SURFACE-WATER DISCHARGE AND EVAPOTRANSPIRATION RATES FOR GRASS AND BARE SOIL ALONG A REACH OF THE RIO GRANDE, ALBUQUERQUE, NEW MEXICO, 1989-95

By Condé R. Thorn

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CONVERSION FACTORS

Multiply	By	To obtain
inch	25.4	millimeter
foot	0.3048	meter
mile	1.609	kilometer
square mile	2.590	square kilometer
cubic foot per second	28.32	liter per second

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.

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ABSTRACT

The surface-water hydrologic system of the Rio Grande in the Albuquerque, New Mexico, area is composed of the Rio Grande; irrigation drains, laterals, canals, and ditches; evapotranspiration; and ground-water recharge. Two east-west cross sections were established to measure surface water entering the study area (north section) and exiting the study area (south section). Data for the calculation of surface-water discharge were collected once every 4 to 8 weeks from August 1989 through February 1995. Discharge of the Rio Grande at the north section ranged from 22 to 5,900 cubic feet per second. Discharge of the Rio Grande at the south section ranged from 21 to 6,060 cubic feet per second.

Data from six areas (three grass-covered areas and three bare-soil areas) were collected for the calculation of evapotranspiration rates from February 1990 through August 1991. The evapotranspiration rate from the grass-covered areas ranged from 0.15 to 4.7 millimeters per day; the evapotranspiration rate from the bare-soil areas ranged from 0.13 to 6.4 millimeters per day.

INTRODUCTION

The surface-water hydrologic system within the Rio Grande flood plain in the Albuquerque, New Mexico, area has undergone many changes through the years. The Middle Rio Grande Conservancy District (MRGCD) was created in 1925 to control floods and lower the water table to prevent waterlogging of irrigated lands along the valley. The MRGCD constructed hundreds of miles of interior and riverside drains, levees, and irrigation diversion dams. The Albuquerque Metropolitan Arroyo Flood Control Authority (AMAFCA), created in 1963, constructed several detention dams and conveyance channels on the terraces and alluvial fans that the City of Albuquerque has developed (Crawford and others, 1993). These structures constructed by the MRGCD and AMAFCA allow for runoff to be either directly or indirectly discharged into the Rio Grande and have complicated the interaction between the surface-water and ground-water systems. Further complicating this interaction between the surface-water and ground-water systems is the conversion of irrigated lands to urban development. A greater understanding of the surface-water hydrologic system needs to be established so that the City of Albuquerque can develop the most efficient and productive management of its water resources.

Purpose and Scope

This report presents a summary of surface-water discharge from the major surface-water components in the flood plain along a reach of the Rio Grande in the Albuquerque, New Mexico, area. Data used for the calculation of surface-water discharge were collected from August 1989 through February 1995. Also contained in this report are evapotranspiration rates calculated from three grass-covered areas and three bare-soil areas on the Rio Grande. Evapotranspiration rates are presented for 14 months from February 1990 through August 1991.

Physical Setting

The Albuquerque Basin, located in central New Mexico (fig. 1), covers approximately 3,060 square miles. The land-surface altitude in the basin ranges from about 6,500 feet above sea level in the northern part of the basin to about 4,800 feet in the southern part of the basin. The eastern boundary of the basin has the greatest topographic relief and is defined by the Sandia, Manzanita, Manzano, and Los Pinos Mountains. The western boundary has little topographic relief and is defined by Mesa Lucero, Sierra Lucero, and Ladron Peak. The convergence of the structural eastern and western boundaries forms the northern and southern boundaries.

The Rio Grande and its associated flood-plain deposits trend in a north-to-south direction in the central part of the Albuquerque Basin. The city of Albuquerque is on the east and west banks of the Rio Grande within the central part of the basin. Directly east of Albuquerque the Sandia Mountains rise to an altitude greater than 10,000 feet above sea level. West of Albuquerque the topography has an average altitude of more than 5,000 feet and is characterized as generally flat with several volcanic features and dune fields (Kernodle and others, 1987).

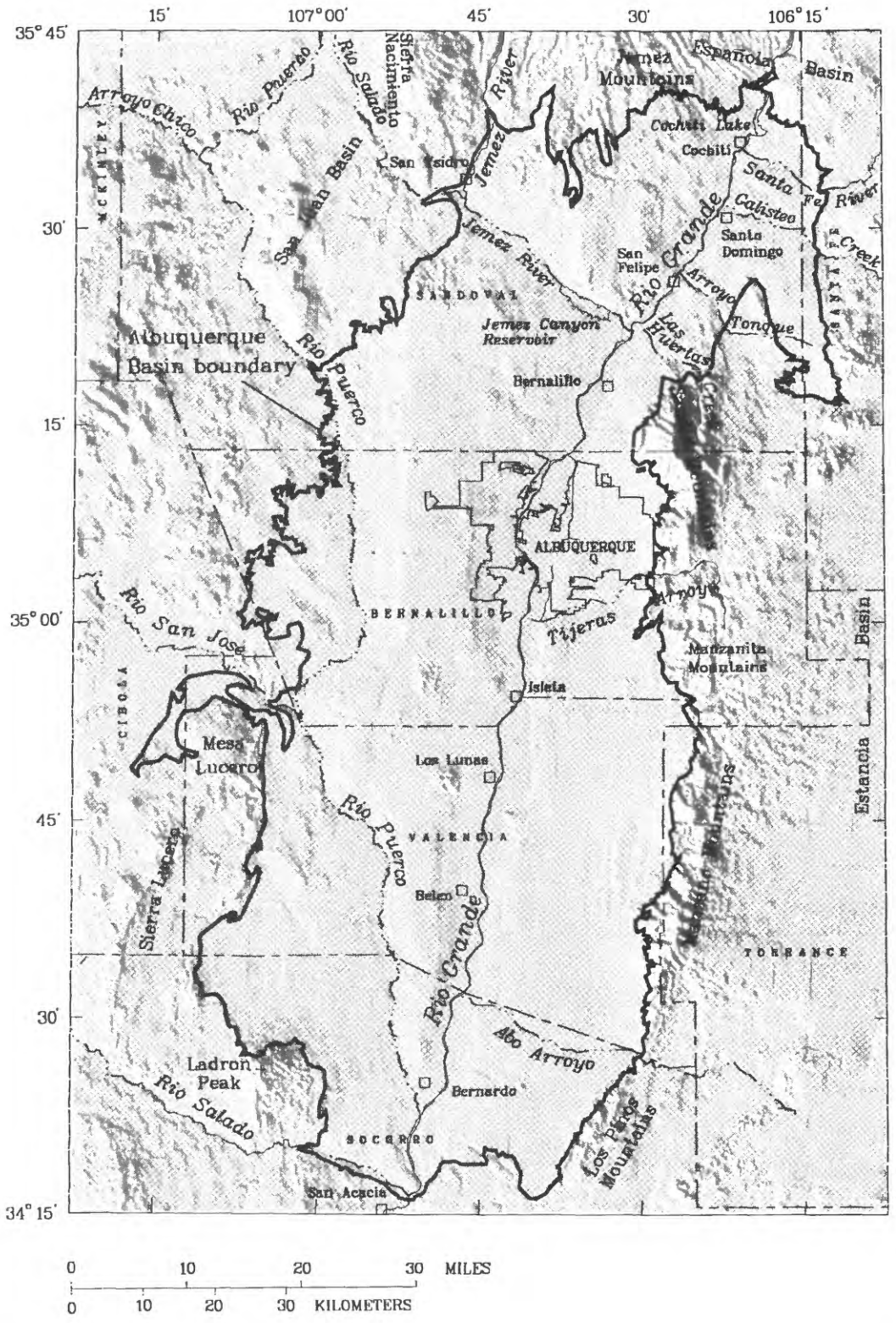

Figure 1.--Shaded relief of the Albuquerque Basin and vicinity, Central New Mexico (from Thorn and others, 1993).

Approach and Methods

Two east-west cross sections, located at the northern and southern boundaries of the study area, were established to make instantaneous surface-water measurements for the calculation of surface water discharge entering and exiting the study area. The northern boundary (north section) is an east-west line through the intersection of the Rio Grande with Paseo del Norte (fig. 2; table 1). An east-west line through the intersection of the Rio Grande with Rio Bravo Boulevard is the southern boundary (south section). Surface-water measurements were made within a 10-hour period every 4 to 8 weeks at all measurement sites along the northern and southern boundaries of the study area. The day selected to make the surface-water measurements was based on the stability of flow in the Rio Grande--that is, about 48 hours would elapse after a release of water from a major reservoir upstream from the study area and after any measurable precipitation within the Albuquerque area. All surface-water measurements were made by U.S. Geological Survey personnel using current meters as outlined in Buchanan and Somers (1984), Kennedy (1984), and Carter and Davidian (1989). In addition to the instantaneous surface-water measurements made, continuous records of streamflow were available from three U.S. Geological Survey gaging stations on the Rio Grande in the study area (figs. 2-5).

The rate of evapotranspiration from three grass-covered and three bare-soil areas was calculated using a hemispherical chamber. The location of the site of the six evapotranspiration areas is shown in figure 2; distance between the individual areas varies from 100 to 150 feet. Descriptions of the six areas and the collection of data for the calculation of evapotranspiration rates are discussed in a subsequent section of this report.

Acknowledgments

The author extends his appreciation to all the hydrologic technicians from the U.S. Geological Survey Albuquerque field office that performed the surface-water measurements on a regular frequency. This report would not have been possible without their commitment to regular visits to the 23 sites over a 4 1/2-year period.

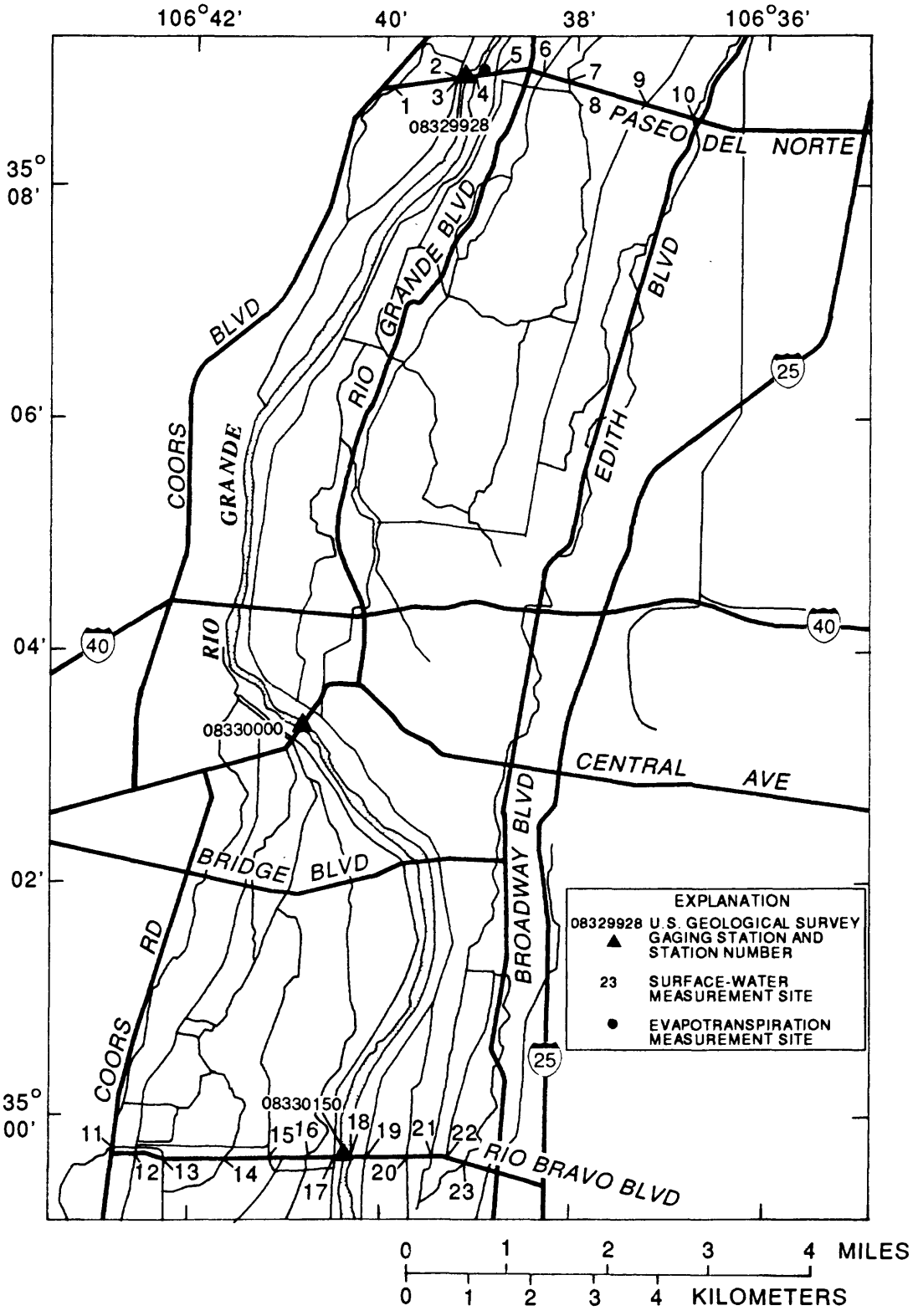

Figure 2.--Location of surface-water measurement sites and evapotranspiration measurement site in the study area. See table 1 for names of surface-water measurement sites.

Table 1.--Site number and name of surface-water measurement sites in the study area

[See figure 2 for location of sites]

Surface-water measurement site number and name			
North section		South section	
1	Corrales Main Canal	11	Gun Club Lateral
2	Ditch	12	Isleta Drain
3	Corrales Riverside Drain	13	Arenal Main Canal
4	Rio Grande at Paseo del Norte	14	Pajarito Lateral
5	Albuquerque Riverside Drain	15	Beckman Lateral
6	Albuquerque Main Canal	16	Atrisco Drain
7	Chamizal Lateral	17	Atrisco Riverside Drain
8	Derromadera Ditch	18	Rio Grande at Rio Bravo Boulevard
9	Alameda Drain	19	Albuquerque Riverside Drain
10	Alameda Lateral	20	Barr Canal
		21	Barelas Ditch
		22	San Jose Drain
		23	San Jose Lateral

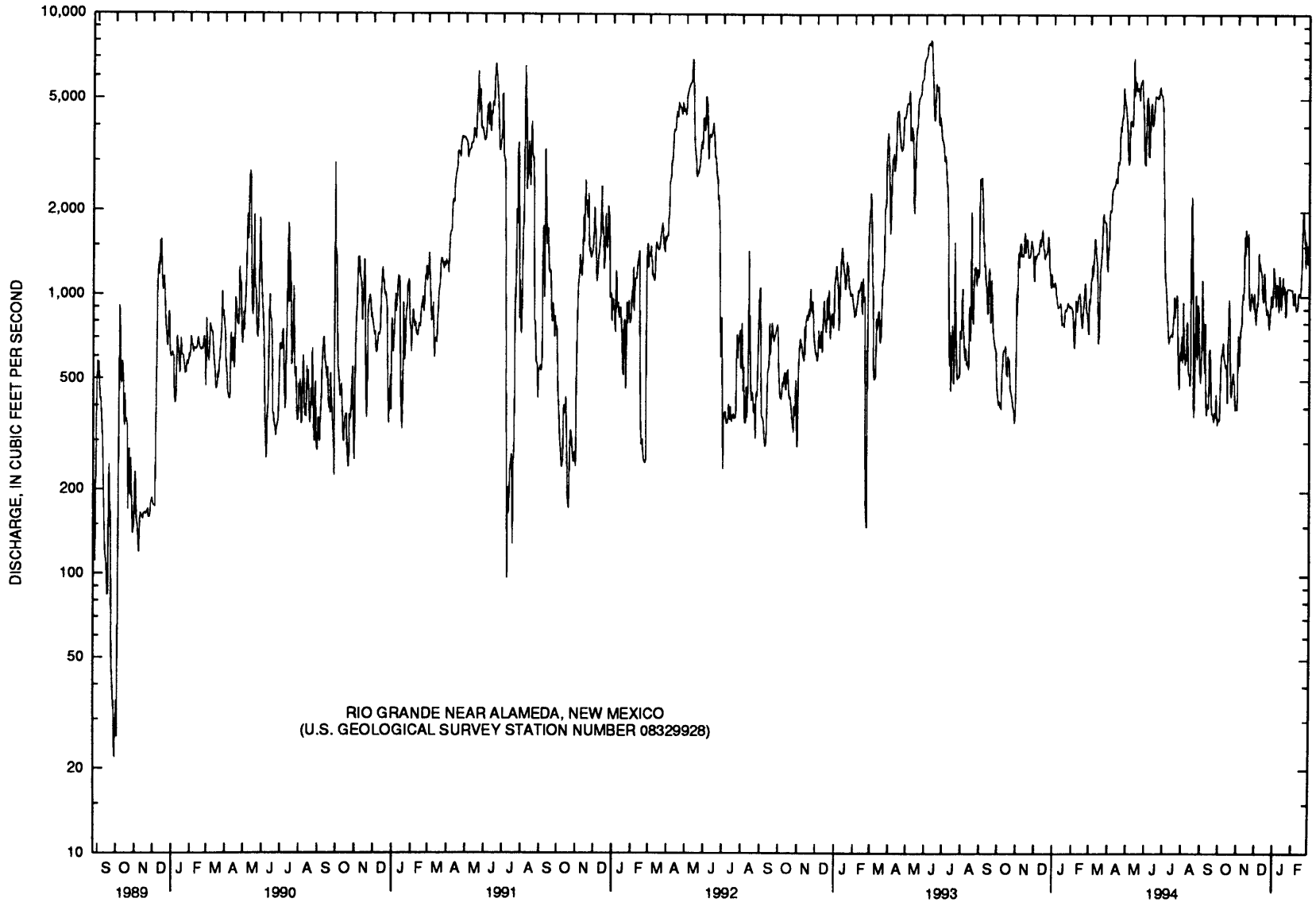

Figure 3.--Mean daily discharge of the the Rio Grande at the U.S. Geological Survey gaging station Rio Grande near Alameda, New Mexico (location shown in figure 2).

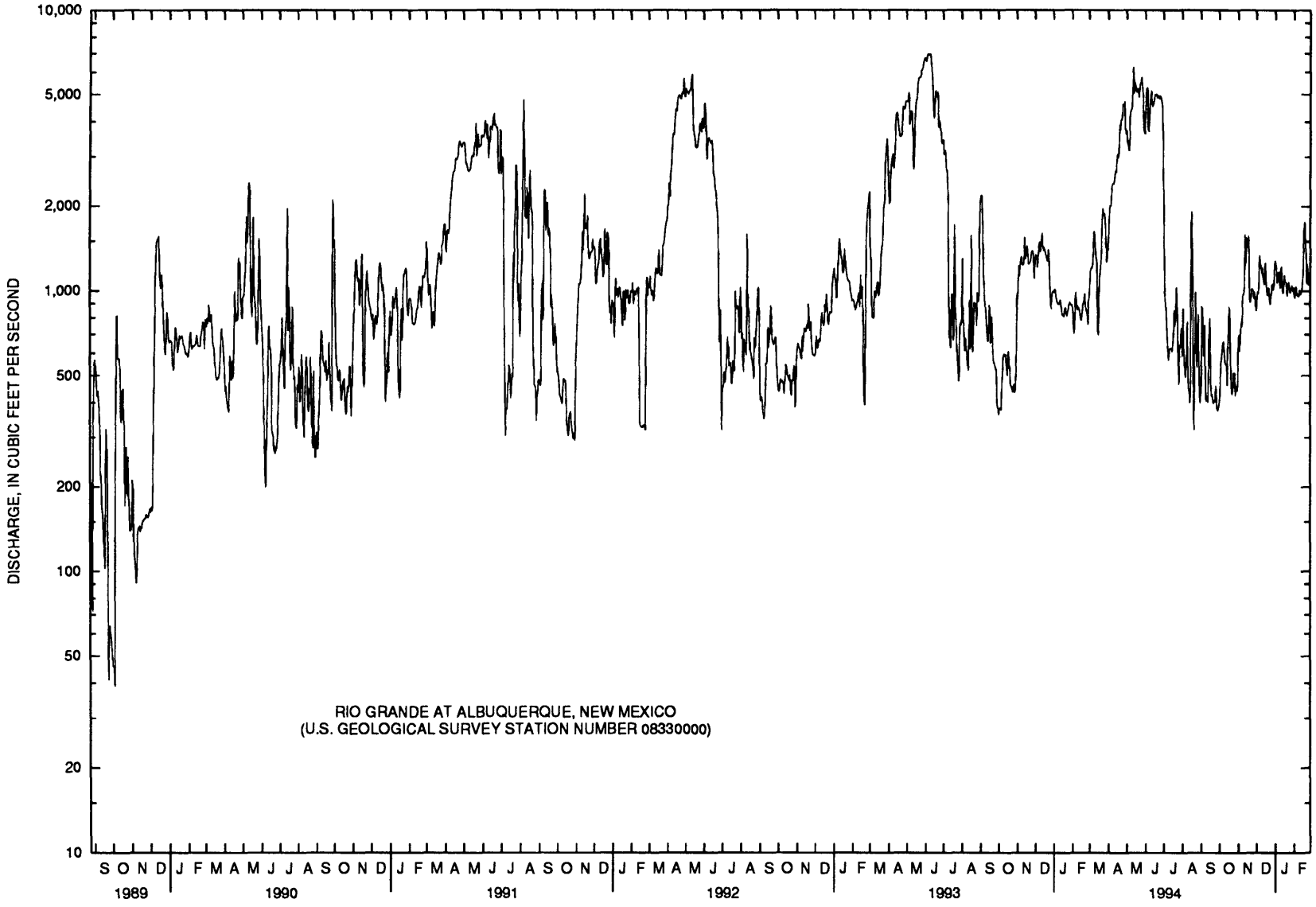

Figure 4.--Mean daily discharge of the the Rio Grande at the U.S. Geological Survey gaging station Rio Grande at Albuquerque, New Mexico (location shown in figure 2).

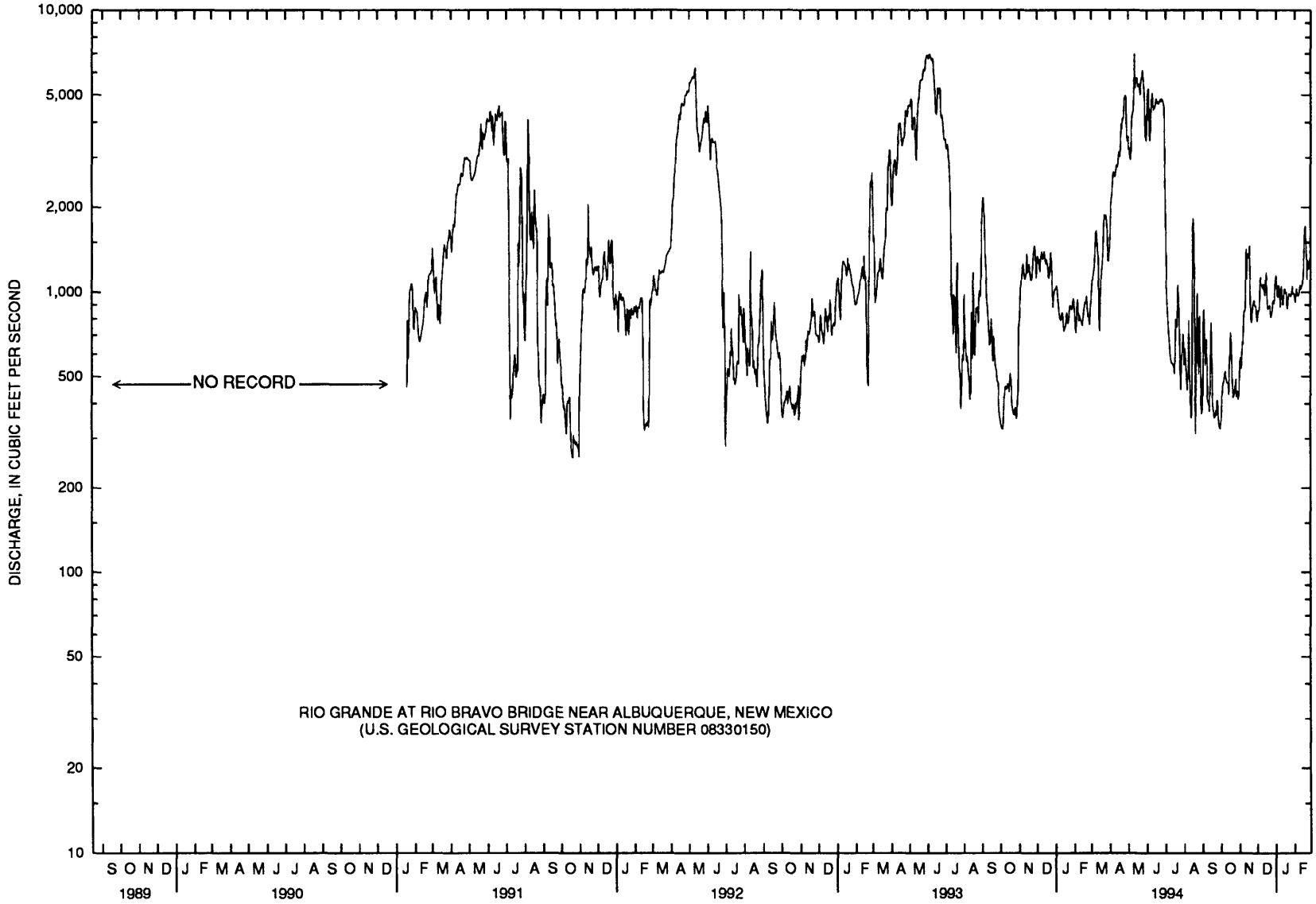

Figure 5.--Mean daily discharge of the the Rio Grande at the U.S. Geological Survey gaging station Rio Grande at Rio Bravo Bridge near Albuquerque, New Mexico (location shown in figure 2).

SURFACE-WATER DISCHARGE

Instantaneous surface-water measurements were made of the Rio Grande and all irrigation drains, laterals, canals, and ditches along the north and south sections. The north section had 10 measurement sites and the south section had 13 measurement sites (fig. 2; table 1). The discharge was calculated for each site, and the sum of discharge for all sites along both the north and south sections represents the total surface-water discharge entering and exiting the study area, respectively (tables 2 and 3).

Rio Grande discharge and total surface-water discharge (total discharge) are shown in table 4 and figures 6 and 7. Discharge of the Rio Grande at the north section ranged from 22 to 5,900 cubic feet per second, and at the south section ranged from 21 to 6,060 cubic feet per second (table 4). Also shown in table 4 and figures 6 and 7 are the differences in discharge between the north and south sections for both Rio Grande discharge and total discharge. Rio Grande discharge entering the study area was greater than Rio Grande discharge exiting the study area (negative difference) on 45 of 61 days; Rio Grande discharge entering the study area was less than that exiting the study area (positive difference) on 16 of the 61 days (table 4; figs. 6 and 7). Total discharge entering the study area was greater than that exiting the study area on 48 of the 59 days shown in table 4 and figures 6 and 7; 11 of the 59 days had lower total discharge entering the study area than total discharge exiting the study area. The total number of measurements of recorded Rio Grande discharge (61) differs from the total number of measurements of recorded total discharge (59) because on two different occasions (September 26, 1991, and February 19, 1992) no measurement was made at one of the sites, therefore a true total discharge could not be calculated (table 4).

Table 2.--Surface-water discharge from the Paseo del Norte (north) section

[See figure 2 for location and table 1 for name of sites. Values are in cubic feet per second; totals are rounded; - -, no data]

Date	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9	Site 10	Total
08/25/89	27	6.6	17	251	156	129	9.2	0	0.9	4.2	600
09/29/89	22	8	13	22	146	91	16	2.8	0	0	320
10/27/89	15	4	4.4	115	130	126	8.9	2	3.8	1.1	410
12/01/89	0	0	4.2	171	212	0	0	0	0	0	390
12/29/89	0	0	5	757	58	0	0	0	0	0	820
01/31/90	0	0	4.8	518	56	0	0	0	0	0	580
02/28/90	0	0	3.8	292	48	0	0	0	0	0	340
03/30/90	20	0	16	875	154	85	11	0.3	5	12	1,180
04/30/90	12	2.5	9.2	681	180	121	11	0.9	4.7	13	1,030
05/31/90	22	0.6	11	1,190	214	136	8.8	0.5	8.8	6.8	1,600
06/29/90	11	1.1	8	428	147	116	7.5	2.3	5.2	3.3	730
07/31/90	0.7	5	10	398	168	120	5.6	0	2.1	11	720
08/30/90	16	7.7	15	285	162	118	13	1.3	0.8	2.7	620
09/27/90	22	1.6	12	260	212	127	14	1.6	3.8	7.2	660
10/30/90	6.5	3.8	13	307	164	117	12	1.1	1.8	6	630
12/11/90	0	0	4.6	699	70	0	0	0	0	0	770
01/10/91	0	0	4.2	1,040	52	0	0	0	0	0	1,100
01/31/91	0	0	4.1	742	64	0	0	0	0	0	810
02/21/91	0	0	4	869	59	0	0	0	0	0	930
03/27/91	9.8	0.2	5	1,290	155	131	15	0	2.6	0	1,610
05/02/91	15	9.4	9.2	3,580	227	115	15	0.4	6.2	6.1	3,980
05/30/91	19	4.4	8.6	3,920	178	176	15	0	13	9.6	4,340
06/28/91	18	4.3	9.2	3,490	184	120	7.1	2.3	4.2	1.3	3,840
07/31/91	13	15	6.4	953	166	145	26	8.6	6	7.1	1,350
08/29/91	15	21	8	399	144	158	18	0	7.9	0	770
09/26/91	8.4	23	5.6	645	169	--	13	2.9	1.7	1.1	--
10/31/91	10	15	4.8	320	145	132	23	1.6	2.4	4.4	660
11/27/91	0	0	6.8	1,430	53	0	0	0	0	0	1,490
12/31/91	0	0	5.2	1,050	55	0	0	0	0	0	1,110
01/30/92	0	0	4.2	859	52	0	0	0	0	0	910
02/19/92	0	0	3.7	306	49	0	0	0	0	0	360
04/08/92	1.2	21	7.8	2,890	163	108	17	1.2	6.1	0	3,210
04/30/92	1.8	9.3	7.4	5,560	179	135	18	3.3	2.8	5.7	5,920
06/30/92	5	11	6.2	912	187	84	11	0.7	0.9	0.1	1,220
07/31/92	17	2.6	4.3	734	177	163	18	3.9	4.8	0	1,120
08/31/92	23	1.7	4.2	1,120	182	130	17	2.3	2.2	11	1,490
09/30/92	6.8	29	2	566	173	125	19	3.9	6.5	5.3	940

Table 2.--Surface-water discharge from the Paseo del Norte (north) section--Concluded

Date	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9	Site 10	Total
11/02/92	0	0	3.4	608	119	0.6	0	0	0	0	730
11/30/92	0	0	4.1	614	61	0	0	0	0	0	680
01/04/93	0	0	4.4	1,160	54	0	0	0	0	0	1,220
01/28/93	0	0	3.9	1,030	82	0	0	0	0	0	1,120
02/26/93	0	0	4.3	1,940	62	0	0	0	0	0	2,010
03/31/93	19	0	13	2,840	145	115	15	0	2.6	4.4	3,150
04/30/93	0	9.9	7.9	4,880	147	98	12	1.4	2.9	10	5,170
05/27/93	15	13	10	5,900	177	170	21	2.2	3.5	2	6,310
06/30/93	14	2.3	6.2	3,550	211	120	13	0	3.1	0	3,920
07/30/93	13	1.7	5.3	811	143	104	19	3.6	4	8.6	1,110
09/30/93	9.7	13	2.4	438	130	104	12	2.4	9	9.4	730
10/22/93	0	25	2.6	450	137	98	16	1.4	1.8	11	740
12/06/93	0	0	3	1,420	67	0	0	0	0	0	1,490
01/28/94	0	0	1.8	943	58	0	0	0	0	0	1,000
02/28/94	0	0	2.3	1,040	50	0	0	0	0	0	1,090
04/01/94	17	0	3.1	1,470	155	113	14	0.8	4.8	9.4	1,790
05/02/94	17	0	3.1	3,230	186	110	15	2.5	3.5	9.1	3,580
06/27/94	20	0	3.6	5,300	189	94	10	4.2	2.3	4	5,630
08/29/94	14	0	1.8	510	154	131	4.4	3	1.5	8.9	830
09/30/94	28	0	2.1	375	138	187	18	3	0.8	4.6	760
10/31/94	19	0	2	397	158	108	13.6	0.4	0.9	2.3	700
12/01/94	0	0	0.3	783	75	0	0	0	0	0	860
01/30/95	0	0	2.6	1,040	50	0	0	0	0	0	1,090
02/28/95	0	0	2.1	1,610	57	0	0	0	0	0	1,670

Table 3.--Surface-water discharge from the Rio Bravo Boulevard (south) section

[See figure 2 for location and table 1 for names of sites. Values are in cubic feet per second; totals are rounded; --, no data]

Date	Site 11	Site 12	Site 13	Site 14	Site 15	Site 16	Site 17	Site 18	Site 19	Site 20	Site 21	Site 22	Site 23	Total
08/25/89	17	8.7	65	0	28	11	30	243	70	56	0	0	0	530
09/29/89	0	9.2	25	11	19	10	29	21	54	60	0	0	0	240
10/27/89	11	6.1	28	1.5	24	7.9	20	112	42	45	0	0	0	300
12/01/89	0	0	0	0	0	0	60	131	170	0	0	0	0	360
12/29/89	0	0	0	0	0	0	17	729	27	0	0	0	0	770
01/31/90	0	0	0	0	0	0	18	511	27	0	0	0	0	560
02/28/90	0	0	0	0	0	0	18	545	29	0	0	0	0	590
03/30/90	29	11	19	15	36	13	26	715	107	51	0	0	0	1,020
04/30/90	3.4	4	37	0.1	25	1.9	21	735	92	12	0	0	0	930
05/31/90	17	4.9	43	5.9	33	13	29	1,020	100	66	0	0	0	1,330
06/29/90	6.6	6.9	55	11	12	8.9	22	313	93	50	0	0	0	580
07/31/90	8.4	9	44	18	27	4.4	36	269	71	52	0	0	0	540
08/30/90	17	6.5	43	3.5	30	8.8	35	183	108	72	0	0	0	510
09/27/90	2.4	7.8	40	10	13	14	33	296	97	60	0	0	0	570
10/30/90	11	4.7	22	2.6	22	10	33	360	77	42	0	0	0	580
12/11/90	0	0.8	0	0	0	0	25	652	29	0	0	0	0	710
01/10/91	0	0.6	0	0	0	0	25	1,060	29	0	0	0	0	1,110
01/31/91	0	0.5	0	0	0	0	20	737	27	0	0	0	0	780
02/21/91	0	0	0	0	0	0	23	898	26	0	0	0	0	950
03/27/91	0	1.4	32	6.3	11	4.4	35	1,450	74	64	0	0	0	1,680
05/02/91	14	8.9	36	9.9	19	6.2	31	2,970	99	54	0	0	0	3,250
05/30/91	19	7.5	49	9	19	7.2	42	4,090	139	63	0	0	0	4,440
06/28/91	21	13	51	5.2	25	4.3	60	3,050	78	59	0	0	0	3,370
07/31/91	0	6.1	44	0	26	9.4	41	1,150	178	65	0	0	0	1,520
08/29/91	15	6.4	42	8.1	34	9.4	31	270	101	63	0	0	0	580
09/26/91	5	12	27	12	19	10	36	600	84	34	0	0	0	840
10/31/91	3.2	22	19	9	28	2.6	37	267	134	39	0	0	0	560
11/27/91	0	1.6	0	0	0	0	32	1,270	28	0	0	0	0	1,330
12/31/91	0	1.2	0	0	0	0	23	913	27	0	0	0	0	960
01/30/92	0	0.8	0	0	0	0	24	824	27	0	0	0	0	880
02/19/92	0	0.5	--	0	0	0	22	338	23	0	0	0	0	--
04/08/92	19	8.6	42	6.6	29	6.8	37	2,640	96	71	0	0	0	2,960
04/30/92	17	9.2	48	1.8	34	6.9	52	5,120	112	67	0	0	0	5,470
06/30/92	11	9.5	56	4.1	22	6.2	31	815	79	56	0	0	0	1,090
07/31/92	7.4	8.7	28	4.4	37	11	41	687	101	89	0	0	0	1,010
08/31/92	14	8.6	41	6.1	27	6.2	31	1,260	96	61	0	0	0	1,550
09/30/92	10	11	42	6	32	3.8	35	543	96	26	0	0	0	800
11/02/92	0	9.3	4.2	1.1	0.1	0	28	501	55	0	0	0	0	600
11/30/92	0	1.1	0	0	0	0	22	690	21	0	0	0	0	730
01/04/93	0	0.2	0	0	0	0	24	1,060	24	0	0	0	0	1,110
01/28/93	0	0.4	0	0	0	0	21	1,070	24	0	0	0	0	1,110
02/26/93	0	0.1	0	0	0	0	21	2,460	21	0	0	0	0	2,500
03/31/93	15	8.1	27	11	30	13	37	2,830	76	54	0	0	0	3,100

Table 3.--Surface-water discharge from the Rio Bravo Boulevard (south) section--Concluded

Date	Site 11	Site 12	Site 13	Site 14	Site 15	Site 16	Site 17	Site 18	Site 19	Site 20	Site 21	Site 22	Site 23	Total
04/30/93	15	8.1	28	4.9	26	10	36	4,690	83	65	0	0	0	4,970
05/27/93	16	10	51	4.5	10	13	45	6,060	92	46	0	0	0	6,350
06/30/93	22	11	56	5.4	37	8.7	40	3,490	80	37	0	0	0	3,790
07/30/93	26	10	75	9.5	11	5.3	25	581	38	57	0	0	0	840
09/30/93	17	14	46	6.2	34	8.9	31	367	87	59	0	0	0	670
10/22/93	8.8	13	38	4.2	35	6.7	30	398	69	59	0	0	0	660
12/06/93	0	0.9	0	0	0	0	29	1,250	25	0	0	0	0	1,300
01/28/94	0	0	0	0	0	0	20	872	23	0	0	0	0	910
02/28/94	0	0	0	0	0	0	18	857	17	0	0	0	0	890
04/01/94	27	7.4	32	11	20	8.5	35	1,460	110	61	0	0	0	1,770
05/02/94	16	6	44	2.1	9.6	7.2	35	3,100	109	48	0	0	0	3,380
06/27/94	20	21	43	5.6	12	20	40	4,790	91	53	0	0	0	5,090
08/29/94	11	14	44	9.2	15	12	25	423	91	62	0	0	0	710
09/30/94	15	8.8	62	6	34	11	26	329	76	24	0	0	0	590
10/31/94	6.7	5.4	30	0	20	10	26	396	110	34	0	0	0	640
12/01/94	0	0	0	0	0	0	23	734	22	0	0	0	0	780
01/30/95	0	0	0	0	0	0	21.4	1,020	24.6	0	0	0	0	1,070
02/28/95	0	0	0	0	0	0	22.1	1,630	23.5	0	0	0	0	1,680

Table 4.--Surface-water discharge and differences between Rio Grande discharge and total discharge from the Paseo del Norte (north) section and the Rio Bravo Boulevard (south) section

[See figure 2 for location and table 1 for names of sites. Values are in cubic feet per second; - -, no data]

Date	Rio Grande discharge			Total discharge		
	Site 4	Site 18	Difference	North section	South section	Difference
08/25/89	251	243	-8	600	530	-70
09/29/89	22	21	-1	320	240	-80
10/27/89	115	112	-3	410	300	-110
12/01/89	171	131	-40	390	360	-30
12/29/89	757	729	-28	820	770	-50
01/31/90	518	511	-7	580	560	-20
02/28/90	292	545	253	340	590	250
03/30/90	875	715	-160	1,180	1,020	-160
04/30/90	681	735	54	1,030	930	-100
05/31/90	1,190	1,020	-170	1,600	1,330	-270
06/29/90	428	313	-115	730	580	-150
07/31/90	398	269	-129	720	540	-180
08/30/90	285	183	-102	620	510	-110
09/27/90	260	296	36	660	570	-90
10/30/90	307	360	53	630	580	-50
12/11/90	699	652	-47	770	710	-60
01/10/91	1,040	1,060	20	1,100	1,110	10
01/31/91	742	737	-5	810	780	-30
02/21/91	869	898	29	930	950	20
03/27/91	1,290	1,450	160	1,610	1,680	70
05/02/91	3,580	2,970	-610	3,980	3,250	-730
05/30/91	3,920	4,090	170	4,340	4,440	100
06/28/91	3,490	3,050	-440	3,840	3,370	-470
07/31/91	953	1,150	197	1,350	1,520	170
08/29/91	399	270	-129	770	580	-190
09/26/91	645	600	-45	- -	840	- -
10/31/91	320	267	-53	660	560	-100
11/27/91	1,430	1,270	-160	1,490	1,330	-160
12/31/91	1,050	913	-137	1,110	960	-150
01/30/92	859	824	-35	910	880	-30
02/19/92	306	338	32	360	- -	- -
04/08/92	2,890	2,640	-250	3,210	2,960	-250
04/30/92	5,560	5,120	-440	5,920	5,470	-450
06/30/92	912	815	-97	1,220	1,090	-130
07/31/92	734	687	-47	1,120	1,010	-110
08/31/92	1,120	1,260	140	1,490	1,550	60
09/30/92	566	543	-23	940	800	-140
11/02/92	608	501	-107	730	600	-130
11/30/92	614	690	76	680	730	50
01/04/93	1,160	1,060	-100	1,220	1,110	-110
01/28/93	1,030	1,070	40	1,120	1,110	-10
02/26/93	1,940	2,460	520	2,010	2,500	490
03/31/93	2,840	2,830	-10	3,150	3,100	-50
04/30/93	4,880	4,690	-190	5,170	4,970	-200
05/27/93	5,900	6,060	160	6,310	6,350	40

Table 4.--Surface-water discharge and differences between Rio Grande discharge and total discharge from the Paseo del Norte (north) section and the Rio Bravo Boulevard (south) section--Concluded

Date	Rio Grande discharge			Total discharge		
	Site 4	Site 18	Difference	North section	South section	Difference
06/30/93	3,550	3,490	-60	3,920	3,790	-130
07/30/93	811	581	-230	1,110	840	-270
09/30/93	438	367	-71	730	670	-60
10/22/93	450	398	-52	740	660	-80
12/06/93	1,420	1,250	-170	1,490	1,300	-190
01/28/94	943	872	-71	1,000	910	-90
02/28/94	1,040	857	-183	1,090	890	-200
04/01/94	1,470	1,460	-10	1,790	1,770	-20
05/02/94	3,230	3,100	-130	3,580	3,380	-200
06/27/94	5,300	4,790	-510	5,630	5,090	-540
08/29/94	510	423	-87	830	710	-120
09/30/94	375	329	-46	760	590	-170
10/31/94	397	396	-1	700	640	-60
12/01/94	783	734	-49	860	780	-80
01/30/95	1,040	1,020	-20	1,090	1,070	-20
02/28/95	1,610	1,630	20	1,670	1,680	10

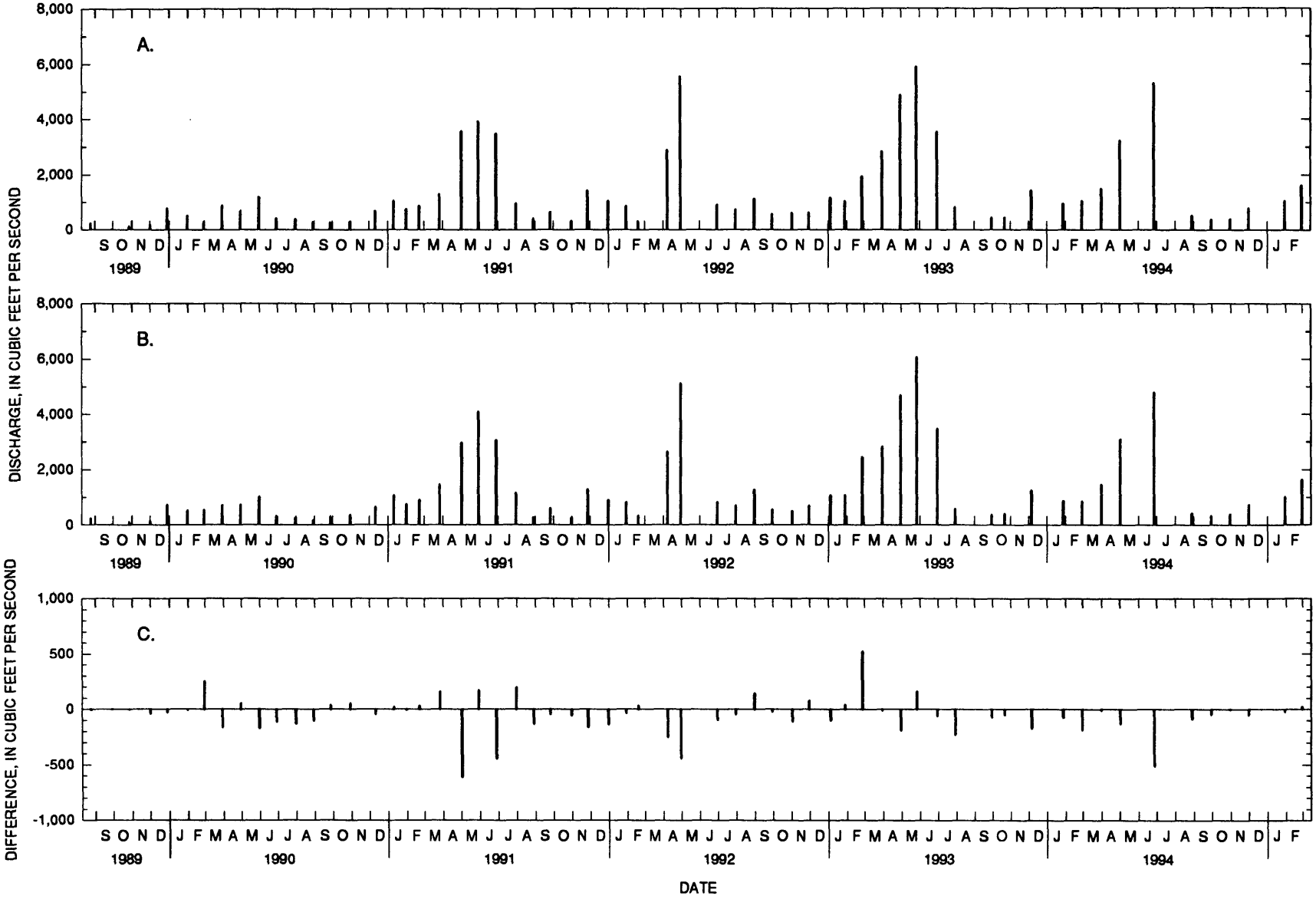

Figure 6.--Rio Grande discharge from the north section (A), south section (B), and the difference between the two (C); see figure 2 for location of A and B and table 4 for listing of discharge values.

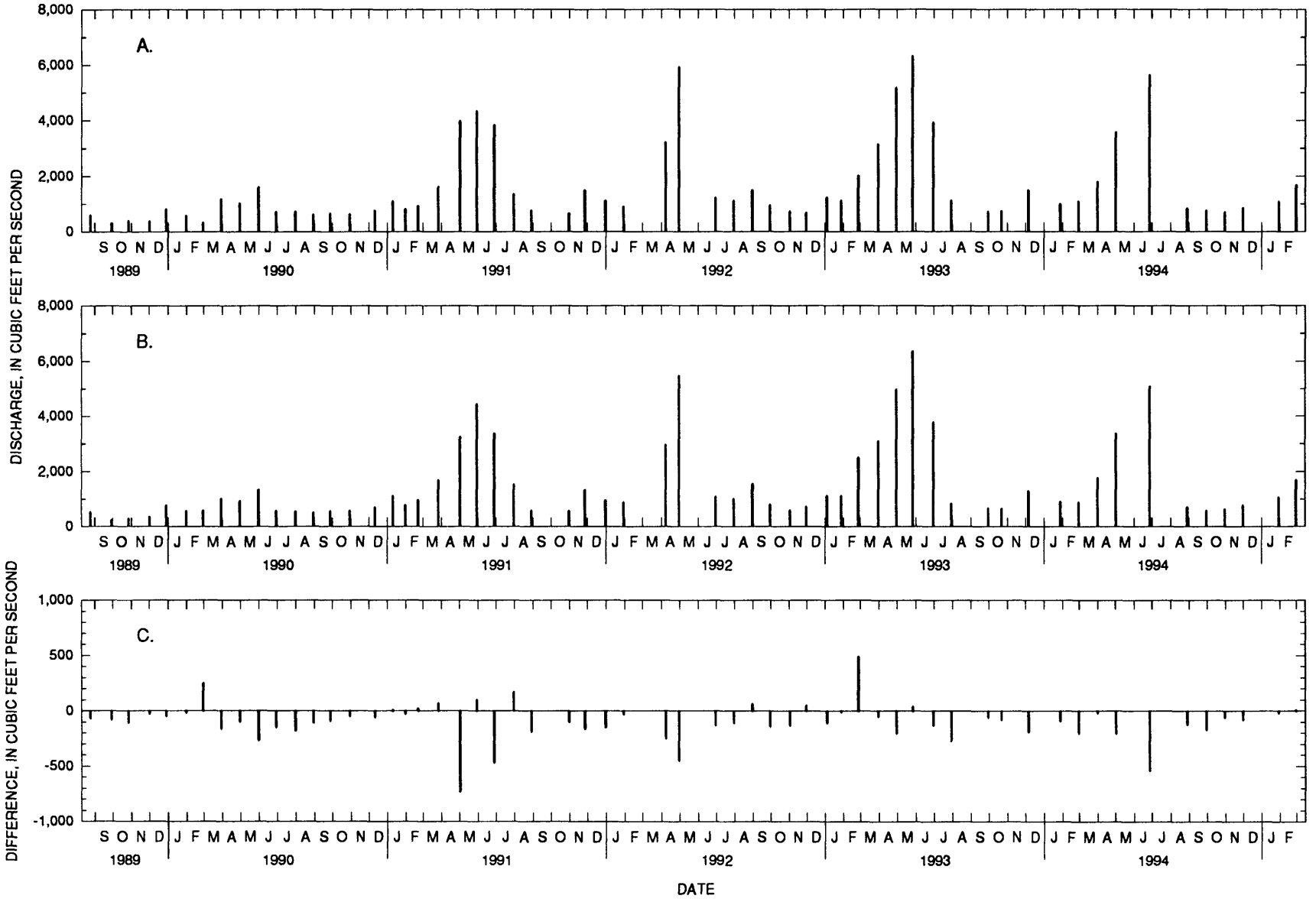

Figure 7.--Total discharge from the north section (A), south section (B), and the difference between the two (C); see figure 2 for location of A and B and table 4 for listing of discharge values.

EVAPOTRANSPIRATION RATES

The evapotranspiration rates from six areas located at Paseo del Norte and the Rio Grande, between surface-water measurement sites 4 and 5 (fig. 2), ranged from 0.13 to 6.4 millimeters per day (table 5). Three areas are covered with grass and three areas are bare soil (fig. 8). These areas represent the evapotranspiration contribution of grass-covered and bare soil along the edge of the river. All six areas are located on the east side of the river along a line perpendicular to the river. Area 1 is closest to the river, 20 to 100 feet from the river edge, depending on the stage of the river at the time of data collection. Area 6, located the farthest distance from the river, is 700 to 800 feet from the river edge. Data were collected from February 23, 1990, through August 29, 1991 (table 5 and fig. 9).

Data were collected using a hemispherical chamber placed at each sampling area for 2-minute intervals (fig. 8). Wet- and dry-bulb temperatures were measured with a psychrometer mounted on the inside of the chamber. Two fans were also mounted on the inside of the chamber to create optimal air mixing during the measurement interval (fig. 8). The wet- and dry-bulb temperatures were recorded every 2 seconds during the 2 minutes the chamber was on the sampling site. A Campbell 21X micrologger[1] was used to record the date, time of day, and wet- and dry-bulb temperatures. The sampling effort always began at area 1 and consecutively progressed to area 6. At the start of each area visit the fans mounted on the inside of the chamber were turned on for 10 to 15 seconds while holding the chamber 3 to 4 feet above ground. The data logger was then turned on and the chamber placed onto the ground, ensuring a proper seal between the ground and the rim of the chamber. At the end of the 2-minute interval the data logger was switched off and the chamber carried to the next area. Once all six areas were visited, 20 minutes would have elapsed before area 1 was revisited for the start of the second round of area visits. This sequence of area visits took place from sunrise to sundown.

From the wet- and dry-bulb temperature data, vapor density curves were constructed and evapotranspiration rates for each area were calculated (table 5). For a complete understanding of data collection using the hemispherical chamber and calculation of evapotranspiration rates, the reader is referred to Stannard (1988). Generally, the greatest evapotranspiration rates are associated with the bare-soil conditions of area 1 (table 5). This area is closest to the river and the evapotranspiration rates are affected by an increase of soil moisture from the river--that is, the site was moist during most visits. Evapotranspiration rates from areas 5 and 6 are shown in figure 9. These two areas were selected to graphically compare the evapotranspiration rates between bare-soil and grass-covered areas that are farthest from the river and least affected by soil moisture contributed from the river. The grass-covered area generally has a greater evapotranspiration rate than the bare-soil area (fig. 9). The exception to this occurred on September 27, 1990; an improper seal between the ground surface and chamber could explain this exception.

[1]Use of brand names in this report is for identification purposes only and does not constitute endorsement by the U.S. Geological Survey.

Table 5.--Evapotranspiration rates at six areas at Paseo del Norte and the Rio Grande, February 1990 through August 1991

[Area 1: bare soil, moist; area 2: grass-covered, moist soil; areas 3 and 5: bare soil, dry; areas 4 and 6: grass-covered, dry soil. All rates are in millimeters per day]

Date	Area 1	Area 2	Area 3	Area 4	Area 5	Area 6
02/23/90	1.3	0.96	0.50	0.59	0.73	0.85
05/17/90	4.3	3.8	1.9	2.2	2.5	2.7
06/28/90	6.4	4.2	2.8	3.2	2.5	2.8
07/26/90	6.1	4.7	0.78	2.3	1.3	2.8
08/30/90	6.3	1.2	0.65	1.1	1.2	1.6
09/27/90	3.5	0.60	0.29	0.53	0.32	0.16
10/25/90	1.8	0.59	0.14	0.21	0.15	0.22
11/29/90	0.27	0.31	0.17	0.16	0.13	0.15
01/17/91	0.57	0.55	0.14	0.23	0.17	0.24
03/14/91	1.2	0.20	0.14	0.21	0.14	0.18
04/25/91	1.7	1.9	0.17	0.50	0.20	0.63
05/23/91	4.6	4.2	1.0	1.1	0.82	1.5
06/27/91	1.6	4.3	0.31	1.3	0.29	0.51
08/01/91	0.52	3.0	0.44	1.3	0.43	1.5
08/29/91	0.62	1.4	0.54	0.91	0.37	0.82

A.

B.

Figure 8.--Hemispherical chamber located at Paseo del Norte and the Rio Grande: (A) grass covered (area 2); (B) bare soil (area 3). Note location of fans (1) and psychrometer (2) mounted on inside of chamber. Also shown in B is the data logger to the right of the chamber.

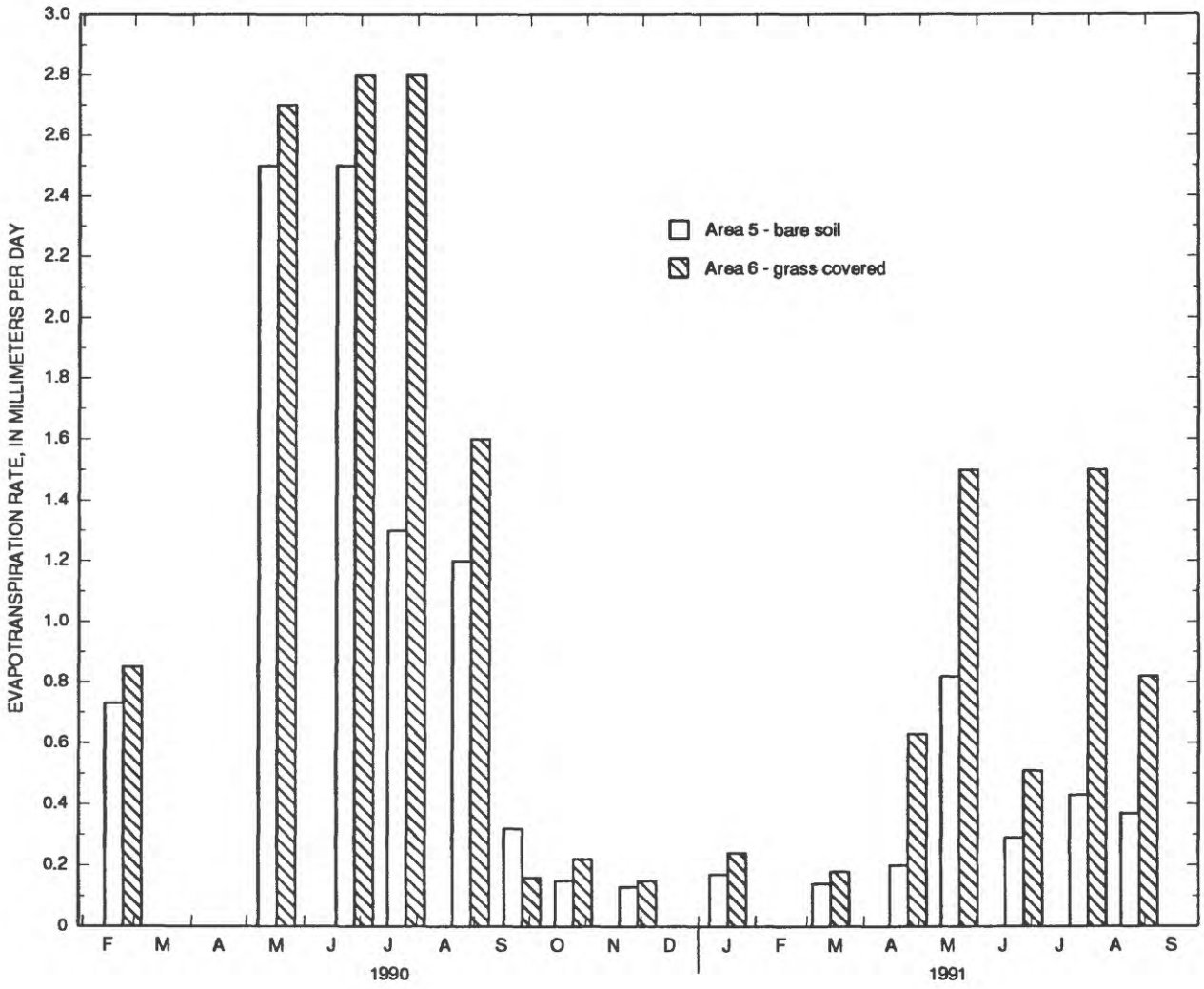

Figure 9.--Evaporanspiration rates calculated at areas 5 and 6 at Paseo del Norte and Rio Grande (location shown in figure 2).

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