HYDROLOGIC, METEOROLOGICAL, AND UNSATURATED-ZONE MOISTURE-CONTENT DATA, FRANKLIN LAKE PLAYA, INYO COUNTY, CALIFORNIA

By John B. Czarnecki

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CONVERSION FACTORS

Multiply	*By*	*To obtain*
centimeter per month	0.3937	inch per month
centimeter per day	0.3937	inch per day
kilometer per hour	0.621	mile per hour
kilometer per day	0.0259	mile per hour
meter (m)	3.281	foot
meter per annum (m/a)	3.281	foot per year
millibars	0.000987	atmosphere
millimeter per month	0.3937	inch per month
foot	30.48	centimeter
inch	2.54	centimeter
mile per hour	1.609	kilometer per hour
mile per day	1.609	kilometer per day
mile per month	1.609	kilometer per month
inch per month	2.54	centimeter per month
inch per day	2.54	centimeter per day

Temperature can be converted to degree Celsius (°C) or degree Fahrenheit (°F) by the equations:

$$°C = 5/9\ (°F - 32)$$
$$°F = 9/5\ (°C) + 32$$

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ABSTRACT

Hydrologic and other data were collected at Franklin Lake playa, one of the principal discharge areas of the Furnace Creek Ranch-Alkali Flat ground-water flow system, located in southern Nevada and adjacent California. This data will be used to further characterize ground-water discharge that occurs at the playa largely as bare-soil evaporation. Data presented include: (1) Hydrographs of water levels in piezometers; (2) vertical hydraulic gradients estimated from piezometer-nest data; (3) meteorological data from weather stations in the vicinity of Franklin Lake playa; and (4) estimates of moisture fluxes based on changes in soil-moisture content in the unsaturated zone.

INTRODUCTION

In arid-climate, regional ground-water-flow systems, discharge that results from evapotranspiration is a major component of ground-water flux. Accurate determination of the rate of evapotranspiration is needed to estimate ground-water flow rates and directions within these systems because evapotranspiration can be an important boundary condition in simulations of the flow system. Further, evapotranspiration generally can be measured more easily than its counterpart, recharge, and for this reason typically is specified explicitly and plays a significant role in the mass balance of these models.

Yucca Mountain (fig. 1), located on the western edge of the Nevada Test Site, is being studied by the U.S. Department of Energy as a potential site for a mined geologic repository for storing high-level radioactive waste. As part of these studies, the U.S. Geological Survey has been investigating the ground-water flow system beneath Yucca Mountain and vicinity because of the potential for ground water to transport radionuclides away from a repository. These investigations, done in cooperation with the U.S. Department of Energy under Interagency Agreement DE-AI08-78ET44802, are part of the Nevada Nuclear Waste Storage Investigations.

The ground-water flow system beneath Yucca Mountain and vicinity was studied and modeled (Czarnecki and Waddell, 1984) using a parameter-estimation method to provide an understanding of the ground-water flow system and of the sensitivity of the model to changes in model-flux variables. From the sensitivity analyses performed, the ground-water discharge that occurs as

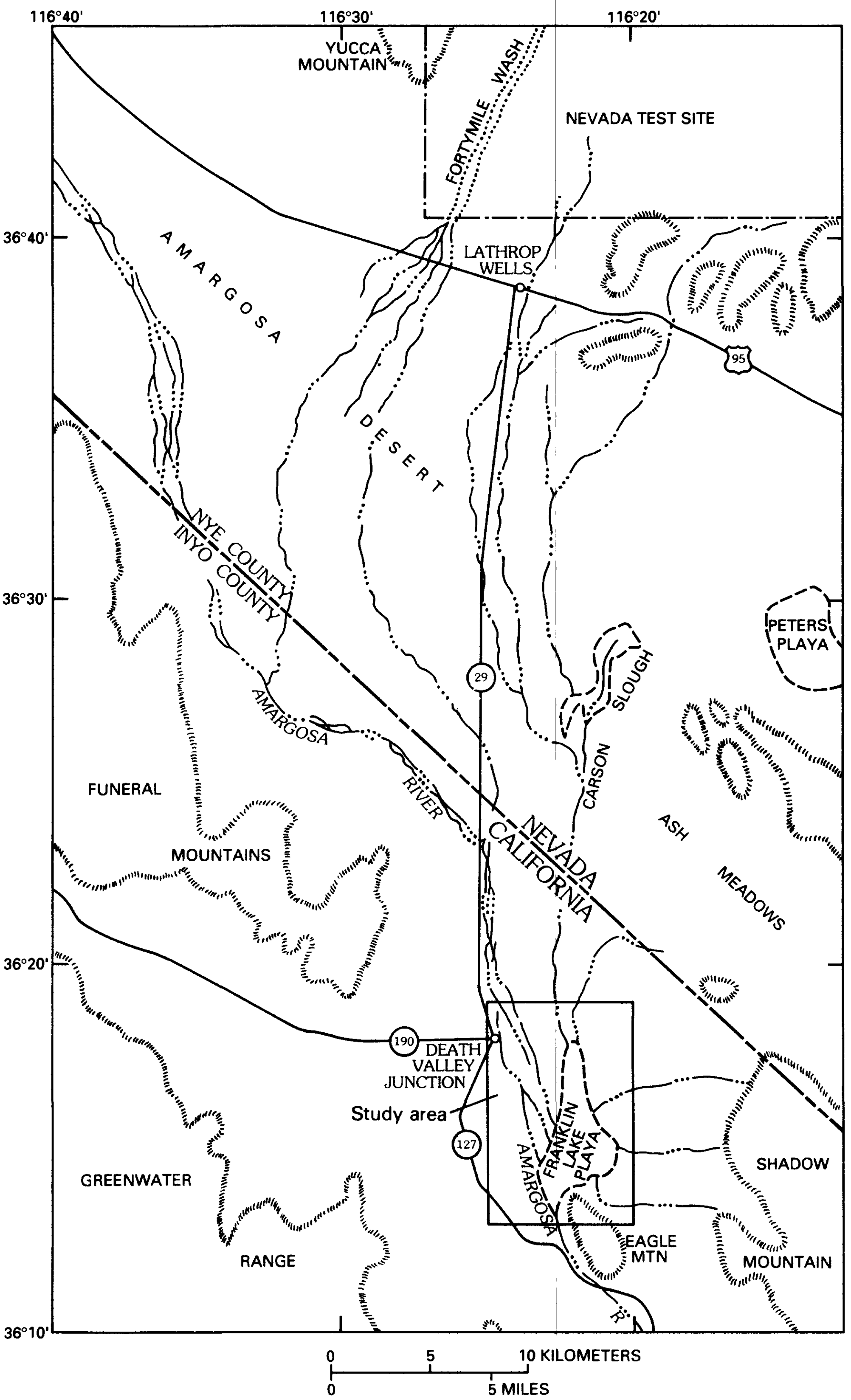

Figure 1.--Location of the study area.

evapotranspiration at Franklin Lake playa, one of the principal ground-water-discharge areas, was determined to have the largest effect on the calculation of transmissivity values at, and downgradient from, Yucca Mountain. Because little was known about the rate of ground-water discharge and evapotranspiration, onsite investigations were made at Franklin Lake playa to quantify these rates and to determine the position of the water table and values of other hydrologic variables. Onsite investigations began in May 1983 and continued until July 1985. This report documents the findings made during this period.

Purpose and Scope

The purpose of this report is to present data pertinent to the characterization of the geohydrology and evapotranspiration at Franklin Lake playa. These data are analyzed (Czarnecki, 1987) using a variety of methods to estimate evapotranspiration at Franklin Lake playa. The scope of this report is limited to reporting only certain data used for characterization; no interpretation is contained herein.

Previous Work

In their study of the hydrology of the Amargosa Desert, Walker and Eakin (1963, p. 23) provided an approximate estimate of the rate of evaporation at Franklin Lake playa (known also as Alkali Flat). Their estimated evaporation rate of 0.3 m/a was based in part on recharge estimates for the Amargosa Desert, using an empirical procedure developed by Eakin and others (1951). Later work was performed by Calzia and others (1979) in which a single drill hole was drilled near the center of the playa by a reverse-circulation process and drill cuttings were logged. The purpose of this hole was, in part, to characterize the mineral potential of the playa waters and sediments, particularly for lithium content. These cuttings later were analyzed by Pantea (1980).

Several wells were drilled at the southern end of the playa (Fred Johnson, American Borate Co., oral commun., 1983) for the purpose of recovering gold and silver thought to be dissolved in the playa waters. At least 12 holes were drilled between 1978 and 1980, ranging in depth from 3 to 17 m. No gold or silver ever was found. However, some of these wells were used in this study to obtain hydrologic and hydrochemical data.

Regional analyses of the ground-water flow system that includes Franklin Lake were conducted by Rush (1970), Winograd and Thordarson (1975), Waddell (1982), Czarnecki and Waddell (1984) and Czarnecki (1985). However, none of these efforts involved direct measurements of hydrologic properties at Franklin Lake playa.

Acknowledgments

The author is indebted to several field assistants from the U.S. Geological Survey for the numerous long, arduous trips made to collect water samples and water-level, moisture-content, and surveying data. This group of people includes William Oatfield, William Townsend, and Ronald Spaulding.

HYDROLOGIC DATA

Characterization of the geohydrology at Franklin Lake playa includes the determination of the potentiometric surface using a network of piezometers and unused wells that are located throughout the study area. Data in the following sections were interpreted by Czarnecki (1987) as part of characterization of the geohydrology of the playa. Piezometers and wells also were used for hydraulic testing to determine transmissivity and hydraulic-conductivity values. These results also were interpreted by Czarnecki (1987).

Hydraulic Head

Hydraulic-head data were collected from a network of 20 piezometers (GS-1 through GS-20, fig. 2) installed on or near the playa and from 15 unused wells on or near the playa. Wells GS-1 through GS-20 were installed in nests at different locations to obtain hydraulic-head measurements at various depths below land surface at a specified site.

All piezometers constructed during this study were designated with a "GS" prefix and were numbered consecutively north to south and east to west. Well numbers not preceded by a prefix represent wells that existed prior to this study and were numbered in the order in which they were found. Missing well numbers (2, 4, 9, and 12) represent uncased boreholes that were found at Franklin Lake playa but were not used in this study because of problems with surface-water inflows resulting from infrequent, major storms.

Water levels in numerous wells were measured. These levels are shown in figures 3*A-H*. Measurements were made using a steel tape; measurement precision generally is to within 0.002 m. Flat hydrographs are typical of wells completed in transmissive sediments; hydrographs with fluctuations indicate less permeable sediments.

Vertical Hydraulic Gradients

Vertical hydraulic gradients were estimated from potentiometric data obtained at various piezometer nests at Franklin Lake playa. An example graph of the line of best fit through water-level altitude data versus well-depth data obtained on May 18, 1983, for wells 1, 3, and 5 is shown in figure 4. The slope of the line of best fit (0.253) is an approximate value of the vertical hydraulic gradient (or change in hydraulic head with depth). Positive gradient values indicate increasing hydraulic head with increasing depth as would be expected in a discharge area. These estimates are shown in figures 5*A-G* and are based on the slope of the line of best fit through plots showing the relation between hydraulic head and piezometer depth. The regression coefficient for each gradient calculation (slope of the line of best fit) has also been plotted.

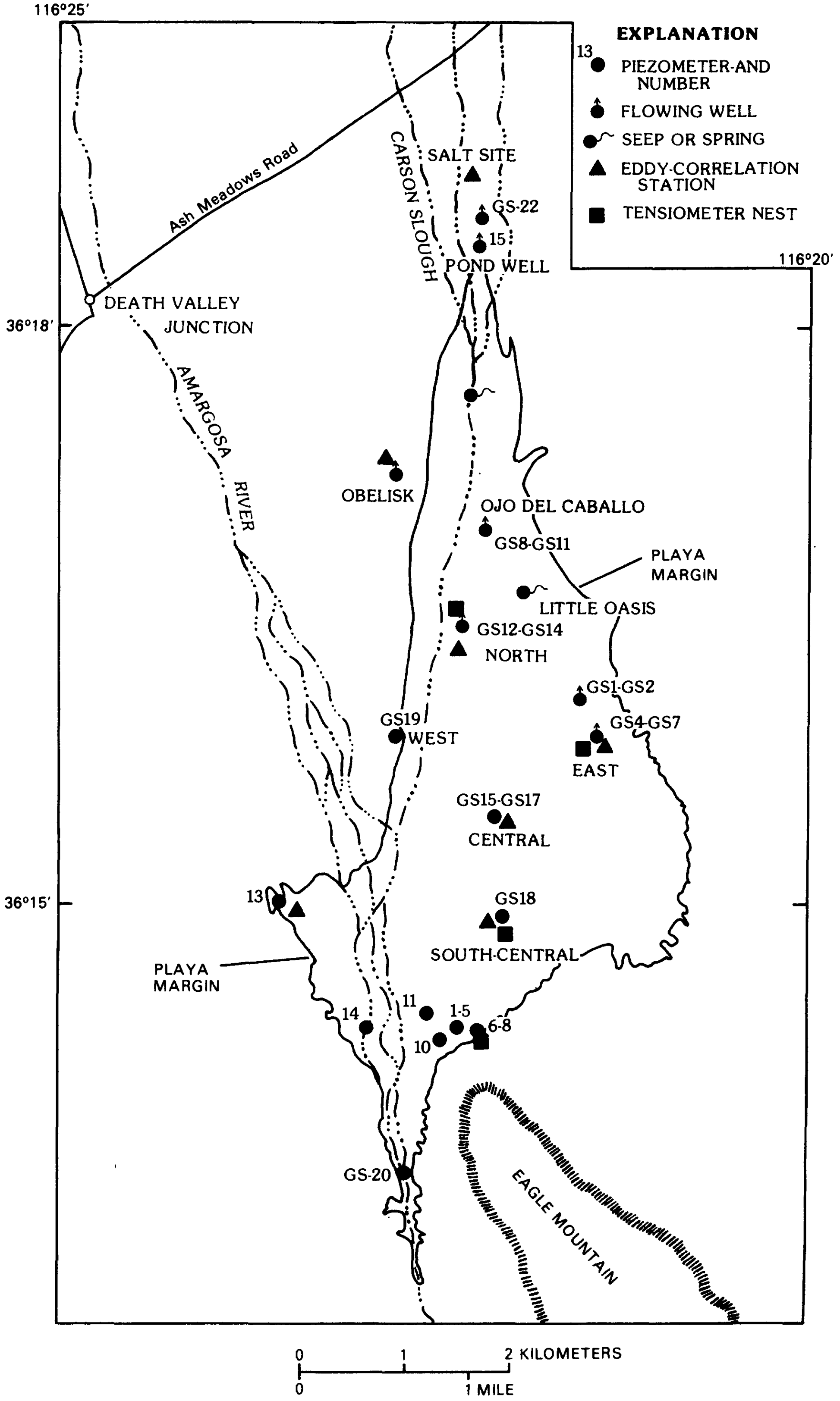

Figure 2.--Study sites at Franklin Lake playa.

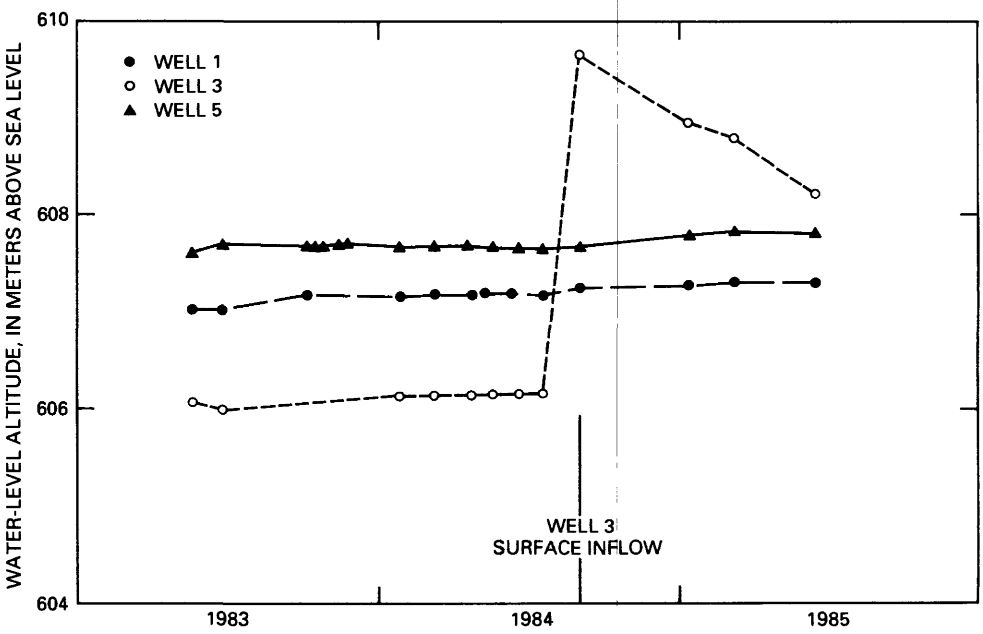

Figure 3*A*.--Water-level altitude in wells 1, 3, and 5.

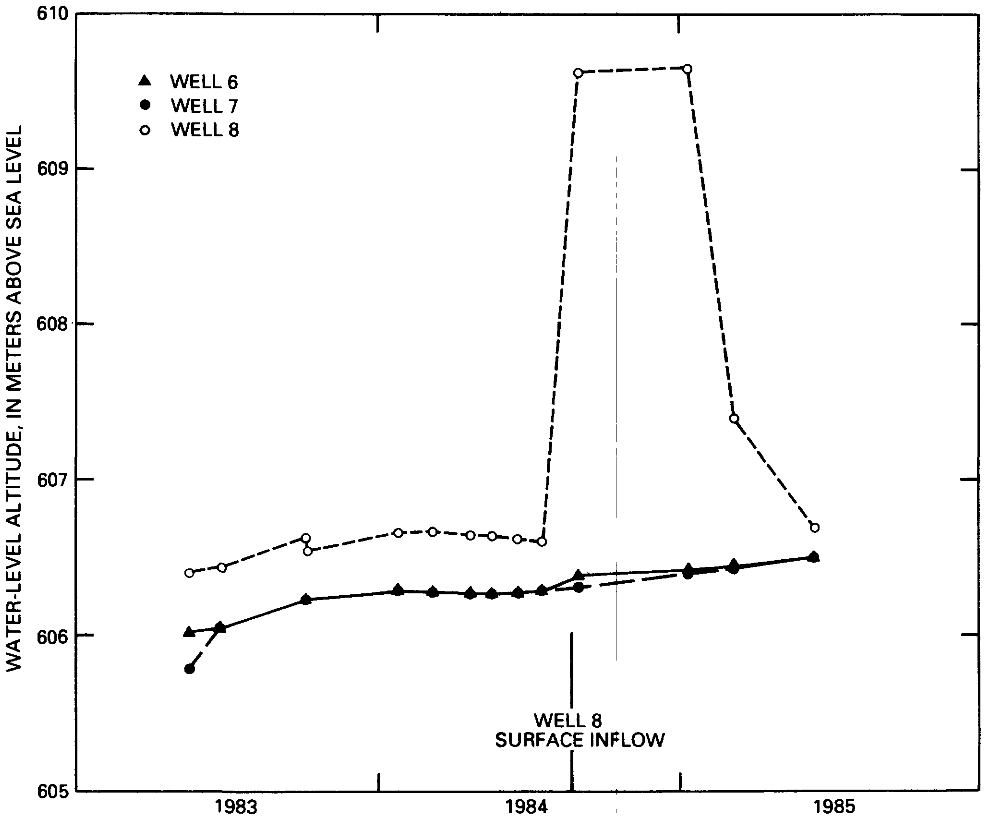

Figure 3*B*.--Water-level altitude in wells 6, 7, and 8.

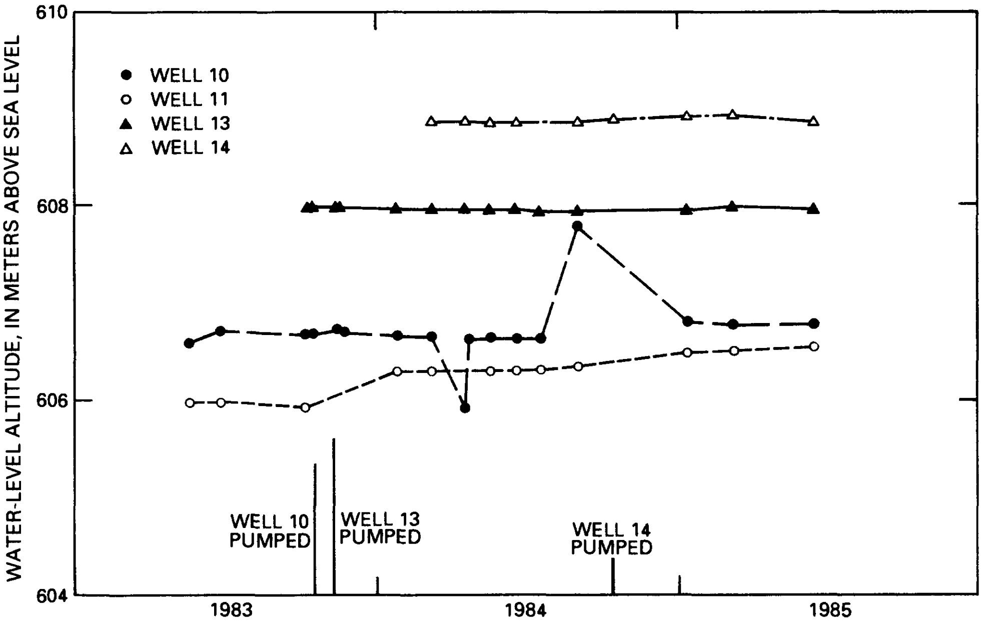

Figure 3C.--Water-level altitude in wells 10, 11, 13, and 14.

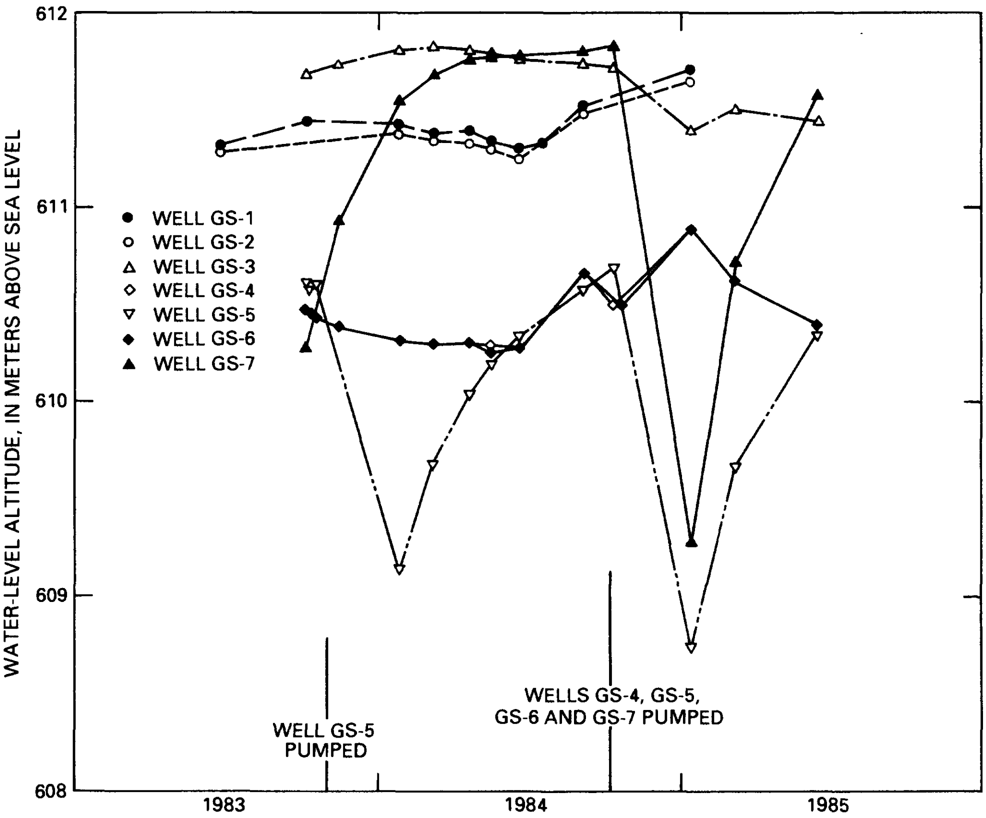

Figure 3D.--Water-level altitude in wells GS-1, GS-2, GS-3, GS-4, GS-5, GS-6, and GS-7.

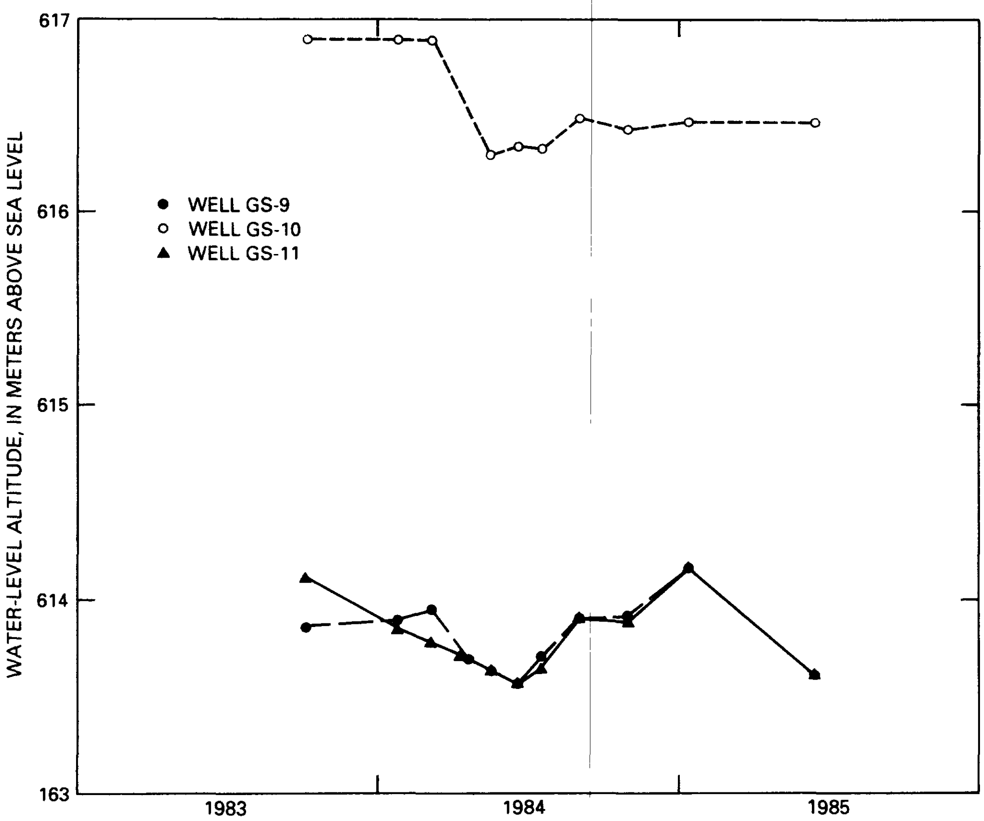

Figure 3*E*.--Water-level altitude in wells GS-9, GS-10, and GS-11.

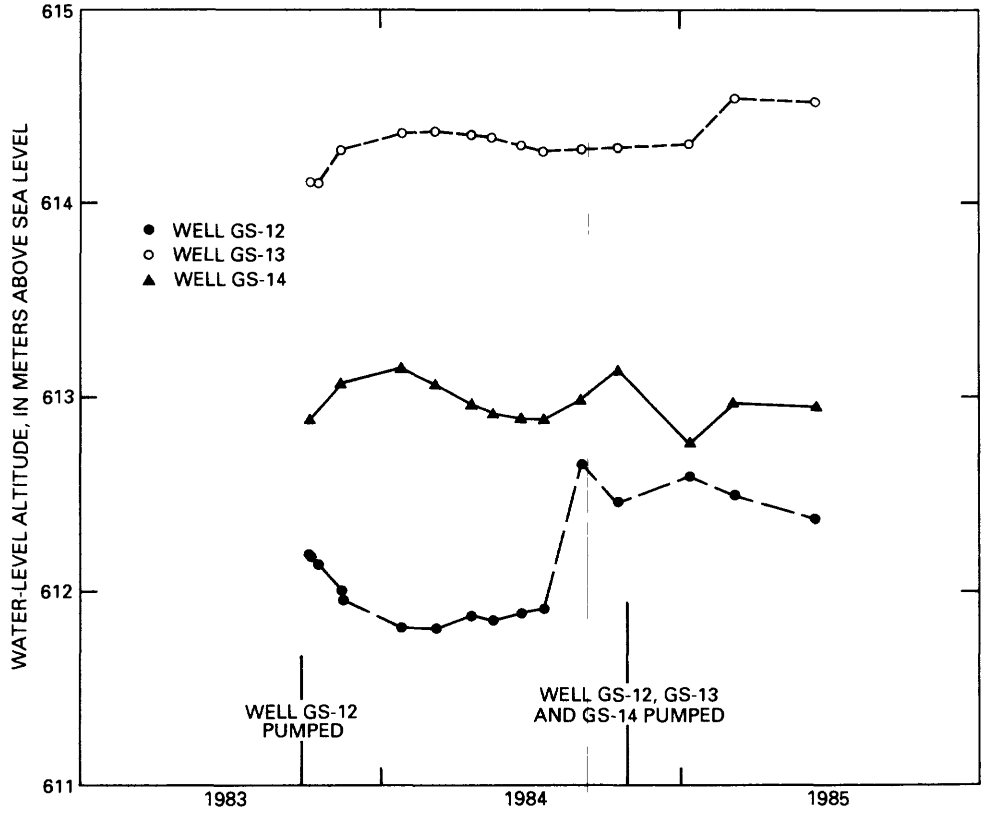

Figure 3*F*.--Water-level altitude in wells GS-12, GS-13, and GS-14.

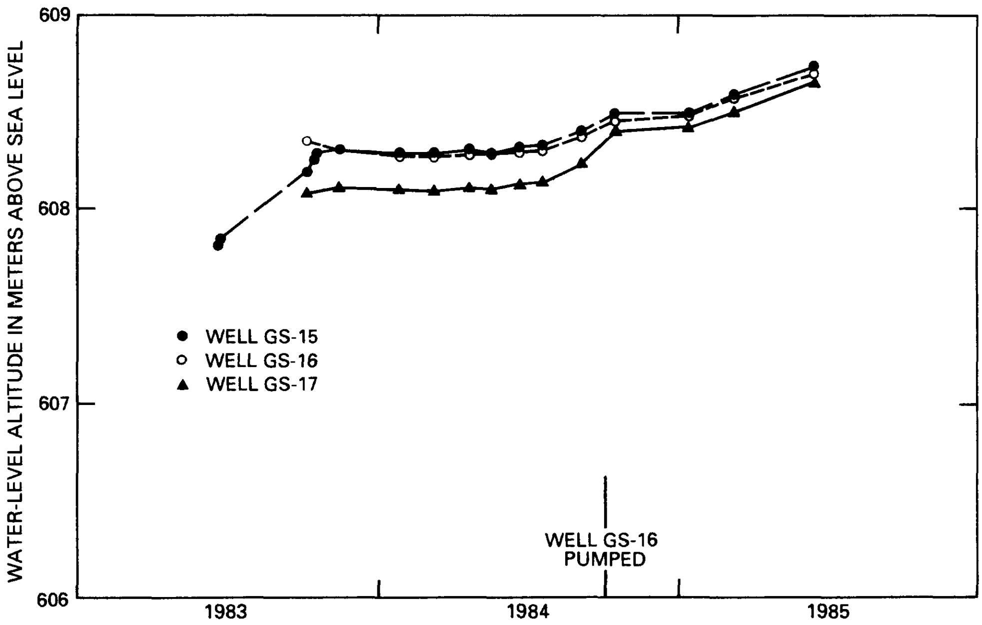

Figure 3*G*.--Water-level altitude in wells GS-15, GS-16, and GS-17.

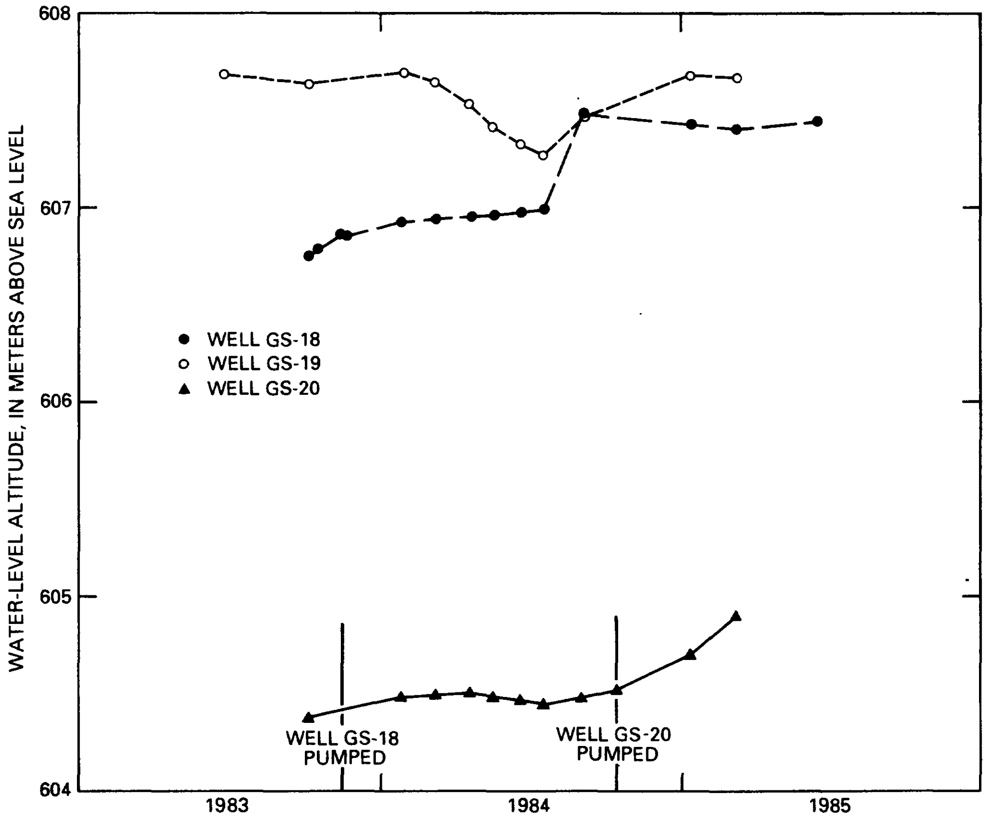

Figure 3*H*.--Water-level altitude in wells GS-18, GS-19, and GS-20.

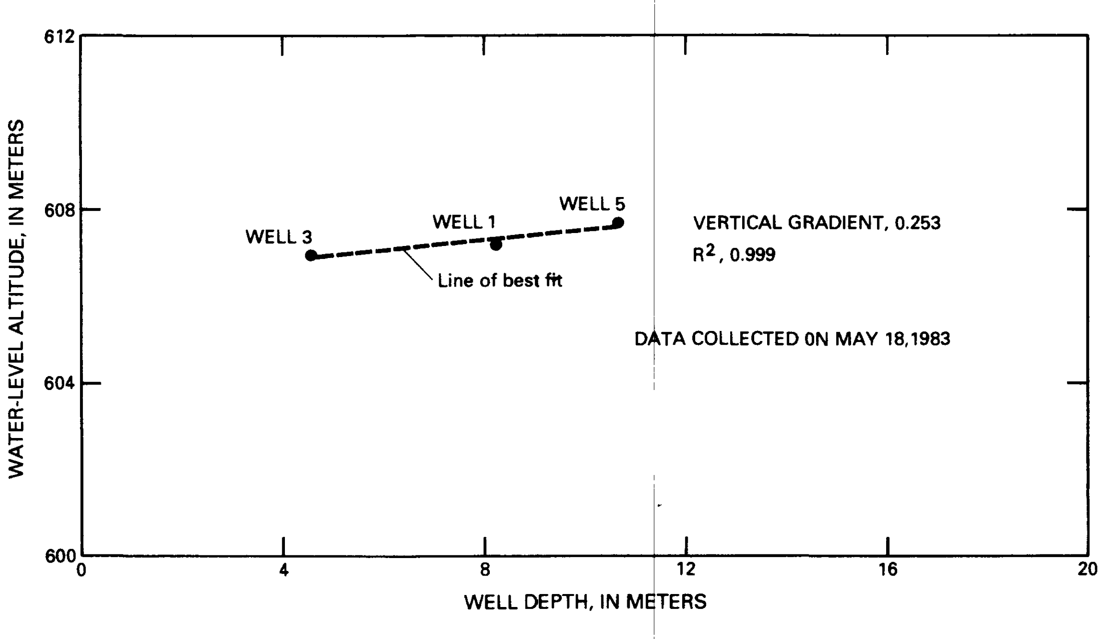

Figure 4.--Example of line of best fit through water-level-altitude data versus well-depth data obtained on May 18, 1983, for wells 1, 3, and 5.

METEOROLOGICAL DATA

Meteorological data used to estimate potential evapotranspiration based on empirical relations were supplied by the U.S. National Weather Service, Nuclear Support Office (Douglas Soule, written commun., 1985) for weather stations located at Mercury, Nev.; Boulder City, Nev.; and Silverpeak, Nev. Mercury, Nev., is located about 60 km northwest of Franklin Lake playa; Boulder City, Nev., is about 140 km southeast; and Silverpeak, Nev., is about 200 km northwest. Meteorologic data for these three stations are listed in tables 1-3. The most complete record exists for Mercury, Nev.; however, pan-evaporation data do not exist for this station.

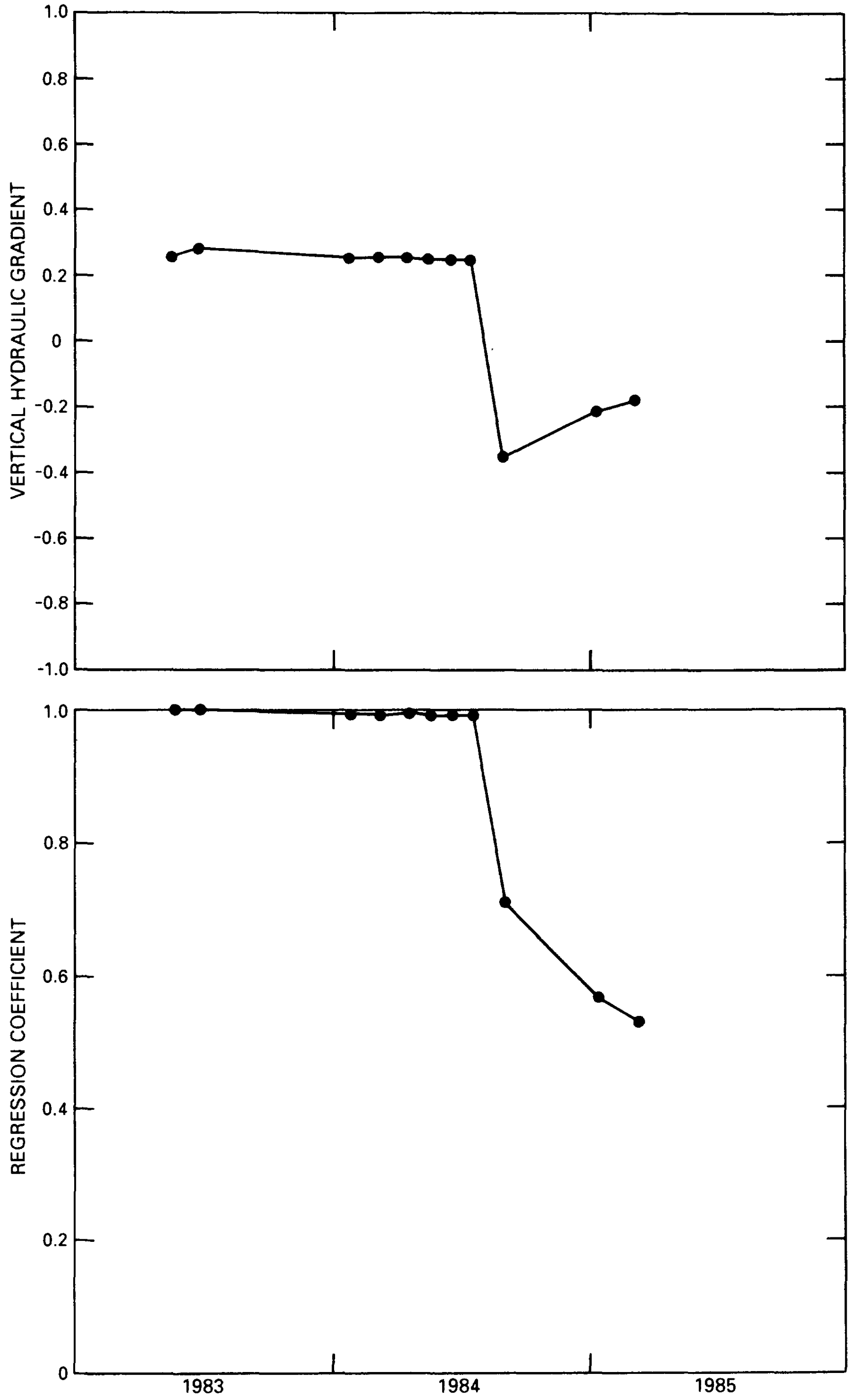

Figure 5A.--Vertical hydraulic gradient and regression coefficient for wells 1, 3, and 5.

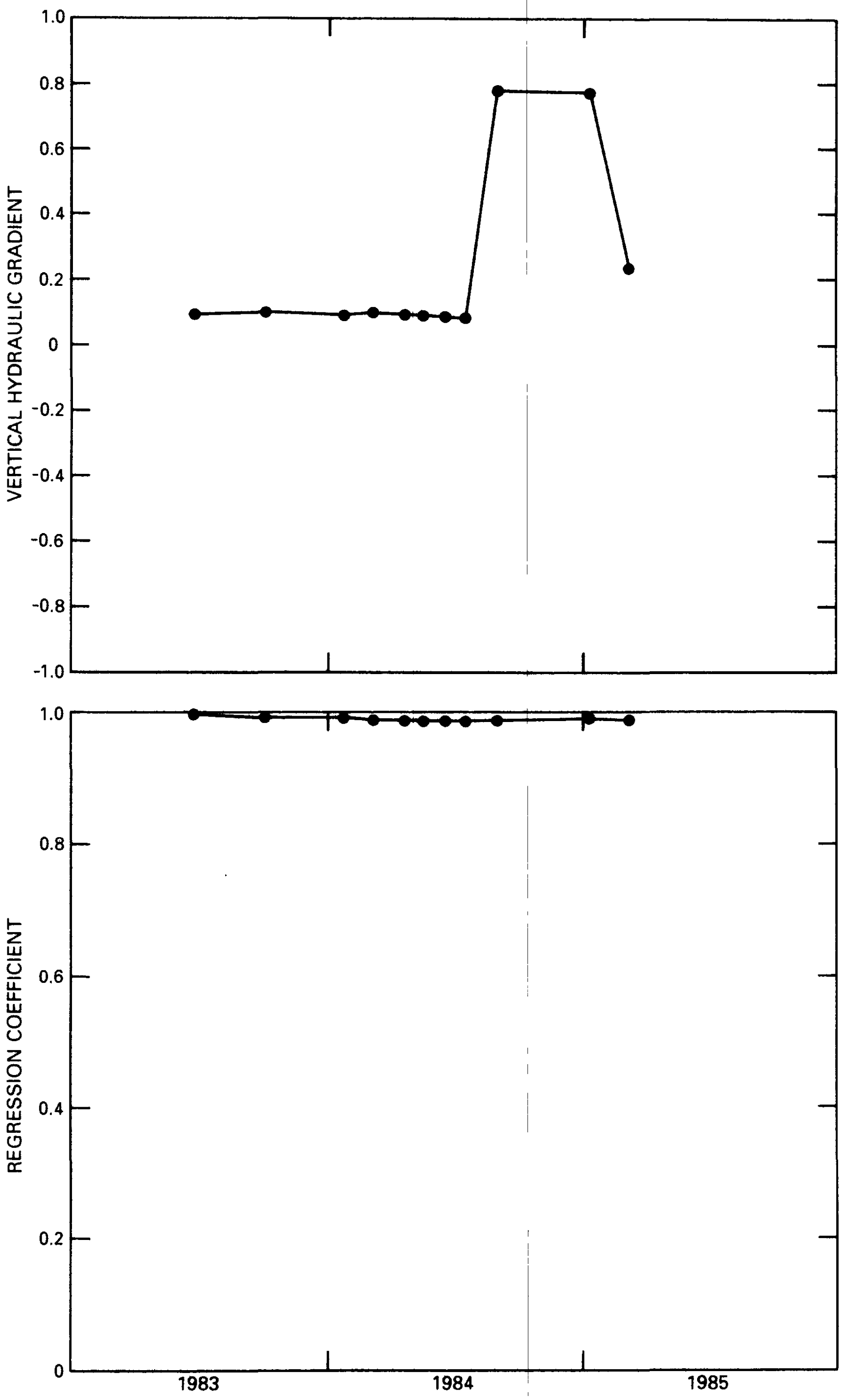

Figure 5*B*.--Vertical hydraulic gradient and regression coefficient for wells 6, 7, and 8.

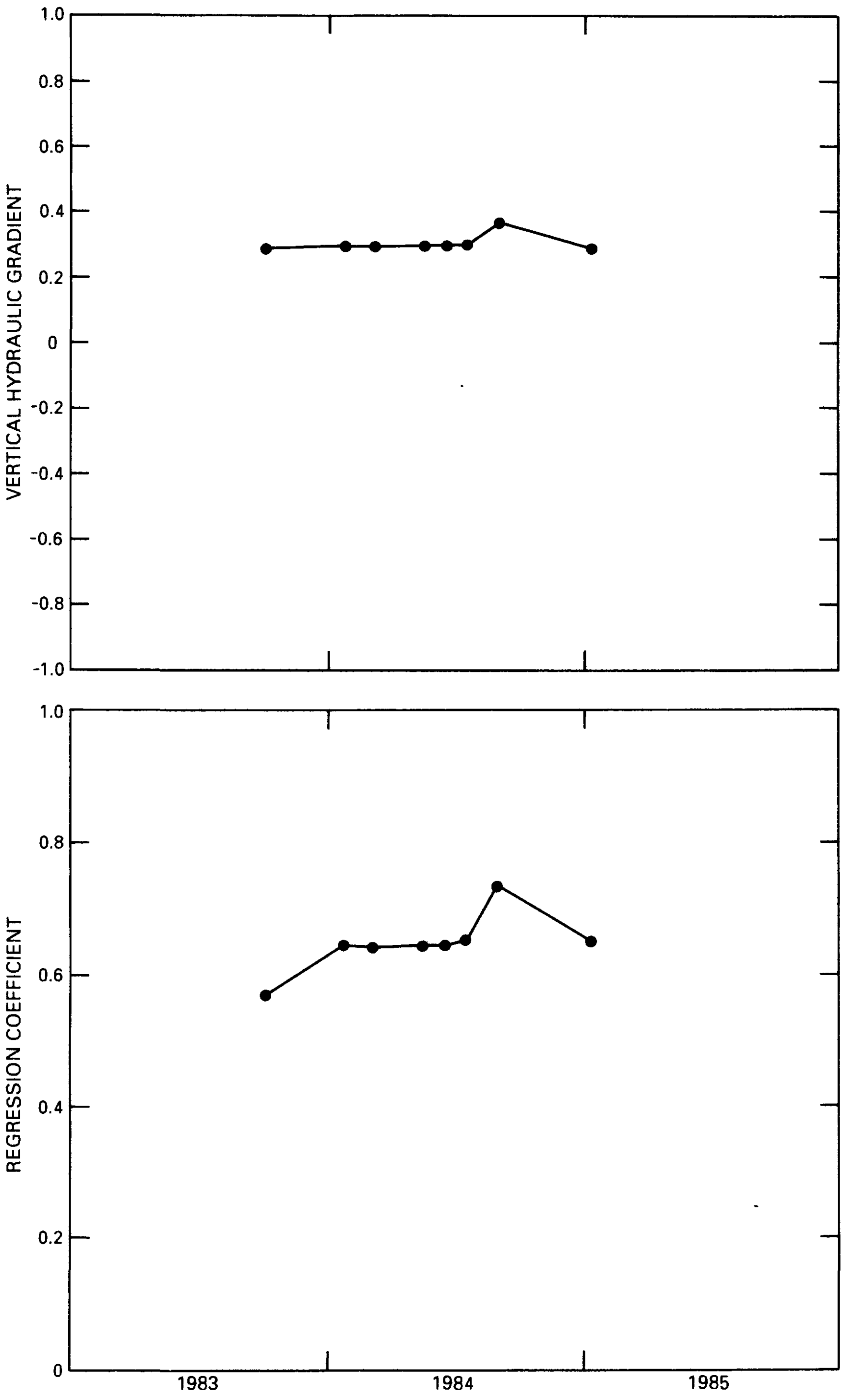

Figure 5C.--Vertical hydraulic gradient and regression coefficient for wells 4, 10, 11, and GS-20.

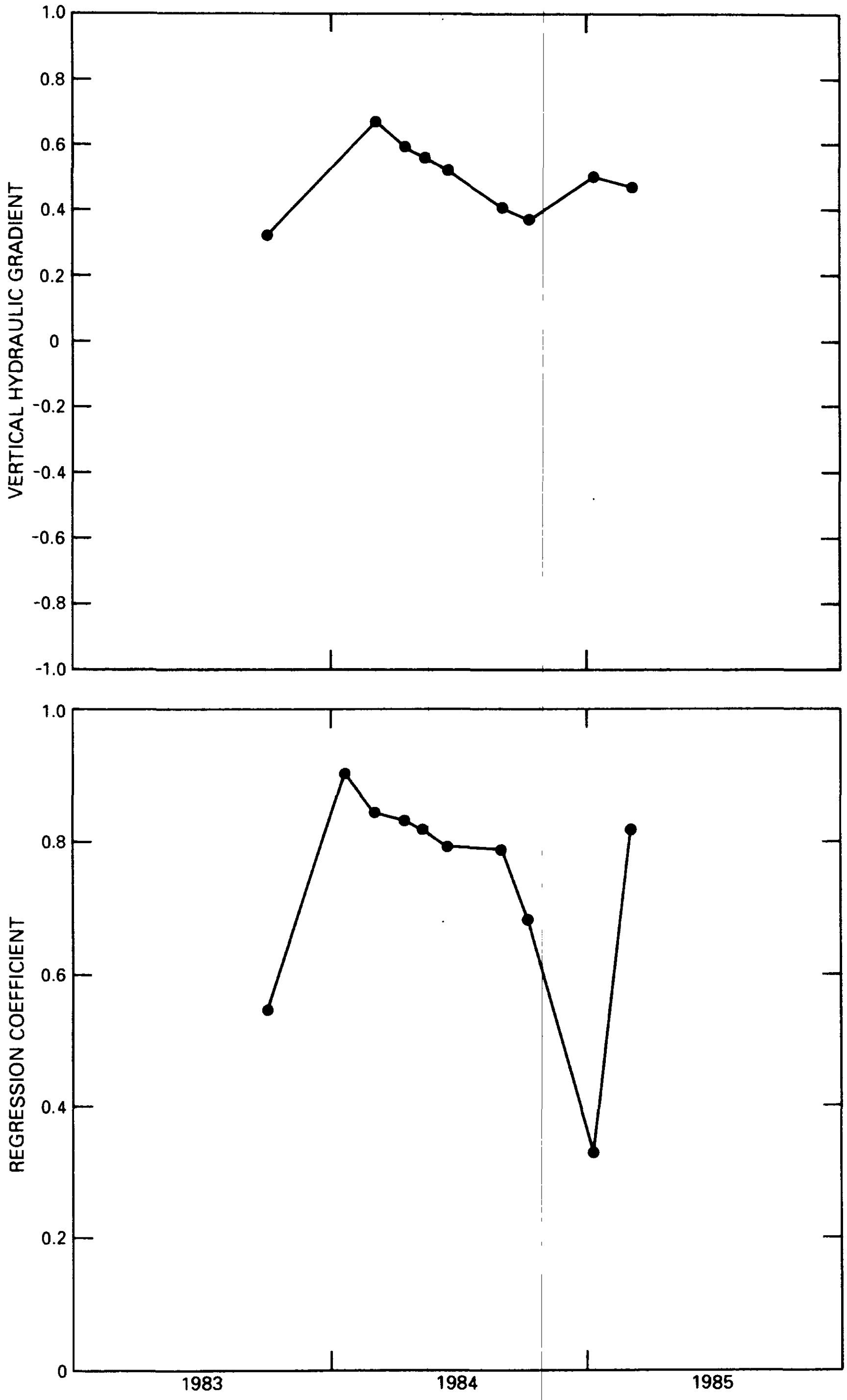

Figure 5*D*.--Vertical hydraulic gradient and regression coefficient for wells GS-3, GS-4, GS-5, and GS-7.

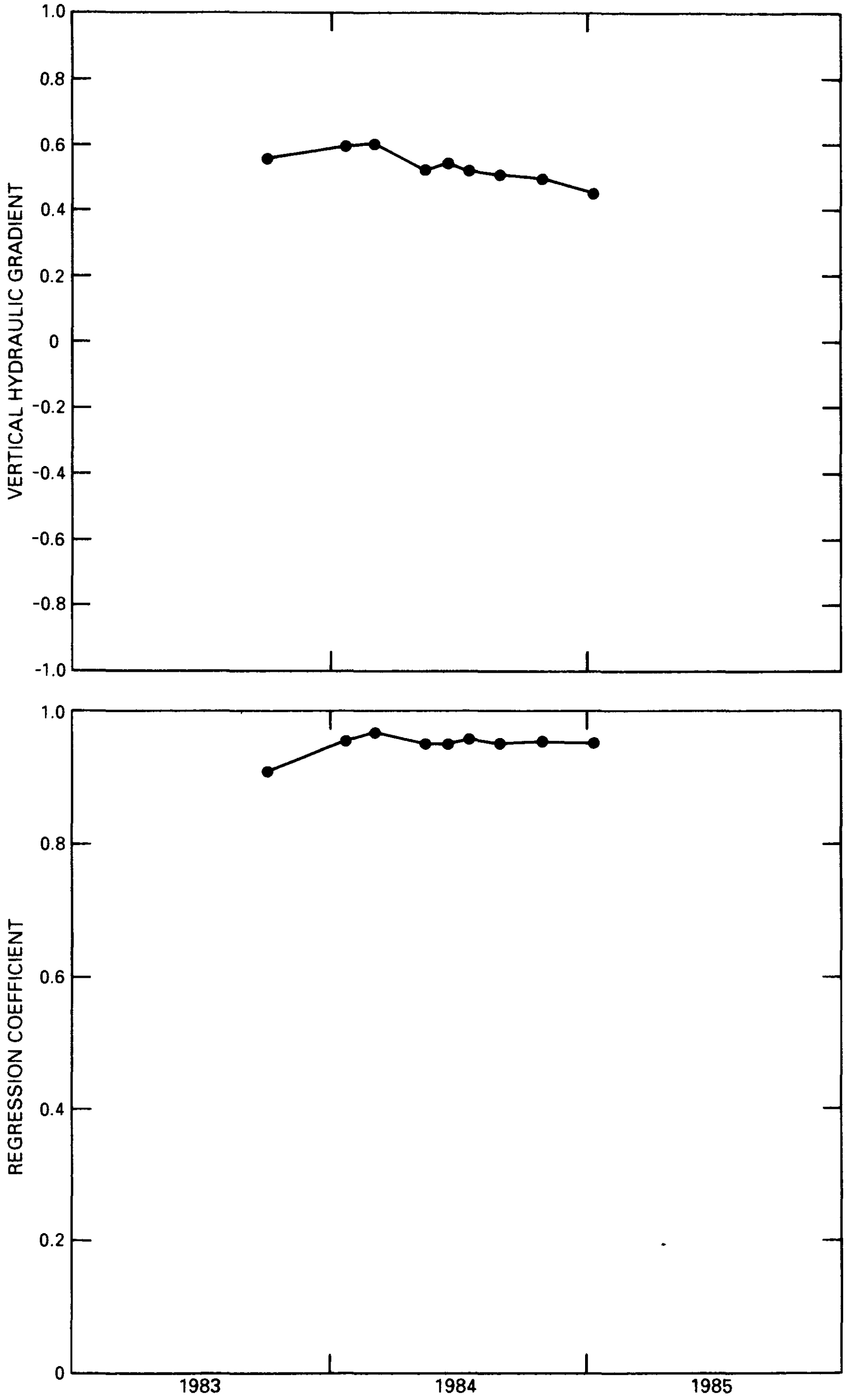

Figure 5*E*.--Vertical hydraulic gradient and regression coefficient for wells GS-9, GS-10, and GS-11.

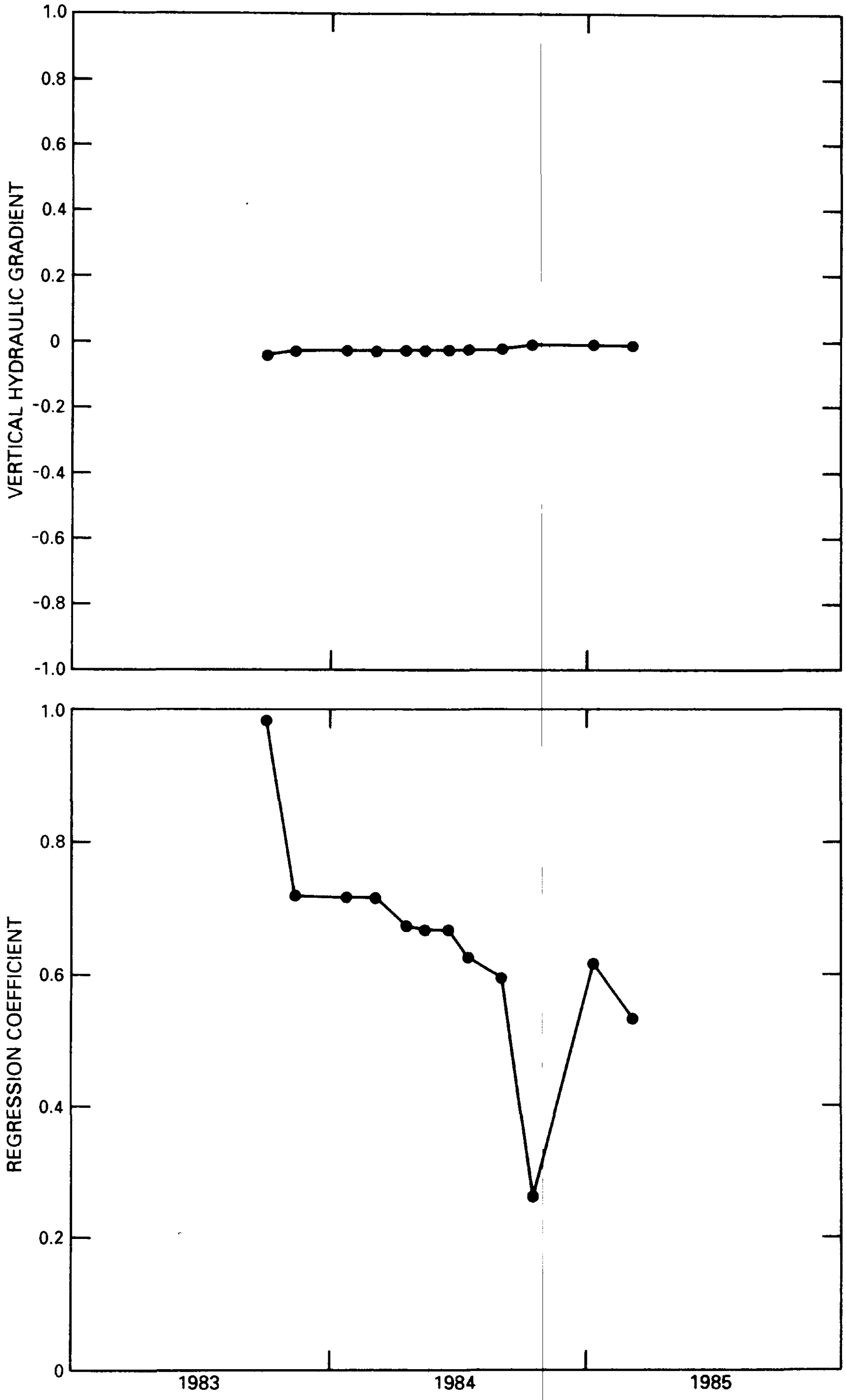

Figure 5*F*.--Vertical hydraulic gradient and regression coefficient for wells GS-15, GS-16, and GS-17.

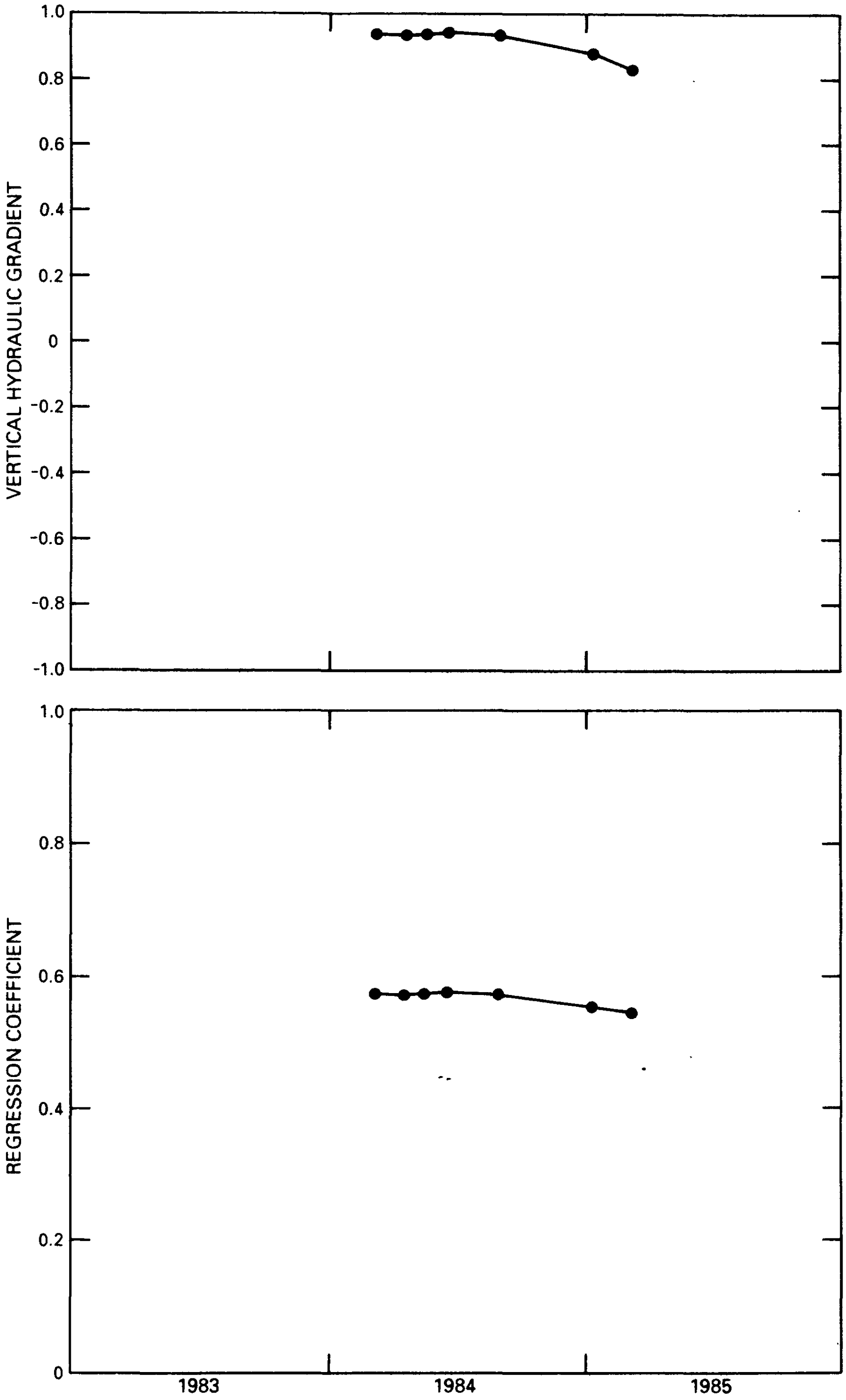

Figure 5G.--Vertical hydraulic gradient and regression coefficient for wells 13, 14, and GS-20.

Table 1.--*Climatological summary for June 1978 to May 1983 for Camp Desert Rock, Mercury, Nevada*

[Source, D.A. Soule, National Weather Service, Nuclear Support Office, written commun., 1985; latitude, 36°37'N; longitude, 116°01'W; elevation, 1,005 meters; T, trace; --, indicates no occurrence]

Month	Temperature (degrees Fahrenheit): Averages: Daily maximum	Daily minimum	Monthly	Extremes: Highest	Year	Lowest	Year	Precipitation (inches): Average monthly	Largest monthly	Year	Smallest monthly	Year	Largest daily	Year	Snow: Average	Largest monthly	Year	Largest daily	Year
Jan.	54.1	33.2	43.6	71	1981	13	1979	0.96	1.79	1979	0.30	1981	0.52	1979	1.1	4.1	1979	3.0	1979
Feb.	58.9	35.8	47.3	78	1981	15	1979	.77	1.89	1980	.21	1981	.63	1980	.4	1.7	1979	1.1	1979
Mar.	61.2	39.1	50.1	78	1979	29	1979	1.66	2.19	1983	1.08	1980	.86	1982	0	T	1980	T	1980
Apr.	71.3	45.9	58.5	95	1981	30	1983	.15	.28	1982	.03	1979	.14	1982	0	T	1983	T	1983
May	80.4	54.1	67.2	102	1983	37	1983	.58	1.57	1981	.02	1979	1.53	1981	0	0	--	0	--
June	92.6	64.0	78.3	106	1981	49	1979	.04	.17	1980	0	1979	.17	1980	0	0	--	0	--
July	99.0	70.0	84.5	108	1980	51	1982	.60	1.72	1982	0	1981	1.57	1982	0	0	--	0	--
Aug.	96.2	68.1	82.2	111	1981	56	1978	.42	1.43	1979	0	1980	.87	1979	0	0	--	0	--
Sept.	89.3	68.1	75.2	102	1979	39	1982	.45	1.18	1982	T	1979	.59	1982	0	0	--	0	--
Oct.	72.5	50.0	63.8	100	1980	33	1979	.20	.58	1978	T	1979	.36	1978	0	0	--	0	--
Nov.	63.1	32.3	50.7	84	1980	25	1981	.61	1.59	1978	T	1980	.62	1978	0	T	1982	T	1982
Dec.	57.1	33.1	45.0	73	1980	17	1978	.29	.88	1978	0	1981	.50	1978	0	0.3	1982	.3	1982

Month	Average relative humidity (percent), Hour (Pacific Standard): 04	10	16	22	Wind speed (miles per hour): Average speed	Peak speed	Year	Average sky cover sunrise to sunset (percent)	Average number of days: Sunrise to sunset: Clear	Partly cloudy	Cloudy	Precipitation (inches): 0.01 or more	0.10 or more	0.50 or more	1.0 or more of rain	1.0 or more of snow	Thunderstorms	Maximum temperature 90 degrees Fahrenheit or more
Jan.	61	47	39	56	8.5	58	1980	5.6	10	7	14	6	4	([1])	0	1	0	0
Feb.	62	44	33	54	9.2	66	1983	6.4	7	7	14	5	2	1	0	([1])	([1])	0
Mar.	63	43	33	53	9.4	56	1983	5.3	10	11	10	7	5	1	0	([1])	1	0
Apr.	44	27	19	33	10.4	52	1982	4.4	13	9	8	3	([1])	0	0	([1])	1	([1])
May	43	25	19	32	9.6	64	1974	4.0	16	8	7	2	1	([1])	([1])	0	1	6
June	24	15	9	17	11.0	64	1974	2.4	21	5	4	([1])	([1])	0	0	0	1	21
July	28	18	13	21	9.4	63	1980	1.9	25	5	2	2	1	([1])	([1])	0	2	29
Aug.	36	22	16	25	8.9	54	1974	2.4	23	4	4	3	1	([1])	0	0	4	27
Sept.	38	24	18	30	8.6	49	1978	2.9	19	7	4	3	1	([1])	0	0	3	17
Oct.	38	24	18	31	8.4	56	1982	3.1	19	7	5	2	1	0	0	0	0	5
Nov.	48	32	25	42	8.2	52	1982	4.4	13	9	8	3	2	([1])	0	([1])	0	0
Dec.	55	38	30	48	7.7	52	1981	4.8	14	5	12	2	1	([1])	0	([1])	0	0

[1]One or more occurrences during the period but averages less than one-half day.

Table 2.--*Summary of temperatures, wind speeds, and pan-evaporation rates for Boulder City, Nevada, 1982-83*

[Source, D.A. Soule, National Weather Service, Nuclear Support Office, written commun., 1985; latitude, 35°55'N; longitude, 114°50'W; elevation, 770 meters; °F, degrees Fahrenheit; mi/mo, miles per month; in/mo, inches per month; --, no measurement available]

Month	Average minimum temperature (°F)	Average maximum temperature (°F)	Wind speed (mi/mo)	Pan evaporation (in/mo)
1982				
January	34.2	52.0	1,390	3.48
February	39.5	59.2	672	3.92
March	41.3	64.1	1,973	6.14
April	45.0	75.8	1,781	9.98
May	53.0	82.7	1,576	13.00
June	57.5	88.6	1,350	14.78
July	64.5	90.6	1,031	14.45
August	65.6	92.1	898	12.62
September	58.3	84.6	1,013	9.10
October	45.1	71.3	1,055	6.85
November	37.4	58.6	974	3.82
December	33.1	53.4	1,076	--
1983				
January	--	--	520	--
February	40.0	57.9	760	3.39
March	42.9	68.1	1,386	6.06
April	41.7	74.6	2,147	8.56
May	51.1	85.6	1,888	13.87
June	57.5	89.7	1,488	16.94
July	61.1	93.0	1,710	17.45
August	65.9	93.2	833	10.01
September	62.6	89.0	1,047	10.49
October	51.7	76.7	823	6.80
November	42.0	61.3	1,639	5.27
December	35.7	54.5	941	3.02
			Average:	[1]8.62

[1]Missing values estimated to be 3.5 inches per month.

Table 3.--*Summary of temperatures, wind speeds, and pan-evaporation rates for Silverpeak, Nevada, 1982-83*

[Source, D.A. Soule, National Weather Service, Nuclear Support Office, written commun., 1985; latitude, 37°40' ; longitude, 117°35' ; elevation, 1,300 meters; °F, degrees Fahrenheit; mi/mo, miles per month; in/mo, inches per month; --, no measurement available]

Month	Average minimum temperature (°F)	Average maximum temperature (°F)	Wind speed (mi/mo)	Pan evapo- ration (in/mo)
1982				
January	--	--	--	--
February	--	--	--	--
March	--	--	4,095	6.90
April	--	--	--	--
May	--	--	--	--
June	--	--	4,032	16.22
July	--	--	3,619	17.83
August	--	--	3,703	16.80
September	48.6	61.3	4,330	11.88
October	37.8	56.7	3,278	6.36
November	--	--	--	--
December	--	--	--	--
1983				
January	--	--	--	--
February	--	--	2,874	--
March	36.2	61.1	4,324	--
April	36.8	64.8	5,224	--
May	44.0	75.7	4,889	12.76
June	50.8	84.7	1,629	16.59
July	49.2	83.6	5,026	20.24
August	57.2	81.6	3,537	13.22
September	50.5	80.1	3,612	12.38
October	41.5	67.1	2,533	6.18
November	33.0	56.0	3,264	--
December	--	--	--	--

Moisture Content in the Unsaturated Zone

Evapotranspiration rates conceivably may be estimated by measuring changes in soil-moisture content in the unsaturated zone. If profiles of the soil-moisture content with depth at various times are obtained, the direction of moisture movement can be inferred from the soil-moisture gradients, and estimates may be made of losses or gains in the moisture content.

Moisture content in the unsaturated zone beneath Franklin Lake playa was determined from logging data using a soil-moisture probe (Campbell Pacific Nuclear, Model 503 Hydroprobe[1]). The soil-moisture probe emits neutrons that are slowed in the presence of water. Moisture content can be obtained by measuring the number of neutrons emitted and deflected back to the probe. Soil-moisture logs for wells GS-4, GS-5, GS-6, GS-15, GS-18, and GS-20 appear in figure 6. These wells were constructed using 5.27-cm-diameter ABS plastic pipe; this construction enabled insertion of the neutron probe and permitted pumping to obtain hydrochemical samples.

The soil-moisture probe was calibrated by first obtaining cores of the shallow unsaturated zone and immediately logging the core hole using the soil-moisture probe with and without plastic casing inserted in the core hole. Moisture content of the sealed core then was measured in the laboratory using a gravimetric procedure. In addition, soil-moisture probe calibrations were made in pipe suspended in air (0 percent water saturation) and in capped pipe suspended in a barrel of water (100 percent water saturation).

Soil-moisture profiles were used to identify changes in moisture content with time in the unsaturated zone, such as from cooler winter months to hot summer months. During these periods, changes in evapotranspiration may occur, and these changes might be indicated by differences in total moisture content of the soil-moisture content profiles. This approach was used to estimate moisture-flux rates. Differences in moisture-content values for different logs for all combinations of periods are listed in table *4A-F*. These differences divided by time were used to estimate moisture flux, E, as:

$$E = \frac{m_1 - m_2}{t_1 - t_2}, \quad t_1 < t_2 \qquad (1)$$

where m_1 is the moisture content of the soil column in centimeters of water measured at time t_1, and m_2 is the content measured at time t_2. The relation between the moisture flux and the difference in time between measurements (profiles) is shown in figure 7. A histogram for all of the fluxes listed in tables *4A-F* is shown in figure 8.

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[1]Any use of brand, firm, or trade names is for identification purposes only and does not constitute endorsement by the U.S. Geological Survey.

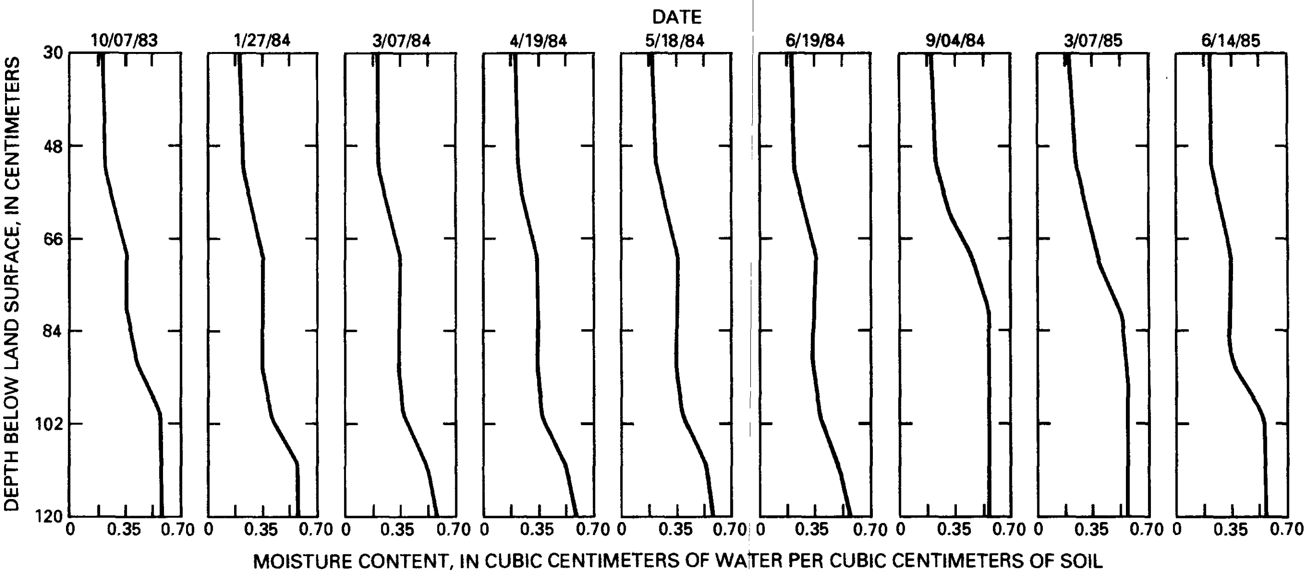

Figure 6*A*.--Moisture-content profiles for well GS-4.

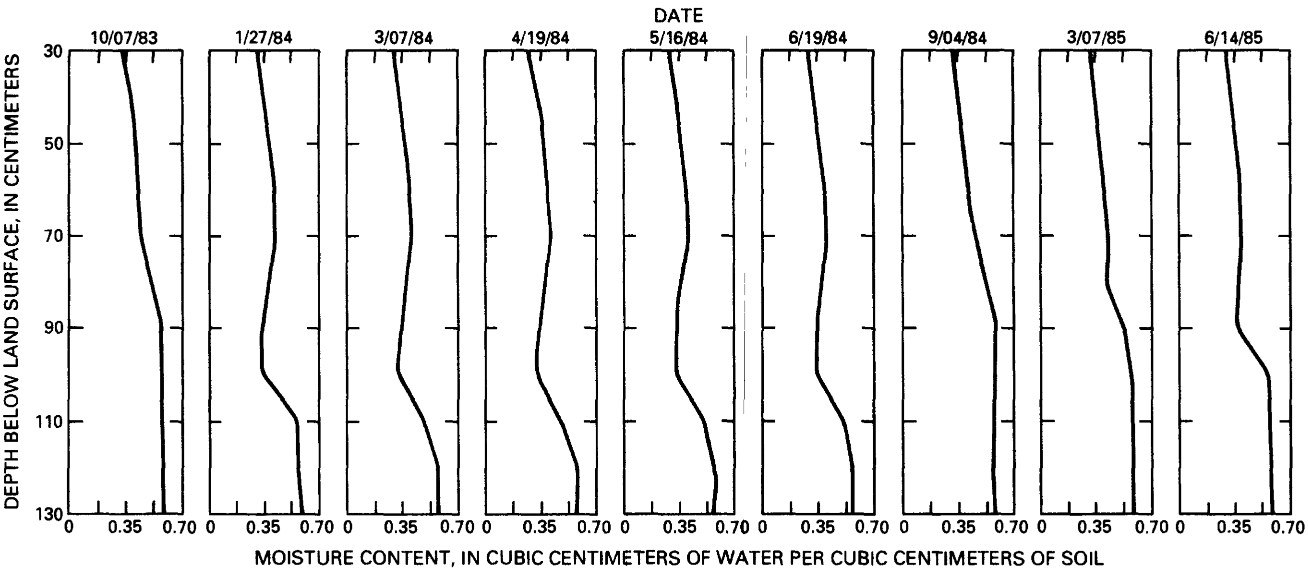

Figure 6*B*.--Moisture-content profiles for well GS-5.

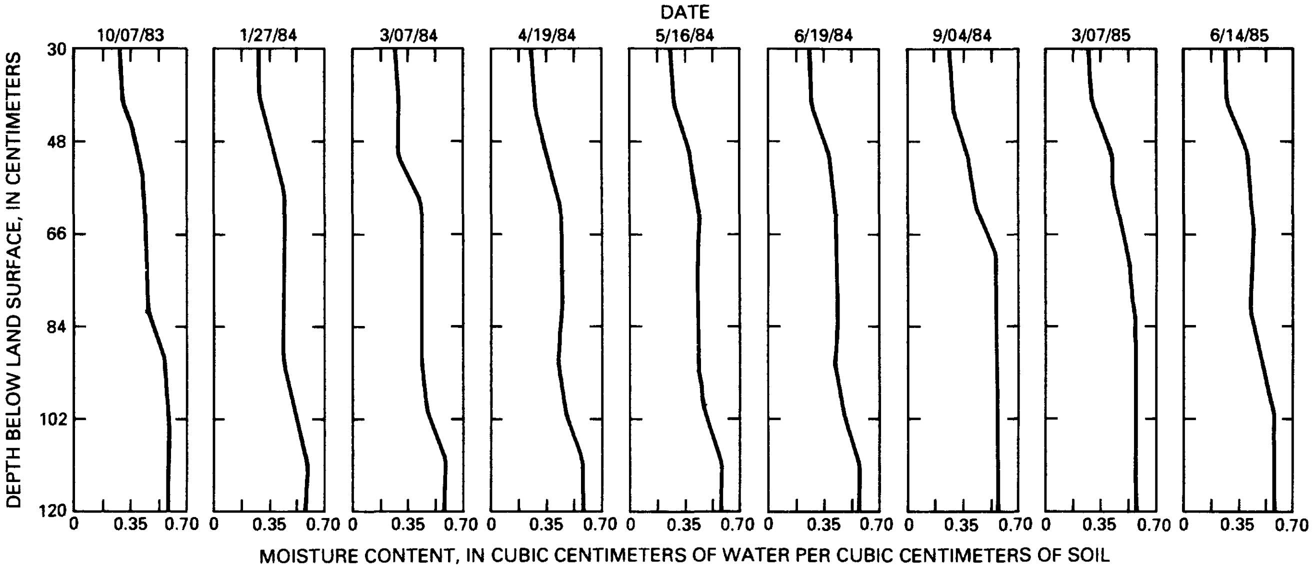

Figure 6*C*.--Moisture-content profiles for well GS-6.

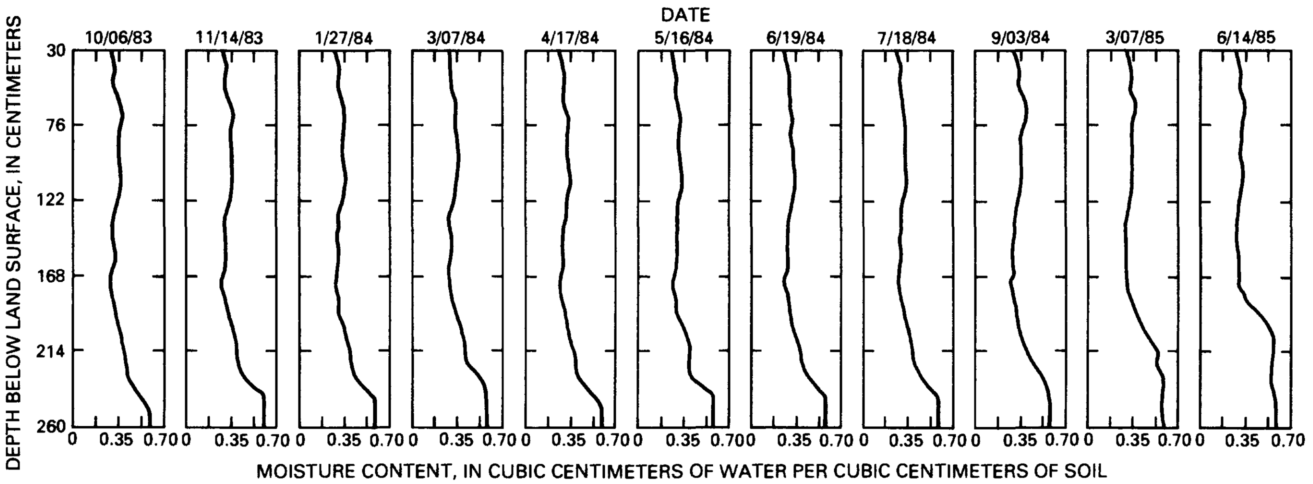

Figure 6*D*.--Moisture-content profiles for well GS-15.

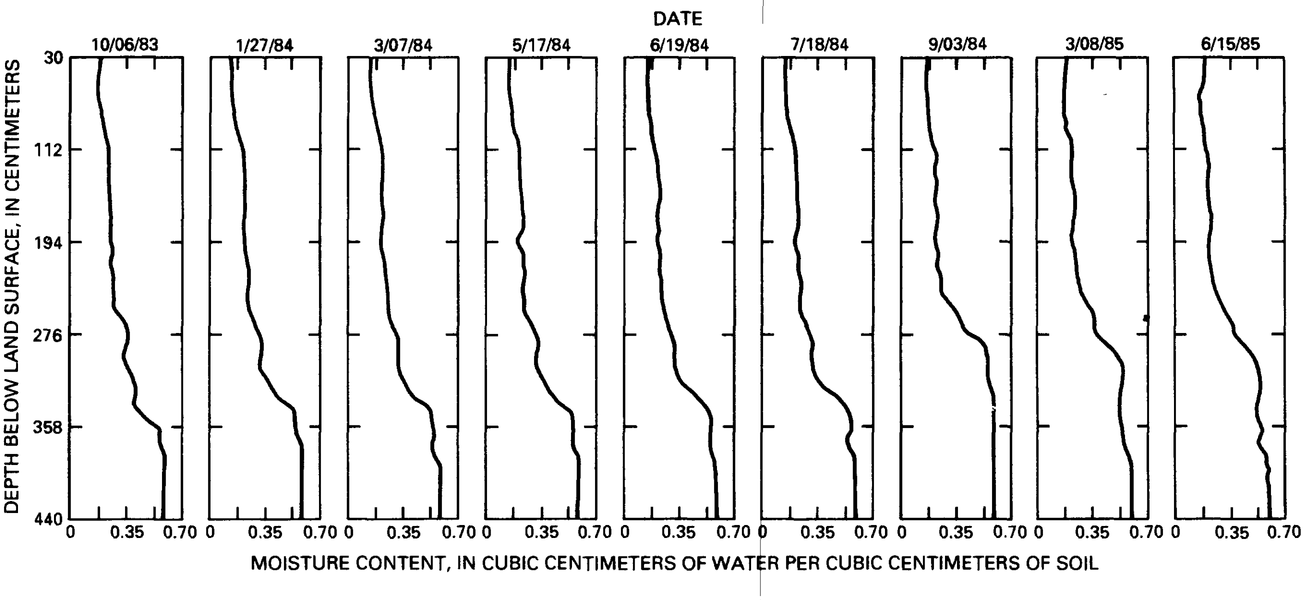

Figure 6*E*.--Moisture-content profiles for well GS-18.

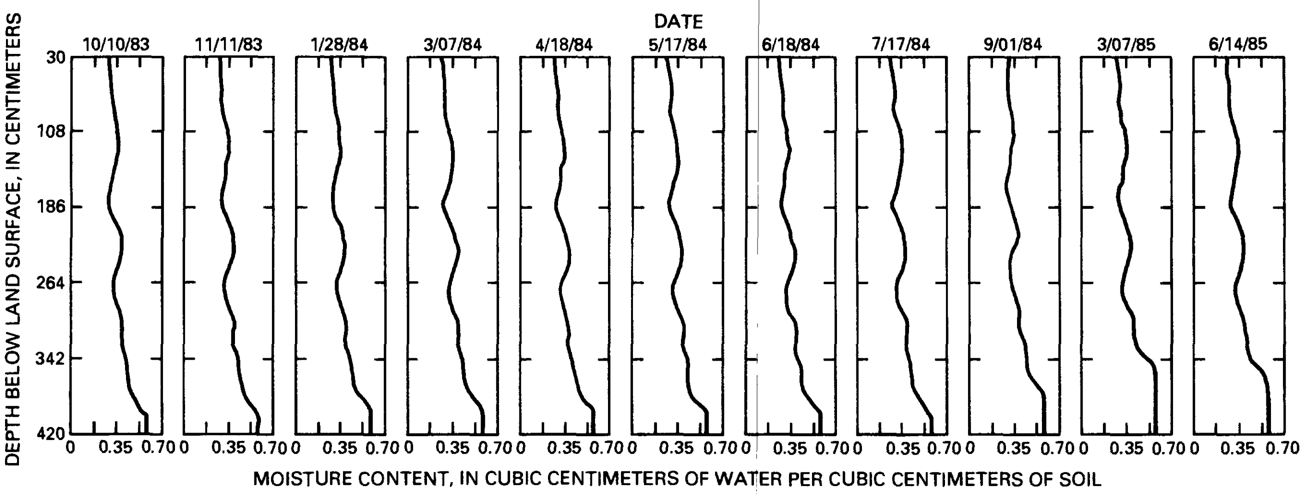

Figure 6*F*.--Moisture-content profiles for well GS-20.

Table 4A.--*Summary of flux values obtained from different neutron logs of well GS-4*

[cm, centimeters, cm/d, centimeters per day]

Period		Duration (days)	Water content		Difference in water content (cm)	Flux (cm/d)
First date	Second date		First date (cm)	Second date (cm)		
10-07-83	1-27-84	112	15.49	15.15	-0.34	-0.003
10-07-83	3-07-84	152	15.49	14.81	-.68	-.004
10-07-83	4-19-84	195	15.49	14.59	-.90	-.005
10-07-83	5-18-84	224	15.49	14.92	-.56	-.003
10-07-83	6-19-84	256	15.49	14.85	-.64	-.003
10-07-83	9-04-84	333	15.49	19.22	3.73	.011
10-07-83	3-07-85	516	15.49	18.01	2.52	.005
10-07-83	6-14-85	615	15.49	15.95	.46	.001
1-27-84	3-07-84	40	15.15	14.81	-.34	-.009
1-27-84	4-19-84	83	15.15	14.59	-.56	-.007
1-27-84	5-18-84	112	15.15	14.92	-.23	-.002
1-27-84	6-19-84	144	15.15	14.85	-.30	-.002
1-27-84	9-04-84	220	15.15	19.22	4.07	.018
1-27-84	3-07-85	405	15.15	18.01	2.85	.007
1-27-84	6-14-85	504	15.15	15.95	.80	.002
3-07-84	4-19-84	42	14.81	14.59	-.22	-.005
3-07-84	5-18-84	71	14.81	14.92	.12	.002
3-07-84	6-19-84	103	14.81	14.85	.04	.000
3-07-84	9-04-84	180	14.81	19.22	4.41	.024
3-07-84	3-07-85	365	14.81	18.01	3.20	.009
3-07-84	6-14-85	464	14.81	15.95	1.14	.002
4-19-84	5-18-84	29	14.59	14.92	.34	.012
4-19-84	6-19-84	61	14.59	14.85	.26	.004
4-19-84	9-04-84	137	14.59	19.22	4.63	.034
4-19-84	3-07-85	322	14.59	18.01	3.42	.011
4-19-84	6-14-85	421	14.59	15.95	1.36	.003
5-18-84	6-19-84	32	14.92	14.85	-.08	-.002
5-18-84	9-04-84	108	14.92	19.22	4.30	.039
5-18-84	3-07-85	293	14.92	18.01	3.08	.011
5-18-84	6-14-85	392	14.92	15.95	1.03	.003
6-19-84	9-04-84	76	14.85	19.22	4.37	.057
6-19-84	3-07-85	261	14.85	18.01	3.16	.012
6-19-84	6-14-85	360	14.85	15.95	1.10	.003
9-04-84	3-07-85	184	19.22	18.01	-1.22	-.007
9-04-84	6-14-85	283	19.22	15.95	-3.27	-.012
3-07-85	6-14-85	99	18.01	15.95	-2.05	-.021

Table 4B.--*Summary of flux values obtained from different neutron logs of well GS-5*

[cm, centimeters, cm/d, centimeters per day]

Period		Duration (days)	Water content		Difference in water content (cm)	Flux (cm/d)
First date	Second date		First date (cm)	Second date (cm)		
10-07-83	1-27-84	112	30.97	26.25	-4.73	-0.042
10-07-83	3-07-84	152	30.97	25.98	-4.99	-.033
10-07-83	4-19-84	195	30.97	25.75	-5.22	-.027
10-07-83	5-16-84	222	30.97	25.40	-5.58	-.025
10-07-83	6-19-84	256	30.97	25.31	-5.66	-.022
10-07-83	9-04-84	333	30.97	30.46	-.51	-.002
10-07-83	3-07-85	516	30.97	27.52	-3.45	-.007
10-07-83	6-14-85	615	30.97	24.94	-6.03	-.010
1-27-84	3-07-84	40	26.25	25.98	-.27	-.007
1-27-84	4-19-84	83	26.25	25.75	-.50	-.006
1-27-84	5-16-84	110	26.25	25.40	-.85	-.008
1-27-84	6-19-84	144	26.25	25.31	-.93	-.006
1-27-84	9-04-84	220	26.25	30.46	4.22	.019
1-27-84	3-07-85	405	26.25	27.52	1.27	.003
1-27-84	6-14-85	504	26.25	24.94	-1.31	-.003
3-07-84	4-19-84	42	25.98	25.75	-.23	-.005
3-07-84	5-16-84	69	25.98	25.40	-.58	-.008
3-07-84	6-19-84	103	25.98	25.31	-.67	-.006
3-07-84	9-04-84	180	25.98	30.46	4.48	.025
3-07-84	3-07-85	365	25.98	27.52	1.54	.004
3-07-84	6-14-85	464	25.98	24.94	-1.04	-.002
4-19-84	5-16-84	27	25.75	25.40	-.35	-.013
4-19-84	6-19-84	61	25.75	25.31	-.44	-.007
4-19-84	9-04-84	137	25.75	30.46	4.71	.034
4-19-84	3-07-85	322	25.75	27.52	1.77	.005
4-19-84	6-14-85	421	25.75	24.94	-.81	-.002
5-16-84	6-19-84	33	25.40	25.31	-.08	-.002
5-16-84	9-04-84	110	25.40	30.46	5.07	.046
5-16-84	3-07-85	295	25.40	27.52	2.12	.007
5-16-84	6-14-85	394	25.40	24.94	-.45	-.001
6-19-84	9-04-84	76	25.31	30.46	5.15	.067
6-19-84	3-07-85	261	25.31	27.52	2.21	.008
6-19-84	6-14-85	360	25.31	24.94	-.37	-.001
9-04-84	3-07-85	184	30.46	27.52	-2.94	-.016
9-04-84	6-14-85	283	30.46	24.94	-5.52	-.019
3-07-85	6-14-85	99	27.52	24.94	-2.58	-.026

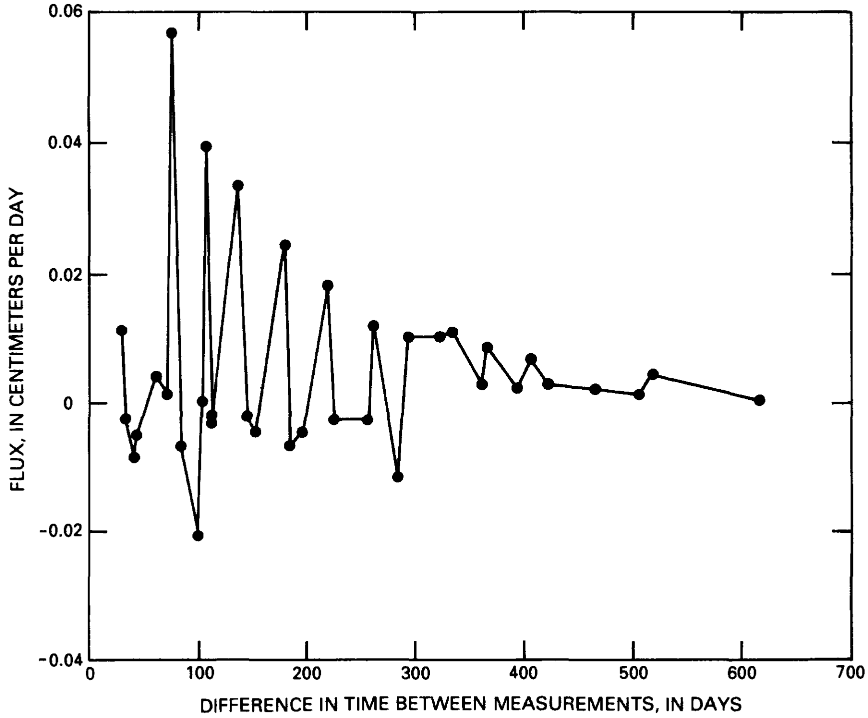

Figure 7*A*.--Relation between moisture flux and the difference in time between measurements for well GS-4.

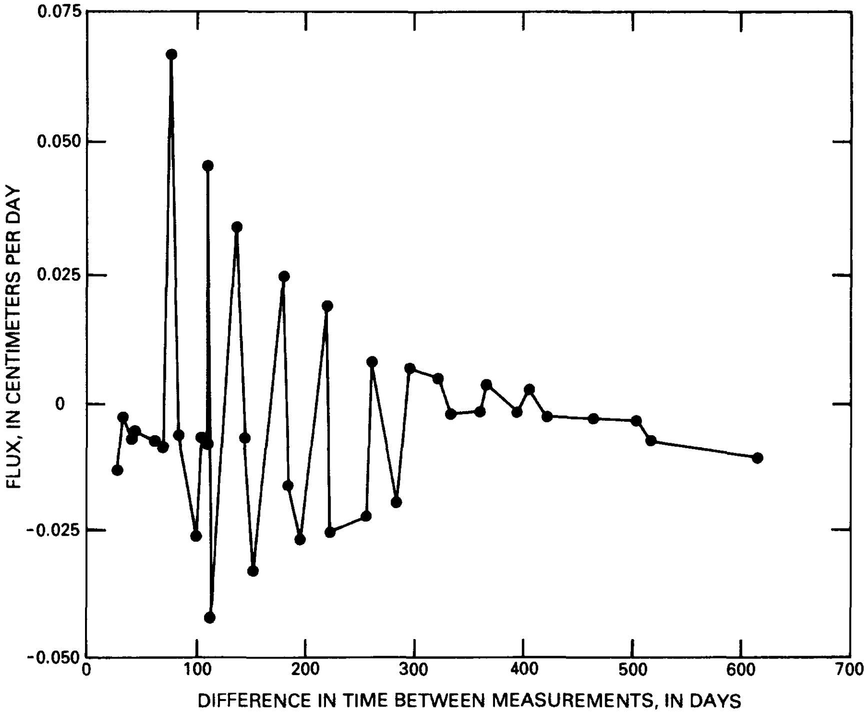

Figure 7*B*.--Relation between moisture flux and the difference in time between measurements for well GS-5.

Table 4C.--*Summary of flux values obtained from different neutron logs of well GS-6*

[cm, centimeters, cm/d, centimeters per day]

Period		Duration (days)	Water content		Difference in water content (cm)	Flux (cm/d)
First date	Second date		First date (cm)	Second date (cm)		
10-07-83	1-27-84	112	28.04	26.85	-1.19	-0.011
10-07-83	3-07-84	152	28.04	25.32	-2.73	-.018
10-07-83	4-19-84	195	28.04	26.04	-2.00	-.010
10-07-83	5-16-84	222	28.04	26.46	-1.59	-.007
10-07-83	6-19-84	256	28.04	26.57	-1.48	-.006
10-07-83	9-04-84	333	28.04	31.69	3.65	.011
10-07-83	3-07-85	516	28.04	32.03	3.99	.008
10-07-83	6-14-85	615	28.04	27.73	-.32	-.001
1-27-84	3-07-84	40	26.85	25.32	-1.53	-.038
1-27-84	4-19-84	83	26.85	26.04	-.81	-.010
1-27-84	5-16-84	110	26.85	26.46	-.39	-.004
1-27-84	6-19-84	144	26.85	26.57	-.28	-.002
1-27-84	9-04-84	220	26.85	31.69	4.84	.022
1-27-84	3-07-85	405	26.85	32.03	5.18	.013
1-27-84	6-14-85	504	26.85	27.73	.88	.002
3-07-84	4-19-84	42	25.32	26.04	.72	.017
3-07-84	5-16-84	69	25.32	26.46	1.14	.016
3-07-84	6-19-84	103	25.32	26.57	1.25	.012
3-07-84	9-04-84	180	25.32	31.69	6.37	.035
3-07-84	3-07-85	365	25.32	32.03	6.72	.018
3-07-84	6-14-85	464	25.32	27.73	2.41	.005
4-19-84	5-16-84	27	26.04	26.46	.42	.016
4-19-84	6-19-84	61	26.04	26.57	.53	.009
4-19-84	9-04-84	137	26.04	31.69	5.65	.041
4-19-84	3-07-85	322	26.04	32.03	5.99	.019
4-19-84	6-14-85	421	26.04	27.73	1.69	.004
5-16-84	6-19-84	33	26.46	26.57	.11	.003
5-16-84	9-04-84	110	26.46	31.69	5.23	.047
5-16-84	3-07-85	295	26.46	32.03	5.57	.019
5-16-84	6-14-85	394	26.46	27.73	1.27	.003
6-19-84	9-04-84	76	26.57	31.69	5.12	.067
6-19-84	3-07-85	261	26.57	32.03	5.46	.021
6-19-84	6-14-85	360	26.57	27.73	1.16	.003
9-04-84	3-07-85	184	31.69	32.03	.34	.002
9-04-84	6-14-85	283	31.69	27.73	-3.96	-.014
3-07-85	6-14-85	99	32.03	27.73	-4.31	-.043

Table 4D.--*Summary of flux values obtained from different neutron logs of well GS-15*

[cm, centimeters, cm/d, centimeters per day]

Period		Duration (days)	Water content		Difference in water content (cm)	Flux (cm/d)
First date	Second date		First date (cm)	Second date (cm)		
10-06-83	11-14-83	39	80.95	80.44	-0.51	-0.013
10-06-83	1-27-84	113	80.95	78.88	-2.07	-.018
10-06-83	3-07-84	153	80.95	81.33	.38	.002
10-06-83	4-17-84	194	80.95	76.98	-3.98	-.020
10-06-83	5-16-84	223	80.95	77.51	-3.44	-.015
10-06-83	6-19-84	257	80.95	77.64	-3.31	-.013
10-06-83	7-18-84	286	80.95	77.59	-3.36	-.012
10-06-83	9-03-84	333	80.95	83.54	2.59	.008
10-06-83	3-07-85	517	80.95	87.59	6.64	.013
10-06-83	6-14-85	617	80.95	89.77	8.82	.014
11-14-83	1-27-84	74	80.44	78.88	-1.56	-.021
11-14-83	3-07-84	114	80.44	81.33	.89	.008
11-14-83	4-17-84	155	80.44	76.98	-3.47	-.022
11-14-83	5-16-84	184	80.44	77.51	-2.94	-.016
11-14-83	6-19-84	218	80.44	77.64	-2.80	-.013
11-14-83	7-18-84	247	80.44	77.59	-2.86	-.012
11-14-83	9-03-84	294	80.44	83.54	3.09	.011
11-14-83	3-07-85	478	80.44	87.59	7.15	.015
11-14-83	6-14-85	577	80.44	89.77	9.33	.016
1-27-84	3-07-84	40	78.88	81.33	2.45	.061
1-27-84	4-17-84	81	78.88	76.98	-1.90	-.024
1-27-84	5-16-84	110	78.88	77.51	-1.37	-.012
1-27-84	6-19-84	144	78.88	77.64	-1.24	-.009
1-27-84	7-18-84	173	78.88	77.59	-1.29	-.007
1-27-84	9-03-84	219	78.88	83.54	4.66	.021
1-27-84	3-07-85	405	78.88	87.59	8.71	.022
1-27-84	6-14-85	504	78.88	89.77	10.89	.022
3-07-84	4-17-84	40	81.33	76.98	-4.36	-.106
3-07-84	5-16-84	69	81.33	77.51	-3.83	-.055
3-07-84	6-19-84	103	81.33	77.64	-3.69	-.036
3-07-84	7-18-84	133	81.33	77.59	-3.74	-.028
3-07-84	9-03-84	179	81.33	83.54	2.21	.012
3-07-84	3-07-85	365	81.33	87.59	6.26	.017
3-07-84	6-14-85	464	81.33	89.77	8.44	.018
4-17-84	5-16-84	29	76.98	77.51	.53	.018
4-17-84	6-19-84	63	76.98	77.64	.66	.011
4-17-84	7-18-84	92	76.98	77.59	.61	.007
4-17-84	9-03-84	138	76.98	83.54	6.56	.047
4-17-84	3-07-85	324	76.98	87.59	10.61	.033
4-17-84	6-14-85	423	76.98	89.77	12.79	.030

Table 4D.--*Summary of flux values obtained from different neutron logs of well GS-15*--Continued

Period		Duration (days)	Water content		Difference in water content (cm)	Flux (cm/d)
First date	Second date		First date (cm)	Second date (cm)		
5-16-84	6-19-84	33	77.51	77.64	0.13	0.004
5-16-84	7-18-84	63	77.51	77.59	.08	.001
5-16-84	9- 3-84	109	77.51	83.54	6.03	.055
5-16-84	3- 7-85	295	77.51	87.59	10.08	.034
5-16-84	6-14-85	394	77.51	89.77	12.26	.031
6-19-84	7-18-84	29	77.64	77.59	-.05	-.002
6-19-84	9-03-84	75	77.64	83.54	5.90	.078
6-19-84	3-07-85	261	77.64	87.59	9.95	.038
6-19-84	6-14-85	360	77.64	89.77	12.13	.034
7-18-84	9-03-84	46	77.59	83.54	5.95	.127
7-18-84	3-07-85	232	77.59	87.59	10.00	.043
7-18-84	6-14-85	331	77.59	89.77	12.18	.037
9-03-84	3-07-85	185	83.54	87.59	4.05	.022
9-03-84	6-14-85	284	83.54	89.77	6.23	.022
3-07-85	6-14-85	99	87.59	89.77	2.18	.022

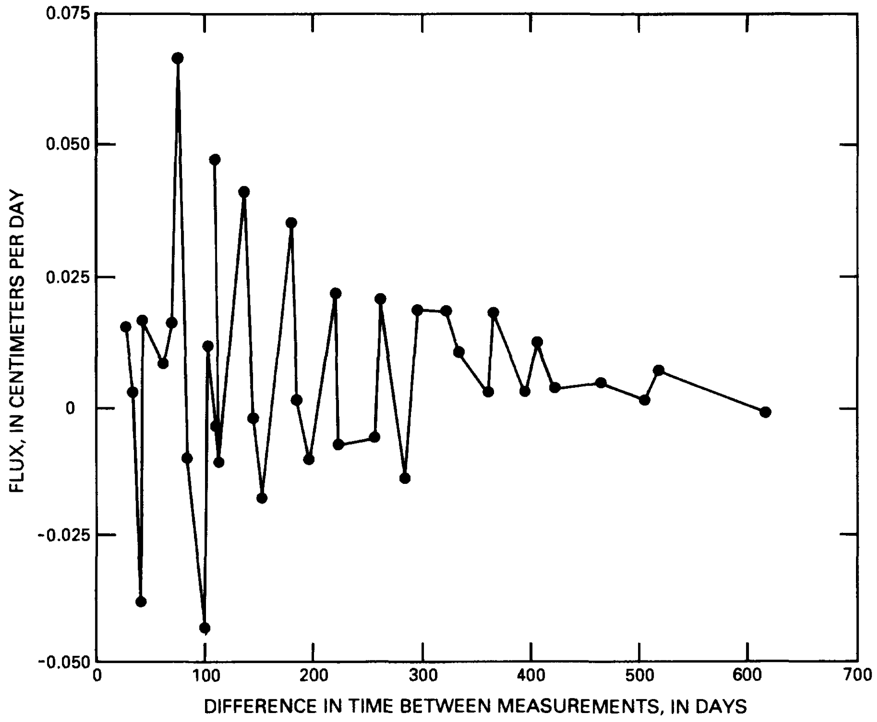

Figure 7*C*.--Relation between moisture flux and the difference in time between measurements for well GS-6.

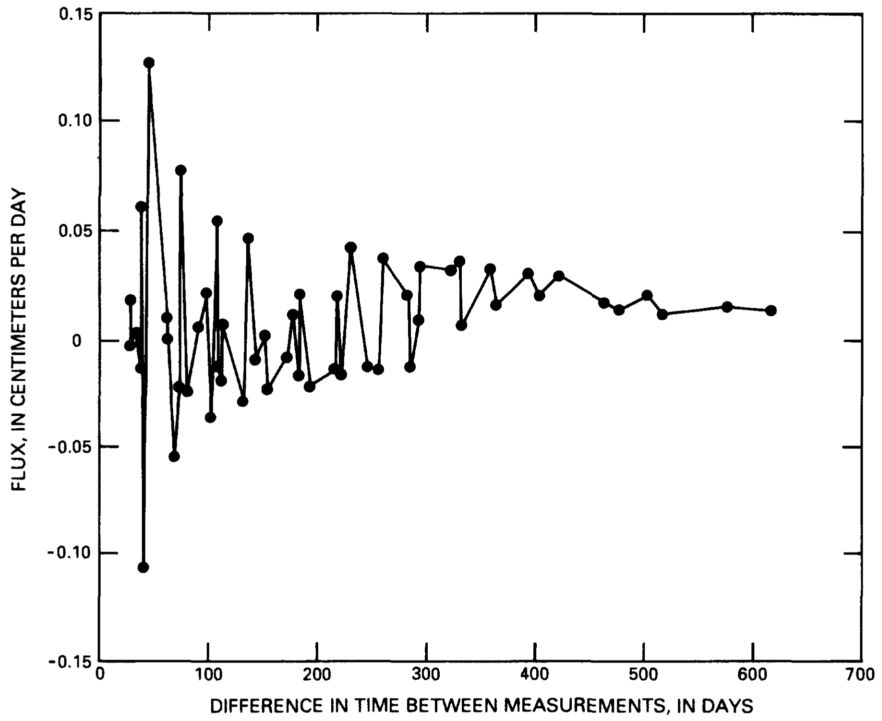

Figure 7*D*--Relation between moisture flux and the difference in time between measurements for well GS-15.

Table 4E.--*Summary of flux values obtained from different neutron logs of well GS-18*

[cm, centimeters, cm/d, centimeters per day]

Period		Duration (days)	Water content		Difference in water content (cm)	Flux (cm/d)
First date	Second date		First date (cm)	Second date (cm)		
10-06-83	1-27-84	113	76.09	69.64	-6.44	-0.057
10-06-83	3-07-84	153	76.09	68.11	-7.98	-.052
10-06-83	5-17-84	224	76.09	68.73	-7.36	-.033
10-06-83	6-19-84	257	76.09	69.00	-7.09	-.028
10-06-83	7-18-84	286	76.09	68.94	-7.14	-.025
10-06-83	9-03-84	333	76.09	85.77	9.69	.029
10-06-83	3-08-85	519	76.09	79.68	3.60	.007
10-06-83	6-15-85	617	76.09	78.58	2.49	.004
1-27-84	3-07-84	40	69.64	68.11	-1.53	-.038
1-27-84	5-17-84	111	69.64	68.73	-.91	-.008
1-27-84	6-19-84	144	69.64	69.00	-.65	-.004
1-27-84	7-18-84	173	69.64	68.94	-.70	-.004
1-27-84	9-03-84	219	69.64	85.77	16.13	.073
1-27-84	3-08-85	406	69.64	79.68	10.04	.025
1-27-84	6-15-85	505	69.64	78.58	8.93	.018
3-07-84	5-17-84	70	68.11	68.73	.62	.009
3-07-84	6-19-84	103	68.11	69.00	.89	.009
3-07-84	7-18-84	133	68.11	68.94	.83	.006
3-07-84	9-03-84	179	68.11	85.77	17.66	.098
3-07-84	3-08-85	366	68.11	79.68	11.57	.032
3-07-84	6-15-85	465	68.11	78.58	10.47	.023
5-17-84	6-19-84	33	68.73	69.00	.27	.008
5-17-84	7-18-84	62	68.73	68.94	.22	.003
5-17-84	9-03-84	108	68.73	85.77	17.04	.156
5-17-84	3-08-85	295	68.73	79.68	10.95	.037
5-17-84	6-15-85	394	68.73	78.58	9.85	.025
6-19-84	7-18-84	29	69.00	68.94	-.05	-.002
6-19-84	9-03-84	75	69.00	85.77	16.78	.221
6-19-84	3-08-85	262	69.00	79.68	10.69	.041
6-19-84	6-15-85	361	69.00	78.58	9.58	.027
7-18-84	9-03-84	46	68.94	85.77	16.83	.358
7-18-84	3-08-85	233	68.94	79.68	10.74	.046
7-18-84	6-15-85	332	68.94	78.58	9.63	.029
9-03-84	3-08-85	186	85.77	79.68	-6.09	-.033
9-03-84	6-15-85	285	85.77	78.58	-7.19	-.025
3-08-85	6-15-85	98	79.68	78.58	-1.10	-.011

Table 4F.--*Summary of flux values obtained from different neutron logs of well GS-20*

[cm, centimeters, cm/d, centimeters per day]

Period		Duration (days)	Water content		Difference in water content (cm)	Flux (cm/d)
First date	Second date		First date (cm)	Second date (cm)		
10-07-83	11-11-83	34	123.57	123.55	-0.02	-0.001
10-07-83	1-28-84	113	123.57	123.41	-.15	-.001
10-07-83	3-07-84	152	123.57	123.04	-.53	-.003
10-07-83	4-18-84	194	123.57	121.97	-1.59	-.008
10-07-83	5-17-84	223	123.57	122.61	-.96	-.004
10-07-83	6-18-84	255	123.57	122.30	-1.27	-.005
10-07-83	7-17-84	284	123.57	121.81	-1.76	-.006
10-07-83	9-01-84	330	123.57	127.05	3.48	.011
10-07-83	3-07-85	516	123.57	128.23	4.66	.009
10-07-83	6-14-85	615	123.57	123.92	.35	.001
11-11-83	1-28-84	78	123.55	123.41	-.13	-.002
11-11-83	3-07-84	117	123.55	123.04	-.50	-.004
11-11-83	4-18-84	159	123.55	121.97	-1.57	-.010
11-11-83	5-17-84	188	123.55	122.61	-.93	-.005
11-11-83	6-18-84	220	123.55	122.30	-1.25	-.006
11-11-83	7-17-84	249	123.55	121.81	-1.73	-.007
11-11-83	9-01-84	295	123.55	127.05	3.51	.012
11-11-83	3-07-85	481	123.55	128.23	4.68	.010
11-11-83	6-14-85	581	123.55	123.92	.38	.001
1-28-84	3-07-84	39	123.41	123.04	-.37	-.009
1-28-84	4-18-84	81	123.41	121.97	-1.44	-.018
1-28-84	5-17-84	110	123.41	122.61	-.80	-.007
1-28-84	6-18-84	142	123.41	122.30	-1.12	-.008
1-28-84	7-17-84	170	123.41	121.81	-1.60	-.009
1-28-84	9-01-84	216	123.41	127.05	3.64	.017
1-28-84	3-07-85	404	123.41	128.23	4.81	.012
1-28-84	6-14-85	503	123.41	123.92	.51	.001
3-07-84	4-18-84	41	123.04	121.97	-1.07	-.025
3-07-84	5-17-84	70	123.04	122.61	-.43	-.006
3-07-84	6-18-84	102	123.04	122.30	-.75	-.007
3-07-84	7-17-84	131	123.04	121.81	-1.23	-.009
3-07-84	9-01-84	177	123.04	127.05	4.01	.023
3-07-84	3-07-85	365	123.04	128.23	5.18	.014
3-07-84	6-14-85	464	123.04	123.92	.88	.002
4-18-84	5-17-84	29	121.97	122.61	.64	.022
4-18-84	6-18-84	61	121.97	122.30	.32	.005
4-18-84	7-17-84	89	121.97	121.81	-.16	-.002
4-18-84	9-01-84	135	121.97	127.05	5.08	0.037
4-18-84	3-07-85	323	121.97	128.23	6.25	.019
4-18-84	6-14-85	422	121.97	123.92	1.95	.005

Table 4F.--*Summary of flux values obtained from different neutron logs of well GS-20*--Continued

Period		Duration (days)	Water content		Difference in water content (cm)	Flux (cm/d)
First date	Second date		First date (cm)	Second date (cm)		
5-17-84	6-18-84	32	122.61	122.30	-.32	-.010
5-17-84	7-17-84	60	122.61	121.81	-.80	-.013
5-17-84	9-01-84	106	122.61	127.05	4.44	.042
5-17-84	3-07-85	294	122.61	128.23	5.61	.019
5-17-84	6-14-85	393	122.61	123.92	1.31	.003
6-18-84	7-17-84	28	122.30	121.81	-.48	-.017
6-18-84	9-01-84	74	122.30	127.05	4.76	.063
6-18-84	3-07-85	262	122.30	128.23	5.93	.023
6-18-84	6-14-85	361	122.30	123.92	1.63	.005
7-17-84	9-01-84	46	121.81	127.05	5.24	.114
7-17-84	3-07-85	233	121.81	128.23	6.41	.027
7-17-84	6-14-85	332	121.81	123.92	2.11	.006
9-01-84	3-07-85	187	127.05	128.23	1.17	.006
9-01-84	6-14-85	286	127.05	123.92	-3.13	-.011
3-07-85	6-14-85	99	128.23	123.92	-4.30	-.043

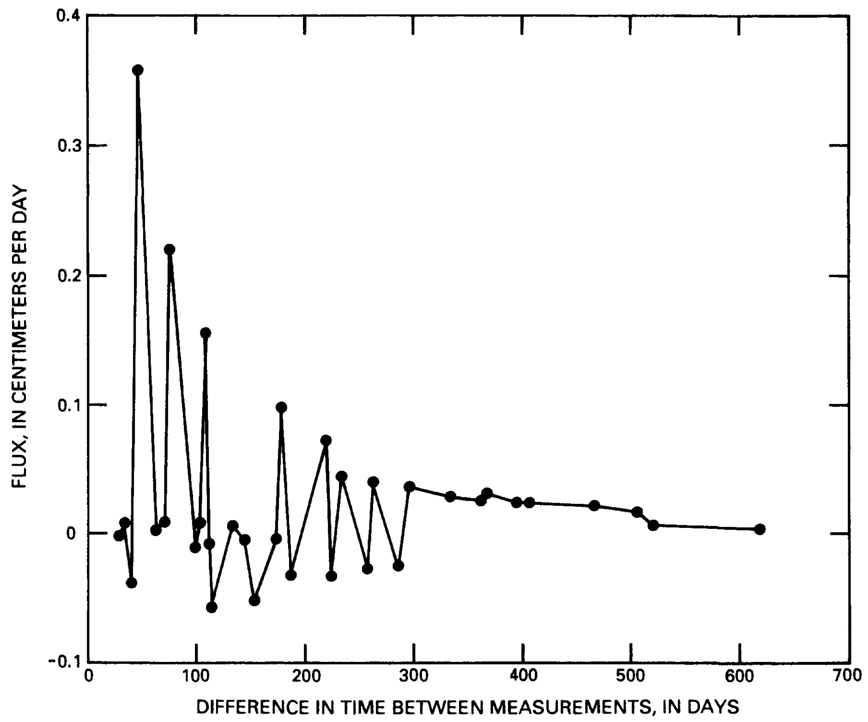

Figure 7*E*.--Relation between moisture flux and the difference in time between measurements for well GS-18.

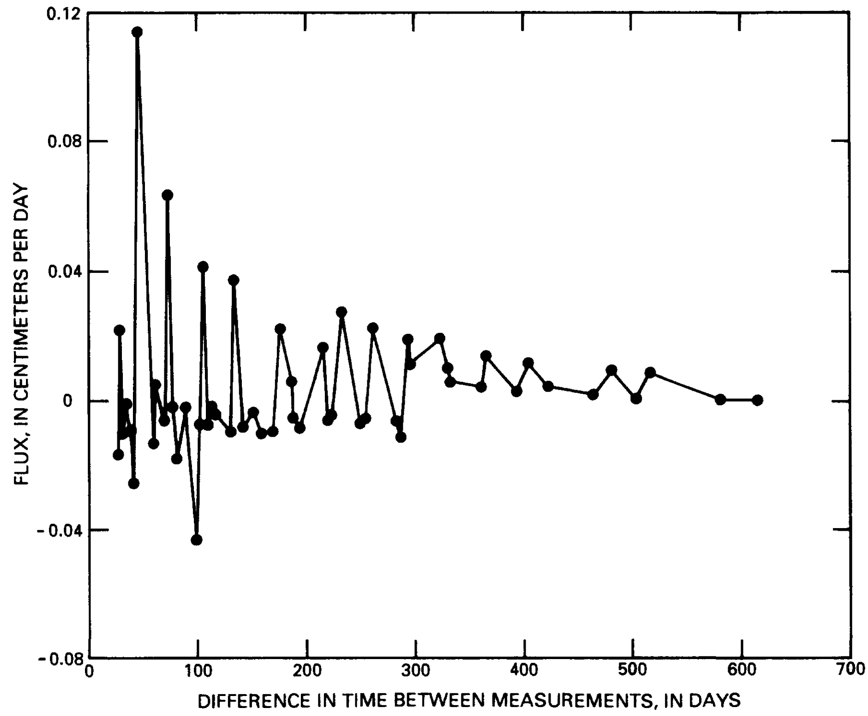

Figure 7*F*.--Relation between moisture flux and the difference in time between measurements for well GS-20.

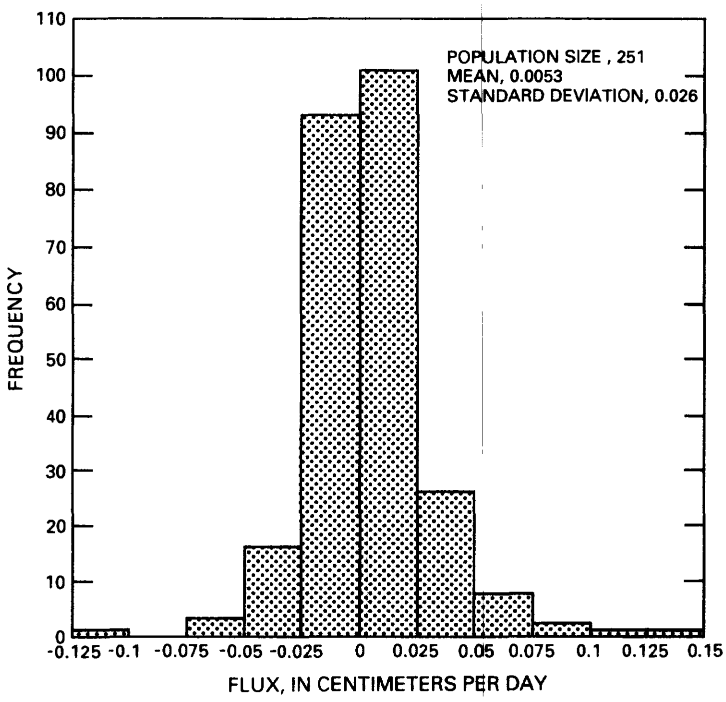

Figure 8.--Distribution of fluxes estimated from changes in soil-moisture content with time.

Figures (*7A-F*) show positive fluxes, indicating an increase in soil moisture with time; and negative fluxes, indicating a decrease in soil moisture with time. Although the times at which sampling occurred are sparse, all of the plots show clusters of points at about 0.0 cm/d. A strong grouping of positive fluxes at GS-20 is shown in figure *7F*; GS-20 is located adjacent to the Amargosa River stream channel. Generally, 1983 received less precipitation than 1984 and 1985.

A limitation to this method is that, although a flux magnitude may be estimated, direction cannot be estimated only from the water content of the soil-moisture profiles. The flow direction might be determined by comparing neutron logs side by side and recording moisture-pulse movements in the profile (fig. 5). This method also has limitations in its applicability for estimating evapotranspiration. The greatest limitation probably is that data for the upper 30 cm of the soil-moisture profile could not be recorded because of the design of the soil-moisture probe. The largest changes in soil moisture likely may occur in the upper 30 cm. Increases or decreases in moisture content in the unsaturated zone can result from changes in water-table position or from recharge that results from precipitation or storm runoff. Evaporative fluxes estimated by this technique give larger magnitude values for smaller time differences and smaller magnitude values for larger times, as would be expected using time as the flux denominator.

SUMMARY

Hydrologic and other data presented in this report were collected to further characterize the geohydrology and ground-water discharge at Franklin Lake playa, Inyo County, California. These data include: (1) Hydrographs of water levels in piezometers; (2) vertical hydraulic gradients estimated from piezometer-nest data; (3) meteorological data from weather stations in the vicinity of Franklin Lake playa; and (4) estimates of moisture fluxes based on changes in soil-moisture content in the unsaturated zone.

Hydrographs of water levels in piezometers vary from being very smooth to having extreme fluctuations. Average water-level altitudes from these hydrographs can be used to contour the water-table altitude in the vicinity of Franklin Lake playa. Vertical hydraulic gradients estimated from piezometer-nest data can be used to estimate ground-water discharge, provided reliable estimates of vertical hydraulic conductivity are available. Evapotranspiration estimates based on changes in soil-moisture content in the unsaturated zone provide a basis of comparison for other methods such as the energy-budget eddy-correlation technique.

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