THE FLOODS OF MAY 17-18, 1985
AND
OCTOBER 6-7, 1985 IN PUERTO RICO

By

Ferdinand Quiñones and Karl G. Johnson

U.S. GEOLOGICAL SURVEY

OPEN-FILE REPORT 87-123

Prepared in cooperation with the

PUERTO RICO DEPARTMENT OF NATURAL RESOURCES,
PUERTO RICO ENVIRONMENTAL QUALITY BOARD,
AND PUERTO RICO HIGHWAY AUTHORITY

San Juan, Puerto Rico

1987

DEPARTMENT OF THE INTERIOR

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CONVERSION FACTORS

For the convenience of readers who may want to use the International Systems of Units (SI), the data may be converted by using the following factors:

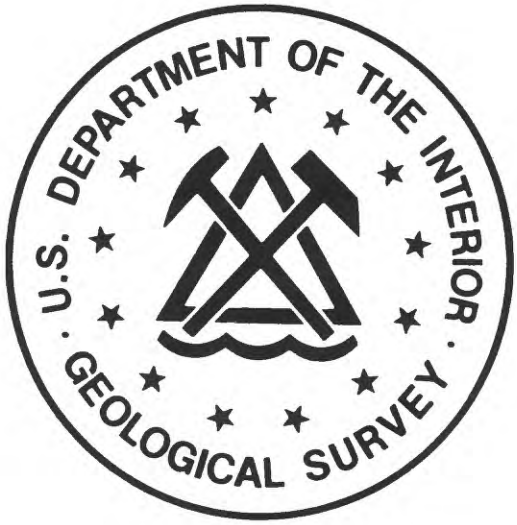
Multiply inch-pound units	by	To obtain SI units
inch (in.)	25.4	millimeter (mm)
	2.54	centimeter (cm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
square mile (mi^2)	2.590	square kilometer (km^2)
acre-foot (acre-ft)	1,233	cubic meter (m^3)
cubic yard (yd^3)	0.7646	cubic meter (m^3)
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/sec)
cubic foot per second per square mile [$(ft^3/s)/mi^2$]	0.01093	cubic meter per second per square kilometer [$(m^3/s)/km^2$]

Specific Combinations

1 acre-ft = 226.3 gal/min, during one day

1 ft^3/s = 448.8 gal/min

1 ft^3/s = 0.65 Mgal/d


U.S. DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

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ABSTRACT

Severe floods occurred in Puerto Rico twice in 1985. During May 15-19, 1985, as much as 25 inches of rainfall produced significant floods along north and north-central basins in the island. A nearly stationary tropical depression affected Puerto Rico during October 5-8, 1985, resulting in 24-hour precipitation totals of as much as 23 inches and severe floods along the south-central coastal areas.

During the May 17-18, 1985 event, the areas most seriously affected by flooding were along the north coast. These included the lower reaches of the Río Grande de Manatí and the Río Grande de Arecibo. Significant flooding also occurred at Utuado and Jayuya. The recurrence interval of most of the flood peaks was generally less than 25 years.

The floods of October 6-7, 1985, affected mostly rural areas in southern Puerto Rico, but caused significant loss of life and widespread property damages. Landslides near Ponce, the collapse of a bridge at Río Coamo, and the destruction of homes near Ponce resulted in about 170 fatalities and more than 125 million dollars in damages. Flooding was also severe at Barceloneta on the north coast. Recurrence intervals equal to or greater than 100 years were estimated for peak discharges at several index stations.

INTRODUCTION

During 1985, severe floods occurred twice throughout Puerto Rico (fig. 1) resulting in significant losses in life and property. The first event occurred during May 15-19, when a low-pressure system resulted in precipitation totals exceeding 14 inches throughout most of south-central and eastern Puerto Rico. A second event was produced by a tropical depression that affected south-central Puerto Rico during October 5-8. Landslides and collapses of several key bridges during the October floods resulted in the death of as many as 170 people. Property losses from both floods were estimated at about 162 million dollars.

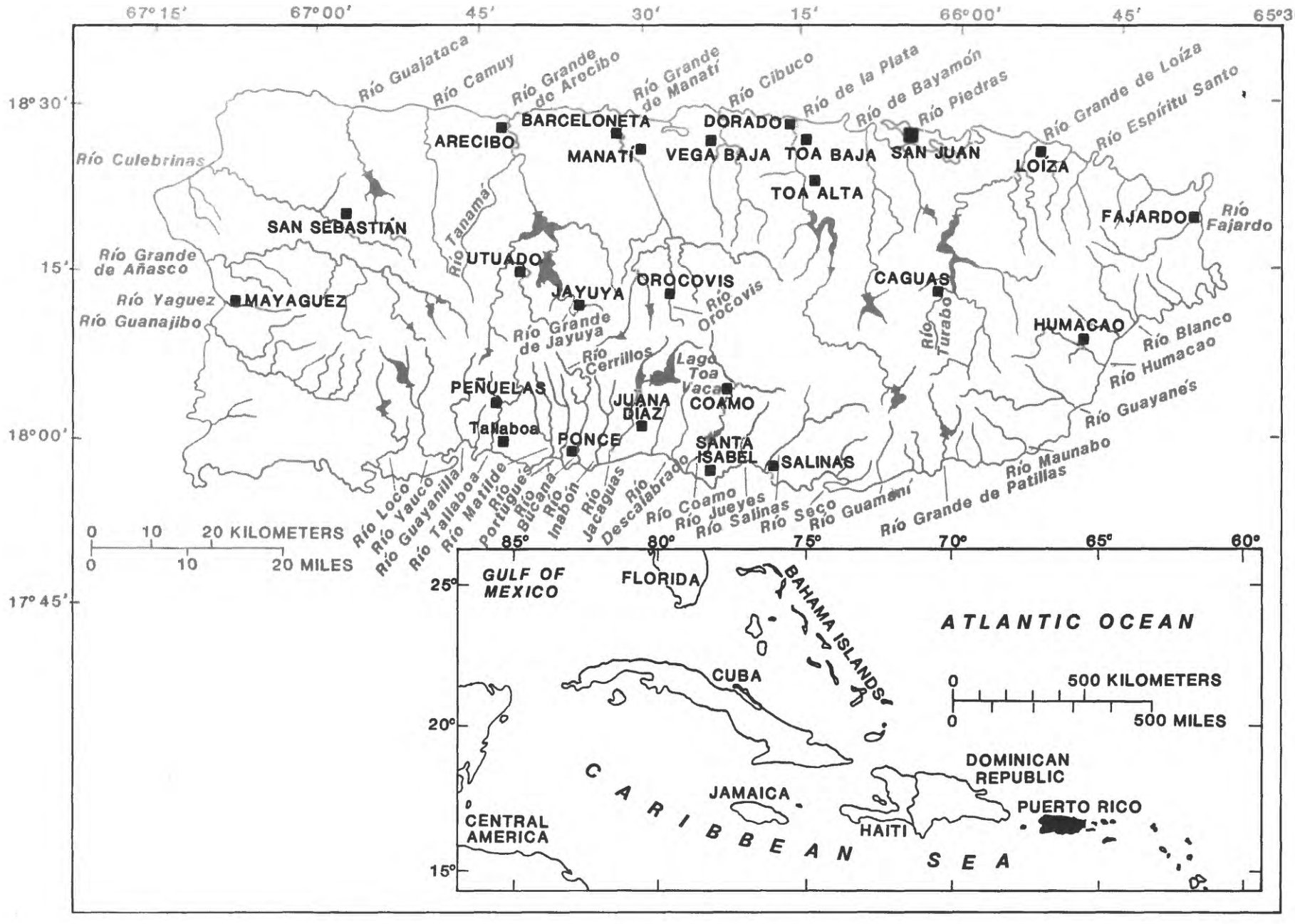


Figure 1.--Map of Puerto Rico showing locations mentioned in this report.

INTRODUCTION (Continued)

The U.S. Geological Survey, Water Resources Division, collected and analyzed data on the magnitude, frequency and extent of the 1985 floods. The investigations were conducted as part of the ongoing cooperative water resources investigation program in cooperation with the Puerto Rico Department of Natural Resources, the Puerto Rico Environmental Quality Board, and the Puerto Rico Highway Authority. Information related to rainfall quantities and intensities throughout the island was provided by Robert Calvesbert, of the National Weather Service, National Oceanic and Atmospheric Administration (NWS-NOAA), U.S. Department of Commerce.

This report summarizes the rainfall and streamflow data collected during the two 1985 flood events. This information should be of value and interest to engineers, developers, planners and government officials. Additionally, it will provide a historical record of data from the floods to supplement several flood atlases now in preparation.

THE FLOODS OF MAY 17-18, 1985

Rainfall

Severe flooding affected most of the north and north-central parts of Puerto Rico during May 17-18 as a result of intense precipitation that began on May 15 and continued through May 19. The rains were produced by a nearly stationary low-pressure center that moved from the northwest on May 15. During the next five days, almost continuous precipitation of varying intensity was recorded throughout most of the south-central and eastern part of Puerto Rico.

Precipitation totals for the 5 days of the storm ranged from 8 to 25 inches (fig. 2). The most intense rainfall occurred over an area extending west of a north-south line at the town of Orocovis toward Mayaguez. A second cell of less intense rainfall affected the Río Grande de Loíza basin, in the eastern part of the island. The recorded precipitation total for the 5-day period May 15-19 was 25.21 inches at Jayuya. Precipitation totals for the 5-day period at individual stations operated by the NWS-NOAA are summarized in table 1.

Flooding and Damages

The most significant floods occurred on May 17 and 18. Flooding was severe in the lower reaches of streams in the Río Grande de Arecibo, the Río Tanamá, the Río Grande de Manatí, the Río Grande de Jayuya, the Río Orocovis, the Río Turabo, the Río de La Plata, and the Río Grande de Añasco basins. Flooding of urban areas was reported at the towns of Arecibo, Utuado, Jayuya, Orocovis, Vega Baja, Dorado, Toa Baja, Barceloneta, Caguas, and Loíza.

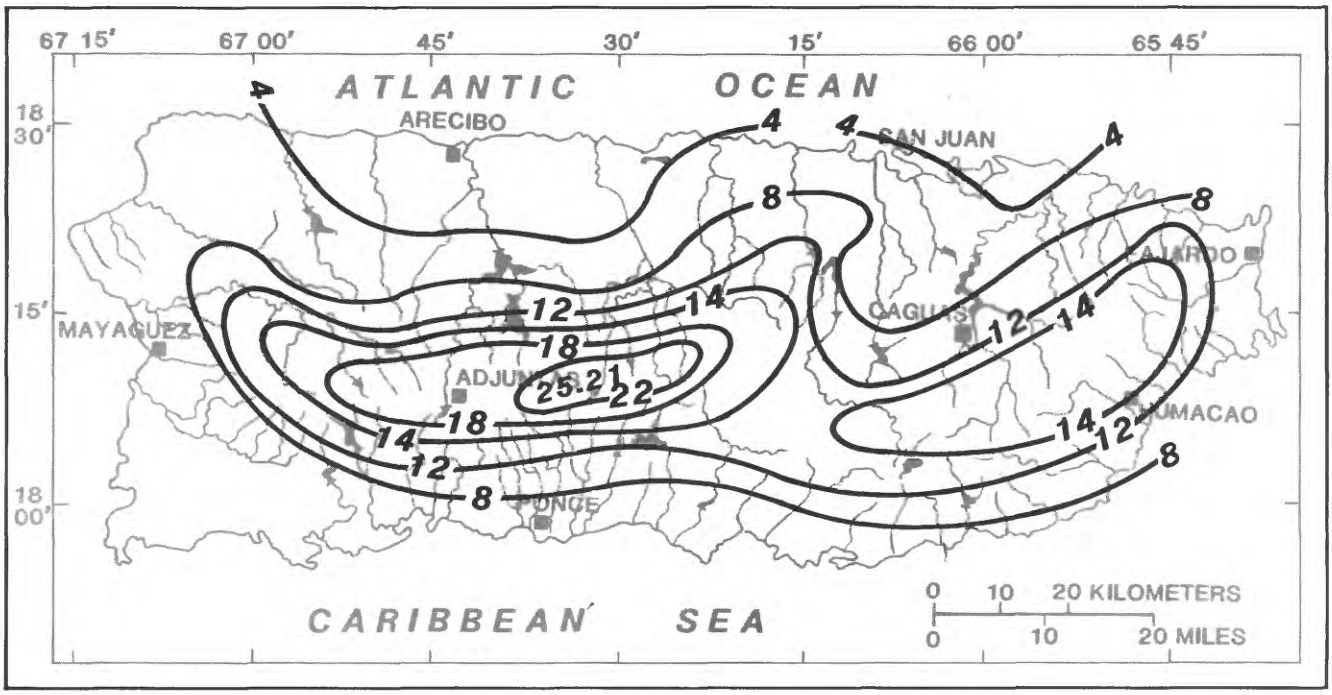


Figure 2.--Cumulative precipitation (isohyets in inches) over Puerto Rico during May 15-19, 1985.

THE FLOODS OF MAY 17–18, 1985 (Continued)

Flooding and Damages (Continued)

The worst flooding occurred at Arecibo and Barceloneta, (fig. 3). The flooding at Arecibo covered slightly less area than during the 1928 record flood (Hickenlooper, 1968). The flood at the town of Barceloneta was lower and inundated a lesser area than the 1970 flood. Undefined conditions appear to have caused backwater effects in several areas in Barceloneta on the Río Grande de Manatí flood plain. The floods at the towns of Jayuya and Utuado were lower than the record floods of 1975 (Johnson, 1982).

Damage estimates to private and public property during the floods reached 37 million dollars according to the Federal Emergency Management Administration (FEMA).

Peak Discharges

The U.S. Geological Survey collected peak stage and flow data from its network of gaging stations throughout Puerto Rico (fig. 4). At sites where recording instruments failed or were damaged during the floods, high-water marks were surveyed shortly after the event to determine the peak stage and discharge. Flood stages, discharges, and other information pertinent to the gaging stations are summarized in table 2. Flood hydrographs at key gaging stations for the period from May 15-21, 1985 are shown in figures 5a to 5d.

Table 1. Daily precipitation, in inches, for May 15-19, 1985 at selected National Weather Service-National Oceanic and Atmospheric Administration (NWS-NOAA) stations throughout Puerto Rico

LOCATION	MAY 15	16	17	18	19	5-DAY TOTALS
NORTH COASTAL						
Borinquen Airport	1.40	0.45	2.00	0.65	0.70	5.20
Candelaria-Toa Baja	.00	.00	2.90	5.00	.00	7.90
Rio Piedras AES	1.27	1.44	.96	1.78	.50	5.95
San Juan WSFO	2.08	T	1.17	.88	.00	4.13
Toa Baja 1 SSW	.75	.90	.78	4.45	1.10	7.98
SOUTH COASTAL						
Aguirre Central	1.45	1.65	.20	2.00	1.70	7.00
Central San Francisco	.18	1.01	.28	.34	2.30	4.11
Lajas AES	.33	1.60	1.57	.40	1.19	5.09
Magueyes Island	.56	1.49	.58	*	*	2.63
Ponce 4 E	.29	3.44	1.34	1.78	1.44	8.29
Ponce City	.90	2.10	.99	.50	1.35	5.84
Santa Isabel 2 ENE	.35	1.30	.40	1.88	.77	4.70
NORTHERN SLOPES						
Canóvanas	2.17	2.15	.45	1.59	.50	6.86
Fajardo	.33	2.25	.90	7.13	.85	11.46
Isabela AES	T	.46	1.22	.70	1.93	4.31
La Muda - Caguas	1.09	.81	1.27	1.50	.76	5.43
Manatí 3 E	.01	1.44	.40	.79	1.46	4.10
Trujillo Alto 2 SSW	2.02	.90	.62	1.40	.95	5.89
SOUTHERN SLOPES						
Corral Viejo	.28	3.17	.89	1.04	5.34	10.72
Juana Díaz Camp	.92	1.76	2.74	3.16	.00	8.58
Maunabo	.34	1.64	.27	4.36	2.02	8.63
Patillas	.69	.06	.07	.37	2.00	3.19
Puerto Real	.25	.47	1.54	.65	1.83	4.74
Roosevelt Roads	.82	.49	2.42	5.82	.00	9.55
Sabana Grande 2 ENE	.57	.18	.65	2.00	4.40	7.80
Yauco 1 NNW	.28	1.75	2.65	1.05	3.22	8.95
EASTERN INTERIOR						
Caguas 1 W	.75	1.50	.72	5.65	.75	9.37
Cayey 1 E	1.10	3.01	1.68	5.20	3.07	14.06
Cidra 1 E	1.10	2.00	1.30	4.45	.60	9.45
Gurabo AES	.80	2.20	.67	7.00	.30	10.97
Juncos	1.08	4.40	1.25	6.18	2.78	15.69
Pico del Este	2.50	2.51	4.50	4.90	.60	15.01
San Lorenzo 3 S	1.42	4.25	.94	7.86	.40	14.87
San Lorenzo Farm 2 NW	.80	3.40	1.10	7.40	1.65	14.35
WESTERN INTERIOR						
Adjuntas AES	.24	2.94	2.29	14.20	.34	20.01
Arecibo Observatory	.00	.46	.35	.75	2.17	3.73
Cerro Maravilla	1.40	4.58	5.72	10.00	2.25	23.95
Coloso	.17	2.00	.45	3.85	.18	6.65
Corozal AES	*	1.13	1.32	7.68	1.33	11.46
Dos Bocas	.00	.73	.47	1.06	3.75	6.01
Jayuya	.03	3.24	4.67	5.57	11.70	25.21
Lares 2 SE	.00	.42	.90	1.55	4.65	7.52
Maricao Fish Hatchery	.00	.25	2.23	2.48	5.66	10.62
Morovis 1 N	.05	1.72	1.97	4.83	1.49	10.06
Negro-Corozal	.09	.85	1.78	2.52	2.15	7.39
San Sebastián 2 WNW	.00	.00	.37	.93	2.55	3.85
Utuado	.07	1.73	1.27	2.54	5.39	11.00
Villalba 1 E	2.10	2.70	3.68	2.27	.00	10.75

EXPLANATION:

T - Trace.
* - No reading from rain gage.

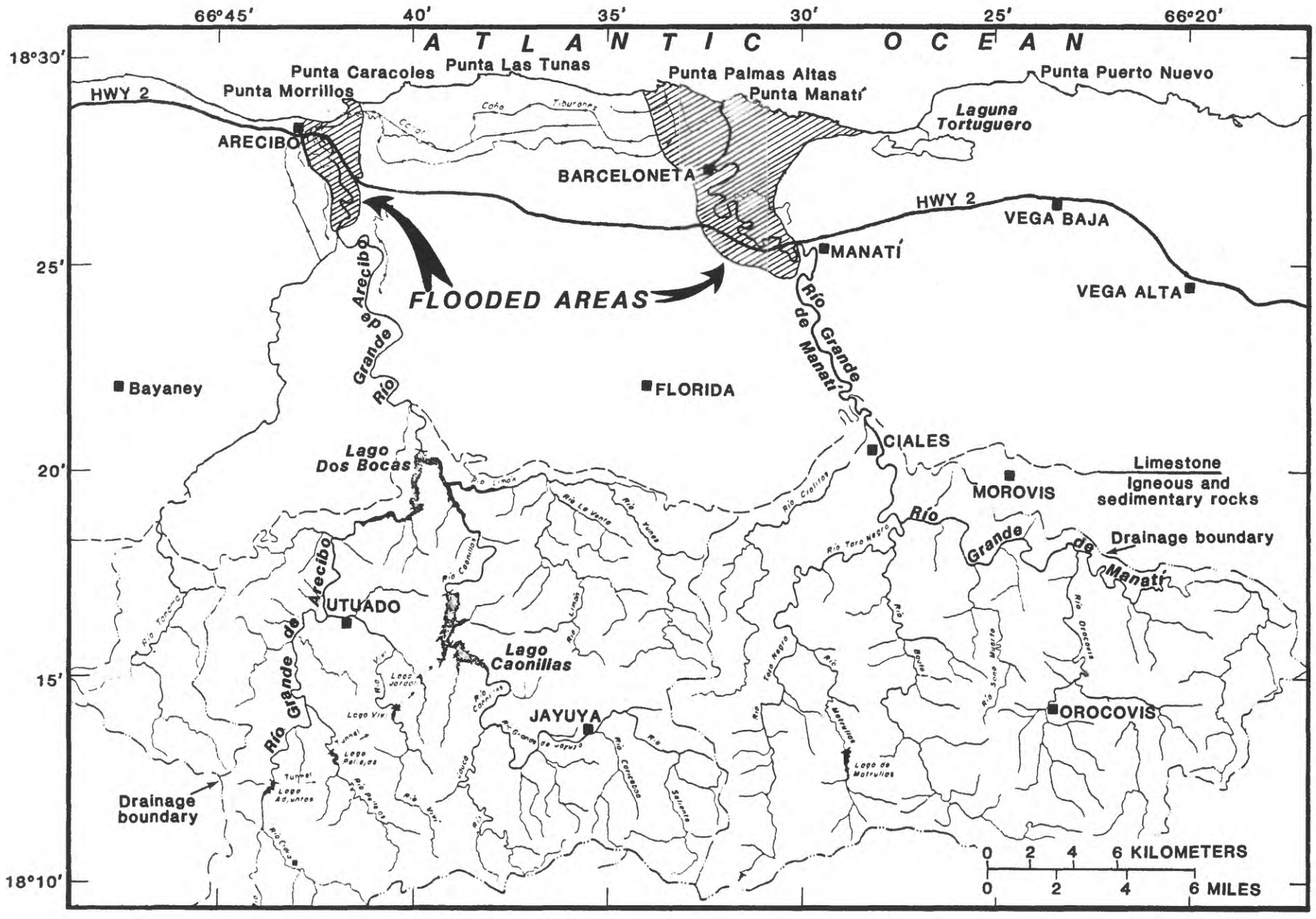


Figure 3.--Areas in Puerto Rico where flooding was most severe during May 1985.

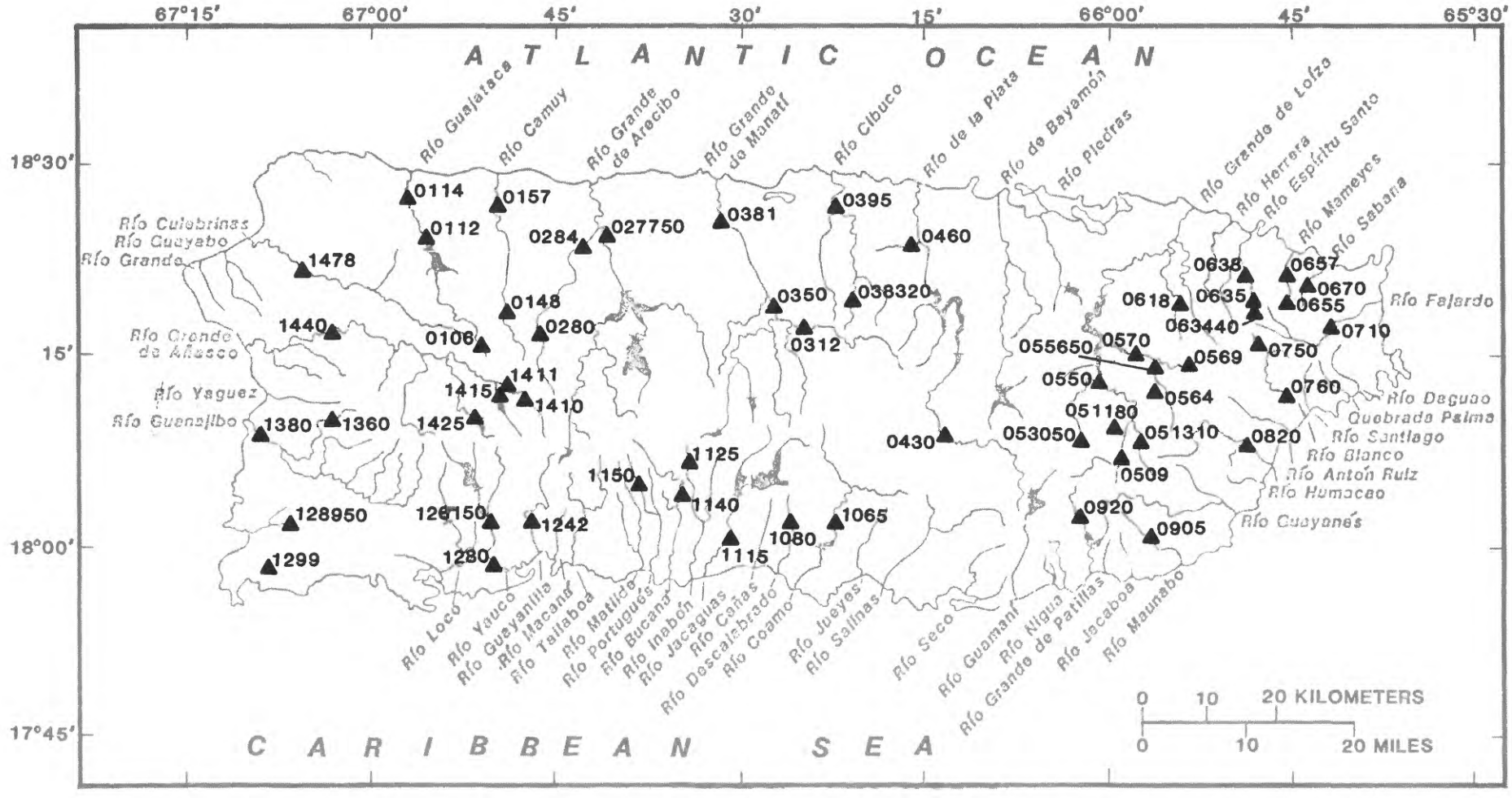


Figure 4.--Network of streamflow gaging stations operated by the U.S. Geological Survey in Puerto Rico.

Table 2. Summary of gage heights and discharges during floods of May 17-18, 1985 at selected U.S. Geological Survey streamflow gaging stations throughout Puerto Rico

STATION NUMBER	STATION NAME	DRAINAGE AREA (sq mi)	PERIOD OF RECORD	MAXIMUM PREVIOUSLY RECORDED						MAXIMUM DURING MAY 17-18, 1985 FLOOD			
				DATE	GAGE HEIGHT (ft)	DISCHARGE		RECURRENCE INTERVAL (yrs)	DAY	GAGE HEIGHT (ft)	DISCHARGE		RECURRENCE INTERVAL (yrs)
						cu ft/s	cu ft/s/sq mi				cu ft/s	cu ft/s/sq mi	
50014800	Río Camuy near Bayaney	ND	1984	09-18-84	11.53	2040	-	ND	18	14.42	3510	ND	ND
50015700	Río Camuy near Hatillo	ND	1984	09-19-84	-	3000	-	ND	18	20.67	6250	ND	ND
50027750	Río Grande de Arecibo above Arecibo	140.00	1982-84	09-13-82	13.05	9310	66	ND	18	18.22	45800	330	ND
50028000	Río Tanamá near Utuado	18.40	1960-84	05-17-63	16.29	8950	486	10	18	17.45	12190	660	50
50028400	Río Tanamá near Charco Hondo	57.60	1969-71, 1983-84	04-21-69	12.22	4120	72	ND	18	17.95	15000	260	ND
50031200	Río Grande de Manatí near Morovis	55.20	1965-84	10-09-70	20.30	35000	634	15	18	17.89	48000	870	50
50035000	Río Grande de Manatí at Ciales	128.00	1960-84	10-09-70	24.00	125000	977	30	18	19.62	74300	580	15
50038100	Río Grande de Manatí at Hwy 2 near Manatí	197.00	1963-84	10-09-70	33.30	119000	604	20	18	33.54	136000	690	25
50038320	Río Cibuco below Corozal	15.10	1970-84	11-07-79	19.80	13600	901	10	18	18.55	10800	720	5
50039500	Río Cibuco at Vega Baja	99.10	1959-84	12-13-81	18.84	30300	306	30	18	18.12	22200	220	20
50043000	Río de la Plata at Proyecto la Plata	54.80	1960-84	08-27-61	32.20	59600	1090	15	18	21.10	26530	480	5
50046000	Río de la Plata near Toa Alta	200.00	1960-84	09-06-60	36.35	95500	478	25	18	21.61	38700	190	5
50050900	Río Grande de Loíza at Quebrada Arenas	6.00	1978-84	07-18-79	13.40	8950	1490	20	18	10.37	4290	715	5
50051150	Quebrada Blanca at El Jaqual	3.25	1985	-	-	-	-	-	17	14.58	7400	2280	ND
50051180	Quebrada Salvatierra near San Lorenzo	3.74	1984	06-10-84	15.12	6300	1680	ND	17	17.10	9320	2490	ND
50051310	Río Cayaguas at Cerro Gordo	10.20	1978-84	08-31-79	9.44	13200	1290	10	18	19.71	8180	800	3
50053050	Río Turabo at Borinquen	7.89	1984	02-15-84	9.75	2650	336	ND	17	17.06	11600	1470	ND
50055000	Río Grande de Loíza at Caguas	89.80	1960-84	09-06-60	31.17	71500	796	20	18	21.40	28000	310	5
50055650	Quebrada Caimito near Juncos	0.82	1984	09-20-84	9.79	228	278	ND	18	12.07	678	830	ND
50056400	Río Valenciano near Juncos	16.40	1972-84	08-31-79	20.17	23300	1420	20	18	21.30	25700	1570	25
50056900	Quebrada Mamey near Gurabo	2.30	1984	06-10-84	8.11	1050	457	ND	18	8.43	1190	520	ND
50057000	Río Gurabo at Gurabo	60.20	1960-84	09-06-60	27.70	74600	1240	15	18	23.35	38200	630	5
50065500	Río Mameyes near Sabana	6.88	1969-73, 1983-84	09-04-73	13.02	19800	2880	10	17	11.44	13900	2020	5
50071000	Río Fajardo near Fajardo	14.90	1960-84	10-24-74	13.62	19600	1320	10	17	9.88	6000	400	2
50111500	Río Jacaguas at Juana Díaz	49.80	1984	09-21-84	8.07	357	7	ND	18	18.78	12700	260	ND
50112500	Río Inabón at Real Abajo	9.70	1964-84	10-09-70	20.60	5720	540	7	18	17.84	3410	350	5
50114000	Río Cerrillos near Ponce	17.80	1964-84	09-16-75	11.20	22400	1260	100	18	14.64	8270	460	5
50115000	Río Portugués near Ponce	8.82	1965-84	09-16-75	10.10	13100	1490	25	18	9.87	3050	350	2
50115900	Río Portugués at Hwy 14 at Ponce	18.60	1965-84	09-16-75	17.38	14500	780	30	18	12.46	5000	270	5
50144000	Río Grande de Añasco near San Sebastián	94.30	1963-84	09-16-75	33.90	140000	1480	100	18	26.77	77200	820	50
50147800	Río Culebrinas at Hwy 404 near Moca	71.20	1969-84	09-16-75	36.60	69000	969	25	18	29.65	32800	460	5

EXPLANATION

ND - Not determined.

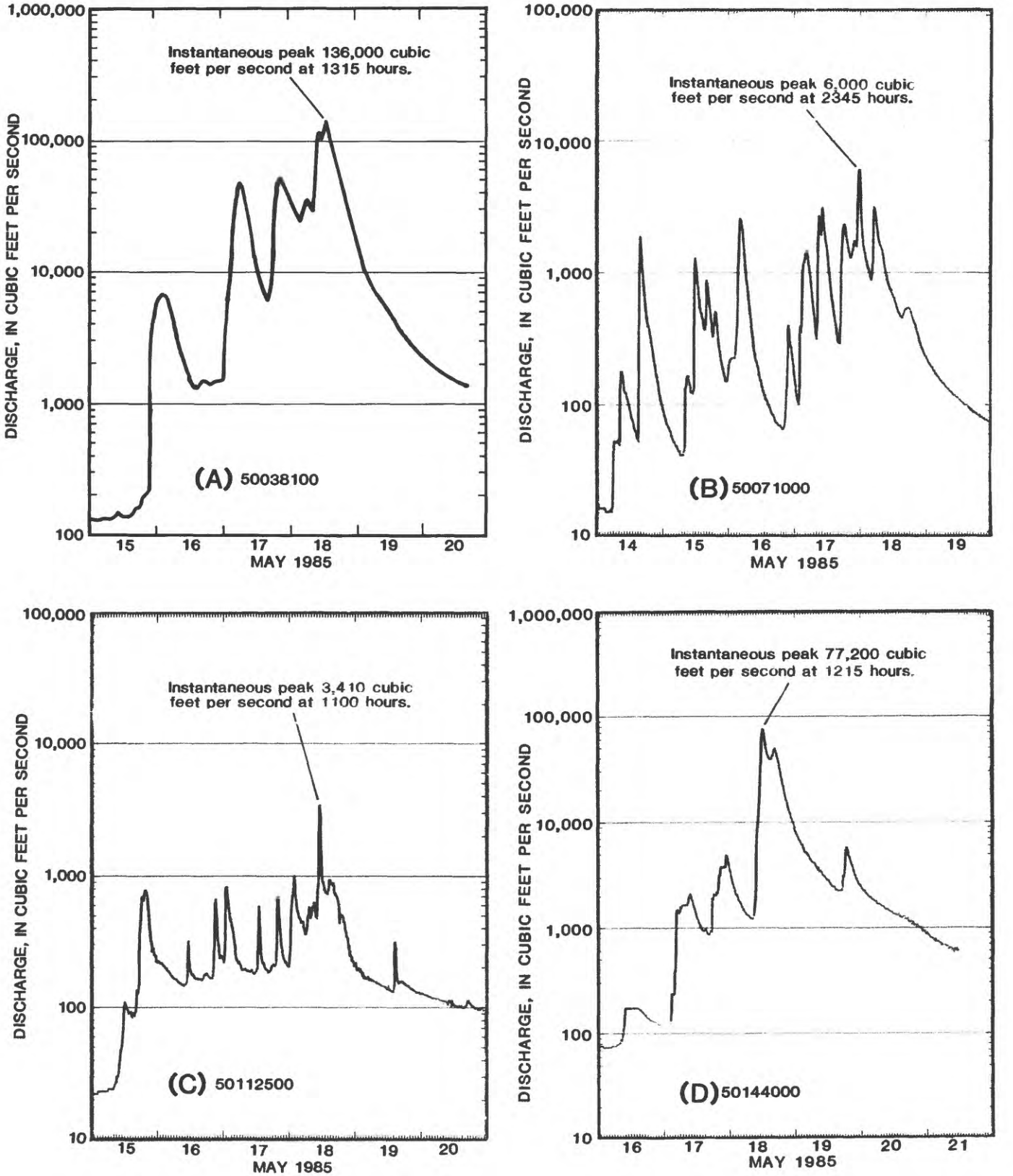


Figure 5.--Discharge hydrographs at key streamflow gaging stations during the May 15-19, 1985 floods at:
(A) Río Grande de Manatí at Highway 2, near Manatí,
(B) Río Fajardo near Fajardo,
(C) Río Inabón at Real Abajo, and
(D) Río Grande de Añasco near San Sebastián.

THE FLOODS OF OCTOBER 6-7, 1985

Rainfall

Intense precipitation induced by a nearly stationary tropical depression occurred over most of southern Puerto Rico during October 6-7, 1985. As much as 23 inches of rainfall occurred north of the towns of Ponce and Coamo during a 24-hour period (fig. 6). The intensity of the precipitation near the town of Peñuelas (fig. 7) was as high as 2.75 inches in one hour and 5.5 inches in two hours. The rainfall was equally distributed between the afternoon of October 6 and the early hours of October 7. Less intense precipitation occurred on October 5. Similarly less intense precipitation occurred on October 8 after the very intense storm of October 7. Precipitation totals for the 4-day period (October 5-8) were as high as 30.66 inches (table 3).

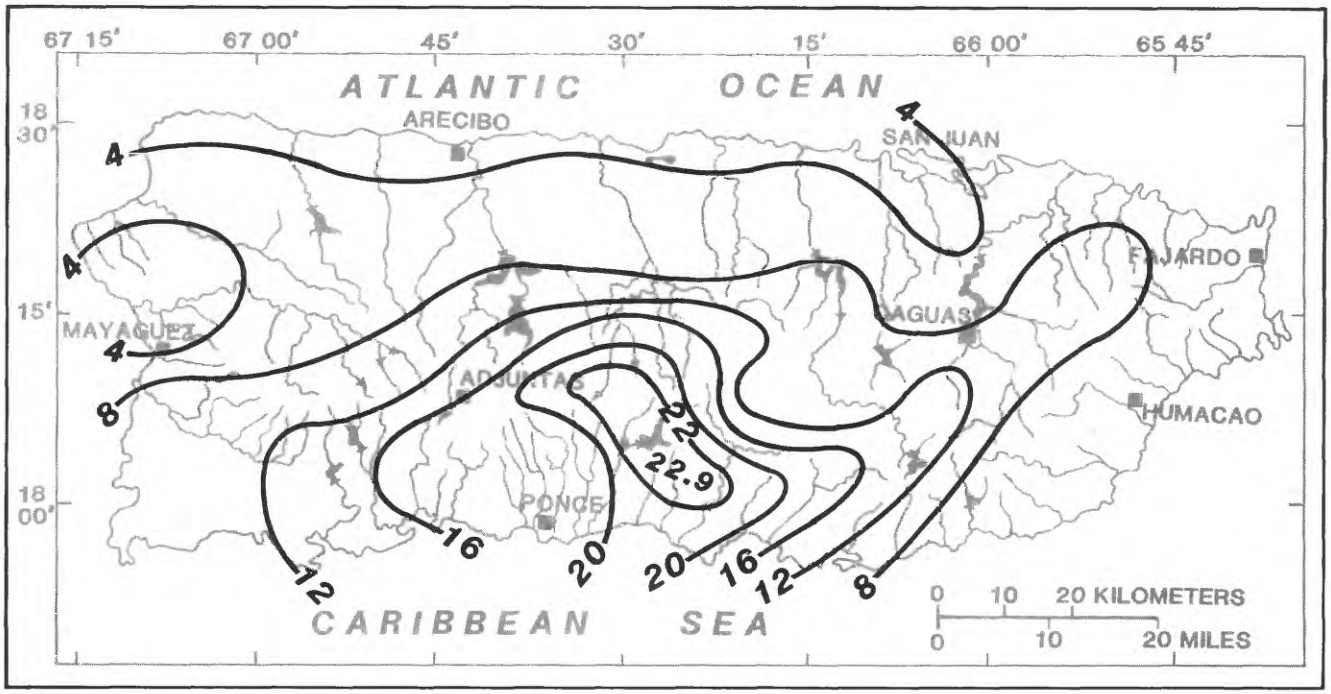


Figure 6.--Cumulative precipitation (isohyets in inches) over Puerto Rico during October 6-7, 1985.

Flooding and Damages

The most severe flooding occurred along the south coast from the town of Santa Isabel, west towards the city of Ponce (fig. 8). Severe flooding also occurred in the lower reaches of the Río de La Plata (near the towns of Toa Alta and Dorado) and the Río Grande de Manatí (at the town of Barceloneta). The urban area of Barceloneta was flooded for the second time in 1985. Preliminary highwater marks surveyed in the center of the town showed that the October flood was about one foot higher than the May 1985 flood. Local less severe flooding was reported at the mountain towns of Utuado and Jayuya.

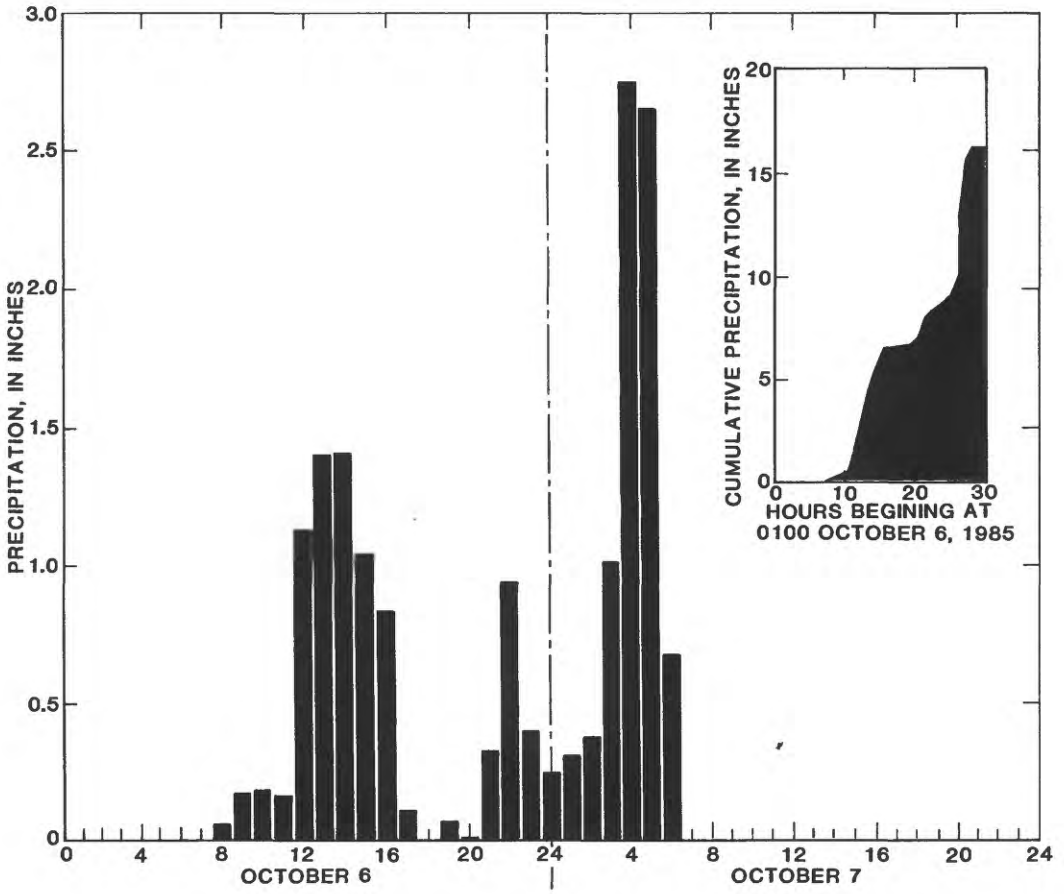


Figure 7.--Hourly and cumulative rainfall during October 6-7, 1985 at Tallaboa gage near Peñuelas, southern Puerto Rico. (Data courtesy of Puerto Rico Energy Power Authority.)

THE FLOODS OF OCTOBER 6-7, 1985 (Continued)

Flooding and Damages (Continued)

The floods along the south coast in the Santa Isabel to Ponce area exceeded the historical floods of 1970 (Haire, 1971). Flooding in the lower valley of the Río Jacaguas (south of the town of Juana Díaz) was not as severe as in the Río Coamo area in spite of about equal precipitation in both basins. The Toa Vaca reservoir attenuated most of the peak, storing a significant amount of the runoff. The reservoir filled-up to its capacity (original capacity of about 55,000 acre-feet) only for the second time since its construction in 1972. Flooding along the Río Cerrillos and the city of Ponce was also minimal in comparison to previous events of lesser magnitude. The Río Cerrillos flood channel contained most of the flood runoff within its boundaries.

Damages to private and public property during the floods were estimated by FEMA at about 125 million dollars. About 3,000 homes were damaged, of which 1,300 were a total loss. The deaths of about 40 people (other than fatalities related to landslides) were attributed to the floods. The worst incident occurred at the Río Coamo bridge on Las Americas Expressway (Highway 52). The approach to the west bound lanes on the bridge collapsed sometime between midnight and 3:00 a.m. on October 7. An unknown number of vehicles plunged into the river, with at least 24 fatalities. Flooding at the Quebrada del Agua (west of the city of Ponce) resulted in 16 fatalities.

Table 3. Daily precipitation, in inches, for October 5-8, 1985 at selected National Weather Service-National Oceanic and Atmospheric Administration (NWS-NOAA) stations throughout Puerto Rico

LOCATION	OCTOBER				4-DAYS TOTALS
	5	6	7	8	
NORTH COASTAL					
Borinquen Airport	0.45	0.60	2.50	0.75	4.30
Candelaria - Toa Baja	.03	3.02	7.96	.32	11.33
Río Piedras AES	1.70	1.45	3.15	.32	6.62
San Juan WSFO	.29	2.92	2.62	T	5.83
Toa Baja 1 SSW	1.04	3.50	7.28	.22	12.04
SOUTH COASTAL					
Aguirre Central	.40	.93	12.30	1.10	14.73
Central San Francisco	.14	.21	12.00	2.10	14.45
Lajas AES	.16	.08	8.45	1.30	9.99
Magueyes Island	.22	*	10.25	2.64	13.11
Ponce 4 E	.52	.75	18.20	2.61	22.08
Ponce City	.58	*	3.70	1.16	5.44
Santa Isabel 2 ENE	.38	.85	21.52	1.93	24.68
Santa Rita	.00	15.00	2.30	.00	17.30
NORTHERN SLOPES					
Canóvanas	1.50	2.45	3.55	.38	7.88
Fajardo	.09	2.16	7.60	.52	10.37
Isabela AES	.02	.19	3.55	.64	4.40
La Muda-Caguas	1.08	1.09	8.10	.51	10.78
Manatí 3 E	.80	.20	6.09	.79	7.88
Trujillo Alto 2 SSW	.50	1.25	4.15	.65	6.55
SOUTHERN SLOPES					
Corral Viejo	.42	.38	15.90	1.01	17.71
Juana Díaz Camp	*	*	22.23	3.02	25.25
Maunabo	.85	2.21	6.33	.11	9.50
Mayaguez Airport	.08	.00	2.01	.50	2.59
Patillas	1.65	1.10	4.90	1.16	8.81
Puerto Real	.00	.00	10.80	.86	11.66
Roosevelt Roads	1.04	5.81	.54	T	7.39
Sabana Grande 2 ENE	.28	.00	13.75	2.25	16.28
Yauco 1 NNW	.14	.23	15.05	1.30	16.72
EASTERN INTERIOR					
Cayey 1 E	.44	1.51	11.60	1.63	15.18
Cidra 1 E	.56	1.25	11.07	2.00	14.88
Gurabo AES	1.00	1.06	7.38	1.19	10.63
Juncos	.87	1.20	8.38	2.12	12.57
Pico del Este	.57	6.75	5.00	.45	12.77
San Lorenzo 3 S	1.15	3.60	5.60	1.05	11.40
San Lorenzo 2 NW	.50	3.60	6.20	.80	11.10
WESTERN INTERIOR					
Adjuntas AES	.10	.20	11.70	3.55	15.55
Arecibo Observatory	.04	.18	7.80	1.90	9.92
Barranquitas 2 SSW	1.00	6.00	10.00	1.05	18.05
Cerro Maravilla	.41	1.95	22.90	5.40	30.66
Corozal AES	.95	.42	7.58	.36	9.31
Dos Bocas	.30	.18	7.00	1.67	9.15
Jayuya	.49	.79	16.41	6.66	24.35
Lares 2 SE	.04	.15	6.70	1.60	8.49
Morovis I N	.62	.72	7.50	.49	9.33
Negro - Corozal	.58	.40	2.66	1.13	4.77
San Sebastián 2 WNW	.06	.02	4.02	1.08	5.18

EXPLANATION:

T - Trace.
* - No reading from rain gage.

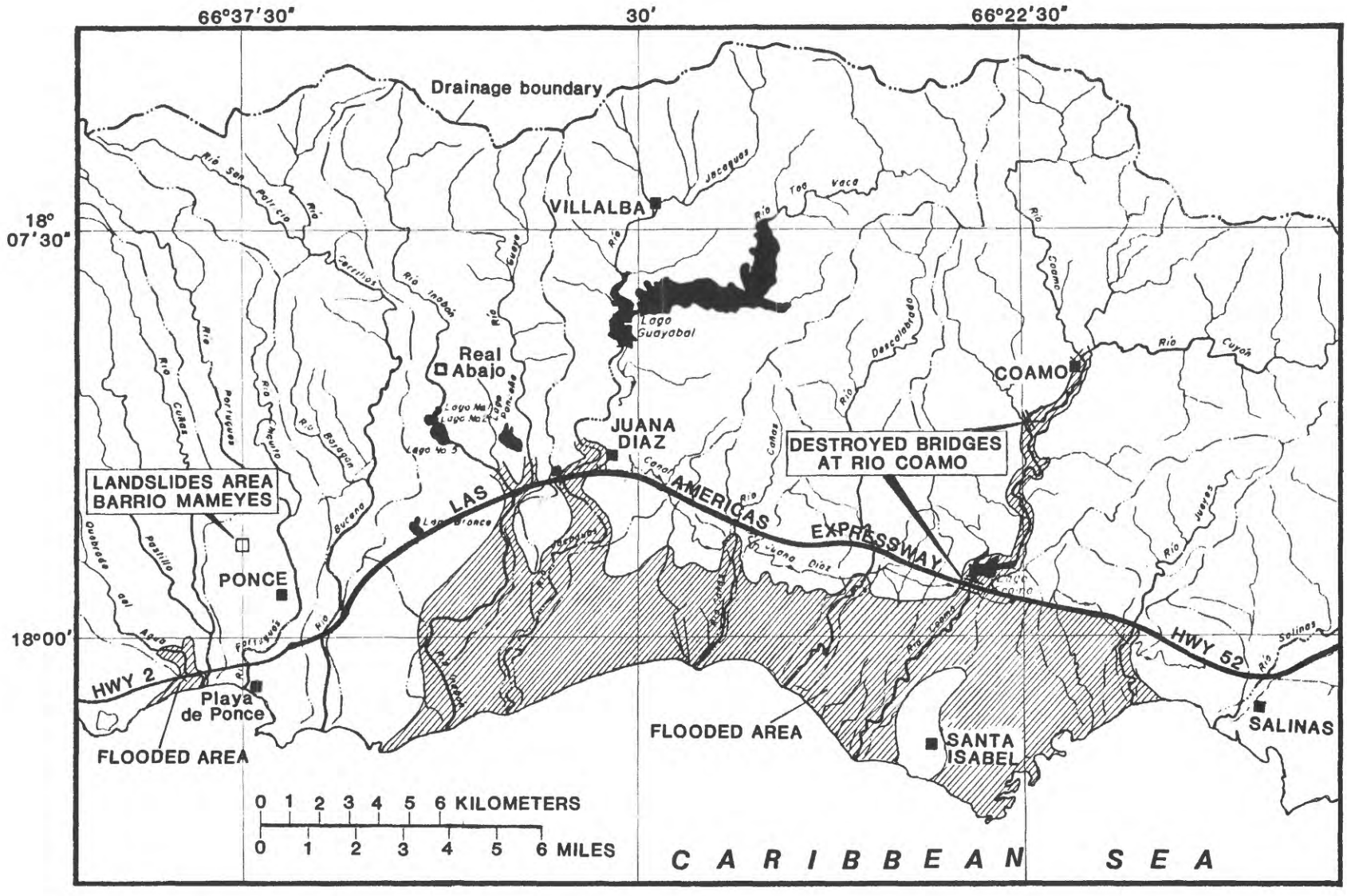


Figure 8.--Areas flooded in southern Puerto Rico during the October 6-7, 1985 floods.

THE FLOODS OF OCTOBER 6-7, 1985 (Continued)

Peak Discharges

The U.S. Geological Survey collected peak stage and discharge information during and after the floods throughout its network of gaging stations in Puerto Rico. Historical peak flows were recorded at several stations in the network. These included gaging stations at the Río Coamo, the Río Inabón, the Río Descalabrado, the Río Jacaguas, the Río Cerrillos, the Río Portugués, and the Río Grande de Manatí (table 4). Recurrence intervals equal to or greater than 100 years were estimated for most of the peaks recorded at the gaging stations from Santa Isabel to Ponce. Discharge hydrographs at key gaging stations showed that the peak discharges occurred during the early hours of October 7 (fig. 9).

Landslides

Landslides occurred throughout Puerto Rico as a result of saturation of the soils during the intense rains of October 5-8. The most severe landslide occurred on a hill at Barrio Mameyes, on the northwestern fringe of the city of Ponce (fig. 10). A slab of calcareous sandstone detached from the crest of the hill, slipping toward the bottom of a populated ravine. Field estimates showed that about 260,000 cubic yards of material slid from the hill.

The Mameyes landslide destroyed about 90 homes causing the death of about 130 people. Most of the houses were buried under mud and debris. The time of occurrence of the incident (around 3:00 a.m. on October 7) and the intensity of the rain at that time, affected the rescue efforts (only about 50 bodies were recovered). Although many other smaller landslides occurred throughout the island, the incident at Mameyes was the only one that resulted in loss of life. The Puerto Rico Department of Natural Resources is currently conducting an inventory of the landslides recorded during the floods.

COMPARISON OF THE 1985 FLOODS WITH HISTORICAL FLOODS

The floods of May and October 1985 were of severe magnitude and extreme frequency. Record peak discharges occurred at several basins including some of the largest in Puerto Rico. The recurrence interval of many of the instantaneous peak discharges equaled or exceeded the 100-year flood.

The "Myers Rating" method can be utilized to compare the intensity of floods from different basins and/or different events (Haire, 1972). In the Myers's technique, the unit discharge (flow per unit area) of a particular flood is compared with the maximum known floods throughout the world or in the study area. In Puerto Rico, the most recent extreme floods occurred in 1960, 1970, and 1975. Data from the 1960 floods and the 1985 floods were compared using the Myers's technique (fig. 11).

Table 4. Summary of gage heights and discharges during floods of October 6-7, 1985 at selected U.S. Geological Survey streamflow gaging stations throughout Puerto Rico

STATION NUMBER	STATION NAME	DRAINAGE AREA (mi²)	PERIOD OF RECORD	MAXIMUM PREVIOUSLY RECORDED					MAXIMUM DURING OCT 6-7, 1985 FLOOD			
				DATE	GAGE HEIGHT (ft)	DISCHARGE ft³/sec	DISCHARGE ft³/sec/mi²	RECURRENCE INTERVAL (yrs)	DAY	GAGE HEIGHT (ft)	DISCHARGE ft³/sec	DISCHARGE ft³/sec/mi²	RECURRENCE INTERVAL (yrs)
50010600	Río Guajataca above Lago de Guajataca	ND	1984-85	05-18-85	12.03	2600	--	ND	6	10.10	1550	ND	ND
50011200	Río Guajataca below Lago de Guajataca	ND	1984-85	09-18-84	9.94	590	--	ND	6	10.40	730	ND	ND
50011400	Río Guajataca above mouth near Quebradillas	ND	1969-70 1984-85	09-19-84	8.10	3090	--	ND	6	7.97[c]	2970	ND	ND
50014800	Rio Camuy near Bayaney	ND	1985	05-18-85	14.42	3510	ND	ND	7	17.70	6490	ND	ND
50015700	Río Camuy near Hatillo	ND	1985	05-18-85	20.67	6250	ND	ND	7	24.81	10500	ND	ND
50027750	Río Grande de Arecibo above Arecibo	140.00	1982-85	05-18-85	18.22	45800	330	ND				ND	
50028000	Río Tanamá near Utuado	18.40	1960-85	05-18-85	17.45	12190	660	50	7	15.69	7840	430	5
50028400	Río Tanamá at Charco Hondo	57.60	1969-71 1983-85	05-18-85	17.95	15000	260	ND	7	17.11[c]	11500	200	ND
50031200	Río Grande de Manatí near Morovis	55.20	1965-85	05-18-85	17.89	48000	870	50	7	13.17[c]	28500	520	12
50035000	Río Grande de Manatí at Ciales	128.00	1960-85	10-09-70	24.00	125000	977	30	7	19.75	75400	590	15
50038100	Río Grande de Manatí at Hwy 2 near Manatí	197.00	1963-85	05-18-85	33.54	136000	690	25	7	33.80	150000[a]	761	30
50038320	Río Cibuco below Corozal	15.10	1970-85	11-07-79	19.80	13600	901	10	7	13.08	4320	290	2
50039500	Río Cibuco at Vega Baja	99.10	1959-85	12-13-81	18.84	30300	306	30	7	17.98	20200	200	15
50043000	Río de la Plata at Proyecto La Plata	54.80	1960-85	08-27-61	32.20	59600	1090	15	6	22.00[c]	28900	530	5
50046000	Río de la Plata at Hwy 2 near Toa Alta	200.00	1960-85	09-06-60	36.35	95500	478	25	7	24.58	75000[a]	375	20
50050900	Río Grande de Loíza at Quebrada Arenas	6.00	1978-85	07-18-79	13.40	8950	1490	20	6	10.03	3870	650	2
50051150	Quebrada Blanca at el Jaqual	3.25	1985	05-17-85	14.58	7400	2280	ND	6	9.24	1500[a]	460	ND
50051180	Quebrada Salvatierra near San Lorenzo	3.74	1985	05-17-85	17.10	9320	2490	ND	6	10.39	1980	530	ND
50051310	Río Cayaguas at Cerro Gordo	10.20	1978-85	08-31-79	9.44	13200	1290	10	6	15.26	3950	390	2
50053050	Río Turabo at Borinquen	7.89	1985	05-17-85	17.06	11600	1470	ND	6	13.27	5120	650	ND
50055000	Rio Grande de Loíza at Caguas	89.80	1960-85	09-06-60	31.17	71500	796	20	6	19.80	22800	250	3
50055650	Quebrada Caimito near Juncos	0.82	1985	05-18-85	12.07	700	850	ND	6	13.37	1000	1220	ND
50056400	Río Valenciano near Juncos	16.40	1972-85	05-18-85	21.30	25700	1570	25	6	11.33	7470	460	2
50056900	Quebrada Mamey near Gurabo	2.30	1985	05-18-85	8.43	1190	520	ND	7	7.66	840	370	ND
50057000	Río Gurabo at Gurabo	60.20	1960-85	09-06-60	27.70	74600	1240	15	6	19.40	19400	320	3
50061800	Río Canóvanas near Campo Rico	9.84	1967-85	12-13-82	13.10	15000	1520	5	6	9.80	6960	710	3
50063440	Quebrada Sonadora near El Verde	1.01	1983-85	12-02-83	8.60	1410	1400	ND	6	7.56	330	330	ND
50063500	Quebrada Toronja at El Verde	0.06	1983-85	07-05-83	1.71	18	281	ND	7	1.60	>10	>170	ND
50063800	Río Espíritu Santo near Río Grande	8.62	1966-85	12-02-83	12.07	12400	1440	10	7	7.59	3490	400	2
50065500	Río Mameyes near Sabana	6.88	1969-73 1983-85	09-04-73	13.02	19800	2880	10	6	8.57	5850	850	2
50067000	Río Sabana at Sabana	3.96	1979-85	04-21-83	19.35	9010	2280	5	6	13.19	2200	560	2
50071000	Río Fajardo near Fajardo	14.90	1961-85	10-24-74	13.62	19600	1320	10	6	10.48	6860	460	2
50075000	Río Icacos near Naguabo	1.26	1945-53 1962-66 1979-85	04-21-83	8.96	2860	2270	75	6	5.18	620	490	2
50092000	Río Grande de Patillas near Patillas	18.30	1966-85	09-16-75	12.45	14800	809	5	6	11.04	5850	320	2
50106500	Río Coamo near Coamo	46.00	1967-68 1970 1984-85	10-09-70	21.40	22000	478	15	7	--	54000	1170	100
50108000	Río Descalabrado near Los Llanos	12.90	1966-69 1984-85	05-21-69	11.50	7000	543	10	7	24.37[c]	18800[a]	1450	100
50111500	Río Jacaguas at Juana Díaz	49.80	1985	05-18-85	18.78	12700	260	ND	7	29.42[c]	37000[a]	740	ND
50112500	Río Inabón at Real Abajo	9.70	1964-85	10-09-70	20.60	5720	540	7	7	--	15000[a]	1550	100
50114000	Río Cerrillos near Ponce	17.80	1964-85	09-16-75	11.20	22400	1260	100	7	20.83	24000[a]	1350	>100
50115000	Río Portugués near Ponce	8.82	1965-85	09-16-75	10.10	13100	1490	25	7	20.20[c]	15500[a]	1760	70
50115900	Río Portugués at Hwy 14 at Ponce	18.60	1963-85	09-16-75	17.38	14500	780	30	7	17.70	>16000	860	35
50124200	Río Guayanilla near Guayanilla	18.90	1981-85	09-12-82	20.40	14700	778	ND	7	19.13[c]	11900	630	ND
50129900	Laguna Cartagena near Boqueron	ND	1984-85	06-11-84	11.04	94	--	ND	7	14.38	7400[a]	ND	ND
50136000	Río Rosario at Rosario	16.40	1975-85	09-16-75	19.60	33800	2060	100	7	10.02	6640	400	2
50138000	Río Guanajibo near Hormigueros	120.00	1973-85	09-16-75	28.50	128000	1070	20	7	28.00[c]	30000[b]	250	5
50144000	Río Grande de Añasco near San Sebastián	134.00	1963-85	09-16-75	33.90	140000	1480	100	7	21.94[c]	53600[a]	400	30
50147800	Río Culebrinas at Hwy 404 near Moca	71.20	1969-85	09-16-75	36.60	69000	969	25	7	26.94	23000	320	5

EXPLANATION

EXPLANATION

a - Estimate based on rating extension
b - Estimate based on poor highwater mark
> - Greater than given value
ND - Not determined
c - High-water mark elevation
e - Estimated, subject to revision.

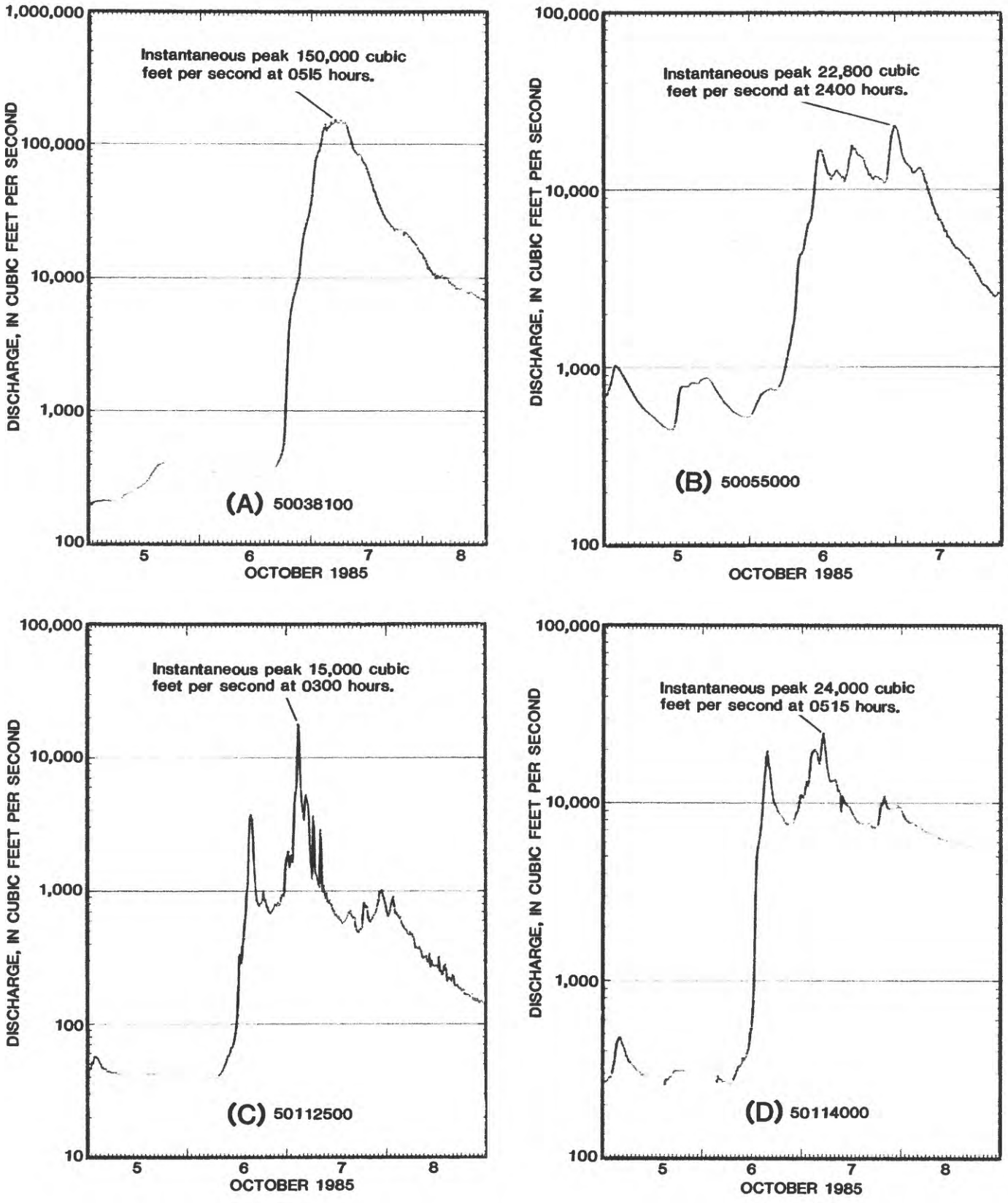
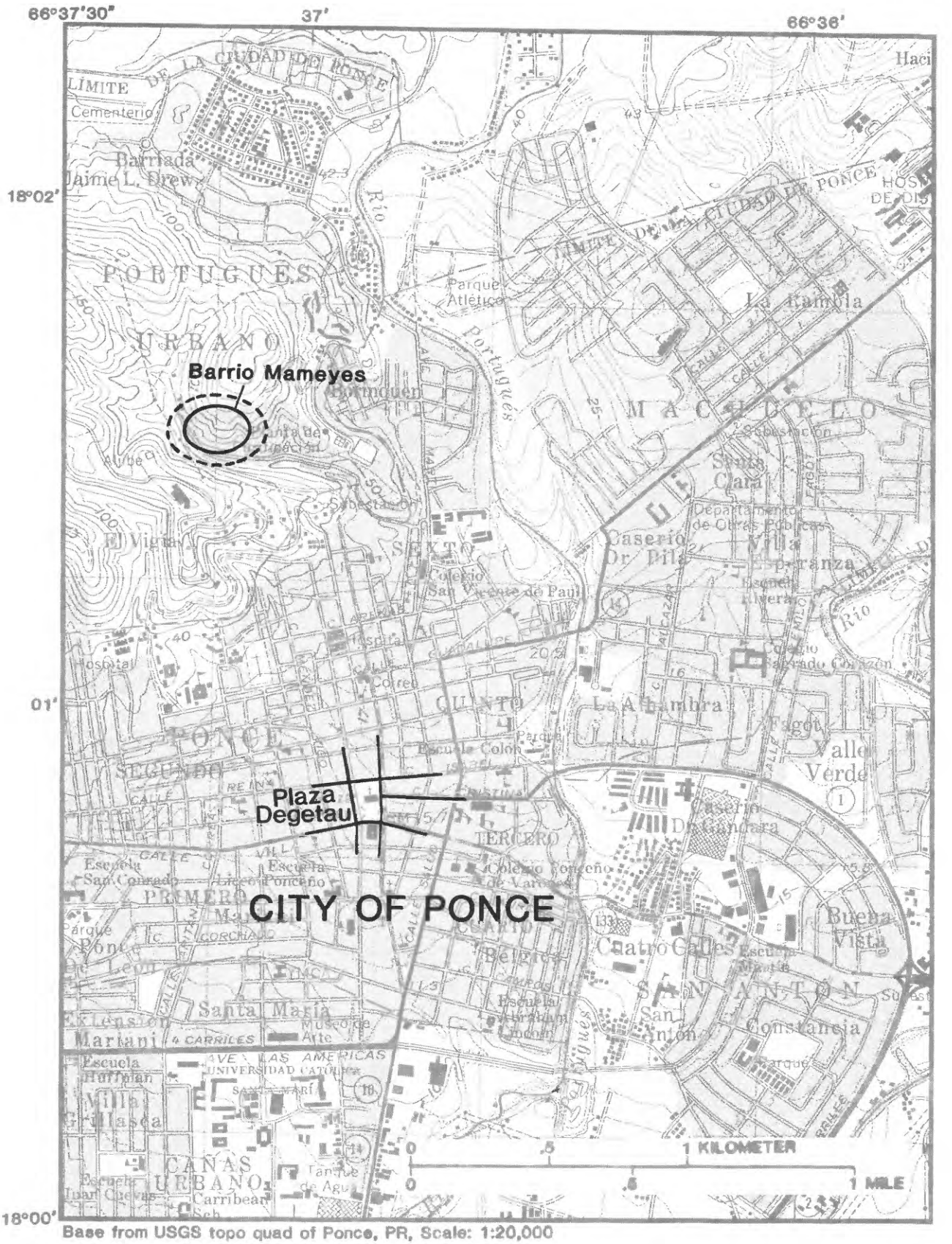


Figure 9.--Discharge hydrographs at key streamflow gaging stations during the October 6-7, 1985 floods at:
(A) Río Grande de Manatí at Highway 2 near Manatí,
(B) Río Grande de Loíza at Caguas,
(C) Río Inabón at Real Abajo, and
(D) Río Cerrillos near Ponce.



Base from USGS topo quad of Ponce, PR, Scale: 1:20,000

Figure 10.--Location of Barrio Mameyes near the city of Ponce in southern Puerto Rico.

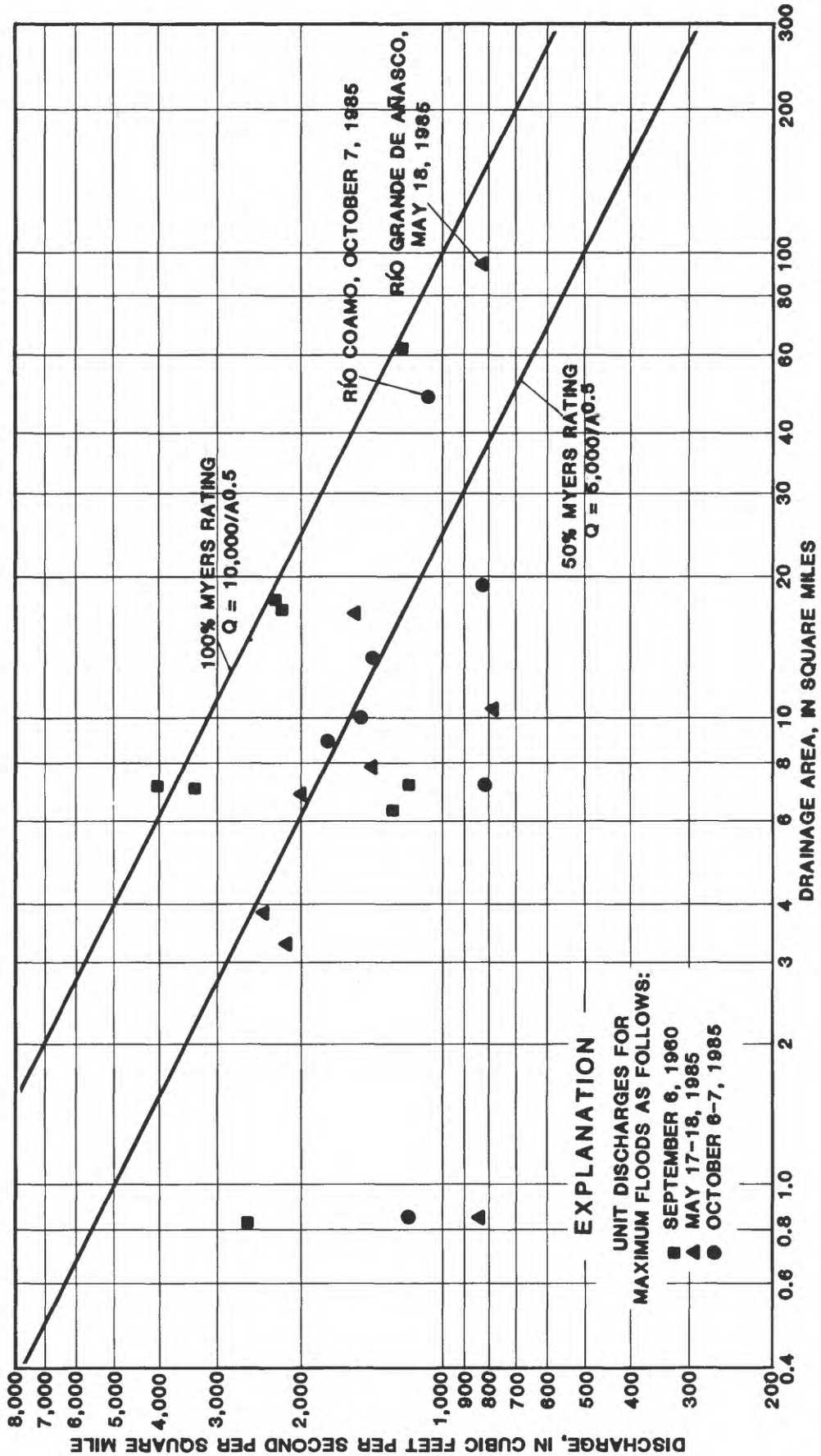


Figure 11.--Comparison of unit discharges during the 1960 and 1985 floods in Puerto Rico.

COMPARISON OF THE 1985 FLOODS WITH HISTORICAL FLOODS (Continued)

The upper line in figure 11 represents the maximum known floods in the world expressed as a correlation between the unit discharge and the drainage area by the equation $Q = 10,000/\sqrt{A}$. This is commonly referred to as the "100 percent Myers rating." The lower line represents the "50 percent Myers rating" expressed by the equation $Q = 5,000/\sqrt{A}$.

The data from the 1985 floods show that the unit discharges were not as high as the 1960 events. At least five (5) events during the 1960 floods approached the 100 percent Myers rating. In general, unit discharges for the 1985 floods were in the vicinity of the 50 percent Myers curve. The only events of the 1985 floods that approached the record 1960 unit discharges occurred at the Río Grande de Añasco near San Sebastián during the May event (table 2) and, the Río Coamo near Coamo during the October event (table 4).

SUMMARY

Puerto Rico was affected by severe floods twice during 1985. During May 15-19, 1985, a low-pressure system that moved from the north resulted in as much as 25 inches of precipitation over the south-central and up to 14 inches over the eastern basins of the island. Flooding was widespread along the mainstem and tributaries of the Río Grande de Arecibo, the Río Grande de Manatí, and the Río de La Plata on the north coast. Urban areas in the towns of Arecibo, Barceloneta, Jayuya, and Utuado were affected by the floods. Less severe flooding occurred at Caguas, Loíza, Dorado, Vega Baja, and Toa Baja. Property losses were estimated at about 37 million dollars.

The second flood event occurred during October 6-7, 1985. A nearly stationary tropical depression, preceded by several days of rainfall, resulted in record precipitation and floods along the south-central and eastern part of Puerto Rico. Precipitation totals were as high as 23 inches during 24 hours. Intensities of 5.5 inches in two hours were recorded near the city of Ponce. Flooding was severe and widespread from Santa Isabel to Ponce. The worst flooding occurred in the Río Coamo basin, but was also significant along the north coast in the towns of Barceloneta, Arecibo, and Toa Baja. Recurrence intervals equal to or greater than 100 years were recorded at several index stations. Property damages were about 125 million dollars.

The rain and floods of October 6-7, 1985 resulted in landslides throughout the affected areas. The worst landslide occurred at Barrio Mameyes, near the city of Ponce. A slab of sandstone with a volume of about 260,000 cubic yards detached from a hill, destroying about 90 homes in the Mameyes community. The death total from the landslide was about 130 people.

The collapse of the approach section of the bridge over the Río Coamo on Las Americas Expressway resulted in the death of 24 people. Flooding at the Quebrada del Agua, west of Ponce, resulted in an additional 16 fatalities.

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Río Grande de Arecibo at Sector Santa Bárbara, near Arecibo, May 19, 1985.

Río Grande de Arecibo at De Diego Expressway bridge in Arecibo, May 19, 1985.

Coamo Dam, downstream side, October 8, 1985.

Lago Coamo at Coamo dam, October 20, 1985.