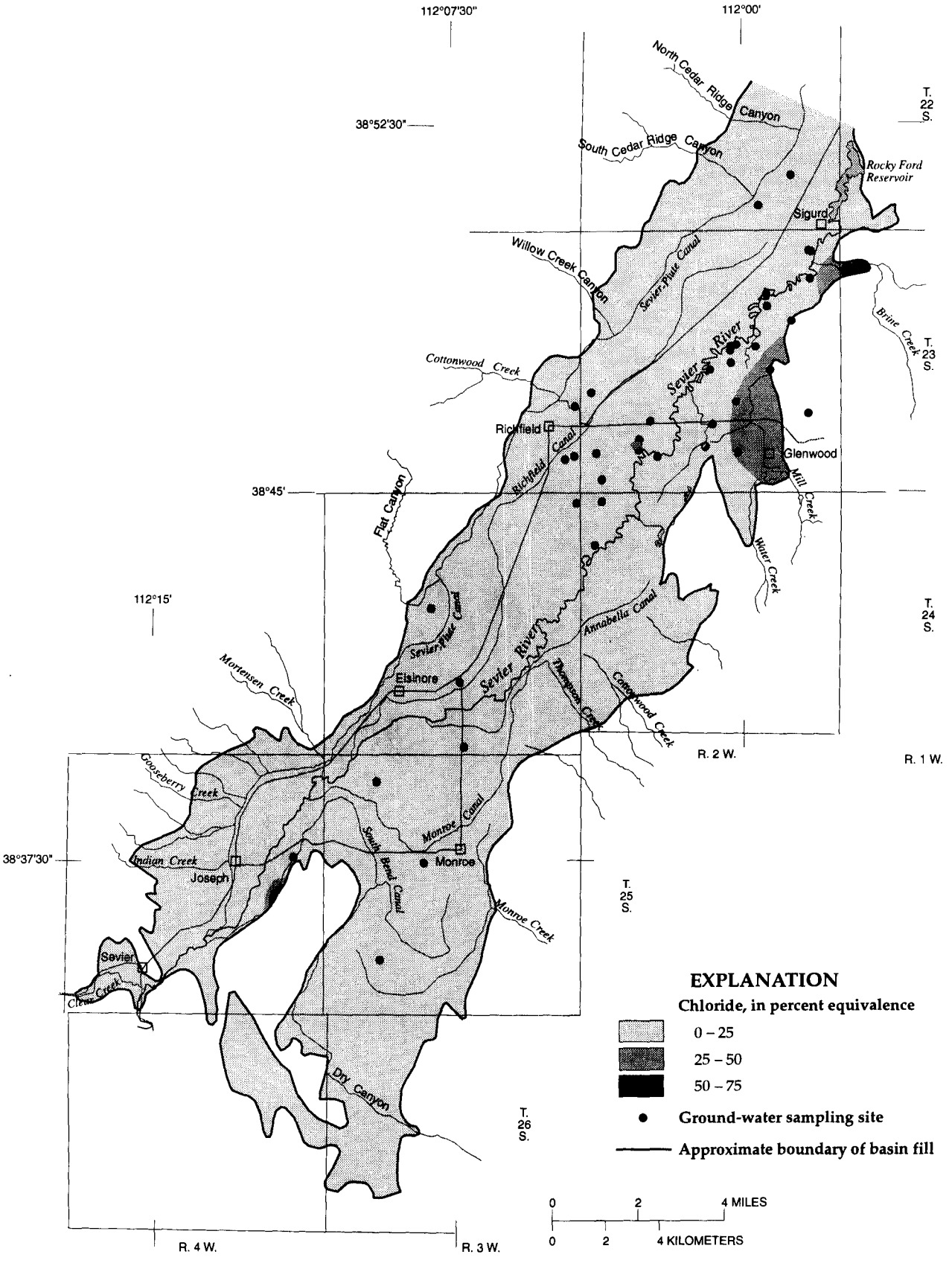


Figure 27. Approximate distribution of chloride, in percent equivalence, Sevier-Sigurd basin.

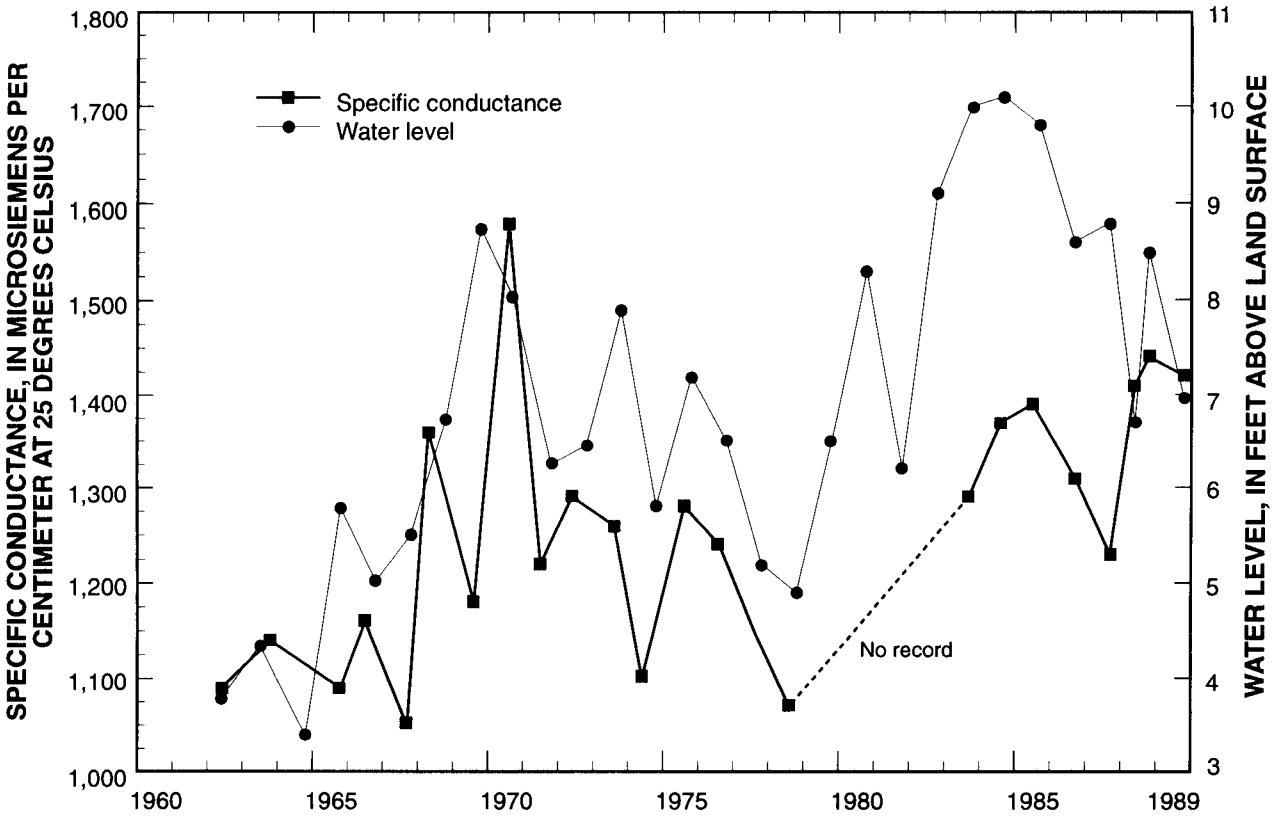


Figure 28. Variation in specific conductance of water from well (C-24-2)6abc-1 and water level in well (C-23-2)31dcb-3, 1962-89.

than in water from the well adjacent to Brine Creek. Also, the concentrations of sodium and chloride are much lower in water from well (C-23-2)23bac-1, with the specific conductance of 1,370 µS/cm (table 26). The sodium and chloride component in the water from this well may be derived from the Arapien Shale whereas the calcium and carbonate component is probably derived from the basin fill.

Changes in Ground-Water Quality with Time

The quality of the ground water from the Sevier-Sigurd basin has not changed substantially in more than 25 years. Specific conductance data for water collected from three wells during 1957 to the present (1989) are shown in figures 28, 29, and 30. Although the specific conductance of water from wells (C-23-2)15dcb-4 and (C-24-2)6abc-1 has varied during this period, no long-term trends can be discerned. The variation in specific conductance of water from well (C-24-2)6abc-1 was compared with the variation in water level in nearby well (C-23-2)31dcb-3 (fig. 28). Water-level data for well (C-24-2)6abc-1 were not used owing to difficulties in accurate measurement. Both wells are located in the flowing-well area southeast of Richfield and are perforated in the deep confined zone. The specific conductance appears to vary directly in relation to water level. A possible explanation for this relation would be that an increase in pressure head causes a zone containing water with a larger dissolved-solids concentration to contribute more water to the flowing-well discharge. The variation in specific conductance of water from well (C-23-2)15dcb-4 (fig. 29), completed in the shallow confined zone, appears to follow similar trends as in well (C-24-2)6abc-1. Major ion analyses of water from the two wells showing variations in specific conductance indicate that the variation can not be attributed to any particular ion.

The specific conductance of water from well (C-23-2)19dab-1 was virtually unchanged from 1957-89 (fig. 30). The water from this well, which is just northeast of Richfield, is derived from Cottonwood Creek and the Flagstaff Limestone. Because of the location of the well, within close proximity to the source of recharge, it is unlikely sufficient stresses would be applied to the ground-water system that would alter the quality of water in this area.

Five wells sampled previously in the Sevier-Sigurd basin were sampled again as part of this study. As with the wells having long-term data, the chemical

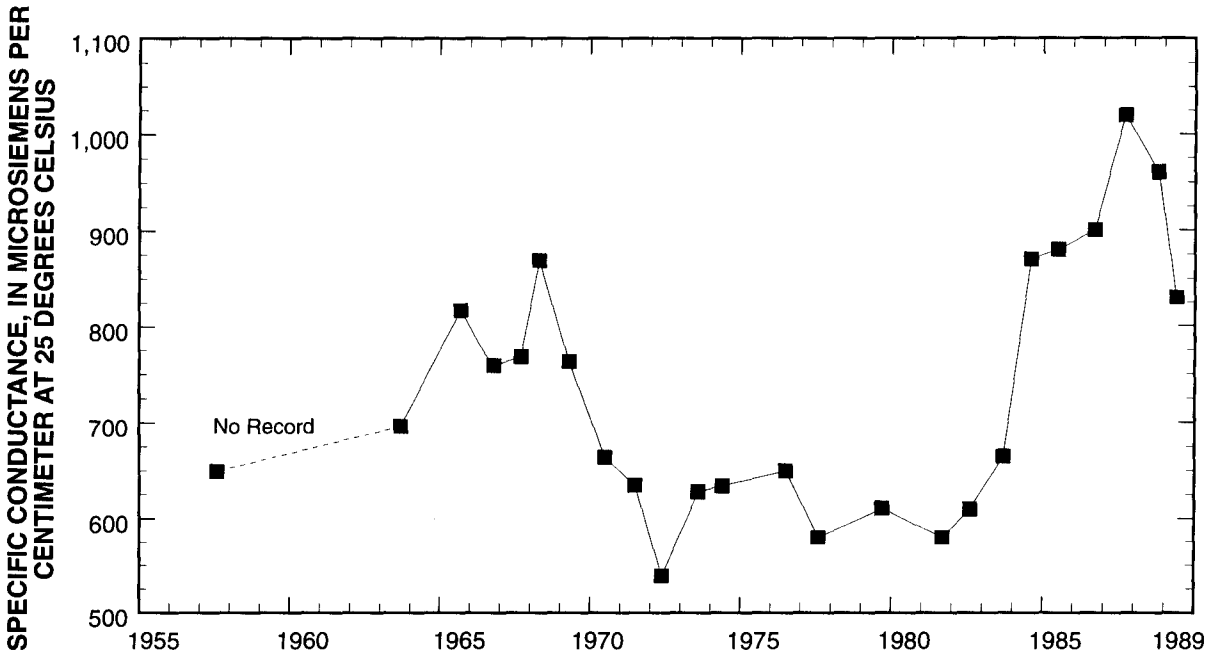


Figure 29. Variation in specific conductance of water from well (C-23-2)15dcb-4, 1957-89.

composition and concentration of the constituents have not changed in four wells. These wells are (C-23-2)15cad-13, 15dbb-1, 27bcc-2, and 34aba-1 (table 26). Major ion analyses of water from well (C-23-3)36abd-1 show more than a seven-fold increase in calcium and almost a 30-fold increase in sulfate from 1959-89. Similarly, specific conductance increased from 750 to 2,950 µS/cm. The first sample was collected shortly after completion of the well. Subsequently, the well owner (oral communication) reported rapid deterioration of water quality after pumping the well for about one month. This well is located adjacent to the area in which the ground water contains a large concentration of sulfate. Continued production from the well probably induced flow from a zone containing gypsum, which is readily soluble.

Isotopic Data and Interpretations

Water was collected from thirteen sites for stable-isotope analysis that included deuterium and oxygen-18 with the intent of delineating ground-water sources. Stable isotopes have been shown to be useful in distinguishing between probable sources in which the ground water is isotopically different. This is possible because stable isotopes are conservative in low-temperature ground-water systems and, therefore, are virtually unaffected by chemical processes.

The stable isotopes are analyzed by measuring the hydrogen ratio (deuterium/hydrogen) and the oxygen ratio (oxygen-18/oxygen-16) in a water sample. The isotope ratios are given as differences from an arbitrary standard known as STANDARD MEAN OCEAN WATER (SMOW) and are expressed in delta (δ) units per mil (parts per thousand or o/oo). The δ values are determined from the following equation:

$$\delta \text{ deuterium or oxygen-18 (in o/oo)} = [(R - R_{standard}) / R_{standard}] \times 1{,}000 \qquad (4)$$

where R and $R_{standard}$ are the isotope ratios of the sample and standard, respectively. A negative δ value indicates that the sample has been depleted in the heavy isotope in comparison with the standard, or conversely, the sample is isotopically lighter than the standard. The accuracy of the measurements are generally within + or - 0.2 o/oo for δ oxygen-18 and + or - 2 o/oo for δ deuterium (Freeze and Cherry, 1979, p. 138).

A relation between δ deuterium and δ oxygen-18, known as the mean global meteoric water line, is represented by the equation

$$\delta \text{ deuterium} = 8 \times \delta \text{ oxygen-18} + d \qquad (5)$$

where d is the deuterium excess (Dansgaard, 1964, p. 456). Craig (1961, p. 1702) determined that the mean global value for d in fresh water is 10. The value for d may differ, however, based on location and geologic time.

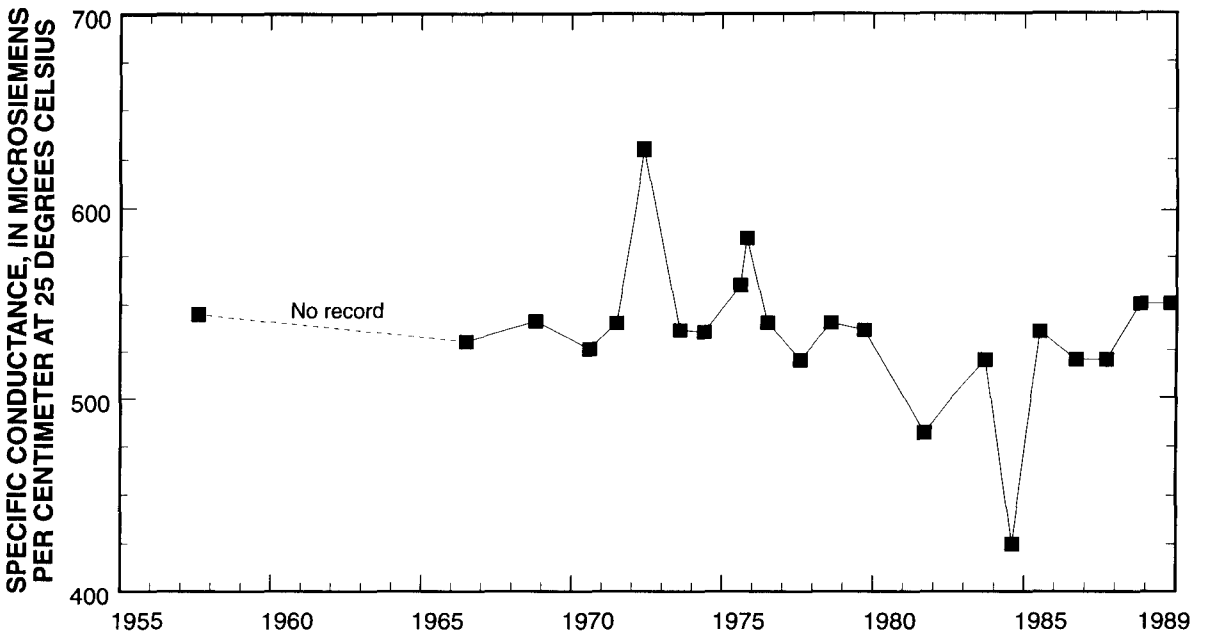


Figure 30. Variation in specific conductance of water from well (C-23-2)19dab-1, 1957-89.

The thirteen stable-isotope analyses were diagrammed in relation to the mean global meteoric water line, as shown in figure 31. Water was collected for analysis from the Sevier River near Sevier, downstream from the confluence with Clear Creek, and at Sigurd before the water flows from the basin. All other samples were collected from wells and springs in the basin. Water in the Sevier River entering the basin is isotopically enriched in deuterium and oxygen-18 compared with the other samples collected (table 13). At the opposite end of the range of values for the Sevier-Sigurd basin, water from spring (C-23-2)25bac-S1 (Indian Spring), north of Glenwood, is most depleted in deuterium and oxygen-18. The water from the Sevier River was either derived from higher altitudes and subsequently enriched by evaporation or derived from lower altitude precipitation that would be enriched in deuterium and oxygen-18 as compared with high altitude precipitation. Water discharging from Indian Spring probably has its source from high altitude precipitation that falls mostly in the form of snow. Altitude and low temperatures are factors that deplete the quantity of deuterium and oxygen-18 in precipitation. Values for stable-isotope analyses of water from the remaining sites indicate that most of the water is a mixture, to a varying degree, of surface water and high-altitude recharge water. Although there is a component indicative of consolidated-rock inflow, stable isotope values for water from the Sevier River at Sigurd and wells (C-23-2)1bdc-1, (C-23-2)19bcd-1, and (C-23-3)36abd-1, lean more toward the enriched end.

Table 13. Isotope analyses from surface and ground water in the Sevier-Sigurd basin

Local identifier	Date	O-18/O-16 Stable isotope ratio per mil	H-2/H-1 Stable isotope ratio per mil
(C-23-2) 1bdc-1	06-28-89	-13.75	-106.0
1bdc-3	07-18-89	-13.40	-103.0
12bab-S1	05-24-89	-15.10	-114.5
19bcd-1	06-29-89	-13.95	-107.5
25bac-S1	05-24-89	-16.30	-124.0
(C-23-2) 28ddd-S1	05-25-89	-15.10	-113.5
31bab- 1	05-26-89	-15.60	-118.0
31cad- 1	05-26-89	-13.10	-101.0
(C-23-3) 36abd- 1	07-18-89	-14.00	-106.0
(C-24-2) 7bac- 2	06-07-89	-15.20	-112.0
(C-24-3) 16dbc- 2	06-09-89	-13.30	-103.0
Sevier River downstream from Clear Creek	05-25-89	-13.05	-100.5
Sevier River at Sigurd	05-26-89	-14.10	-108.5

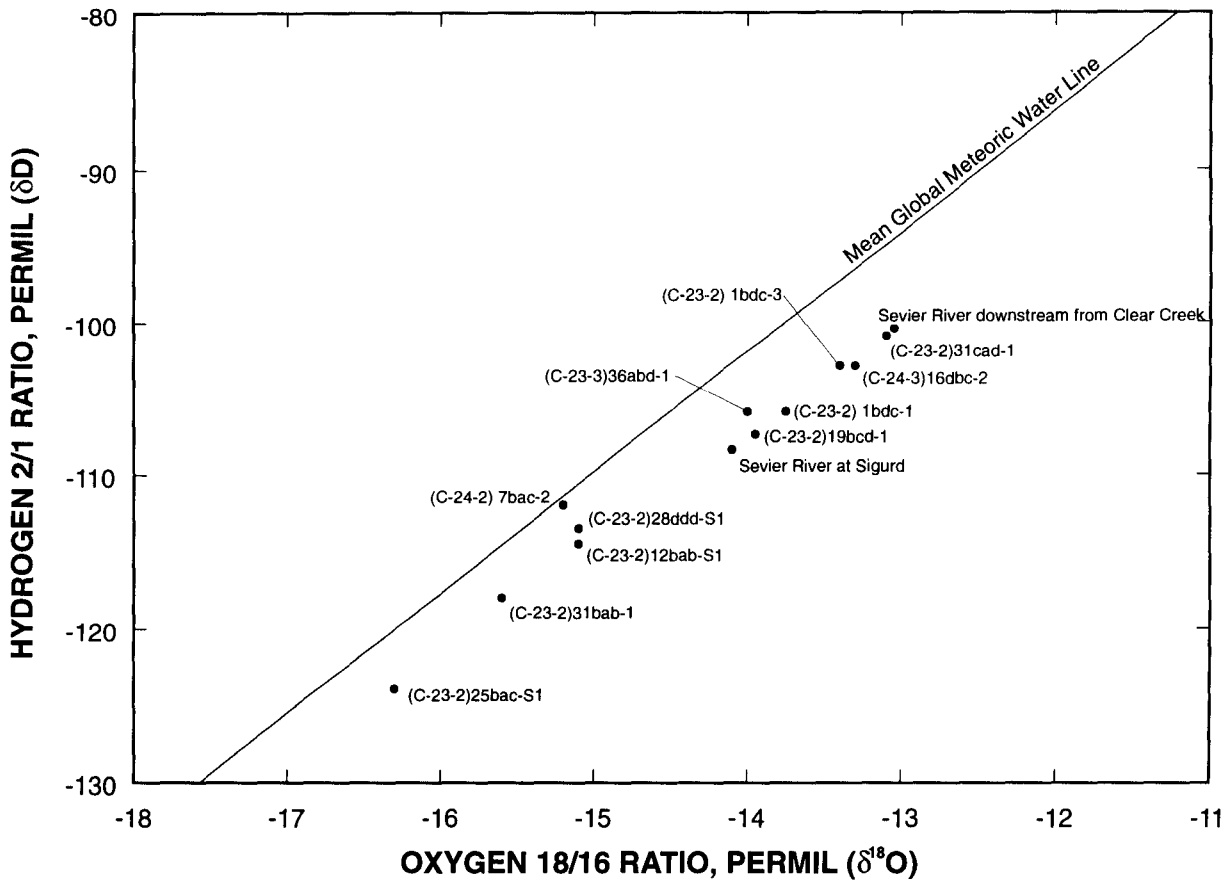


Figure 31. Relation of deuterium to oxygen-18 in surface and ground water in the Sevier-Sigurd basin.

Stable isotope values and major-ion chemistry for water from spring (C-23-2)12bab-S1, Black Knoll Spring, and the group of springs at (C-23-2)28ddd-S1 near Bull Claim Hill, indicate a mixture of basin-fill and consolidated-rock sources of water.

Water from well (C-23-2)31bab-1 has stable-isotope values close to those of Indian Spring, thus indicating a consolidated-rock source. The source for this water is from the west side of the basin and probably from the Flagstaff Limestone. The slightly enriched signature of this water may be because of precipitation falling on the downslope of the plateau to the west.

Water from well (C-23-2)31cad-1 has values almost identical to the water from the Sevier River entering the basin, thus indicating that the source of the water in this well is derived from seepage of Sevier River irrigation water. The water from this well has calcium and sulfate as the predominant ions, whereas the predominant ions in water in the Sevier River are calcium and bicarbonate. The reason for the change in chemical composition is probably because of the dissolution of gypsum within the basin fill. The resulting increase in calcium causes calcium carbonate to precipitate. Within the framework of the ground-water system, this interpretation is the most plausible. As shown by the potentiometric surface on plate 1, well (C-23-2)31cad-1 is downgradient from the recharge area in the south one-half of the basin and upgradient from the nearest outcrop of the Arapien Shale. This same process may be occurring in the area south of Sigurd where calcium and sulfate also are predominant ions (fig. 26). This evidence would indicate that ground-water inflow from the Arapien Shale is not in sufficient quantities to substantially influence the quality of ground water in the basin.

HYDROLOGY OF OTHER BASINS IN THE CENTRAL SEVIER VALLEY

The primary emphasis of this study was placed on the Sevier-Sigurd basin with data collection designed for estimating water-budget components. Certain phases of the data collection, such as water-level measurements and ground-water sampling, were also completed in the other basins. Lack of data in some areas, however, prevented a complete hydrologic analysis. On

the basis of the available data, estimates for some water-budget components were made for the other basins.

Junction-Marysvale Basin

Several ungaged perennial and ephemeral streams drain into the Junction-Marysvale basin from both sides. The water from these streams is generally diverted for irrigation or allowed to flow into the Sevier River and Piute Reservoir during periods of major runoff. The empirical equation (Christensen and others, 1986, p. 8) used for streams in the Sevier-Sigurd basin was applied to the streams in the Junction-Marysvale basin. The estimated discharges for the streams are listed in table 14. The estimates of Young and Carpenter (1965, p. 28) for average base flow are listed for comparison.

Long-term ground-water data do not indicate any major change in water levels, as shown in figure 32. As in the Sevier-Sigurd basin, seasonal ground-water fluctuations are related to the availability of surface water from runoff or irrigation. Water levels are at a minimum during the winter or early spring prior to spring runoff and the irrigation season. Water levels are at a maximum in September or October at the end of the irrigation season.

Table 14. Estimated mean annual flow in ungaged streams in the Junction-Marysvale basin

	Estimated mean annual flow		
Ungaged stream	Cubic feet per second	Acre-feet per year	Young and Carpenter, 1965 acre-feet per year
City Creek	7.7	5,570	3,700
Dry Creek	11.5	8,330	—
Tenmile Creek	3.3	2,390	1,500
Manning Creek	12.5	9,050	3,700
Cottonwood Creek	7.2	5,200	2,200
Pine Creek	12.8	9,270	3,700
Beaver Creek	8.1	5,860	2,900

Ground water in the Junction-Marysvale basin generally has a specific conductance of less than 500 µS/cm (table 26). Water from most wells sampled has calcium and bicarbonate as the predominant ions

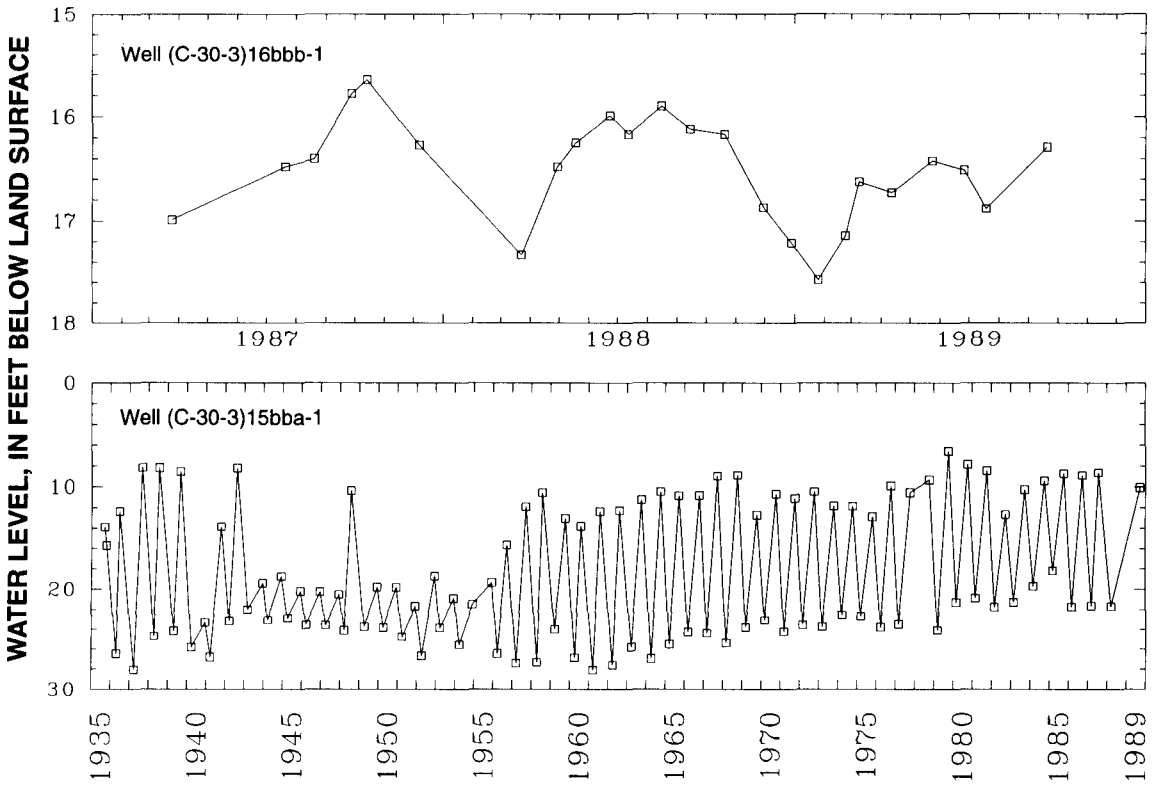


Figure 32. Water-level fluctuations in observation wells in the Junction-Marysvale basin.

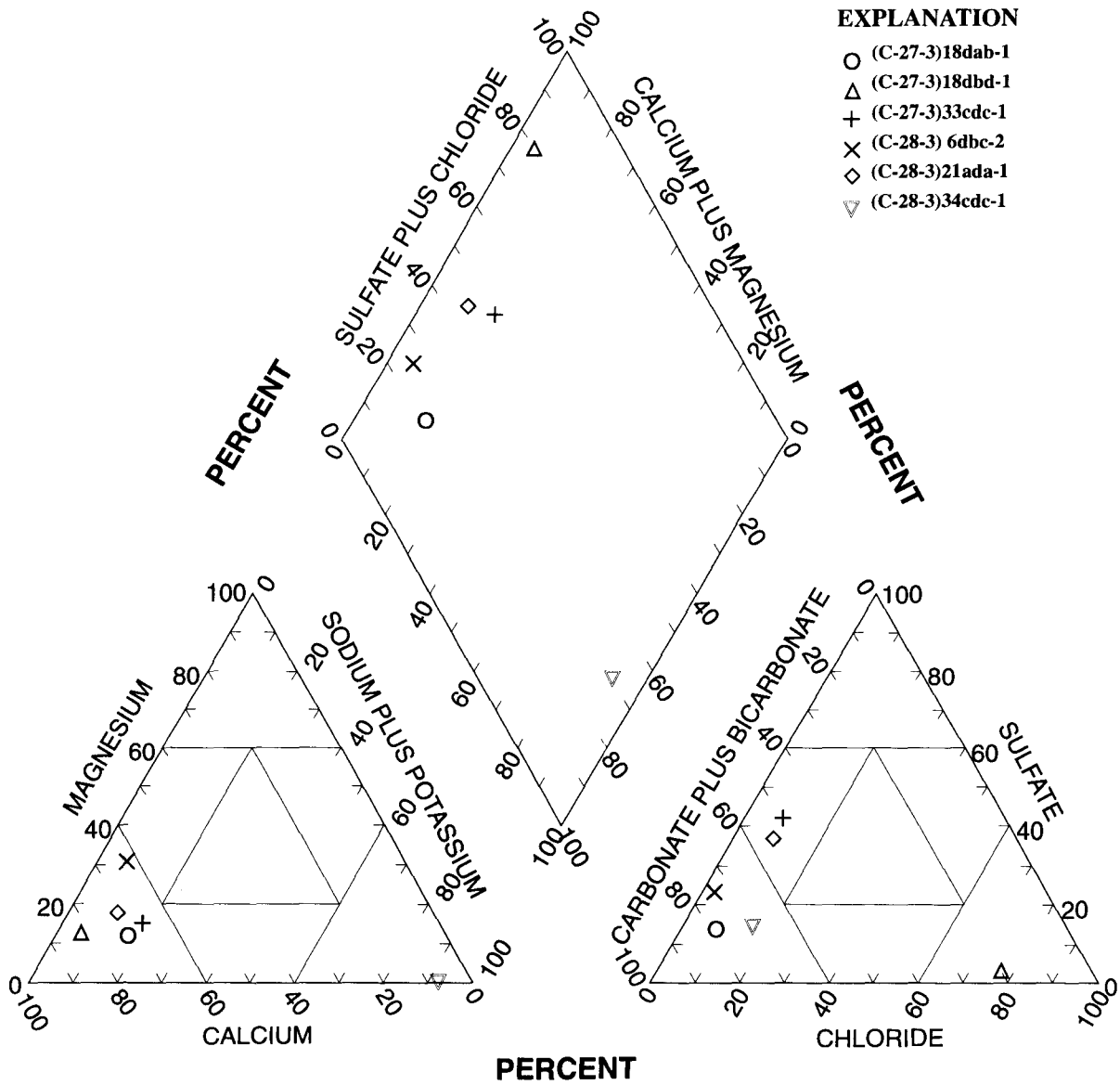


Figure 33. Chemical composition of water from wells in the Junction-Marysvale basin.

(fig. 33). Water from well (C-27-3)18dbd-1 has calcium and chloride as the predominant ions and the specific conductance is 3,310 µS/cm. The source for the large concentrations of calcium and chloride is unknown. Young and Carpenter (1965, table 11) sampled one well in the Junction-Marysvale basin. This well could not be sampled during this study, therefore, no comparison could be made over time.

Northern Basins

The three northern basins include the Aurora-Redmond basin, the Redmond-Gunnison basin, and the Gunnison-Sevier Bridge Reservoir basin as described by Young and Carpenter (1965, p. 16-18). Because of lack of ground-water data and the relation of the ground-water system to the Sevier River, the three basins are combined in this report for simplification of water-budget estimates.

Surface Water

As in the Sevier-Sigurd basin, the Sevier River is the main source of water for irrigation in the northern basins. Water is diverted into the Rocky Ford Canal, the West View Canal, the Gunnison-Fayette Canal, and the Dover Canal. The Piute and Vermillion Canals transport water into the northern basins that was diverted in the Sevier-Sigurd basin. Water for the

Rocky Ford Canal is diverted just downstream from the Rocky Ford Reservoir and just upstream from the gage on the Sevier River near Sigurd.

Tributary inflow comes from both perennial and ephemeral streams. The principal perennial streams include Lost Creek, Salina Creek, Willow Creek, and San Pitch River. Only Salina Creek has a gaging station before water from the creek enters the Sevier River. Lost Creek is similar to Brine Creek in that all the water is diverted upstream before entering the basin. Water that does enter the Sevier River is mostly derived from base flow as Lost Creek crosses the Arapien Shale. Young and Carpenter (1965, p. 28) estimated the base flow to be 1 ft^3/s or about 720 acre-ft/yr. Discharge measurements made during the seepage study on the Sevier River were 0.5 ft^3/s in August 1988 and 7 ft^3/s in October 1988.

The San Pitch River and Willow Creek presently are ungaged prior to entering the Sevier River. Generally, nearly all the water in both drainages is diverted upstream for irrigation. Water does enter the Sevier River from the San Pitch River, however, during winter and early spring months. This flow is reported in the annual reports for the Sevier River Water Distribution System (Utah Division of Water Rights, 1971-83). Some of this flow comes from Sixmile and Twelvemile Creeks that flow into the San Pitch River downstream from Gunnison Reservoir. Young and Carpenter (1965, p. 29) estimated the average base flow in Willow Creek to be about 1,500 acre-ft/yr. A revised estimate is presented later in this report.

Like most streams in the area, most of the water in Salina Creek is diverted for irrigation. The gage on Salina Creek is downstream from all diversions; therefore, all of the water reported in table 15 enters the Sevier River.

Known inflows and diversions for the northern basins from 1970 through 1982 are listed in table 15. Diversion data were obtained from the annual reports of the Sevier River Water Distribution System (Utah Division of Water Rights, 1971-83). Data for water years 1983 and 1984 were not included because of incomplete diversion data on account of flooding.

Ground-water discharge to the Sevier River probably is the primary source of water for the estimated gains. Other sources may include undiverted water from tributary streams and runoff from irrigated fields. Data are inadequate to distinguish between ground-water and surface-water gains to the river. The average estimated gain for 1970-82 is 88,300 acre-ft/yr.

Average annual discharges for ungaged ephemeral and smaller perennial streams are listed in table 16. The estimates were made by using the same method as in the other basins. Because of smaller drainage areas and lower altitudes, the estimated average annual discharges are smaller than in the other basins with the exception of Twelvemile Creek.

Ground Water

Ground-water levels in the northern basins, like the Sevier-Sigurd basin, fluctuate seasonally and over long periods in response to water available for irrigation and in the Sevier River. Water levels have been measured intermittently at three wells since 1935 and monthly at 10 wells during this study (table 24).

Seasonal water-level fluctuations in the northern basins are caused mainly by changes in recharge from irrigation water and from ephemeral streams during spring months. Water levels, therefore, begin to rise in May because of spring runoff and early season irrigation. Water levels continue to rise throughout the summer and reach their maximum levels in September or October before beginning their decline (fig. 34).

Long-term water-level fluctuations follow the same trends as in the Sevier-Sigurd basin because the same processes affect recharge to the ground-water system. Precipitation over the entire drainage area determines the quantity of water available for streams and canals and thus the quantity available for irrigation. Long-term trends in ground-water levels, therefore, will be similar to trends in precipitation. Long-term water-level fluctuations for observation wells are shown in figure 34.

Recharge components to the ground-water system that were estimated for the northern basins include infiltration from precipitation on the floor of the basins, losses from the Sevier River, and underflow from the Salina and Lost Creek drainages. Recharge from precipitation was calculated using the same method applied to the Sevier-Sigurd basin. The surface area of the basin fill, 182 mi^2, was multiplied by the 1935-88 average annual precipitation as measured in Salina, 10.06 in/yr (Burden and others, 1989, p. 48). Five percent of the calculated total precipitation was assumed to infiltrate to the ground-water system, about 4,900 acre-ft/yr.

Recharge to the ground-water system by losses from the Sevier River was calculated to be 2 ft^3/s (about 1,500 acre-ft/yr) during August 1988. As explained previously, measurements taken during August 1988

Table 15. Total annual flow in the Sevier River, diversions from the river, and estimated gains to the river in the northern basins for water years 1970-82

[Data in acre-feet (rounded)]

Segment	1970 Inflow	1970 Outflow	1971 Inflow	1971 Outflow	1972 Inflow	1972 Outflow
Sevier River near Sigurd	98,100		57,600		39,100	
Salina Creek	26,400		22,300		7,120	
West View Canal		7,790		7,160		5,780
Gunnison-Fayette Canal		7,860		9,420		7,660
Dover Canal		3,700		2,840		2,780
San Pitch River	18,400		15,500		5,450	
Sevier River near Gunnison		228,200		172,000		119,900
Totals	142,900	247,600	95,400	191,400	51,700	136,100
Gains	104,700		96,000		84,400	

Segment	1973 Inflow	1973 Outflow	1974 Inflow	1974 Outflow	1975 Inflow	1975 Outflow
Sevier River near Sigurd	117,500		77,000		47,200	
Salina Creek	39,000		31,600		23,500	
West View Canal		7,220		7,080		7,460
Gunnison-Fayette Canal		8,570		10,500		9,480
Dover Canal			3,220		3,520	3,440
San Pitch River	33,200		26,400		10,800	
Sevier River near Gunnison		252,300		216,000		157,000
Totals	189,700	271,300	135,000	237,100	81,500	177,400
Gains	81,600		102,100		95,900	

Segment	1976 Inflow	1976 Outflow	1977 Inflow	1977 Outflow	1978 Inflow	1978 Outflow
Sevier River near Sigurd	38,100		34,500		52,000	
Salina Creek	8,090		2,850		16,300	
West View Canal		6,120		6,370		6,590
Gunnison-Fayette Canal		7,680		6,830		8,170
Dover Canal		3,440		2,860		3,510
San Pitch River	12,800		—		3,450	
Sevier River near Gunnison		131,400		84,400		106,800
Totals	59,000	148,600	37,400	100,500	71,800	125,100
Gains	89,600		63,100		53,300	

Segment	1979 Inflow	1979 Outflow	1980 Inflow	1980 Outflow	1981 Inflow	1981 Outflow
Sevier River near Sigurd	96,800		154,600		96,400	
Salina Creek	20,000		31,200		11,300	
West View Canal		7,360		10,430		7,640
Gunnison-Fayette Canal		8,340		9,540		9,350
Dover Canal		3,650		4,360		3,500
San Pitch River	15,300		30,000		—	
Sevier River near Gunnison		180,200		315,900		199,400
Totals	132,100	199,600	215,800	340,200	107,700	219,990
Gains	67,500		124,400		112,200	

Segment	1982 Inflow	1982 Outflow
Sevier River near Sigurd	70,800	
Salina Creek	27,500	
West View Canal		6,760
Gunnison-Fayette Canal		7,200
Dover Canal		3,190
San Pitch River	46,200	
Sevier River near Gunnison		200,600
Totals	144,500	217,800
Gains	73,300	

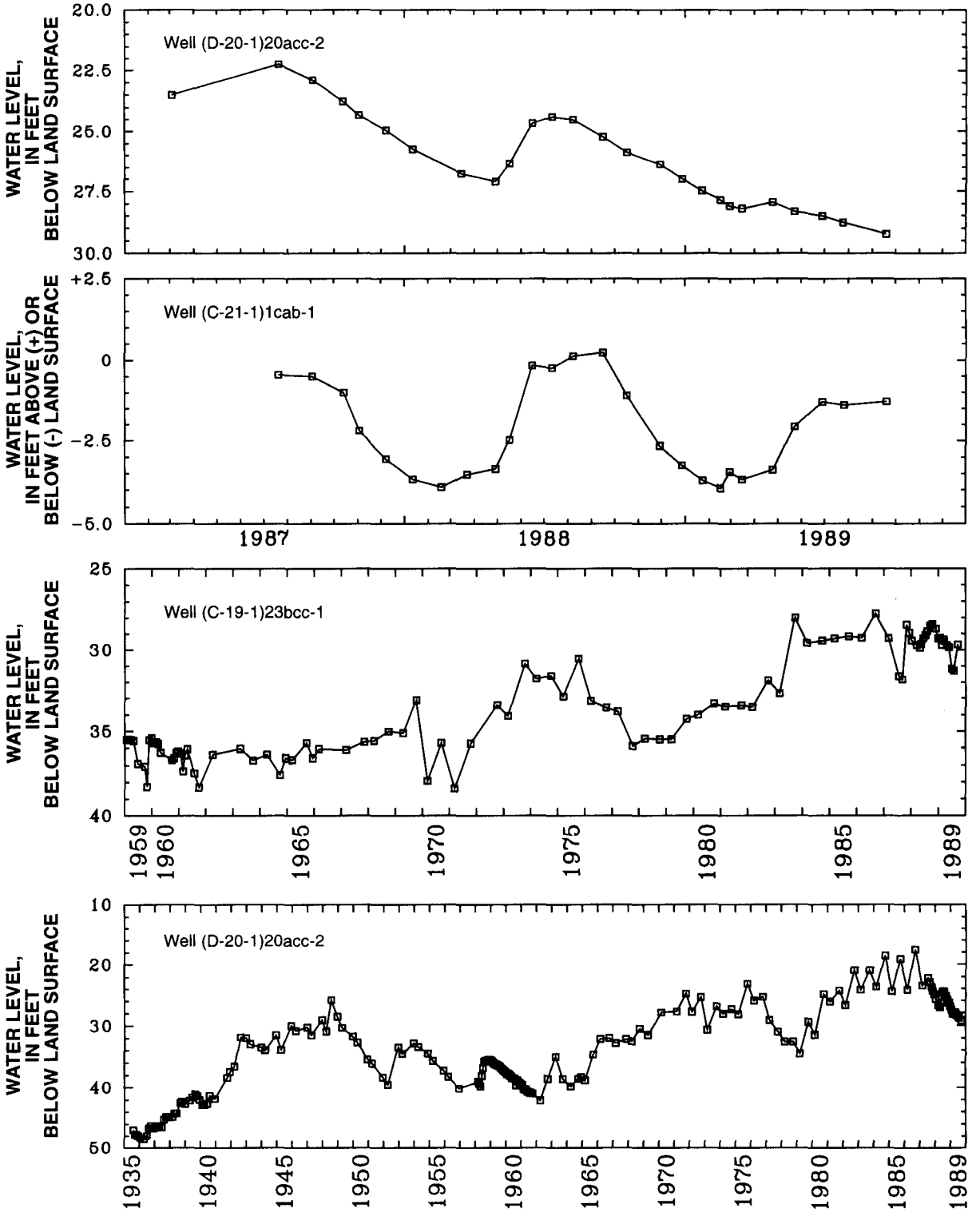


Figure 34. Water-level fluctuations in observation wells in the northern basins, 1935–89.

Table 16. Estimated mean annual flow in ungaged streams in the northern basins

Ungaged streams	Estimated mean annual flow Cubic feet per second	Acre-feet per year
Willow Creek	7.8	5,650
Lone Cedar Canyon	0.6	435
Twelvemile Creek	23.2	16,800
Hayes Canyon	3.0	2,150

were assumed to be representative of average annual ground-water conditions because water levels were not yet at their yearly maximum levels as in October. Although ground-water levels were assumed to be average for the year, the calculated yearly losses from the river might be small because ground-water levels were above the long-term average level. It is possible, therefore, that more water than the calculated 1,500 acre-ft/yr might recharge the ground-water system.

Similar to Brine Creek in the Sevier-Sigurd basin, ground-water inflow beneath Salina and Lost Creeks was determined because of the possible contribution of water containing a large concentration of dissolved solids that might be derived from the Arapien Shale. The ground-water inflow was calculated by multiplying the hydraulic conductivity, the hydraulic gradient, and cross-sectional area of the fill material near the mouth of each canyon. Values for each parameter were determined by using the same methods that were applied at Brine Creek. Ground-water inflow at Salina Creek was calculated to be 0.2 ft^3/s or about 150 acre-ft/yr and ground-water inflow at Lost Creek was 0.1 ft^3/s or about 75 acre-ft/yr. The ground-water inflow from both drainages does not constitute a substantial part of the ground-water budget.

Other sources of ground-water inflow to the northern basins include 2,000 acre-ft/yr from the Sevier-Sigurd basin (Young and Carpenter, 1965, p. 51) and an unknown quantity of ground-water inflow from the San Pitch River drainage. Data were insufficient to calculate this flow.

Discharge components from the ground-water system estimated for the northern basins include evapotranspiration, discharge from wells, gains to the Sevier River, and spring discharge from the basin fill. The total quantity of evapotranspiration in the northern basins is estimated to be about 30,000 acre-ft/yr, 5,600 acre-ft of which is estimated to be supplied by direct precipitation (Utah Department of Natural Resources, Division of Water Resources, written commun., 1988). Most of the remaining 24,400 acre-ft/yr of the estimated evapotranspiration is assumed to come from ground water. Water supplied to phreatophytes, other than directly from ground water, might come from springs, flowing wells, and water applied for irrigation. The percentage of water supplied by these sources could not be estimated.

The estimate for evapotranspiration is much smaller than the 60,000 acre-ft/yr reported by Young and Carpenter (1965, p. 49). The difference in the number of acres having phreatophyte vegetation is the cause for the large disparity. The Utah Department of Natural Resources classified 8,400 acres of phreatophytes, whereas Young and Carpenter classified 20,000.

Discharge from wells in the northern basins was estimated to be 7,400 acre-ft for 1988. Most of the discharge from wells is from flowing irrigation wells. This discharge was calculated to be 6,200 acre-ft using the same method as was used in calculating discharge in the Sevier-Sigurd basin.

Discharge from the ground-water system to the Sevier River was estimated to be 117 ft^3/s or about 85,000 acre-ft/yr using data based on the August 1988 measurement period. As discussed previously, water levels during 1988 were generally above long-term average levels; therefore, gains to the river determined from 1988 seepage studies might not represent long-term average gains.

By adding the estimated spring discharge from the basin fill of 27,000 acre-ft/yr (Young and Carpenter, 1965, p. 48) to evaporation, discharge from wells, and gains to the Sevier River, the total discharge from the ground-water system in the northern basins is about 144,000 acre-ft/yr. Recharge from identifiable sources is 8,600 acre-ft/yr; therefore, about 135,000 acre-ft/yr is from infiltration from irrigated lands, underflow from the San Pitch River drainage, inflow from consolidated rock, and infiltration from ungaged ephemeral streams. As with the Sevier-Sigurd basin, recharge from unconsumed irrigation water probably is the largest component of recharge; however, data are insufficient to quantify each component.

Water Quality

Water quality and chemical composition of water in the Sevier River from Rocky Ford Reservoir north to the Sevier Bridge Reservoir is different than that in the Sevier-Sigurd basin. Specific conductance of water

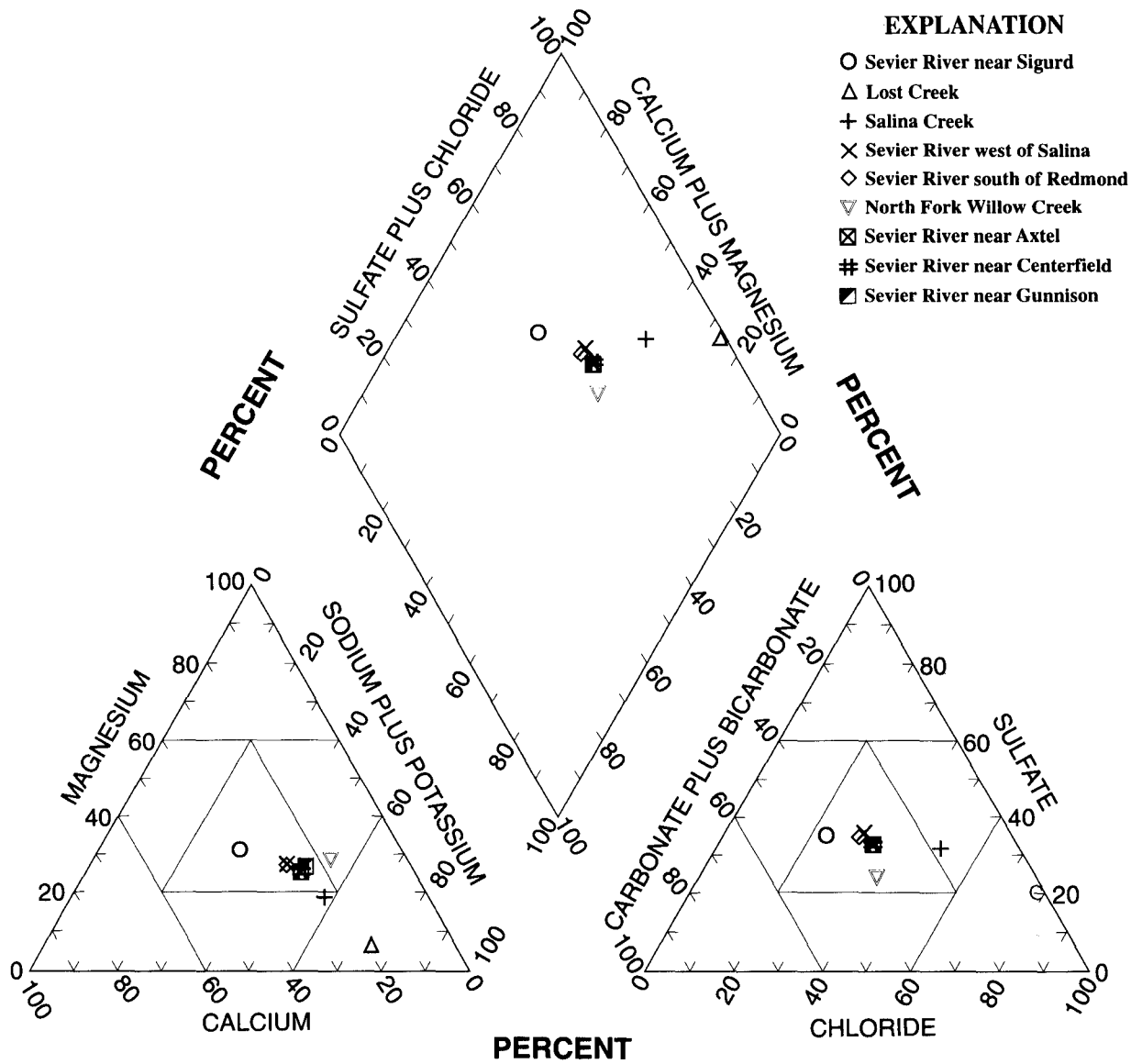


Figure 35. Chemical composition of water from the Sevier River and tributary inflows in the northern basins.

from the Sevier River in the northern basins generally is two times larger than in the Sevier-Sigurd basin. Specific conductance ranges from about 1,000 to almost 2,000 µS/cm (table 28). Differences in chemical composition include increased concentrations of sodium, chloride, and sulfate ions as shown in figures 24 and 35.

The chemical composition of water from tributary inflows show larger percentages of sodium and chloride ions than do inflows in the Sevier-Sigurd basin, with the exception of Brine Creek. Water in Brine and Lost Creeks are sodium-chloride brines because of the solubility of halite in the Arapien Shale. The chemical composition of water in Willow and Salina Creeks probably is influenced by the Arapien Shale, but not to the same degree.

Although tributary inflows might be a major contribution to the increased dissolved solids of the river, ground-water inflow probably contributes more to the load over an entire year. The dissolved-solids concentrations of ground-water inflow for reaches on the Sevier River were calculated by using the same procedure as applied in the Sevier-Sigurd basin. Only chemical data obtained during August 1988 were used. During October 1988, a major inflow, which was not

present during August, was inadvertently not sampled. Dissolved solids and calculated loads are shown in figure 36. Sampling sites and the calculated dissolved solids for ground-water inflows over various reaches are shown in figure 37. The calculated dissolved solids of ground-water inflow for the two reaches between Rocky Ford Reservoir and Redmond (R7 to R8, R8 to R9, fig. 37) are very similar to those for ground-water inflow in the northern part of the Sevier-Sigurd basin. Calculated dissolved solids of ground-water inflows for the three reaches north of Redmond are substantially larger than those of other reaches on the Sevier River.

The chemical composition of ground water in the northern basins is a mixture of all major ions (fig. 38). Unlike the Sevier-Sigurd basin, however, there is a noticeable increase in sodium as the predominant cation. This might be the result of a more pronounced influence of the Arapien Shale and the solubility of halite.

As with the Sevier-Sigurd basin, the quality of ground water in the northern basins has not changed substantially for over 30 years. Wells (C-18-1)25dcc-1 and (C-21-1)13abd-1 were sampled sporadically from 1959 to the present. Chemical analyses of water from these wells has shown almost no change of any constituents over this period. Similarly, chemical analyses of water from well (C-22-1)5bac-1, collected in 1957 and 1989, has shown almost no change (table 26).

SIMULATION OF THE GROUND-WATER SYSTEM, SEVIER-SIGURD BASIN

A finite-difference, three-dimensional, digital-computer model developed by McDonald and Harbaugh (1988) was used to simulate three-dimensional ground-water flow in the basin fill of the Sevier-Sigurd basin (fig. 1). Available data from other reports, data from other agencies, and data collected during this study presented earlier in this report were combined to create a conceptual model of the area. The data also were used in the construction and calibration of the digital-computer model simulating steady-state and transient conditions. The data and the terminology used to define various zones of the ground-water system were presented earlier in the ground-water hydrology section of this report.

Design and Development of the Computer Model

Discretization of Ground-Water System

The basin-fill ground-water system was discretized horizontally by superimposing a rectangular grid over the horizontal plane of the area to be simulated. The system was divided vertically into three layers representing different aquifer zones. The horizontal grid coordinates extend vertically into all layers, dividing the ground-water system into rectangular blocks called cells. The model program uses a point at the center of each cell, called a node, to represent all characteristics of the model cell.

The horizontal grid consists of 58 rows and 40 columns, with each cell covering 0.125 mi^2 (fig. 39). The vertical division of the ground-water system closely follows the zones identified in previous sections of this report illustrated in figures 5 to 7. Layer 1 simulates unconfined zones representing, approximately, the top 50 feet of saturated fill in the basin. Layers 2 and 3 represent the shallow and deep confined zones, and the unconfined zones in the south end of the basin and along the west margin of the basin where confining layers are not present. The division between layer 2 and layer 3 is defined by the confining clay-silt layer that is approximately 150 to 200 feet below the land surface where it exists. Confining units were not simulated as separate layers. Vertical flow between model layers was simulated by estimating the vertical conductance of the confining units (McDonald and Harbaugh, 1988, p. 138-144).

Boundary Conditions and Data Requirements

The ground-water flow model requires that specific types of mathematical boundaries be assigned to the simulated ground-water system to simulate impermeable (no-flow) boundaries, recharge, and discharge. Data are entered to numerically define these boundaries, and the hydraulic properties of the ground-water system. Initial estimates of hydraulic properties used in the model were based on independent estimates presented earlier in this report. Initial estimates of recharge and discharge used in the steady-state simulation were based on long-term average fluxes summarized in table 12. Where possible, reasonable limits for the parameters were defined for use during model calibration.

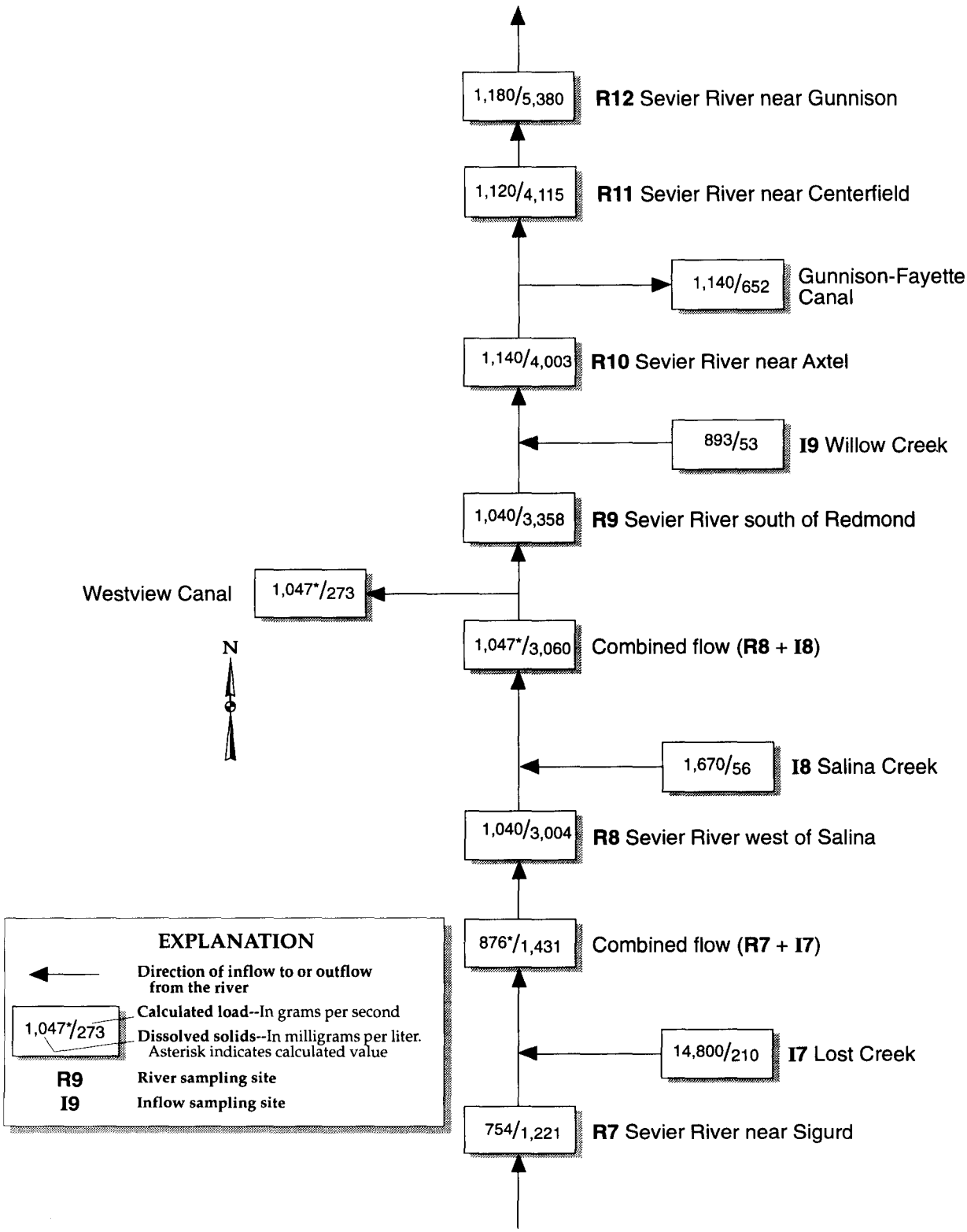


Figure 36. Dissolved-solids and calculated loads for the Sevier River, tributary inflows, and diversions in the northern basins during August 1988.

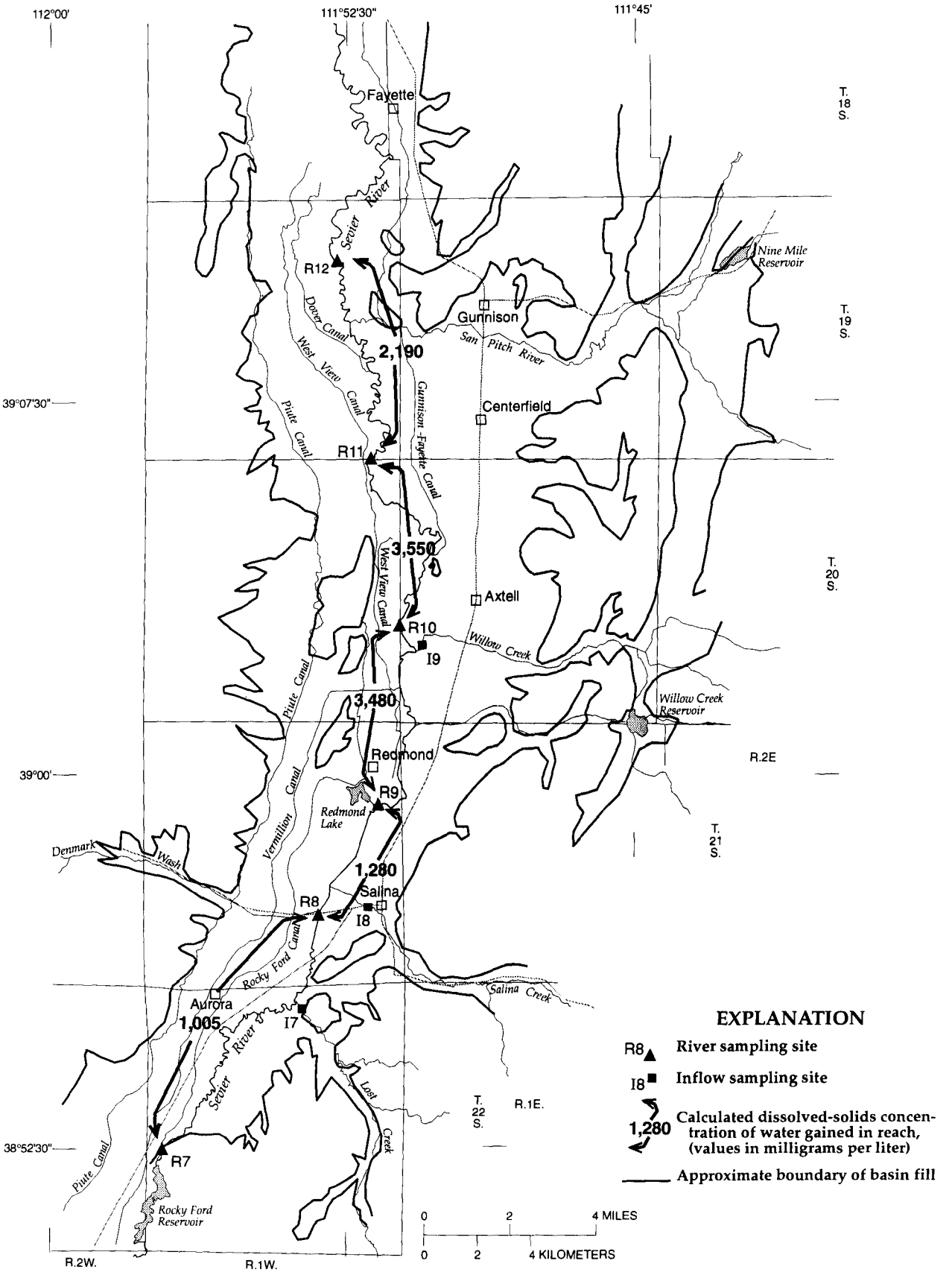


Figure 37. Sampling sites and calculated dissolved-solids concentration of water gained along the Sevier River in the northern basins during August 1988.

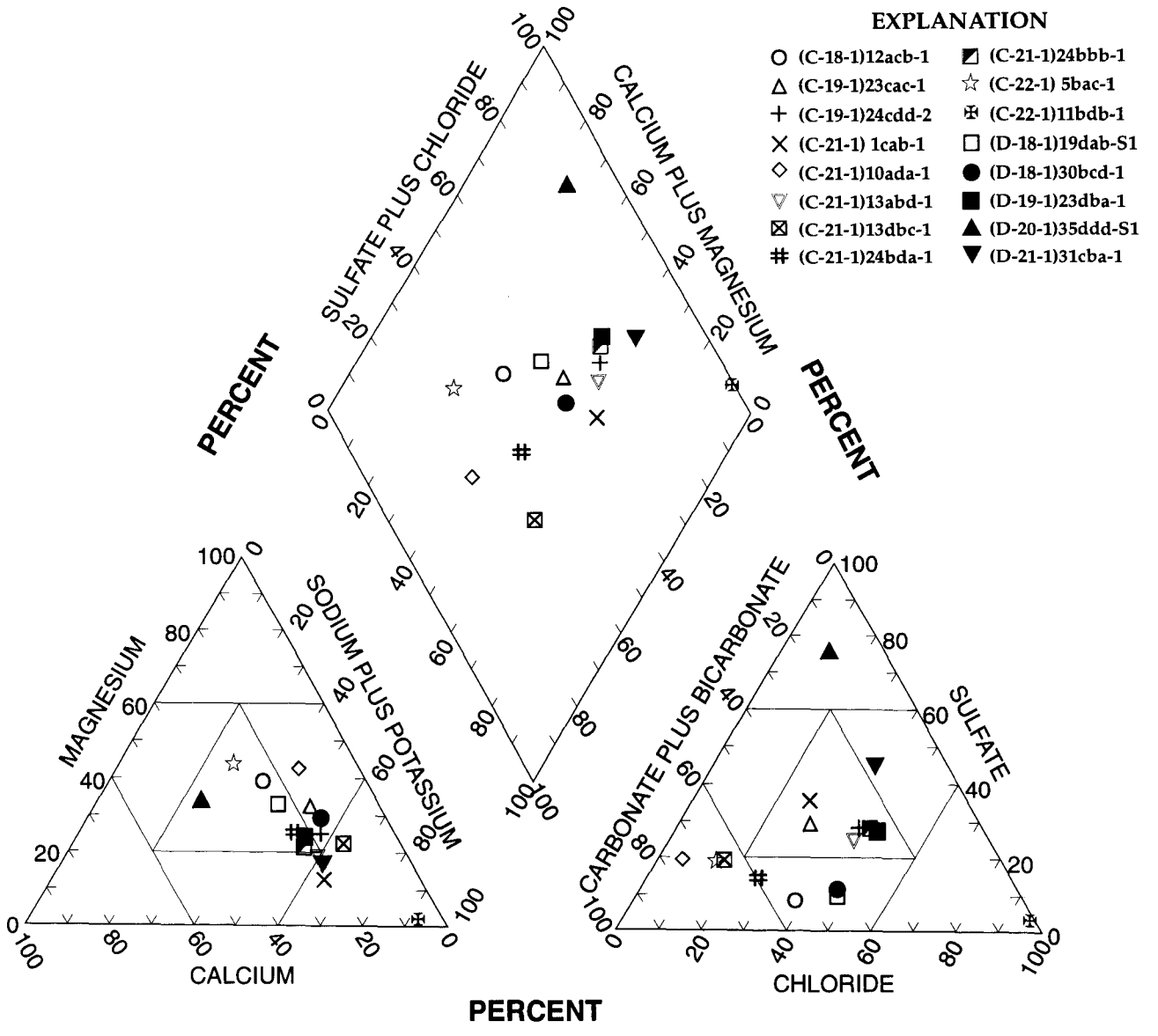


Figure 38. Chemical composition of water from selected wells and springs in the northern basins.

No Flow

Inactive nodes, nodes with transmissivity set to zero, simulate impermeable (no-flow) boundaries; thus water cannot enter or leave the ground-water system through these nodes. The location of inactive nodes and the approximate basin-fill boundary are shown in figure 39. In most cases, the no-flow boundary coincides with the contact between basin fill and consolidated rock. A no-flow boundary was placed below layer 3 to simulate consolidated rock underlying the basin fill. The inactive nodes northeast of Joseph in layers 1, 2, and 3 vary slightly where the saturated basin fill thins above shallow consolidated rock.

Recharge

Specified-flux boundaries, representing constant inflow or outflow, were used to simulate recharge entering layer 1 from (1) seepage from irrigated fields, (2) seepage from canals, (3) seepage from perennial and ephemeral streams other than the Sevier River, and (4) infiltration of precipitation on the valley floor. Initial recharge rates for these sources were based on estimates of long-term average values presented in table 3.

Land-use data obtained from the Utah Department of Natural Resources, Division of Water Resources (written commun., 1988) were used to identify irrigated areas and to assign specified-flux nodes

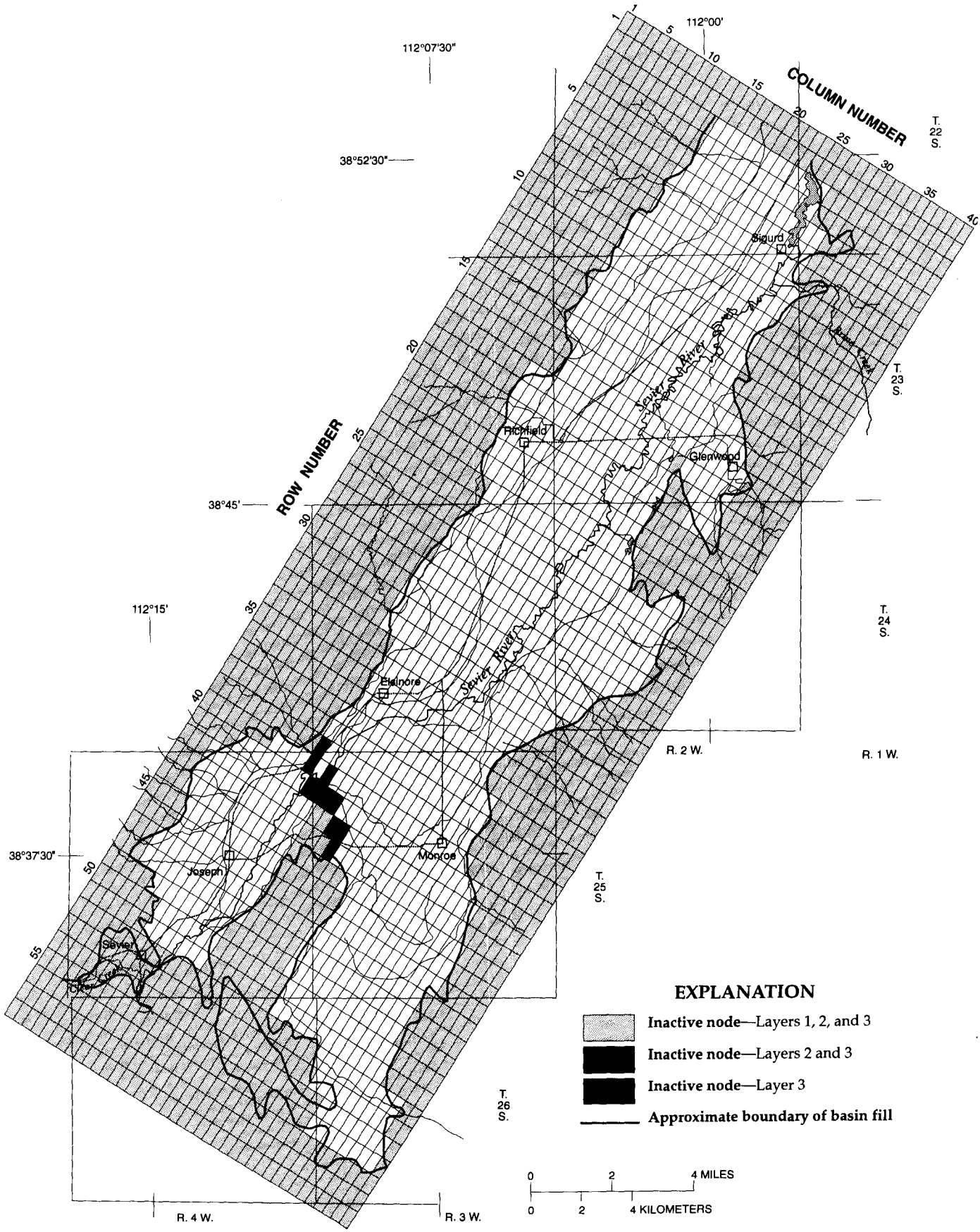


Figure 39. Computer model grid and location of inactive nodes in the simulated area.

that were used to simulate recharge from irrigated fields (fig. 40).

The estimated annual recharge to the basin fill from irrigated fields and consolidated rock is 72,400 acre-ft (table 3). Initial recharge rates assigned to specified-flux nodes simulating seepage from irrigated fields were based on the assumption that inflow from consolidated rock makes up only a small percentage of the estimated recharge from both sources. Recharge was distributed to all cells indicated in figure 40 on the basis of land use. In cases where these model cells contained areas of unirrigated lands, such as wetlands, the assigned recharge rate was adjusted to compensate for the percentage of the cell that did not contain irrigated land.

A reasonable maximum limit for recharge by seepage from irrigated fields for use during model calibration was assumed to be 92,100 acre-ft/yr. This is the average quantity of unconsumed irrigation water in the basin (table 5).

Estimates of recharge to the ground-water system for simulation along reaches of major canals, as shown in figure 41, were determined from seepage studies of the Sevier-Piute Canal (Cruff, 1977, p. 4-5), and the Richfield, South-Bend, and Vermillion Canals (Herbert and Smith, 1989, p. 4-5). Specified-flux nodes simulating recharge from perennial and ephemeral streams were assigned in recharge areas where these streams enter the basin (fig. 41). All active nodes were simulated as receiving recharge from precipitation.

To simulate recharge from consolidated rock, head-dependent nodes were placed along the no-flow boundary in layers 1, 2, and 3 west of Richfield and in layer 2 north of Glenwood (fig. 41). The head-dependent boundary provides flow into or out of a model node from an external source that is proportional to the difference between the water level assigned to the external source and the computed water level at the node. Rates of flow from head-dependent nodes can be adjusted by varying the conductance between the external source and the node. In this case, the value represents the conductance of the interface between the consolidated rock and the ground-water system. A water level of 5,386 feet was assigned to head-dependent nodes west of Richfield and represents water levels measured in piezometers finished in fractured limestone (Liddle, 1967, p. 2). Water levels specified for head-dependent nodes northeast of Glenwood range from 5,420 to 5,480 feet and approximate the altitude, as determined from a topographic map, of consolidated-rock contact springs located to the south. Because recharge to the ground-water system from consolidated rock is not well defined, conductance values were initially set to zero to simulate no contribution from consolidated rock.

Recharge to the ground-water system from the Sevier River is simulated by using the river head-dependent boundary (fig. 42). The river boundary provides flow into or out of a model node from a river source that is proportional to the difference between the water level assigned to the river source and the computed water level at the node. Recharge to the ground-water system from the river is simulated at nodes where the computed water level is below the specified river-stage altitude.

Flow rates at river head-dependent nodes can be adjusted by varying the streambed conductance. Streambed conductance (C) was estimated using the equation, $C = KA/M$. Hydraulic conductivity (K) and thickness (M) of the streambed are not measured and are difficult to estimate, resulting in a considerable range of values for possible streambed conductance (C). The variable (A) is the area through which the water moves between the aquifer and the stream. Limits for streambed conductance used in the model were 400 to 130,000 ft^2/d, on the basis of measured streambed areas; estimates for thickness of streambeds were from 1 to 10 feet, and estimates for hydraulic conductivity of streambeds were from 0.1 to 1 ft/d. Specified streambed altitudes were determined using topographic maps. Specified altitudes of water levels in river nodes representing the Sevier River ranged from 1 to 2 feet above the altitude of the streambed. These altitudes were based on an average gage height of about 1.5 feet at the U.S. Geological Survey gaging station 10194000, Sevier River above Clear Creek, and on measurements made in the field.

Discharge

Head-dependent, constant-head, and specified-flux boundaries were used to simulate discharge from the ground-water system by (1) evapotranspiration, (2) drains, (3) flowing and pumped wells, (4) springs, (5) seepage to the Sevier River, and (6) subsurface outflow at the north end of the basin.

Assignment of evapotranspiration nodes (fig. 43) was based on the delineation of wetland areas from land-use data (Utah Department of Natural Resources, Division of Water Resources, written commun., 1988). The head-dependent simulation of evapotranspiration is based on the assumption of a linear change between

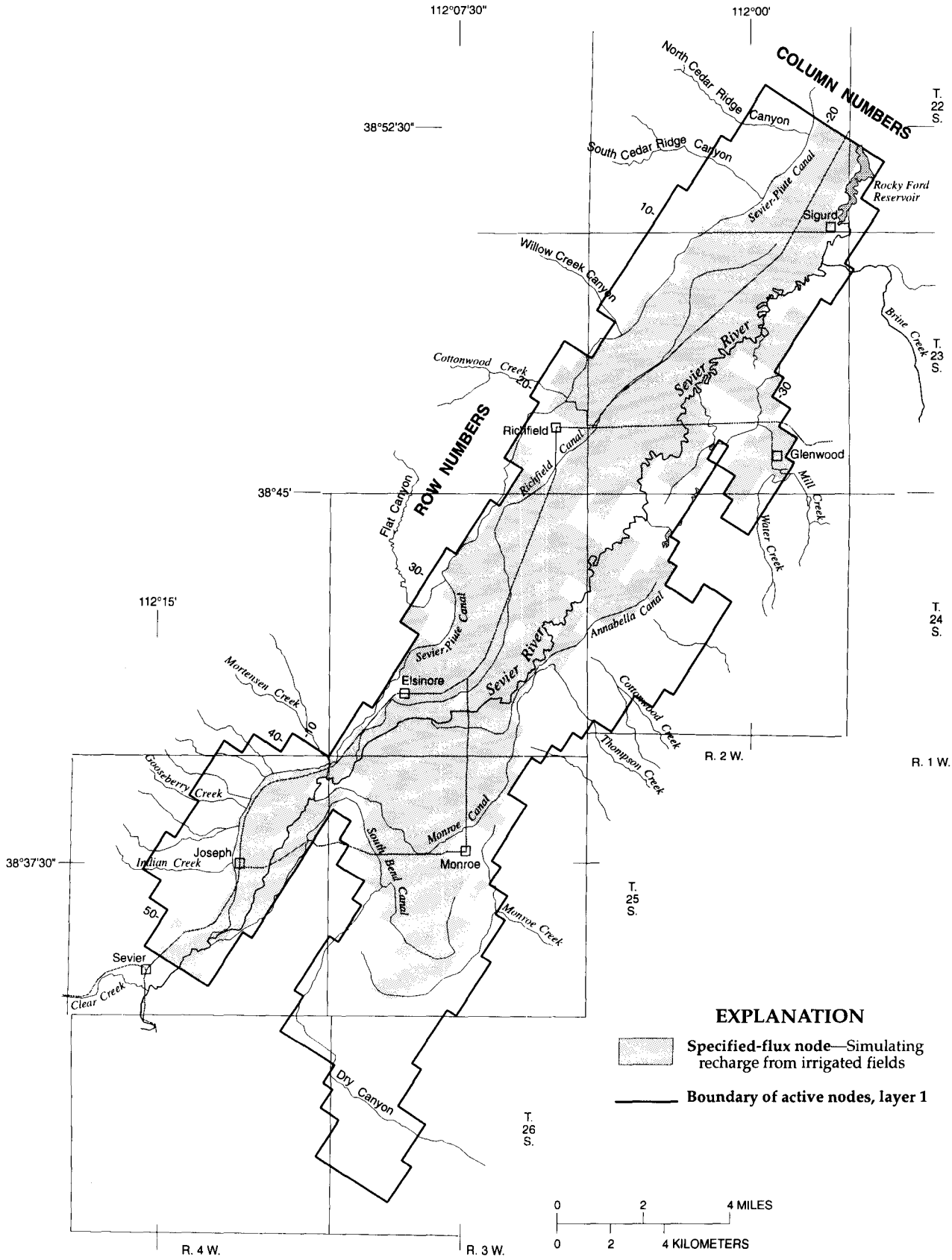


Figure 40. Location of specified-flux nodes simulating recharge from irrigated fields in layer 1.

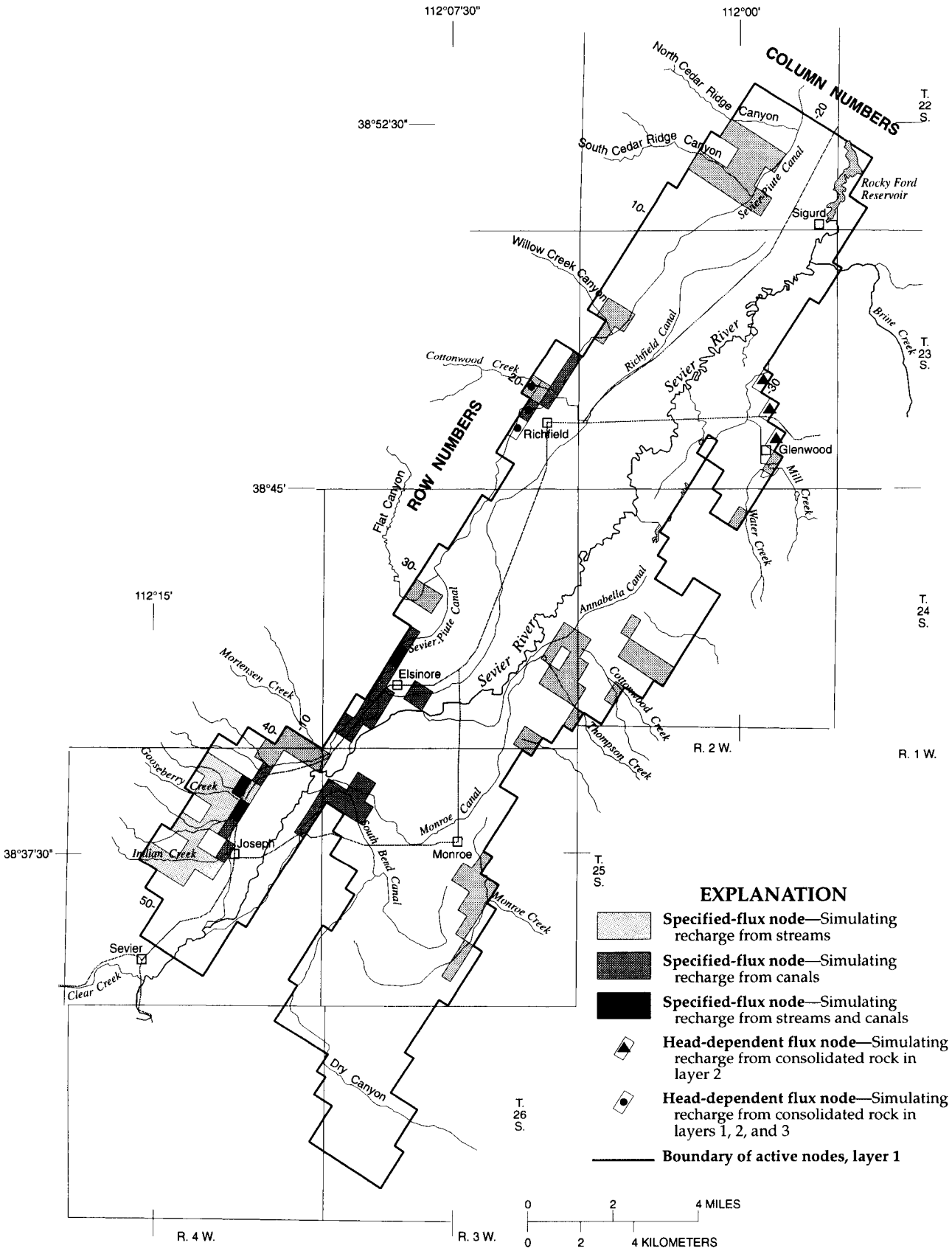


Figure 41. Location of specified-flux nodes simulating recharge from streams and canals in layer 1 and head-dependent flux nodes simulating recharge from consolidated rock.

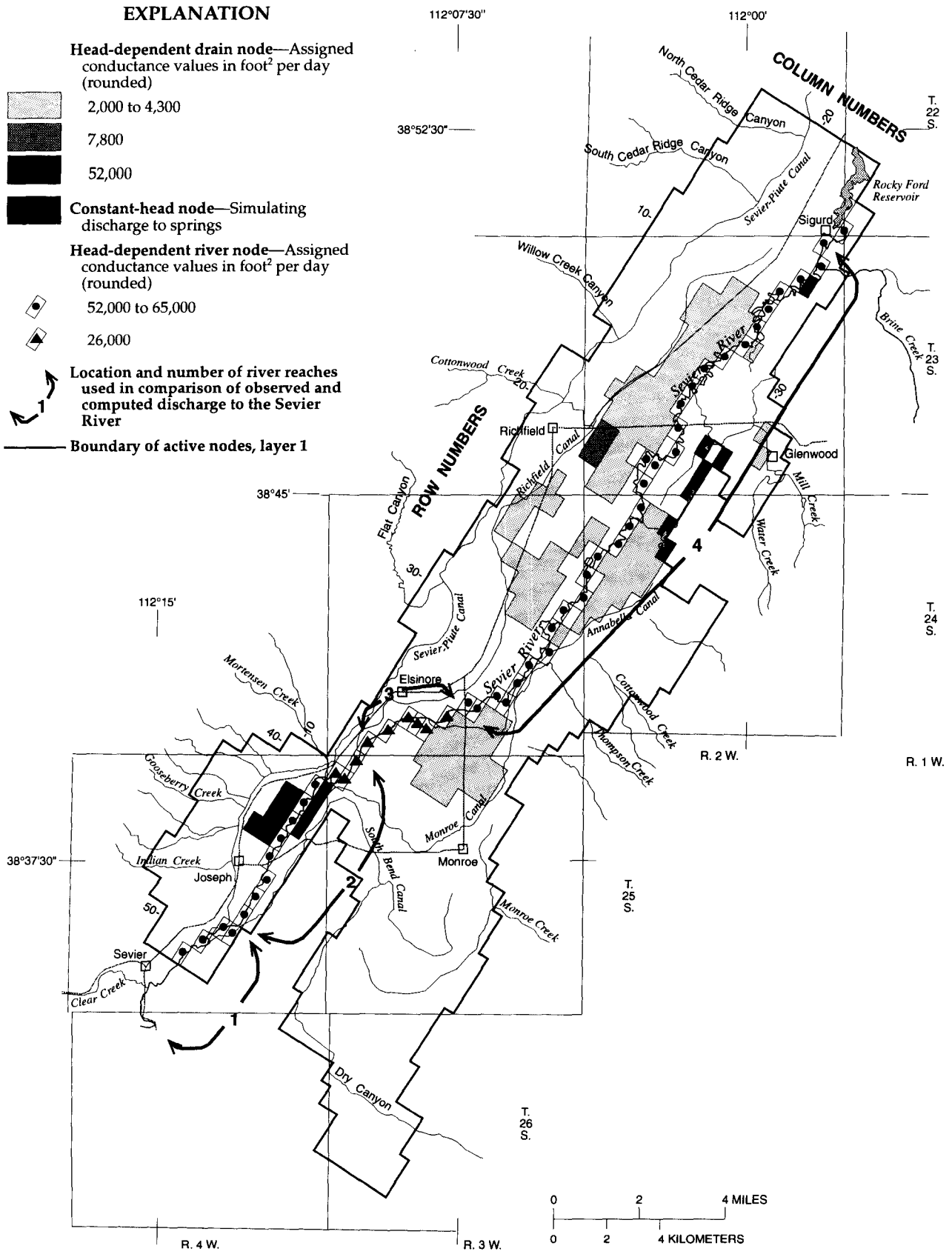


Figure 42. Location of head-dependent drain nodes and head-dependent river nodes and node conductance, and location of constant-head nodes simulating discharge to springs in layer 1.

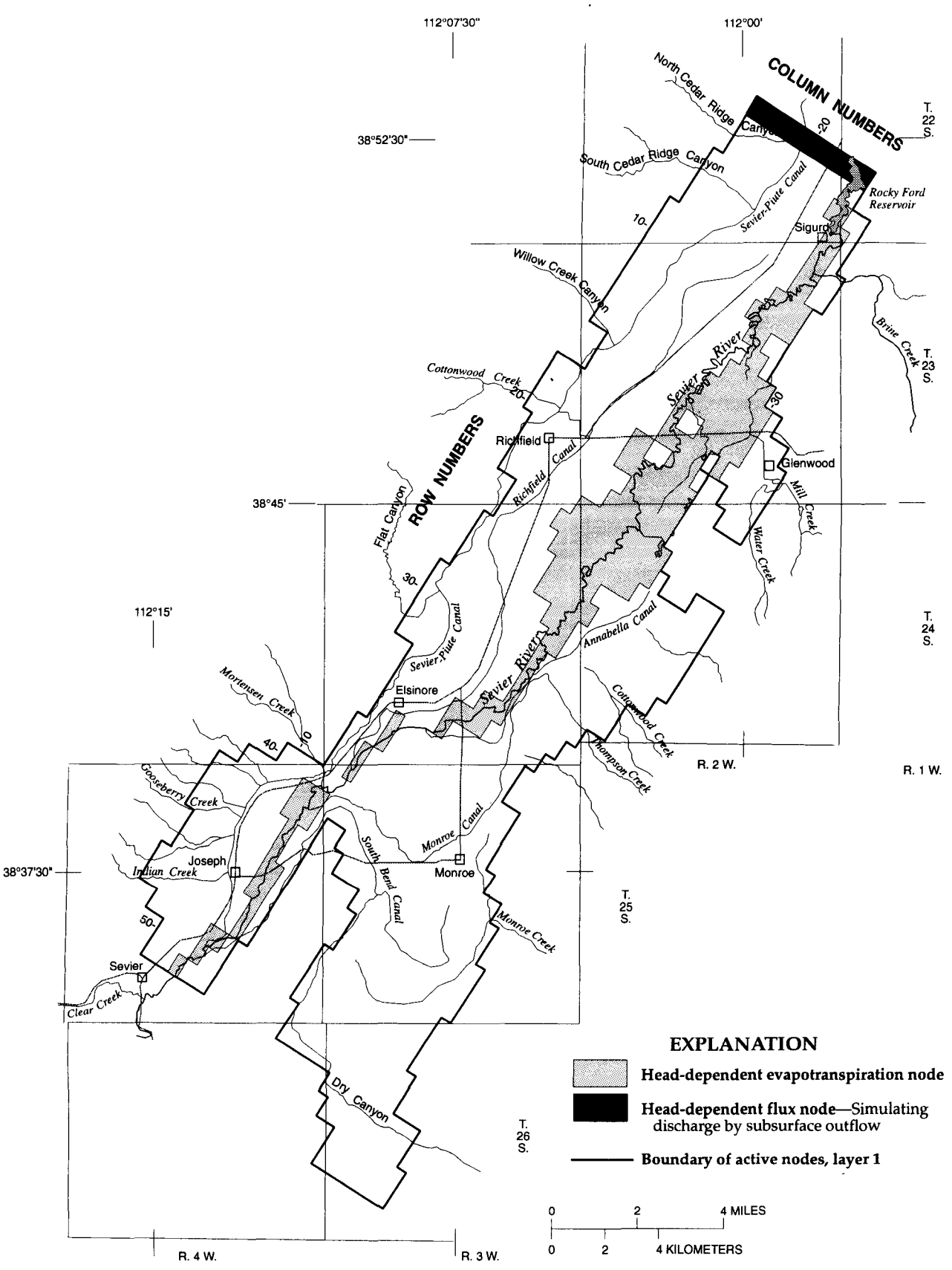


Figure 43. Location of head-dependent evapotranspiration nodes and head-dependent flux nodes simulating discharge by subsurface outflow in layer 1.

a maximum evapotranspiration rate when the water level is at or above the land surface, to an evapotranspiration rate of zero when the water level is below a specified extinction depth. The maximum evapotranspiration rate used in the model was 3.2 ft/yr and the extinction depth at which evapotranspiration is assumed to be zero was set at 10 feet below the land surface. The rate of 3.2 ft/yr corresponds to the rate estimated by the U.S. Department of Agriculture (1969, table 23) for saltgrass, the most common phreatophyte in the area.

Discharge by drains constructed in some farm and residential areas was simulated by using the head-dependent drain boundary, allowing simulated discharge to drains to vary with changes in computed water levels. No discharge at drain nodes is simulated when the water level at the node declines below the specified drain altitude. Distribution of drain nodes simulating seepage to drains (fig. 42) and drain altitudes were based on observations made in the field, and on unpublished records obtained from the Soil Conservation Service, Richfield Office. Drain conductance was not measured in the field. Conductance values for drain nodes were determined during model calibration by adjusting values in order to match the estimated annual discharge to drains of 10,000 acre-ft (table 6).

Head-dependent drain nodes also were used to simulate discharge by flowing wells in layer 2 (fig. 44). By specifying the altitude of the land surface as the drain altitude, discharge by flowing wells will not be simulated when computed water levels in drain nodes decline below the land surface. Assigned conductance values were based on the distribution of flowing wells in the area and were adjusted during model calibration in order to match the estimated annual discharge by flowing wells of 8,400 acre-ft (table 10).

Specified-flux nodes in layers 2 and 3 were used to simulate discharge by pumped wells. Discharge rates at these nodes were specified to approximate an estimated discharge from public supply, industrial, and large-diameter irrigation wells for 1957 of 1,100 acre-ft/year. Discharge from these wells for 1957 was estimated using reported well discharge for 1963 (Young and Carpenter, 1965, table 7), and records supplied by municipalities. Estimates for 1957 were used because water levels measured in 1957 were to be compared with computed water levels during steady-state calibration.

Discharge from numerous domestic, stock, and small-diameter irrigation pumped wells was not simulated in the model because location and estimates of discharge for individual wells could not, in most cases, be determined. Discharge from these wells make up about one percent of the total discharge from the ground-water system.

Constant-head nodes in layer 1 were used to simulate discharge of confined ground water from layer 2 by springs along the east margin of the basin (fig. 42). The rate of flow to the constant-head node is proportional to the difference in the specified altitude of the constant head and the computed water level in adjacent nodes. The flow to the constant-head node from the node below can be adjusted by varying the vertical conductance between the two nodes.

Discharge to the Sevier River from the ground-water system is simulated by the river head-dependent boundary discussed earlier in this section. Discharge to the Sevier River is simulated at river nodes where the computed water level is above the specified water level of the river.

Head-dependent nodes were placed just inside the no-flow boundary in layer 1 at the north end of the basin to simulate ground water leaving the system as subsurface outflow (fig. 43). Altitude values for these nodes were estimated from the potentiometric surface map for the principal ground-water reservoir of the shallow confined zone for September 1988 (pl. 1) and ranged from 5,190 to 5,223 feet. Conductance values for these nodes were determined during model calibration by adjusting the values to simulate average discharge of about 2,000 acre-ft/yr (table 12).

Hydraulic Properties

Initial values of hydraulic conductivity for layer 1 were based on average values reported in the ground-water hydrology section of this report. The values ranged from 5 ft/d for fine-grained basin fill to 370 ft/d for coarse-grained basin fill. Initial values of transmissivity for layers 2 and 3 were derived by multiplying the estimated thickness of coarse-grained basin fill in layers 2 and 3 by the hydraulic conductivity for coarse-grained basin fill of 370 ft/d. Hydraulic-conductivity values for coarse-grained basin fill derived from aquifer tests and specific-capacity data ranged from 50 to 1,000 ft/d. Thus, it was assumed reasonable that transmissivity values could be varied substantially from initial values during calibration.

The computer model calculates vertical-conductance terms from data incorporating vertical hydraulic conductivity and aquifer thickness. The resulting term is called "vertical leakance" (McDonald and Harbaugh,

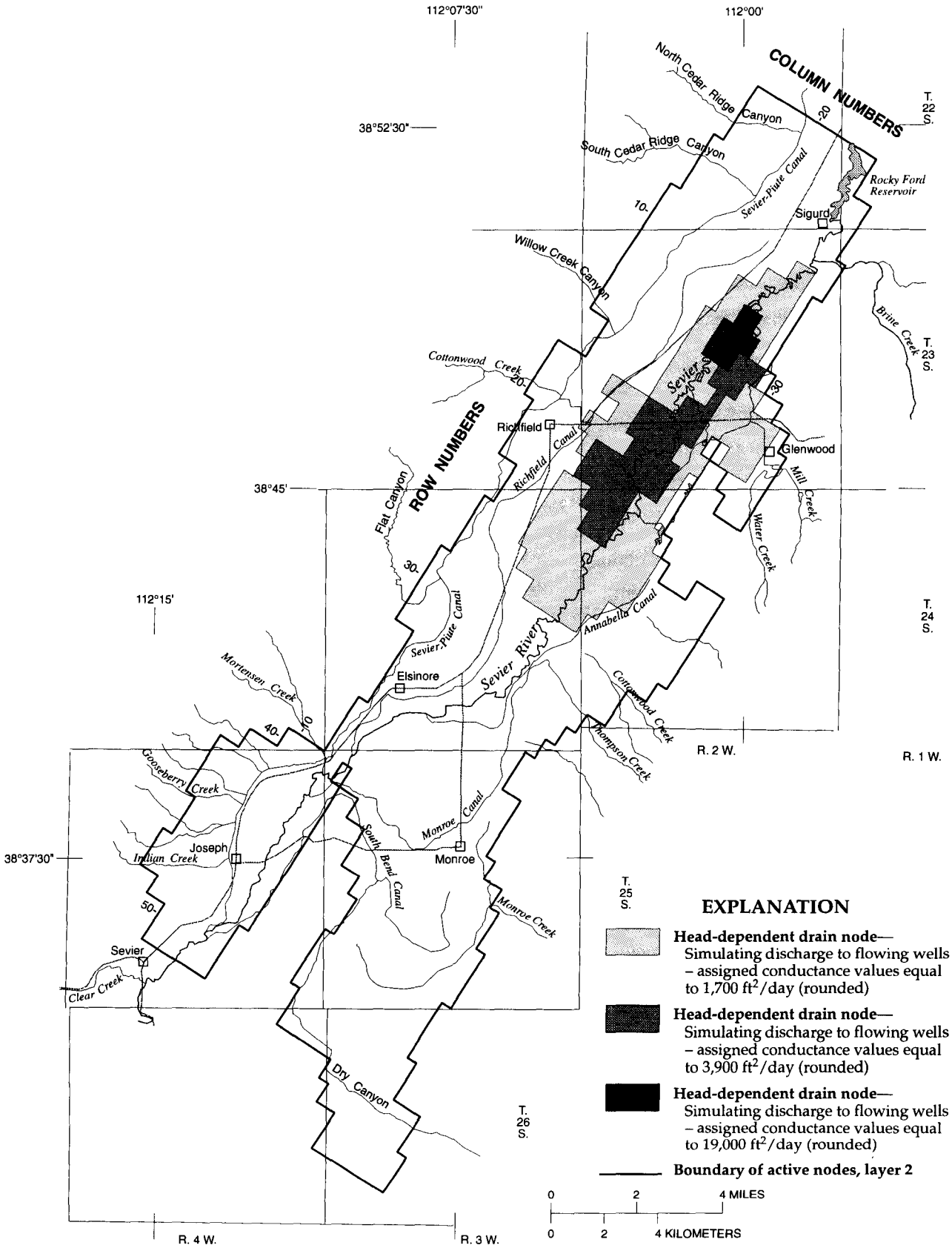


Figure 44. Location of head-dependent drain nodes simulating discharge by flowing wells in layer 2 and node conductance.

1988, p. 5-12), and is calculated by dividing vertical hydraulic conductivity by the distance between the centers of adjoining layers. The ratio of horizontal hydraulic conductivity to vertical hydraulic conductivity is typically larger than 1. Aquifer tests done in other alluvial basins in the State yielded vertical hydraulic-conductivity values for clay confining layers of 0.001 ft/d (Clark and Appel, 1985, p. 47) and 0.006 ft/d (Holmes, 1984, p. 9). Vertical hydraulic-conductivity values used to calculate initial vertical-leakance values ranged from 0.1 percent of horizontal hydraulic conductivity for fine-grained basin fill to 10 percent of horizontal hydraulic conductivity for coarse-grained basin fill.

The allowable range used for storage coefficients in transient simulations was 0.2 for unconfined zones to 0.0001 for confined zones. These values are based on descriptions of material in drillers' logs and the results of aquifer tests in the Sevier-Sigurd basin.

Model Calibration

Model calibration consisted of steady-state and transient simulations. During the calibration process, values for hydraulic properties, and rates of recharge and discharge were varied within prescribed ranges until a reasonable match between computed and measured water levels, and computed and estimated recharge and discharge was achieved.

Steady-State Calibration

Method

Steady-state conditions require that the volume of water flowing into the simulated system equal the volume of water flowing out of the system. Changes in the volume of water stored in the ground-water system occur from year to year as the result of variations in recharge related to precipitation and diversions for irrigation. Fluxes calculated or estimated for a given year, therefore, would not accurately represent steady-state conditions. It was assumed that steady-state conditions in the basin could be defined more reasonably by the long-term average fluxes defined earlier in this report and summarized in table 12.

The calibration of the model to steady-state conditions involved a comparison of water levels computed by the model with 74 water levels measured primarily during the summer of 1957. In areas where water-level data were insufficient or were not available, more recent data were used. Water levels measured in 1957 were selected to represent steady-state conditions because the estimated recharge for 1957 was approximately the same as the estimated long-term annual recharge, and because water-level data were available for the time period. Sixty-two water levels used in steady-state calibration were measured in wells completed in the zone represented by layer 2. In addition to comparing water levels, the calibration also involved comparing head-dependent computed discharge with measured or estimated discharge. Values for hydraulic properties and rates of recharge and discharge were adjusted within prescribed ranges on a trial and error basis until the best results were obtained. The values adjusted most were those for transmissivity, vertical leakance, conductance at head-dependent boundaries, and recharge from irrigated fields and ephemeral streams.

Results of Calibration

Calibration of the steady-state model resulted in a reasonable match between computed water levels and measured water levels. Statistics for residuals (differences between computed water levels and measured water levels) were analyzed during the calibration to determine the accuracy of a simulation. The mean of the residuals, which indicates the bias in the distribution of positive and negative values, was -0.8 foot at the end of the calibration. The absolute value of each residual also was determined; the mean of these values was 5.5 feet. This value is termed the residual error. The standard deviation of the residuals was 7 feet. The range of residuals for the simulation (measured water level minus computed water level) was from -24 feet to 14 feet. Contours based on water levels measured in wells from 150 to 300 feet deep during 1957 and contours based on computed water levels for layer 2 are shown in figure 45. Because water-level data for layer 3 are few, contours from computed water levels and contours based on measured levels were not compared.

Values for conductance at head-dependent boundaries simulating seepage to or from the Sevier River, discharge to drains and flowing wells and subsurface outflow were adjusted during calibration in order to match measured water levels, and measured or estimated flow. Conductance values for river nodes were within prescribed limits and ranged from 26,000 ft^2/day to 65,000 ft^2/day (rounded)(fig. 42). Assigned conductance at drain nodes simulating discharge to drains ranged from 2,000 ft^2/day to 52,000 ft^2/day

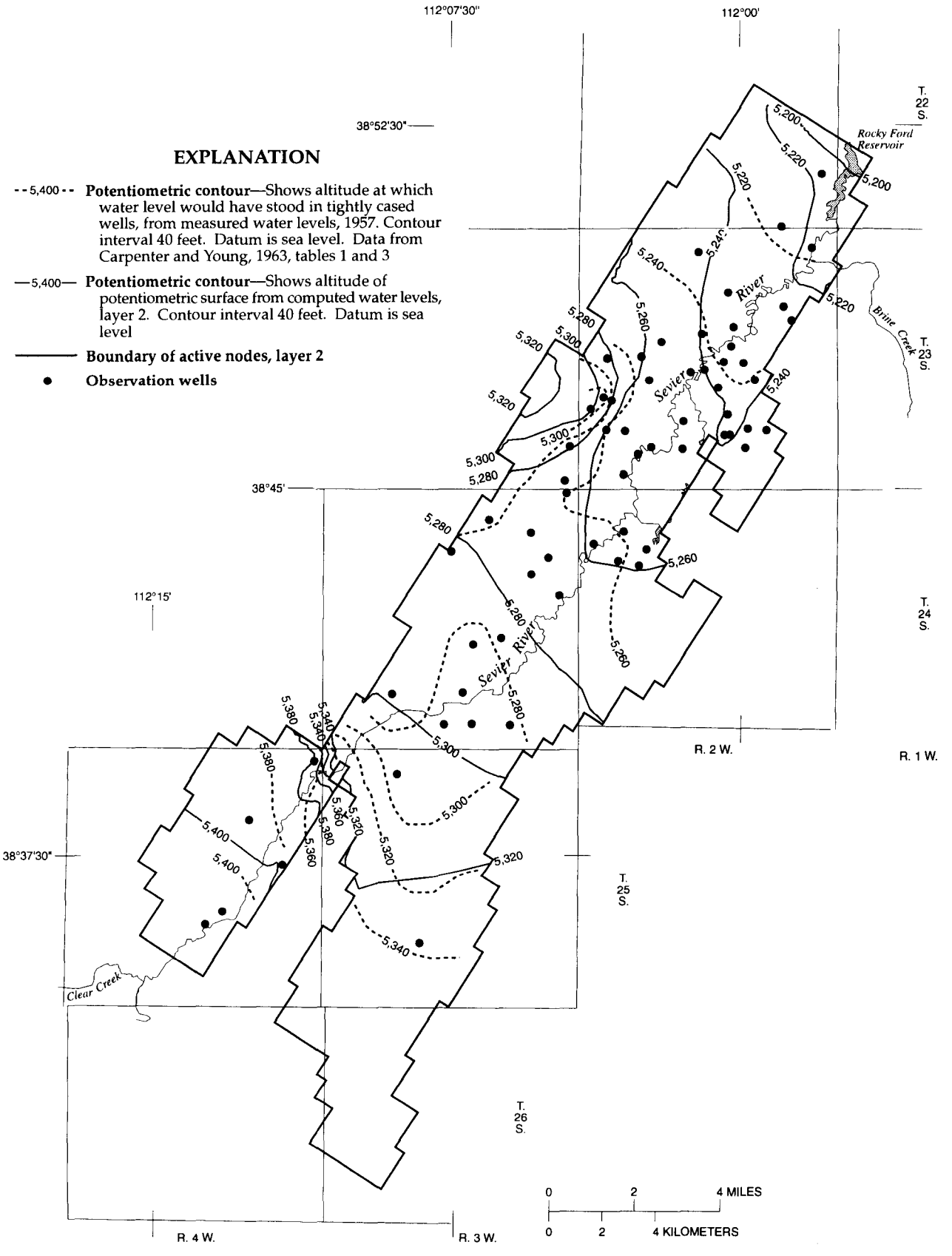


Figure 45. Potentiometric contours based on measured water levels for 1957 and computed water levels in layer 2.

(rounded)(fig. 42). Assigned conductance at drain nodes simulating discharge to flowing wells ranged from 1,700 ft^2/day to 19,000 ft^2/day (rounded)(fig. 44). Conductance values for nodes simulating subsurface outflow at the north end of the basin ranged from 26,000 ft^2/day to 35,000 ft^2/day (rounded).

A steep water-level gradient exists just east of Richfield (pl. 1), where sand and gravel aquifers transporting recharge from various sources along the basin margin west of Richfield thin substantially. During the steady-state calibration, it was evident that the high water levels in that area could not be simulated by adjusting recharge at specified-flux nodes representing seepage from the Sevier-Piute canal and from Cottonwood Creek (fig. 41). Conductance values for head-dependent flux nodes in layers 1 to 3 west of Richfield, which were initially set to zero, were adjusted to simulate recharge from consolidated rock until a reasonable match to measured water levels in that area was obtained. The resulting conductance values at these nodes were 860 ft^2/day (rounded) for nodes in layer 3; 2,600 ft^2/day for nodes in layer 2; and 3,500 ft^2/day for nodes in layer 1. The simulated subsurface inflow from consolidated rock west of Richfield was 9,300 acre-ft/yr (rounded). Conductance values for head-dependent nodes northeast of Glenwood simulating recharge from consolidated rock also were adjusted to obtain a better match to measured water levels in that area. The resulting conductance value for each node was 250 ft^2/day (rounded). The simulated inflow from consolidated rock northeast of Glenwood was 1,300 acre-ft/yr (rounded).

The estimated ground-water budget for the conceptual model of the Sevier-Sigurd basin (table 12) requires recharge of 72,400 acre-ft/yr from consolidated rock and irrigated fields to balance total discharge. The steady-state simulation computes recharge from consolidated rock to be 10,600 acre-ft/yr (rounded). A difference of 61,800 acre-ft/yr representing an estimate for recharge from irrigated fields is obtained by subtracting the computed recharge from consolidated rock from the independent estimate for combined recharge from consolidated rock and irrigated fields. Simulation of this recharge of 61,800 acre-ft/yr in the model resulted in a poor match between computed and measured water levels in areas of irrigated fields. Specified recharge from irrigated fields was adjusted during calibration until a good match between measured and simulated hydraulic head throughout the basin was obtained. A recharge of 43,200 acre-ft/yr from irrigated fields resulted in the best match.

The steady-state ground-water budget has a reasonable correspondence with the independent estimates of the conceptual model water budget (table 17). Total flow into and out of the ground-water system computed by the steady-state model is about 22 percent less than independent estimates.

Table 17. Ground-water budget for steady-state calibration, computed by the model compared with independent estimate on the basis of field data

[Data in acre-feet per year; ?, unknown]

Conceptual model: Field data from table 12.

	Conceptual model	Steady-state model
Recharge from		
Precipitation	2,100	2,200
Consolidated rock and irrigated fields	72,400	53,800
Consolidated rock	(?)	(10,600)
Irrigated fields	(?)	(43,200)
Canals	8,900	9,000
Sevier River	10,100	8,400
Other streams	19,200	14,200
Total	112,700	87,600
Discharge to		
Evapotranspiration	23,200	14,600
Sevier River	47,400	29,800
Alluvial springs	18,000	18,900
Drains	10,000	12,100
Wells	12,100	9,700
Subsurface outflow	2,000	2,500
Total	112,700	87,600

The computed steady-state ground-water budget is only an approximation; however, the discrepancy between the model-computed and conceptual ground-water budgets may indicate that independent estimates for some components of discharge, and therefore the independent estimate for total recharge, may be large.

The largest difference between estimated and computed discharge rates is for ground-water discharge to the Sevier River. It is possible that part of the discrepancy is the result of inflow to the river from irrigation water derived from surface runoff or discharge to the river from shallow perched zones. Inflow to the

Table 18. Computed steady-state flow rates at river and drain nodes in layer 1 and measured gains and losses in August and October 1988

[Data in cubic-feet per second]

River reach	Total computed gain (+) or loss (-) steady-state simulation			Measured gain (+) or loss (-)	
	At river nodes	At drain nodes	Total	Measurements made during August 1988	Measurements made during October 1988
1	-3.6	0	-3.6	-8	+4
2	+9.3	+2.0	+11.3	+44	+32
3	-2.4	+1.3	-1.1	-6	-1
4	+25.8	+13.4	+39.2	+66	+51

river from these sources could not be measured in the field, and therefore, were not differentiated from recharge to the river from the ground water in the independent estimate.

Computed steady-state flow rates at river and drain nodes were compared with the results of seepage studies conducted on the Sevier River in August and October, 1988 (G.W. Sandberg, U.S. Geological Survey, 1989, written commun.) (table 18). The reported gains in the river from ground water, which were derived from seepage studies, include ground water discharged to the river from buried drains. Computed discharge to drain nodes, therefore, was added to discharge to river nodes for the comparison. River reaches used in the analysis are shown in figure 42.

The volume of water diverted for irrigation in the Sevier-Sigurd basin for 1988 was greater than average (fig. 16) and water levels were relatively high (fig. 15). For this reason, computed steady-state flow rates to and from the Sevier River were not expected to match values measured during seepage studies made in 1988. The comparison, however, does indicate that the steady-state simulation can approximate losing and gaining reaches in the river as determined by seepage studies.

Transient Calibration

The hydrologic system defined in the steady-state calibration was analyzed using transient simulations. These simulations were made by representing natural fluctuations in recharge over a period of time. Variations in withdrawal from pumped and flowing wells were also simulated. Computed and measured water-level changes and flow to and from the Sevier River were compared to measure the accuracy of the simulations.

Two transient-state calibration procedures were used. The first procedure consisted of 32 yearly stress periods using estimated recharge data for 1957-88 and water level data from 1958-88. The second consisted of 24 monthly stress periods using monthly recharge data and water-level data for 1958-59.

Values for aquifer properties were adjusted during the transient simulations, mostly at nodes simulating confined zones. Following these adjustments, the steady-state simulation was run using the modified data parameters. The results of the simulations indicated no substantial change in computed water levels at the nodes used for calibration in the simulations. The final distributions that were used in all simulations for parameters that define the aquifer characteristics are shown in figures 46 to 52. A specific yield value of 0.1 was used in all active nodes in layer 1.

Transient Calibration Using Annual Recharge Rates for 1957-88

Method

Calibration for 1957-88 was done by simulating yearly variations in recharge to the ground-water system. Final water levels computed in the steady-state simulation were used as initial water levels in the first stress period of the transient simulation. The simulation period was divided into 32 stress periods of one year in length. During each stress period, all external stresses on the simulated system were held constant. Each stress period was divided into 3 time steps. The length of the first time step of each stress period was 77 days (rounded) and was increased with advancing time

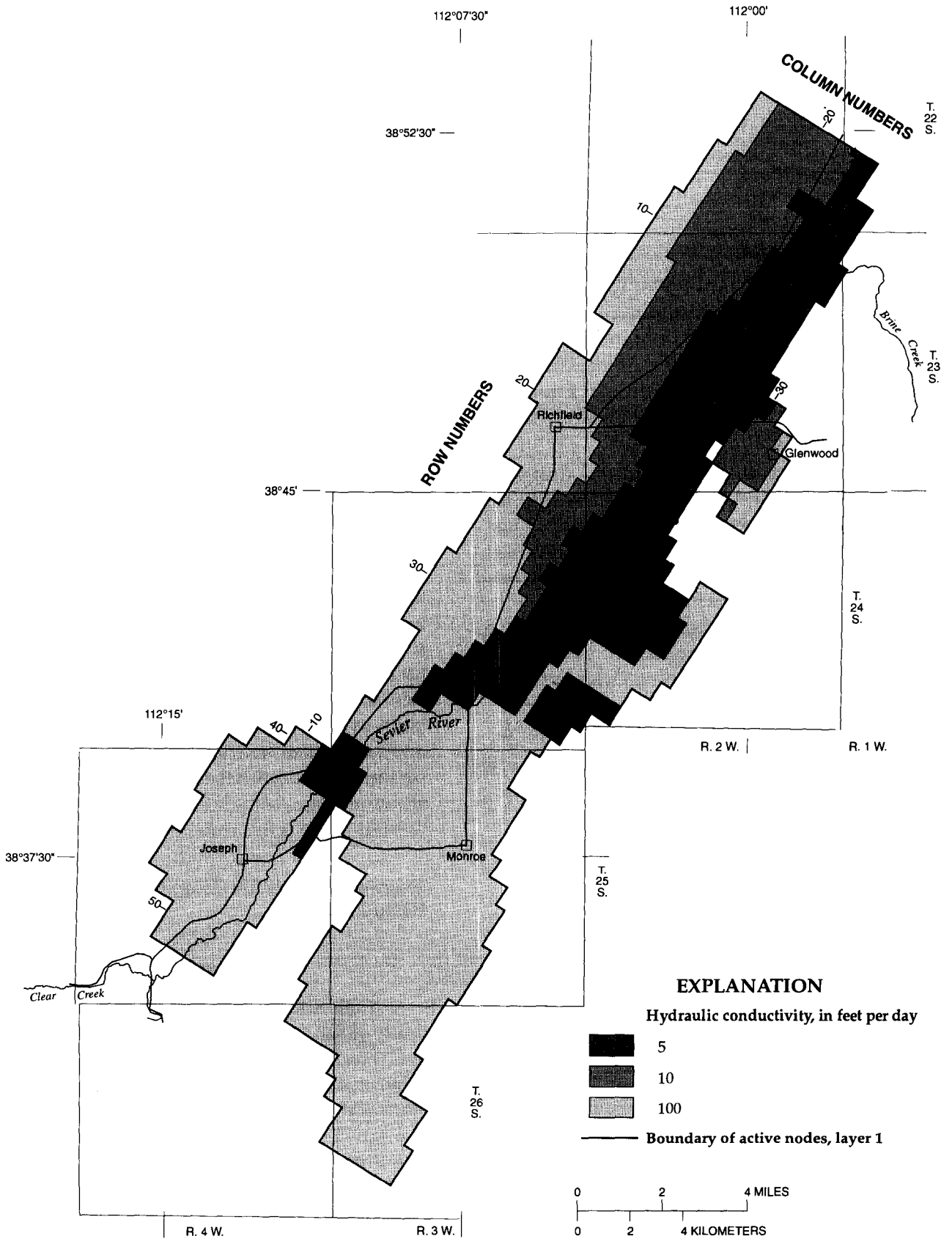


Figure 46. Final distribution of hydraulic-conductivity values for layer 1.

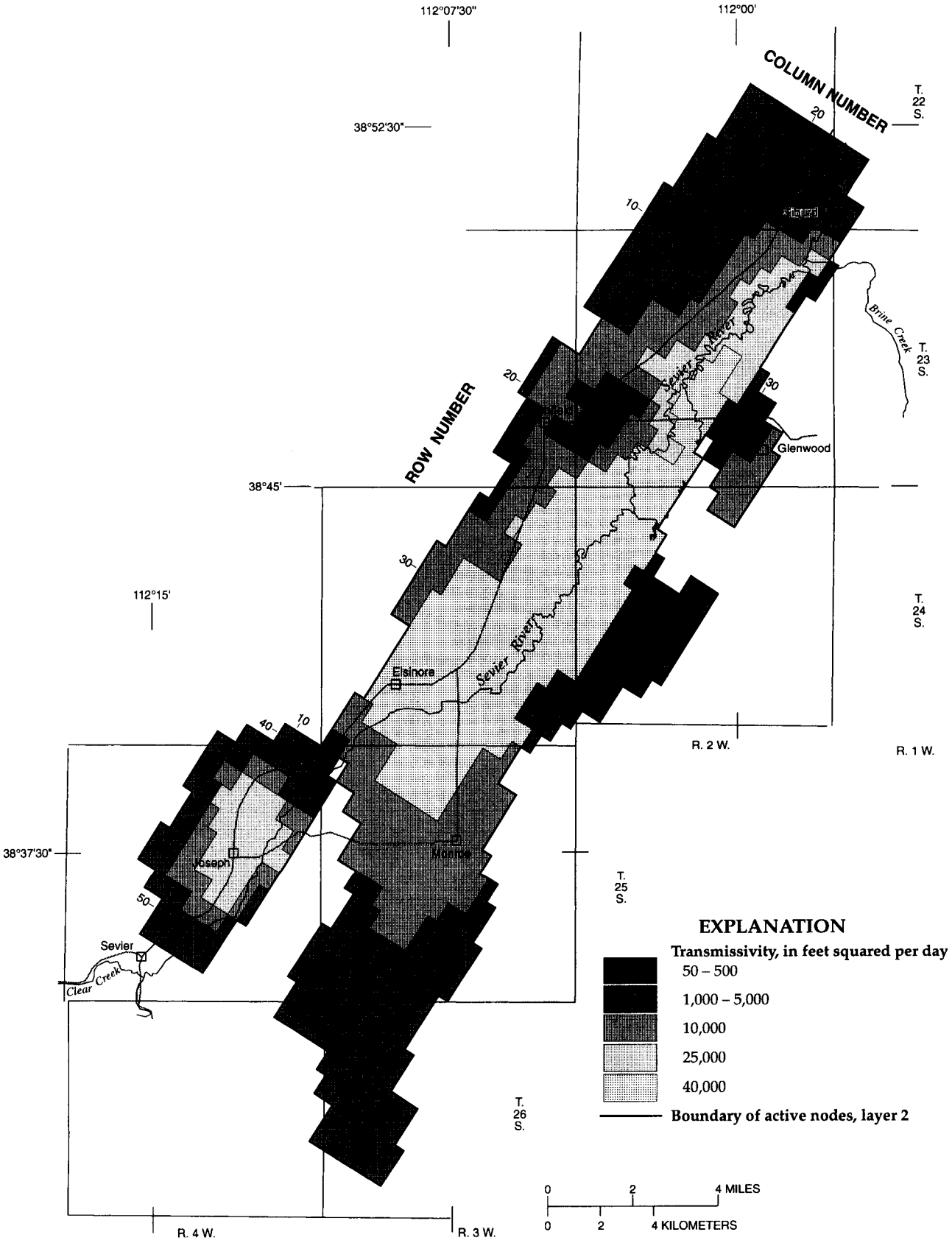


Figure 47. Final distribution of transmissivity values for layer 2.

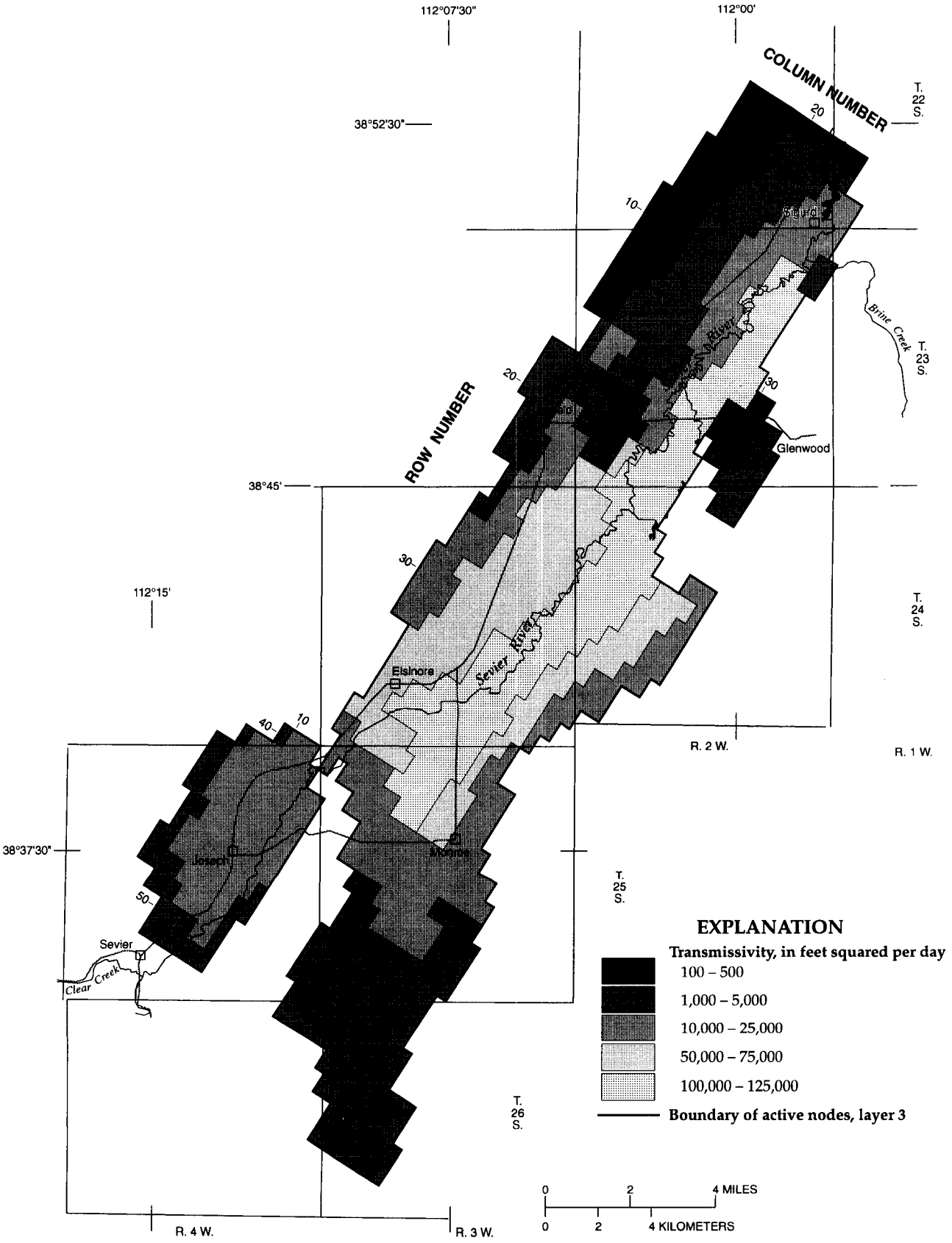


Figure 48. Final distribution of transmissivity values for layer 3.

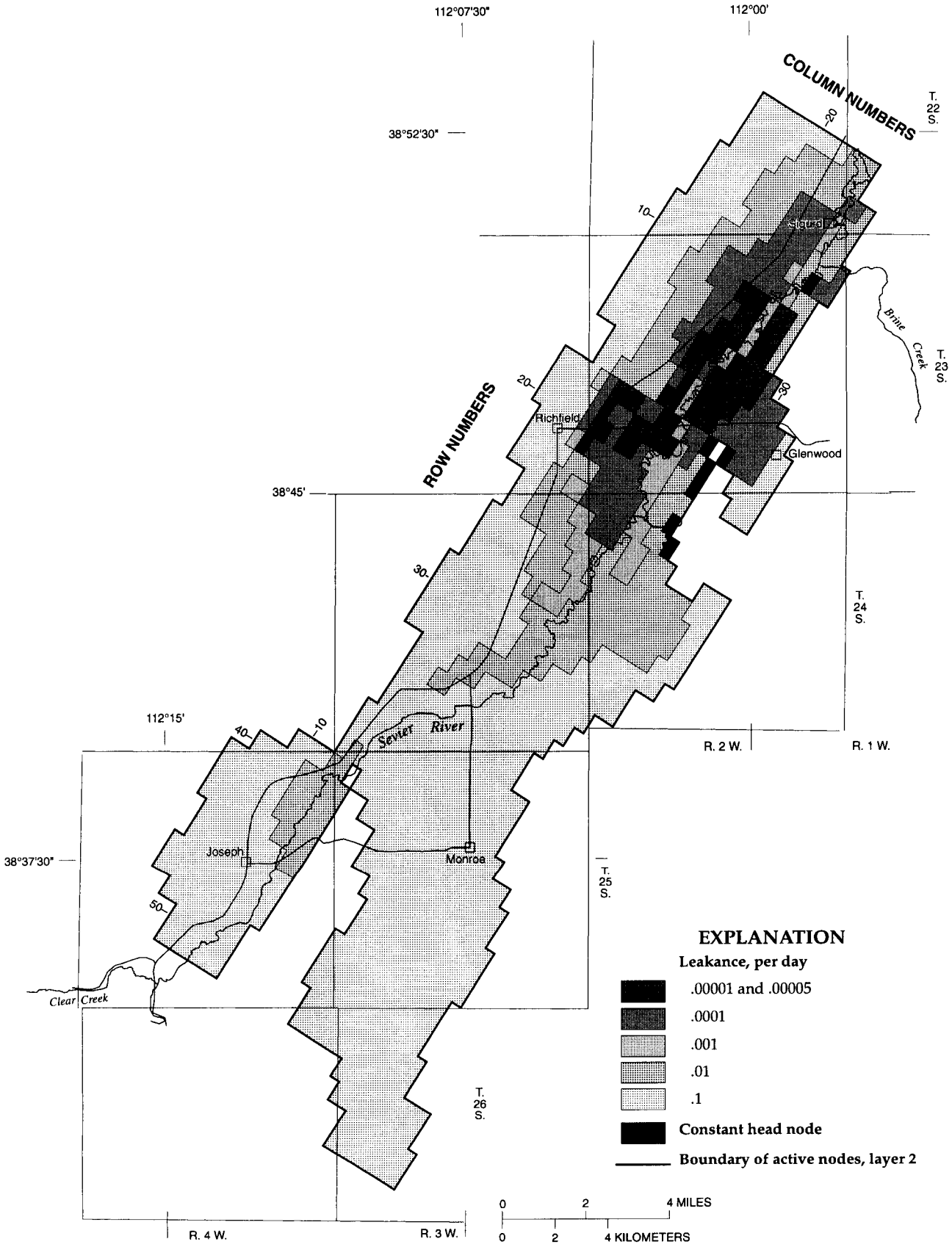


Figure 49. Final distribution of vertical-leakance values between layers 1 and 2.

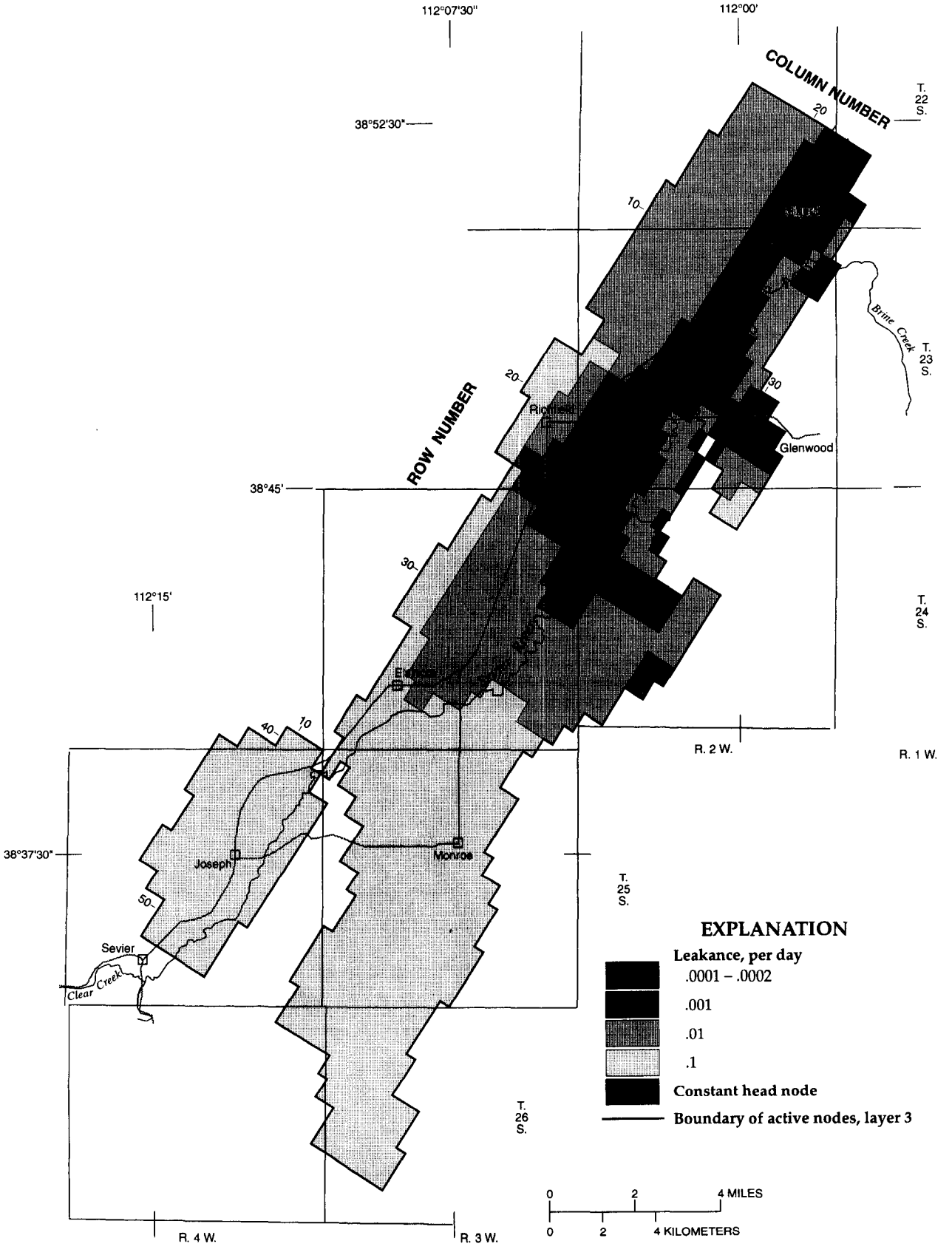


Figure 50. Final distribution of vertical-leakance values between layers 2 and 3.

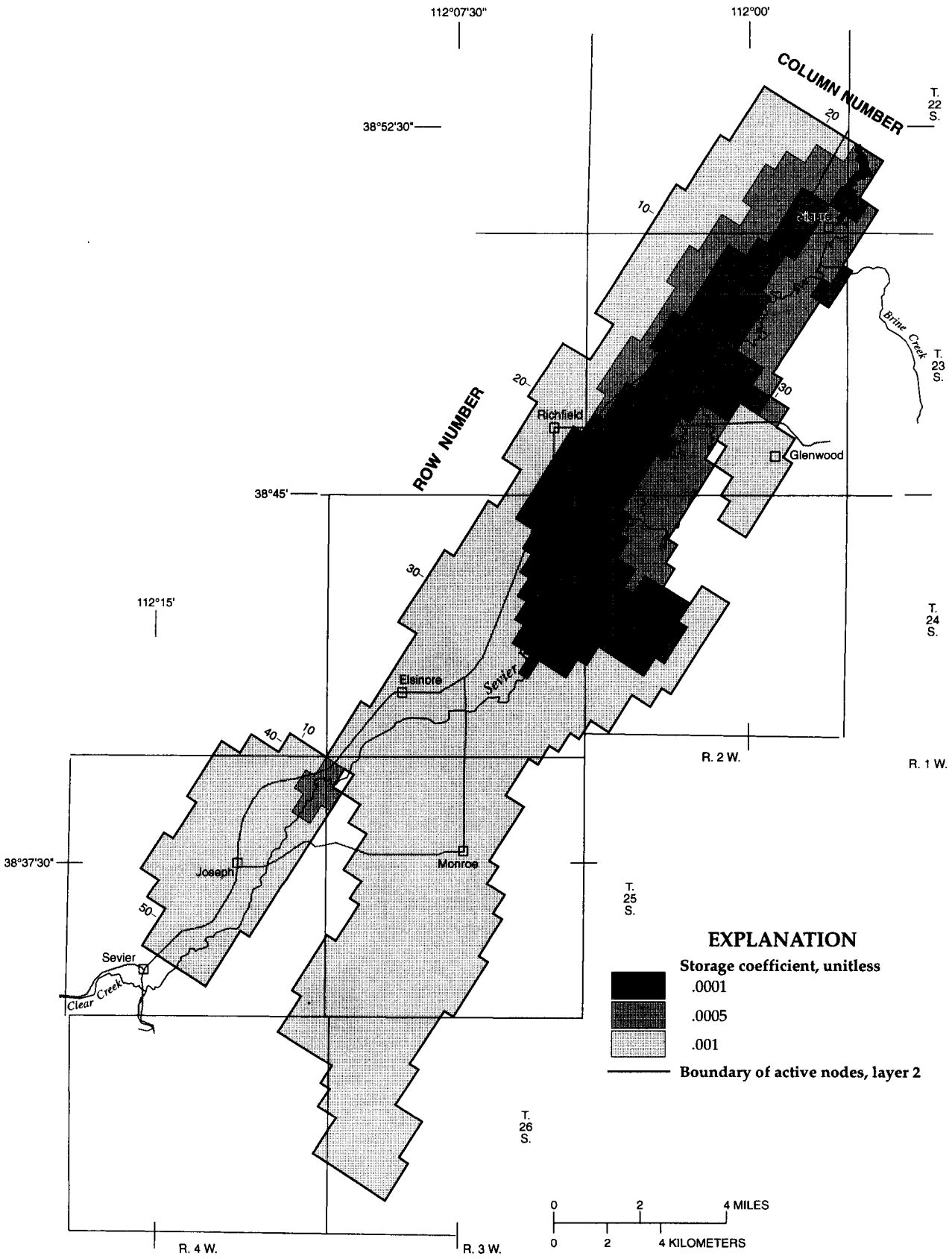


Figure 51. Final distribution of storage-coefficient values used during transient simulations for layer 2.

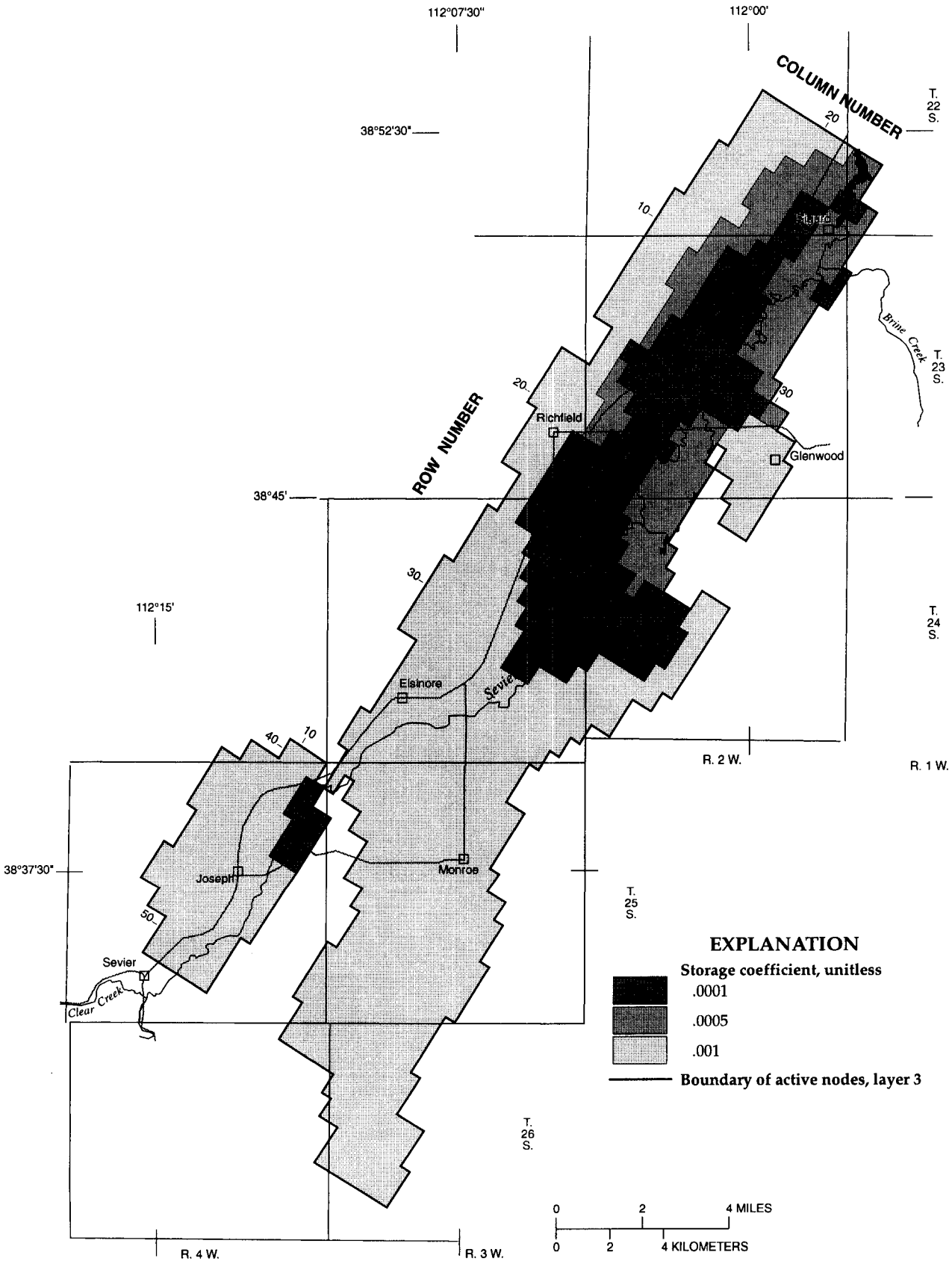


Figure 52. Final distribution of storage-coefficient values used during transient simulations for layer 3.

by a time-step multiplier of 1.5. Time-step length was reduced during the transient calibration to ensure that the accuracy of the simulation was not effected by truncation error resulting from an inappropriate initial time-step size. Results of simulations using shorter time steps did not indicate a significant change in model-computed water levels or flow rates.

During calibration, annual computed water-level changes were compared with annual measured water-level changes. Also, computed discharge of ground water to the Sevier River was compared with estimated annual discharge to the river.

Specified recharge rates used in the simulation for each yearly stress period were varied from steady-state values on the basis of the assumption that recharge varies with annual fluctuations in precipitation on the valley floor, snow pack in the adjacent mountains, discharge in losing canals, and the quantity of water diverted for irrigation by canals. Annual values for these components were compared with averages computed for 1957-86. Variation in recharge rates was adjusted during calibration in order to match measured water-level changes and estimated annual variations in discharge to the Sevier River. The best match was obtained when recharge rates used in the steady-state simulation were multiplied by factors (F) computed using the following relations with a lower limit of F = 0.2:

$$F(\text{recharge from direct precipitation}) = (P/P(av) - 1) + 1.0,$$
$$F(\text{recharge from seepage from canals}) = (C/C(av) - 1) + 1.0,$$
$$F(\text{recharge from streams other than the Sevier River}) = [(SP/SP(av) - 1) \times 3] + 1.0,$$
$$F(\text{seepage from irrigated fields}) = [(DIV/DIV(av) - 1) \times 3] + 1. \quad (6)$$

where: P = Precipitation at Richfield, during a given year stress period,

P(av) = Average precipitation (1957-86) at Richfield,

C = Diversions to canals containing losing reaches during a given year stress period,

C(av) = Average diversions (1957-86) to canals containing losing reaches,

SP = April snow pack at Squaw Spring station ((C-27-2)3, Wasatch Plateau, 12 miles southeast of Monroe) for a given year stress period,

SP(av) = Average April snow pack (1957-86) at Squaw Spring station ((C-27-2)3, Wasatch Plateau, 12 miles southeast of Monroe)

DIV = Water diverted from the Sevier River and Clear Creek to canals minus exports by canals to other areas during a given year stress period,

DIV(av) = Average quantity of water diverted (1957-86) from the Sevier River and Clear Creek to canals minus exports by canals to other areas.0.

For example, in 1958, water diverted for use in the Sevier-Sigurd basin from the Sevier River and Clear Creek was estimated to be 130,000 acre-ft (table 2), or 28,600 acre-ft more than average. The steady-state recharge rate representing seepage from unconsumed irrigation water on irrigated fields of 43,200 acre-ft/yr was multiplied by a factor of 1.8 from the relation F = [(130,000/101,400 - 1) * 3] + 1 to obtain the recharge rate from irrigation water of about 77,800 acre-ft/yr for the stress period representing the year 1958. For 1959, water diverted for use in the Sevier-Sigurd basin from the Sevier River and Clear Creek was estimated to be about 76,000 acre-ft and F is equal to 0.2. Recharge simulated at specified-flux boundaries for the 1957-88 transient simulation is shown in figure 53.

Discharge from pumped, public-supply, industrial, and large-diameter irrigation wells was varied according to annual withdrawal estimates. Annual discharge from these wells was estimated to have increased from 1,100 acre-ft/yr for 1957 to 2,400 acre-ft/yr for 1988. This increase, however, is small compared with other sources of discharge and did not have a substantial effect on computed water-level changes during the simulation period.

Results of 1957-88 Annual Calibration

Calibration of the simulation resulted in a reasonable match between computed and measured water-level changes for the simulation period. Computed and measured water-level changes for 5 observation wells are shown in figure 54. Computed water levels from the steady-state simulation were used as initial conditions for this simulation. Although steady-state water levels closely match water levels measured in 1957, they were not assumed to represent water levels at the

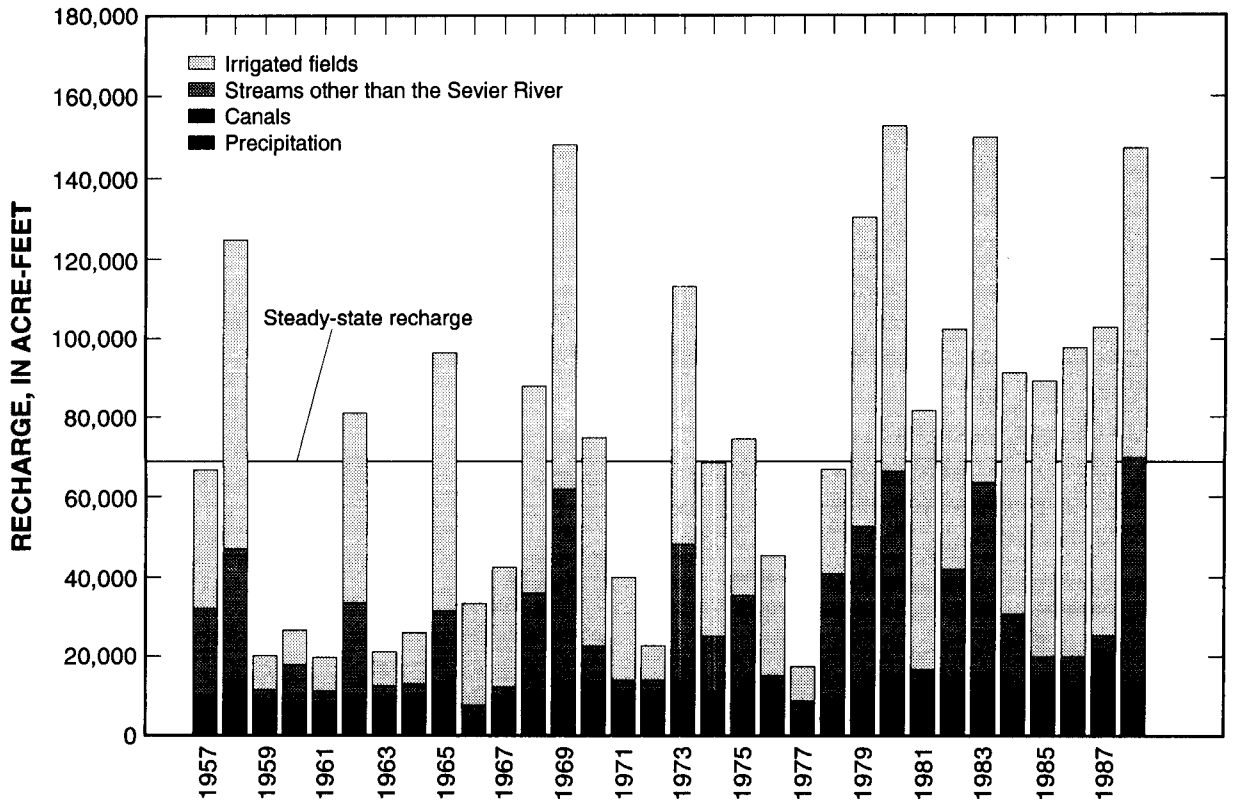


Figure 53. Simulated recharge at specified-flux boundaries for the 1957-88 transient simulation.

beginning of 1957 (the first stress period). Computed water-level declines for the first stress period, therefore, were not used in the comparison in figure 54 to reduce error caused by the initial conditions.

At the completion of the calibration, computed water levels for stress period 32, representing conditions at the end of 1988, were compared with water levels measured in 41 wells during 1988. Statistics computed for the residuals indicate results similar to those observed in the steady-state simulation. The mean of the residuals was -3.4 feet, the absolute value of the residuals, or the mean error, was 6.6 feet, and the standard deviation was 7.6 feet. Differences between computed and measured water levels ranged from -26 feet to 9 feet.

Potentiometric contours based on water levels measured in wells from 150 to 300 feet deep, and potentiometric contours based on computed water levels in layer 2 for stress period 32 are shown in figure 55. The figure indicates that contours from computed water levels closely match contours based on measured values, particularly in the northern part of the basin.

Computed flow at river and drain nodes for the simulation period was compared with estimates of net gains in the Sevier River resulting from direct seepage and discharge by drains (fig. 56). The estimated annual net gain to the Sevier River resulting from direct seepage and discharge by drains was derived by subtracting estimated ungaged tributary and spring inflow to the river from the measured gain in the river (table 2). These values were compared with the computed net gain that was assumed to be represented by the relation: (recharge to river nodes - discharge to river nodes) + (discharge to drain nodes - 6,000 acre-feet). An estimated 6,000 acre-ft/yr is diverted annually from drains for irrigation and does not discharge into the river; therefore, it is subtracted from the computed discharge to drain nodes.

The comparison indicates a reasonable match between computed and estimated annual net gain in the Sevier River for the simulation period. Computed gain, however, is generally lower than the estimated values. Possible overestimation of ground-water discharge to the Sevier River in conceptual-model estimates also was indicated in the results of the steady-state calibration (table 17). The consistent difference in computed and estimated ground-water discharge to the Sevier River may be because of two reasons: (1) Discharge to the river from ungaged sources such as streams and

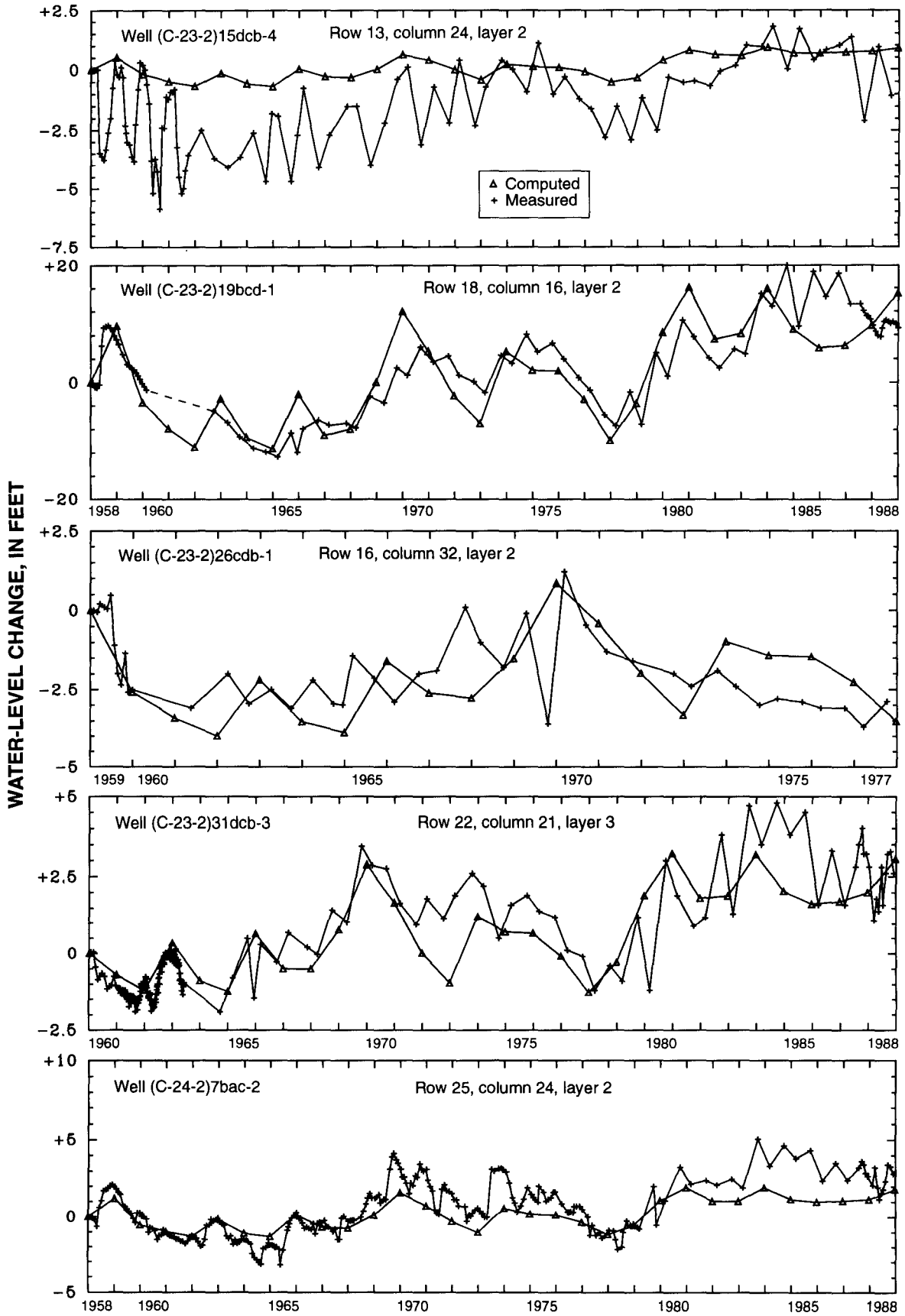


Figure 54. Computed and measured water-level changes for five observation wells.

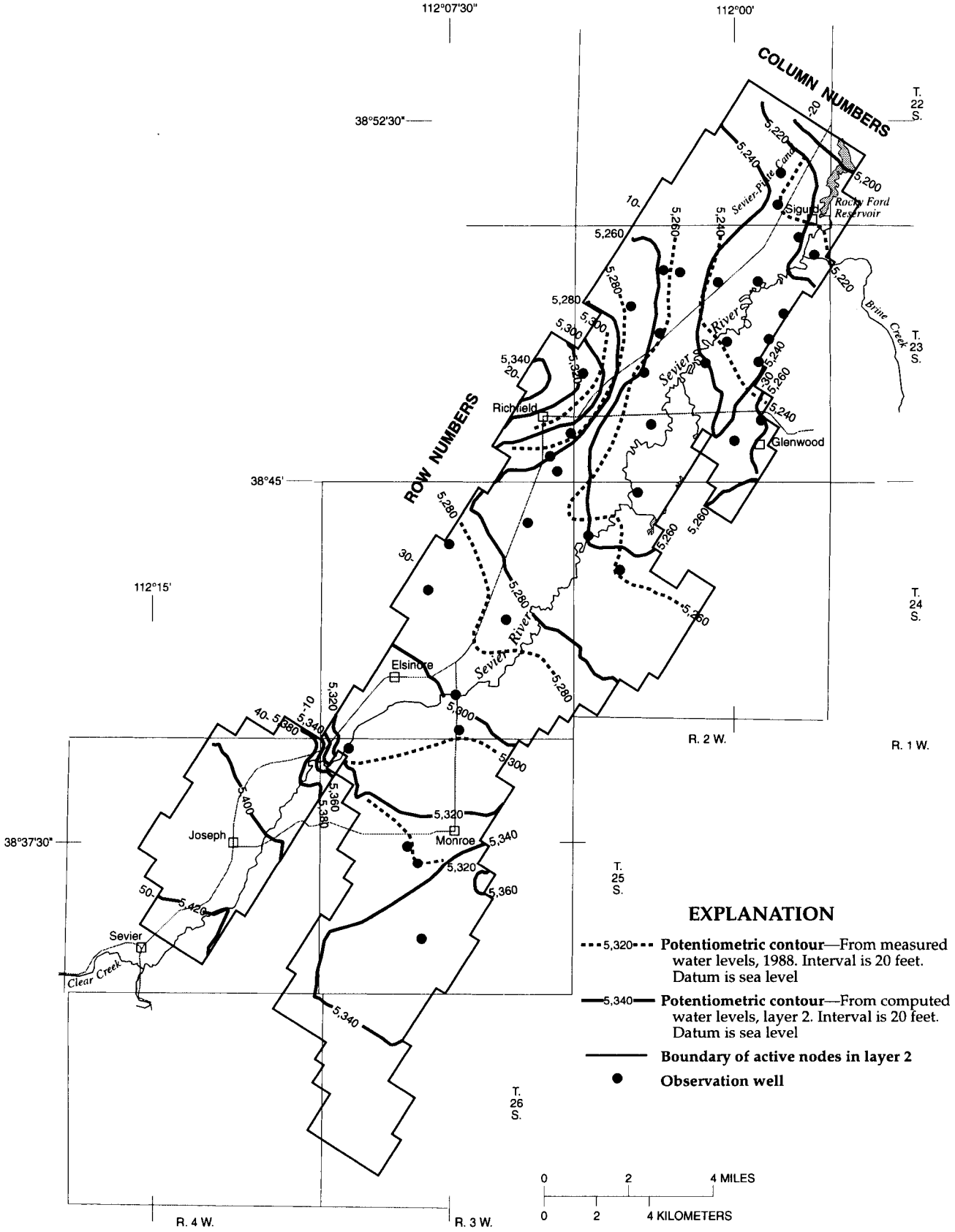


Figure 55. Potentiometric contours based on measured water levels for 1988 and computed water levels in layer 2.

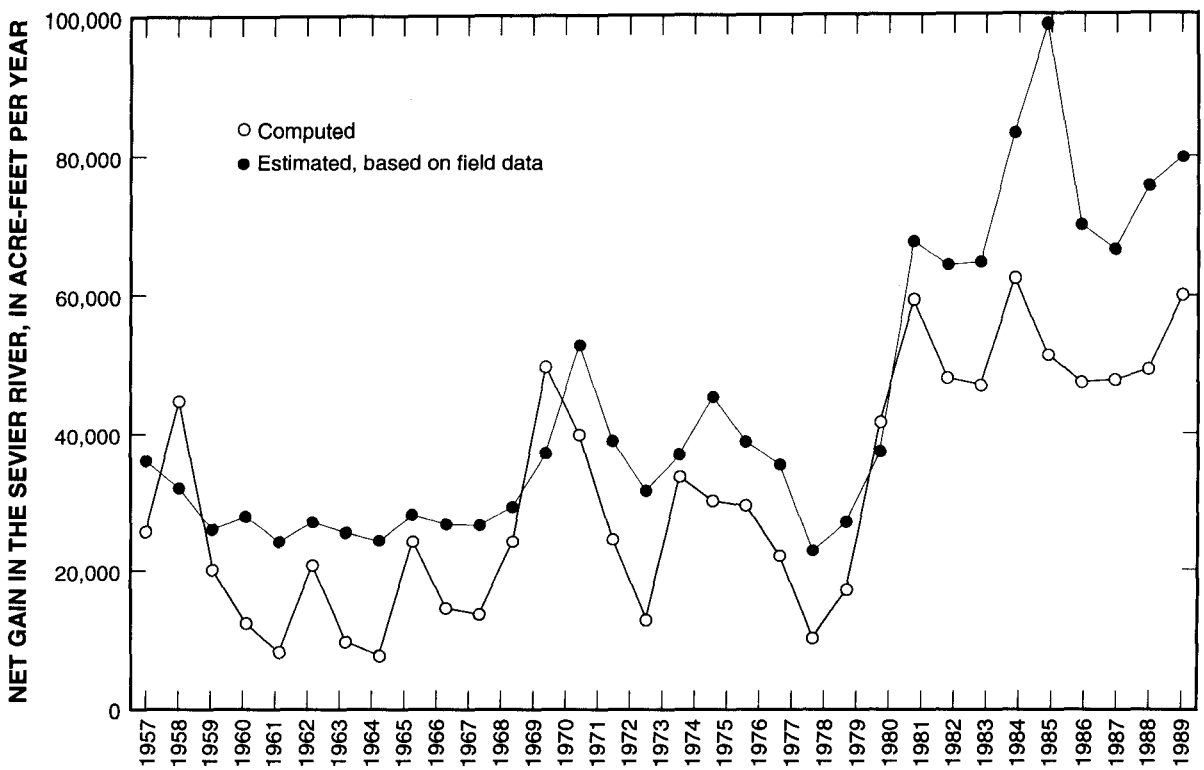


Figure 56. Computed and estimated net gains in the Sevier River resulting from direct seepage and from discharge by drains.

springs, particularly for periods of above average precipitation and snow pack, is underestimated in conceptual-model estimates and (2) irrigation return flow to the river by surface runoff or movement in perched zones in the shallow subsurface might constitute a substantial percentage of the measured gain in the river assumed to come from the ground-water system.

Model-computed discharge to head-dependent boundaries simulating discharge to springs, by evapotranspiration, to flowing wells, and by subsurface outflow vary with changes in simulated recharge. Variations in computed discharge for these components and simulated recharge at specified-flux boundaries for the 1957-88 transient simulation are shown in figure 57.

Transient Calibration Using Monthly Recharge Rates for 1958-59

Method

A second transient simulation was completed using water-level data collected monthly at wells in the simulated area during 1958-59. The purpose of this simulation was to provide another method of testing estimates of recharge defined during the first transient simulation and to provide information on the monthly distribution of water levels and fluxes.

The two-year simulation period was divided into 24 stress periods of one month in length. During each stress period, all external stresses on the simulated system were held constant. One time-step was used in each stress period. For some simulations during this transient calibration, stress periods were divided into multiple time-steps of varying lengths. Results of simulations using multiple time-steps in a stress period did not, however, indicate a substantial change in model-computed water levels or flow rates.

Calibration was done by simulating monthly fluctuations in recharge to the ground-water system during 1958-59 and comparing computed water levels with measured water levels. Computed flow rates representing ground-water discharge to the Sevier River for monthly stress periods were compared with the results of seepage studies of the river. Computed water levels from the first transient simulation for the end of stress period 1, representing conditions during 1957, were used as initial conditions in the 1958-59 monthly transient simulation.

Annual recharge from precipitation on the valley floor used in the 1957-88 transient simulation for stress periods representing 1958 and 1959 were divided into

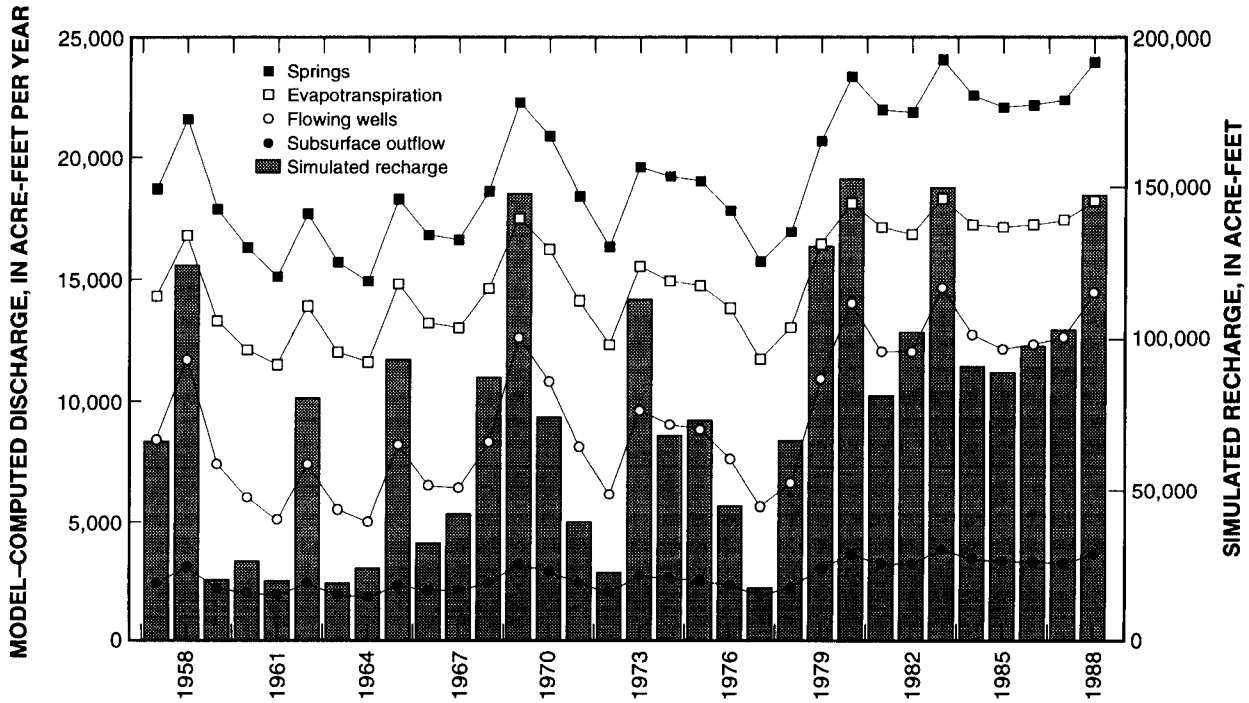


Figure 57. Variations in computed discharge to springs, by evapotranspiration, to flowing wells, and by subsurface outflow, and simulated recharge at specified-flux boundaries for the 1957-88 transient simulation.

monthly rates on the basis of monthly precipitation records at Richfield. Annual recharge from canals used in the 1957-88 transient simulation for stress periods representing 1958 and 1959 were divided into monthly rates on the basis of the measured quantity of flow each month in canals where recharge is simulated.

Recharge rates representing seepage to the ground-water system from irrigated fields were determined by comparing estimates of water applied for irrigation with the estimated crop consumptive use for each monthly stress period. The following relation was used to compute recharge from applied irrigation water for a given monthly stress period: Recharge = (Applied irrigation water - crop consumptive use) x F.

The factor F represents the percentage of unconsumed irrigation water that was simulated as recharge to the ground-water system in the first transient simulation for the stress periods representing 1958 and 1959. For example, the total recharge from irrigated fields for stress period 2 (representing 1958) in the first transient simulation was about 77,800 acre-ft, or about 70 percent of the estimated unconsumed irrigation water for that year. The factor F for the monthly stress period representing conditions in 1958, therefore, equals 0.70.

The total recharge from irrigated fields for stress period 3 (representing 1959) in the first transient simulation was about 8,700 acre-ft and the factor F was calculated to be 0.14 for the monthly stress period in 1959. This relatively small amount reflects below-average diversions from the Sevier River and Clear Creek during 1959. Using the factor F assures that the specified recharge for monthly stress periods, when totaled, will approximate the specified recharge for yearly stress periods representing 1958 and 1959 in the previous transient simulation.

Estimates of recharge rates representing seepage from perennial and ephemeral streams for monthly stress periods used in the 1958-59 transient simulation were based on the total recharge applied in the first transient simulation for the stress periods representing 1958 and 1959, and estimates of the percent of annual streamflow in tributaries that occurs in a given month. Streamflow measurements made by the Soil Conservation Service (written commun., 1988) at Monroe Creek during 1960-65, and at North Cedar Ridge and South Cedar Ridge Canyons during 1964-65 were used to estimate the percentage of total flow in perennial and ephemeral streams that is discharged in a given month. The recharge to the ground-water system from streams used in the first transient simulation for the stress periods representing 1958 and 1959 was multiplied by the defined percentage for a given month to determine a recharge rate for that monthly stress period.

Simulated recharge at specified-flux boundaries for irrigated fields, streams, and canals for the 1958-59 transient simulation are shown in figure 58. Recharge from precipitation on the valley floor is only a small percentage of the total recharge used during the 1958-59 simulation and is not represented in figure 58.

Conductance values for drain nodes in layer 2, used to simulate discharge from flowing wells, were varied between stress periods. Low conductance values ranging from 260 ft^2/day to 2,900 ft^2/day (rounded) were used during stress periods representing winter months when discharge is mainly from stock and domestic flowing wells. These values were increased by a factor of 10 during the irrigation season to represent the uncapping of flowing irrigation wells. Specified discharge rates representing withdrawals from pumped irrigation wells also were adjusted to represent monthly variations. Discharge from pumped irrigation wells was simulated only from May to September of each year.

Water altitudes in river nodes were varied as much as three feet between stress periods. This was done to simulate the fluctuation of stage in the Sevier River caused mainly by releases from Piute Reservoir, seasonal changes in inflow to the river from tributaries and springs, and diversions of river water to canals during the irrigation season. Assigned altitudes for monthly stress periods were based on mean-monthly flows at the U.S. Geological Survey gaging station 10194000, Sevier River above Clear Creek, and from measurements made in the field. Stage in the river is usually highest from April to August, and is lowest from October to November.

Results of 1958-59 Monthly Transient Calibration

Monthly transient calibration resulted in a reasonable match between computed and measured water-level changes for the 1958-59 simulation period at most of the calibration sites (figs. 59-61). Analysis of computed and measured monthly water levels indicates that trends in measured water-level changes because of monthly changes in recharge, ground-water withdrawal, and the rate of discharge by evapotranspiration were approximated. Computed water levels used as initial conditions for this simulation were not assumed to represent water levels on January 1, 1958. Computed water-level declines from stress period 1, repre-

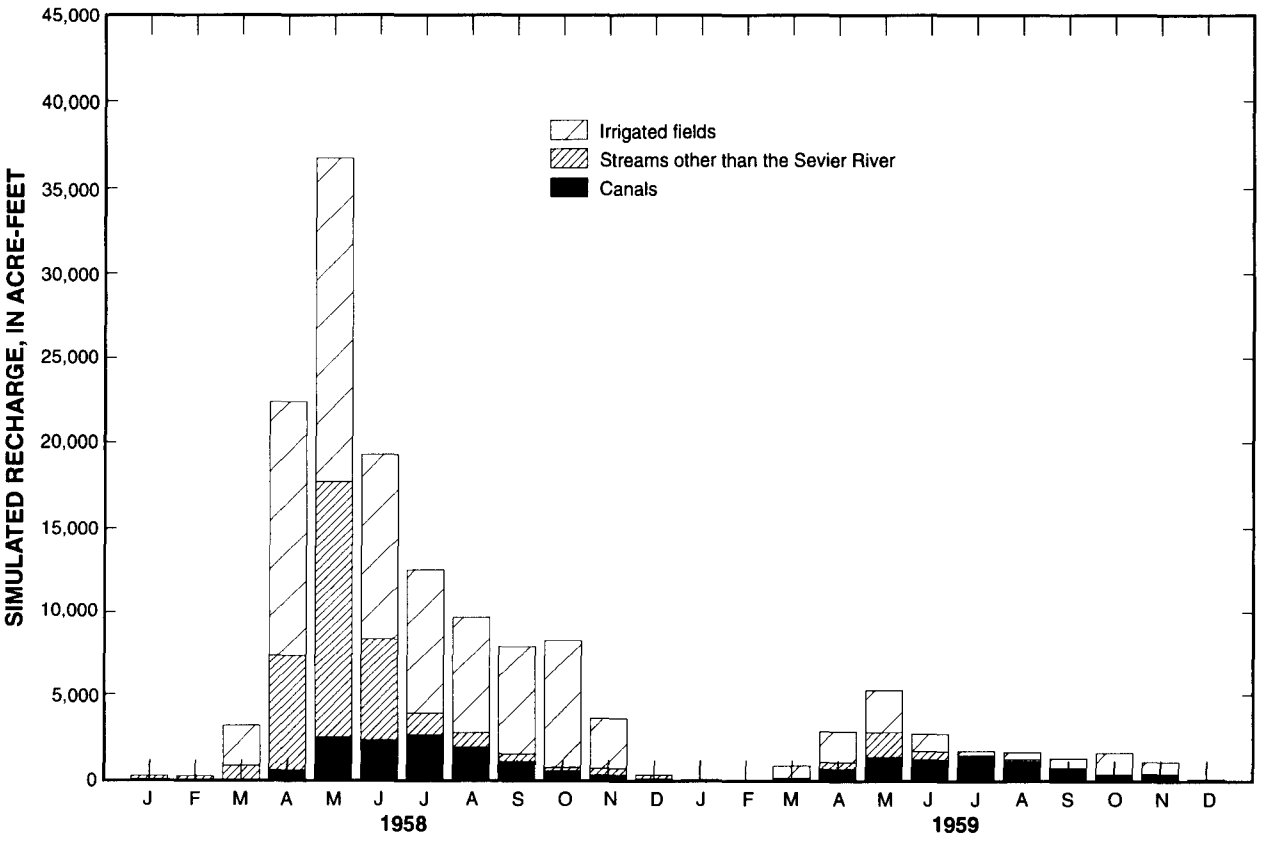


Figure 58. Simulated recharge at specified-flux boundaries for irrigated fields, streams, and canals for the 1958-59 transient simulation.

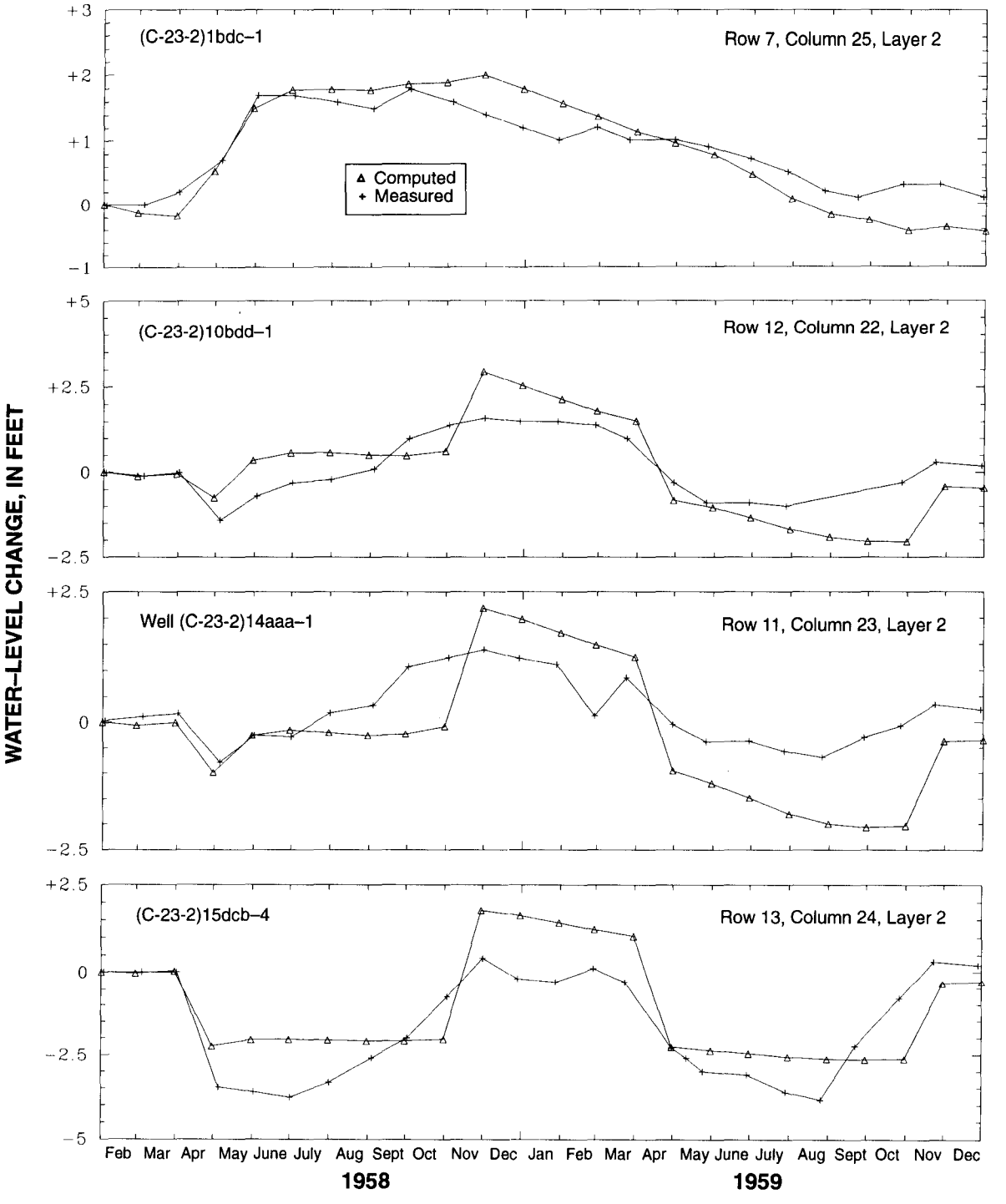


Figure 59. Computed and measured water-level changes from February 1958 to December 1959 for 12 wells completed in the shallow confined zone.

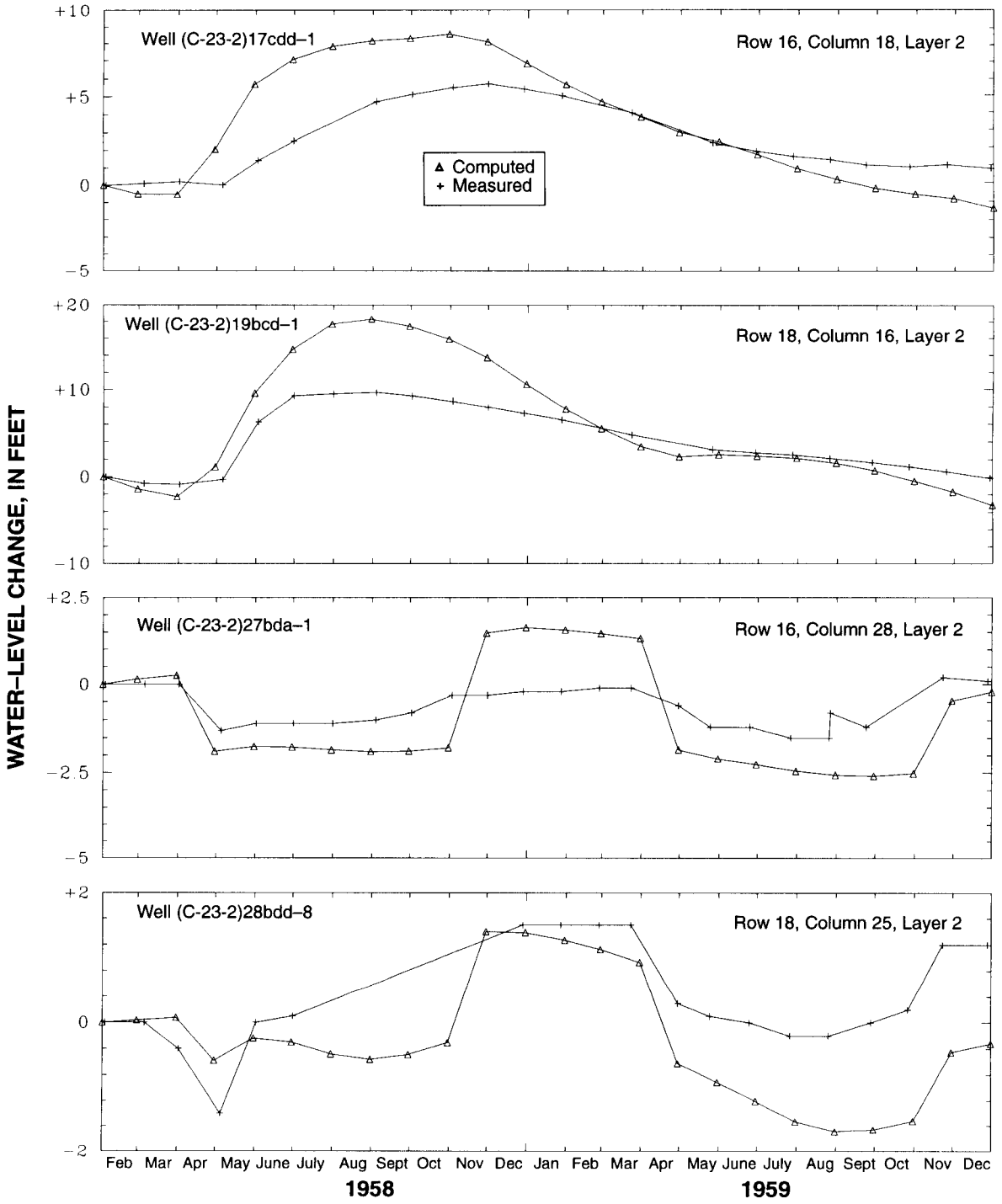


Figure 59. Computed and measured water-level changes from February 1958 to December 1959 for 12 wells completed in the shallow confined zone–Continued.

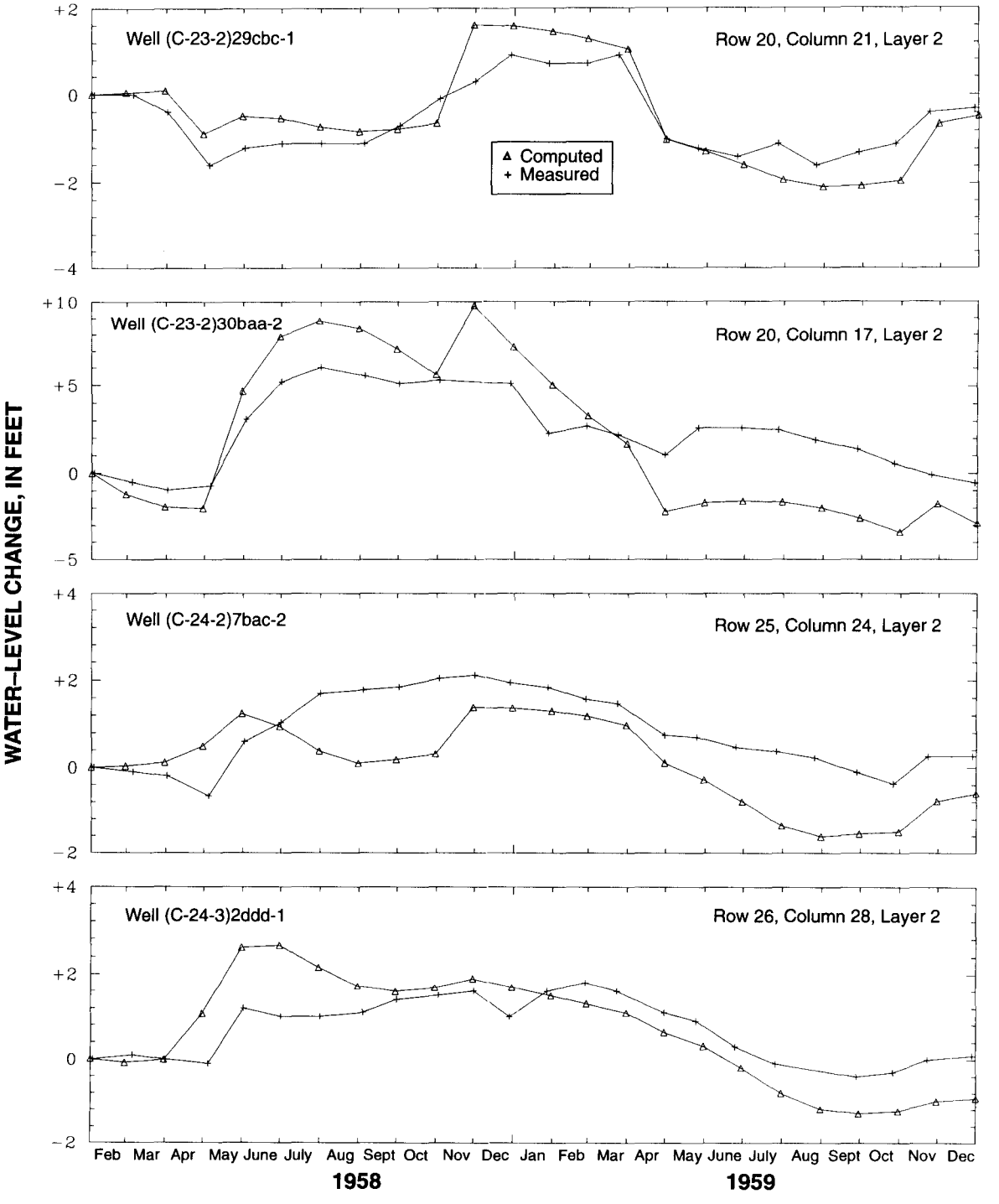


Figure 59. Computed and measured water-level changes from February 1958 to December 1959 for 12 wells completed in the shallow confined zone–Continued.

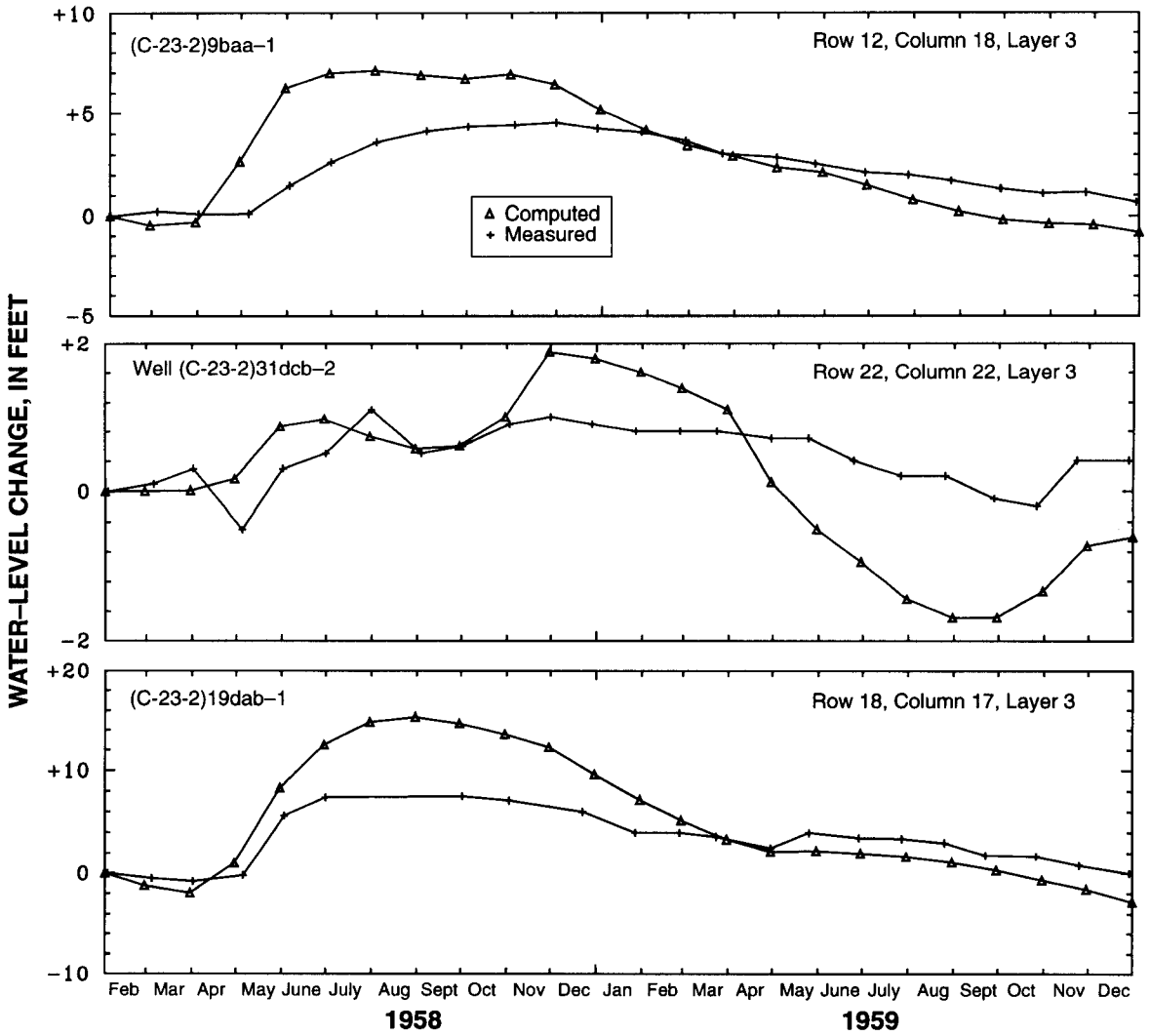


Figure 60. Computed and measured water-level changes from February 1958 to December 1959 for three wells completed in the deep confined zone.

senting conditions during January 1958, therefore, were not used in the comparisons to reduce error caused by the initial conditions.

Computed and measured water-level changes in wells finished in the confined zones represented by layers 2 and 3 are shown in figures 59 and 60. These wells are within or near the primary flowing-well area of the basin, and in some cases near phreatophyte areas where ground water is discharged by evapotranspiration. The declines in water levels in these wells caused by increases in discharge from flowing irrigation wells and discharge by evapotranspiration during spring and summer months are generally simulated accurately. The best match between computed and measured water levels is in the south one-half of the basin where wells are completed in the primary unconfined zones of the ground-water system (fig. 61).

Computed flow rates at river and drain nodes for stress periods 8 and 10, which represent conditions for August and October of 1958, were compared with the results of the seepage study conducted on the Sevier River in August and October of 1988 (table 19). The comparison was assumed to be a reasonable method for determining the accuracy of the simulation because estimated recharge to the ground-water system during those years was similar on the basis of data for precipitation and diversions from the river (fig. 53).

The comparison indicates a reasonable match between computed and measured flow rates in the river for reaches 1 and 4. Computed discharge for reach 2, near Joseph, is substantially lower than measured values. Lack of hydrologic data for the area from Sevier to Joseph makes it difficult to determine the reasons for

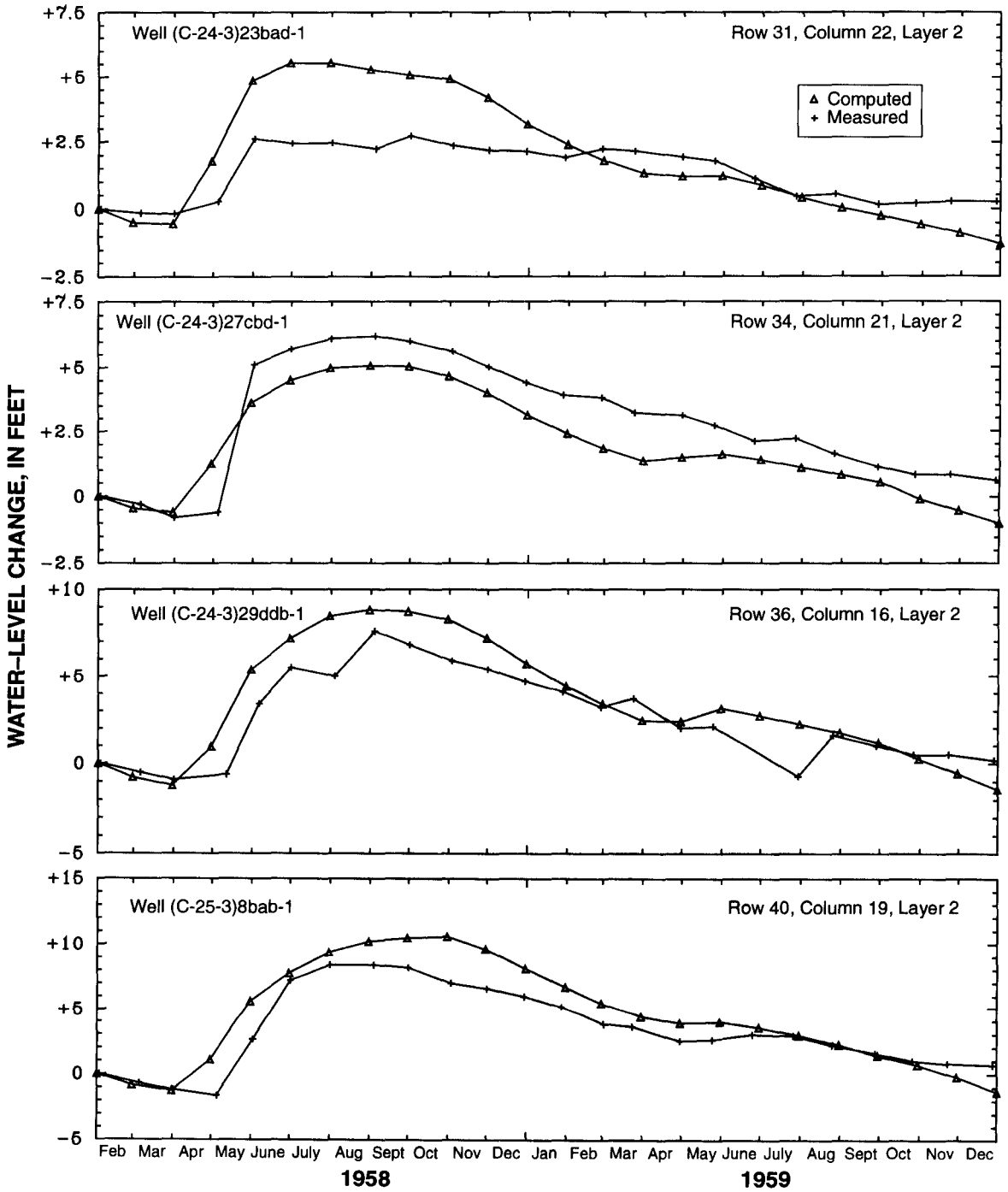


Figure 61. Computed and measured water-level changes from February 1958 to December 1959 for eight wells completed in the unconfined zones.

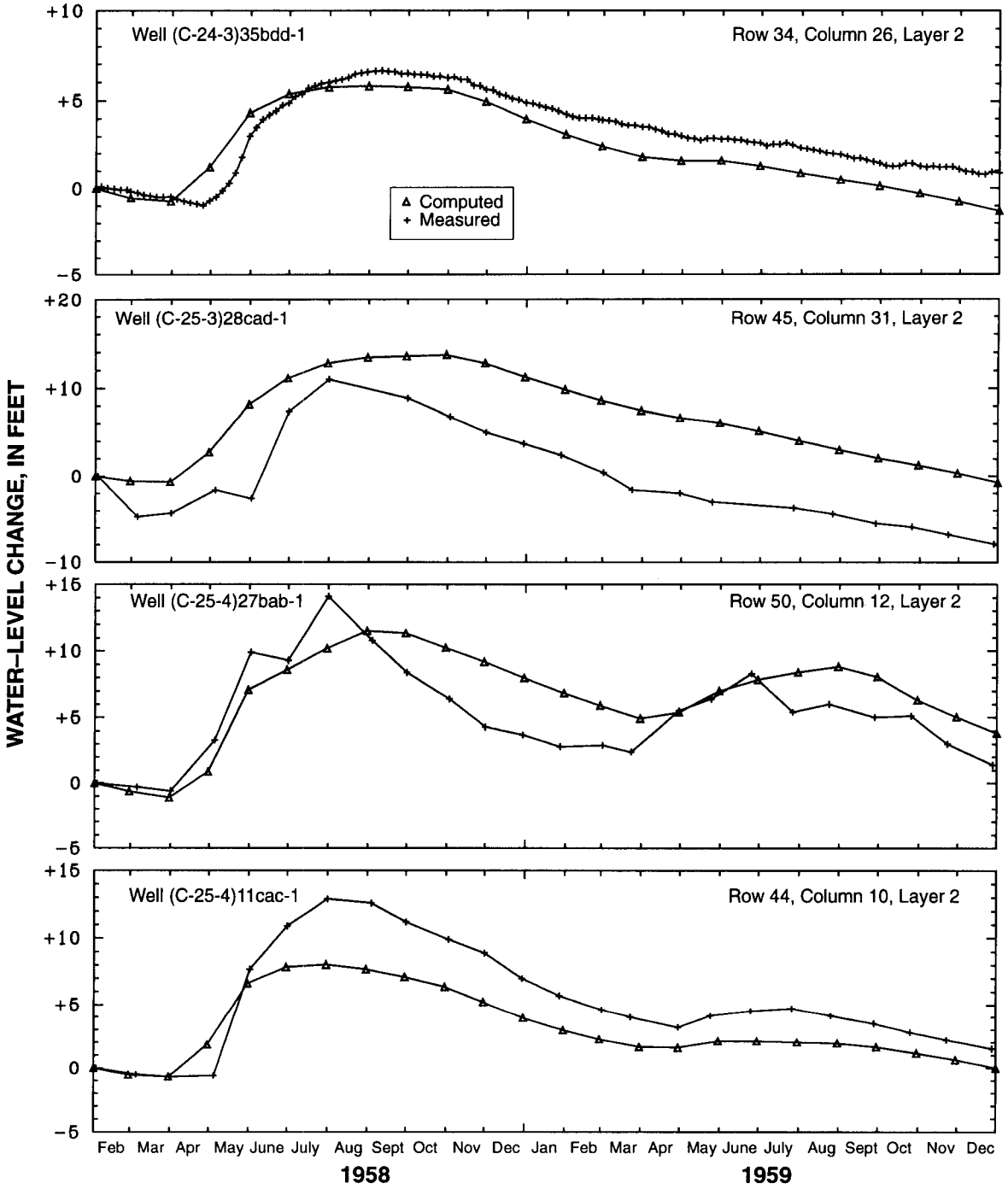


Figure 61. Computed and measured water-level changes from February 1958 to December 1959 for eight wells completed in the unconfined zones–Continued.

Table 19. Computed flow rates at river and drain nodes in layer 1 for stress periods representing August and October 1958, and measured gains and losses in August and October 1988

[Data in cubic-feet per second]

River reach	Total computed gain (+) or loss (-) transient simulation stress period 8, representing August 1958			Measured gain (+) or loss (-), August 1988
	At river	At drain	Total	
1	-7.2	0	-7.2	-8
2	+15.6	+2.0	+17.6	+44
3	+3.9	+3.9	+7.8	-6
4	+33.6	+22.3	+55.9	+66
River reach	**Total computed gain (+) or loss (-) transient simulation stress period 8, representing October 1958**			**Measured gain (+) or loss (-), October 1988**
	At river	At drain	Total	
1	-2.4	0	-2.4	+4
2	+20.3	+1.7	+22.0	+32
3	+5.9	+3.9	+9.8	-1
4	+42.6	+22.3	+64.9	+51

the discrepancy between computed and measured discharge to the river. Analysis of individual river nodes in reach 3 indicates that the reach does include nodes simulating losing river reaches; however, the model simulates a net gain for the entire reach. Variations in computed discharge to the Sevier River, to springs, by evapotranspiration, and by flowing wells, and simulated recharge at specified-flux boundaries for the 1958-59 transient simulation are shown in figure 62.

Particle-Tracking Analysis

After model calibration was completed, some components of the model were analyzed using a particle-tracking post-processing software package as described by Pollock (1989). The package computes three-dimensional flow paths on the basis of output from the steady-state simulation. Given an initial position of a particle in a cell, the package computes the coordinates of any other point along its flow path. Flow paths for water simulated as discharging from the ground-water system to the Sevier River and to alluvial springs were generated by defining particles within, or on the faces of model cells that contain boundaries representing those features. These particles were then tracked backwards along their flow path to recharge source points.

Flow paths generated by backtracking from particles in cells containing river nodes representing points of ground-water discharge to the Sevier River are indicated in figure 63. One particle was defined at the center of each cell where discharge is simulated. The resulting flow path represents the simulated path traveled by a particle of water from where it recharges the ground-water system to where it discharges into the Sevier River. Recharge entering the ground-water system in the southern end of the basin from irrigated fields, canals, and by seepage from the river moves northerly and discharges into the Sevier River in the central part of the basin (fig. 63). Some ground-water discharge to the river in the central part and most of the northern part of the basin originates as recharge from various sources west of Richfield and from irrigated fields west of the river.

Some recharge source points for ground water discharging to alluvial springs are indicated in figure 64. The figure shows ground water in some areas flowing under the river and discharging at springs along the east margin of the basin.

It should be noted that each flow path illustrated in figures 63 and 64 represents the simulated movement of one particle of water in the simulated system. These figures do not indicate all possible recharge source areas for ground water discharging to the Sevier River

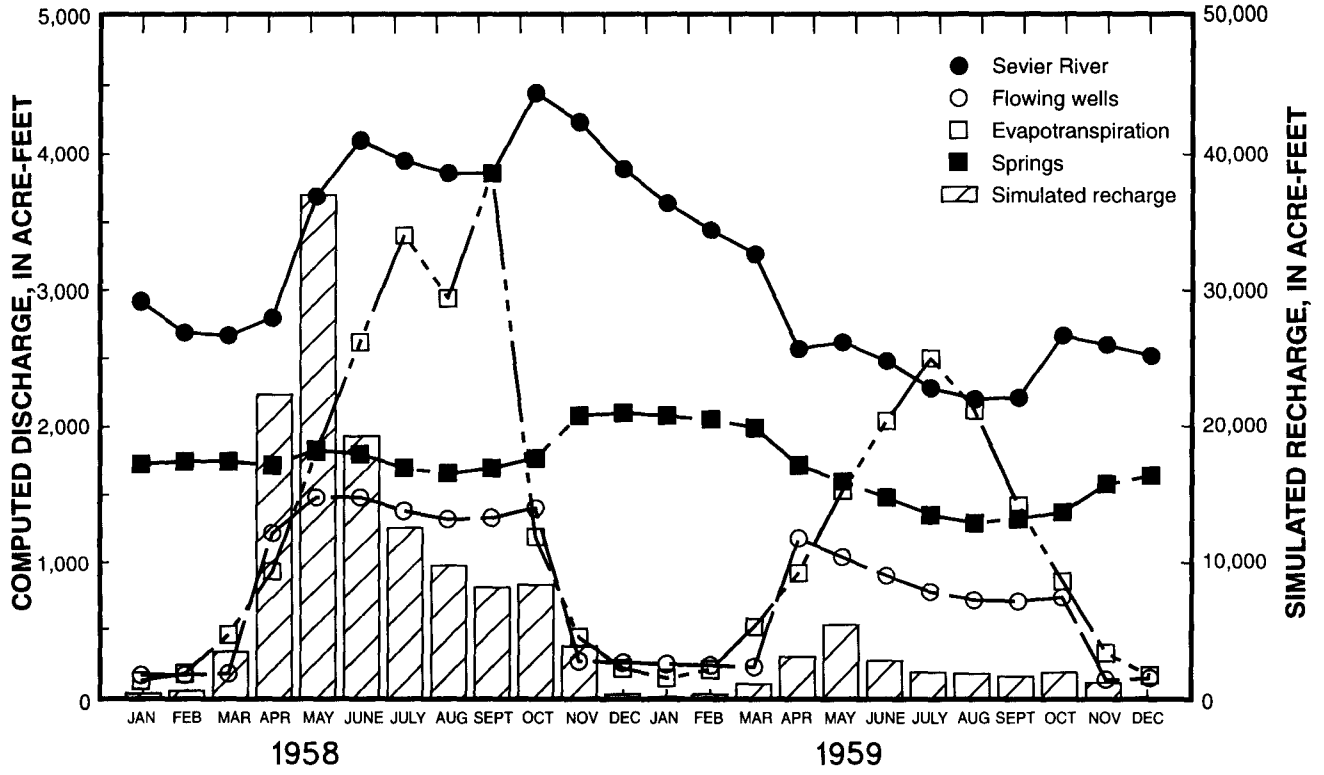


Figure 62. Variations in computed discharge to the Sevier River, to springs, by evapotranspiration, and to flowing wells, and simulated recharge at specified-flux boundaries for the 1958-59 transient simulation.

and to alluvial springs. Additional particles placed within or on cell faces would produce a more complete representation of areas contributing water to the various discharge points.

Sensitivity Analysis

Sensitivity analysis is an evaluation of the effect of changes in individual model parameters on model results. Where ranges of possible values for model parameters were large, such as for hydraulic properties of the aquifer and recharge from irrigated fields, sensitivity analyses were done as part of the simulation and calibration process. Significant hydrologic effects resulting from changes in model parameters are discussed below. All changes discussed are with respect to the reported final model simulations.

The general effect of changes in hydraulic conductivity and transmissivity is to control the down-basin water-level gradient. Lowering the transmissivity values in layers 2 and 3 throughout the basin steepened the simulated hydraulic gradient, raising water levels particularly in the vicinity of primary recharge areas. Increases in transmissivity from calibrated values had less of an effect on the hydraulic gradient. Changing hydraulic conductivity in layer 1 had little effect on regional water levels. Decreasing transmissivity values during the transient simulation also raised water levels near recharge areas, but had little effect on the trends in simulated water-level fluctuations.

Vertical leakance, from which the model calculates vertical hydraulic conductance, controls the water-level gradient in the vertical plane. Decreasing the leakance between layers increases the hydraulic gradient between them. Substantial water-level increases in layers 2 and 3 were observed when vertical leakance between layers 1 and 2 were reduced in the northern and central parts of the simulated area.

Changes in values for storage coefficient affected the magnitude of water-level declines and rises throughout the area during transient simulations, particularly in recharge areas where vertical-leakance values are relatively large. For example, an order of magnitude increase for the storage coefficient in layers 2 and 3 reduced simulated water-level declines during September 1958 to December 1959, in wells (C-24-3)35bdd-1 and (C-24-3)27cbd-1, from about 7 feet to 4 feet. Changes in storage-coefficient values had a lesser effect on water-level changes in the northern and central parts of the simulated area where vertical leakance is relatively small.

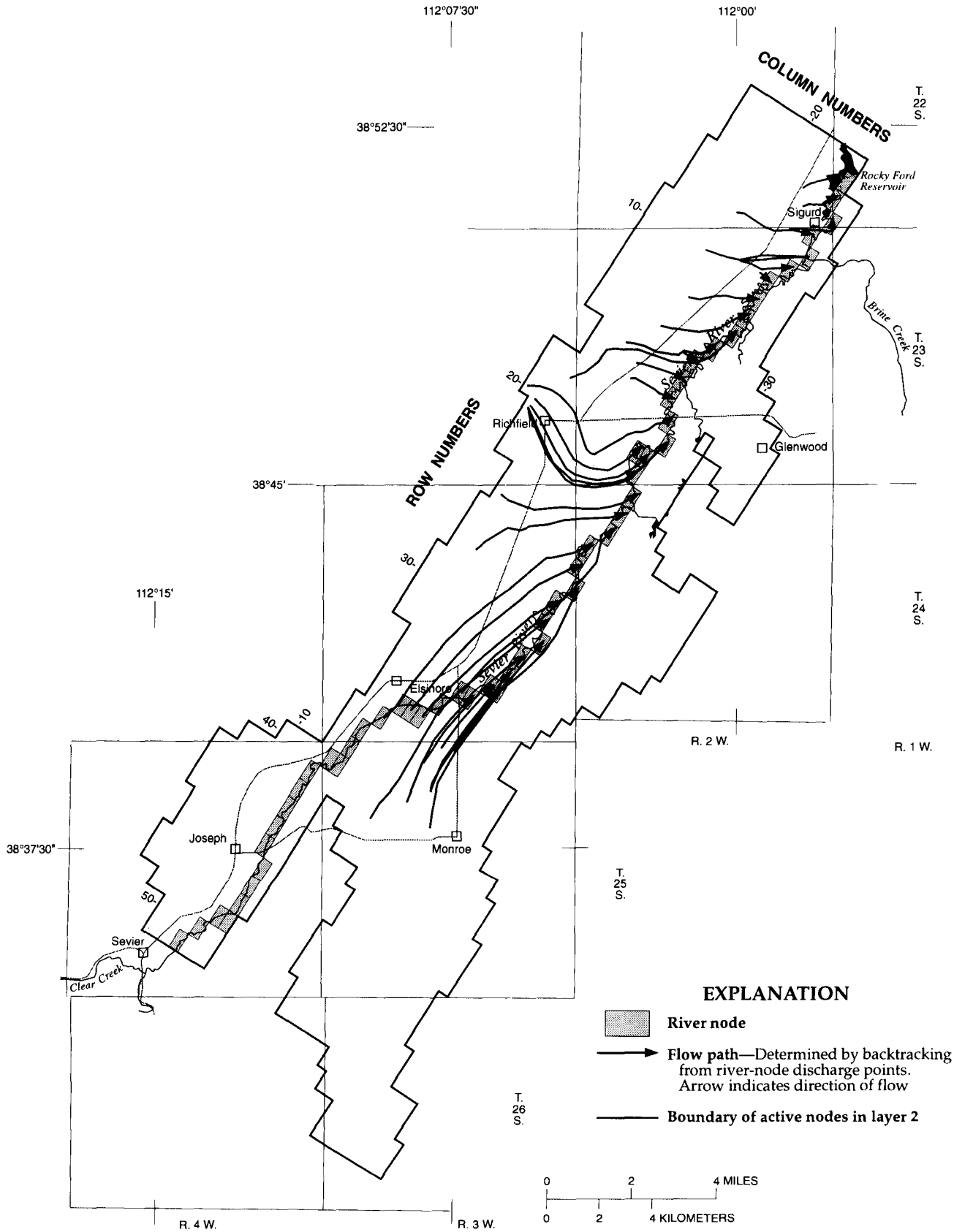


Figure 63. Flow paths for particles simulating discharge from the ground-water system to the Sevier River in layer 1.

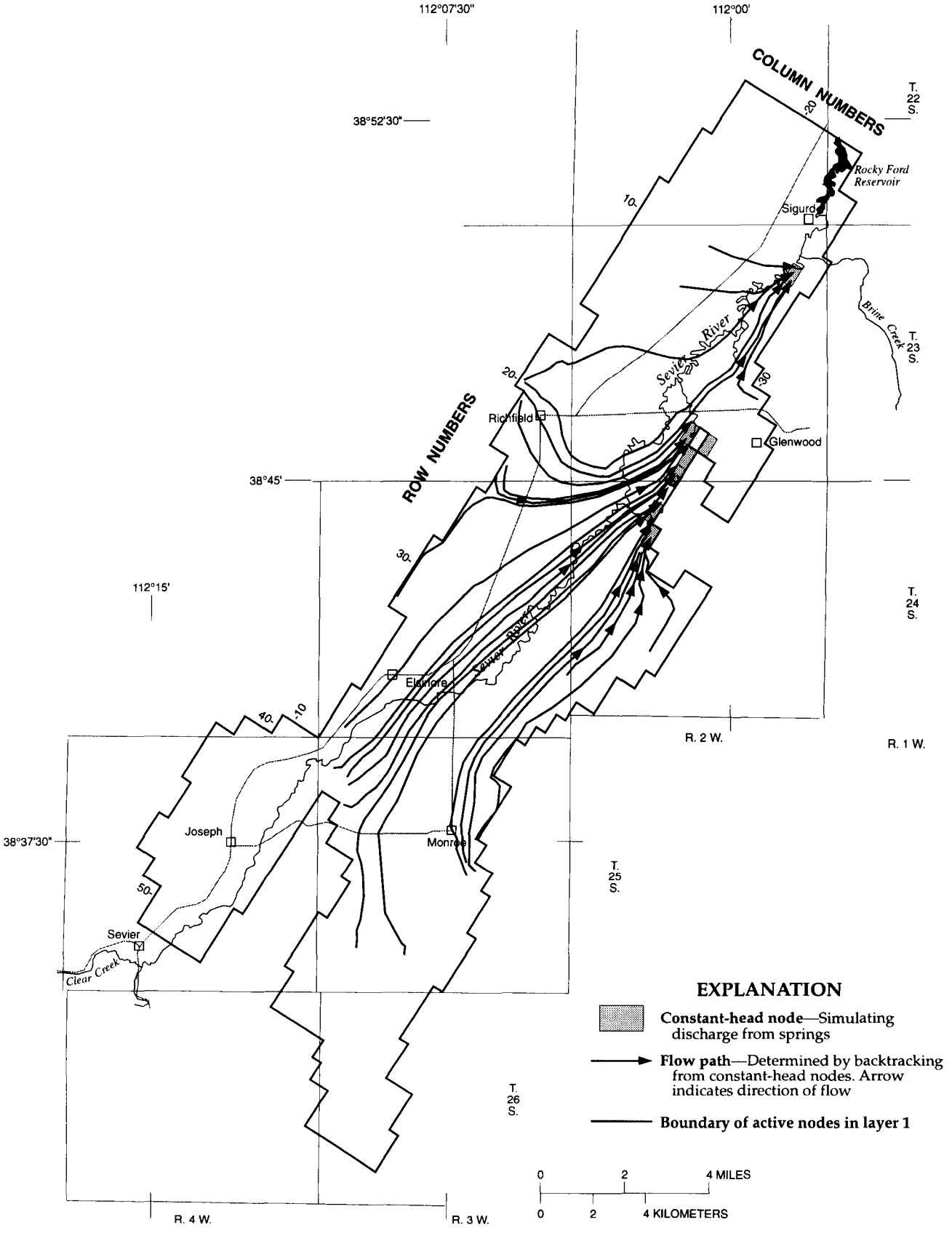


Figure 64. Flow paths for particles simulating discharge from confined zones to alluvial springs in layer 1.

Recharge by seepage from irrigated fields is the largest component of recharge to the ground-water system (table 17). Increasing or decreasing the rate has a substantial effect on water levels and fluxes throughout the simulated area. The range for reasonable values for this component was large because of a lack of field data on which to base estimates. Variation from the final reported rate, however, was limited because of resulting effects on water levels and fluxes.

Limitations of Model

This model is based on mathematical representations of ground-water flow and on a simplified set of assumptions about the hydrologic system in the Sevier-Sigurd basin. As a result, the model has some limitations. One example is ground-water discharge by springs that is simulated by using constant-head nodes. Simulation of stresses on the system that cause water levels in spring areas to drop below the outlet altitude specified in constant-head nodes would change these nodes from areas of discharge to areas of recharge. This condition would be unreasonable and users should monitor water-level changes at these nodes during simulations.

Most water-level data available for the area, and used in steady-state and transient calibrations, are from wells completed in the basin fill represented by layer 2. Because of the lack of water-level data for layer 3, the accuracy of vertical hydraulic conductivity and vertical-leakance values that were used in the model to simulate the confining layer could not be checked in all areas. Simulated local water-level changes in layer 2 caused by simulated pumping in layer 3, therefore, might not be accurate in some areas; however, trends in computed water-level changes throughout the area are believed to be reasonable.

Water-level data were not available for the Poverty Flat area in the southeast corner of the simulated area. Computed water levels from the steady-state simulation and computed water-level changes from transient simulations, therefore, could not be compared with measured water-level changes during calibration.

Relations were defined during transient calibration that describe yearly and monthly variations in recharge on the basis of changes in precipitation, snow pack in adjacent mountains, and water diverted to canals for irrigation. Results of the calibration process generally validate the assumption that recharge to the system varies with changes in these components. Calibration results, however, indicate that the relations between changes in the components listed above and changes in recharge to the ground-water system may not be fully predicted in some areas.

Simulations did not accurately reproduce measured water levels, measured water-level changes, and measured and estimated discharge to the Sevier River, in some areas. The overall accuracy of the simulations, however, is considered to be good using these indicators of accuracy: (1) Residuals (the difference between measured and computed water levels), (2) the match between computed and measured water-level changes, (3) the match between simulated and estimated budget components, and (4) the match between computed and measured ground-water discharge to the Sevier River.

The set of boundary conditions, fluxes, and hydrologic properties used in the model do not necessarily represent a unique solution. Different sets of data entered into the model might yield similar results. Discrepancies between computed and measured water levels and computed and estimated fluxes may, in part, be the result of simplified assumptions used to develop and calibrate the model. A reasonable match between computed and measured water levels and fluxes for the area, however, was achieved, and it is believed that future simulations to determine the effects of regional changes in recharge and discharge to the ground-water system should yield reasonable results.

Predictive Simulations

Predictive simulations were made with the objective of estimating the effects of increased withdrawals from pumped wells, and decreased seepage from irrigated fields on water levels and fluxes relative to steady-state conditions. Specified recharge rates and aquifer properties defined during steady-state model calibration were used for these simulations. Because increases in withdrawals were to be determined relative to withdrawals from pumped wells for 1988, well discharge was increased in the steady-state model by 1,300 acre-ft to represent discharge from public supply, industrial, and large-diameter irrigation pumped wells for 1988. Computed water levels from this simulation were used as starting water levels for all predictive simulations. No substantial changes in computed water levels resulted from the 1,300 acre-ft increase in well discharge.

By using hydrologic conditions defined from steady-state calibration as initial conditions for transient predictive simulations, changes in water levels, and fluxes relative to initial steady-state conditions are

obtained rather than actual water levels. If changes in water levels are small relative to the thickness of the simulated aquifer, then this can be an efficient method of using the model to examine the effects of changes to the system. This modeling strategy uses the principle of superposition and allows the effects of one stress on the system to be isolated from the effects of all other stresses acting on the system. Superposition applies to linear systems. The simulated Sevier-Sigurd basin ground-water system is unconfined in layer one and is therefore a nonlinear system. If changes in water levels during predictive runs are large relative to the thickness of the simulated aquifer, then simulation results may be erroneous. Superposition is discussed in detail in a report by Reilly and others (1984).

Two 20-year simulations were made where the quantity of recharge representing seepage from irrigated fields was reduced. The simulation period was divided into 20 time steps of 1 year in length. Recharge rates simulating seepage from irrigated fields were uniformly reduced by 25 percent in the first simulation, reducing the annual recharge rate from irrigated fields from 43,200 acre-ft/yr (steady-state condition) to 32,400 acre-ft/yr. The results showed that computed water-level declines at the end of the 20-year period are less than 4 feet for most of the area in layer 2 (fig. 65). Similar water-level declines were computed for layers 1 and 3. The simulated decrease in recharge caused reductions in all computed discharge. Simulated discharge to the Sevier River was affected the most, where discharge decreased from a steady-state rate of 29,800 acre-ft/yr to 26,800 acre-ft/yr (table 20).

In the second predictive simulation, recharge rates simulating seepage from irrigated fields was reduced by 50 percent, or 21,600 acre-feet/yr. The simulation resulted in projected water-level declines of about 1 to 8 feet at the end of the 20-year period over most of the area (fig. 66), and computed discharge to the Sevier River was 4,800 acre-ft/yr lower than the steady-state flow rate (table 20).

Two additional 20-year (20 yearly time steps) predictive simulations were made to show the effects of increasing withdrawals from pumped wells by 15,000 and 25,000 acre-ft/yr from 1988 estimates. The withdrawals were distributed among nodes having pumped wells located near Richfield and Monroe (figs. 67 and 68).

Computed water-level declines of less than 6 feet occurred over most of the area when simulated withdrawals from pumped wells were increased by 15,000 acre-ft/yr (fig. 67). Computed water-level declines of as much as 12 feet in some areas are simulated when withdrawals from wells are increased by 25,000 acre-ft/yr (fig. 68). The simulated increase in withdrawals from wells of 25,000 acre-ft/yr reduced all discharge except for subsurface outflow from the basin. Discharge to the Sevier River was affected the most, where discharge decreased about 4,800 acre-ft/yr from model-computed steady-state conditions. The effects of simulated increases in withdrawals from pumped wells on various components of discharge and recharge are summarized in table 20.

Reducing seepage from irrigated fields or increasing well withdrawals from steady-state conditions did not result in an identical reduction in total discharge from the ground-water system. Recharge from the Sevier River and from consolidated rock is dependent on the water-table altitude and the altitude of the potentiometric surface in confined zones. The predictive simulations indicate that if water levels decrease as the result of reduced seepage from irrigated fields or an increase in well withdrawals, recharge to the system from consolidated-rock aquifers and the Sevier River will increase.

NEED FOR FUTURE STUDY

Because of the complex relation between surface and ground water in the central Sevier Valley and more specifically, the Sevier-Sigurd basin, more detailed information is needed to refine recharge and discharge estimates used in the ground-water flow model. Seepage studies on ungaged ephemeral and perennial streams are needed to quantify recharge to the ground-water system during spring runoff. Frequent discharge measurements or semi-permanent gages are needed on these streams to determine the quantity of water being diverted for irrigation or reaching major canals, and subsequently used for irrigation. Presently, many simplifying assumptions are made in order to include an estimate for the quantity of this water into the recharge component from irrigation.

More data collection is needed to improve estimates of discharge from the ground-water system to the Sevier River and to large alluvial springs. As part of the modeling effort for this study, all gains to the river were assumed to be discharge from the ground-water reservoir. Water-quality data collected during seepage studies on the Sevier River, however, indicate that some unmeasured gains to the river might be the result of direct runoff from irrigation. A detailed analysis of the surface-water system in the Sevier-Sigurd basin for an

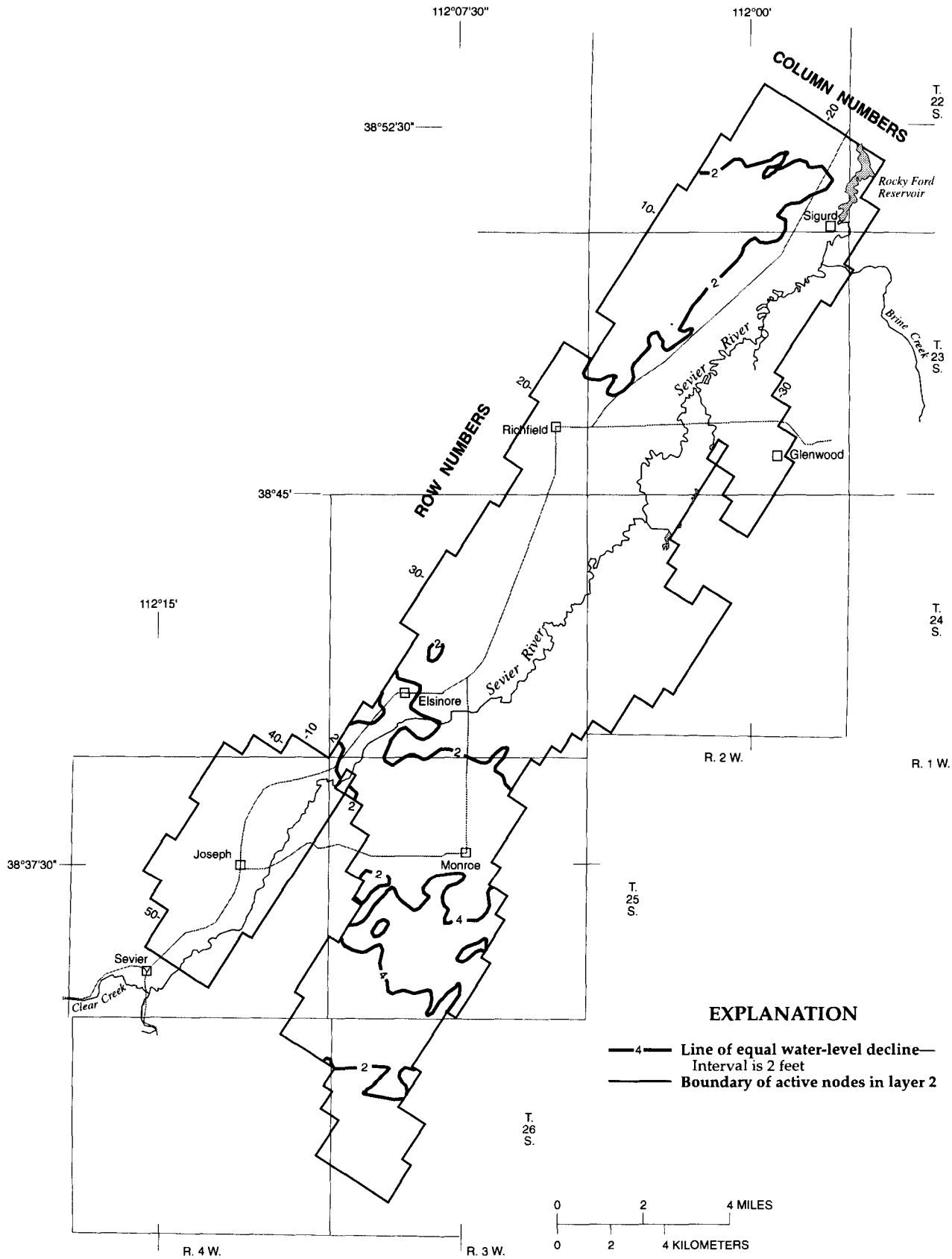


Figure 65. Simulated declines in water levels in layer 2 during a 20-year period as a result of a reduction in seepage from irrigated fields to 32,400 acre-feet per year (a 25-percent reduction from steady-state conditions).

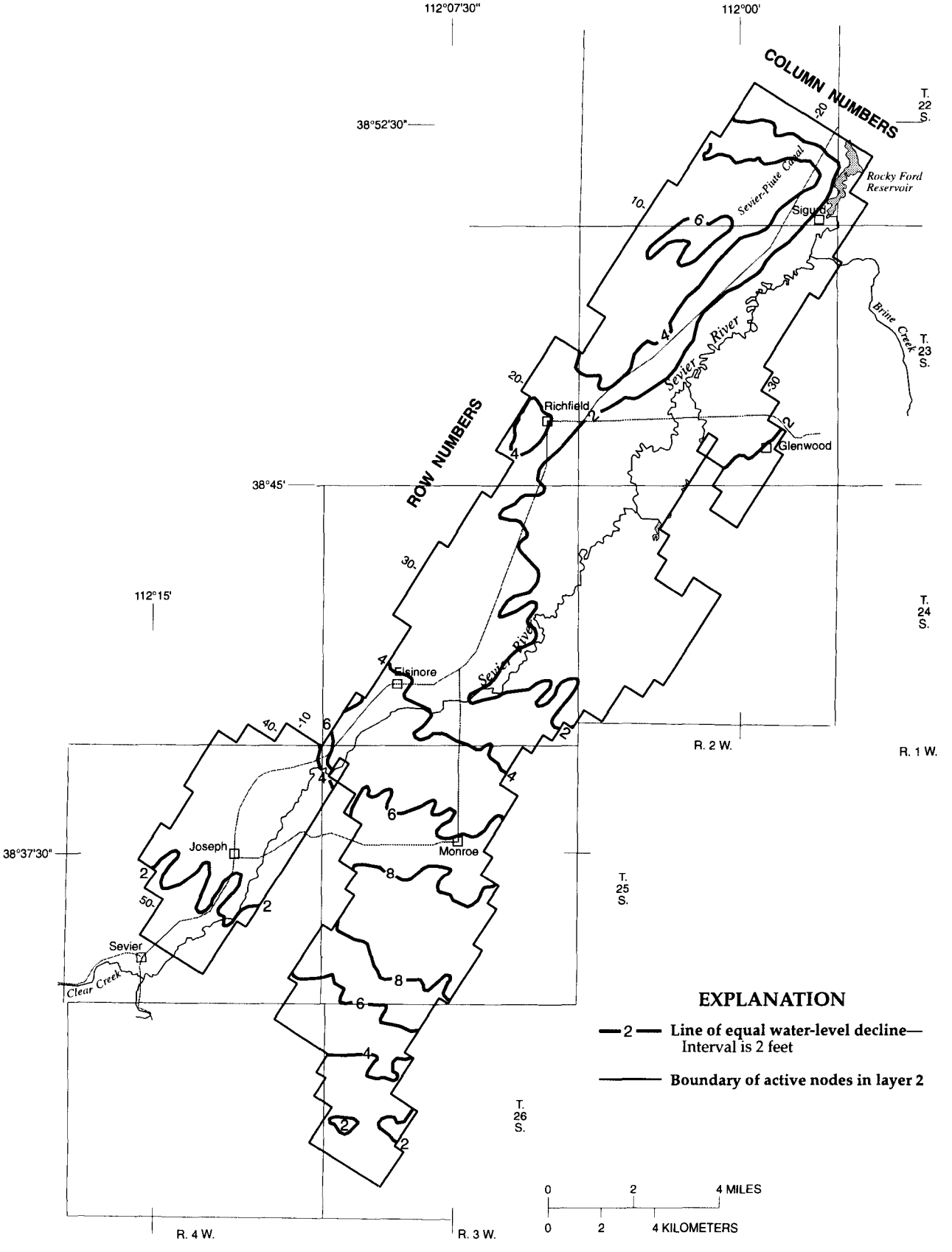


Figure 66. Simulated declines in water levels in layer 2 during a 20-year period as a result of a reduction in seepage from irrigated fields to 21,600 acre-feet per year (a 50-percent reduction from steady-state conditions).

Table 20. Ground-water budget for steady-state and predictive transient simulations

[All simulations in acre-feet per year; —, not applicable]

Budget element	Steady-state	Predictive simulations (end of 20-year simulation period)			
		25 percent reduction in flood-irrigated cropland	50 percent reduction in flood-irrigated cropland	15,000 ac-ft/yr increase in pumping well discharge	25,000 ac-ft/yr increase in pumping well discharge
Recharge					
Seepage from precipitation	2,200	2,200	2,200	2,200	2,200
Seepage from irrigated fields	43,200	32,400	21,600	43,200	43,200
Inflow from consolidated rock	10,600	10,900	11,100	11,600	11,800
Seepage from canals	9,000	9,000	9,000	9,000	9,000
Seepage from the Sevier River	8,400	10,300	13,100	12,000	14,600
Seepage from streams other than the Sevier River	14,200	14,200	14,200	14,200	14,200
Storage	—	100	100	200	300
Total	87,600	79,100	71,300	92,400	95,300
Discharge					
Evapotranspiration	14,600	13,500	12,400	13,300	12,100
Seepage to the Sevier River	29,800	26,800	25,000	26,700	25,000
Springs	18,900	17,300	15,900	16,500	14,700
Drains	12,100	9,700	7,700	9,900	8,900
Pumping wells	1,100	2,400	2,400	17,500	27,400
Flowing wells	8,600	7,100	5,900	6,000	4,700
Subsurface outflow	2,500	2,200	2,000	2,500	2,500
Total	87,600	79,000	71,300	92,400	95,300

entire irrigation season is needed to quantify runoff from irrigated fields. Continuous-recording gaging stations would be needed at several points along the river in addition to all points of known inflow. Water samples for chemical analyses could be collected on a regular basis at all points of inflow and just above all points of diversion in addition to the gaging stations on the river. These chemical analyses would refine the total load calculations and improve our understanding of the quality of water entering the river.

Discharge from large alluvial springs could be monitored for an entire year in order to determine any seasonal fluctuations and to better estimate the total discharge from the ground-water system. This monitoring would also quantify water available for irrigation and thus, refine the estimate for recharge by seepage from irrigated fields.

Ground-water inflow from the Brine and Lost Creek drainages was estimated to be a small quantity, but the large concentrations of sodium, calcium, chloride, and sulfate make this water unsuitable for most uses. Presently, ground water downgradient from the mouths of both canyons apparently remains unaffected. A test-drilling program coincident with water sampling and aquifer testing could lead to a better understanding of the extent and movement of this water in the basin fill.

CONCLUSIONS

The hydrologic system in the Sevier-Sigurd basin of the Central Sevier Valley, is a complex system in which surface- and ground-water systems are interrelated. The extensive surface-water irrigation system, which consists of numerous canals and ditches, provides the primary source for recharge to the ground-water system. The largest quantity of recharge is derived from seepage of applied irrigation water. Seep-

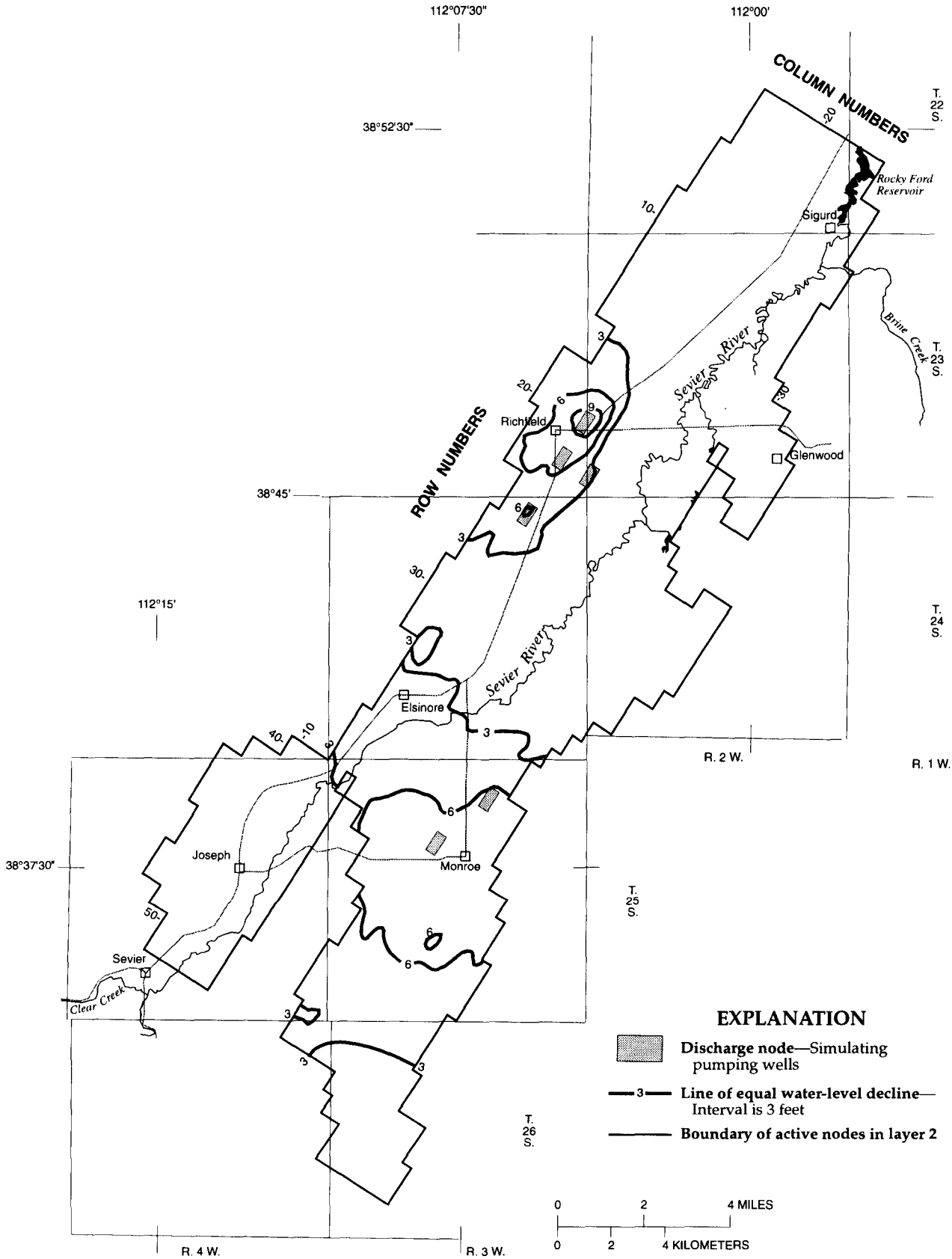


Figure 67. Simulated declines in water levels in layer 2 during a 20–year period as a result of an increase in withdrawals from pumped wells by 15,000 acre-feet per year from estimates for 1988.

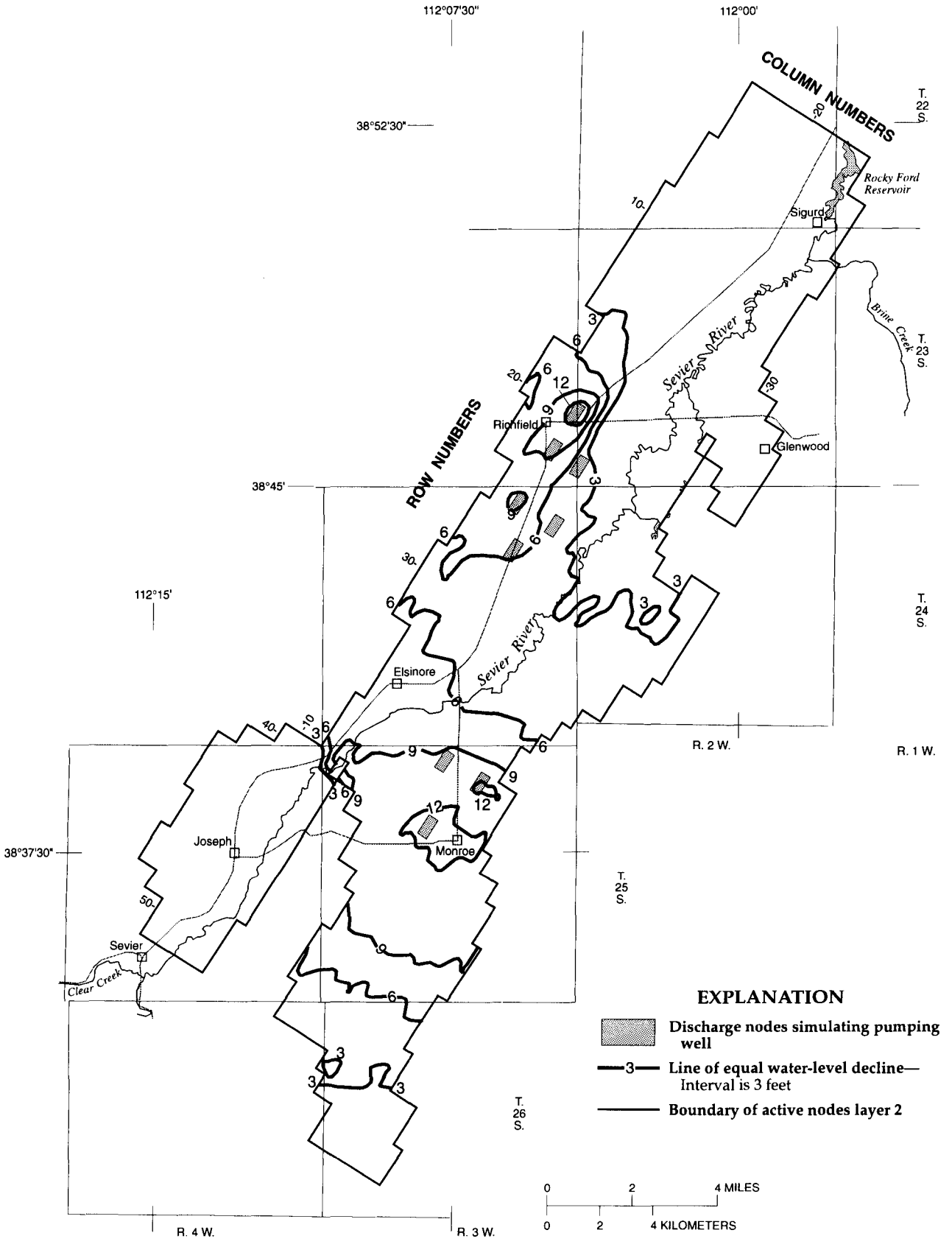


Figure 68. Simulated declines in water levels in layer 2 during a 20-year period as a result of an increase in withdrawals from pumped wells by 25,000 acre-feet per year from estimates for 1988.

age from canals, the Sevier River, and other perennial and ephemeral streams is the next largest component.

Data from chemical analyses were used to calculate the dissolved-solids load in the Sevier River at the time of the two measurement periods (August and October 1988) during the seepage study. By accounting for the load in water diverted from and the load in water entering the Sevier River, any increase for a reach of river could be attributed to the dissolved-solids contentration of ground-water seepage. Through this process, ground-water seepage to the river was determined to be the largest component of inflow along most reaches during the nonirrigation season. During the irrigation season, however, increased runoff from irrigated fields could contribute a substantial quantity of water to some river reaches.

Ground-water inflow from the Brine Creek drainage does not contribute an appreciable quantity of water to the basin-fill aquifer. The inflow was estimated to be 0.1 ft^3/s (about 75 acre-ft/yr), which is minimal compared to the overall ground-water budget for the Sevier-Sigurd basin. Although this water has large concentrations of sodium and chloride, it does not appear to be affecting the quality of the ground water in the basin.

Stable-isotope data indicate that the water in wells southeast of Richfield having large sulfate concentrations is derived from the Sevier River. The large sulfate concentration in ground water from the shallow confined zone, therefore, probably is the result of dissolution of gypsum within the basin-fill material rather than being a result of ground-water inflow from the Arapien Shale.

A computer model was used to simulate three dimensional ground-water flow in the Sevier-Sigurd basin. The model was calibrated for steady-state conditions using water levels measured in 1957, and for transient conditions using yearly water-level changes from 1957-88 and monthly water-level changes from 1958-59.

Aquifer properties, discharge, recharge, and variations in recharge with time were evaluated during calibration of the model. Calibration of the steady-state simulation indicated that recharge from consolidated rock west of Richfield and north of Glenwood totals about 10,600 acre-ft/yr. During calibration of transient simulations, changes in recharge to the ground-water system were correlated directly to changes in precipitation on the valley floor, snowpack in the adjacent mountains, discharge in losing canals, and water diverted to canals for irrigation.

Predictive simulations were made to evaluate the effects of decreased seepage from irrigated fields and increased well discharge relative to steady-state conditions. The computer model estimated water-level declines of 1 to 8 feet for most of the basin as a result of converting 50 percent of irrigated fields from flood irrigation to sprinkler irrigation. The simulated decrease in seepage from irrigated fields caused reductions in computed discharge. Simulated discharge to the Sevier River was affected the most, where discharge was reduced by 4,800 acre-ft/yr. The simulation to evaluate the effects of increasing discharge from pumped wells near Richfield and Monroe by 25,000 acre-ft/yr projected water-level declines of as much as 12 feet, and discharge to the Sevier River was decreased by 4,800 acre-ft/yr.

REFERENCES CITED

Bouwer, Herman, 1989, The Bouwer and Rice slug test--an update: Ground Water, v. 27, no. 3, p. 304-309.

Bouwer, Herman, and Rice, R.C., 1976, A slug test for determining hydraulic conductivity of unconfined aquifers with completely or partially penetrating wells: Water Resources Research, v. 12, no. 3, p. 423-428.

Burden, C.B., and others, 1989, Ground-water conditions in Utah, spring of 1989: Utah Division of Water Resources Cooperative Investigations Report No. 29, 83 p.

Carpenter, C.H., and Young, R.A., 1963, Ground-water data, central Sevier Valley, parts of Sanpete, Sevier, and Piute Counties, Utah: U.S. Geological Survey Open-File Report (duplicated as Utah Basic-Data Report 3), 34 p.

Christensen, R.C., Johnson, E.B., and Plantz, G.G., 1986, Manual for estimating selected streamflow characteristics of natural-flow streams in the Colorado River Basin in Utah: U.S. Geological Survey Water-Resources Investigation Report 85-4297, 39 p.

Clark, D.W., and Appel, C.L., 1985, Ground-water resources of northern Utah Valley, Utah: Utah Department of Natural Resources Technical Publication No. 80, 115 p.

Craig, H., 1961, Standard for reporting concentrations of deuterium and oxygen-18 in natural water: Science, v. 133, p. 1702-1703.

Cruff, R.W., 1977, Seepage study of the Sevier Valley-Piute Canal, Sevier County, Utah: Utah Department of Natural Resources Technical Publication No. 58, 31 p.

Dansgaard, W., 1964, Stable isotopes in precipitation: Tullus, v. 16, p. 436-468.

Fenneman, N.M., 1931, Physiography of western United States: New York, McGraw-Hill, 534 p.

Feth, J.H., Barker, D.A., Moore, L.G., Brown, R.J., and Veirs, C.E, 1966, Lake Bonneville--Geology and hydrology of the Weber Delta district, including Ogden,

Utah: U.S. Geological Survey Professional Paper 518, 76 p.

Freeze, R.A., and Cherry, J.A., 1979, Groundwater: Englewood Cliffs, N.J., Prentice-Hall, 604 p.

Gilliland, W.N., 1951, Geology of the Gunnison quadrangle, Utah: University of Nebraska Studies, New Series 8, 10 p.

———1963, Sevier-Sanpete Valley anticline of central Utah: Geological Society of America Bulletin, v. 74, no. 2, p. 115-124.

Hahl, D.C., and Cabell, R.E., 1965, Quality of surface water in the Sevier Lake basin, Utah, 1964: U.S. Geological Survey Open-File Report (duplicated as Utah-Basic Data Release 10), 24 p.

Hahl, D.C., and Mundorff, J.C., 1968, An appraisal of the quality of surface water in the Sevier Lake basin, Utah: Utah Department of Natural Resources Technical Publication No. 19, 44 p.

Hardy, C.T., 1952, Eastern Sevier Valley, Sevier and Sanpete Counties, Utah: Utah Geological and Mineral Survey Bulletin 43, 98 p.

Herbert, L.R., and Smith, G.J., 1989, Seepage study of the South Bend, Richfield, and Vermillion Canals, Sevier County, Utah: Utah Department of Natural Resources Technical Publication No. 97, 50 p.

Holmes, W.F., 1984, Ground-water hydrology and projected effects of ground-water withdrawals in the Sevier Desert, Utah: Utah Department of Natural Resources Technical Publication No. 79, 54 p.

Hood, J.W., and Waddell, K.M., 1968, Hydrologic reconnaissance of Skull Valley, Tooele County, Utah: Utah Department of Natural Resources Technical Publication No. 18, 57 p.

Huber, A.L., Haws, F.W., Hughes, T.C., Bagley, J.M., Hubbard, K.G., and Richardson, E.A., 1982, Consumptive use and water requirements for Utah: Utah Department of Natural Resources Technical Publication No. 75, 92 p.

Johnson, A.I., 1967, Specific yield—Compilation of specific yields for various materials: U.S. Geological Survey Water-Supply Paper 1662-D, 74 p.

Liddle, W.J., 1967, Design recommendations adjacent to the Richfield Spring: Utah State Department of Highways internal memorandum dated June 21, 1967, 4 p.

Lohman, S.W., 1972, Ground-water hydraulics: U.S. Geological Survey Professional Paper 708, 70 p.

McDonald, M.G., and Harbaugh, A.W., 1988, A modular three-dimensional finite-difference ground-water flow model: U.S. Geological Survey Techniques of Water-Resources Investigations, book 6, chap. A1, various pagination.

Picard, M.D., 1980, Stratigraphy, petrography, and origin of evaporites in Jurassic Arapien Shale, central Utah, *in* Henry Mountains Symposium: Utah Geological Association Publication 8, p. 129-150.

Picard, M.D., and Kadir, Uygur, 1982, Mixed terrigenous-carbonate rocks in Jurassic Arapien Shale of central Utah, *in* Overthrust belt of Utah: Utah Geological Association Publication 10, p. 181-198.

Pollock, D.W., 1989, Documentation of computer programs to compute and display pathlines using results from the U.S. Geological Survey three-dimensional finite-difference ground-water flow model: U.S. Geological Survey Open-File Report 89-381, 188 p.

Razem, A.C., and Steiger, J.I., 1981, Ground-water conditions in Tooele Valley, Utah: Utah Department of Natural Resources Technical Publication No. 69, 95 p.

Reilly, T.E., Franke, O.L., and Bennett, G.D., 1984, The principle of superposition and its application in ground-water hydraulics: U.S. Geological Survey Open-File Report 84-459, 36 p.

Richardson, G.B., 1907, Underground water in Sanpete and central Sevier Valleys, Utah: U.S. Geological Survey Water-Supply Paper 199, 63 p.

Sepehr, Mansour, 1984, Field condition hydrologic modeling for identification of salinity sources in a stream-aquifer system: Logan, Utah State University, Ph.D. dissertation, 228 p.

Spieker, E.M., 1946, Late Mesozoic and early Cenozoic history of central Utah: U.S. Geological Survey Professional Paper 205-D, p. 117-161.

———1949, The transition between the Colorado Plateaus and the Great Basin in central Utah: Utah Geological Society Guidebook 4, 106 p.

U.S. Department of Agriculture, 1969, Water budget analysis, Sevier River basin, Utah: Appendix IV, 92 p.

U.S. Geological Survey, 1989, Water-resources data for Utah, water year 1988: U.S. Geological Survey Water-Data Report UT-88-1, 364 p.

U.S. Weather Bureau, 1963, Normal annual precipitation (1931-60) for the State of Utah: Washington, D.C., map of Utah, scale 1:500,000, 1 sheet.

Utah Division of Water Rights, 1956-89, Annual reports for the Sevier River Water Distribution System [variously paged].

Woolley, R.R., 1947, Utilization of surface-water resources of Sevier Lake basin, Utah: U.S. Geological Survey Water-Supply Paper 920, 393 p.

Young, R.A., 1960, Ground-water areas and well logs, central Sevier Valley, Utah: U.S. Geological Survey Open-File Report, 20 p.

Young, R.A., and Carpenter, C.H., 1965, Ground-water conditions and storage in the central Sevier Valley, Utah: U.S. Geological Survey Water-Supply Paper 1787, 95 p.

Table 21. Records of selected wells

[—, no data available]

Location: See figure 2 for an explanation of the numbering system for data sites.
Owner or user: Refers to last known owner or user.
Primary use of water: H, domestic or household; I, irrigation; N, industrial; P, public supply; S, stock; U, unused.
Casing: Diameter reported from driller's log or measured in the field. Finish: O, open end; P, perforated; S, screened. extent of perforated or screened interval is unknown.
Altitude of land surface: In feet above sea level.
Water level: Feet above (+) or below (-) land surface.
Discharge of flowing wells: E, estimated; gal/min, gallons per minute.
Water-quality parameters: Temperature: °C, degrees Celsius; Specific conductance: µS/cm, microsiemens per centimeter at
Other data available: C, chemical analysis (table 26); K, temperature, specific conductance, and chloride concentration

Location	Owner or user	Date well drilled	Primary use of water	Depth drilled (feet)	Casing Diameter (inches)	Casing Depth (feet)	Casing Finish	Casing (feet)
		SANPETE COUNTY						
(C-18-1) 12acb-1	—	1936	—	300	—	—		—
25ddc-1	U.S. Geological Survey	1959	U	500	2	10		—
(C-19-1) 11cac-1	L. Malmgren	—	S	41	3	—		—
11cac-2	L. Malmgren	1958	S	42	2	42	O	
23bcc-1	C. H. Beal	1934	—	186	12	—	P	50-(?)
23cac-1	J. Sorensen	—	—	—	—	—		—
24cdd-2	Westview Sevier Bridge Irrigation Co.	1900	—	50	2	50		—
35cdd-2	A. Fransden	1977	S	216	6	203		—
(C-20-1) 24dca-1	D. Christensen	1942	S	55	4	55		—
(D-18-1) 19dab-1	Fayette City	1976	H	60	8,6,3	60	P	30-60
30bcd-1	M. Mellor	1931	U	75	1.5	75		—
(D-19-1) 14dba-1	D. Larsen	1976	U	178	12,8	178.4	P	60-178
23acd-1	J. Gilbert	1950	S	35	4	35		—
23dba-1	B. Christensen	1948	H	—	4	—		—
(D-19-2) 17aad-2	W. G. Frischknect	1932	S	97	2	—		—
32aac-1	—	1935	I	166	12	—		—
(D-20-1) 5aaa-1	May	1973	U	76	6	67		—
8abd-1	F. Christensen	1955	U	311	4	311		—
17ada-1	J. Lira	1980	U	57	6	57		—
17adb-1	T. Shinsel	1979	U	49	—	49		—
20acc-2	Fed Land Bank	1917	—	66	48	—		—
20dab-1	H. Jenson	1959	U	188	4	188		—
20dab-2	H. Jenson	1967	U	78	4	78		—
20dba-1	D. Jenson	1950	U	80	—	—		—
21dad-1	J. Bunner	1976	S	200	6	135		—
28dbb-1	L. Sorenson	1953	U	136	4	133		—
(D-20-2) 5dbc-2	White Sage Dairy	1978	S	140	6	—		—
8bda-1	E. Hansen	1959	U	62	4	—		—
18aaa-1	—	—	I	140	—	—		—
		SEVIER COUNTY						
(C-20-1) 25dcd-1	A. Christensen	1951	S	46	4	46		—
(C-21-1) 1cab-1	J. Yeaman	1978	U	81	6	81		—
2ccd-1	C. Christensen	1945	U	115	—	—		—
10ada-1	H. Nelson	1950	S	75	4	75		—
10dcd-1	J. Peterson	1941	U	95	4,3	95	P	83-95
(C-21-1) 13abd-1	R. E. Noyes	1956	S	291	4	—		—
13dbc-1	D. Christensen	1956	S	38	4	38		—
14bab-1	L. Jensen	1956	U	63	4	63		—
23adb-1	B. Robins	1967	S	292	4,3	292	P	272-292

Upper and lower limits of perforations or screen given in feet below land surface, if known, and questioned (?) if

25 degrees Celsius. Measured in the field except where noted by L, laboratory value.
of water (table 25); L, drillers' log (table 23); W, water-level measurements (table 24).

Altitude of land surface (feet)	Water level (feet)	Date water level measured	Discharge of flowing wells (gal/min)	Date discharge measured	Water-quality parameters: Temperature (°C)	Specific conductance (µS/cm)	Date measured	Other data available
				SANPETE COUNTY				
5,085	—	—	—	—	—	890	05-10-88	C
5,014	+4.00	10-28-59	—	—	12.0	1,580	10-21-59	C,K,W
5,030	—	—	11.7	09-30-88	11.5	2,350	09-30-88	
5,030	-0.49	09-30-88	5 E	09-30-88	11.5	2,280	09-30-88	W
5,070	-31.62	07-20-87	—	—	—	—	—	
5,055	-20.69	07-20-87	—	—	—	2,800 L	07-25-89	C,W
5,040	—	—	60 E	09-30-88	12.0	2,600	09-30-88	C,K
5,205	-154.80	03-27-87	—	—	—	—	—	
5,080	-4.23	05-29-87	—	—	—	—	—	
5,150	—	—	—	—	19.0	1,000	10-15-87	
5,010	+7.0	06-15-88	—	—	15.0	1,600	10-15-87	C,K,W
5,215	-10.8	08-08-88	—	—	—	—	—	W
5,210	-16.90	07-15-88	—	—	—	2,210	07-15-88	K
5,210	—	—	—	—	—	2,420	07-15-88	C,K
5,418	+3.64	08-28-56	—	—	—	—	—	K,W
5,540	-44.0	02-01-65	—	—	—	—	—	W
5,110	-44.61	05-27-87	—	—	—	—	—	W
5,095	+2.4	05-28-87	—	—	—	—	—	
5,155	-8.52	05-28-87	—	—	—	—	—	
5,110	-2.24	05-28-87	—	—	—	—	—	W
5,145	-22.24	07-21-87	—	—	—	—	—	W
5,150	-20.02	05-28-87	—	—	—	—	—	
5,150	-21.36	05-28-87	—	—	—	—	—	W
5,150	-22.75	05-28-87	—	—	—	—	—	
5,225	—	—	—	—	—	3,850	05-29-87	K
5,240	-87.50	03-05-87	—	—	—	—	—	W
5,605	—	—	—	—	—	1,550	08-08-88	K
5,590	-39.07	08-08-88	—	—	—	—	—	
5,635	-31.78	03-01-87	—	—	—	—	—	W
				SEVIER COUNTY				
5,090	-4.29	09-29-87	—	—	—	—	—	W
5,100	-0.45	07-21-87	—	—	13.5	1,900	06-30-89	C,W
5,160	-38.57	07-21-87	—	—	—	—	—	W
5,165	-34.61	09-29-87	—	—	12.0	1,240	08-21-89	C,K,W
5,170	-38.3	09-29-87	—	—	—	—	—	
5,110	+11.2	03-06-87	—	—	16.5	720	03-06-87	C,K,W
5,120	-6.68	07-22-87	—	—	11.0	1,880	06-29-89	C
5,120	-8.18	07-22-87	—	—	—	—	—	W
5,120	+6.0	09-30-88	1.5 E	09-30-88	19.5	750	09-30-88	K

Table 21. Records of selected wells—Continued

Location	Owner or user	Date well drilled	Primary use of water	Depth drilled (feet)	Casing Diameter (inches)	Casing Depth (feet)	Finish (feet)
			SEVIER COUNTY—Continued				
(C-21-1) 24bbb-1	D. G. Burgess	1927	U	280	4	280	—
24bda-1	B. Camp	1979	S	73	6	73	—
27cca-2	L. Mason	1946	U	142	5,	142	—
33acc-1	—	1911	—	200	3	200	—
33acc-2	E. Sarnkron	1970	S	205	4	—	—
(C-22-1) 3bbd-1	Howard	1959	H	116	4	116	—
4aab-1	C. M. Curtis	1955	S	49	4	49	—
5bac-1	Aurora City	1952	P	490	8	490	P 455-490
6dbb-1	R. M. Buckey	1975	H	193	6	193	—
7cdc-1	Johnson Feedlot	1973	S	522	8,6	522	P 465-522
7dcb-1	Klein	1978	H	128	6	128	—
8dab-1	Johnson Livestock	1979	S	59	6	59	—
11bba-1	U.S. Geological Survey	1988	U	17.0	2	17.0	P 9.5-14.5
11bdb-1	U.S. Geological Survey	1988	U	14.5	2	14.5	P 7.0-12.0
18ccd-1	A. Mason	1954	—	100	4	100	—
19bad-1	U.S. Geological Survey	1960	U	363	6	—	—
(C-22-2) 13bdd-1	S. Donnell	1968	S	216	6	207	—
24ddd-1	G. Christsen, W. Little	1979	—	107	6	104	O
26dac-1	J. Lewis	1978	H	134	6	134	—
26dac-2	V. Weeks	1977	U	141	6	141	—
34dbd-1	L.D.S. Church Farm	1979	S	240	6	240	P 185-240
35bcc-1	D. Brown	1982	H	160	6	160	—
35dab-1	C. King	1945	U	100	5	100	—
(C-23-1) 6ccd-1	U.S. Geological Survey	1987	U	21.0	2	21.0	P 18.0-21.0
6cdb-1	U.S. Geological Survey	1987	U	21.0	2	21.0	P 18.0-21.0
(C-23-2) 1aab-1	United States Gypsum Company	1988	N	350	16,12	350	P 295-317 320-327 334-341
1aba-3	Sigurd City	1971	—	400	12	400	P 295-325 338-360 370-400
1bca-1	Forsyte	1921	U	100	3	100	—
1bdc-1	J. Jorgensen	1915	I	125	2	125	—
1bdc-3	J. Jorgensen	1987	U	18	—	—	—
1ccc-1	P. Warnock	1985	—	131	—	—	—
1dbc-1	G. Riches	1978	H	74	6	74	—
8cdc-1	—	1952	S	132	6	132	—
9abb-1	U.S. Geological Survey	1960	—	594	—	—	—
9baa-1	F. Wall	1945	S	475	3, 1.25	425	—
9bbb-1	R. Buchanon	1963	S	468	4	430	—
9daa-1	U. S. Geological Survey	1960	—	739	—	—	—
10bdb-1	J. Coons	1985	U	157	6	157	—
10bdd-1	E. Anderson	1949	—	87	2.5	—	—
10dcc-1	U.S. Geological Survey	1960	—	805	—	—	—
11bdb-1	T. Anderson	1906	S	86	—	—	—
(C-23-2) 11bdb-2	T. Anderson	1976	H	160	6.63	160	P 145-160
11dda-3	C. W. Cowley	—	S	90	—	—	
14aaa-1	S. Breinholt	1952	S	61	2	61	—
14cbb-1	M. W. Breinholt	1908	S	65	2	65	—
14cbc-1	U. S. Geological Survey	1960	—	511	—	—	—
14cbc-2	C. Wall	1961	S	71	4	71	—

Altitude of land surface (feet)	Water level (feet)	Date water level measured	Discharge of flowing wells (gal/min)	Date discharge measured	Water-quality parameters: Temperature (°C)	Specific conductance (µS/cm)	Date measured	Other data available
				SEVIER COUNTY—Continued				
5,123.49	-1.0	09-29-87	—	—	18.0	750	06-29-89	C,K
5,135	-11.41	09-29-87	—	—	—	1,680	09-29-87	C,W
5,170	-39.81	09-29-87	—	—	—	—	—	W
5,181.94	-41.18	09-29-87	—	—	—	—	—	W
5,185	-42.71	10-15-87	—	—	—	—	—	
5,140	-0.63	11-06-87	—	—	—	3,500	11-06-87	W
5,150	-14.15	11-06-87	—	—	—	—	—	
5,250	—	—	—	—	14.0	580	05-29-87	C,K
5,300	-117.20	05-27-87	—	—	14.0	1,140	05-27-87	W
5,300	—	—	—	—	16.0	800	05-27-87	L
5,245	-76.08	05-27-87	—	—	—	—	—	W
5,155	-5.00	05-27-87	—	—	—	740	05-27-87	W
5,200	-7.35	08-09-89	—	—	—	—	—	
5,205	-5.20	08-09-89	—	—	13.5	109,000 L	08-09-89	C,L
5,255	—	—	—	—	—	—	—	
5,180	-18.3	04-14-60	—	—	—	—	—	
5,350	-165.58	01-14-88	—	—	—	—	—	W
—	—	—	—	—	—	—	—	L
5,320	—	—	—	—	15.0	720	05-28-87	C,K
5,320	-93.19	05-28-87	—	—	—	—	—	W
5,350	—	—	—	—	—	640	05-28-87	
5,350	—	—	—	—	12.0	530	05-28-87	C,K
5,260	-39.05	05-28-87	—	—	—	—	—	W
5,320	-15.77	03-24-88	—	—	—	—	—	W
5,310	-2.98	01-13-88	—	—	16.0	16,200	08-09-89	C,W
5,220	—	—	—	—	—	—	—	L
—	—	—	—	—	—	—	—	
—	—	—	—	—	—	—	—	L
—	—	—	—	—	—	—	—	
—	—	—	—	—	—	—	—	
—	—	—	—	—	—	—	—	
5,233.1	-10.09	02-03-88	—	—	—	—	—	W
5,217.40	+1.3	03-05-87	—	—	—	1,460	07-21-87	C,K,W
5,220	-1.08	10-15-87	—	—	—	1,540	07-18-89	C,K,W
5,220	+0.7	05-29-87	—	—	—	—	—	
5,240	-19.32	05-28-87	—	—	12.0	710	05-28-87	K,W
5,380	-116.22	05-29-87	—	—	14.0	620	05-29-87	W
5,269	-9.5	04-28-60	—	—	—	—	—	
5,269	-18.00	03-05-87	—	—	—	—	—	W
5,360	-95.18	05-29-87	—	—	—	640	05-29-87	L,W
5,255	-5	06-06-60	—	—	—	—	—	
5,250	-16.68	05-29-87	—	—	—	—	—	W
5,250	-14.8	07-25-56	—	—	—	—	—	
5,232	+0.9	04-16-60	—	—	11.5	1,170	04-18-60	
5,227.7	+3.23	01-28-58	—	—	11.5	1,050	01-15-88	C,K
5,220	—	—	—	—	11.5	860	01-15-88	C,K
5,225.6	+7.54	09-26-88	2.5	09-26-88	11.5	1,950	09-26-88	K
5,225.0	+5.4	02-03-88	12.3 E	09-27-88	11.5	1,370	02-03-88	C,K
5,234.6	—	—	—	—	12.0	2,650	02-03-88	
5,234	—	—	—	—	11.0	770	04-19-60	
5,230	—	—	—	—	11.5	2,610	09-27-88	C,K

Table 21. Records of selected wells—Continued

Location	Owner or user	Date well drilled	Primary use of water	Depth drilled (feet)	Casing Diameter (inches)	Casing Depth (feet)	Finish (feet)
	SEVIER COUNTY—Continued						
(C-23-2) 14cdd-1	C.J. Wall	1946	I	103	10	103	P 30-103
14dbc-1	Venice Ward	1970	I	190	3.5	160	—
15cad-13	D. Roberts	1925	H	80	2	—	—
15dbb-1	S. Brienholt	1935	I	178	2	178	P 75-178
15dcb-4	T. Christensen	1905	H	75	2	75	—
16dcd-1	W. Stewart	1980	H	172	6	157	—
17cdd-1	P. Hansen	—	—	177	3	177	
17daa-2	T. Christensen	1976	S	60	6	60	
19bcd-1	—	—	—	199	—	—	
19dab-1	W. Hallows	1924	—	310	—	—	
19dcb-1	R. Peterson	1956	—	132	2	—	
20acd-1	C. Gledhill	1955	U	105	3	105	
20bbc-1	M. Ross	1978	H	100	6.62	100	P 80-100
21aad-2	R. Buchanan	1905	U	83	2	—	
21aad-3	U.S. Geological Survey	1988	U	16.5	2	16.5	P 11.5-13.5
22abb-3	R. Henrie	—	I	84	—	—	
22acb-1	A.C. Roberts	1979	H	84	3	84	
22baa-1	J.L. Davis	—	—	70	—	—	
22bab-2	—	1914	I	81	—	—	
22bad-1	H.P. Buchanan	1910	S	68	—	—	
22bbc-4	R. Buchanan	—	I	75	—	—	
22bcc-2	R. Buchanan	1915	I	82	4	82	
22bcc-3	R. Buchanan	1915	—	82	—	—	
22bda-1	U.S. Geological Survey	1988	U	12.0	2	12.0	P 6.5-9.0
22bdc-1	R. Cowley	1914	I	80	—	—	
22cdd-1	G. Rickenbach	1921	S	65	—	—	
22daa-1	Venice Pumping Company	1919	I	60	3	60	
22dcc-2	J. Rickenbach	1945	S	181	6	181	P 72-(?)
23bac-1	Buchanan Farms	1968	S	32	2	32	P 30-32
26cab-1	H.E. Heilesen	1929	S	55	—	—	
26cdb-1	N.C. Johnson	1934	—	48	4	—	
27bcc-2	G. Peterson	1900	I	80	2	80	
27bda-1	R. Buchanan	1905	—	65	—	—	
28bdc-1	C. Anderson, W. Harris	1964	—	500	8	475.5	P 120-475.5
28bdd-8	C. Anderson	1952	—	76	6	76	
29aca-3	W. Sorenson	—	I	71	—	—	
29acb-4	W. Sorenson	—	I	—	—	—	
29cbc-1	—	1955	—	65	4	—	
29cdb-1	Sorenson	1905	I	83.5	3	70	
29cdb-2	U.S. Geological Survey	1987	U	33	2	24	P 21-23
29cdc-1	H. Sorenson	1890	I	60	—	—	
29cdc-2	H. Sorenson	1905	I	70	2	60	
29dad-1	C. Seegmiller	1912	S	83	4	—	
29dba-1	M. Hardle	1987	S	70	4	70	P 65-70
(C-23-2) 29dcd-1	U.S. Geological Survey	1987	U	33	1.5	25.8	S 22.8-25.8
30baa-2	L. Bagley	1956	S	75	—	—	—
30ccc-1	S. Petersen	1973	S	75	4	75	—
30cdd-1	L. Savage	1963	S	73	2	73	—
30dcd-2	A.J. Wilson	1954	S	60	4	60	—
31aac-3	Vermillion Canal Co.	—	I	65	—	—	—
31abb-2	A. Helquist	1954	I	78	6	78	—
31abb-3	T. Staples	1954	S	84	2	84	—

Altitude of land surface (feet)	Water level (feet)	Date water level measured	Discharge of flowing wells (gal/min)	Date discharge measured	Water-quality parameters: Temperature (°C)	Specific conductance (µS/cm)	Date measured	Other data available
			SEVIER COUNTY—Continued					
5,275	-20.7	02-03-88	—	—	17.5	2,530	08-21-89	W
5,275	-51.02	05-28-87	—	—	—	—	—	W
5,235	+6.25	11-15-57	—	—	15.5	2,000	06-02-88	C
5,234.71	+5.0	04-25-58	—	—	13.5	1,120	06-02-88	C
5,233.99	+8.65	03-04-87	75	03-04-87	12.0	1,020	03-04-87	C,K,W
5,245	—	—	60	02-03-88	13.0	1,400	02-03-88	K
5,295.50	-37.8	07-25-56	—	—	—	—	—	
5,285	-21.63	05-28-87	—	—	12.0	1,420	05-28-87	W
5,335	-13.66	07-22-87	—	—	—	810	07-22-87	C,W
5,289	—	—	—	—	15.5	520	08-20-87	C,K
—	+16.6	08-15-57	—	—	—	—	—	
5,270	-19.70	02-02-88	—	—	—	—	—	W
5,295	—	—	—	—	—	1,070	07-02-87	
5,239.6	—	—	30 E	10-19-88	11.0	700	10-19-88	
5,240	-6.31	10-21-89	—	—	14.0	1,050	08-09-89	C,L
5,233.8	+8.15	09-28-88	—	—	11.0	880	09-28-88	K
5,235	+9.29	09-28-88	—	—	13.0	2,790	09-28-88	K
5,235	—	—	—	—	12.0	770	09-29-88	C,K
5,234.8	—	—	—	—	—	600	02-03-88	
5,235	—	—	3.2	09-28-88	12.5	1,180	09-28-88	K
5,240	+6.32	09-29-88	—	—	12.0	680	09-29-88	K
5,240.3	—	—	150 E	09-28-88	11.5	620	09-28-88	K
5,240	—	—	118 E	09-28-88	11.5	650	09-28-88	
5,240	-2.64	10-21-89	—	—	—	—	—	L
5,240	—	—	72 E	09-28-88	12.0	620	09-28-88	K
5,240	+5.13	09-28-88	43 E	09-28-88	12.5	1,500	09-28-88	K
5,240	—	—	107 E	09-29-88	12.0	1,280	09-29-88	K
5,240	—	—	120	09-28-88	13.0	780	09-28-88	C,K
5,230	+3.05	02-03-88	—	—	14.5	1,140	02-03-88	C,K,W
5,246.2	+4.4	02-03-88	—	—	11.5	640	02-03-88	K,W
5,251.30	-0.73	07-21-87	—	—	—	—	—	W
5,241.3	+4.2	08-10-56	—	—	13.5	640	11-05-87	C
5,240	+3.3	09-07-56	—	—	—	—	—	
—	—	—	—	—	—	—	—	L
5,244	+1.0	10-01-56	—	—	—	—	—	
5,250	-5.0	02-04-88	—	—	11.0	620	02-04-88	K
5,250	—	—	—	—	11.5	650	02-04-88	C,K
5,252	+1.1	09-07-56	—	—	—	—	—	
5,250	+4.8	08-04-87	—	—	10.5	800	08-05-87	C,K
5,250	-2.85	09-28-87	—	—	13.0	1,750	11-05-87	C,K,W
5,250	+2.27	05-17-57	—	—	—	2,800	12-09-87	C,K
5,250	—	—	—	—	11.0	1,580	01-14-88	C,K
5,250	+4.8	06-02-88	—	—	11.0	3,000	06-02-88	K,W
5,250	—	—	—	—	12.0	890	08-04-87	
5,250	-4.04	01-14-88	—	—	—	—	—	W
5,290.15	+19.7	03-05-87	—	—	14.0	1,000	03-05-87	K,W
5,270	-6.86	09-26-88	—	—	—	—	—	
5,260	+1.64	09-27-88	—	—	13.0	630	09-27-88	K
5,254	-4.5	02-04-88	—	—	12.0	700	02-04-88	
5,250	+1.64	10-06-59	60	09-28-88	10.5	2,240	09-28-88	L
5,255	—	—	0.01E	09-27-88	—	710	09-27-88	K
5,255	+4.52	09-27-88	—	—	12.5	690	09-27-88	K

Table 21. Records of selected wells—Continued

Location	Owner or user	Date well drilled	Primary use of water	Depth drilled (feet)	Casing Diameter (inches)	Casing Depth (feet)	Finish (feet)
			SEVIER COUNTY—Continued				
(C-23-2) 31abd-1	—	—	—	I	—	4	— —
31acc-3	R. Christensen	1971	I	575	12	565	P 250-280 335-342 365-430 465-482 505-565
31bab-1	D. Utley	1954	S	86	4	86	—
31bac-1	K. Savage	1979	H	71	6	71	—
31bac-2	Sp. Hendrickson	—	S	—	—	—	—
31bad-1	Cpp. Eyre	1981	S	60	6	60	—
31bbc-1	F. M. Wall	1954	U	73	2	73	—
31bbd-1	D. Isabel	1956	—	75	2	75	—
31bca-1	Dp. Ogden	1900	—	61	2	61	—
31bcc-1	M. Ogden	1963	S	63	2	63	—
31bdc-3	G. Ogden	1956	I	—	—	—	—
31caa-1	J. Allen	1978	H	214	6	214	—
31cac-1	J. Allen	1964	S	62	4	62	P 57-62
31cad-1	J. Allen	1965	S	60	4	60	P 54-60
31cda-1	J.I. Curtis	1926	S	63	—	—	—
31dcb-2	V. Erickson	1916	S	225	2	225	—
31dcb-3	—	—	—	764	—	—	—
32aac-1	M. Seegmiller	—	I	63	3	—	—
34aba-1	R. Peterson	1900	I	50	—	—	—
(C-23-3) 24ddc-1	Ideal Dairy	1979	S	127	6	127	—
25bab-1	Richfield City	1960	U	781	8,6	463	P 210-240 258-280 330-400 423-460
25bab-2	Richfield City	—	P	—	—	—	—
25cac-1	U.S. Geological Survey	1960	—	800	—	—	—
25dda-1	B. Christensen	1988	S	71	—	71	—
36aaa-2	R. Palmer	1965	S	80	2	80	P 75-80
(C-23-3) 36aab-1	F. Riddle	1955	S	90	—	—	—
36aac-1	Intermountain Packing Co.	1947	—	268	5	268	O
36abd-1	K. Colby	1959	S	256	4	256	—
36baa-1	Richfield City	1987	P	700	20,16	700	P 340-345 370-375 485-500 510-520
36bdd-1	State of Utah	1955	U	68	—	68	—
36dbd-1	G. Luglio	1982	—	226	6,4	226	—
36dcd-1	L. Poulson	1966	—	63	2	63	P 61-63
(C-23-3) 36dda-1	Richfield City	1955	—	420	6,4	420	P 380-420
(C-24-2) 5abc-1	M.S. Cowley	1955	S	66	4	66	—
5cad-1	U.S. Geological Survey	1959	—	585	—	—	—
6abc-1	V. Erickson	1952	S	308	12	225	P 225-(?)
6dbc-1	N. Mortensen	1981	I	300	12.75	300	P 186-298
7add-1	R. Barney	1930	S	65	—	—	—
7bac-2	—	1911	U	131	3	131	—
7dcb-1	L. Nebeker	1978	H	108	6	108	—
8bcd-1	K. Carr	1930	U	40	—	—	—
17abd-1	—	1978	—	148	12.75	140	P 110-140

Altitude of land surface (feet)	Water level (feet)	Date water level measured	Discharge of flowing wells (gal/min)	Date discharge measured	Water-quality parameters: Temperature (°C)	Specific conductance (µS/cm)	Date measured	Other data available
			SEVIER COUNTY—Continued					
5,250	+6.89	09-28-88	—	—	10.5	1,280	09-28-88	K
5,255	—	—	—	—	12.0	490	09-29-88	K
—	—	—	—	—	—	—	—	
—	—	—	—	—	—	—	—	
—	—	—	—	—	—	—	—	
—	—	—	—	—	—	—	—	
5,260	+3.40	09-27-88	4.95	09-27-88	13.5	710	09-27-88	C,K
5,260	+3.42	09-27-88	—	—	12.5	770	09-27-88	K
5,260	+3.49	09-27-88	1.63	09-27-88	12.0	800	09-27-88	K
5,255	+5.40	09-27-88	—	—	—	840	09-27-88	K
5,260	-.49	09-28-88	—	—	—	—	—	
5,260	-2.01	05-21-57	—	—	—	—	—	
5,258	+.35	05-23-57	—	—	—	—	—	
5,260	—	—	7 E	09-29-88	—	1,860	09-29-88	K
5,260	—	—	20 E	09-28-88	10.5	3,310	09-28-88	K
5,255	—	—	—	—	—	760	09-29-88	K
5,255	—	—	5 E	09-29-88	10.5	4,060	09-29-88	K
5,255	+5.33	09-29-88	35.7	09-29-88	10.5	4,070	09-29-88	C,K
5,254	+3.23	05-21-57	49.5 E	09-29-88	10.0	4,190	09-29-88	K
5,254.31	+3.58	09-06-56	—	—	11.0	—	09-06-56	
5,254	+8.1	07-21-87	—	—	13.5	180	07-21-87	K,W
5,248	—	—	—	—	11.5	3,500	02-04-88	C,K
5,247	+4.8	02-03-88	5	05-15-59	11.5	1,120	02-03-88	C,K,W
5,350	—	—	—	—	—	610	04-28-88	C,K
5,400	—	—	—	—	—	—	—	
—	—	—	—	—	—	—	—	
—	—	—	—	—	—	—	—	
—	—	—	—	—	—	—	—	
5,400	—	—	—	—	—	—	—	
5,300	-14	04-25-60	—	—	—	—	—	
5,290	-5.74	04-28-88	—	—	—	—	—	W
5,270	-4.88	09-26-88	—	—	—	—	—	
5,280	-12.82	07-16-66	—	—	—	760	04-28-88	C,K
—	-16.1	04-23-57	—	—	—	—	—	L
5,280	-16.59	04-29-88	—	—	—	2,920	04-29-88	C,K,W
5,310	-42.53	05-25-89	—	—	—	—	—	L
—	—	—	—	—	—	—	—	
—	—	—	—	—	—	—	—	
—	—	—	—	—	—	—	—	
5,275	-8.13	04-28-88	—	—	—	—	—	W
5,265	—	—	—	—	—	—	—	
5,260	+4.4	09-28-87	—	—	10.0	4,200	09-28-87	K,W
—	—	—	—	—	—	—	—	
5,250	+3.6	04-28-88	14	04-28-88	—	1,690	04-28-88	K,W
5,258	0	09-22-59	—	—	—	—	—	
5,255	+4.3	05-11-88	18	05-11-88	11.0	1,410	05-11-88	C,K,W
5,255	+2.6	06-02-88	—	—	—	—	—	L
5,260	+1.39	04-17-57	0.4	09-26-88	12.0	940	09-26-88	K
5,262.90	+2.30	08-05-87	—	—	10.5	500	06-07-89	C,K,W
5,260	—	—	—	—	—	640	09-27-88	K
5,260	-1.17	09-01-86	—	—	11.5	870	05-11-88	K
5,335	—	—	—	—	—	—	—	

Table 21. Records of selected wells—Continued

Location	Owner or user	Date well drilled	Primary use of water	Depth drilled (feet)	Casing Diameter (inches)	Casing Depth (feet)	Finish (feet)
			SEVIER COUNTY—Continued				
17bbb-1	C. Roberts	1955	U	90	4	90	—
19aac-1	Annabella City	1976	P	205	10	205	P 165-205
19bcd-1	R. Ross	1949	S	199	4	199	—
(C-24-3) 1aad-1	C. Anderton	1949	U	63	2	63	—
1bcb-1	G. W. & H. Ogden	1971	I	845	12,8	845	P 265-280 295-325 338-360 370-400 500-530 660-735 760-763 815-845
2cba-2	Richfield City	1964	I	644	10	644	P 600-644
2ddd-1	V. Ogden	1954	U	63	2	63	—
10bcc-1	L. Hansen	1954	S	154	4	154	—
13bbc-1	E. Bagley	1947	S	210	5	210	—
13bcc-1	Talbot	1963	U	237	4	237	—
16dbc-1	C. Magelby	1961	U	238	4	238	—
16dbc-2	Harvard Farms	1984	S	250	6	250	—
21dad-1	C. Christensen	1982	S	297	6	297	—
23bad-1	Central L.D.S. Ward	1946	U	115	8	115	P 87-(?)
25bdb-1	Cartensen	1982	U	320	10	320	P 295-320
27bca-1	Richfield Auction Co.	1976	S	80	6	80	—
27cbd-1	Utah Food Products Co.	1944	—	100	8	100	P 60-100
27ccd-1	Hansen	1944	U	70	5	70	—
28bcd-1	Elsinore City	1978	P	254	16,12	254	P 205-243
29ddb-1	Elsinore City	—	P	191	—	—	—
34bdc-1	R. Johnson	1976	H	100	6	100	—
34cdb-1	G. Bagley	1973	U	40	4	40	—
34cdb-2	R. Bagley	1978	H	60	6	60	—
35bdd-1	J. D. Washburn	1944	—	116	4	112	—
(C-25-3) 4aac-1	R. Taylor	1974	H	105	6	105	—
5cba-1	A. Adams	1981	H	100	6	100	—
5dab-1	J. Anderton	1928	U	70	3	70	—
6abd-1	—	—	—	—	—	—	—
6cda-1	C. Parks	1975	—	192	6	192	—
8bab-1	H. C. Olsen	1942	—	100	4,3	100	—
15dba-1	H. Parsons	1977	H	196	6	196	—
16bdc-1	K. Leavitt	1977	—	202	6	202	—
16cbb-1	S. Ware	1977	H	110	6	110	—
(C-25-3) 16cdc-1	S. Holgate	1982	U	111	6	111	—
28cad-1	N. Woodbury	1949	U	137	5	137	—
29cac-1	E. Payne	1981	—	216	6	216	—
(C-25-4) 11cac-1	R. G. Bradbury	—	—	39	3	39	—
13bdb-1	Johnson	1936	H	70	5	70	—
13cbc-1	E. Meacham	1936	—	73	5	73	—
27bab-1	P. Gilaro	1936	—	89	5	89	—
28abd-1	N. & C. Lein	1980	—	420	10,6	420	P 300-420
32aba-2	P. Gilbert	1938	—	64	6	—	—
32baa-1	G. McCarty	1978	U	108	6	108	—
(D-21-1) 31cba-1	U.S. Geological Survey	1988	U	21.5	2	21.5	P 14.0-19.0
31cdb-1	U.S. Geological Survey	1988	U	22.0	2	22.0	P 14.5-19.5

Altitude of land surface (feet)	Water level (feet)	Date water level measured	Discharge of flowing wells (gal/min)	Date discharge measured	Water-quality parameters: Temperature (°C)	Specific conductance (µS/cm)	Date measured	Other data available
				SEVIER COUNTY—Continued				
5,260	-1.02	05-13-88	—	—	—	—	—	W
5,375	—	—	—	—	—	—	—	
5,340	-13.66	07-22-87	—	—	—	—	—	
5,255	+5.40	05-12-88	34	05-12-88	10.5	3,780	05-12-88	C,K,W
5,275	-4.02	08-08-88	—	—	—	—	—	L
—	—	—	—	—	—	—	—	
—	—	—	—	—	—	—	—	
—	—	—	—	—	—	—	—	
—	—	—	—	—	—	—	—	
—	—	—	—	—	—	—	—	
—	—	—	—	—	—	—	—	L
—	—	—	—	—	—	—	—	
5,280	—	—	—	—	—	—	—	
5,270	-6.46	09-15-88	—	—	—	—	—	K,W
5,390	-108.27	03-05-87	—	—	—	—	—	W
5,280	-3.24	07-21-87	—	—	—	—	—	
5,280	-5.46	05-31-88	—	—	—	—	—	W
5,480	-208.92	05-31-88	—	—	—	—	—	
5,480	—	—	—	—	12.5	1,850	06-09-89	C,W
5,405	-107.48	07-22-87	—	—	—	—	—	W
5,298.50	-19.90	03-05-87	—	—	—	—	—	W
5,500	-183.00	08-12-88	—	—	—	—	—	W
5,340	—	—	—	—	13.0	860	06-04-88	C,K
5,325	-33.2	07-11-56	—	—	—	—	—	
5,305	-9.73	05-31-88	—	—	—	—	—	W
5,355	—	—	—	—	—	—	—	L
5,328.65	—	—	—	—	—	—	—	
5,310	-11.09	07-21-87	—	—	—	810	07-21-87	
5,310	-8.86	07-21-87	—	—	12.0	760	08-23-89	C,K,W
5,310	—	—	—	—	—	870	07-21-87	
5,322.63	-43.33	07-21-56	—	—	—	—	—	W
5,310	-14.38	07-02-87	—	—	—	—	—	
5,350	-61.17	07-02-87	—	—	—	710	07-02-87	C,K
5,335	-38.07	06-03-88	—	—	—	—	—	
5,355	-69.09	07-20-87	—	—	—	—	—	W
—	—	—	—	—	—	—	—	L
5,345.18	-72.4	07-23-56	—	—	—	—	—	
5,445	—	—	—	—	—	2,320	06-29-88	
5,375	—	—	—	—	11.5	450	06-15-89	C
5,380	-51.59	07-02-87	—	—	—	730	07-02-87	W
5,390	-67.44	06-28-88	—	—	—	—	—	W
5,445	-101.30	03-04-87	—	—	—	—	—	W
5,500	—	—	—	—	15.0	500	06-27-89	C
5,412	-29.3	09-17-56	—	—	—	—	—	
5,444	-42.95	05-31-88	—	—	—	500	05-25-89	C,K
5,426	-41.2	07-23-56	—	—	—	—	—	
5,478	-63.0	09-19-56	—	—	—	—	—	
5,530	-33.09	07-21-87	—	—	15.0	690	07-21-87	K,L,W
5,593.10	-54.2	02-08-57	—	—	14.0	—	11-20-56	
5,620	-68.16	06-29-88	—	—	—	—	—	
5,230	-10.59	08-08-89	—	—	15.5	3,750	08-08-89	C,L
5,235	-10.28	08-08-89	—	—	14.0	2,780	08-08-89	

Table 21. Records of selected wells—Continued

Location	Owner or user	Date well drilled	Primary use of water	Depth drilled (feet)	Casing Diameter (inches)	Casing Depth (feet)	Casing Finish (feet)
			PIUTE COUNTY				
(C-27-3) 7ddd-1	Gregerson	1955	—	75	6	75	—
17bcb-1	W. James	1978	U	101	6	101	—
18dbd-1	B. Shepherd	1975	H	118	8	118	P 100-118
18dab-1	G. Prince	1948	S	114	5	114	—
32add-1	D. Lay	1943	U	150	5,4	150	P 63-92 130-150
33cdc-1	O. P. Laird	—	—	—	—	—	—
[1](C-28-3) 6aaa-1	C. Pearson	1948	H	110	—	—	—
6dbc-2	K. Blackwell	1924	H	120	—	—	—
8ddb-1	P. Swalburg	1942	H	190	4	177	—
21ada-1	B. Shepherd	—	H	—	—	—	—
22bbc-1	S. Henrie	1952	U	98	4	98	P 75-98
34cdc-1	Piute Reservoir and Irrigation Co.	1956	H	237	4	—	—
(C-30-3) 15bba-1	O. P. Jessen	1920	U	40	24	—	—
16bbb-1	P. J. Jensen	1948	U	407	6	—	—

[1]Reported by Carpenter and Young, 1963, as (C-28-3)5bbb-1.

Altitude of land surface (feet)	Water level (feet)	Date water level measured	Discharge of flowing wells (gal/min)	Date discharge measured	Water-quality parameters			Other data available
					Temperature (°C)	Specific conductance (µS/cm)	Date measured	
				PIUTE COUNTY				
5,850	-30.83	03-25-87	—	—	—	—	—	W
5,845	-24.57	06-30-88	—	—	—	—	—	W
5,970	—	—	—	—	11.0	3,310	06-08-89	C
5,925	-23.50	06-30-88	—	—	—	225	06-30-88	C,K
5,890	-39.19	07-13-88	—	—	—	—	—	W
—	—	—	—	—	—	—	—	
5,890	—	—	—	—	11.5	410	06-14-89	C
6,035	-22.59	07-01-88	—	—	—	—	—	
6,110	—	—	—	—	—	345	07-01-88	C,K
6,150	—	—	—	—	—	1,000	07-14-88	K
5,950	—	—	—	—	13.5	610	06-14-89	C
5,900	-53.10	07-14-88	—	—	—	—	—	W
5,930	—	—	—	—	15.0	350	06-14-89	C
6,006.50	-21.69	03-23-88	—	—	—	—	—	W
6,000	-16.99	03-25-87	—	—	—	—	—	W

Table 22. Records of selected springs

[—, no data]

Location: See figure 2 for an explanation of the numbering system for data sites.
Primary use of water: I, irrigation; P, public supply; S, stock; U, unused.
Altitude of land surface: In feet above sea level.
Source of water: Qal, alluvium of Quaternary age; Tv, volcanic rocks of Tertiary age; Tf, Flagstaff limestone of Tertiary age, Fz, fault zone.
Discharge: gal/min, gallons per minute; E, estimated.
Water-quality parameters: Temperature: °C, degrees Celsius; Specific conductance: µS/cm, microsiemens per centimeter at 25 degrees Celsius.
Other data available: C, chemical analysis (table 27).

Location	Name of spring	Primary use of water	Altitude of land surface (feet)	Source of water	Discharge (gal/min)	Date discharge measured	Water-quality parameters: Temperature (°C)	Specific conductance (µS/cm)	Date measured	Other data available
				Sanpete County						
(D-18-1)19dab-S1	Fayette Spring	P	5,120	Tf	—	—	19.0	1,000	10-15-87	
(D-19-2)33acd-S1	—	—	—	—	—	—	10.0	760	07-13-65	C
(D-20-1)25aac-S1	Michaelson Spring	—	5,550	Qal	—	—	12.0	920	05-14-87	
				Sevier County						
(C-21-1)11aaa-S1	Redmond Lake Spring	—	5,115	Qal	—	—	21.0	950	09-27-68	C
(C-23-2)12bab-S1[1]	Black Knoll Spring	—	5,240	Qal	6,960	08-11-88	13.5	740	08-15-88	C
(C-23-2)25bac-S1[2]	Indian Creek Springs	I	5,500	Tv	—	—	17.0	395	08-15-88	C
(C-23-2)25ccb-S1	—	S	5,500	Qal	3.2	05-24-89	16.5	300	05-24-89	
(C-23-2)28ddd-S1	—	I	5,250	Qal	—	—	13.0	620	05-25-89	C
(C-23-3)26aca-S1	Richfield Spring	P	—	Tf	—	—	20.0	550	07-30-57	C
(C-24-2)4ccb-S1[3]	Spring Hill Springs	—	5,290	Qal	—	—	13.0	730	10-28-68	C
(C-25-3)10dda-S1	Monroe Hot Spring	—	5,450	Fz,Tv	15 E	1966	42.0	4,000	05-17-66	C
(C-25-3)11cac-S1	—	—	5,590	Fz,Tv	—	—	76.5	4,100	05-02-66	C
(C-25-3)15dda-S1	Cooper Spring	—	5,590	—	—	—	33.0	3,900	04-18-67	C
(C-25-3)27dcd-S1	—	—	5,900	—	—	—	—	—	—	
(C-25-4)23aac-S1	Joseph Hot Springs	—	5,480	Fz,Tv	25 E	11-06-87	—	6,800	11-06-87	C
(C-25-4)23add-S1	—	—	5,470	Fz,Tv	—	—	63.0	7,680	05-03-66	C
(D-20-1)35ddd-S1	Neils Spring	U	5,640	Qal	—	—	12.0	2,450	11-06-87	C

[1]Reported by Carpenter and Young, 1963, as (C-23-2)12bbc.
[2]Reported by Carpenter and Young, 1963, as (C-23-2)25bdb.
[3]Reported by Carpenter and Young, 1963, and by Mundorff, 1971, as (C-24-2)4cbd.

Table 23. Drillers' logs of selected wells

Location: See figure 2 for an explanation of the numbering system for data sites.
Altitude: Altitude of land surface, in feet above sea level; —, no data.
Thickness: In feet.
Depth: Depth to bottom of interval, in feet below land surface.

Material	Thickness	Depth
(C-22-1)7cdc-1 Log by Scott Stephenson Drilling Co. Altitude 5,300		
Clay, gravel, and boulders	162	162
Clay and gravel	23	185
Boulders	2	187
Clay and gravel	10	197
Clay, silt, and sand	93	290
Clay and gravel, and cemented gravel	28	318
Hardpan	2	320
Clay and gravel	25	345
Clay	35	380
Hardpan	2	382
Clay, some gravel	28	410
Clay	10	420
Clay, some gravel	45	465
Clay, gravel	57	522
(C-22-1)11bdb-1 Log by U.S. Geological Survey Altitude 5,205		
Silt, sand, and a little gravel; light brown and dry	3.5	3.5
Gravel, silt, fine sand, gravel in intermittent layers	1.5	5
Silt, fine sand, some gravel in thin layers; moist	2	7
Silt, fine sand, small amount of gravel; moist	4	11
Clay, silt, sand, and gravel; dark gray and wet	2	13
Silt, sand, and gravel; formation tighter than above	1.5	14.5
(C-22-2)24ddd-1 Log by Ellsworth Drilling Altitude —		
Clay and sand	20	20
Sand and gravel	6	26
Clay and sand	14	40
Sand and gravel	18	58
Boulders	2	60
Sand	12	72
Gravel; water	3	75
Sand and gravel	21	96
Silt, sand, and gravel	11	107
(C-23-2)1aab-1 Log by Lee Drilling Co. Altitude 5,220		
Fill	2	2
Clay	19	21
Sandy clay and boulders	14	35
Sandy clay	32	67
Sandy clay and gravel	18	85
Sandy clay	7	92
Clay and gravel; hard	10	102
Hardpan	5	107
Clay, sand, and gravel	8	115
Sandy clay	40	155
Sand	5	160
Sand and gravel	9	169
Clay and gravel; hard	15	184
Gravel; water	11	195
Clay	6	201
Sand and gravel; water	20	221
Clay and gravel	9	230
Hardpan	15	245
Sand	8	253
Clay and gravel; hard	13	266
Gravel; water	8	274
Clay, sticky	19	293
Gravel; water	24	317
Hardpan	3	320
Gravel; water	7	327
Clay and gravel; hard	7	334
Gravel; water	7	341
Clay, sticky	5	346
Clay and gravel; hard	4	350
(C-23-2)1aba-3 Log by Clair A. Stephenson Drilling Co. Altitude —		
Top soil	6	6
Clay and sand layers	94	100
Gravel; water	15	115
Clay, sand, and gravel layers; water	70	185
Clay	20	205
Clay, sand, and gravel layers; water	25	230
Sand; water	15	245
Clay, red	10	255
Sand, little gravel; water	25	280
Clay	15	295
Sand and gravel; water good	30	325
Sand	13	338
Sand and gravel; water good	22	360
Clay	10	370
Sand and gravel; water good	15	385
Clay and gravel layers; water	15	400

Table 23. Drillers' logs of selected wells—Continued

Material	Thickness	Depth
(C-23-2)9bbb-1 Log by Sharp Well Drilling Co. Altitude 5,360		
Clay, silt, gravel, cobbles, and boulders	85	85
Clay	30	115
Clay, gravel, and cobbles; few rocks	55	170
Clay and silt	146	316
Conglomerate	4	320
Clay, silt, and cobbles; few rocks	60	380
Gravel and cobbles, packed tightly	50	430
Clay and silt	38	468
All clay brown with occasional thin streaks; red		
(C-23-2)21aad-3 Log by U.S. Geological Survey Altitude 5,240		
Silt and gravel, brown; moist	5	5
Sandy silt, brown; moist	5	10
Sandy clay, brown; very moist	4	14
Sandy clay, reddish brown; saturated	2.5	16.5
(C-23-2)22bda-1 Log by U.S. Geological Survey Altitude 5,240		
Clay, brown; moist	1	1
Clay, gray to red; moist	2.5	3.5
Clay, gray; wet	3.5	7
Clay, gray; wet	3	10
Clay, gray; wet, very plastic	2	12.0
(C-23-2)28bdc-1 Log by Cecil Stephenson Drilling Co. Altitude —		
Top soil	8	8
Clay (?)	7	15
Clay, gray	10	25
Sand, gray; water	5	30
Clay and sand, gray	25	55
Sand and gravel	10	65
Gravel, coarse	41	106
Clay, red	4	110
Sand and gravel	40	150
Gravel, coarse	16	166
Clay, gray	9	175
Clay and sand, gray	20	195
Sand and gravel, black	3	198
Gravel	40	238
Clay, red	12	250
Gravel, small	16	266
Clay, brown	9	275
Gravel, small	15	290
Gravel, coarse	4	294
Clay, brown	31	325
Gravel	45	370
(C-23-2)28bdc-1—Continued		
Clay, red	19	389
Gravel	9	398
Clay, light brown	7	405
Gravel	2	407
Clay, light brown	8	415
Conglomerate, gray	20	435
Gravel	28	463
Conglomerate	7	470
Clay, brown	30	500
(C-23-2)31acc-3 Log by Clair A. Stephenson Drilling Co. Altitude 5,250		
Top soil	3	3
Clay and sand	57	60
Sand and gravel; water	50	110
Clay, red	50	160
Conglomerate	10	170
Clay	40	210
Hardpan	5	215
Sand, little gravel; water	35	250
Sand and gravel; water good	30	280
Clay, red	55	335
Sand and gravel; water good	7	342
Clay and sand; layers	23	365
Sand and gravel; water good	65	430
Clay	35	465
Sand and gravel; water good	17	482
Hardpan	23	505
Sand and gravel; water good	60	565
Clay, light tan	10	575
(C-23-3)36baa-1 Log by Binning Drilling Co. Altitude 5,310		
Clay	10	10
Clay; water for 8 feet	10	20
Clay	10	30
Clay; water for 3 feet	10	40
Clay	5	45
Clay, silt, and sand	5	50
Clay and silt	5	55
Clay	20	75
Clay; water	5	80
Clay and sand	5	85
Clay	55	140
Clay, gray	10	150
Clay	20	170
Clay and volcanic gravel	5	175
Clay	45	220
Clay, silt, and sand	15	235
Clay	5	240
Clay, silt, and gravel	5	245

Table 23. Drillers' logs of selected wells—Continued

Material	Thickness	Depth
(C-23-3)36baa-1—Continued		
Clay	95	340
Clay and gravel	5	345
Clay	25	370
Clay and volcanic rock	5	375
Clay	55	430
Clay, little gravel in clay	5	435
Clay	50	485
Sand and gravel; water	5	490
Gravel; water	10	500
Clay	100	600
Sand	5	605
Clay, sand, and gravel	10	615
Clay, sand, and gravel, gray	10	625
Clay, sand, and gravel	25	650
Clay and sand	20	670
Sand	10	680
Clay, sand, and gravel	20	700
(C-24-2)6dbc-1 Log by Scott Stephenson Drilling Co. Altitude 5,255		
Surface material	7	7
Clay	15	22
Gravel	6	28
Clay, sand, and gravel, mixed	10	38
Clay, blue	8	46
Gravel	11	57
Clay	6	63
Gravel	26	89
Clay	4	93
Gravel	6	99
Sand	5	104
Sand and gravel	14	118
Sand	9	127
Clay	39	166
Sand and gravel	24	190
Clay	38	228
Sand and gravel	72	300
(C-24-3)1bcb-1 Log by Clair A. Stephenson Drilling Co. Altitude 5,275		
Top soil	6	6
Clay and sand, layers; water in sand past 50 feet	94	100
Gravel; water	15	115
Clay and sand, layers; water	70	185
Clay and sand	20	205
Sand and gravel; water	15	220
Clay and sand, layers	25	245
Clay, red	10	255
Clay and sand	10	265
(C-24-3)1bcb-1—Continued		
Sand and gravel; water perforated	15	280
Clay	15	295
Sand and gravel; water perforated	30	325
Sand	13	338
Sand and gravel; water perforated	22	360
Clay	10	370
Sand and gravel; water perforated	30	400
Clay	100	500
Sand and gravel; water perforated	30	530
Clay	130	660
Sand and gravel; water perforated	75	735
Clay and gravel, imbedded	25	760
Gravel; water good, perforated	3	763
Clay, sticky	52	815
Sand and gravel; water perforated	5	820
Clay, gravel, and sand layers; water hard, perforated	25	845
(C-24-3)28bcd-1 Log by Camer Drilling Co. Altitude 5,355		
Top soil	2	2
Clay, tan	53	55
Clay and gravel; dry	27	82
Gravel and cobbles; dry	23	105
Sand and gravel, dirty	15	120
Clay and fine gravel	10	130
Clay	75	205
Sand and gravel; water	39	244
Sand and gravel	10	254
(C-25-3)6cda-1 Log by Sharp Well Drilling Co. Altitude —		
Clay, silt, gravel, and cobbles	152	152
Clay, silt, sand, and gravel	18	170
Clay, gravel, and cobbles	15	185
Clay, sand, silt, and gravel	6	191
Sand and gravel	1	192
(C-25-4)28adb-1 Log by Clear Water Drilling Altitude 5,530		
Top soil, gravel, silt, and clay	60	60
Clay, gray	40	100
Clay, white, bentonitic	220	320
Clay and hardpan, white clay with thin sandstone layers, water in sandstones	100	420

Table 23. Drillers' logs of selected wells—Continued

Material	Thickness	Depth
(D-21-1)31cba-1 Log by U.S. Geological Survey Altitude 5,230		
Fine sand, and clay, brown	2.5	2.5
Gravel, cobbles, some sand	3	5.5
Sand, and intermittent gravel	1.5	7
Gravel, with sand and silt; layered	7	14
Fine sand, silt, and a little gravel	3	17
Gravel and sand	0.5	17.5
Fine sand, silt, some gravel; very moist, wet at 19 feet	4.0	21.5

Table 24. Water levels in selected wells

Location: See figure 2 for an explanation of the numbering system for hydrologic-data sites.
Altitude: Altitude of land surface, in feet above sea level.
Water levels are in feet above (+) or below land surface.
Letters appearing after water-level measurements: R, reported; P, recently pumped.

Date	Water level
(C-18-1)25ddc-1	
Altitude 5,014	
OCT 28, 1959	+4.00
NOV 27	+5.60
AUG 31, 1960	+4.50
SEP 28	+4.40
OCT 26	+4.50
NOV 28	+4.60
DEC 21	+5.10
FEB 23, 1961	+5.50
28	+5.20
MAR 31	+5.50
APR 26	+4.70
MAY 23	+4.10
JUN 26	+4.10
JUL 25	+4.40
AUG 22	+4.20
SEP 28	+4.50
OCT 29	+4.50
NOV 30	+4.60
DEC 31	+5.20
JAN 31, 1962	+6.00
FEB 09	+5.60
APR 03	+4.70
SEP 27	+4.30
APR 09, 1963	+5.20
SEP 26	+4.80
APR 02, 1964	+5.20
OCT 03	+4.63
MAR 09, 1965	+5.33
SEP 20	+5.50
DEC 10	+4.99
MAR 04, 1966	+5.70
SEP 19	+4.90
MAR 06, 1967	+5.90
NOV 07	+6.00
MAR 19, 1968	+5.70
SEP 30	+5.70
APR 15, 1969	+5.90
OCT 09	+7.20
MAR 06, 1970	+5.00
SEP 11	+6.40
MAR 08, 1971	+5.20
OCT 15	+6.40
MAR 01, 1972	+6.60
OCT 03	+7.00
MAR 01, 1973	+7.00
OCT 15	+8.40
MAR 14, 1974	+8.10
(C-18-1)25ddc-1—Continued	
OCT 02, 1974	+7.90
MAR 10, 1975	+7.40
OCT 10	+7.70
MAR 17, 1976	+7.17
OCT 14	+7.60
MAR 22, 1977	+6.60
OCT 04	+4.10
MAR 16, 1978	+4.20
OCT 03	+5.00
MAR 13, 1979	+4.10
OCT 02	+5.40
MAR 06, 1980	+4.50
OCT 02	+5.60
OCT 06, 1981	+4.60
SEP 29, 1982	+8.40
(C-19-1)23bcc-1	
Altitude 5,070	
SEP 05, 1935	37.58
NOV 23	37.31
JAN 26, 1936	37.50
MAR 04	37.33
APR 23	37.10
JUN 17	36.90
AUG 06	37.08
SEP 30	37.31
NOV 28	36.59
FEB 06, 1937	36.67
APR 10	36.58
JUN 09	36.10
AUG 02	36.04
SEP 25	35.48
NOV 02	35.05
DEC 09	34.86
FEB 24, 1938	35.01
APR 10	35.35
AUG 25	34.01
OCT 07	33.45
DEC 21	33.09
FEB 28, 1939	33.96
APR 17	34.82
JUN 16	34.77
AUG 23	37.52
OCT 15	33.27
DEC 05	33.14
MAR 26, 1940	34.08
JUN 05	34.37
DEC 05	33.58
MAR 19, 1941	35.25
(C-19-1)23bcc-1—Continued	
DEC 05, 1941	33.12
MAR 18, 1942	35.14
AUG 10	31.31
DEC 20	30.13
MAR 25, 1943	31.50
DEC 16	31.18
MAR 19, 1944	35.64
DEC 04	29.69
APR 03, 1945	31.10
DEC 06	29.52
MAR 21, 1946	31.04
DEC 18	29.90
MAR 27, 1947	30.69
DEC 13	29.90
JUL 22, 1948	31.80
DEC 13	29.97
APR 04, 1949	31.37
DEC 13	29.79
MAR 30, 1950	31.25
DEC 10	30.08
MAR 27, 1951	31.48
DEC 11	30.79
APR 07, 1952	32.12
DEC 08	29.55
MAR 17, 1953	30.33
DEC 10	29.77
MAR 26, 1954	31.48
NOV 30	32.49
MAR 22, 1955	33.07
DEC 06	35.21
MAR 22, 1956	34.61
DEC 05	35.69
JAN 03, 1957	32.10
FEB 04	32.50
28	32.90
APR 03	35.40
MAY 03	36.80
OCT 01	35.70
FEB 12, 1958	35.77
MAR 12	35.77
APR 03	34.37
MAY 06	36.55
JUN 10	36.00
OCT 03	36.95
NOV 04	36.10
NOV 28	36.47
DEC 31	35.60
JAN 29, 1959	35.50

Table 24. Water levels in selected wells—Continued

Date	Water level
(C-19-1)23bcc-1—Continued	
FEB 26, 1959	35.49
MAR 27	35.51
APR 28	35.55
JUN 26	36.90
SEP 29	37.08
OCT 28	38.27
NOV 27	35.52
DEC 31	35.41
JAN 26, 1960	35.69
FEB 29	35.65
MAR 28	35.75
APR 29	36.26
SEP 28	36.69
OCT 26	36.57
NOV 28	36.26
DEC 21	36.20
JAN 26, 1961	36.30
FEB 23	37.35
MAR 21	36.42
APR 26	36.06
JUL 25	37.47
SEP 28	38.30
APR 03, 1962	36.37
APR 09, 1963	36.03
SEP 26	36.71
APR 02, 1964	36.38
SEP 24	37.57
DEC 10	36.58
MAR 09, 1965	36.69
SEP 20	35.69
DEC 10	36.58
MAR 04, 1966	36.05
MAR 06, 1967	36.10
NOV 07	35.62
MAR 19, 1968	35.56
SEP 30	35.00
APR 15, 1969	35.10
OCT 09	33.10
MAR 06, 1970	37.93
SEP 11	35.69
MAR 08, 1971	38.37
OCT 15	35.72
OCT 04, 1972	33.40
MAR 01, 1973	34.05
OCT 15	30.84
MAR 14, 1974	31.78
OCT 02	31.60
MAR 11, 1975	32.89
OCT 10	30.52
MAR 18, 1976	33.15
OCT 14	33.55
(C-19-1)23bcc-1—Continued	
MAR 22, 1977	33.79
SEP 30	35.00
MAR 16, 1978	35.43
OCT 03	35.47
MAR 13, 1979	35.47
OCT 02	34.23
MAR 06, 1980	33.98
OCT 02	33.33
MAR 05, 1981	33.49
OCT 06	33.42
MAR 03, 1982	33.51
SEP 29	31.88
MAR 01, 1983	32.70
SEP 27	27.97
MAR 07, 1984	29.56
SEP 26	29.42
MAR 11, 1985	29.28
SEP 19	29.15
MAR 12, 1986	29.25
SEP 10	27.73
MAR 04, 1987	29.26
JUL 20	31.62
SEP 03	31.83
NOV 03	28.42
DEC 08	28.92
JAN 12, 1988	29.42
MAR 15	29.68
APR 29	29.85
MAY 17	29.62
JUN 15	29.27
JUL 12	29.08
AUG 08	28.84
SEP 16	28.47
OCT 17	28.39
NOV 29	28.67
DEC 28	29.29
JAN 23, 1989	29.25
FEB 15	29.68
FEB 28	29.35
MAR 16	29.35
APR 25	29.70
MAY 23	29.82
JUN 28	31.15
JUL 25	31.30
SEP 19	29.66
(C-19-1)23cac-1 Altitude 5,055	
MAR 11, 1985	20.90
SEP 19	21.56
MAR 12, 1986	21.47
SEP 10	18.88
(C-19-1)23bcc-1—Continued	
MAR 04, 1987	21.33
JUL 20	20.69
SEP 03	20.37
OCT 13	20.16
NOV 03	20.21
DEC 08	20.78
JAN 12, 1988	21.30
MAR 15	22.12
APR 29	21.75
MAY 17	21.30
JUN 15	20.82
JUL 12	20.53
AUG 08	20.35
SEP 16	19.92
OCT 17	20.05
NOV 29	20.59
DEC 28	20.89
JAN 23, 1989	21.19
FEB 15	21.43
28	21.21
MAR 10	21.32
APR 25	21.41
JUN 28	21.62
(C-19-1)35cdd-2 Altitude 5,205	
MAR 27, 1987	154.80
MAR 23, 1988	155.18
SEP 14	154.07
FEB 28, 1989	154.05
MAR 16	154.18
(C-20-1)24dca-1 Altitude 5,080	
MAY 29, 1987	4.23
SEP 03	4.39
OCT 13	4.05
NOV 03	4.60
(C-20-1)25dcd-1 Altitude 5,090	
APR 09, 1958	8.4
MAY 06	6.9
JUN 03	6.2
JUL 02	6.8
AUG 05	7.2
SEP 03	7.1
OCT 03	6.4
NOV 04	6.8
28	7.3
DEC 31	7.3
JAN 29, 1959	7.8
FEB 26	7.9

Table 24. Water levels in selected wells—Continued

Date	Water level
(C-20-1)25dcd-1—Continued	
MAR 25, 1959	8.4
APR 28	5.9
MAY 26	6.8
JUN 26	6.2
JUL 28	6.9
AUG 27	7.2
SEP 29	7.2
OCT 28	6.9
NOV 27	7.5
DEC 29	7.8
SEP 29, 1987	4.29
MAR 23, 1988	4.86
SEP 14	3.20
MAR 01, 1989	4.57
(C-21-1)1cab-1	
Altitude 5,100	
JUL 21, 1987	0.45
SEP 03	0.50
OCT 14	1.00
NOV 03	2.20
DEC 08	3.06
JAN 12, 1988	3.68
FEB 18	3.92
MAR 23	3.53
APR 29	3.36
MAY 17	2.48
JUN 16	0.16
JUL 12	0.24
AUG 08	+0.13
SEP 16	+0.24
OCT 17	1.09
NOV 29	2.66
DEC 28	3.25
JAN 24, 1989	3.71
FEB 16	3.95
28	3.45
MAR 16	3.68
APR 25	3.38
MAY 23	2.06
JUN 28	1.29
JUL 26	1.39
SEP 19	1.28
(C-21-1)2ccd-1	
Altitude 5,160	
JUL 21, 1987	38.57
SEP 03	37.80
OCT 14,	37.75
NOV 03,	38.04
DEC 08	39.41
(C-21-1)10ada-1	
Altitude 5,165	
AUG 15, 1956	43.24
SEP 05	43.62
OCT 05	43.84
NOV 06	43.67
DEC 04	43.85
JAN 03, 1957	44.13
FEB 01	44.38
27	44.41
APR 02	44.38
30	44.39
MAY 31	42.76
JUN 26	42.54
JUL 25	43.80
SEP 03	43.66
30	43.97
NOV 06	43.82
DEC 03	43.75
JAN 02, 1958	42.54
FEB 04	41.05
MAR 05	41.23
APR 03	41.39
MAY 06	41.70
JUN 03	41.25
JUL 02	40.99
AUG 05	40.78
SEP 03	41.69
OCT 03	40.76
NOV 04	40.34
28	40.66
DEC 30	40.98
JAN 29, 1959	40.58
FEB 26	40.35
MAR 25	40.92
APR 28	41.41
MAY 26	41.40
JUN 26	41.65
JUL 28	41.90
AUG 27	42.67
SEP 29	43.13
OCT 28, 1986	42.80
NOV 27	42.85
DEC 29	42.56
SEP 29, 1987	34.61
OCT 14	35.60
NOV 03	36.39
SEP 14, 1988	34.20
OCT 17	35.71
NOV 29	37.80
DEC 28	38.90
JAN 23, 1989	39.50
(C-21-1)10ada-1—Continued	
FEB 16, 1989	40.12
MAR 07	40.54 R
(C-21-1)13abd-1	
Altitude 5,110	
SEP 05, 1956	+7.00
OCT 05	+7.20
NOV 06	+8.40
DEC 04	+7.75
JAN 03, 1957	+8.75
FEB 01	+8.75
27	+8.80
APR 02	+9.40
30	+9.20
MAY 31	+9.30
JUN 26	+8.80
JUL 25	+8.10
AUG 30	+8.20
SEP 30	+8.10
NOV 06	+9.00
DEC 03	+9.20
JAN 02, 1958	+9.20
FEB 04	+8.80
MAR 05	+9.30
APR 03	+9.50
MAY 06	+9.50
JUN 03	+9.50
JUL 02	+8.90
AUG 05	+8.50
SEP 03	+8.10
OCT 03	+7.80
NOV 05	+9.30
28	+9.35
DEC 30	+8.60
JAN 29, 1959	+8.40
FEB 27	+8.80
MAR 25	+9.30
APR 28	+9.00
MAY 26	+10.80
JUN 26	+10.10
JUL 28	+9.40
AUG 27	+8.00
SEP 29	+9.20
OCT 27	+9.80
NOV 27	+9.20
DEC 29	+8.40
JAN 26, 1960	+9.10
FEB 29	+9.30
MAR 28	+9.70
APR 28	+9.60
MAY 27	+9.20
JUN 21	+7.90

Table 24. Water levels in selected wells—Continued

Date	Water level
(C-21-1)13abd-1—Continued	
JUL 26, 1960	+8.00
AUG 31	+7.50
SEP 27	+7.65
OCT 26	+8.40
NOV 28	+8.40
DEC 22	+8.20
MAR 06, 1987	+11.2
JUL 21	+12.0
SEP 02	+11.9
OCT 14	+13.0
NOV 04	+13.1
JAN 13, 1988	+12.1
FEB 18	+11.1
MAR 15	+11.00
APR 29	+12.0
MAY 17	+12.05
JUN 16	+12.8
JUL 13	+12.55
AUG 11	+12.9
SEP 16	+12.6
OCT 17	+12.48
NOV 29	+11.70
DEC 28	+11.30
JAN 23, 1989	+11.89
FEB 16	+10.70
MAR 01	+10.65
APR 25	+11.00
MAY 23	+11.40
JUN 29	+11.10
JUL 26	+11.60
SEP 19	+11.30
(C-21-1)13dbc-1	
Altitude 5,120	
JUL 22, 1987	6.68
SEP 14, 1988	6.44
MAR 01, 1989	8.06
(C-21-1)14bab-1	
Altitude 5,120	
JUL 22, 1987	8.18
SEP 03	7.68
MAR 23, 1988	9.55
SEP 14	7.03
MAR 07, 1989	9.63
(C-21-1)24bda-1	
Altitude 5,135	
SEP 29, 1987	11.41
OCT 14	11.40
NOV 04	11.88
DEC 08	12.70
MAR 24, 1988	14.04
(C-21-1)24bda-1—Continued	
APR 29, 1988	13.91
MAY 17	13.16
JUN 16	11.71
JUL 13	11.08
AUG 11	11.05
SEP 16	11.26
OCT 17	11.59
NOV 29	12.56
MAR 07, 1989	13.78 R
APR 25	13.60
MAY 23	12.20
JUN 28	11.85
JUL 25	12.49
(C-21-1)27cca-2	
Altitude 5,170	
AUG 08, 1956	44.90
SEP 20	46.05
OCT 05	45.35
NOV 05	45.24
DEC 03	45.25
JAN 03, 1957	45.20
FEB 01	45.18
27	44.43
APR 02	44.62
30	43.11
MAY 31	42.92
JUN 26	42.48
JUL 25	42.42
AUG 30	42.55
SEP 30	42.85
NOV 05	42.16
DEC 03	41.95
JAN 02, 1958	42.07
FEB 04	42.15
MAR 05	41.17
APR 03	40.88
MAY 06	41.02
JUN 03	40.60
JUL 02	40.68
AUG 05	40.80
SEP 03	40.85
OCT 02	40.79
NOV 05	40.83
28	40.83
DEC 30	40.85
JAN 29, 1959	40.83
FEB 27	40.66
18	40.80
MAR 25	40.59
APR 30	39.34
MAY 26	39.21
(C-21-1)27cca-2—Continued	
JUN 29, 1959	39.22
JUL 28	39.22
AUG 26	38.14
SEP 29	37.97
OCT 27	37.92
NOV 25	37.46
DEC 29	37.60
SEP 29, 1987	39.81
OCT 15	39.29
NOV 04	39.54
DEC 08	39.90
JAN 18, 1988	40.54
MAR 23	40.50
APR 29	41.18
MAY 17	41.09
JUN 16	40.93
JUL 13	40.50
AUG 11	39.78
SEP 16	38.40
OCT 01	38.68
NOV 29	39.45
DEC 29	40.05
JAN 24, 1989	40.41
FEB 16	40.80
MAR 01	40.34
APR 25	41.37
MAY 23	41.19
JUN 28	41.16
JUL 26	41.07
SEP 19	40.54
(C-21-1)33acc-1	
Altitude 5,181.94	
AUG 08, 1956	46.94
SEP 05	47.28
OCT 05	47.19
NOV 05	47.09
DEC 03	46.96
JAN 03, 1957	47.08
FEB 28	46.84
APR 02	46.87
JUN 26	45.87
JUL 25	46.52
AUG 30	46.52
SEP 30	46.63
NOV 05	46.55
DEC 03	46.04
JAN 02, 1958	46.70
JAN 29	45.47
FEB 04	46.73
MAR 05	46.64
APR 03	46.88

Table 24. Water levels in selected wells—Continued

Date	Water level
(C-21-1)33acc-1—Continued	
MAY 06, 1958	46.65
JUN 03	44.96
JUL 02	46.02
AUG 05	45.75
SEP 03	45.59
OCT 02	45.30
NOV 05	45.06
DEC 01	45.19
30	45.60
FEB 27, 1959	45.10
MAR 25	45.79
APR 30	45.52
MAY 26	48.32
JUN 29	46.07
JUL 28	45.98
AUG 26	46.44
SEP 29	46.53
OCT 27	45.85
NOV 25	45.91
DEC 29	45.97
JAN 25, 1960	46.07
FEB 25	45.78
MAR 28	45.75
APR 28	46.01
MAY 23	45.88
JUN 21	46.08
JUL 26	46.66
AUG 31	47.16
SEP 27	47.07
OCT 26	46.70
NOV 28	46.86
DEC 22	46.88
SEP 29, 1987	41.18
DEC 29, 1988	41.10
JAN 24, 1989	41.46
FEB 16	41.75
MAR 01	41.44
APR 25	42.39
MAY 23	42.18
JUN 28	42.25
JUL 26	42.20
(C-22-1)3bbd-1	
Altitude 5,140	
NOV 06, 1987	0.63
MAR 23, 1988	0.67
SEP 15	+0.3
MAR 01, 1989	0.81
JUN 28	1.70
(C-22-1)6dbb-1	
Altitude 5,300	
MAY 27, 1987	117.20
SEP 02	115.15
MAR 23, 1988	120.25
SEP 15	116.11
MAR 01, 1989	119.59
(C-22-1)7dcb-1	
Altitude 5,245	
MAY 27, 1987	76.08
SEP 02	75.90
OCT 15	75.44
NOV 04	75.58
DEC 08	75.61
JAN 13, 1988	76.08
FEB 19	75.40
APR 28	75.89
MAY 17	76.16
JUN 16	76.32
JUL 13	75.95
AUG 11	75.26
SEP 16	74.42
OCT 17	74.60
NOV 29	75.15
DEC 29	75.52
(C-22-1)8dab-1	
Altitude 5,155	
MAY 27, 1987	5.00
SEP 03	5.55
SEP 15, 1988	4.72
MAR 01, 1989	4.95
(C-22-2)13bdd-1	
Altitude 5,350	
JAN 14, 1988	165.58
MAR 24	166.89
APR 29	165.74
MAY 18	164.80
JUN 16	164.00
JUL 13	164.08
AUG 11	164.05
SEP 16	164.12
OCT 17	164.05
NOV 30	164.67
DEC 29	164.85
MAR 01, 1989	165.94
APR 25	166.69
MAY 24	164.48
JUN 28	163.83
JUL 26	163.68
SEP 19	163.81
(C-22-2)26dac-2	
Altitude 5,320	
MAY 28, 1987	93.19
MAR 24, 1988	96.25
SEP 15	90.81
MAR 08, 1989	96.30
(C-22-2)35dab-1	
Altitude 5,260	
OCT 15, 1977	38.49
MAY 28, 1987	39.05
SEP 02	37.22
OCT 15	38.49
NOV 04	39.25
05	39.25
DEC 08	40.18
JAN 13, 1988	41.05
FEB 18	41.66
MAR 23	41.75
APR 29	41.37
MAY 18	40.07
JUN 16	38.16
JUL 13	37.80
AUG 15	36.47
SEP 16	36.79
OCT 17	37.99
NOV 29	39.61
DEC 28	40.45
JAN 24, 1989	41.08
FEB 22	41.70
MAR 08	41.79
APR 11	41.38
MAY 23	39.86
JUN 26	39.42
JUL 18	38.73
AUG 22	38.61
SEP 19	38.04
(C-23-1)6ccd-1	
Altitude 5,320	
MAR 24, 1988	15.77
JUN 16	15.60
AUG 15	15.54
OCT 17	15.43
DEC 28	15.38
FEB 22, 1989	15.23
MAR 08	15.21
APR 11	15.12
JUN 26	15.11
AUG 24	16.77

Table 24. Water levels in selected wells—Continued

Date	Water level
(C-23-1)6cdb-1	
Altitude 5,310	
JAN 13, 1988	2.98
MAR 03	2.61
APR 28	2.83
JUN 16	3.16
AUG 15	2.91
OCT 17	2.82
(C-23-2)1bca-1	
Altitude 5,233.1	
FEB 17, 1958	13.96
FEB 03, 1988	10.09
SEP 15	7.82
MAR 08, 1989	10.37
(C-23-2)1bdc-1	
Altitude 5,217.40	
SEP 13, 1956	1.9
OCT 05	1.9
NOV 05	1.9
DEC 03	1.8
JAN 03, 1957	1.8
FEB 01	1.8
28	1.6
APR 02	1.2
30	1.2
MAY 31	0.8
JUN 26	0.5
JUL 25	0.6
AUG 30	0.9
SEP 30	1.0
NOV 05	0.6
DEC 03	1.0
JAN 02, 1958	1.0
FEB 03	1.0
MAR 05	1.0
APR 02	0.8
MAY 06	0.3
JUN 03	+0.7
JUL 02	+0.7
AUG 05	+0.6
SEP 03	+0.5
OCT 02	+0.8
NOV 05	+0.6
DEC 01	+0.4
30	+0.2
JAN 28, 1959	0.0
FEB 27	+0.2
MAR 25	0.0
APR 30	0.0
MAY 26	0.1
JUN 29	0.3
(C-23-2)1bdc-1—Continued	
JUL 28, 1959	0.5
AUG 26	0.8
SEP 21	0.9
OCT 27	0.7
NOV 25	0.7
DEC 29	0.9
MAR 05, 1987	+1.3
JUL 21	+1.3
AUG 17	+2.0
SEP 02	+1.6
OCT 15	+1.8
(C-23-2)1bdc-3	
Altitude 5,220	
SEP 29, 1987	+1.19
OCT 15	+1.08
JAN 13, 1988	+0.18
FEB 19	0.10
MAR 24	+0.11
MAY 18	+0.44
JUL 14	+0.85
AUG 15	+1.62
OCT 17	+1.18
DEC 28	+0.34
FEB 22, 1989	0.10
MAR 08	0.07
MAY 23	+0.33
JUN 26	+0.35
JUL 18	+0.48
(C-23-2)1dbc-1	
Altitude 5,240	
MAY 28, 1987	19.32
MAR 25, 1988	18.50
SEP 15	18.89
MAR 08, 1989	18.92
(C-23-2)8cdc-1	
Altitude 5,380	
MAY 29, 1987	116.22
JUL 02	117.20
MAR 25, 1988	118.90
SEP 15	116.40
MAR 01, 1989	118.50
(C-23-2)9baa-1	
Altitude 5,269	
JAN 31, 1958	25.27
MAR 05	25.07
APR 02	25.20
MAY 06	25.18
JUN 03	23.81
JUL 01	22.67
(C-23-2)9baa-1—Continued	
AUG 01, 1958	21.70
SEP 04	21.17
OCT 02	20.95
NOV 03	20.87
DEC 01	20.76
29	21.04
JAN 28, 1959	21.22
FEB 27	21.63
MAR 24	22.25
APR 30	22.43
MAY 26	22.75
JUN 29	23.18
JUL 28	23.30
AUG 26	23.58
SEP 28	23.98
29	23.98
OCT 27	24.21
NOV 25	24.16
DEC 29	24.64
JAN 25, 1960	24.56
FEB 25	24.85
MAR 25	24.85
28	25.06
APR 28	25.42
MAY 23	25.47
JUN 21	25.58
JUL 25	25.53
AUG 30	25.64
SEP 27	25.95
OCT 25	26.17
NOV 25	26.14
DEC 22	26.30
MAR 05, 1987	18.00
JUL 21	17.58
AUG 17	17.50
SEP 03	17.00
OCT 15	17.68
NOV 04	17.75
DEC 09	18.20
JAN 13, 1988	18.98
FEB 19	19.85
MAR 16	19.74
APR 30	20.46
MAY 19	19.98
JUN 17	18.95
JUL 13	18.98
AUG 17	18.48
SEP 15	18.19
OCT 19	18.20
NOV 30	18.58
DEC 29	18.86

Table 24. Water levels in selected wells—Continued

Date	Water level
(C-23-2)9baa-1—Continued	
JAN 24, 1989	19.37
FEB 16	20.05
MAR 01	20.20
APR 25	20.96
MAY 23	20.45
JUN 28	20.08
JUL 26	19.95
AUG 24	19.30
SEP 20	19.85
(C-23-2)9bbb-1	
Altitude 5,360	
MAY 29, 1987	95.18
SEP 03	93.27
MAR 25, 1988	96.51
SEP 15	94.31
MAR 01, 1989	96.30
C-23-2)10bdb-1	
Altitude 5,250	
MAY 29, 1987	16.68
AUG 02	15.37
OCT 15	15.40
DEC 09	16.02
MAR 25, 1988	17.27
APR 30	17.42
MAY 19	17.47
JUN 17	16.82
JUL 13	16.54
AUG 17	15.60
SEP 15	15.20
OCT 19	15.39
NOV 30	16.04
DEC 29	16.39
MAR 01, 1989	17.15
APR 25	17.86
JUN 30	17.12
JUL 26	16.68
AUG 24	16.42
(C-23-2)11bdb-1	
Altitude 5,227.7	
MAY 18, 1988	+6.1
JUN 16	+6.3
JUL 13	+6.2
AUG 17	+8.1
SEP 15	+8.1
OCT 19	+7.5
NOV 29	+7.3
DEC 28	+6.9
JAN 26, 1989	+7.0
FEB 22	+6.5
MAR 08	+6.4
(C-23-2)11bdb-1—Continued	
APR 11, 1989	+5.8
MAY 23	+6.4
JUN 16	+6.4
JUL 26	+7.9
AUG 24	+7.10
SEP 19	+7.40
(C-23-2)14aaa-1	
Altitude 5,225.0	
AUG 08, 1956	+2.71
SEP 07	+2.55
OCT 08	+2.60
NOV 05	+2.97
DEC 04	+3.36
JAN 03, 1957	+3.33
31	+3.23
FEB 28	+3.38
APR 04	+3.13
30	+2.75
MAY 31	+2.70
JUN 26	+2.99
JUL 25	+3.08
AUG 30	+3.20
SEP 30	+3.39
NOV 05	+4.03
DEC 03	+3.87
30	+4.07
FEB 03, 1958	+4.03
MAR 05	+4.11
APR 02	+4.17
MAY 05	+3.22
JUN 02	+3.75
JUL 01	+3.72
AUG 01	+4.18
SEP 04	+4.33
OCT 02	+5.07
NOV 03	+5.24
DEC 01	+5.39
29	+5.23
JAN 28, 1959	+5.11
FEB 27	+4.12
MAR 24	+4.86
APR 30	+3.96
MAY 26	+3.62
JUN 29	+3.63
JUL 27	+3.43
AUG 26	+3.31
SEP 28	+3.70
OCT 27	+3.93
NOV 23	+4.34
DEC 29	+4.24
JAN 25, 1960	+4.10
(C-23-2)14aaa-1—Continued	
FEB 25, 1960	+4.06
MAR 28	+3.92
APR 28	+2.97
MAY 23	+3.00
JUN 21	+3.03
JUL 25	+2.90
AUG 30	+2.87
SEP 27	+3.17
OCT 25	+3.36
NOV 25	+3.88
DEC 22	+3.80
FEB 03, 1988	+5.00
SEP 15	+6.80
(C-23-2)14cdd-1	
Altitude 5,275	
FEB 03, 1988	20.7
APR 28	20.62
MAR 24	20.80
SEP 15	23.12
MAR 02, 1989	20.77
(C-23-2)14dbc-1	
Altitude 5,275	
MAY 28, 1987	51.02
JUL 21	50.69
SEP 03	50.35
OCT 15	50.28
NOV 04	50.36
DEC 08	50.53
JAN 13, 1988	50.81
FEB 18	50.99
MAR 24	50.97
APR 28	51.05
MAY 18	51.25
JUN 17	50.98
JUL 13	50.84
AUG 17	50.50
SEP 15	50.24
OCT 19	50.35
NOV 29	50.58
DEC 28	50.70
JAN 24, 1989	50.84
FEB 22	51.07
MAR 08	50.99
APR 11	51.13
MAY 23	51.13
JUN 26	50.62
JUL 18	50.68
AUG 22	50.60
SEP 19	50.66

Table 24. Water levels in selected wells—Continued

Date	Water level
(C-23-2)15dcb-4	
Altitude 5,233.99	
AUG 07, 1935	+2.56
SEP 06	+3.07
OCT 11	+3.10
NOV 23	+5.40
JAN 26, 1936	+6.40
APR 22	+3.52
JUN 17	+2.88
AUG 05	+3.70
SEP 20	+3.88
NOV 26	+5.70
FEB 06, 1937	+6.80
APR 07	+6.70
JUN 09	+4.40
AUG 03	+3.30
SEP 25	+4.70
NOV 04	+6.80
DEC 09	+8.70
FEB 23, 1938	+8.80
APR 12	+6.70
JUN 04	+4.80
AUG 25	+4.70
OCT 07	+6.80
NOV 09	+7.50
DEC 20	+9.60
FEB 28	+8.60
APR 19	+5.80
JUN 16, 1939	+4.10
AUG 22	+3.90
OCT 16	+7.30
DEC 05	+8.60
FEB 08, 1940	+9.00
APR 01	+7.90
MAY 01	+5.50
JUN 05	+4.00
DEC 05	+8.70
MAR 20, 1941	+8.60
DEC 04	+8.70
MAR 18, 1942	+9.30
AUG 10	+5.50
DEC 20	+9.60
MAR 25, 1943	+9.50
DEC 15	+7.90
MAR 18, 1944	+8.40
DEC 03	+9.60
MAR 03, 1945	+9.70
DEC 06	+8.90
MAR 20, 1946	+8.40
DEC 18	+8.30
MAR 26, 1947	+8.10
DEC 12	+9.00

Date	Water level
(C-23-2)15dcb-4—Continued	
MAR 17, 1948	+8.30
JUL 22	+4.20
DEC 12	+8.00
APR 03, 1949	+7.80
DEC 11	+9.00
MAR 27, 1950	+6.00
APR 07, 1952	+6.10
DEC 08	+7.80
MAR 17, 1953	+7.10
DEC 15	+7.10
MAR 26, 1954	+6.90
DEC 01	+5.80
MAR 22, 1955	+7.00
DEC 05	+6.30
MAR 21, 1956	+6.20
DEC 05	+6.00
FEB 27, 1957	+6.20
APR 04	+5.20
30	+4.20
MAY 31	+3.30
JUN 26	+3.10
JUL 25	+3.20
AUG 30	+3.90
SEP 30	+4.30
NOV 05	+6.60
DEC 02	+7.20
DEC 30	+7.00
FEB 03, 1958	+7.30
MAR 05	+7.30
APR 02	+7.30
MAY 05	+3.82
JUN 02	+3.68
JUL 01	+3.52
AUG 01	+3.97
SEP 04	+4.70
OCT 02	+5.30
NOV 03	+6.55
DEC 01	+7.70
29	+7.10
JAN 28, 1959	+7.00
FEB 27	+7.40
MAR 24	+7.00
APR 30	+5.00
MAY 12	+4.70
25	+4.30
JUN 29	+4.20
JUL 29	+3.68
AUG 26	+3.46
SEP 22	+5.05
OCT 27	+6.50

Date	Water level
C-23-2)15dcb-4—Continued	
NOV 23, 1959	+7.60
DEC 28	+7.50
JAN 25, 1960	+7.30
FEB 25	+6.70
MAR 28	+5.90
APR 28	+3.49
MAY 23	+2.10
JUN 21	+3.56
JUL 25	+3.02
AUG 30	+1.42
SEP 27	+4.90
OCT 25	+4.90
NOV 25	+6.20
DEC 22	+6.10
JAN 26, 1961	+6.40
FEB 23	+6.40
MAR 21	+6.50
APR 25	+4.08
MAY 22	+2.80
JUN 26	+2.10
JUL 25	+2.31
AUG 22	+3.06
SEP 28	+3.73
APR 03, 1962	+4.80
SEP 26	+3.60
APR 09, 1963	+3.20
SEP 26	+3.65
APR 02, 1964	+4.70
SEP 25	+2.62
DEC 10	+5.50
MAR 09, 1965	+5.40
SEP 14	+2.63
DEC 10	+4.60
MAR 04, 1966	+6.55
OCT 05	+3.20
MAR 06, 1967	+4.60
NOV 07	+5.80
MAR 19, 1968	+5.80
SEP 30	+3.30
APR 15, 1969	+5.10
OCT 09	+6.90
MAR 06, 1970	+7.40
SEP 09	+4.20
MAR 10, 1971	+6.60
OCT 06	+5.10
MAR 01, 1972	+7.70
OCT 04	+5.00
MAR 05, 1973	+6.60
OCT 15	+7.70
MAR 15, 1974	+7.30
OCT 04	+6.40

Table 24. Water levels in selected wells—Continued

Date	Water level
C-23-2)15dcb-4—Continued	
MAR 10, 1975	+8.40
OCT 10	+6.30
MAR 15, 1976	+7.00
OCT 08	+6.10
MAR 22, 1977	+5.70
OCT 06	+4.50
MAR 16, 1978	+5.80
OCT 03	+4.40
MAR 03, 1979	+6.15
13	+6.15
OCT 02	+4.80
MAR 06, 1980	+6.98
OCT 02	+6.77
MAR 05, 1981	+6.83
OCT 06	+6.63
MAR 02, 1982	+7.22
SEP 30	+7.45
MAR 01, 1983	+8.30
SEP 27	+8.25
MAR 07, 1984	+9.10
SEP 26	+7.30
MAR 11, 1985	+9.00
SEP 30	+7.70
MAR 20, 1986	+8.10
SEP 16	+8.30
MAR 04, 1987	+8.65
SEP 02	+5.20
MAR 16, 1988	+8.24
SEP 15	+6.24
(C-23-2)17daa-2	
Altitude 5,285	
MAY 28, 1987	21.63
SEP 29	20.19
MAR 25, 1988	23.14
SEP 15	21.23
MAR 01, 1989	22.75
(C-23-2)19bcd-1	
Altitude 5,335	
AUG 07, 1956	30.3
SEP 06	30.54
OCT 08	31.04
NOV 05	31.51
DEC 03	31.95
JAN 03, 1957	32.22
FEB 01	32.64
27	32.94
APR 03,	33.35
30	33.48
MAY 31	31.16
JUN 26	27.00

Date	Water level
(C-23-2)19bcd-1—Continued	
JUL 25, 1957	25.64
AUG 30	25.44
DEC 30	26.00
FEB 03, 1958	26.39
MAR 05	27.16
APR 02	27.28
MAY 06	26.70
JUN 03	20.13
JUL 01	17.12
AUG 01	16.92
SEP 04	16.75
OCT 02	17.15
NOV 03	17.76
DEC 01	18.45
29	19.13
JAN 28, 1959	19.91
MAR 24	21.63
MAY 26	23.31
JUN 29	23.66
JUL 28	23.87
AUG 26	24.25
SEP 28	24.74
OCT 27	25.25
NOV 25	25.79
DEC 29	26.49
JAN 25, 1960	27.04
FEB 25	27.68
SEP 24, 1962	31.26
APR 09, 1963	33.21
SEP 26	35.66
APR 07, 1964	37.55
SEP 24	38.20
MAR 09, 1965	39.07
SEP 20	34.93
DEC 10	38.25
MAR 04, 1966	34.24
OCT 05	32.80
MAR 06, 1967	33.63
NOV 07	33.35
MAR 19, 1968	34.10
SEP 30	28.80
APR 15, 1969	29.85
OCT 09	23.97
MAR 06, 1970	25.22
SEP 09	20.42
MAR 08, 1971	22.95
OCT 06	21.92
MAR 01, 1972	25.17
OCT 02	26.24
MAR 05, 1973	28.12
OCT 15	21.78

Date	Water level
(C-23-2)19bcd-1—Continued	
MAR 15, 1974	23.17
OCT 04	18.28
MAR 10, 1975	21.21
OCT 10	19.76
MAR 15, 1976	22.44
OCT 08	25.67
MAR 22, 1977	27.65
OCT 06	31.95
MAR 16, 1978	33.75
OCT 03	27.97
MAR 13, 1979	33.52 P
OCT 01	21.39 R
MAR 06, 1980	25.39 R
OCT 02	15.87 R
MAR 05, 1981	18.72 R
OCT 06	22.26 R
MAR 03, 1982	23.98 R
SEP 29	20.75 R
MAR 01, 1983	21.65 R
SEP 28	11.30 R
MAR 07, 1984	13.47 R
SEP 26	6.42 R
MAR 11, 1985	16.96 P
SEP 30	7.58 R
MAR 20, 1986	11.89
SEP 16	7.87 R
MAR 04, 1987	13.11
JUL 21	13.54
SEP 03	14.27
OCT 15	15.16
NOV 04	15.25
DEC 09	15.78
JAN 13, 1988	16.75
FEB 19	17.86
MAR 16	18.52
APR 30	18.69
MAY 19	17.29
JUN 17	16.15
JUL 13	15.90
AUG 17	16.14
SEP 13	16.42
OCT 19	16.15
NOV 29	16.67
DEC 29	17.22
JAN 23, 1989	17.93
FEB 16	18.70
MAR 01	18.99
APR 25	20.61
MAY 23	20.00
JUN 28	19.97
JUL 26	19.6

Table 24. Water levels in selected wells—Continued

Date	Water level
(C-23-2)19bcd-1—Continued	
AUG 22, 1989	19.60
SEP 20	20.84
(C-23-2)20acd-1	
Altitude 5,270	
FEB 02, 1988	19.70
JUL 15	21.04
SEP 14	20.57
OCT 19	19.56
NOV 29	19.29
DEC 29	19.38
JAN 23, 1989	19.44
FEB 16	19.70
MAR 01	19.59
APR 25	21.59
MAY 24	21.4
JUN 28	21.68
JUL 26	21.74
AUG 24	21.78
(C-23-2)23bac-1	
Altitude 5,230	
FEB 03, 1988	+3.05
MAR 24	+3.0
APR 28	+3.09
SEP 15	+1.83
MAR 02, 1989	+3.10
(C-23-2)26cab-1	
Altitude 5,246.2	
JUN 21, 1957	+8.0
FEB 03, 1988	+4.4
SEP 15	+5.57
MAR 08, 1989	+4.23
(C-23-2)26cdb-1	
Altitude 5,251.30	
OCT 01, 1935	+5.00
OCT 11	+3.13
NOV 23	+4.00
JAN 26, 1936	+5.15
APR 22	+4.30
JUN 17	+3.50
AUG 05	+3.85
SEP 30	+3.80
NOV 26	+4.75
FEB 06, 1937	+5.25
APR 07	+4.25
JUN 08	+3.35
AUG 03	+3.90
SEP 25	+4.10
DEC 08	+5.10
APR 12, 1938	+6.10
(C-23-2)26cdb-1—Continued	
JUN 05, 1938	+4.15
AUG 24	+3.90
OCT 07	+4.55
DEC 20	+5.90
MAR 01, 1939	+5.75
APR 18	+4.55
JUN 16	+3.55
AUG 22	+2.70
OCT 16	+4.30
DEC 06	+5.80
FEB 08, 1940	+6.25
APR 01	+5.00
MAY 01	+3.80
JUN 05	+3.45
DEC 05	+5.70
MAR 20, 1941	+5.30
DEC 04	+5.50
MAR 18, 1942	+6.80
AUG 19	+3.60
DEC 17	+5.40
MAR 25, 1943	+5.40
DEC 15	+5.20
MAR 18, 1944	+5.40
DEC 03	+6.10
MAR 02, 1945	+6.00
DEC 07	+4.60
MAR 20, 1946	+4.50
DEC 18	+5.60
DEC 12, 1947	+6.70
JUL 22, 1948	+5.20
DEC 12	+6.90
APR 03, 1949	+5.60
DEC 11	+7.00
MAR 29, 1950	+6.20
DEC 10	+6.30
MAR 26, 1951	+6.40
DEC 09	+5.60
APR 07, 1952	+4.70
DEC 08	+7.10
MAR 16, 1953	+5.30
DEC 15	+6.50
MAR 26, 1954	+5.40
DEC 01	+5.70
MAR 22, 1955	+4.60
DEC 05	+4.80
MAR 21, 1956	+5.30
AUG 29	+3.40
SEP 07	+3.23
25	+4.10
OCT 22	+4.60
29	+4.70
(C-23-2)26cdb-1—Continued	
NOV 05, 1956	+4.60
DEC 03	+4.70
JAN 03, 1957	+4.70
FEB 28	+5.00
APR 02	+4.90
30	+5.30
MAY 29	+4.80
JUN 25	+5.60
JUL 24	+5.30
AUG 28	+6.10
SEP 27	+6.00
NOV 05	+6.50
DEC 30	+5.80
FEB 03, 1958	+5.05
MAR 06	+4.70
APR 02	+5.30
MAY 05	+4.80
JUN 02	+5.30
JUL 01	+5.30
AUG 01	+4.70
SEP 04	+4.05
JAN 28, 1959	+4.10
FEB 27	+4.05
MAR 24	+4.30
APR 30	+4.20
MAY 25	+4.15
JUN 25	+4.57
JUL 27	+3.00
AUG 26	+2.10
SEP 24	+1.75
OCT 27	+2.75
NOV 23	+1.52
DEC 29	+1.60
MAY 18, 1961	+1.00
APR 03, 1962	+2.10
SEP 26	+1.15
APR 09, 1963	+1.60
SEP 26	+1.00
APR 02, 1964	+1.90
SEP 25	+1.15
DEC 15	+1.10
MAR 10, 1965	+2.67
SEP 14	+1.95
MAR 04, 1966	+1.20
OCT 05	+2.10
MAR 06, 1967	+2.20
NOV 07	+4.20
MAR 19, 1968	+3.10
SEP 30	+2.30
APR 15, 1969	+4.00
OCT 22	+0.50

Table 24. Water levels in selected wells—Continued

Date	Water level
(C-23-2)26cdb-1—Continued	
MAR 06, 1970	+5.30
SEP 09	+3.65
MAR 08, 1971	+2.80
OCT 16	+2.50
OCT 04, 1972	+2.10
MAR 05, 1973	+1.70
OCT 12	+2.20
MAR 22, 1974	+1.70
OCT 10	+1.10
MAR 12, 1975	+1.30
OCT 10	+1.20
MAR 15, 1976	+1.00
OCT 08	+1.00
MAR 22, 1977	+0.40
OCT 06	+1.22
MAR 16, 1978	1.70
OCT 03	1.95
MAR 12, 1979	1.83
OCT 02	2.52
MAR 05, 1980	2.19
OCT 02	2.03
MAR 05, 1981	2.82
OCT 06	2.39
MAR 02, 1982	2.83
SEP 30	2.13
MAR 01, 1983	2.65
SEP 27	0.79
MAR 07, 1984	0.93
MAR 18, 1987	1.10
JUL 21	0.73
SEP 03	0.70
MAR 16, 1988	0.92
(C-23-2)29cdb-2	
Altitude 5,250	
SEP 28, 1987	2.85
OCT 14	0.46
NOV 03	1.75
DEC 08	2.08
JAN 14, 1988	2.82
FEB 19	2.27
MAR 24	2.71
APR 28	1.74
MAY 19	0.43
JUL 14	2.20
JUL 15	2.38
AUG 16	2.47
SEP 15	2.69
OCT 19	2.34
NOV 30	2.77
DEC 29	2.83
JAN 24, 1989	2.95
(C-23-2)29cdb-2—Continued	
APR 28, 1989	2.20
JUN 29	2.31
(C-23-2)29dad-1	
Altitude 5,250	
JUN 02, 1988	+4.8
JUL 14	+4.41
AUG 16	+5.83
SEP 15	+5.17
OCT 19	+6.10
NOV 29	+6.10
DEC 29	+6.10
MAR 01, 1989	+6.00
APR 25	+4.8
AUG 24	+4.02
(C-23-2)29dcd-1	
Altitude 5,250	
JAN 14, 1988	4.04
FEB 19	3.53
MAR 24	3.44
JUL 14	3.76
SEP 15	3.23
OCT 19	3.92
NOV 29	4.27
DEC 29	4.25
JAN 24, 1989	4.25
(FEB 16,	4.21
MAR 01	3.00
APR 25	3.55
MAY 24	2.92
JUN 29	3.79
(C-23-2)30baa-2	
Altitude 5,290.15	
SEP 27, 1956	+8.00
OCT 09	+8.60
NOV 02	+7.80
DEC 06	+7.80
JAN 03, 1957	+7.40
FEB 01	+7.20
27	+7.00
APR 02	+6.60
30	+6.10
MAY 31	+7.40
JUN 26	+9.40
JUL 25	+10.90
AUG 30	+12.20
SEP 30	+12.20
NOV 05	+12.30
DEC 02	+11.40
30	+11.40
(C-23-2)30baa-2—Continued	
FEB 03, 1958	+12.20
MAR 05	+11.70
APR 02	+11.25
MAY 06	+11.50
JUN 03	+15.30
JUL 01	+17.40
AUG 01	+18.25
SEP 05	+17.75
OCT 02	+17.30
NOV 03	+17.50
DEC 29	+17.30
JAN 28, 1959	+14.50
FEB 27	+14.90
MAR 24	+14.40
APR 30	+13.25
MAY 26	+14.80
JUN 29	+14.80
JUL 28	+14.70
AUG 26	+14.10
SEP 28	+13.60
OCT 27	+12.75
NOV 25	+12.10
DEC 29	+11.65
JAN 25, 1960	+11.30
FEB 25,	+10.65
MAR 28	+9.90
APR 28	+10.00
MAY 23	+10.00
JUN 21	+10.40
JUL 25	+10.40
AUG 30	+9.90
SEP 26	+9.60
OCT 25	+9.70
NOV 25	+9.90
DEC 22	+9.00
MAR 05, 1987	+19.7
JUL 01	+20.45
AUG 04	+19.20
SEP 03	+20.3
OCT 15	+19.3
NOV 04	+19.2
DEC 09	+19.1
JAN 13, 1988	+18.7
FEB 18	+18.0
MAR 16	+16.40
APR 30	+17.2
MAY 19	+17.5
JUN 17	+18.9
JUL 13	+19.9
AUG 17	+19.1
SEP 14	+18.6

Table 24. Water levels in selected wells—Continued

Date	Water level
(C-23-2)30baa-2—Continued	
OCT 19, 1988	+18.8
NOV 30	+18.2
DEC 29	+17.35
JAN 24, 1989	+16.70
MAR 01	+15.70
APR 25	+15.40
MAY 24	+16.50
JUN 29	+16.60
JUL 25	+17.30
AUG 22	+15.70
SEP 20	+15.40
(C-23-2)31dcb-3	
Altitude 5,254	
SEP 28, 1959	+5.27
OCT 20	+5.46
27	+4.77
NOV 23	+5.58
DEC 28	+5.55
JAN 25, 1960	+5.35
FEB 25	+5.35
MAR 29	+4.85
APR 28	+4.45
MAY 23	+4.55
JUN 22	+4.65
JUL 25	+4.55
AUG 30	+4.14
SEP 26	+4.23
OCT 25	+4.27
NOV 25	+4.55
DEC 22	+4.25
JAN 26, 1961	+4.15
FEB 05	+4.10
10	+4.11
15	+4.15
20	+4.00
25	+4.02
28	+4.00
MAR 05	+4.06
10	+4.07
15	+4.09
20	+4.06
25	+4.12
31	+4.04
APR 05	+4.10
10	+3.90
15	+4.00
20	+4.12
25	+4.05
30	+3.94
MAY 05	+3.93
10	+3.87
(C-23-2)31dcb-3—Continued	
MAY 15, 1961	+3.80
20	+3.83
25	+3.85
31	+3.89
JUN 05	+3.92
10	+3.88
15	+3.57
20	+3.92
25	+3.91
30	+3.90
JUL 05	+3.93
10	+3.67
15	+3.89
20	+3.75
25	+3.81
31	+3.91
AUG 05	+3.90
10	+3.89
15	+3.87
20	+3.81
25	+3.81
31	+3.72
SEP 05	+3.40
10	+3.69
15	+3.70
20	+3.65
25	+3.70
30	+3.71
OCT 05	+3.46
10	+3.67
15	+3.67
20	+3.77
25	+3.79
31	+3.89
NOV 05	+3.91
10	+4.06
15	+4.20
20	+4.31
25	+4.26
30	+4.17
DEC 05	+4.14
10	+4.27
15	+4.28
20	+4.39
25	+4.33
31	+4.27
JAN 05, 1962	+4.39
10	+4.10
15	+4.53
20	+4.53
25	+4.25
(C-23-2)31dcb-3—Continued	
JAN 31, 1962	+4.18
FEB 05	+4.47
10	+4.06
15	+3.88
20	+3.90
25	+3.84
28	+3.87
MAR 05	+3.95
10	+3.93
15	+4.01
20	+3.75
25	+3.75
31	+3.77
APR 05	+3.42
10	+3.62
15	+3.64
20	+3.63
25	+3.56
30	+3.50
MAY 05	+3.57
10	+3.63
15	+3.54
20	+3.79
25	+3.79
31	+3.97
JUN 05	+3.70
10	+4.11
15	+4.21
20	+4.24
25	+4.30
30	+4.01
JUL 05	+4.48
10	+4.50
15	+4.30
20	+4.62
25	+4.80
31	+4.90
AUG 05	+4.87
10	+4.99
15	+4.70
20	+4.94
25	+5.04
31	+5.12
SEP 05	+5.12
10	+5.19
15	+4.99
20	+4.95
25	+5.23
30	+5.26
OCT 05	+5.33
10	+5.26

Table 24. Water levels in selected wells—Continued

Date	Water level
(C-23-2)31dcb-3—Continued	
OCT 15 1962	+5.17
20	+5.19
25	+5.20
31	+5.21
NOV 05	+5.20
10	+5.21
15	+5.26
20	+5.30
25	+5.25
30	+5.14
DEC 05	+5.10
10	+5.23
15	+5.42
20	+5.11
25	+5.33
31	+5.33
JAN 05, 1963	+5.30
10	+5.23
15	+5.20
20	+5.25
25	+5.38
31	+5.26
FEB 05	+4.97
10	+5.04
15	+5.44
20	+5.02
25	+4.92
28	+4.94
MAR 05	+4.95
10	+5.06
15	+5.09
20	+4.90
25	+4.88
31	+4.98
APR 05	+4.90
10	+4.42
15	+4.64
20	+4.46
25	+4.41
30	+4.31
MAY 05	+4.09
10	+4.29
15	+4.29
20	+3.96
27	+4.22
JUN 03	+4.35
SEP 24, 1964	+3.39
MAR 09, 1965	+4.50
SEP 14	+5.79
DEC 10	+3.85
MAR 04, 1966	+5.60
(C-23-2)31dcb-3—Continued	
OCT 05, 1966	+5.02
MAR 06, 1967	+5.98
NOV 07	+5.50
MAR 19, 1968	+5.27
SEP 30	+6.74
APR 15, 1969	+6.32
OCT 22	+8.75
MAR 06, 1970	+8.15
SEP 09	+8.05
MAR 10, 1971	+6.95
OCT 15	+6.25
MAR 01, 1972	+7.10
OCT 04	+6.45
MAR 05, 1973	+7.20
OCT 12	+7.90
MAR 15, 1974	+7.50
OCT 04	+5.80
MAR 12, 1975	+6.90
OCT 10	+7.20
MAR 15, 1976	+6.70
OCT 08	+6.50
MAR 22, 1977	+5.40
OCT 06	+5.20
MAR 16, 1978	+4.10
OCT 04	+4.90
MAR 13, 1979	+4.40
OCT 01	+6.50
MAR 06, 1980	+4.10
OCT 02	+8.30
MAR 04, 1981	+7.20
OCT 06	+6.20
MAR 02, 1982	+6.50
SEP 30	+9.10
MAR 01, 1983	+6.60
SEP 28	+10.00
MAR 07, 1984	+8.80
SEP 26	+10.10
MAR 11, 1985	+9.10
SEP 30	+9.80
MAR 20, 1986	+6.90
SEP 16	+8.60
MAR 04, 1987	+6.90
JUL 21	+8.1
SEP 04	+8.8
OCT 14	+9.3
NOV 04	+8.5
DEC 08	+8.5
JAN 13, 1988	+8.1
MAR 16	+6.40
APR 21	+7.1
MAY 18	+6.7
(C-23-2)31dcb-3—Continued	
JUN 23, 1988	+8.1
JUL 13	+6.9
AUG 16	+7.9
SEP 13	+8.5
OCT 19	+8.58
NOV 29	+7.90
MAR 08, 1989	+7.00
APR 11	+6.50
MAY 24	+6.70
JUN 29	+7.2
JUL 26	+6.3
AUG 22	+7.60
SEP 20	+6.95
(C-23-2)34aba-1 Altitude 5,247	
SEP 07, 1956	+6.60
OCT 09	+7.20
NOV 05	+7.50
DEC 03	+8.90
JAN 02, 1957	+9.00
31	+8.75
FEB 28	+8.50
JUL 23	+10.30
AUG 28	+12.10
SEP 27	+11.70
NOV 15	+11.30
DEC 02	+11.20
DEC 30	+11.30
FEB 03, 1958	+10.75
MAR 06	+10.70
APR 02	+10.00
MAY 05	+9.20
JUN 02	+10.00
JUL 01	+9.50
AUG 01	+9.00
SEP 04	+9.00
OCT 02	+8.75
MAY 25, 1959	+8.24
JUN 25	+8.50
JUL 27	+7.50
AUG 26	+7.60
SEP 28	+7.80
OCT 27	+7.80
NOV 23	+8.90
DEC 29	+8.00
JAN 25, 1960	+8.60
FEB 25	+7.90
MAR 29	+7.80
APR 28	+7.00
MAY 23	+6.65
JUN 21	+6.90

Table 24. Water levels in selected wells—Continued

Date	Water level
(C-23-2)34aba-1—Continued	
JUL 25, 1960	+6.10
AUG 30	+6.15
OCT 19	+5.11
NOV 30	+4.42
SEP 27	+6.70
OCT 25	+7.90
NOV 25	+9.15
DEC 22	+8.20
FEB 03, 1988	+4.8
SEP 15	+5.44
FEB 16, 1989	+3.53
MAR 01	+3.66
APR 11	+3.49
MAY 24	+3.61
JUN 29	+4.02
JUL 26	+4.31
AUG 24	+4.57
SEP 20	+5.22
(C-23-3)25dda-1	
Altitude 5,290	
APR 28, 1988	5.74
SEP 15	5.10
MAR 08, 1989	5.59
(C-23-3)36abd-1	
Altitude 5,280	
APR 29, 1988	16.59
SEP 13	14.04 R
MAR 08, 1989	15.50
(C-23-3)36bdd-1	
Altitude 5,275	
JUL 23, 1956	11.59
APR 28, 1988	8.13
SEP 15	8.08
MAR 01, 1989	7.92
(C-23-3)36dcd-1	
Altitude 5,260	
SEP 28, 1987	+4.4
OCT 14	+4.6
NOV 04	+4.6
DEC 20	+4.6
MAR 25, 1988	+4.33
APR 28	+4.26
MAY 19	+4.10
JUN 17	+3.76
JUL 13	+4.09
AUG 16	+4.21
SEP 13	+5.54
OCT 19	+4.68
NOV 29	+4.78
(C-23-3)36dcd-1—Continued	
JAN 24, 1989	+4.58
FEB 22	+4.41
MAR 08	+4.66
APR 11	+4.06
MAY 23	+3.81
JUN 28	+3.65
JUL 19	+3.20
AUG 24	+3.37
(C-24-2)5abc-1	
Altitude 5,250	
APR 19, 1957	+1.67
APR 28, 1988	+3.6
SEP 15	+3.72
MAR 09, 1989	+4.07
(C-24-2)6abc-1	
Altitude 5,255	
OCT 31, 1956	+3.64
NOV 05	+3.75
12	+3.82
15	+3.05
NOV 18, 1957	+4.64
26	+4.70
DEC 02	+4.85
09	+4.70
23	+4.50
30	+4.49
JAN 06, 1958	+4.50
13	+4.50
18	+4.50
27	+4.50
FEB 03	+4.50
10	+4.50
17	+4.50
24	+4.50
MAR 03	+4.70
10	+4.50
17	+4.50
25	+4.50
31	+4.00
APR 07	+4.00
NOV 10	+6.00
17	+5.75
24	+6.00
DEC 01	+5.75
22	+5.65
29	+5.50
JAN 05, 1959	+5.25
NOV 12	+5.10
23	+5.01
DEC 28	+4.95
(C-24-2)6abc-1—Continued	
JAN 25, 1960	+4.80
FEB 25	+4.80
MAR 29	+4.50
NOV 25	+3.40
JAN 26, 1961	+3.10
FEB 23	+3.00
MAR 21	+3.02
MAR 05, 1987	+4.7
MAY 11, 1988	+4.3
JUN 03	+6.8
SEP 14	+6.9
MAR 09, 1989	+6.79
(C-24-2)7bac-2	
Altitude 5,262.90	
OCT 12, 1935	0.22
NOV 23	0.06
JAN 26, 1936	0.26
APR 20	0.64
JUN 17	0.29
AUG 05	+0.13
SEP 30	+0.25
NOV 26	+0.72
FEB 07, 1937	+0.48
APR 07	0.06
MAY 01	0.25
15	0.05
JUN 08	+1.10
AUG 03	+2.40
SEP 26	+2.98
NOV 04	+3.20
DEC 07	+3.15
FEB 22, 1938	+2.40
APR 12	+1.95
JUN 05	+2.85
OCT 07	+4.80
DEC 20	+3.95
MAR 02, 1939	+2.70
APR 19	+2.22
JUN 16	+2.25
AUG 22	+2.71
OCT 17	+2.60
DEC 07	+2.65
FEB 08, 1940	+2.25
APR 01	+2.10
MAY 01	+1.65
JUN 05	+1.93
SEP 19, 1956	2.54
OCT 09	2.60
NOV 02	2.62
30	2.57
JAN 02, 1957	2.62

Table 24. Water levels in selected wells—Continued

Date	Water level
(C-24-2)7bac-2—Continued	
FEB 26, 1957	2.39
APR 01	2.20
JUNE 29	2.94
MAY 29	2.66
JUN 25	2.13
JUL 24	1.73
AUG 28	1.81
SEP 27	1.20
NOV 04	1.16
DEC 02	0.82
30	0.85
FEB 03, 1958	0.92
MAR 06	1.02
APR 02	1.11
MAY 05	1.57
JUN 02	0.32
JUL 01	+0.12
AUG 01	+0.78
SEP 04	+0.86
OCT 02	+0.93
NOV 03	+1.13
DEC 01	+1.20
29	+1.03
JAN 28, 1959	+0.92
FEB 27	+0.65
MAR 24	+0.55
APR 30	0.17
MAY 25	0.22
JUN 25	0.45
JUL 27	0.55
AUG 26	0.70
SEP 28	1.03
OCT 27	1.30
NOV 23	0.67
DEC 28	0.66
JAN 25, 1960	0.90
FEB 25	0.92
MAR 29	1.08
APR 28	1.95
MAY 23	1.66
JUN 22	1.73
JUL 25	1.85
AUG 30	2.46
SEP 26	2.18
OCT 25	2.15
NOV 25	1.77
DEC 22	1.90
JAN 26, 1961	2.07
FEB 23	2.18
MAR 21	2.21
APR 25	2.25
(C-24-2)7bac-2—Continued	
MAY 22, 1961	2.41
JUN 26	2.41
JUL 25	2.56
AUG 22	2.57
SEP 26	2.73
OCT 30,	2.55
NOV 27	2.25
DEC 26	2.24
JAN 31, 1962	2.24
MAR 05	2.35
26	2.60
APR 30	2.90
MAY 28	2.84
JUN 26	2.43
JUL 26	1.48
AUG 28	1.46
SEP 24	1.09
OCT 29	1.17
NOV 30	1.11
DEC 26	1.15
JAN 25, 1963	1.18
FEB 25	1.40
MAR 25	1.48
APR 29	2.19
MAY 27	2.36
JUN 24	2.20
JUL 30	2.75
AUG 28	2.46
SEP 26	2.68
OCT 28	2.62
NOV 27	2.40
DEC 30	2.47
JAN 31, 1964	2.49
FEB 27	2.58
MAR 31	2.71
APR 30	3.37
MAY 28	3.63
JUN 30	3.77
JUL 31	3.97
AUG 31	4.08
SEP 24	3.03
OCT 30	2.98
DEC 10	2.68
31	2.80
JAN 29, 1965	2.83
FEB 27	2.86
MAR 09	3.00
MAR 31	2.93
MAY 05	3.10
26	4.12
JUN 30	3.16
(C-24-2)7bac-2—Continued	
AUG 31, 1965	1.82
SEP 14	1.60
SEP 30,	1.36
OCT 31	0.99
DEC 03	0.81
31	0.64
FEB 11, 1966	1.05
MAR 04	1.00
29	1.32
APR 28	1.68
MAY 31	1.60
JUN 30	1.68
JUL 31	1.76
AUG 31	1.38
SEP 28	2.05
OCT 31	1.36
NOV 30	1.27
DEC 30	1.30
FEB 02, 1967	1.17
MAR 02	1.56
28	1.60
JUN 02	1.90
30	1.72
AUG 08	2.42
31	2.42
OCT 02	1.00
NOV 01	0.89
JAN 04, 1968	1.20
FEB 02	1.17
MAR 01	1.15
25	1.15
JUL 01	0.95
31	0.57
SEP 05	0.09
30	+0.30
OCT 28	+0.60
NOV 27	+0.30
JAN 08, 1969	+0.30
FEB 03	+0.40
MAR 07	+0.55
26	0.00
MAY 14	+0.25
JUN 09	+0.23
AUG 05	+2.20
SEP 03	+3.00
30	+3.20
NOV 04	+2.80
26	+2.60
JAN 05, 1970	+2.20
30	+1.70
FEB 27	+1.70

Table 24. Water levels in selected wells—Continued

Date	Water level
(C-24-2)7bac-2—Continued	
MAR 26, 1970	+1.30
MAY 08	+0.60
29	+1.30
JUN 26	+1.15
AUG 05	+1.80
28	+1.70
OCT 01	+2.55
27	+2.20
NOV 23	+2.10
DEC 31	+2.20
JAN 26, 1971	+1.50
FEB 26	+1.10
MAR 29	+0.80
APR 30	0.45
MAY 27	0.66
JUN 30	0.75
AUG 09	+0.90
SEP 13	+1.20
OCT 15	+0.80
NOV 19	+0.75
DEC 27	+0.60
JAN 24, 1972	+0.20
MAR 01	+0.21
28	0.20
JUN 26	0.23
JUL 28	1.20
AUG 23	0.80
SEP 20	0.85
OCT 05	0.68
NOV 17	0.45
DEC 20	0.35
JAN 24, 1973	0.57
FEB 23	0.70
MAR 05	0.70
APR 04	0.93
MAY 07	0.93
JUL 05	+2.20
AUG 14	+2.10
OCT 12	+2.25
NOV 15	+2.30
DEC 10	+2.20
JAN 30, 1974	+2.05
MAR 15	+1.33
APR 26	+0.35
MAY 28	0.00
JUL 03	0.60
AUG 20	0.20
SEP 30	+0.25
NOV 27	+1.00
JAN 15, 1975	+0.57
FEB 12	+0.35
(C-24-2)7bac-2—Continued	
MAR 12, 1975	+0.20
APR 18	+0.05
MAY 04	+1.10
JUL 09	+0.72
AUG 12	+0.12
SEP 12	+0.25
OCT 20	+0.35
NOV 24	+0.70
DEC 16	+0.73
MAR 15, 1976	0.06
JUN 07	0.60
26	0.63
JUL 20	0.59
AUG 26	0.63
SEP 08	0.25
OCT 08	0.25
NOV 24	0.22
DEC 29	0.42
MAR 22, 1977	0.90
APR 20	2.13
MAY 24	1.46
JUL 14	2.14
SEP 01	1.95
OCT 05	2.32
JAN 10, 1978	1.81
MAR 16	1.83
APR 11	2.43
MAY 11	3.09
JUL 09	2.92
28	1.92
SEP 19	1.18
OCT 04	1.47
NOV 08	1.45
DEC 20	1.37
JAN 12, 1979	1.50
FEB 20	1.60
MAR 13	1.70
OCT 01	+1.10
NOV 08	1.45
MAR 06, 1980	+0.16
OCT 02	+2.35
MAR 04, 1981	+1.25
OCT 06	+1.49
MAR 02, 1982	+1.20
SEP 30	+1.58
MAR 01, 1983	+1.00
SEP 29	+4.15
MAR 07, 1984	+2.40
SEP 26	+3.70
MAR 11, 1985	+2.90
SEP 30	+3.40
(C-24-2)7bac-2—Continued	
MAR 20, 1986	+1.45
SEP 16	+2.60
MAR 04, 1987	+1.50
AUG 05	+2.30
SEP 16	+2.70
OCT 14	+2.50
NOV 04	+1.96
SEP 20	+0.89
DEC 09	+1.75
FEB 19, 1988	+1.15
MAR 16	+1.10
APR 27	+1.05
MAY 18	+0.25
JUN 17	+0.66
JUL 14	+0.89
AUG 16	+1.44
SEP 14	+2.49
OCT 19	+2.37
NOV 29	+1.92
FEB 22, 1989	+1.01
MAR 09	+1.00
APR 11	+0.18
MAY 23	0.09
JUN 26	+0.78
JUL 19	+0.66
(C-24-2)17bbb-1 Altitude 5,260	
MAY 13, 1988	1.02
SEP 13	0.63
OCT 19	0.87
NOV 29	1.08
DEC 29	1.11
JAN 25, 1989	1.30
FEB 22	1.42
MAR 09	1.13
APR 11	1.67
MAY 23	1.71
JUN 26	2.11
JUL 19	2.40
AUG 22	2.30
SEP 20	2.05
(C-24-3)1aad-1 Altitude 5,255	
APR 11, 1957	+2.5
MAY 12, 1988	+5.40
SEP 16	+5.35
MAR 08, 1989	+5.66

Table 24. Water levels in selected wells—Continued

Date	Water level
(C-24-3)1bcb-1	
Altitude 5,275	
AUG 08, 1988	4.02
SEP 15	3.57
MAR 02, 1989	5.47
SEP 20	5.41
(C-24-3)2ddd-1	
Altitude 5,270	
SEP 19, 1956	3.2
OCT 03	3.3
NOV 02	3.3
30	3.1
JAN 02, 1957	2.8
31	2.5
FEB 26	2.4
APR 01	2.0
29	2.5
MAY 29	2.6
JUN 25	2.2
JUL 23	2.1
AUG 28	2.1
SEP 27	1.9
NOV 04	1.7
DEC 02	1.5
30	1.3
FEB 03, 1958	1.3
MAR 06	1.2
APR 01	1.3
MAY 05	1.4
JUN 02	0.1
JUL 01	0.3
AUG 01	0.3
SEP 04	0.2
OCT 01	+0.1
NOV 03	+0.2
DEC 01	+0.3
DEC 29	0.3
JAN 28, 1959	+0.3
FEB 27,	+0.5
MAR 24	+0.3
APR 30	0.2
MAY 25	0.4
JUN 25	1.0
JUL 27	1.4
SEP 28	1.7
OCT 27	1.6
NOV 23	1.3
DEC 28	1.2
JAN 25, 1960	1.3
FEB 25	1.0
MAR 29	1.0
APR 26	1.5
(C-24-3)2ddd-1—Continued	
MAY 23, 1960	1.5
JUN 22	2.0
JUL 25	2.4
AUG 30	2.9
SEP 26	2.9
OCT 25	2.7
NOV 25	2.2
DEC 22	2.2
SEP 15, 1988	6.46
MAR 08, 1989	5.89
(C-24-3)10bcc-1	
Altitude 5,390	
SEP 19, 1956	116.19
OCT 03	116.40
NOV 02	116.83
30	117.10
JAN 02, 1957	117.13
31	117.17
FEB 26	117.20
APR 01	117.38
29	118.50
MAY 29	117.59
JUN 25	117.32
JUL 24	116.29
AUG 28	115.59
SEP 27	115.27
NOV 04	115.31
DEC 02	115.26
30	115.13
APR 01, 1958	115.77
JUN 02	113.26
MAR 05, 1987	108.27
JUL 20	105.05
SEP 28	105.77
OCT 14	106.22
DEC 07	107.14
MAR 24, 1988	109.42
APR 29	107.88
MAY 18	107.50
JUN 17	106.98
JUL 14	105.55
AUG 16	105.38
SEP 13	105.76
OCT 20	106.69
NOV 30	107.42
DEC 29	107.93
JAN 26, 1989	108.72
FEB 23	109.40
MAR 10	109.77
APR 12	110.11
MAY 23	106.60
(C-24-3)10bcc-1—Continued	
JUN 26, 1989	106.59
JUL 26	107.59
AUG 28	109.01
SEP 20	107.52
(C-24-3)13bcc-1	
Altitude 5,280	
MAY 31, 1988	5.46
JUL 16	4.85
SEP 13	3.33
OCT 19	4.87
NOV 29	4.51
DEC 29	4.96
JAN 26, 1989	5.54
FEB 22	5.96
MAR 09	6.04
APR 11	6.55
MAY 23	6.36
JUN 28	5.86
JUL 26	6.13
AUG 24	5.90
(C-24-3)16dbc-1	
Altitude 5,480	
MAY 31, 1988	208.92
SEP 14	196.53
OCT 20	196.21
NOV 30	196.35
DEC 29	196.32
JAN 26, 1989	196.86
FEB 23	197.11
MAR 10	197.50
APR 12	197.94
(C-24-3)16dbc-1	
Altitude 5,480	
MAY 23, 1989	197.94
JUN 28	198.05
JUL 16	197.94
AUG 24	197.75
SEP 20	197.86
(C-24-3)21dad-1	
Altitude 5,405	
JUL 22, 1987	107.48
SEP 28	107.38
OCT 14	107.43
(C-24-3)23bad-1	
Altitude 5,298.50	
JUL 11, 1956	23.30
SEP 04	24.40
OCT 03	25.04

Table 24. Water levels in selected wells—Continued

Date	Water level
(C-24-3)23bad-1—Continued	
NOV 02, 1956	25.26
30	25.31
JAN 02, 1957	25.78
31	24.30
FEB 26	24.00
APR 01	23.55
29	24.16
MAY 29	24.17
JUN 25	23.38
JUL 23	23.13
AUG 28	23.10
SEP 27	23.02
NOV 04	23.19
DEC 02	23.00
DEC 30	22.84
FEB 03, 1958	22.93
MAR 06	23.04
APR 01	23.07
MAY 05	22.63
JUN 02	20.29
JUL 01	20.47
AUG 01	20.45
SEP 04	20.67
OCT 01	20.18
NOV 03	20.55
DEC 01	20.72
30	20.76
JAN 29, 1959	21.00
FEB 27	20.67
MAR 24	20.75
APR 30	20.98
MAY 25	21.12
JUN 25	21.79
JUL 27	22.45
AUG 26	22.37
SEP 28	22.75
OCT 27	22.71
NOV 23	22.64
DEC 28	22.64
DEC 16, 1960	24.17
MAR 05, 1987	19.90
JUL 20	19.50
SEP 28	19.21
OCT 14	19.40
DEC 07	20.50
MAR 24, 1988	20.30
APR 29	19.95
MAY 18	19.52
JUN 17	19.62
JUL 14	19.28
AUG 16	19.52
(C-24-3)23bad-1—Continued	
SEP 13, 1988	18.84
OCT 19	19.30
NOV 29	19.94
DEC 28	20.42
JAN 26, 1989	20.59
FEB 22	20.80
MAR 09	20.45
APR 11	20.82
MAY 23	20.41
JUN 26	20.10
JUL 26	20.32
(C-24-3)25bdb-1 Altitude 5,500	
AUG 12, 1988	183.00
SEP 13	182.61
OCT 19	182.55
NOV 29	183.44
DEC 28	183.48
JAN 25, 1989	184.02
FEB 22	184.52
MAR 09	184.63
APR 11	184.75
MAY 23	184.72
JUN 28	184.88
JUL 19	184.87
AUG 23	184.38
SEP 20	184.59
(C-24-3)27ccd-1 Altitude 5,305	
MAR 27, 1957	19.20
MAY 31, 1988	9.73
JUL 14	7.95
AUG 16	7.51
SEP 13	7.39
OCT 19	7.96
NOV 29	9.21
DEC 29	10.19
JAN 25, 1989	11.10
FEB 22	11.95
MAR 09	11.88
APR 11	12.08
MAY 23	10.71
JUN 27	10.48
JUL 26	10.10
AUG 22	10.00
SEP 20	10.90
(C-24-3)34cdb-1 Altitude 5,310	
JUL 21, 1987	8.86
AUG 20	8.00
SEP 28	7.97
OCT 14	8.11
DEC 07	10.02
MAR 24, 1988	13.14
APR 28	12.35
MAY 18	12.01
JUN 03	10.93
23	10.38
JUL 15	9.09
AUG 16	8.29
SEP 13	8.03
OCT 19	8.58
NOV 29	9.88
DEC 29	11.05
JAN 25, 1989	12.14
FEB 22	13.19
MAR 09	13.52
APR 11	13.75
MAY 23	12.52
JUN 27	12.48
AUG 23	11.74
SEP 20	12.25
(C-24-3)35bdd-1 Altitude 5,322.63	
JUL 21, 1956	43.33
SEP 04	44.26
27	44.95
OCT 02	45.03
05	45.09
10	45.18
15	45.26
20	45.33
25	45.42
31	45.42
NOV 05	45.42
10	45.51
15	45.57
20	45.59
25	45.62
30	45.66
DEC 05	45.49
10	45.45
15	45.40
20	45.44
25	45.42
31	45.50
JAN 05, 1957	45.45
10	45.47

Table 24. Water levels in selected wells—Continued

Date	Water level
(C-24-3)35bdd-1—Continued	
JAN 15, 1957	45.48
20	45.50
25	45.56
31	45.55
FEB 05	45.54
10	45.50
15	45.49
20	45.57
25	45.56
28	45.49
MAR 05	45.41
10	45.35
15	45.42
20	45.36
25	45.29
31	45.22
APR 05	45.19
10	45.24
15	45.38
20	45.46
25	45.58
30	45.65
MAY 05	45.73
10	45.73
15	45.82
20	45.81
25	45.75
31	45.53
JUN 05	45.31
10	44.90
15	44.65
20	44.39
25	44.23
30	44.05
JUL 05	43.81
10	43.69
15	43.50
20	43.26
25	42.90
31	42.72
AUG 05	42.61
10	42.55
15	42.53
20	42.31
25	42.23
31	42.21
SEP 05	42.10
10	41.95
15	41.84
20	41.84
25	41.79
(C-24-3)35bdd-1—Continued	
SEP 30, 1957	41.82
OCT 05	41.77
10	41.69
15	41.69
20	41.73
25	41.77
31	41.78
NOV 05	41.77
10	41.76 E
15	41.70
20	41.68
25	41.69
30	41.68
DEC 05	41.65
10	41.67
15	41.65
20	41.69
25	41.76
31	41.85
JAN 05, 1958	41.89
10	41.87
15	42.03
20	42.09
25	42.13
31	42.29
FEB 05	42.32
10	42.40
15	42.45
20	42.50
25	42.50
28	42.59
MAR 05	42.67
10	42.79
15	42.85
20	42.91
25	42.91
31	42.89
APR 05	43.04
10	43.16
15	43.25
20	43.32
25	43.40
30	43.13
MAY 05	42.90
10	42.55
15	42.13
20	41.54
25	40.66
31	39.42
JUN 05	38.94
10	38.48
(C-24-3)35bdd-1—Continued	
JUN 15, 1958	38.24
20	38.00
25	37.69
30	37.56
JUL 05	37.18
10	37.04
15	36.75
20	36.62
25	36.49
31	36.42
AUG 05	36.32
10	36.25
15	36.15
20	35.94
25	35.88
30	35.83
SEP 05	35.78
10	35.76
15	35.79
20	35.82
25	35.93
30	35.90
OCT 05	35.96
10	35.97
15	35.98
20	36.07
25	36.06
31	36.15
NOV 05	36.10
10	36.24
15	36.25
20	36.57
25	36.60
30	36.79
DEC 05	36.82
10	37.04
15	37.12
20	37.29
25	37.35
31	37.53
JAN 05, 1959	37.57
10	37.69
15	37.80
20	37.87
25	38.01
31	38.19
FEB 05	38.32
10	38.38
15	38.40
20	38.40
25	38.46

Table 24. Water levels in selected wells—Continued

Date	Water level
(C-24-3)35bdd-1—Continued	
FEB 28, 1959	38.50
MAR 05	38.54
10	38.59
15	38.74
20	38.81
25	38.81
31	38.90
APR 05	38.91
10	39.04
15	39.13
20	39.30
25	39.30
30	39.42
MAY 05	39.53
10	39.57
15	39.67
20	39.57
25	39.54
31	39.61
JUN 05	39.58
10	39.64
15	39.65
20	39.75
25	39.78
30	39.82
JUL 05	40.00
10	39.90
15	39.91
20	39.82
25	39.94
31	40.12
AUG 05	40.17
10	40.24
15	40.31
20	40.41
25	40.46
31	40.52
SEP 05	40.62
10	40.75
15	40.72
20	40.84
25	40.93
30	41.01
OCT 05	41.15
10	41.19
15	41.17
20	41.02
25	41.02
31	41.18
NOV 05	41.24
10	41.19
(C-24-3)35bdd-1—Continued	
NOV 15, 1959	41.24
20	41.23
25	41.22
30	41.36
DEC 05	41.48
10	41.51
15	41.63
20	41.65
25	41.52
31	41.57
JAN 05, 1960	41.83
10	41.85
15	41.94
20	42.07
25	42.15
31	42.27
FEB 05	42.39
10	42.43
15	42.57
20	42.67
25	42.63
28	42.70
MAR 05	42.72
10	42.70
15	42.71
20	42.75
25	42.68
31	42.68
APR 05	42.83
10	42.87
15	42.90
20	42.96
25	43.09
30	43.22
MAY 05	43.32
10	43.39
15	43.40
20	43.40
25	43.42
31	43.34
JUN 05	43.26
10	43.31
15	43.37
20	43.37
25	43.38
30	43.38
JUL 05	43.32
10	43.34
15	43.32
20	43.38
25	43.45
(C-24-3)35bdd-1—Continued	
JUL 31, 1960	43.51
AUG 05	43.61
10	43.67
15	43.73
20	43.80
25	43.88
31	44.01
SEP 05	44.12
10	44.12
15	44.32
20	44.38
25	44.49
30	44.60
OCT 05	44.71
10	44.73
15	44.78
20	44.79
25	44.74
31	44.78
NOV 05	44.80
10	44.71
15	44.72
20	44.69
25	44.72
30	44.81
DEC 05	44.89
10	44.93
15	44.97
20	45.04
25	45.08
31	45.17
APR 03, 1962	47.16
SEP 24	42.17
APR 09, 1963	43.73
SEP 26	45.63
APR 02, 1964	46.99
SEP 24	46.52
MAR 09, 1965	47.22
SEP 14	43.37
DEC 10	46.35
MAR 04, 1966	42.74
OCT 05	42.59
MAR 06, 1967	43.80
NOV 07	41.28
MAR 19, 1968	42.35
SEP 30	37.53
APR 15, 1969	38.11
OCT 09	31.70
MAR 06, 1970	35.31
SEP 09	35.30
MAR 10, 1971	36.44

Table 24. Water levels in selected wells—Continued

Date	Water level
(C-24-3)35bdd-1—Continued	
OCT 06, 1971	35.46
MAR 01, 1972	40.76
OCT 02	35.50
MAR 05, 1973	40.82
OCT 12	35.87
MAR 15, 1974	40.62
OCT 04	41.06
OCT 20, 1975	38.02
MAR 15, 1976	40.30
MAR 22, 1977	41.51
OCT 06	43.12
MAR 16, 1978	44.12
OCT 04	41.63
MAR 13, 1979	43.55
OCT 01	39.13
MAR 06, 1980	37.89
(C-25-3)6abd-1	
Altitude 5,355	
MAR 01, 1978	80.77 R
OCT 02	78.40 R
MAR 03, 1979	80.62 R
OCT 01	71.87 R
MAR 06, 1980	75.70 R
OCT 02	68.97 R
MAR 04, 1981	73.56 R
OCT 06	71.55 R
MAR 02, 1982	75.82 R
SEP 29	72.15 R
MAR 01, 1983	74.65 R
SEP 28	61.94 R
MAR 07, 1984	68.48 R
SEP 26	64.42 R
MAR 11, 1985	71.07 R
SEP 30	64.85 R
MAR 20, 1986	73.39 R
SEP 16	67.62 R
MAR 04, 1987	75.00 R
JUL 20	69.09
SEP 28	69.50
MAR 24, 1988	75.97
SEP 16	69.04
MAR 10, 1989	74.91
SEP 20	73.02
(C-25-3)16cbb-1	
Altitude 5,380	
JUL 02, 1987	51.59
SEP 28	50.68
MAR 25, 1988	58.55
SEP 16	50.87
MAR 09, 1989	57.34
(C-25-3)16cdc-1	
Altitude 5,390	
JUN 28, 1988	67.44
SEP 13	68.59
OCT 19	70.52
NOV 29	71.03
DEC 29	72.66
JAN 25, 1989	72.84
FEB 22	75.12
MAR 09	75.89
APR 12	77.00
MAY 23	76.54
JUN 27	76.30
JUL 19	76.49
AUG 23	76.92
SEP 20	77.34
(C-25-3)28cad-1	
Altitude 5,445	
JUL 21, 1956	124.6
SEP 04	124.0
OCT 03	124.1
NOV 02	125.4
30	125.9
JAN 02, 1957	125.8
31	126.5
FEB 26	127.0
APR 29	127.8
MAY 29	127.7
JUN 25	122.8
AUG 28	107.0
SEP 27	106.2
NOV 04	110.7
DEC 30	111.1
FEB 03, 1958	111.3
MAR 06	116.0
APR 01	115.6
MAY 05	112.9
JUN 02	113.9
JUL 01	103.9
AUG 01	100.3
OCT 01	102.4
NOV 03	104.5
DEC 01	106.3
30	107.6
JAN 28, 1959	108.9
MAR 02	110.9
24	112.9
APR 30	113.3
MAY 25	114.3
JUL 27	115.0
AUG 26	115.7
SEP 28	116.8
(C-25-3)28cad-1—Continued	
OCT 26, 1959	117.2
NOV 23	118.1
DEC 28	119.2
JAN 25, 1960	120.6
FEB 25	121.3
MAR 29	122.6
APR 26	123.6
MAY 23	124.0
JUN 20	122.1
JUL 25	121.4
AUG 30	121.1
SEP 26	121.4
OCT 25	121.3
NOV 25	123.1
MAR 04, 1987	101.30
JUL 21	100.15
SEP 28	96.68
OCT 14	97.61
DEC 07	100.40
MAR 24, 1988	105.97
APR 29	108.75
MAY 18	109.98
JUN 23	107.28
JUL 14	105.14
AUG 16	102.87
SEP 13	100.14
OCT 19	102.22
NOV 29	104.59
DEC 29	105.79
JAN 25, 1989	107.23
FEB 22	108.85
MAR 09	109.62
APR 12	111.27
MAY 23	112.74
JUN 27	112.68
JUL 19	111.88
AUG 23	110.69
SEP 20	110.39
(C-25-4)28abd-1	
Altitude 5,530	
MAR 04, 1981	36.76
OCT 05	29.64 R
MAR 02, 1982	38.47 R
SEP 29	28.85 R
MAR 01, 1983	38.34 R
SEP 28	31.10 R
MAR 08, 1984	38.98 R
SEP 26	33.65 R
MAR 11, 1985	39.97
SEP 19	31.87
MAR 20, 1986	40.87

Table 24. Water levels in selected wells—Continued

Date	Water level
(C-25-4)28abd-1—Continued	
SEP 16, 1986	34.39 R
MAR 04, 1987	39.82
JUL 21	33.09
SEP 28	34.52
OCT 14	34.00
DEC 07	36.76
MAR 24, 1988	40.56
APR 29	40.49
MAY 18	38.54
JUN 23	35.35
JUL 14	33.22
AUG 16	31.79
SEP 14	31.71
OCT 20	33.57
NOV 30	36.40
DEC 29	38.00
JAN 26, 1989	39.24
FEB 23	40.26
MAR 10	40.61
APR 12	40.90
MAY 23	36.47
JUN 26	34.41
JUL 19	34.20
AUG 23	33.62
SEP 20	34.33
(C-27-3)7ddd-1	
Altitude 5,850	
AUG 02, 1956	28.13
SEP 04	31.82
OCT 04	33.59
NOV 02	34.09
30	34.09
JAN 02, 1957	34.42
31	34.44
FEB 26	33.88
APR 01	34.97
29	31.77
MAY 29	25.77
JUN 25	9.62
JUL 24	18.06
AUG 28	25.61
SEP 27	29.05
NOV 04	30.08
DEC 02	30.77
30	31.05
FEB 03, 1958	31.82
MAR 06	32.43
APR 01	31.91
MAY 05	28.55
JUN 02	9.67
JUL 01	14.93

Date	Water level
(C-27-3)7ddd-1—Continued	
AUG 01, 1958	23.49
SEP 04	28.32
OCT 01	30.20
NOV 03	31.92
DEC 01	32.58
30	32.76
JAN 28, 1959	32.97
MAR 02	33.04
25	33.23
MAY 01	30.93
25	24.80
JUN 25	19.67
JUL 27	29.42
AUG 24	31.86
SEP 28	33.75
OCT 26	34.25
NOV 23	34.25
DEC 28	34.90
JAN 25, 1960	35.07
FEB 25	34.87
MAR 29	34.19
APR 26	29.06
MAY 23	18.80
JUN 20	17.87
JUL 25	27.70
AUG 30	32.45
SEP 26	33.76
OCT 25	34.12
NOV 25	34.32
DEC 29	34.63
JAN 26, 1961	34.81
FEB 28	35.10
MAR 31	34.68
APR 30	32.91
MAY 31	16.83
JUN 30	21.89
JUL 31	29.70
AUG 31	29.95
SEP 30	29.16
OCT 31	29.57
NOV 30	30.73
DEC 26	31.28
MAR 25, 1987	30.83
JUL 21	24.18
SEP 28	29.48
MAR 24, 1988	32.30
SEP 16	24.40
MAR 09, 1989	33.19

Date	Water level
(C-27-3)17bcb-1	
Altitude 5,845	
JUN 30, 1988	24.57
DEC 29	35.85
JAN 26, 1989	35.93
FEB 23	36.21
MAR 09	35.90
APR 12	33.67
MAY 24	26.75
JUN 26	26.73
JUL 19	32.10
SEP 20	37.07
(C-27-3)32add-1	
Altitude 5,890	
AUG 05, 1956	45.1
SEP 04	44.4
OCT 04	44.4
NOV 02	44.4
30	42.8
JAN 02, 1957	43.9
31	45.4
FEB 26	45.8
APR 01	46.3
29	45.5
MAY 29	45.1
JUN 25	44.3
JUL 24	44.0
AUG 28	44.2
SEP 27	43.6
NOV 04	42.8
DEC 02	42.8
30	43.2
FEB 03, 1958	43.4
MAR 06	43.5
APR 01	44.3
MAY 05	46.2
JUN 02	43.3
JUL 01	44.0
AUG 01	43.6
SEP 04	43.3
OCT 01	43.6
NOV 03	44.2
DEC 01	44.1
30	44.1
JAN 28, 1959	43.3
MAR 02	44.6
25	44.9
MAY 01	44.8
25	44.6
JUN 25	44.7
JUL 27	45.8
AUG 24	44.9

Table 24. Water levels in selected wells—Continued

Date	Water level
(C-27-3)32add-1—Continued	
SEP 28, 1959	45.5
OCT 26	45.9
NOV 23	45.0
DEC 28	44.7
JAN 25, 1960	44.3
FEB 25	44.2
MAR 29	45.1
APR 26	46.4
MAY 23	45.2
JUN 20	44.5
JUL 25	45.1
SEP 26	45.7
OCT 25	44.7
NOV 25	45.7
DEC 29	45.2
JAN 26, 1961	44.6
FEB 23	45.3
MAR 20	46.0
APR 25	46.3
MAY 22	45.8
JUN 26	45.5
JUL 25	46.6
AUG 22	45.7
SEP 25	45.7
JUL 13, 1988	39.19
SEP 14	39.87
OCT 20	38.70
NOV 30	42.20
DEC 29	43.65
JAN 26, 1989	44.39
FEB 23	44.56
MAR 09	44.07
APR 12	44.29
MAY 24	41.15
JUN 26	41.27
JUL 19	35.72
SEP 20	41.95
(C-28-3)22bbc-1	
Altitude 5,900	
JAN 14, 1957	56.97
JUL 14, 1988	53.10
SEP 14	54.19
OCT 20	54.91
NOV 30	55.50
DEC 29	55.70
JAN 26, 1989	55.84
FEB 23	55.89
MAR 09	55.67
APR 12	54.85
MAY 24	54.16
JUN 26	54.08
(C-28-3)22bbc-1—Continued	
JUL 19, 1989	54.44
SEP 20	55.16
(C-30-3)15bba-1	
Altitude 6,006.50	
SEP 09, 1935	13.90
OCT 12	15.71
JAN 27, 1936	24.80
APR 20	26.46
JUN 17	12.39
AUG 04	12.84
SEP 28	14.55
NOV 26	20.56
FEB 09, 1937	26.58
MAR 26	28.05
JUN 07	10.38
AUG 24	8.13
DEC 07	19.43
FEB 22, 1938	24.17
APR 12	24.73
JUL 15	8.18
AUG 24	8.38
OCT 05	10.30
DEC 19	20.59
MAR 02, 1939	23.19
APR 21	24.21
AUG 21	8.56
OCT 18,	16.89
DEC 07	21.85
MAR 25, 1940	25.82
DEC 07	23.34
MAR 21, 1941	26.79
OCT 08	13.88
DEC 03	19.12
MAR 17, 1942	23.19
AUG 08	8.21
DEC 07	19.36
MAR 10, 1943	22.03
DEC 15	19.42
MAR 18, 1944	23.10
DEC 03	18.75
APR 03, 1945	22.90
DEC 07	20.23
MAR 20, 1946	23.58
DEC 16	20.27
MAR 26, 1947	23.61
DEC 10	20.56
MAR 16, 1948	24.15
JUL 21	10.36
DEC 10	19.70
APR 03, 1949	23.76
DEC 10	19.81
(C-30-3)15bba-1—Continued	
MAR 29, 1950	23.87
DEC 09	19.83
MAR 26, 1951	24.79
DEC 09	21.70
APR 06, 1952	26.66
DEC 07	18.70
MAR 16, 1953	23.87
DEC 10	20.92
MAR 25, 1954	25.57
DEC 02	21.53
DEC 04, 1955	19.37
MAR 20, 1956	26.44
SEP 11	15.65
OCT 04	15.70
13	16.90
26	19.15
31	19.84
NOV 05	20.48
10	21.03
15	21.57
20	22.04
25	22.36
30	22.68
DEC 05	23.05
10	23.42
15	23.79
20	24.12
25	24.45
31	24.81
JAN 05, 1957	25.10
10	25.37
20	25.64
25	26.06
31	26.32
FEB 05	26.52
10	26.71
25	27.19
28	27.26
MAR 05	27.35
10	27.37
15	27.38
APR 10	27.17
15	25.66
20	24.91
25	24.38
MAY 05	22.52
20	19.90
JUN 15	17.33
20	17.72
25	16.47
30	15.96

Table 24. Water levels in selected wells—Continued

Date	Water level
(C-30-3)15bba-1—Continued	
JUL 05, 1957	16.55
10	15.84
15	15.24
20	15.91
25	14.52
31	14.45
AUG 05	14.36
10	14.18
15	13.49
20	13.79
25	13.92
31	13.77
SEP 05	12.68
10	11.91
15	13.00
20	12.80
25	13.89
30	14.68
OCT 05	15.10
10	16.02
15	16.77
20	17.55
25	18.31
31	19.08
NOV 05	19.66
10	20.17
15	20.62
20	21.08
25	21.52
30	21.94
DEC 05	22.30
10	22.72
15	23.08
20	23.43
25	23.77
31	24.12
JAN 05, 1958	24.40
10	24.68
15	24.95
20	25.18
25	25.41
31	25.66
FEB 05	25.85
10	26.03
15	26.21
20	26.30
25	26.49
28	26.58
MAR 05	26.70
10	26.83
15	26.94
(C-30-3)15bba-1—Continued	
MAR 20, 1958	27.04
25	27.10
31	27.16
APR 05	27.21
10	27.25
15	27.30
20	27.27
25	26.63
30	25.64
MAY 05	24.16
10	22.62
15	20.40
20	19.12
25	15.42
31	14.31
JUN 05	13.28
10	12.71
15	13.05
20	11.72
25	12.10
30	12.60
JUL 05	10.71
10	11.78
15	11.89
20	10.56
25	11.95
31	11.56
AUG 05	11.04
10	12.21
15	11.97
20	11.04
25	11.87
31	11.04
SEP 05	10.74
10	11.38
15	11.52
20	11.36
25	12.34
30	12.78
OCT 05	13.46
10	14.45
15	15.33
20	16.11
25	16.70
31	17.00
NOV 05	17.24
10	17.34
15	17.54
20	17.67
25	17.80
DEC 05	18.45
(C-30-3)15bba-1—Continued	
DEC 10, 1958	18.95
15	19.48
20	19.92
25	20.34
31	20.85
JAN 05, 1959	21.19
10	21.50
15	21.82
20	22.08
25	22.35
31	22.65
FEB 05	22.98
10	23.19
15	23.38
20	23.53
25	23.66
28	23.72
MAR 05	23.80
10	23.89
15	23.96
20	24.02
25	23.90
31	23.90
APR 05	23.96
10	23.36
15	20.93
20	21.40
25	20.38
30	18.82
MAY 05	18.86
10	18.04
15	16.94
20	16.97
25	16.63
30	16.03
JUN 05	15.68
10	15.08
15	15.43
20	15.30
25	13.98
30	15.07
JUL 05	14.48
10	13.59
15	14.53
20	14.42
25	13.86
31	14.80
AUG 05	13.93
10	13.97
15	14.75
20	13.94

Table 24. Water levels in selected wells—Continued

Date	Water level
(C-30-3)15bba-1—Continued	
AUG 25, 1959	13.31
31	14.48
SEP 05	13.38
10	13.47
15	14.27
20	13.16
25	13.59
30	13.06
OCT 05	14.78
10	16.02
15	16.94
20	17.70
25	18.29
31	18.75
NOV 05	19.15
10	19.55
15	19.95
20	20.35
25	20.51
30	20.50
DEC 05	20.56
10	20.87
15	21.29
20	21.74
25	22.12
31	22.53
JAN 05, 1960	22.88
10	23.23
15	23.58
20	23.93
25	24.18
31	24.46
FEB 05	24.66
10	24.84
15	25.05
20	25.26
25	25.40
29	25.56
MAR 05	25.76
10	25.96
15	26.16
20	26.36
25	26.56
31	26.76
APR 05	26.85
10	26.10
15	25.45
20	23.90
25	22.28
30	22.04
MAY 05	20.78
(C-30-3)15bba-1—Continued	
MAY 10, 1960	18.83
23	16.53
JUN 20	15.14
JUL 25	13.81
AUG 31	14.73
SEP 26	14.70
OCT 25	18.73
NOV 25	20.60
DEC 29	23.75
JAN 26, 1961	25.68
FEB 23	27.65
MAR 20	28.08
APR 21	25.90
MAY 22	17.60
JUL 03	15.19
25	12.38
AUG 22	13.84
SEP 25	13.19
OCT 30	18.50
NOV 27	21.50
DEC 27	23.61
FEB 01, 1962	25.40
MAR 05	26.59
30	27.58
APR 30	22.44
MAY 28	16.08
JUL 03	13.41
AUG 01	12.29
28	12.78
SEP 24	12.39
OCT 29	17.19
DEC 03	20.57
26	22.24
JAN 28, 1963	23.87
FEB 27	25.05
MAR 25	25.80
APR 29	20.80
MAY 28	15.77
JUL 01	13.85
30	12.48
AUG 28	11.95
SEP 23	11.24
DEC 04	19.26
APR 08, 1964	26.93
SEP 24	10.44
DEC 07	19.41
MAR 19, 1965	25.53
SEP 10	10.86
MAR 07, 1966	24.30
OCT 04	10.81
MAR 03, 1967	24.40
(C-30-3)15bba-1—Continued	
SEP 13, 1967	8.94
MAR 04, 1968	25.41
SEP 30	8.88
MAR 12, 1969	23.83
OCT 07	12.72
MAR 09, 1970	23.10
OCT 06	10.66
MAR 12, 1971	24.23
OCT 04	11.09
MAR 01, 1972	23.58
OCT 05	10.44
MAR 08, 1973	23.75
OCT 12	11.84
MAR 20, 1974	22.56
OCT 07	11.86
MAR 13, 1975	22.69
OCT 21	12.88
MAR 25, 1976	23.80
OCT 04	9.87
MAR 01, 1977	23.51
OCT 05	10.53
OCT 03, 1978	9.31
MAR 12, 1979	24.09
OCT 01	6.58
MAR 05, 1980	21.29
OCT 01	7.82
MAR 03, 1981	20.89
OCT 01	8.43
MAR 02, 1982	21.78
SEP 21	12.66
MAR 02, 1983	21.28
SEP 19	10.25
MAR 08, 1984	19.68
SEP 26	9.40
MAR 12, 1985	18.17
SEP 30	8.71
MAR 06, 1986	21.74
SEP 17	8.88
MAR 18, 1987	21.63
JUL 21	8.61
SEP 28	9.77
MAR 23, 1988	21.69
SEP 20, 1989	10.06
(C-30-3)16bbb-1 Altitude 6,000	
MAY 25, 1959	23.65
JUN 25	23.28
JUL 27	23.92
AUG 24	23.05
SEP 28	22.80
OCT 26	23.95

Table 24. Water levels in selected wells—Continued

Date	Water level
(C-30-3)16bbb-1—Continued	
NOV 23, 1959	24.62
DEC 28	25.40
JAN 25, 1960	26.03
FEB 25	26.37
MAR 29	26.72
APR 26	26.19
MAY 23	24.81
JUN 20	24.09
JUL 25	24.28
AUG 30	23.90
SEP 26	23.81
OCT 25	24.49
NOV 25	24.81
DEC 29	25.89
JAN 26, 1961	26.62
FEB 23	26.98
MAR 20	26.85
APR 21	27.22
MAY 22	25.34
JUL 03	24.48
25	23.83
AUG 22	23.43
SEP 25	23.62
OCT 30	24.61
NOV 27	25.53
DEC 27	26.41
FEB 01, 1962	27.24
MAR 05	27.34
30	27.28
APR 30	25.71
MAY 28	23.46
JUL 03	22.78
AUG 01	22.54
28	22.31
SEP 24	22.42
OCT 29	23.50
DEC 03	24.83
26	25.52
JAN 28, 1963	26.31
FEB 27	26.50
MAR 25	26.80
APR 29	26.01
MAY 28	25.00
JUL 01	23.89
30	23.65
AUG 28	23.48
SEP 23	22.85
MAR 25, 1987	16.99
JUL 21	16.48
AUG 20	16.40
SEP 28	15.78
(C-30-3)16bbb-1—Continued	
OCT 14, 1987	15.65
DEC 07	16.27
MAR 23, 1988	17.33
APR 29	16.48
MAY 18	16.25
JUN 23	15.99
JUL 12	16.17
AUG 16	15.90
SEP 14	16.12
OCT 20	16.17
NOV 30	16.87
DEC 29	17.21
JAN 26, 1989	17.57
FEB 23	17.14
MAR 09	16.62
APR 12	16.73
MAY 24	16.42
JUN 26	16.51
JUL 19	16.88
SEP 20	16.29
(D-18-1)30bcd-1	
Altitude 5,010	
SEP 18, 1956	+0.8
OCT 08	+0.9
NOV 06	+1.0
DEC 04	+1.2
JAN 04, 1957	+1.2
FEB 28	+1.6
APR 03	+1.5
MAY 03	+1.2
JUN 03	+1.3
28	+1.3
JUL 26	+1.2
OCT 01	+1.2
NOV 06	+1.6
DEC 03	+1.5
JAN 02, 1958	+1.8
FEB 04	+2.2
MAR 05	+2.4
APR 03	+2.3
MAY 06	+2.0
JUN 03	+2.2
JUL 02	+1.9
AUG 05	+1.7
SEP 03	+1.7
OCT 03	+1.7
NOV 04	+2.0
28	+2.1
DEC 31	+2.1
JAN 29, 1959	+2.5
FEB 26	+2.6
(D-18-1)30bcd-1—Continued	
MAR 27, 1959	+3.4
APR 28	+2.3
MAY 27	+2.0
JUN 26	+1.9
JUL 30	+1.4
AUG 27	+1.3
SEP 30	+1.3
OCT 28	+1.3
NOV 27	+1.6
DEC 31	+2.0
JAN 26, 1960	+2.0
FEB 29	+2.1
MAR 28	+2.0
APR 29	+1.7
MAY 27	+1.7
JUN 21	+1.3
JUL 26	+0.8
AUG 31	+0.8
SEP 28	+0.8
OCT 26	+0.8
NOV 28	+1.1
DEC 21	+1.2
JAN 26, 1961	+1.3
FEB 23	+1.2
MAR 21	+1.5
APR 26	+1.4
MAY 23	+1.2
JUN 26	+0.9
JUL 25	+0.7
AUG 22	+0.5
SEP 28	+0.7
JUN 15, 1988	+7.0
SEP 12	+6.3
FEB 28, 1989	+6.3
MAR 16	+6.6
(D-1-91)14dba-1	
Altitude 5,215	
AUG 08, 1988	10.8
SEP 16	10.94
OCT 17	11.53
NOV 29	12.22
DEC 28	12.56
JAN 23, 1989	12.76
FEB 15	12.93
28	12.62
MAR 16	12.87
APR 25	12.85
MAY 23	12.78
JUN 28	12.53
JUL 25	12.49
SEP 19	12.92

Table 24. Water levels in selected wells—Continued

Date	Water level
(D-19-1)23acd-1	
Altitude 5,210	
JUL 15, 1988	16.90
SEP 14	17.35
FEB 28, 1989	18.90
MAR 16	19.16
(D-19-2)17aad-2	
Altitude 5,418	
AUG 06, 1935	+6.00
SEP 05	+5.50
OCT 10	+4.73
NOV 22	+4.21
JAN 25, 1936	+3.53
MAR 04	+3.27
APR 23	+3.23
JUN 18	+10.70
AUG 06	+11.80
SEP 30	+9.60
NOV 28	+8.80
FEB 05, 1937	+6.50
APR 10	+5.55
JUN 09	+7.90
SEP 25	+7.30
NOV 02	+7.30
DEC 09	+6.90
AUG 28, 1956	+3.64
SEP 28	+3.46
NOV 01	+4.29
APR 24, 1961	+2.31
MAY 23	+3.36
JUN 26	+5.05
JUL 26	+4.75
AUG 22	+4.52
SEP 28	+3.78
APR 05, 1962	+3.73
SEP 28	+10.05
APR 11, 1963	+5.85
SEP 25	+6.25
APR 01, 1964	+4.25
30	+2.59
JUL 08	+7.41
31	+7.28
SEP 01	+7.81
28	+6.96
NOV 03	+6.15
DEC 11	+6.37
FEB 09, 1965	+4.47
MAR 22	+3.96
APR 27	+3.69
MAY 27	+6.57
JUN 22	+7.45
JUL 27	+11.95
(D-19-2)17aad-2—Continued	
AUG 27, 1965	+11.15
SEP 28	+11.05
OCT 25	+9.65
NOV 30	+8.85
DEC 30	+8.05
JAN 29, 1966	+7.25
MAR 15	+5.45
APR 15	+5.65
MAY 16	+6.10
JUN 14	+7.45
JUL 18	+6.85
SEP 20	+5.55
NOV 02	+4.85
MAR 21, 1967	+3.35
MAR 07, 1968	+4.25
SEP 25	+9.10
MAR 04, 1969	+6.70
SEP 24	+9.90
MAR 11, 1970	+7.00
SEP 15	+9.30
MAR 08, 1971	+5.10
SEP 16	+9.60
MAR 06, 1972	+5.50
SEP 27	+5.10
MAR 15, 1973	+3.55
SEP 26	+4.90
MAR 19, 1974	+5.60
SEP 13	+8.70
MAR 04, 1975	+5.80
SEP 04	+9.90
MAR 02, 1976	+6.30
SEP 22	+4.60
MAR 02, 1977	+4.30
OCT 04	+2.70
MAR 09, 1978	+2.90
SEP 12	+6.60
MAR 07, 1979	+4.60
SEP 11	+6.48
MAR 04, 1980	+4.25
SEP 29	+10.30
MAR 03, 1981	+7.00
SEP 12	+7.50
MAR 08, 1982	+4.80
SEP 14	+10.50
MAR 09, 1983	+6.10
SEP 12	+12.70
(D-19-2)32aac-1	
Altitude 5,540	
AUG 06, 1935	31.67
SEP 05	33.47
OCT 10	35.93
(D-19-2)32aac-1—Continued	
NOV 22, 1935	38.70
JAN 25, 1936	41.48
MAR 02	43.35
APR 23	44.71
JUN 18	18.83
AUG 06	20.74
SEP 03	27.68
NOV 28	31.75
FEB 05, 1937	35.58
APR 10	38.50
JUN 09	21.77
18	19.50
AUG 02	24.10
SEP 25	29.90
NOV 02	32.43
DEC 09	34.74
FEB 24, 1938	38.19
APR 10	40.20
JUN 03	21.75
JUN 04	21.09
AUG 25	23.37
OCT 08	28.16
DEC 21	31.52
MAR 02, 1939	35.16
APR 17	37.01
JUN 16	23.55
AUG 23	28.78
OCT 15	31.32
DEC 05	34.78
FEB 07, 1940	36.83
MAR 26	37.31
JUN 04	13.98
AUG 01	22.24
DEC 05	31.21
MAR 19, 1941	36.00
SEP 28	24.40
DEC 07	29.04
AUG 08, 1942	19.80
MAR 25, 1943	36.14
DEC 17	37.30
DEC 04, 1944	29.04
MAR 03, 1945	34.07
DEC 06	27.89
MAR 21, 1946	35.85
DEC 18	33.28
MAR 27, 1947	37.95
DEC 13	30.09
MAR 17, 1948	35.71
JUL 22	18.63
DEC 13	31.37
APR 04, 1949	36.80

Table 24. Water levels in selected wells—Continued

Date	Water level
(D-19-2)32aac-1—Continued	
SEP 28, 1964	38.15
DEC 10	42.15
FEB 01, 1965	44.0
09	44.23
MAR 22	45.72
APR 27	46.07
MAY 14	44.08
27	39.29
JUN 22	24.60
AUG 27	23.64
SEP 28	26.85
OCT 25	29.23
NOV 30	32.66
DEC 28	34.83
JAN 29, 1966	37.02
MAR 15	39.89
APR 15	40.98
JUN 14	34.65
NOV 02	42.32
MAR 21, 1967	46.23
NOV 29	40.70
MAR 05, 1968	45.08
MAR 04, 1969	39.93
SEP 24	31.24
MAR 11, 1970	39.86
MAR 06, 1972	41.18
MAR 15, 1973	45.92
MAR 19, 1974	38.68
MAR 04, 1975	36.74
SEP 04	27.65
MAR 02, 1976	37.91
SEP 22	40.11
MAR 02, 1977	42.96
(D-20-1)5aaa-1	
Altitude 5,110	
MAY 27, 1987	44.61
SEP 03	38.34
OCT 13	39.86
NOV 03	41.58
DEC 08	43.83
JAN 12, 1988	46.38
FEB 18	48.00
MAR 23	48.93
APR 29	48.69
MAY 17	46.89
JUN 15	42.11
JUL 12	39.07
AUG 08	38.18
SEP 16	37.20
OCT 17	38.81
NOV 29	42.25

Date	Water level
(D-20-1)5aaa-1—Continued	
DEC 28, 1988	44.50
JAN 23, 1989	46.12
FEB 16	47.00
28	47.44
MAR 16	47.84
APR 25	47.80
MAY 23	45.71
JUN 28	43.50
JUL 25	42.20
SEP 19	42.68
(D-20-1)17ada-1	
Altitude 5,155	
MAY 28, 1987	8.52
SEP 03	9.08
MAR 23, 1988	8.49
SEP 14	9.45
FEB 28, 1989	7.84
MAR 16	7.92
(D-20-1)20acc-2	
Altitude 5,145	
AUG 01, 1935	47.00
AUG 06	47.01
SEP 05	47.81
OCT 10	47.73
NOV 23	48.01
JAN 26, 1936	48.33
APR 22	48.52
JUN 17	48.00
AUG 06	46.68
SEP 30	46.25
NOV 28	46.70 P
FEB 06, 1937	46.57 P
APR 10	46.30 R
JUN 09	46.55 R
AUG 02	45.22 R
SEP 25	44.80 R
NOV 04	44.78 R
DEC 09	44.83 R
FEB 23, 1938	44.81 R
APR 10	44.25 R
JUN 04	44.17 R
AUG 25	42.50 R
OCT 07	42.35 R
DEC 21	42.66
APR 17, 1939	42.09
JUN 16	41.62
AUG 23	41.08
OCT 15	41.38
DEC 05	41.98
FEB 07, 1940	42.80

Date	Water level
(D-20-1)20acc-2—Continued	
MAR 26, 1940	42.81
JUN 05	42.63
AUG 01	41.32
DEC 05	41.84
SEP 28, 1941	38.35
DEC 05	37.40
MAR 18, 1942	36.58
AUG 10	31.84
DEC 20	31.99
MAR 25, 1943	32.98
DEC 16	33.52
MAR 19, 1944	33.94
DEC 04	31.52
APR 03, 1945	33.90
DEC 06	29.97
MAR 21, 1946	30.80
DEC 18	30.22
MAR 27, 1947	31.50
DEC 13	29.04
MAR 17, 1948	30.89
JUL 22	25.82
DEC 13	28.49
APR 04, 1949	30.31
DEC 13	31.75
MAR 30, 1950	32.70
DEC 10	35.42
MAR 27, 1951	36.05
DEC 11	38.32
APR 07, 1952	39.52
DEC 08	33.52
MAR 17, 1953	34.53
DEC 10	32.85
MAR 26, 1954	33.44
NOV 20	34.51
MAR 22, 1955	35.68
DEC 06	37.25
MAR 22, 1956	38.24
DEC 05	40.15
MAR 12, 1958	39.03
APR 03	39.36
MAY 06	39.82
JUN 03	38.11
JUL 02	36.82
AUG 05	35.76
SEP 03	35.62
OCT 03	35.59
NOV 04	35.54
28	35.51
DEC 31	35.58
JAN 29, 1959	35.70
FEB 26	35.92

Table 24. Water levels in selected wells—Continued

Date	Water level
(D-20-1)20acc-2—Continued	
MAR 25, 1959	36.13
APR 28	36.22
MAY 26	36.31
JUN 26	36.40
JUL 28	36.47
AUG 27	36.72
SEP 29	36.94
OCT 28	37.17
NOV 27	37.32
DEC 29	37.50
JAN 26, 1960	37.78
FEB 29	37.76
MAR 28	37.98
APR 29	38.13
MAY 27	38.45
JUN 21	38.44
JUL 26	38.52
AUG 31	39.63
SEP 27	38.84
OCT 26	39.08
NOV 28	39.32
DEC 21	39.40
JAN 26, 1961	39.52
FEB 23	40.18
MAR 21	40.35
APR 26	40.30
MAY 23	40.70
JUN 26	40.75
JUL 25	40.93
AUG 22	40.87
SEP 28	41.00
APR 03, 1962	42.12
SEP 27	38.58
APR 09, 1963	35.00
SEP 26	38.60
APR 02, 1964	39.82
SEP 24	38.55
DEC 10	38.27
MAR 09, 1965	38.82
SEP 20	34.67
MAR 04, 1966	32.13
OCT 05	32.00
MAR 06, 1967	32.84
NOV 07	32.18
MAR 19, 1968	32.52
SEP 30	30.51
APR 15, 1969	31.52
MAR 06, 1970	27.88
MAR 08, 1971	27.72
OCT 15	24.80
MAR 01, 1972	27.77
(D-20-1)20acc-2—Continued	
OCT 04, 1972	25.40
MAR 01, 1973	30.67
OCT 15	26.89
MAR 14, 1974	28.09
OCT 02	27.38
MAR 11, 1975	28.19
OCT 16	23.13
MAR 18, 1976	25.98
OCT 15	25.35
MAR 22, 1977	29.10
OCT 05	30.98
MAR 16, 1978	32.63
OCT 03	32.61
MAR 13, 1979	34.56
OCT 02	29.42
MAR 06, 1980	31.50
OCT 02	24.92
MAR 05, 1981	26.17
OCT 06	24.33
MAR 03, 1982	26.75
SEP 29	20.97
MAR 01, 1983	24.20
SEP 27	20.98
MAR 07, 1984	23.70
SEP 26	18.59
MAR 11, 1985	24.47
SEP 19	19.10
MAR 12, 1986	24.18
SEP 10	17.58
MAR 04, 1987	23.50
JUL 21	22.24
SEP 03	22.90
OCT 13	23.77
NOV 03	24.32
DEC 08	24.95
JAN 12, 1988	25.74
MAR 15	26.77
APR 29	27.10
MAY 17	26.35
JUN 16	24.66
JUL 12	24.39
AUG 08	24.51
SEP 16	25.23
OCT 17	25.88
NOV 29	26.38
DEC 28	26.99
JAN 23, 1989	22.47
FEB 16	27.85
28	28.10
MAR 16	28.20
APR 25,	27.93
(D-20-1)20acc-2—Continued	
MAY 23, 1989	28.32
JUN 28	28.50
JUL 25	28.76
SEP 19	29.23
(D-20-1)20dab-2	
Altitude 5,150	
MAY 28, 1987	21.36
SEP 03	21.36
MAR 23, 1988	25.18
SEP 14	23.22
(D-20-1)28dbb-1	
Altitude 5,240	
SEP 05, 1956	112.89
OCT 05	113.19
NOV 06	113.62
DEC 04	113.83
JAN 03, 1957	114.13
FEB 01	114.53
27	114.85
APR 02	115.36
30	115.20
MAY 31	116.14
JUL 25	115.98
SEP 03	116.06
30	115.80
NOV 06	115.16
DEC 03	114.98
JAN 02, 1958	114.54
MAR 05	115.20
APR 03	114.20
JUN 03	113.86
JUL 02	113.69
AUG 05	111.72
SEP 03	110.46
OCT 03	108.44
NOV 04	108.46
28	108.37
FEB 26, 1959	108.75
MAR 25	107.87
MAY 26	106.82
JUL 28	106.34
AUG 27	106.30
SEP 29	106.54
OCT 28	106.71
NOV 27	107.02
JAN 26, 1960	107.02
FEB 29	107.10
MAR 28	107.17
APR 29	107.62
MAY 27	107.46

Table 24. Water levels in selected wells—Continued

Date	Water level
(D-20-1)28dbb-1—Continued	
JUN 21, 1960	107.50
JUL 26	107.68
AUG 31	108.00
SEP 27	108.33
OCT 26	108.82
NOV 28	109.61
DEC 21	109.30
MAR 05, 1987	87.50
JUL 20	89.15
SEP 03	89.55
MAR 23, 1988	92.68
JUN 16	93.97
JUL 12	94.86
AUG 08	94.07
SEP 16	94.50
MAR 01, 1989	96.40
(D-20-2)8bda-1	
Altitude 5,590	
AUG 08, 1988	39.07
SEP 14	40.20
FEB 28, 1989	44.05
(D-20-2)18aaa-1	
Altitude 5,635	
JUN 23, 1958	27.20
JUL 02	26.26
AUG 05	25.60
SEP 03	25.68
OCT 03	26.70
NOV 04	27.88
28	29.05
DEC 31	30.30
JAN 29, 1959	31.25
FEB 26	31.70
MAR 27	32.57
APR 28	33.43
MAY 27	34.07
JUN 26	35.14
JUL 30	35.67
AUG 27	36.20
SEP 30	37.26
OCT 28	37.88
NOV 27	38.52
DEC 31	39.51
FEB 29, 1960	41.02
MAR 28	41.53
APR 29	42.20
MAY 27	41.88
JUN 21	41.00
JUL 26	41.04
AUG 31	41.47
(D-20-2)18aaa-1—Continued	
SEP 28, 1960	42.09
OCT 26	42.50
NOV 28	43.26
DEC 21	44.85
FEB 09, 1965	44.54
MAR 22	45.72
APR 27	46.70
MAY 27	48.72
JUN 22	39.33
JUL 27	34.94
AUG 27	33.24
SEP 28	32.33
OCT 25	34.33
DEC 28	34.12
JAN 29, 1966	34.99
MAR 15	36.12
APR 15	37.10
MAY 16	36.80
JUN 14	37.87
JUL 18	36.14
SEP 20	37.30
NOV 02	38.22
MAR 21, 1967	41.61
JUL 20	30.69
MAR 07, 1968	42.33
MAR 04, 1969	37.13
MAR 11, 1970	32.95
MAR 08, 1971	31.42
MAR 06, 1972	30.71
MAR 15, 1973	36.72
MAR 19, 1974	26.76
MAR 04, 1975	27.34
MAR 02, 1976	27.19
MAR 02, 1977	34.54
MAR 09, 1978	42.83
MAR 07, 1979	39.66
MAR 04, 1980	37.08
MAR 03, 1981	28.45
MAR 08, 1982	30.80
MAR 09, 1983	25.49
MAR 12, 1984	23.20
SEP 09	22.73
MAR 04, 1985	24.79
SEP 09	26.34
MAR 12, 1986	28.26
SEP 04	27.89
MAR 01, 1987	31.78
04	31.37
SEP 02	31.83
03	31.82
OCT 13	32.78
(D-20-2)18aaa-1—Continued	
NOV 01, 1987	33.58
04	33.58
DEC 08	34.10
JAN 12, 1988	34.80
MAR 01	35.70
15	36.02
APR 29	36.70
MAY 20	37.01
JUN 16	36.77
JUL 12	35.85
AUG 08	36.14
31	36.60
SEP 16	37.00
OCT 17	37.39
NOV 29	38.20
DEC 29	38.77
JAN 23, 1989	39.10
FEB 15	39.68
28	40.00
MAR 16	39.69
APR 25	40.37
MAY 23	40.98
JUN 28	41.19
JUL 25	41.65

Table 25. Temperature, specific conductance, and chloride concentration of water in selected wells

[—, no data]

Location: See figure 2 for an explanation of the numbering system for data sites.
Temperature: °C, degrees Celsius; measured in the field.
Specific conductance: µS/cm, microsiemens per centimeter at 25 degrees Celsius; measured in the field.
Chloride: mg/L, milligrams per liter; measured at the U.S. Geological Survey office except where noted; L, laboratory value.

Location	Date measured	Temperature (°C)	Specific conductance (µS/cm)	Chloride (mg/L)
(C-18-1)25ddc-1	09-20-65	11.5	1,810	380 L
	08-03-66	12.0	1,810	410 L
	08-05-69	17.0	1,850	—
	06-26-70	10.0	1,930	430 L
	06-30-71	11.0	1,900	—
	08-15-73	18.5	1,680	—
	07-02-74	13.0	1,850	—
	06-16-76	12.5	1,710	360 L
	07-02-77	14.0	1,680	370 L
	07-19-78	12.0	1,820	380 L
	08-22-79	9.0	1,700	400 L
	08-27-80	17.0	1,800	—
	07-08-82	13.0	1,690	420 L
(C-19-1)11cac-1	09-30-88	11.5	2,350	330
(C-19-1)11cac-2	09-30-88	11.5	2,280	310
(C-19-1)24cdd-2	09-30-88	12.0	2,600	—
	06-29-89	12.0	2,590	400 L
(C-21-1)10ada-1	11-29-88	12.0	1,200	35
	12-28-88	11.0	1,190	30
	01-23-89	12.0	1,160	—
	02-16-89	12.0	1,200	—
	03-07-89	12.0	1,220	—
	07-17-89	12.0	1,250	26 L
	08-21-89	12.0	1,240	—
(C-21-1)13abd-1	09-20-65	18.0	750	100 L
	06-08-66	16.5	750	—
	09-19-69	16.0	740	110 L
	06-26-70	15.0	740	110 L
	07-08-82	17.0	760	—
	08-09-83	19.0	790	110 L
	07-10-84	18.5	780	—
	06-27-85	18.0	780	—
	08-19-86	18.5	740	110 L
	03-06-87	16.5	720	—
	07-21-87	16.0	760	110
	08-20-87	18.0	720	—
	09-02-87	—	750	110
	10-14-87	17.0	740	—
	11-04-87	18.0	740	—
	01-13-88	18.0	750	110
	02-18-88	16.5	740	—
	04-29-88	17.5	740	120
	05-17-88	—	780	—

Table 25. Temperature, specific conductance, and chloride concentration of water in selected wells—Continued

Location	Date measured	Temperature (°C)	Specific conductance (µS/cm)	Chloride (mg/L)
(C-21-1)13abd-1—Continued	06-16-88	18.5	750	100
	07-13-88	18.0	740	120
	08-11-88	18.5	760	110
	09-16-88	18.0	760	110
	10-17-88	18.0	780	120
	11-29-88	17.0	750	110
	12-28-88	17.0	750	120
	01-23-89	17.0	740	—
	02-16-89	17.0	740	—
	03-01-89	17.0	760	—
	04-25-89	18.0	790	—
	05-23-89	17.5	780	—
	06-29-89	17.0	750	—
	09-19-89	17.0	760	110 L
(C-21-1)23adb-1	09-30-88	—	750	110
(C-21-1)24bbb-1	09-29-87	—	740	—
	03-24-88	13.0	740	100
	06-29-89	18.0	750	110 L
(C-22-1) 5bac-1	05-29-87	14.0	580	—
	06-28-89	16.0	580	29 L
(C-22-2)26dac-1	05-28-87	15.0	720	—
	06-27-89	13.5	670	20 L
(C-22-2)35bcc-1	05-28-87	12.0	530	—
	06-27-89	13.0	570	12 L
(C-23-2) 1bdc-1	07-21-87	16.0	1,460	94
	10-15-87	13.0	1,330	—
	01-13-88	—	1,350	85
	03-24-88	—	1,280	83
	06-28-89	12.0	1,600	84 L
(C-23-2) 1bdc-3	03-24-88	8.0	1,120	71
	07-18-89	—	1,540	6 L
(C-23-2) 1dbc-1	05-28-87	12.0	710	—
	09-15-88	12.5	700	58
(C-23-2)11bdb-1	01-15-88	11.5	1,050	—
	04-29-88	—	—	43
	05-18-88	12.0	1,080	38
	06-16-88	11.0	990	39
	07-13-88	12.0	1,080	44
	08-17-88	11.5	1,070	40
	09-15-88	11.5	1,110	38
	10-19-88	12.0	1,110	41
	11-29-88	11.0	1,110	42
	12-28-88	10.5	1,100	41
	01-26-89	11.0	1,110	—
	02-22-89	11.0	1,110	—
	03-08-89	11.0	1,090	—

Table 25. Temperature, specific conductance, and chloride concentration of water in selected wells—Continued

Location	Date measured	Temperature (°C)	Specific conductance (µS/cm)	Chloride (mg/L)
(C-23-2)11bdb-1—Continued	04-11-89	11.0	1,100	—
	05-23-89	11.0	1,120	—
	06-16-89	11.0	1,190	34 L
	08-24-89	11.0	1,100	—
	09-19-89	11.0	1,110	—
(C-23-2)11bdb-2	01-15-88	11.5	860	—
	02-03-88	—	—	25
	03-24-88	12.0	790	39
	05-18-88	13.0	890	40
	06-16-88	12.0	810	37
	07-13-88	12.5	900	41
	08-17-88	12.5	850	38
	09-15-88	12.0	890	36
	10-19-88	—	910	40
	11-29-88	12.0	890	41
	12-28-88	11.5	860	40
	01-26-89	12.0	870	—
	02-22-89	12.0	870	—
	03-08-89	12.0	880	—
	04-11-89	12.0	880	—
	05-23-89	12.0	910	—
	06-16-89	12.0	950	31 L
	08-24-89	12.0	890	—
(C-23-2)11dda-3	09-26-88	11.5	1,950	95
(C-23-2)14aaa-1	02-03-88	11.5	1,370	110
	09-15-88	11.5	1,480	99
	03-08-89	11.5	1,490	—
	05-24-89	11.5	1,500	99 L
(C-23-2)14cbc-2	09-27-88	11.5	2,610	61
(C-23-2)15dcb-4	09-26-63	10.0	700	30 L
	09-14-65	10.5	820	36 L
	06-09-66	12.0	770	—
	09-22-66	10.5	760	32 L
	08-07-67	11.0	770	33 L
	03-19-68	10.0	870	39 L
	04-15-69	12.0	760	—
	06-26-70	10.0	660	25 L
	06-30-71	11.0	640	—
	05-01-72	10.0	540	21 L
	07-25-73	10.0	630	25 L
	05-28-74	11.0	630	27 L
	06-10-76	12.5	650	—
	07-01-77	14.0	580	—
	08-21-79	12.0	610	—
	08-27-81	11.0	580	37 L
	07-09-82	10.0	610	—
	08-09-83	12.0	660	41 L
	07-10-84	11.5	870	71 L
	06-27-85	13.5	880	—

Table 25. Temperature, specific conductance, and chloride concentration of water in selected wells—Continued

Location	Date measured	Temperature (°C)	Specific conductance (µS/cm)	Chloride (mg/L)
(C-23-2)15dcb-4—Continued	08-19-86	12.0	900	—
	03-04-87	12.0	1,020	—
	08-20-87	11.5	1,020	130 L
	09-02-87	12.0	1,180	137
	01-13-88	11.5	960	—
	09-15-88	11.0	960	88
	05-25-89	10.5	830	58 L
	09-19-89	11.5	860	—
(C-23-2)16dcd-1	02-03-88	13.0	1,400	85
(C-23-2)19dab-1	06-09-66	16.0	530	—
	09-30-68	9.0	540	34 L
	07-06-70	17.5	530	24 L
	06-30-71	15.0	540	—
	05-01-72	10.5	630	26 L
	07-16-73	14.5	540	22 L
	05-28-74	14.0	540	21 L
	07-08-75	14.0	560	—
	10-10-75	17.0	580	—
	06-10-76	15.5	540	—
	07-01-77	15.5	520	—
	07-12-78	15.0	540	—
	08-21-79	16.0	540	—
	08-27-81	15.5	480	19 L
	07-09-82	13.5	500	—
	08-09-83	16.0	520	—
	07-10-84	15.5	425	—
	06-27-85	16.5	540	19 L
	08-19-86	16.0	520	—
	08-20-87	15.5	520	22 L
	09-15-88	15.0	550	22
(C-23-2)22abb-3	09-28-88	11.0	880	39
(C-23-2)22acb-1	09-28-88	13.0	2,790	72
(C-23-2)22baa-1	09-29-88	12.0	770	29
	06-27-89	12.0	600	25 L
(C-23-2)22bad-1	09-28-88	12.5	1,180	45
(C-23-2)22bbc-4	09-29-88	12.0	680	22
	11-30-88	11.0	650	25
(C-23-2)22bcc-2	09-28-88	11.5	620	24
(C-23-2)22bdc-1	09-28-88	12.0	620	48
(C-23-2)22cdd-1	09-28-88	12.5	1,500	59
(C-23-2)22daa-1	09-29-88	12.0	1,280	85

Table 25. Temperature, specific conductance, and chloride concentration of water in selected wells—Continued

Location	Date measured	Temperature (°C)	Specific conductance (µS/cm)	Chloride (mg/L)
(C-23-2)22dcc-2	09-28-88	13.0	780	87
	06-15-89	13.0	840	82 L
(C-23-2)23bac-1	02-03-88	14.5	1,140	210
	03-24-88	—	1,200	200
	09-15-88	15.0	1,310	200
	05-26-89	14.5	1,370	190 L
(C-23-2)26cab-1	02-03-88	11.5	640	49
	09-15-88	12.0	660	43
	03-08-89	11.0	670	—
(C-23-2)29aca-3	02-04-88	11.0	620	24
	09-15-88	12.0	660	23
(C-23-2)29acb-4	02-04-88	11.5	650	—
	05-25-89	11.5	680	20 L
(C-23-2)29cdb-1	08-05-87	10.5	800	—
	11-05-87	11.5	750	29 L
	09-15-88	11.0	740	29
(C-23-2)29cdb-2	11-03-87	—	1,700	—
	11-05-87	13.0	1,750	140 L
	12-08-87	—	1,580	—
	01-14-88	—	1,580	99
	03-24-88	—	1,580	100
	04-28-88	—	1,550	100
	07-15-88	—	1,550	95
	08-16-88	—	1,520	98
	09-15-88	—	1,560	93
(C-23-2)29cdc-1	12-09-87	—	2,800	74
	01-14-88	11.0	3,400	85
	02-19-88	10.5	3,100	91
	03-24-88	11.0	3,320	92
	04-28-88	—	3,400	85
	05-19-88	11.5	3,320	84
	07-14-88	11.5	3,300	86
	08-16-88	11.5	3,410	88
	09-15-88	11.0	3,450	85
	10-19-88	11.0	3,450	91
	11-30-88	10.0	3,280	94
	12-29-88	—	3,400	83
	01-24-89	10.0	3,400	—
	05-25-89	10.5	3,640	78 L
(C-23-2)29cdc-2	01-14-88	11.0	1,580	50
	02-19-88	10.5	1,480	49
	03-24-88	11.0	1,460	42
	04-27-88	—	—	52
	04-28-88	—	1,640	—
	05-19-88	12.0	1,600	51
	07-14-88	11.5	1,500	53

Table 25. Temperature, specific conductance, and chloride concentration of water in selected wells—Continued

Location	Date measured	Temperature (°C)	Specific conductance (µS/cm)	Chloride (mg/L)
(C-23-2)29cdc-2—Continued	08-16-88	11.0	1,770	49
	09-15-88	11.0	1,750	50
	10-19-88	12.0	1,750	53
	11-30-88	10.0	1,750	54
	12-29-88	10.0	1,750	—
	01-24-89	10.0	1,750	—
	05-25-89	10.5	1,970	47 L
(C-23-2)29dad-1	06-02-88	11.0	3,000	87
	07-14-88	11.0	3,400	91
	08-16-88	11.0	3,410	87
	09-15-88	10.5	3,500	80
	11-29-88	10.5	3,100	74
	12-29-88	—	3,000	83
	01-24-89	10.0	3,200	—
	02-16-89	10.0	3,090	—
	06-29-89	10.5	3,420	—
	08-24-89	10.5	3,230	—
(C-23-2)30baa-2	03-05-87	14.0	1,000	—
	05-15-87	—	—	19
	07-01-87	14.5	920	—
	08-04-87	14.0	820	18
	09-03-87	14.0	810	16
	10-15-87	13.0	790	—
	11-04-87	13.0	780	—
	12-09-87	13.5	800	—
	01-13-88	13.0	800	17
	02-18-88	12.0	740	18
	04-30-88	13.0	800	17
	05-19-88	12.0	770	17
	06-17-88	13.5	840	15
	07-13-88	13.5	830	19
	08-17-88	13.5	800	18
	09-14-88	14.0	840	17
	10-19-88	14.0	840	20
	11-30-88	13.0	800	20
	12-29-88	—	810	19
	01-24-89	12.5	830	—
	02-16-89	13.0	820	—
	03-01-89	—	860	—
	05-24-89	—	840	—
	09-20-89	14.0	810	—
(C-23-2)30cdd-1	09-27-88	13.0	630	25
(C-23-2)31abb-2	09-27-88	—	710	29

Table 25. Temperature, specific conductance, and chloride concentration of water in selected wells—Continued

Location	Date measured	Temperature (°C)	Specific conductance (µS/cm)	Chloride (mg/L)
(C-23-2)31abb-3	09-27-88	12.5	690	27
(C-23-2)31abd-1	09-28-88	10.5	1,280	62
(C-23-2)31acc-3	09-29-88	12.0	490	38
(C-23-2)31bab-1	09-27-88	13.5	710	30
	05-26-89	13.5	720	23 L
(C-23-2)31bac-1	09-27-88	12.5	770	31
(C-23-2)31bac-2	09-27-88	12.0	800	33
(C-23-2)31bad-1	09-27-88	—	840	36
(C-23-2)31bcc-1	09-29-88	—	1,860	66
(C-23-2)31bdc-3	09-28-88	10.5	3,310	76
(C-23-2)31caa-1	09-28-88	—	760	50
(C-23-2)31cac-1	09-29-88	10.5	4,060	55
(C-23-2)31cad-1	09-29-88	10.5	4,070	48
	05-26-89	10.5	4,320	38 L
(C-23-2)31cda-1	09-29-88	10.0	4,190	46
(C-23-2)31dcb-3	03-04-87	—	240	—
	07-21-87	13.5	180	—
	09-04-87	—	155	39
	10-04-87	12.0	180	—
(C-23-2)32aac-1	02-04-88	11.5	3,500	—
	07-15-88	10.5	3,400	42
	06-15-89	10.5	3,400	34 L
(C-23-2)34aba-1	02-03-88	11.5	1,120	—
	09-15-88	11.5	1,200	130
	10-19-88	12.0	1,190	140
	11-30-88	11.0	1,140	160
	02-16-89	11.0	1,140	—
	03-01-89	12.0	1,200	—
	04-11-89	12.0	1,180	—
	05-24-89	11.0	1,180	—
	08-24-89	11.5	1,220	—
	09-20-89	12.0	1,180	—
(C-23-3)24ddc-1	04-28-88	—	610	16
	06-27-89	16.0	610	12 L
(C-23-3)36aab-1	04-28-88	—	760	51
	06-07-89	13.0	840	39 L

Table 25. Temperature, specific conductance, and chloride concentration of water in selected wells—Continued

Location	Date measured	Temperature (°C)	Specific conductance (µS/cm)	Chloride (mg/L)
(C-23-3)36abd-1	04-29-88	—	2,920	54
	07-18-89	14.5	2,950	41 L
(C-23-3)36dcd-1	09-28-87	10.0	4,200	—
	10-14-87	10.5	3,950	—
	11-04-87	11.0	3,900	—
	12-09-87	10.0	3,980	—
	06-17-88	10.0	3,600	47
	07-13-88	10.0	3,950	49
	08-16-88	10.5	3,920	45
	09-13-88	10.0	4,020	44
	10-19-88	10.0	4,150	48
	11-29-88	10.0	4,100	48
	12-29-88	—	—	48
	01-24-89	—	3,880	—
	02-22-89	10.0	4,030	—
	03-08-89	10.0	4,030	—
	05-23-89	10.0	4,070	—
	06-28-89	10.0	4,080	—
	07-19-89	10.0	4,160	—
	08-24-89	10.0	4,050	—
(C-24-2) 5abc-1	04-28-88	—	1,690	49
	09-15-88	11.5	1,620	46
	03-09-89	11.0	1,620	—
(C-24-2) 6abc-1	05-25-62	10.0	1,090	30 L
	09-26-63	10.0	1,140	32 L
	09-14-65	10.5	1,090	31 L
	06-09-66	11.0	1,160	30 L
	08-07-67	10.5	1,050	28 L
	03-19-68	10.0	1,360	32 L
	07-14-69	10.0	1,180	35 L
	06-26-70	9.5	1,580	30 L
	06-30-71	11.0	1,220	26 L
	05-24-72	10.0	1,290	26 L
	07-05-73	10.0	1,260	27 L
	05-28-74	10.5	1,100	28 L
	07-09-75	10.0	1,280	—
	07-11-76	11.5	1,240	—
	07-01-77	12.0	1,150	—
	07-12-78	11.0	1,070	—
	08-09-83	12.0	1,290	31 L
	07-10-84	11.5	1,370	—
	06-27-85	12.5	1,390	—
	08-19-86	12.5	1,310	24 L
	03-05-87	11.0	1,400	—
	08-20-87	11.0	1,230	—
	02-04-88	11.0	1,320	28
	05-11-88	11.0	1,410	27
	09-14-88	11.0	1,440	27
	03-09-89	11.0	1,600	—
	09-20-89	11.0	1,420	—

Table 25. Temperature, specific conductance, and chloride concentration of water in selected wells—Continued

Location	Date measured	Temperature (°C)	Specific conductance (µS/cm)	Chloride (mg/L)
(C-24- 2)7add-1	09-26-88	12.0	940	46
(C-24-2) 7bac-2	01-14-87	—	740	22
	03-04-87	11.0	370	—
	07-01-87		690	—
	09-28-87	10.5	600	—
	10-14-87	11.0	540	—
	11-04-87	11.5	470	—
	12-09-87	11.0	520	—
	01-14-88	10.5	520	—
	02-19-88	10.5	490	19
	04-27-88	11.0	550	—
	05-18-88	11.5	540	19
	06-17-88	11.0	530	20
	07-14-88	11.0	510	20
	08-16-88	11.0	410	20
	09-14-88	11.0	520	19
	10-19-88	11.0	540	20
	11-29-88	11.0	520	21
	12-28-88	11.0	520	20
	02-22-89	10.5	520	—
	03-09-89	10.5	510	—
	04-11-89	11.0	510	—
	05-23-89	10.0	490	—
	06-07-89	10.5	500	14 L
	06-26-89	10.5	520	—
	07-19-89	10.5	510	—
	09-20-89	10.5	465	—
(C-24-2) 7dcb-1	09-27-88	—	640	46
(C-24-2) 8bcd-1	05-11-88	11.5	870	40
(C-24-3) 1aad-1	05-12-88	10.5	3,780	41
	09-16-88	11.0	3,700	38
	01-25-89	10.5	3,810	—
	03-08-89	10.5	3,810	—
	05-26-89	10.5	4,000	34 L
(C-24-3)27bca-1	06-04-88	13.0	860	—
	06-07-89	12.0	880	27 L
(C-24-3)34cdb-1	06-30-89	11.5	750	27 L
	08-23-89	12.0	760	—
(C-25-3) 5cba-1	07-02-87	—	710	24
	06-27-89	13.5	740	29 L
(C-25-4)13bdb-1	05-31-88	—	550	22
	05-25-89	—	500	19 L
(C-25-4)28abd-1	07-21-87	15.0	690	37
(C-27-3)18dab-1	06-30-88	—	225	8.0
	06-08-89	8.5	210	4.6 L

Table 25. Temperature, specific conductance, and chloride concentration of water in selected wells—Continued

Location	Date measured	Temperature (°C)	Specific conductance (µS/cm)	Chloride (mg/L)
[1] (C-28-3) 6aaa-1	07-01-88	—	—	14
(C-28-3) 6dbc-2	07-01-88	—	345	6.5
	06-08-89	11.5	350	2.3 L
(C-28-3) 8ddb-1	07-14-88	—	1,000	17
(D-18-1)30bcd-1	10-15-87	15.0	1,600	270 L
	01-12-88	12.5	1,420	—
	03-23-88	13.0	1,460	250
	06-15-88	12.5	1,640	260
	07-12-88	13.0	1,650	260
	08-08-88	13.0	1,560	260
	09-12-88	12.5	1,630	240
	10-17-88	13.5	1,640	250
	11-29-88	12.0	1,540	280
	12-28-88	12.0	1,570	280
	01-23-89	12.0	1,650	—
	02-28-89	12.0	1,650	—
(D-19-1)23acd-1	07-15-88	—	2,210	360
(D-19-1)23dba-1	07-15-88	—	2,420	410
	06-13-89	15.5	2,480	430 L
(D-19-2)17aad-2	04-27-65	9.0	1,020	65 L
	03-02-76	9.0	900	—
(D-20-1)21dad-1	05-29-87	—	3,850	690
(D-20-2) 5dbc-2	08-08-88	—	1,550	55

[1]Reported by Carpenter and Young, 1963, as (C-28-3)5bbb-1.

Table 26. Chemical analyses of water from selected wells

[mg/L, milligrams per liter; µg/L, micrograms per liter; —, no data; <, less than]

Location: See figure 2 for an explanation of the numbering system for data sites.
Specific conductance: µS/cm, microsiemens per centimeter at 25 degrees Celsius; measured in the field except where
pH: Measured in the field except where noted by L, laboratory value.
Temperature: °C, degrees Celsius; measured in the field.
Alkalinity: Measured in the field except where noted by L, laboratory value.
Solids, dissolved: Sum of constituents except where noted R, residue on evaporation at 180 degrees C.
Iron: Dissolved except where noted by T, total.
Lithium: Noted by M where an earlier, less accurate than the present method of analysis was used.

Location	Date measured	Specific conductance (µS/cm)	pH (standard units)	Temperature, water (°C)	Hardness, total (mg/L as $CaCO_3$)	Hardness, noncarbonate (mg/L as $CaCO_3$)	Alkalinity, field (mg/L as $CaCO_3$)	Solids, dissolved (mg/L)	Calcium, dissolved (mg/L as Ca)	Magnesium, dissolved (mg/L as Mg)
(C-18-1)12acb-1	05-10-88	890	7.6	—	290	48	239 L	484	44	43
(C-18-1)25ddc-1	10-21-59	1,580	7.4	12.0	490	280	—	1,020	78	72
	09-20-65	1,810	7.8	11.5	450	200	—	976	74	64
	08-03-66	1,810	—	12.0	—	—	—	—	—	—
	06-26-70	1,930	—	10.0	—	—	—	—	—	—
	06-16-76	1,710	7.3	12.5	400	150	254	959	63	59
	07-02-77	1,680	7.8	14.0	420	170	246	960	68	60
	07-19-78	1,820	7.4	12.0	460	210	250	979	72	69
	08-22-79	1,700	7.7	9.0	380	150	230	897	58	56
	07-08-82	1,690	7.7	13.0	330	150	175 L	829	45	52
(C-19-1)23cac-1	09-03-57	3,280	7.6	11.5	700	210	—	2,010	120	100
	07-25-89	2,800 L	7.3 L	—	750	130	618 L	1,760	100	120
(C-19-1)24cdd-2	06-29-89	2,590	7.3	12.0	570	190	447	1,530	92	82
(C-21-1) 1cab-1	06-30-89	1,900	7.4	13.5	330	0	367	1,190	85	29
(C-21-1)10ada-1	07-17-89	1,250	7.4	12.0	380	0	513	768	38	70
(C-21-1)13abd-1	08-20-59	760	7.9	19.0	150	30	—	484	35	15
	09-20-65	750	7.5	18.0	150	36	—	443 R	—	—
	09-19-69	740	—	16.0	150	—	—	—	—	—
	06-26-70	740	—	15.0	—	—	—	—	—	—
	08-09-83	790	7.6	19.0	140	21	124 L	461	30	17
	08-19-86	740	7.1	18.5	140	29	114 L	450	29	17
	09-16-88	760	8.1	18.0	—	—	—	—	—	—
	09-19-89	760	7.9	17.0	140	25	113 L	448	29	16
(C-21-1)13dbc-1	06-29-89	1,880	7.3	11.0	350	0	649	1,110	51	53
(C-21-1)24bbb-1	06-29-89	750	8.0	18.0	150	66	112	434	32	18
(C-21-1)24bda-1	11-06-87	1,650	7.3	13.0	430	0	515 L	990	82	54
(C-22-1) 5bac-1	08-26-57	—	7.9 L	15.5	230	45	183 L	371	37	33
	06-28-89	580	7.7	16.0	220	17	201	346	35	32
(C-22-1)11bdb-1	08-09-89	109,000 L	6.9	13.5	5,800	5,700	142	84,600	1,700	380
(C-22-2)26dac-1	05-28-87	720	—	15.0	—	—	—	—	—	—
	06-27-89	670	7.6	13.5	250	0	273	375	41	36
(C-22-2)35bcc-1	06-27-89	570	7.6	13.0	250	13	239	296	45	33

noted by L, laboratory value.

Sodium, dissolved (mg/L as Na)	Potassium, dissolved (mg/L as K)	Bicarbonate, field (mg/L as HCO_3)	Sulfate, dissolved (mg/L as SO_4)	Chloride, dissolved (mg/L as Cl)	Fluoride, dissolved (mg/L as F)	Bromide, dissolved (mg/L as Br)	Silica, dissolved (mg/L as SiO_2)	Boron, dissolved (µg/L as B)	Iron, dissolved (µg/L as Fe)	Lithium, dissolved (µg/L as Li)	Manganese, dissolved (µg/L as Mn)	Strontium, dissolved (µg/L as Sr)
73	2.0	—	38	120	0.20	0.07	17	50	16	31	—	—
—	—	—	95	430	—	—	17	—	—	—	—	—
200	—	—	86	380	—	—	22	—	—	—	—	—
—	—	—	—	410	—	—	—	—	—	—	—	—
—	—	—	—	420	—	—	—	—	—	—	—	—
210	3.5	—	87	360	0.40	—	22	60	—	—	—	—
200	3.3	—	87	370	0.50	—	24	70	—	—	—	—
190	3.5	—	90	380	0.60	—	21	70	—	—	—	—
210	3.4	—	23	400	0.60	—	7.6	70	—	—	—	—
190	3.1	—	5.0	420	0.50	—	6.0	60	1,800	—	370	—
440	6.2	—	520	400	0.5	—	34	—	110 T	1,600 M	0	—
350	3.8	—	440	340	0.60	0.36	37	780	30	120	10	1,400
350	3.6	545	360	400	0.30	0.37	13	360	20	90	<10	1,400
270	7.3	447	340	190	0.90	0.21	43	570	610	77	340	820
130	3.5	625	130	26	0.30	0.08	63	450	9	110	2	1,500
—	—	—	94	110	—	—	51	—	—	—	—	—
91	—	—	88	100	—	—	—	—	—	—	—	—
—	—	—	—	110	—	—	—	—	—	—	—	—
—	—	—	—	110	—	—	—	—	—	—	—	—
95	4.7	—	87	110	0.60	—	41	260	<3	—	<1	—
90	4.5	—	89	110	0.60	—	40	260	6	—	<1	—
—	—	—	—	—	—	—	—	—	—	—	—	—
92	3.7	—	87	110	0.50	—	40	270	4	—	2	—
280	2.5	792	190	110	1.0	0.15	31	420	21	110	150	920
84	4.4	137	92	110	0.50	0.08	39	270	11	54	<1	560
200	4.4	—	120	160	0.40	0.12	34	310	6	48	—	—
37	6.1	—	63	51	0.30	—	34	—	—	0 M	—	—
33	5.5	245	56	29	0.40	0.10	33	150	<3	26	<1	430
30,000	350	173	3,000	49,000	0.10	28	20	2,000	2,400	170	620	33,000
—	—	—	—	—	—	—	—	—	—	—	—	—
48	1.6	333	50	20	0.20	0.08	13	170	<3	17	<1	310
19	1.7	292	28	12	0.20	0.06	15	60	4	14	1	380

Table 26. Chemical analyses of water from selected wells—Continued

Location	Date measured	Specific conductance (µS/cm)	pH (standard units)	Temperature, water (°C)	Hardness, total (mg/L as $CaCO_3$)	Hardness, noncarbonate (mg/L as $CaCO_3$)	Alkalinity, field (mg/L as $CaCO_3$)	Solids, dissolved (mg/L)	Calcium, dissolved (mg/L as Ca)	Magnesium, dissolved (mg/L as Mg)
(C-23-1) 6cdb-1	08-09-89	16,200	7.2	16.0	2,200	2,000	227	10,300	620	150
(C-23-2) 1bdc-1	06-28-89	1,600	7.1	12.0	650	180	471	952	110	92
(C-23-2) 1bdc-3	07-18-89	1,540	7.2	—	540	0	569	897	100	70
(C-23-2)11bdb-1	06-16-89	1,190	7.3	11.0	470	50	440	642	96	56
(C-23-2)11bdb-2	06-16-89	950	7.2	12.0	400	72	353	498	93	40
(C-23-2)14aaa-1	05-24-89	1,500	7.7	11.5	720	520	202	1,030	200	54
(C-23-2)14cbc-2	06-28-89	2,590	7.0	11.5	1,600	1,300	342	2,170	410	140
(C-23-2)15cad-13	04-25-58	2,830	7.5	11.0	1,140	740	—	1,820	220	140
	06-02-88	2,000	7.0	15.5	850	630	228 L	1,100	160	110
(C-23-2)15dbb-1	04-25-58	820	7.9	11.0	400	260	—	534	109	30
	06-02-88	1,120	7.4	13.5	560	480	81 L	719	150	44
(C-23-2)15dcb-4	07-15-57	650	7.7	10.0	310	52	261	400	69	34
	09-26-63	700	7.6	10.0	350	100	254	452 R	—	—
	09-14-65	820	7.6	10.5	410	150	—	536 R	—	—
	06-09-66	770	7.5	12.0	—	—	—	—	—	—
	09-22-66	760	7.7	10.5	380	130	—	506 R	—	—
	08-07-67	770	—	11.0	—	—	—	—	—	—
	03-19-68	870	—	10.0	—	—	—	—	—	—
	04-15-69	760	—	12.0	370	130	244	—	—	—
	06-26-70	660	—	10.0	—	—	—	—	—	—
(C-23-2)15dcb-4	05-01-72	540	7.8	10.0	250	12	239	307	46	33
	07-25-73	630	7.6	10.0	300	44	254	373	63	34
	05-28-74	630	7.9	11.0	290	43	252	378	62	34
	08-21-79	610	—	12.0	—	—	—	368 R	—	—
	08-27-81	580	7.7	11.0	300	74	230	386	64	35
	08-09-83	660	7.4	12.0	330	53	276 L	417	69	38
	07-10-84	870	7.1	11.5	410	140	275 L	503	85	48
	08-20-87	1,020	7.7 L	11.5	530	300	222 L	630	110	61
	09-15-88	960	7.6	11.0	—	—	—	—	—	—
	05-25-89	830	7.5	10.5	400	130	265	481	83	46
(C-23-2)19bcd-1	06-29-89	1,040	7.2	13.5	510	22	503	579	72	81
(C-23-2)19dab-1	07-15-57	540	7.8	17.0	260	23	241	312	51	33
	09-30-68	540	7.7	9.0	260	17	239	—	—	—
	07-06-70	530	—	17.5	—	—	—	—	—	—
	05-01-72	630	7.6	10.5	290	39	250	379	58	35
	07-16-73	540	7.7	14.5	260	25	238	310	49	34
	05-28-74	540	7.7	14.0	260	24	237	307	50	33
	08-21-79	540	—	16.0	—	—	—	274 R	—	—
	08-27-81	480	7.4	15.5	260	30	230	302	48	34
	06-27-85	540	7.5	16.5	260	58	201 L	282	49	33
	08-20-87	520	7.8 L	15.5	260	39	217 L	301	48	33
(C-23-2)21aad-3	08-09-89	1,050	7.5	14.0	480	110	364	637	93	59
(C-23-2)22baa-1	06-27-89	600	7.3	12.0	360	92	278	459	81	38

Sodium, dissolved (mg/L as Na)	Potassium, dissolved (mg/L as K)	Bicarbonate, field (mg/L as HCO_3)	Sulfate, dissolved (mg/L as SO_4)	Chloride, dissolved (mg/L as Cl)	Fluoride, dissolved (mg/L as F)	Bromide, dissolved (mg/L as Br)	Silica, dissolved (mg/L as SiO_2)	Boron, dissolved (µg/L as B)	Iron, dissolved (µg/L as Fe)	Lithium, dissolved (µg/L as Li)	Manganese, dissolved (µg/L as Mn)	Strontium, dissolved (µg/L as Sr)
3,000	26	277	1,900	4,400	0.60	2.2	27	680	100	100	30	11,000
80	5.0	574	260	84	0.20	0.20	33	240	10	37	1	720
130	7.1	694	210	6.0	0.40	0.16	34	400	110	73	75	740
60	6.3	537	110	34	0.30	0.10	25	230	47	37	110	700
35	5.4	431	61	31	0.20	0.10	35	130	37	33	<1	1,000
47	4.7	246	460	99	0.30	0.14	38	60	260	29	1,000	2,300
37	6.8	417	1,300	53	0.20	0.16	35	370	30	40	80	2200
—	—	—	520	460	—	—	15	—	—	—	—	—
100	6.9	—	310	250	0.20	0.61	23	520	2,000	51	—	—
—	—	—	200	63	—	—	30	—	—	—	—	—
18	3.6	—	360	50	0.10	0.12	31	50	10	26	—	—
21	4.1	—	51	29	0.20	—	35	—	—	—	—	—
—	—	—	100	30	—	—	—	—	—	—	—	—
22	—	—	140	36	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	120	32	—	—	—	—	—	—	—	—
—	—	—	—									
—	—	—	—	21	—	—	18	—	—	—	—	—
—	—	—	—	25	—	—	34	—	—	—	—	—
—	—	—	—	27	—	—	35	—	—	—	—	—
16	3.5	—	26	—	—	—	—	—	—	—	—	—
18	2.9	—	44	—	—	—	—	—	—	—	—	—
19	3.1	—	47	—	—	—	—	—	—	—	—	—
—	—	—	—	37	0.60	—	35	40	19	—	2	—
19	3.0	—	52	—	—	—	—	—	—	—	—	—
19	3.3	—	44	41	0.50	—	33	50	<3	—	<1	—
21	3.8	—	71	71	0.40	—	33	50	<3	—	<1	—
24	4.3	—	130	130	0.30	—	32	70	8	—	2	—
—	—	—	—	—	—	—	—	—	—	—	—	—
21	3.6	323	74	58	0.40	0.13	34	60	<3	31	1	750
36	1.7	614	57	18	0.20	0.08	16	270	7	44	4	740
15	3.2	—	26	21	—	—	18	—	—	—	—	—
—	—	—	—	34	—	—	—	—	—	—	—	—
—	—	—	—	24	—	—	—	—	—	—	—	—
19	3.4	—	54	26	—	—	34	—	—	—	—	—
15	2.3	—	28	22	—	—	17	—	—	—	—	—
15	2.7	—	26	21	—	—	17	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—
16	2.5	—	27	19	0.20	—	17	20	10	—	2	—
15	2.4	—	24	19	0.20	—	17	40	<3	—	1	—
16	7.6	—	26	22	0.20	—	17	40	6	—	1	—
36	6.0	444	92	80	0.80	0.16	51	160	31	43	11	750
18	3.0	340	98	25	0.30	0.08	34	100	8	27	<1	700

Table 26. Chemical analyses of water from selected wells—Continued

Location	Date measured	Specific conductance (µS/cm)	pH (standard units)	Temperature, water (°C)	Hardness, total (mg/L as $CaCO_3$)	Hardness, noncarbonate (mg/L as $CaCO_3$)	Alkalinity, field (mg/L as $CaCO_3$)	Solids, dissolved (mg/L)	Calcium, dissolved (mg/L as Ca)	Magnesium, dissolved (mg/L as Mg)
(C-23-2)22dcc-2	06-15-89	840	7.6	13.0	190	0	192	460	53	13
(C-23-2)23bac-1	05-26-89	1,370	7.6	14.5	260	79	176	769	69	20
(C-23-2)27bcc-2	09-21-56	490	8.0	13.0	180	39	—	—	—	—
	11-05-87	640	7.9	13.5	230	84	145 L	401	62	18
(C-23-2)29acb-4	05-25-89	680	7.5	11.5	320	22	356	380	60	40
(C-23-2)29cdb-1	11-05-87	750	7.6	11.5	350	110	247 L	404	70	43
(C-23-2)29cdb-2	11-05-87	1,750	7.6	13.0	740	460	285 L	1,070	140	95
(C-23-2)29cdc-1	05-25-89	3,640	7.1	10.5	1,800	1,400	330	2,890	460	150
(C-23-2)29cdc-2	05-25-89	1,970	7.3	10.5	940	620	328	1,420	230	89
(C-23-2)31bab-1	05-26-89	720	7.4	13.5	320	20	305	396	60	41
(C-23-2)31cad-1	05-26-89	4,320	7.0	10.5	2,100	1,500	544	3,640	510	190
(C-23-2)32aac-1	06-15-89	3,400	7.0	10.5	1,600	1,100	530	2,930	450	120
(C-23-2)34aba-1	09-21-56	870	7.3	11.5	360	30	—	—	—	—
	05-24-89	1,180	7.3	11.0	500	170	328 L	681	140	36
(C-23-3)24ddc-1	06-27-89	610	7.4	16.0	290	0	295	328	58	36
(C-23-3)36aab-1	06-07-89	840	7.4	13.0	390	87	298	455	79	46
(C-23-3)36abd-1	07-09-59	750	8.0	11.5	340	57	—	415	60	47
	07-18-89	2,950	7.4	14.5	1,800	1,600	209	2,520	440	160
(C-24-2) 6abc-1	09-24-56	900	7.4	10.5	420	180	—	—	—	—
	07-15-57	1,000	7.6	11.0	460	220	—	668	123	37
	05-25-62	1,090	7.6	10.0	490	270	218	762	130	39
	09-26-63	1,140	7.5	10.0	540	270	271	848 R	—	—
	09-14-65	1,090	7.9	10.5	500	240	—	822 R	—	—
	06-09-66	1,160	8.0	11.0	560	300	—	890 R	—	—
	08-07-67	1,050	7.6	10.5	490	220	—	792 R	—	—
	03-19-68	1,360	7.7	10.0	640	350	—	1,020	170	52
	07-14-69	1,180	7.8	10.0	560	270	289	834	140	48
	06-26-70	1,580	7.2	9.5	750	420	338	1,130	200	63
	06-30-71	1,220	7.4	11.0	530	250	282	729	140	43
	05-24-72	1,290	7.2	10.0	560	260	292	878	150	44
	07-05-73	1,260	7.5	10.0	490	190	294	735	130	39
	05-28-74	1,100	7.6	10.5	550	280	274	841	150	43
	08-09-83	1,290	7.1	12.0	610	300	306 L	920	160	50
	08-19-86	1,310	7.2	12.5	620	390	228 L	858	160	53
	05-11-88	1,410	7.2	11.0	670	430	241 L	957	170	59
	09-14-88	1,440	7.2	11.0	710	470	241 L	1,010	180	63
(C-24-2) 7bac-2	06-07-89	500	7.5	10.5	230	42	201	305	62	19
(C-24-3) 1aad-1	05-26-89	4,000	7.1	10.5	2,100	1,500	543	3,360	500	200
(C-24-3)16dbc-2	06-09-89	1,850	7.4	12.5	790	490	305	1,400	150	100

Sodium, dis-solved (mg/L as Na)	Potas-sium, dis-solved (mg/L as K)	Bicar-bonate, field (mg/L as HCO_3)	Sulfate, dis-solved (mg/L as SO_4)	Chlo-ride, dis-solved (mg/L as Cl)	Fluo-ride, dis-solved (mg/L as F)	Bromide, dis-solved (mg/L as Br)	Silica, dis-solved (mg/L as SiO_2)	Boron, dis-solved (µg/L as B)	Iron, dis-solved (µg/L as Fe)	Lithium, dis-solved (µg/L as Li)	Manga-nese, dis-solved (µg/L as Mn)	Stron-tium, dis-solved (µg/L as Sr)
86	4.1	235	67	82	0.40	0.09	38	100	7	10	4	570
170	5.4	215	160	190	0.50	0.13	47	140	13	30	4	910
30	—	—	44	34	—	—	—	140	—	—	—	—
44	3.7	—	92	53	0.40	0.09	34	260	5	41	—	—
25	3.1	335	30	20	0.30	0.05	25	60	4	31	<1	450
28	3.4	—	48	29	0.40	0.08	30	80	220	39	—	—
97	9.0	—	380	140	0.60	0.15	37	300	240	73	—	—
220	10	403	1,700	78	0.10	0.18	38	690	30	70	40	2,900
90	6.9	400	720	47	0.30	0.11	36	270	4	54	11	2,900
31	3.1	372	38	23	0.40	0.07	20	80	13	33	2	430
330	12	664	2,200	38	0.10	0.12	37	820	50	70	50	2,200
270	13	647	1,700	34	0.20	0.04	36	660	20	60	90	2,000
56	—	—	42	70	—	—	—	—	—	—	—	—
55	3.2	—	63	140	0.30	0.12	46	70	8	23	<1	670
14	2.4	360	15	12	0.20	0.03	12	30	5	24	1	370
28	3.2	363	52	39	0.40	0.08	25	70	790	36	150	550
—	—	—	54	46	—	—	6.6	—	—	—	—	—
100	12	255	1,600	41	0.20	0.12	34	410	20	60	10	4,600
40	—	—	210	33	—	—	—	—	—	—	—	—
40	4.0	—	250	32	0	—	32	—	20 T	400 M	30	—
—	—	—	330	30	—	—	29	—	—	—	—	—
—	—	—	350	32	—	—	—	—	—	—	—	—
52	—	—	300	31	—	—	—	—	—	—	—	—
—	—	—	360	30	—	—	—	—	—	—	—	—
—	—	—	300	28	—	—	—	—	—	—	—	—
96	—	—	490	32	—	—	—	—	—	—	—	—
64	4.1	—	330	35	—	—	30	—	—	—	—	—
—	—	—	550	30	—	—	—	—	—	—	—	—
57	3.9	—	290	26	—	—	—	—	—	—	—	—
67	4.7	—	380	26	—	—	31	—	—	—	—	—
49	3.9	—	280	27	—	—	30	—	—	—	—	—
60	4.2	—	360	28	—	—	32	—	—	—	—	—
59	4.3	—	390	31	0.20	—	31	180	3	—	7	—
58	4.3	—	380	24	0.20	—	30	200	8	—	5	—
62	4.4	—	450	23	0.20	0.09	32	190	6	33	—	—
67	4.8	—	490	23	0.20	—	31	220	4	—	11	—
18	3.0	245	43	14	0.30	0.05	30	60	4	15	2	310
250	11	663	2,000	34	0.20	0.09	36	660	40	70	100	1,900
120	19	373	740	26	0.30	0.09	52	390	24	88	<1	7,500

Table 26. Chemical analyses of water from selected wells—Continued

Location	Date measured	Specific conductance (µS/cm)	pH (standard units)	Temperature, water (°C)	Hardness, total (mg/L as $CaCO_3$)	Hardness, noncarbonate (mg/L as $CaCO_3$)	Alkalinity, field (mg/L as $CaCO_3$)	Solids, dissolved (mg/L)	Calcium, dissolved (mg/L as Ca)	Magnesium, dissolved (mg/L as Mg)
(C-24-3)27bca-1	06-07-89	880	7.1	12.0	360	0	377	526	91	31
(C-24-3)34cdb-1	06-30-89	750	7.2	11.5	310	0	296	460	89	20
(C-25-3) 5cba-1	06-27-89	740	7.3	13.5	290	0	290	433	82	21
(C-25-3)16bdc-1	06-15-89	450	7.2	11.5	180	10	172	267	53	12
(C-25-3)29cac-1	06-27-89	500	7.5	15.0	220	31	197	306	70	12
(C-25-4)13bdb-1	05-25-89	500	7.7	—	190	0	220	330	51	15
(C-27-3)18dbd-1	06-08-89	3,310	7.0	11.0	1,300	1,000	348	1,620	460	44
(C-27-3)18dab-1	06-08-89	210	7.2	8.5	90	8	81	132	31	3.1
(C-27-3)33cdc-1	06-14-89	410	7.7	11.5	190	86	116	302	63	8.6
(C-28-3) 6dbc-2	06-08-89	350	7.8	11.5	170	42	132	199	46	14
(C-28-3)21ada-1	06-14-89	610	7.6	13.5	280	120	170	368	90	14
(C-28-3)34cdc-1	06-14-89	350	8.8	15.0	14	0	120	211	5.3	0.13
(D-18-1)30bcd-1	10-15-87	1,600	7.6	15.0	360	15	345 L	904	50	57
(D-19-1)23dba-1	06-13-89	2,480	7.2	15.5	590	270	322	1,500	110	75
(D-21-1)31cba-1	08-08-89	3,750	7.6	15.5	740	400	371	2,410	160	81

Sodium, dissolved (mg/L as Na)	Potassium, dissolved (mg/L as K)	Bicarbonate, field (mg/L as HCO_3)	Sulfate, dissolved (mg/L as SO_4)	Chloride, dissolved (mg/L as Cl)	Fluoride, dissolved (mg/L as F)	Bromide, dissolved (mg/L as Br)	Silica, dissolved (mg/L as SiO_2)	Boron, dissolved (µg/L as B)	Iron, dissolved (µg/L as Fe)	Lithium, dissolved (µg/L as Li)	Manganese, dissolved (µg/L as Mn)	Strontium, dissolved (µg/L as Sr)
54	4.3	—	55	27	0.40	0.07	35	160	7	44	<1	660
41	3.9	361	53	27	0.30	0.09	30	90	13	19	2	510
40	3.4	354	48	29	0.40	0.09	33	110	5	34	1	620
23	1.5	210	40	8.7	0.30	0.04	25	50	8	6	1	380
18	1.8	240	53	6.2	0.40	0.04	28	40	3	8	<1	550
43	5.7	268	31	19	0.50	0.06	33	110	27	48	1	1,300
31	6.0	424	53	810	0.30	0.10	32	90	80	30	10	3,300
7.7	0.80	99	14	4.6	0.60	<0.01	20	10	5	<4	<1	210
18	3.1	142	88	13	0.30	0.04	43	50	12	13	<1	540
4.8	0.80	161	40	2.3	0.30	<0.01	12	10	10	8	<1	320
16	0.90	208	110	18	0.20	0.07	18	50	4	16	<1	1,000
73	0.40	130	24	16	1.3	0.08	19	210	170	9	3	51
200	3.0	—	91	270	0.30	0.16	23	150	—	78	—	—
310	4.2	393	350	430	0.60	0.19	19	280	20	90	<10	5,000
530	7.0	453	860	540	0.80	0.39	26	570	70	110	160	3,700

Table 27. Chemical analyses of water from selected springs

[mg/L, milligrams per liter; µg/L, micrograms per liter; —, no data; <, less than]

Location: See figure 2 for an explanation of the numbering system for springs.
Source of water: Qal, alluvium of Quaternary age; Tv, volcanic rocks of Tertiary age; Tf, Flagstaff limestone of Tertiary
Specific conductance: µS/cm, microsiemens per centimeter, at 25 degrees Celsius; measured in the field except where
pH: Measured in the field except where noted by L, laboratory value.
Temperature: °C, degrees Celsius; measured in the field.
Alkalinity: Measured in the field except where noted by L, laboratory value.
Solids, dissolved: Sum of constituents except where noted by R, residue on evaporation, at 180 degrees Celsius.
Iron: Dissolved except where noted by T, total.
Lithium: Noted by M where an earlier, less accurate than the present, method of analysis was used.

Location	Source of water	Date measured	Specific conductance (µS/cm) units)	pH (standard	Temperature, water (°C)	Hardness, total (mg/L as $CaCO_3$)	Hardness, noncarbonate (mg/L as $CaCO_3$)	Alkalinity, field (mg/L as $CaCO_3$)	Solids, dissolved (mg/L)	Calcium, dissolved (mg/L as Ca)	Magnesium, dissolved (mg/L as Mg)
(C-21-1)11aaa-S1	Qal	09-27-68	950	7.8	21.0	190	5	180	599	28	28
(C-23-2)12bab-S1	Qal	08-15-88	740	8.1L	13.5	290	130	163 L	441	77	24
(C-23-2)25bac-S1	Tv	05-24-89	395	7.9	17.0	100	0	104	246	28	8.3
(C-23-2)28ddd-S1	Qal	09-21-56	540	7.7	13.0	210	56	—	—	—	—
		05-25-89	620	7.9	13.0	210	58	186	355	56	17
(C-23-3)26aca-S1	Tf	07-30-57	550	7.9	20.0	270	25	—	310	45	38
		05-28-63	350	8.0	—	200	26	—	206	55	14
		06-06-66	550	8.3	22.0	270	35	—	310	51	35
(C-24-2) 4ccb-S1	Qal	10-28-68	730	7.8	13.0	320	150	179	445	79	31
(C-25-3)10dda-S1	Fz,Tv	05-17-66	4,000	7.6	42.0	710	460	—	2,680	260	17
(C-25-3)11cac-S1	Fz,Tv	05-02-66	4,100	7.8	76.5	640	510	—	2,620	200	34
(C-25-3)15dda-S1	—	04-18-67	3,900	7.9	33.0	900	590	—	2,700	280	49
(C-25-3)27dcd-S1	—	04-18-67	620	7.4	25.0	240	93	—	427	70	15
(C-25-4)23aac-S1	Fz,Tv	07-23-57	7,790	6.9	54.5	850	500	—	5,150	280	36
		09-11-57	7,520	6.6	64.0	—	—	—	4,970	260	44
		11-06-87	6,800	8.0	—	500	270	228 L	4,940	140	37
(C-25-4)23add-S1	Fz,Tv	05-03-66	7,680	7.6	63.0	850	520	—	5,080	260	49
		05-15-67	7,530	7.8	64.5	810	490	—	5,180	250	46
(D-18-1)19dab-S1	Tf	08-27-57	1,020	7.6	18.0	300	50	—	553	49	43
		10-15-87	1,000	7.8	19.0	280	82	203 L	533	48	40
(D-19-2)33acd-S1	—	07-13-65	760	8.0	10.0	380	45	—	415	74	48
(D-20-1)35ddd-S1	Qal	11-06-87	2,450	7.3	12.0	910	720	189 L	1,800	200	100

age; Fz, fault zone.
noted by L, laboratory value.

Sodium, dissolved (mg/L as Na)	Potassium, dissolved (mg/L as K)	Bicarbonate, field (mg/L as HCO_3)	Sulfate, dissolved (mg/L as SO_4)	Chloride, dissolved (mg/L as Cl)	Fluoride, dissolved (mg/L as F)	Bromide, dissolved (mg/L as Br)	Silica, dissolved (mg/L as SiO_2)	Boron, dissolved (µg/L as B)	Iron, dissolved (µg/L as Fe)	Lithium, dissolved (µg/L as Li)	Manganese, dissolved (µg/L as Mn)	Strontium, dissolved (µg/L as Sr)
140	4.2	—	89	160	1.0	—	37	200	—	—	—	—
35	3.6	—	100	61	0.30	0.11	34	110	5	27	—	—
39	2.5	127	10	48	0.20	0.05	45	30	17	10	11	300
32	—	—	76	36	—	—	—	—	—	—	—	—
41	4.2	186	68	42	0.50	0.10	34	200	24	36	<1	520
12	4.0	—	27	20	0.20	—	14	—	40 T	500 M	10	—
3.8	0.60	—	14	10	0.10	—	6.3	0	—	—	—	—
15	3.2	—	29	20	0.30	—	11	—	—	—	—	—
29	3.2	—	98	63	0.80	—	34	100	—	—	—	—
580	62	—	930	620	2.8	—	52	260	—	—	—	—
600	66	—	930	660	2.8	—	51	270	—	—	—	—
550	49	—	920	600	1.8	0.16	51	230	—	—	—	—
44	1.5	—	160	14	1.8	—	32	—	—	—	—	—
1,440	68	—	1,270	1,750	2.7	—	85	—	560 T	8,000 M	160	—
1,380	45	—	1,250	1,690	6.0	—	84	4,800	—	1,500 M	—	—
1,600	41	—	1,300	1,600	2.9	—	78	4,800	30	—	—	—
1,500	60	—	1,300	1,700	3.0	—	77	400	—	—	—	—
1,500	47	—	1,400	1,700	4.6	0.30	76	3,700	—	—	—	—
99	1.9	—	43	150	0.30	—	13	—	0	300 M	0	—
98	2.3	—	48	160	0.20	—	13	40	10	—	—	—
24	—	—	34	18	—	—	14	—	—	—	—	—
130	4.5	—	1,100	120	0.80	0.19	25	380	—	100	—	—

Table 28. Chemical analyses of surface water collected during seepage study

[mg/L, milligrams per liter; µg/L, micrograms per liter; —, no data; <, less than]

Location: See figure 2 for an explanation of the numbering system for data sites.
Specific conductance: µS/cm, microsiemens per centimeter at 25 degrees Celsius; Measured in the field except where
pH: Measured in the field except where noted by L, laboratory value.
Temperature: °C, degrees Celsius.

Site identifier	Location	Date	Specific conductance (µS/cm)	pH (standard units	Temperature, water (°C)	Hardness, total (mg/L as $CaCO_3$)	Hardness, noncarbonate, dissolved, field (mg/L as $CaCO_3$)	Alkalinity, lab mg/L as $CaCO_2$	Solids, residue at 180 °C, dissolved (mg/L)	Calcium, dissolved (mg/L as Ca)	Magnesium, dissolved (mg/L as Mg)
R1	Sevier River above Clear Creek near Sevier	08-09-88	460	8.7	19.0	210	210	219	288	51	20
		10-25-88	500	8.1	9.0	210	210	210	294	48	22
I1	Clear Creek at Sevier	08-09-88	260	8.2	14.0	100	100	93	176	32	5.3
		10-25-88	305	8.2L	7.5	110	110	105	197	37	5.4
R2	Sevier River near Joseph	08-09-88	460	8.6	20.0	210	210	215	260	50	20
		10-25-88	480	8.0	9.0	200	200	200	287	46	20
R3	Sevier River near Elsinore	08-09-88	520	8.4	20.0	220	220	230	324	56	20
		10-25-88	560	8.0	10.5	220	220	221	337	55	21
R4	Sevier River near Central	08-09-88	573	8.3	21.5	240	240	242	338	61	21
		10-25-88	690	8.0L	11.0	280	280	269	417	71	24
I2	(C-24-2)5cad	10-26-88	780	7.7	6.0	330	330	213	493	84	28
R5	Sevier River east of Richfield	08-09-88	780	8.2	22.0	330	330	260	496	77	34
		10-25-88	1,090	7.7	10.0	440	440	291	715	99	48
I3	(C-23-2)28adc	10-27-88	660	7.7	10.0	250	250	176	404	67	21
I4	(C-23-2)15daa	10-26-88	705	7.9	10.5	260	260	163	436	66	22
I5	(C-23-2)12bab-S1	08-15-88	740	8.1L	13.5	290	290	163	452	77	24
I6	Brine Creek near Mouth	08-17-88	48,800 L	8.0	18.5	3,300	3,300	132	35,300	960	210
		10-25-88	17,800	7.7	18.5	2,500	2,500	157	11,600	720	160
R6	Sevier River at Sigurd	08-09-88	1,010	8.1	23.0	390	390	257	652	85	42
		10-25-88	990	8.2L	12.0	380	380	235	638	87	39
R7	Sevier River near Sigurd	08-09-88	1,110	8.2	22.5	420	420	248	754	90	47
		10-25-88	1,050	7.6	12.0	380	380	238	649	86	40
I7	Lost Creek at mouth near Aurora	08-10-88	51,000	8.0	25.5	3,000	3,000	143	14,800	910	180
		10-25-88	4,730	8.3	12.0	420	420	155	2,560	120	29
R8	Sevier River west of Salina	08-10-88	1,670	8.0	21.5	490	490	294	1,040	100	59
		10-26-88	1,430	7.9	10.5	430	430	261	856	95	47
I8	Salina Creek at Salina	08-15-88	2,490 L	8.7	21.0	580	580	239	1,670	130	63
		10-26-88	1,280	8.4	10.5	390	390	267	737	66	54
R9	Sevier River south of Redmond	08-10-88	1,690	8.1	21.5	500	500	316	1,040	100	60
		10-26-88	1,430	8.0	12.0	410	410	264	856	85	47

noted L, laboratory value.

Sodium, dissolved (mg/L as Na)	Sodium, adsorption ratio	Potassium, dissolved (mg/L as K)	Sulfate, dissolved (mg/L as SO_4)	Chloride, dissolved (mg/L as Cl)	Fluoride, dissolved (mg/L as F)	Bromide, dissolved (mg/L as Br)	Silica, dissolved (mg/L as SiO_2)	Nitrogen, NO_2+NO_3 dissolved (mg/L as N)	Arsenic, dissolved (µg/L as As)	Boron, dissolved (µg/L as B)	Iron, dissolved (µg/L as Fe)	Lithium, dissolved (µg/L as Li)	Selenium, dissolved (µg/L as Se)
26	0.8	4.0	29	10	0.30	0.025	27	0.120	—	70	11	13	—
32	1	4.1	40	13	0.30	0.037	8.6	<0.100	—	90	6	13	—
16	0.7	1.8	13	17	0.70	0.019	30	<0.100	—	30	10	10	—
19	0.8	2.0	15	19	0.60	0.024	34	<0.100	—	30	5	10	—
26	0.8	3.9	25	11	0.30	0.037	27	<0.100	—	70	7	14	—
31	1	3.8	37	14	0.40	0.036	19	<0.100	—	80	7	15	—
33	1	3.9	34	16	0.40	0.037	29	0.350	—	90	8	22	—
39	1	3.8	44	21	0.40	0.049	24	0.540	—	110	<3	24	—
36	1	3.9	37	19	0.30	0.040	29	0.610	—	100	8	22	—
46	1	4.0	61	29	0.30	0.064	26	1.20	—	130	<3	25	—
39	0.9	3.8	110	58	0.80	0.096	34	1.70	—	160	9	24	—
49	1	4.8	120	28	0.30	0.046	30	0.560	—	140	7	27	—
75	2	5.1	220	48	0.40	0.088	29	1.10	—	200	6	38	—
38	1	3.9	85	42	0.40	0.091	34	1.60	—	180	7	34	—
48	1	3.3	110	53	0.30	0.055	37	0.780	—	120	9	24	—
35	0.9	3.6	100	61	0.30	0.11	34	1.80	—	110	5	27	—
12,000	91	51	1,900	20,000	0.30	11	19	<0.100	1	1,600	—	130	<1
3,300	29	20	2,000	5,000	0.40	2.2	29	0.210	2	730	—	110	1
73	2	5.2	170	78	0.40	0.080	34	0.750	—	210	7	38	—
74	2	4.8	170	83	0.40	0.095	33	1.10	—	200	7	38	—
87	2	6.5	200	98	0.40	0.097	32	0.520	—	210	5	39	—
170	4	4.9	160	83	0.40	0.10	33	1.10	—	200	6	38	—
4,000	32	16	2,400	6,900	0.40	3.3	26	<0.100	2	730	—	110	1
790	17	6.6	160	1,300	0.20	0.83	33	<0.100	3	140	—	30	<1
180	4	6.8	300	200	0.40	0.18	33	1.60	—	300	8	47	—
140	3	5.2	220	170	0.40	0.15	32	1.60	—	250	8	42	—
360	6	10	400	490	0.50	0.10	25	<0.100	4	270	—	70	<1
130	3	3.6	150	150	0.30	0.13	13	0.260	2	170	—	61	1
180	4	6.6	300	200	0.40	0.17	33	1.80	—	330	6	49	—
140	3	5.4	210	160	0.40	0.14	31	1.50	—	270	9	45	—

Table 28. Chemical analyses of surface water collected during seepage study—Continued

Site identifier	Location	Date	Specific conductance (µS/cm)	pH (standard units	Temperature, water (°C)	Hardness, total (mg/L as $CaCO_3$)	Hardness, noncarbonate, dissolved, field (mg/L as $CaCO_3$)	Alkalinity, lab mg/L as $CaCO_2$	Solids, residue at 180 °C, dissolved (mg/L)	Calcium, dissolved (mg/L as Ca)	Magnesium, dissolved (mg/L as Mg)
I9	Willow Creek near Axtell	08-15-88	1,570	8.6	21.0	380	380	281	893	56	58
R10	Sevier River near Axtell	08-10-88	1,700	8.2	18.0	490	490	318	1,140	97	59
		10-26-88	1,510	8.1	12.5	420	420	277	910	86	49
R11	Sevier River near Centerfield	08-10-88	1,810	8.2	21.5	490	490	311	1,120	98	60
		10-26-88	1,610	8.1	12.5	420	420	280	954	87	50
R12	Sevier River below San Pitch River near Gunnison	08-10-88	1,940	8.1	22.0	520	520	344	1,180	99	67
		10-27-88	1,800	8.0	11.0	470	470	315	1,020	91	58

Sodium, dissolved (mg/L as Na)	Sodium, adsorption ratio	Potassium, dissolved (mg/L as K)	Sulfate, dissolved (mg/L as SO_4)	Chloride, dissolved (mg/L as Cl)	Fluoride, dissolved (mg/L as F)	Bromide, dissolved (mg/L as Br)	Silica, dissolved (mg/L as SiO_2)	Nitrogen, NO_2+NO_3 dissolved (mg/L as N)	Arsenic, dissolved (µg/L as As)	Boron, dissolved (µg/L as B)	Iron, dissolved (µg/L as Fe)	Lithium, dissolved (µg/L as Li)	Selenium, dissolved (µg/L as Se)
200	4	2.1	180	220	0.70	0.13	24	2.60	6	180	—	75	2
210	4	6.9	300	240	0.40	0.17	33	1.70	—	360	6	54	—
160	3	5.4	220	190	0.40	0.14	31	1.40	—	290	22	48	—
210	4	6.8	300	240	0.50	0.15	33	1.30	—	350	10	57	—
170	4	5.5	230	200	0.40	0.14	31	1.40	—	310	9	51	—
230	4	6.8	320	260	0.40	0.20	29	2.10	—	360	5	63	—
210	4	5.6	260	230	0.40	0.16	29	1.90	—	330	13	58	—

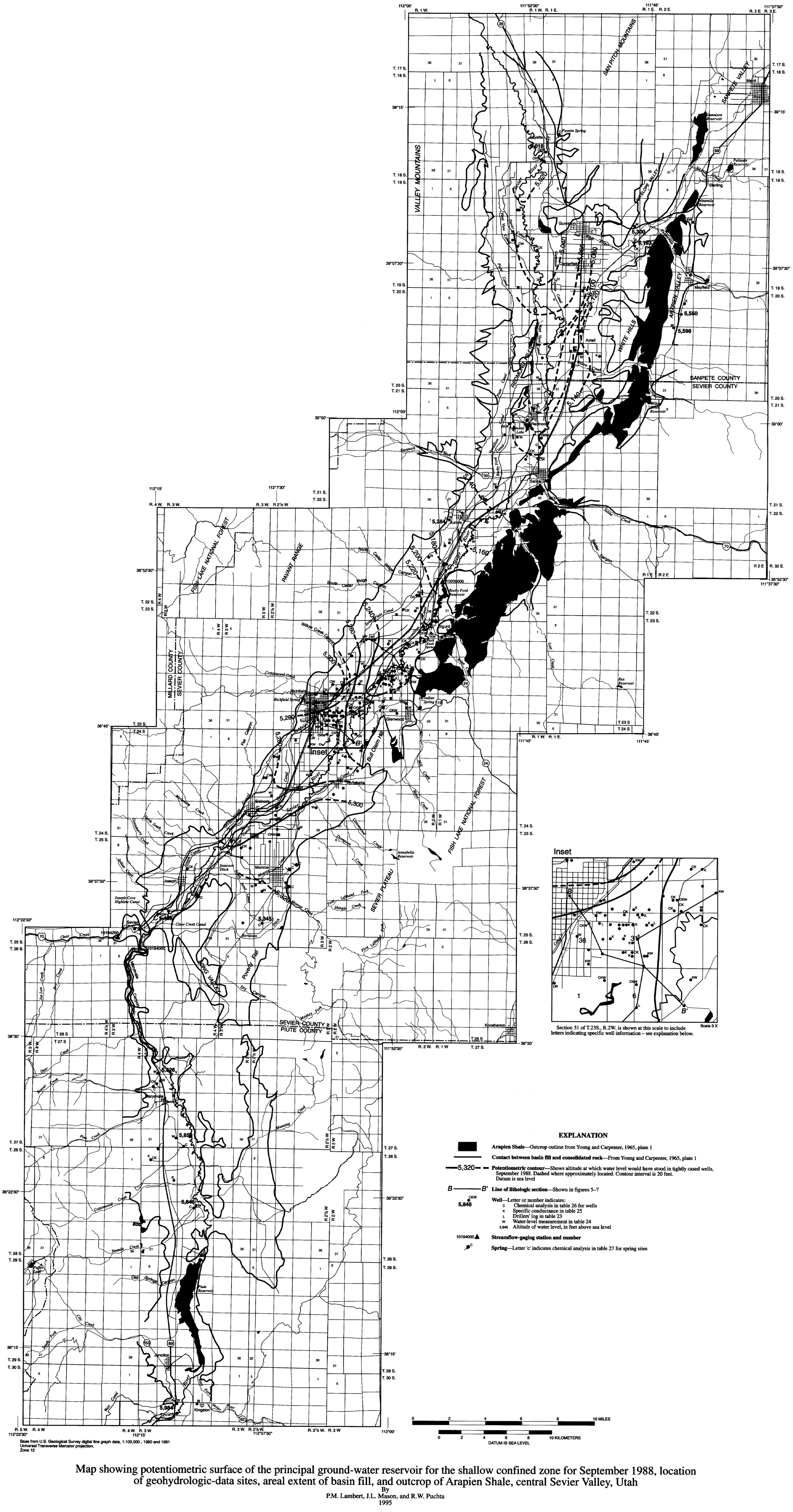
☆ U.S. GOVERNMENT PRINTING OFFICE: 1995 - 673-346 / 02002 REGION NO. 8

The Utah Department of Natural Resources receives federal aid and prohibits discrimination on the basis of race, color, sex, age, national origin or disability. For information or complaints regarding discrimination, contact the Executive Director, Utah Department of Natural Resources, 1636 West North Temple #316, Salt Lake City, UT 84116-3193 or Office of Equal Opportunity, US Department of the Interior, Washington, DC 20240.

250 5/95

Printed with vegetable oil ink.

PREPARED BY THE U.S. GEOLOGICAL SURVEY
IN COOPERATION WITH
UTAH DEPARTMENT OF NATURAL RESOURCES,
DIVISION OF WATER RIGHTS



Map showing potentiometric surface of the principal ground-water reservoir for the shallow confined zone for September 1988, location of geohydrologic-data sites, areal extent of basin fill, and outcrop of Arapien Shale, central Sevier Valley, Utah

By
P.M. Lambert, J.L. Mason, and R.W. Puchta
1995