

# Flood of January 5-6, 1992, in Puerto Rico

By Heriberto Torres-Sierra

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U.S. DEPARTMENT OF THE INTERIOR  
BRUCE BABBITT, Secretary

U.S. GEOLOGICAL SURVEY  
Gordon P. Eaton, Director

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For additional information write to:

District Chief  
U.S. Geological Survey  
GSA Center  
651 Federal Drive, Suite 400-15  
San Juan, Puerto Rico 00965

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## CONVERSION FACTORS

	Multiply	By	To obtain
cubic foot per second ( $\text{ft}^3/\text{s}$ )		0.02832	cubic meter per second
cubic foot per second per square mile [ $(\text{ft}^3/\text{s})/\text{mi}^2$ ]		0.01093	cubic meter per second per square kilometer
foot		0.3048	meter
inch		25.4	millimeter
mile		1.609	kilometer
square mile ( $\text{mi}^2$ )		2.590	square kilometer

### Specific Combinations

$$1 \text{ ft}^3/\text{s} = 448.8 \text{ gal/min}$$

$$1 \text{ ft}^3/\text{s} = 0.6463 \text{ Mgal/d}$$

# Flood of January 5-6, 1992, in Puerto Rico

By Heriberto Torres-Sierra

## ABSTRACT

Severe flooding affected at least 40 municipalities in Puerto Rico during January 5-6, 1992. A combined weather system, consisting of a cold front and an upper level trough, produced 24-hour total rainfall of as much as 20 inches on the island's mountainous interior. Rainfall intensities for 1-, 2-, 3-, and 6-hour durations exceeded previously recorded islandwide maximum values.

The most severe flooding occurred in areas along the Río de La Plata (at the towns of Cayey, Comerío, Toa Baja, and Dorado) and the Río Grande de Patillas (at the town of Patillas). Significant flooding also occurred at Salinas and Ponce. Flood discharges on the Río de La Plata and the Río Grande de Patillas were the largest on record. The unit discharge for these two rivers are among the largest in the world.

The damage caused by the flood of January 5-6 was estimated at more than \$150 million. There were 23 lives lost, 167 persons injured, and 17 hospitalized. About 550 persons were forced from their homes by the flood, 78 houses were destroyed, and about 4,200 others were damaged.

## INTRODUCTION

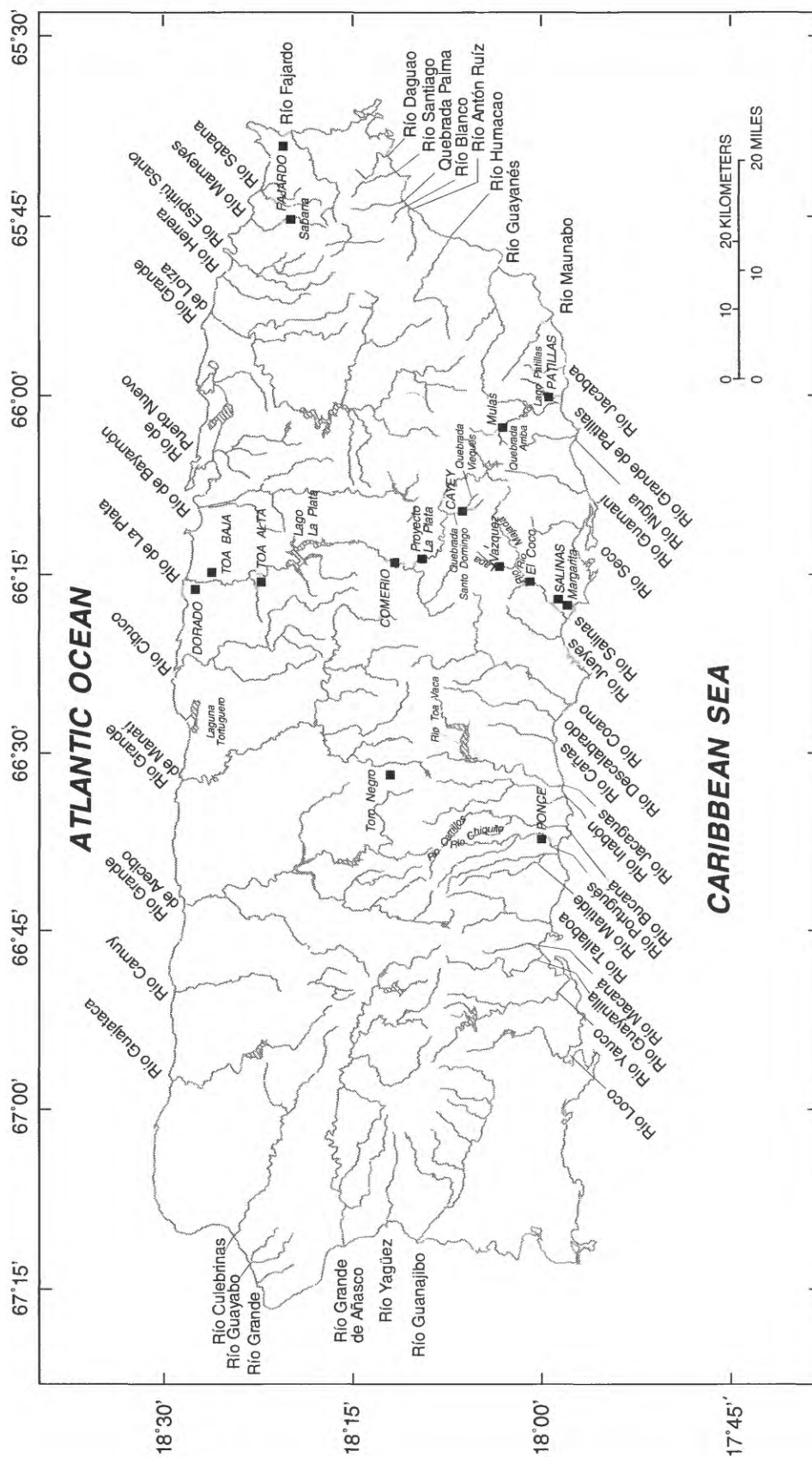
During January 5-6, 1992, most of the mountainous interior and several areas along the northern, eastern, and south coasts of Puerto Rico experienced moderate to severe floods (fig. 1). More than half of the island's towns were affected (40 municipalities). This flood was produced by intense rainfall generated by the unusual combination of a cold front and an upper level pressure trough. As much as 20 inches of rain fell on the interior of Puerto Rico. Damage to houses, businesses, farmlands,

livestock, highways, bridges, and other public and private properties were in excess of \$150 million.

The U.S. Geological Survey collected and analyzed data on the magnitude and frequency of peak discharge recorded at streamflow-gaging stations throughout Puerto Rico. At gaging stations, where recording instruments failed or were damaged during the flood, high-water marks were surveyed soon after the event to determine the peak stage and discharge. Peak discharges at the Río de La Plata at Proyecto La Plata and at the Río Grande de Patillas near Patillas were estimated using indirect-discharge measurement techniques.

This report was prepared by the U.S. Geological Survey, Caribbean District, with funding from the agency's Office of Surface Water. The report provides a general description of the storm and flood, flood damage, and peak stages and discharges for the January 5-6, 1992, flood and for previous maximum floods at selected gaging stations.

Information related to rainfall quantities and intensities throughout the island was provided by the National Weather Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce. The Federal Emergency Management Administration, the Puerto Rico Department of Agriculture, and the Puerto Rico Department of Transportation and Public Works provided information on damage caused by the rain, floods, and landslides. The information presented in this report can be of value and interest to engineers, developers, planners, and government officials.



## DESCRIPTION OF STORM

On Saturday, January 4, 1992, an extensive area of low pressure at the surface and aloft was located off the eastern coast of the United States. An associated cold front extended from the Bahamas southwest to Hispaniola. At 8:00 a.m., Sunday, January 5, the front was positioned northeast to southwest across the Dominican Republic. As the day progressed, convective activity ahead of the cold front became more intense. By 2:00 p.m., a surface pressure trough had developed over Puerto Rico ahead of the nearly stationary cold front. A weak surface low pressure system also developed near the Gulf of Venezuela reinforcing the moist southwest airflow (fig. 2).

By 4:00 p.m., the unusual combination of all these rain-producing weather systems began to produce nearly stationary thunderstorms and heavy rains on the mountainous interior of Puerto Rico. By Sunday evening, the showers and isolated thunderstorms had spread over the island. Strong thunderstorm activity and heavy rains continued throughout Sunday night and into the early morning hours of Monday, January 6. By 8:00 a.m., Monday, the stationary cold front remained over Hispaniola. The surface trough ahead of the cold front, and the weak low pressure system to the southwest of Puerto Rico had dissipated. Although scattered showers and thunderstorms persisted, the heavy rains had diminished.

General rainfall totals ranged from about 2 inches in the northern part of Puerto Rico to 20 inches in the interior of the island (fig. 3). The largest 24-hour rainfall total recorded was 20.3 inches at Toro Negro (table 1; fig. 4). As much as 19.6 inches of rain fell in Cayey, exceeding the previous 24-hour record of 12.8 inches on August 30, 1979. Rainfall intensities for 1-, 2-, 3-, and 6-hour durations of 5.9, 8.4, 11.2, and 18.4 inches exceeded previous islandwide maximums of 4.3, 6.7, 7.8, and 10.4 inches, respectively.

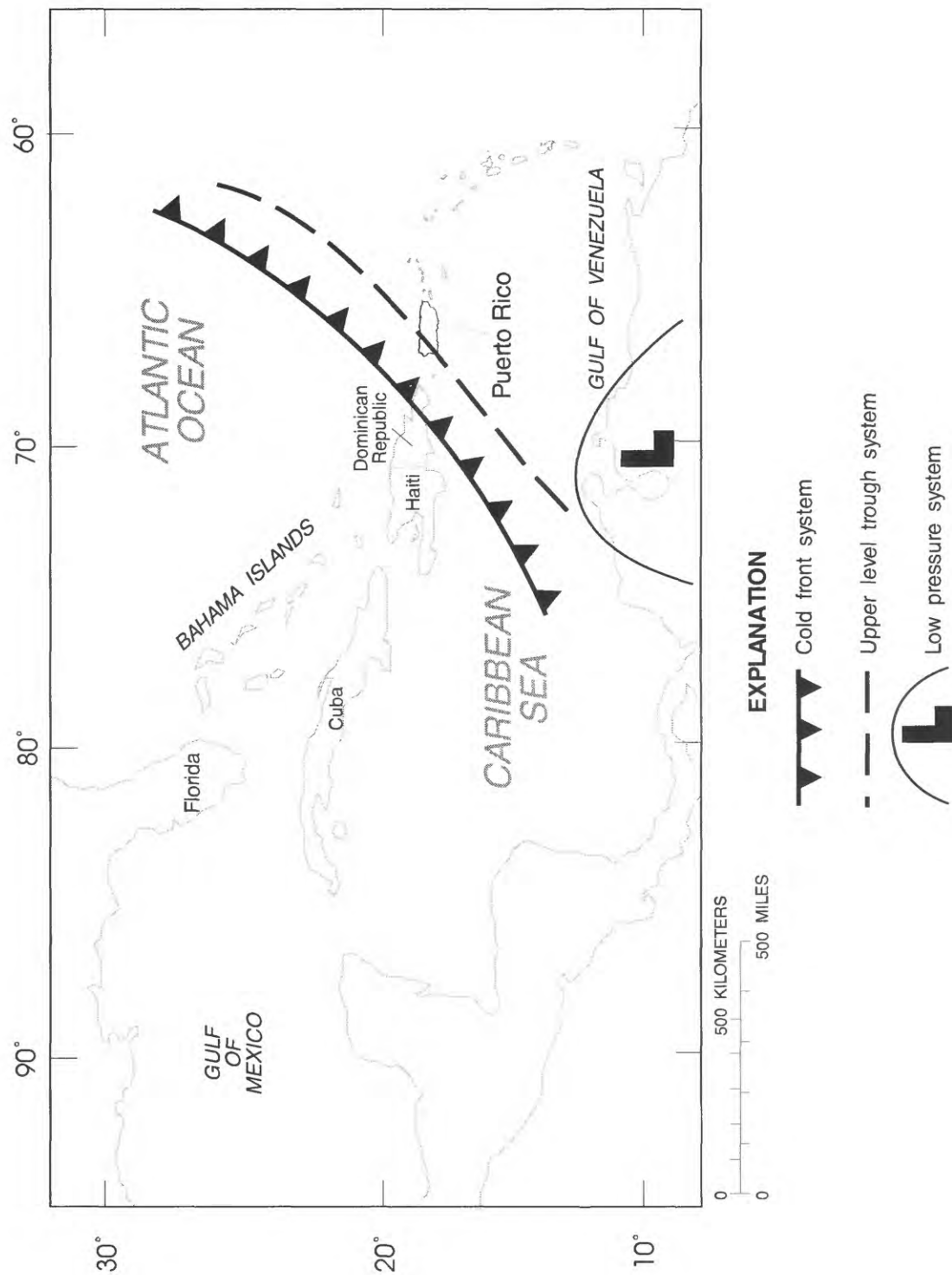
## DESCRIPTION OF FLOOD

During January 5-6, 1992, at least 40 of the 78 municipalities in Puerto Rico were affected by the worst flooding since the October 7, 1985, flood. Floodwaters inundated downtown areas and neighborhoods, washing away homes, businesses, vehicles, bridges, and portions of roads. Twenty persons drowned as floodwaters swept away their vehicles and they attempted to cross flooded bridges and roads. The most affected municipalities were Patillas, Cayey, Comerío, Toa Baja, Dorado, Salinas, and Ponce. Many landslides occurred on the slopes of the island's mountainous interior. About 15 main thoroughfares were obstructed or destroyed by floodwaters and landslides.

At Patillas, the floodwaters of the Río Grande de Patillas and tributaries destroyed 15 houses and severely damaged another 141 houses. Most of these houses were affected by the Quebrada Arriba, a major tributary of the Río Grande de Patillas upstream of the Lago Patillas. The residents of Barrio Mulas were isolated when the Río Grande de Patillas destroyed the bridge on Highway 754. The gaging station on the Río Grande de Patillas was extensively damaged. Several older citizens living along the Quebrada Arriba and the Río Grande de Patillas indicated that this flood was the greatest they had ever experienced.

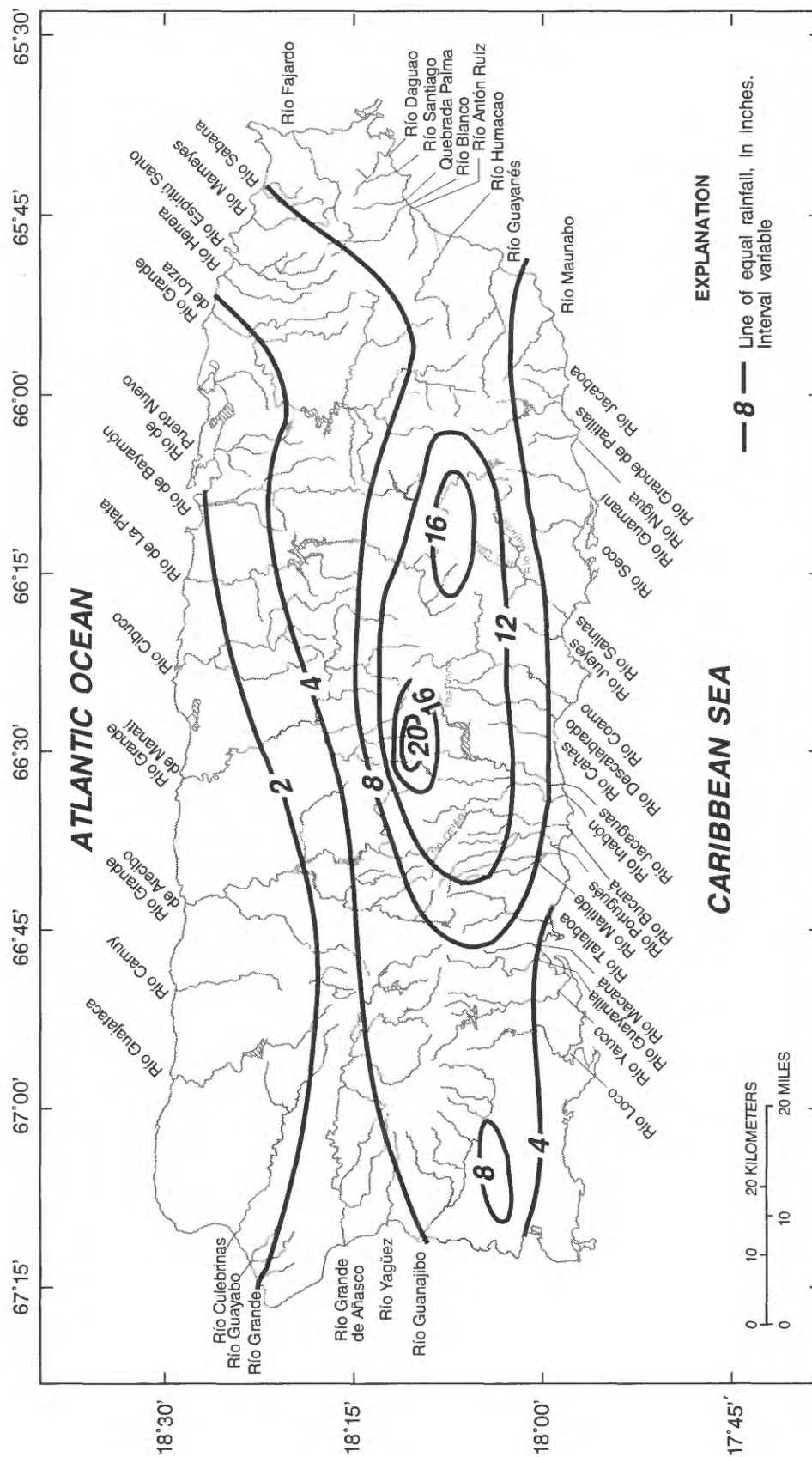
Floods along the Río de La Plata and upper reach tributaries were particularly noteworthy. At Cayey, the Quebrada Santo Domingo and the Quebrada Vieques rose quickly, flooding homes and businesses in downtown Cayey. Floodwaters washed away 10 municipal vehicles, including three new garbage trucks worth \$55,000 each. At the Proyecto La Plata gaging station, the river crested at a stage of 36.39 feet, exceeding the previous maximum of record by 4 feet. The bridge on Highway 173, downstream of the gaging station, was washed away by the floodwaters. The Río de La Plata flooded homes and businesses in the Comerío downtown area and partially destroyed the bridge on Highway 775, a newly built sewage pipeline, and the gaging station in Comerío.





**Figure 2.** Location of the weather systems which produced intense rain over Puerto Rico during the evening of January 5, 1992.





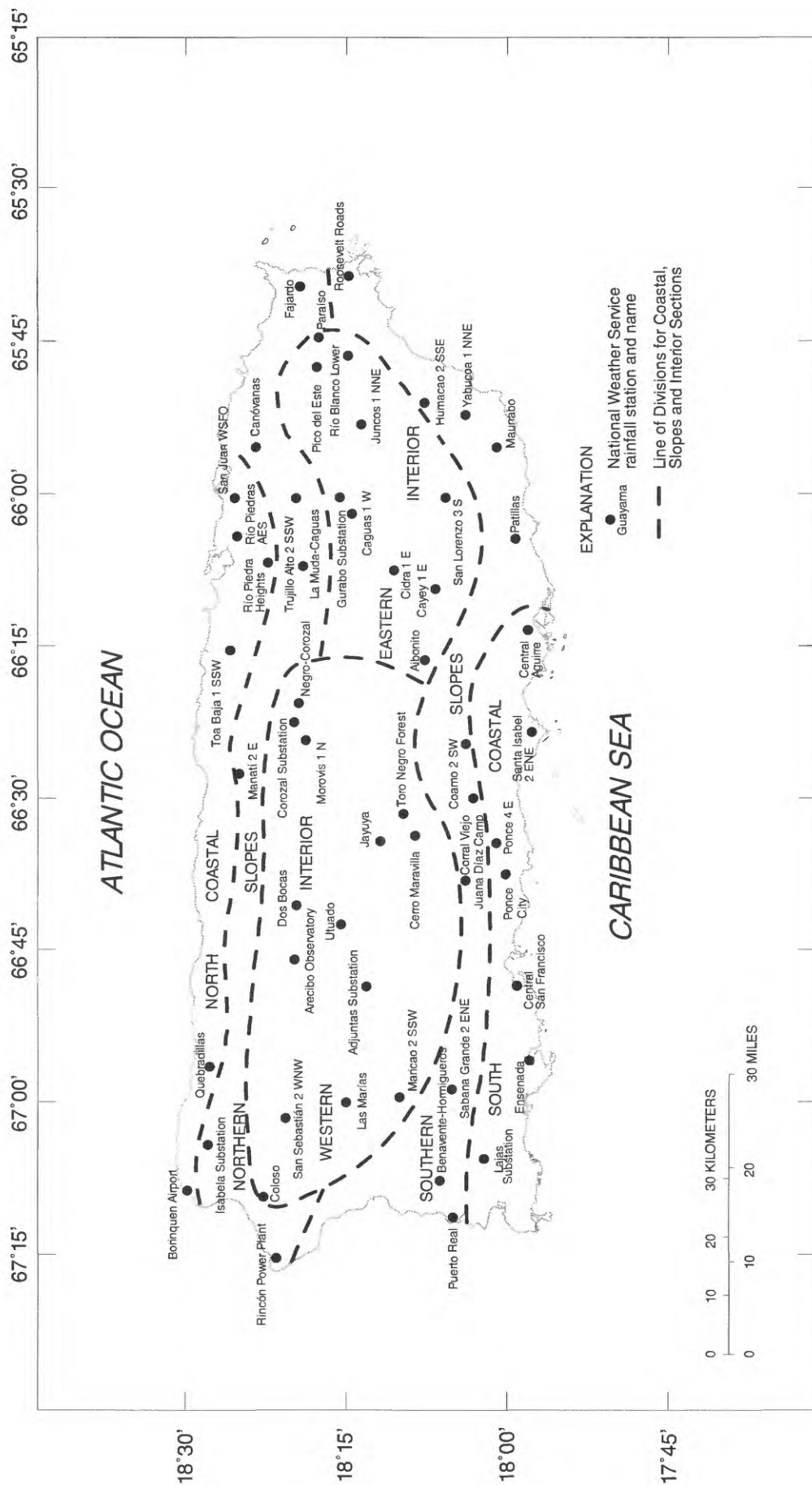
**Figure 3.** Cumulative rainfall over Puerto Rico during January 5-6, 1992 (Source: Rainfall data compiled by National Weather Service).

**Table 1.** Daily rainfall, in inches, for January 5-6, 1992, at selected National Weather Service stations throughout Puerto Rico (National Oceanic and Atmospheric Administration, 1992)

[--, daily rainfall value not available]

Climatic subdivision and station name	January 5	January 6	Total	Climatic subdivision and station name	January 5	January 6	Total
<u>WESTERN INTERIOR</u>				<u>SOUTHERN SLOPES</u>			
Adjuntas Substation	0.31	6.63	6.94	Benavente-Hormigueros	0.00	3.05	3.05
Arecibo Observatory	0.00	1.70	1.70	Coamo 2 SW	0.00	9.00	9.00
Cerro Maravilla	2.00	12.00	14.00	Corral Viejo	0.32	12.15	12.47
Coloso	0.00	1.40	1.40	Guayama	0.00	4.82	4.82
Corozal Substation	0.00	6.10	6.10	Humacao 2 SSE	0.00	12.00	12.00
Dos Bocas	0.00	1.22	1.22	Juana Díaz Camp	0.00	10.15	10.15
Jayuya	0.14	7.20	7.34	Maunabo	0.00	7.60	7.60
Las Marías	0.02	1.14	1.16	Patillas	0.00	2.10	2.10
Maricao 2 SSW	--	--	6.40	Puerto Real	0.00	4.80	4.80
Morovis 1 N	0.00	2.96	2.96	Roosevelt Roads	4.65	1.64	6.29
Negro-Corozal	0.00	8.00	8.00	Sabana Grande 2 ENE	0.00	5.00	5.00
San Sebastián 2 WNW	0.00	1.37	1.37	Yabucoa 1 NNE	0.00	10.90	10.90
Toro Negro Forest	0.75	20.30	21.05				
Utüado	0.00	3.55	3.55				
				<u>NORTH COAST</u>			
<u>EASTERN INTERIOR</u>				Borinquen Airport	0.00	0.40	0.40
Aibonito	0.30	5.00	5.30	Quebradillas	--	--	3.66
Caguas 1 W	0.05	6.95	7.00	Río Piedras AES	0.05	2.00	2.05
Cayey 1 E	0.10	19.56	19.66	Río Piedras Heights	0.00	4.60	4.60
Cidra 1 E	0.05	10.36	10.41	San Juan WSFO	0.00	2.24	2.24
Gurabo Substation	0.07	7.11	7.18	Toa Baja 1 SSW	0.00	3.30	3.30
Juncos 1 NNE	0.00	6.57	6.57				
Paraiso	0.40	8.20	8.60	<u>SOUTH COAST</u>			
Pico del Este	1.60	10.10	11.70	Central Aguirre	0.00	2.05	2.05
Río Blanco Lower	5.14	2.11	7.25	Central San Francisco	0.02	2.92	2.94
San Lorenzo 3 S	0.54	5.60	6.14	Ensenada	0.05	4.16	4.21
<u>NORTHERN SLOPES</u>				Lajas Substation	0.01	10.00	10.01
Canóvanas	0.15	4.95	5.10	Ponce 4 E	0.20	8.30	8.50
Fajardo	0.00	8.00	8.00	Ponce City	1.66	5.49	7.15
Isabela Substation	0.02	1.92	1.94	Santa Isabel 2 ENE	0.00	5.00	5.00
La Muda-Caguas	0.00	4.93	4.93				
Manatí 2 E	0.00	1.43	1.43				
Rincón Power Plant	--	--	2.25				
Trujillo Alto 2 SSW	0.05	4.01	4.06				

Note: Data are reported for 24-hour periods starting at 8:00 a.m. of one day and ending at 8:00 a.m. of the next day.



**Figure 4.** Location of selected National Weather Service rainfall stations that recorded rainfall data during January 5-6, 1992.

Farther downstream at the La Plata Dam, the water level increased 19 feet in 6 hours. The gaging station at Highway 2 had a peak discharge of 110,000 cubic feet per second (ft<sup>3</sup>/s), which exceeded the previous maximum of record, 95,000 ft<sup>3</sup>/s, produced during the flood of September 6, 1960 (Barnes and Bogart, 1961). Downtown Toa Baja and nearby low-lying areas were hard hit by the floodwaters of the Río de La Plata. In many homes, the floodwaters reached a depth of 7 feet. Water hyacinths carried from the Lago La Plata by the Río de La Plata proved to be a menace to bridges and culverts. At Dorado, water hyacinths and bamboo blocked the opening of the bridge on Highway 693, forcing floodwaters over and around the bridge, resulting in severe damage to the bridge deck, abutments, and piers.

On the southern coast, the towns of Salinas and Ponce were the most affected by the January 5-6, 1992, flood. At Salinas, the Río Lapa flooded the rural area of Vázquez, and the Río Nigua flooded the communities of El Coco and Margarita, destroying a bridge and 10 houses, and damaging 164 other houses. At Ponce, an extensive area near the confluence of the Río Chiquito and the Río Portugués was inundated from the floodwaters.

The northeastern area of Puerto Rico also experienced notable floods when the Río Sabana and the Río Fajardo overflowed their banks. At the gaging station on the Río Sabana at Sabana, the peak stage exceeded the previous maximum of record (19.35 feet) by 0.39 feet, while at the Río Fajardo near Fajardo gaging station the peak stage almost equalled the maximum of record (20.00 feet). The Río Fajardo gage house was washed away during the flood and found about 2 miles downstream.

## **FLOOD DAMAGE**

The rain, floods, and landslides caused extensive damage to private and public property. Total damages were estimated at \$155 million by the Federal Emergency Management Administration. The flood of January 5-6, 1992, resulted in 23 deaths, 20 of which involved motor vehicles. There were also 167 persons injured; 17 requiring hospitalization.

Emergency housing, medical attention, food, and clothing were provided for thousands of people as 78 houses were destroyed and 4,241 others damaged. Damage to homes, including those destroyed, was estimated at \$20.5 million. As a result of the flooding, about 550 persons were left homeless. Damage to businesses was estimated at \$11.5 million. This damage occurred mostly in the towns of Toa Baja, Cayey, and Patillas.

The Puerto Rico Department of Agriculture reported considerable damage to farmland, with losses of approximately \$5.0 million. The damage to vegetable crops alone was \$1.6 million. The plantain and banana crops suffered a loss of \$0.5 million. Damage to the agricultural infrastructure in Puerto Rico was about \$1.0 million.

Public facilities, roads, and bridges sustained more than \$24 million of damage. At least 5 bridges were destroyed and 20 were damaged. Many water filtration plants, sewage treatment plants, pumping stations, and aqueduct systems were severely damaged.

## **SUMMARY OF FLOOD STAGES AND DISCHARGES**

During the January 5-6, 1992 flood, the U.S. Geological Survey collected peak stage and discharge information from gaging stations throughout Puerto Rico. High-water marks were surveyed shortly after the event to determine the peak stages and discharges at sites where recording instruments failed or were damaged during the flood. The gaging stations on the Río Grande de Patillas near Patillas and on the Río Fajardo near Fajardo were washed away by the floodwaters. Twelve others were rendered inoperable, because of the accumulation of heavy debris and partial washouts. Indirect discharge measurements were made to calculate the peak discharges at the Río de La Plata at Proyecto La Plata and at the Río Grande de Patillas near Patillas, where the historical maximum stages and discharges were exceeded considerably.

Hydrologic information indicates that floods of moderate to severe intensity occurred in the basins of the Río de La Plata, the Río Grande de Loíza, the Río Sabana, the Río Fajardo, the Río Grande de Patillas, the Río Lapa, the Río Majada, the Río Toa Vaca, and the Río Cerrillos (fig. 5). Flood stages, discharges, recurrence intervals, and other information pertinent to selected gaging stations within these basins are summarized in table 2. For purposes of comparison, the table also includes the recorded stage, discharge, and recurrence interval of the highest recorded peak discharges prior to January 5-6, 1992.

Recurrence intervals for peak discharges at gaging stations that have more than 10 years of record were determined by using the methods recommended by the U.S. Interagency Advisory Committee on Water Data (1982). Recurrence intervals for peak discharges at gaging stations with less than 10-years of record were estimated using the regional regression analysis for ungaged sites in Puerto Rico described in López and others (1979). This analysis, based mainly on the drainage area and mean annual precipitation of the basin, was used to compute the peak discharges for floods of 2-, 10-, 25-, 50-, and 100-year recurrence intervals.

Peak discharges were exceeded at 18 gaging stations, and 11 streams had maximum flows in excess of 1,000 cubic feet per second per square mile ( $\text{ft}^3/\text{s}/\text{mi}^2$ ). The largest flows during the flood were registered at the gaging stations along the Río de La Plata. The Río de La Plata at Comerío (site 3) had a peak discharge of 127,000  $\text{ft}^3/\text{s}$  [ $1,170 (\text{ft}^3/\text{s})/\text{mi}^2$ ], the Río de La Plata below La Plata Dam (site 5) had a peak discharge of 127,000  $\text{ft}^3/\text{s}$  [ $734 (\text{ft}^3/\text{s})/\text{mi}^2$ ], and the Río de La Plata at Highway 2 near Toa Alta (site 6) had a peak discharge of 118,000  $\text{ft}^3/\text{s}$  [ $590 (\text{ft}^3/\text{s})/\text{mi}^2$ ]. The station with the largest flow per square mile during the flood was the Río Grande de Loíza at Quebrada Arenas (site 7) with 3,030  $\text{ft}^3/\text{s}/\text{mi}^2$  (18,200  $\text{ft}^3/\text{s}$ ). Discharge hydrographs for selected gaging stations are shown in figure 6.

The relation of unit-peak discharge, in cubic feet per second per square mile, to the size of drainage area, in square miles, at selected gaging sites for the January 5-6,

1992, flood is shown in figure 7. The lines shown in the figure are expressions of the Myers formula,

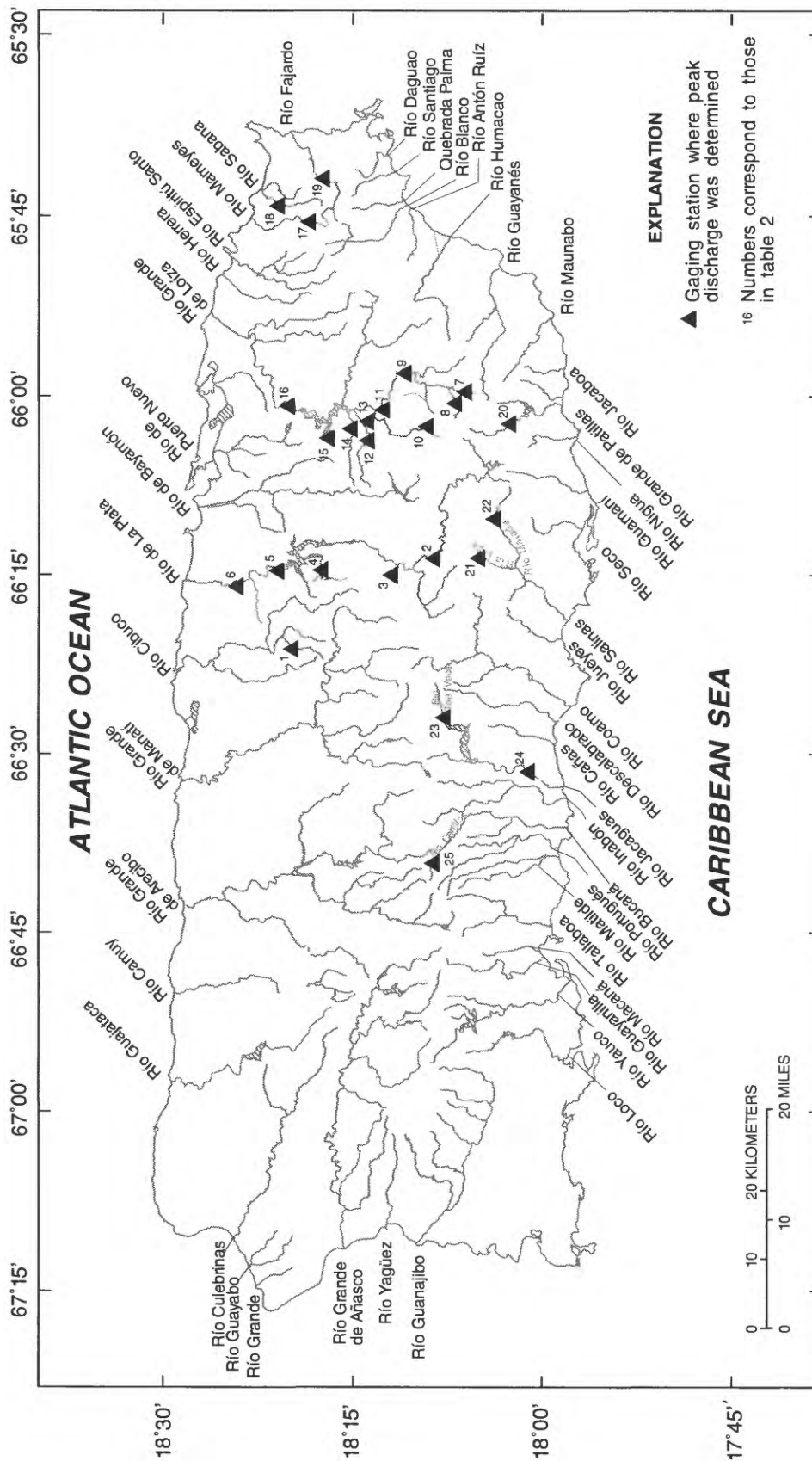
$$Q = C/A^{0.5}$$

where  $Q$  = discharge ( $\text{ft}^3/\text{s}$ )  
 $C$  = constant,  
 and  $A$  = drainage area ( $\text{mi}^2$ ).

The Myers scale is a method for comparing peak discharges from different drainage basins and from flood to flood in the same basin. In the Myers 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. The upper line in figure 7 represents an approximation of the maximum known floods in the world expressed as a correlation between the unit discharge and the drainage area by the equation  $Q = 10,000/A^{0.5}$ . This is commonly referred to as the "100 percent Myers rating." The line labeled  $Q = 8,000/A^{0.5}$  is 80 percent on the Myers scale and also indicates an extremely high ratio of discharge to drainage area. The lower line represents the "50 percent Myers rating" expressed by the equation  $Q = 5,000/A^{0.5}$ . The lines provide a basis for estimating the possible range of peak discharges for a basin, but do not indicate the frequency of such peaks.

During the flood of January 5-6, 1992, the discharge at five of the measured sites had a Myers rating in excess of 80 percent; the discharge at two of these exceeded 100 percent. The peak discharge for these five streams, when compared with peak discharge of streams of the same size in other parts of the world, rank among the highest known. However, a Myers rating of 80 percent or above is not extremely rare in Puerto Rico. For the flood of September 6, 1960, peak discharges occurred at nine sites in Puerto Rico with a Myers rating in excess of 80 percent, the Myers rating exceeded 100 percent at four sites (Barnes and Bogart, 1961). During the flood of October 5-10, 1970, the 80 percent Myers rating was exceeded at four sites, and the 100 percent Myers rating was exceeded at two sites (Haire, 1972). Data from the 1985 floods indicate that the peak discharge for two streams exceeded the 80 percent Myers rating (Quiñones and Johnson, 1987).





**Figure 5.** Location of selected gaging stations that collected flood data in the most affected areas during the January 5-6, 1992, flood.

**Table 2.** Summary of peak stages and discharges prior to and during January 5-6, 1992, at selected U.S. Geological Survey streamflow-gaging stations in Puerto Rico

[mi<sup>2</sup>, square miles; ft, feet above an arbitrary datum; ft<sup>3</sup>/s, cubic feet per second; --, not determined; <, less than; >, greater than]

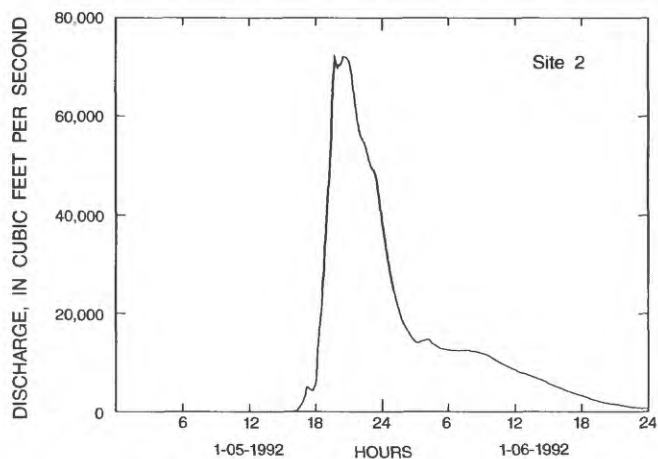
Site no. (fig. 5-7)	Station number	Station name	Drainage area (mi <sup>2</sup> )	Period of record	Previous maximum discharge			Flood of January 1992			
					Date	Peak stage (ft)	Maximum discharge (ft <sup>3</sup> /s)	Day	Peak stage (ft)	Peak discharge (ft <sup>3</sup> /s)	Recurrence interval (years)
1	50038320	Río Cibuco below Corozal	15.1	1970-92	11/07/79	19.80	13,600	5	19.32	11,900	6
2	50043000	Río de La Plata at Proyecto La Plata	54.8	1960-92	08/27/61	32.20	59,600	5	36.39	73,600	40
3	50043800	Río de La Plata at Comerío	109	1988-92	09/18/89	17.36	32,000	5	29.22	127,000	80
4	50044830	Río Guadiana at Guadiana	9.19	1990-92	02/05/91	11.54	4,600	5	13.36	6,670	10
5	50045010	Río de La Plata below La Plata Dam	173	1989-92	09/18/89	22.98	48,800	5	34.76	127,000	25
6	50046000	Río de La Plata at Highway 2 near Toa Alta	208	1960-92	09/06/60	136.35	95,500	5	26.39	118,000	25
7	50050900	Río Grande de Loíza at Quebrada Arenas	6.00	1978-92	11/05/83	14.78	11,700	5	17.52	18,200	60
8	50051150	Quebrada Blanca at El Jagual	3.25	1985-92	05/17/85	14.58	7,400	5	14.30	7,180	12
9	50051800	Río Grande de Loíza at Highway 183 near San Lorenzo	25.0	1990-92	10/20/90	16.60	7,510	5	31.37	40,700	70
10	50053025	Río Turabo above Borinquen	7.14	1990-92	10/21/90	--	22,400	5	21.07	12,000	35
11	50055000	Río Grande de Loíza at Caguas	89.8	1960-92	09/06/60	31.17	71,500	5	24.20	42,800	6
12	50055100	Río Cagüitas near Aguas Buenas	5.30	1990-92	10/15/90	15.24	1,460	5	15.96	1,770	5
13	50055225	Río Cagüitas at Villa Blanca at Caguas	16.9	1991-92	07/16/91	13.16	2,060	5	19.87	13,300	20
14	50055390	Río Bairoa at Bairoa	5.08	1991-92	07/16/91	10.24	742	5	12.32	1,580	4
15	50058350	Río Cañas at Río Cañas	7.53	1990-92	10/17/90	20.55	3,830	5	20.15	3,580	7
16	50059050	Río Grande de Loíza below Damsite	209	1987-92	11/27/87	39.57	124,300	5	33.79	79,500	7
17	50065500	Río Mameyes near Sabana	6.88	1969-73 1983-92	09/18/89	13.19	20,500	5	10.27	10,300	2
18	50067000	Río Sabana at Sabana	3.96	1980-92	04/21/83	19.35	9,010	5	19.74	9,600	13
19	50071000	Río Fajardo near Fajardo	14.9	1962-92	09/18/89	20.00	23,500	5	19.88	23,300	15
20	50092000	Río Grande de Patillas near Patillas	18.3	1966-92	09/16/75	12.45	14,800	5	--	30,900	>100
21	50100200	Río Lapa near Rabo del Buey	9.92	1989-92	10/20/90	10.23	1,750	5	17.82	15,700	60
22	50100450	Río Majada at La Plena	16.7	1989-92	10/25/90	10.34	3,820	5	17.19	15,200	15
23	50110900	Río Toa Vaca above Lago Toa Vaca	7.64	1989-92	08/24/89	9.62	3,740	5	13.24	8,700	25
24	50111500	Río Jacaguas at Juana Díaz	49.8	1984-92	10/07/85	29.42	40,000	5	22.81	20,700	4
25	50113800	Río Cerrillos above Lago Cerrillos near Ponce	15.4	1989-92	09/25/90	--	32,500	5	9.64	8,100	4

<sup>1</sup> Gage at different site and datum.

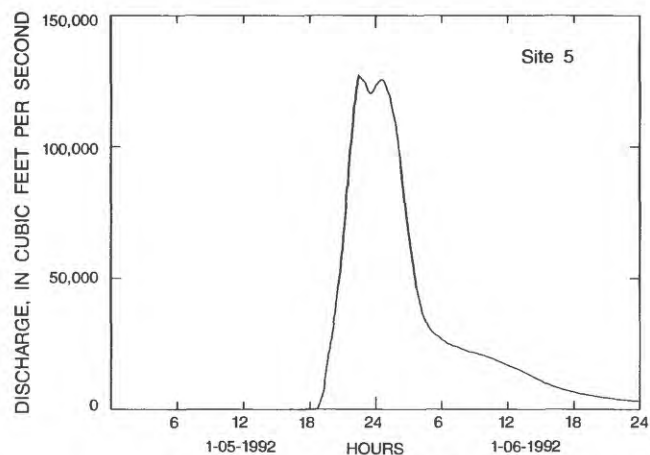
<sup>2</sup> Discharge estimate based on a daily mean discharge correlation with the Río Grande de Loíza at Caguas gaging station (station 50055000).

<sup>3</sup> Discharge estimate based on a daily mean discharge correlation with the Río Portugues near Ponce gaging station (station 50115000).

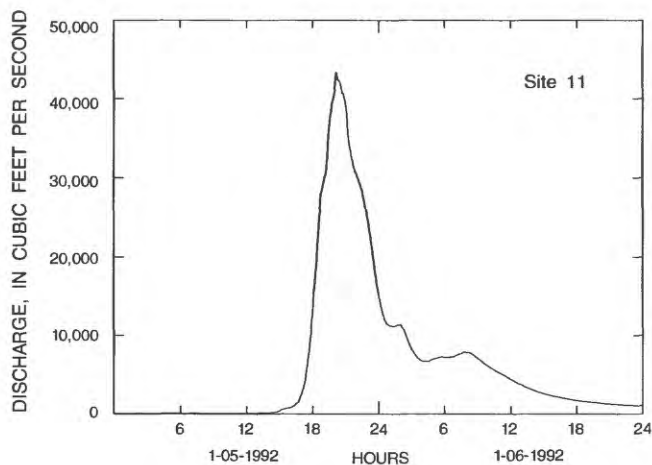




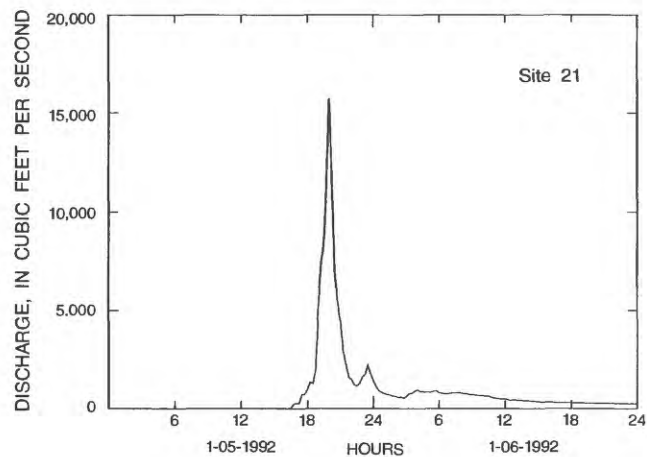
50043000 RÍO DE LA PLATA AT PROYECTO LA PLATA,  
PUERTO RICO



50045010 RÍO DE LA PLATA BELOW LA PLATA DAM,  
PUERTO RICO

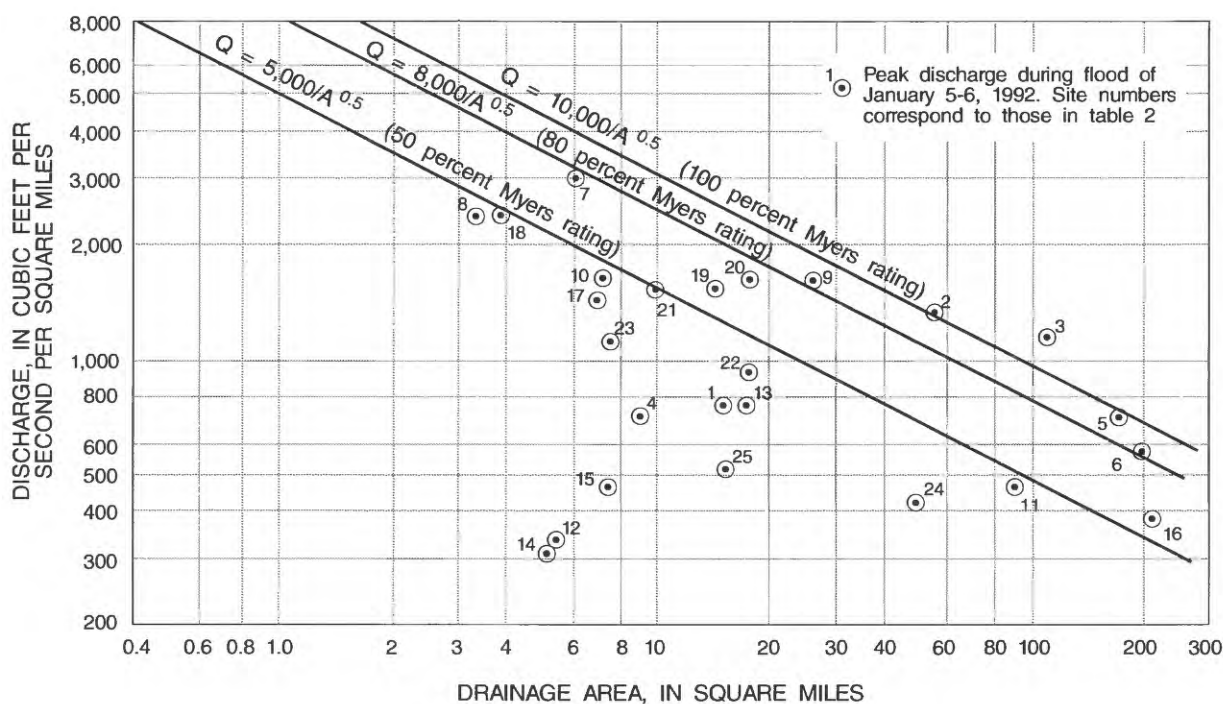


50055000 RÍO GRANDE DE LOÍZA AT CAGUAS,  
PUERTO RICO



50100200 RÍO LAPA NEAR RABO DEL BUEY,  
PUERTO RICO

**Figure 6.** Discharge hydrographs at selected streamflow-gaging stations during the January 5-6, 1992, flood.



**Figure 7.** Relation of unit peak discharge (Q) to size of drainage area (A) at selected gaging stations for the January 5-6, 1992, flood in Puerto Rico.

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