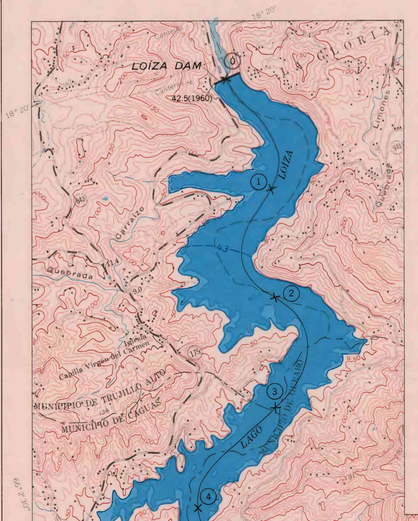
PREPARED IN COOPERATION WITH THE
COMMONWEALTH OF PUERTO RICO
DEPARTMENT OF PUBLIC WORKS



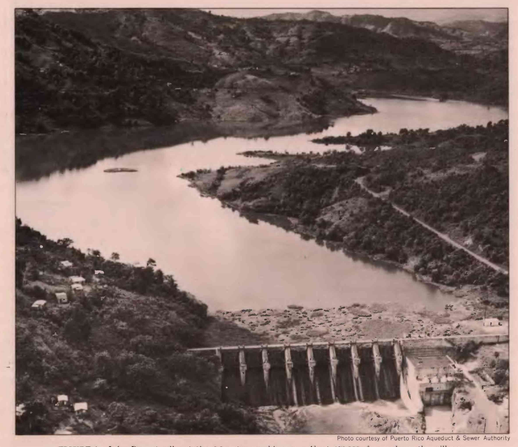


Photo courtesy of Puerto Rico Aqueduct & Sewer Authority

FIGURE 3.—*Loiza Dam at valley station 0.0 on topographic map. About 170,000 cfs passed over the spillway at the peak of the flood of September 6, 1960.*

FLOODS AT CAGUAS, GURABO, JUNCOS, AND SAN LORENZO, PUERTO RICO

This report provides hydrologic information on major floods in the upper and middle reaches of the Río Grande de Loíza basin. The information can be used by the planner, designer, or any other interested person to help reach rational decisions related to land use in the flood plains. Among the data presented are tabulations of flood discharge and flood stage, flood profiles, and a map of the area inundated by the flood of September 6, 1960. The area of inundation and flood profiles are specifically for valley conditions that existed at the time of the floods. Stage and discharge frequency curves also are presented, from which the magnitude of future floods of selected recurrence intervals can be estimated.

This study is based partly upon information collected in interviews with residents in the study area. All elevations are in meters above mean sea level datum. All discharges are in cubic feet per second (cfs).

Drainage basin.—The Río Grande de Loíza basin, the largest basin in Puerto Rico, lies in the central part of eastern Puerto Rico (fig. 1). Río Grande de Loíza flows northward from Sierra de Cayey, part of Cordillera Central, and empties into Océano Atlántico. The drainage area at the mouth is about 310 sq mi (square miles). At Loíza Dam, which marks the northern limit of the floods study, the drainage area is 207 sq mi; whereas at the U.S. Geological Survey gaging station on old Highway 30 at Caguas (shown in fig. 2) the drainage area is about 90 sq mi.

Río Grande de Loíza has three principal tributaries: Río Turabo, Río Cagüitas, and Río Gurabo. Of these Río Gurabo is the largest, with a drainage area of about 60 sq mi at the U.S. Geological Survey gaging station on Highway 181 at Gurabo (point 8 in fig. 1).

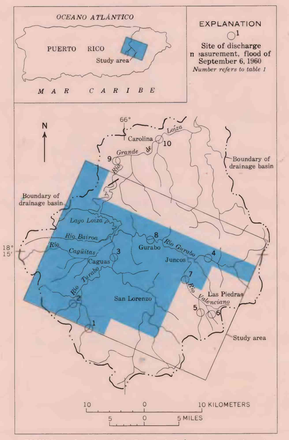


FIGURE 1.—*Location of Río Grande de Loíza drainage basin and study area*

Water is diverted from Río Grande de Loíza at Loíza Dam to supply water to the San Juan metropolitan area. During extremely dry conditions, water is diverted into Río Gurabo from the east to supplement storage in Lago Loíza. Streamflow also is used for the water supply of Caguas, Gurabo, Juncos, San Lorenzo, and smaller communities, but none of the diversions and uses have detectable effect on flood characteristics of the several streams.

Several dams have been constructed for water supply, but the only significant impounding structure is Loíza Dam (fig. 3), completed in 1954. Lago Loíza has a storage capacity of about 20,000 acre-feet at the full reservoir elevation of 40.1 meters. The design flood stage is 43.0 meters, which provides an additional temporary storage capacity of about 5,000 acre-feet.

The flood plains of the upper Río Grande de Loíza basin are devoted largely to raising sugarcane, but dairying also is an important land use.

Highways, urbanizations, and industries are causing swift and dramatic cultural changes in parts of the basin. Notably, the city of Caguas and its environs are expanding rapidly.

Flood history.—A great flood probably occurred in 1899, but residents in the Río Grande de Loíza basin could supply no information on it. Other major floods occurred in 1928, 1932, 1943, 1945, 1952, 1956, 1960, and 1961. The August 4, 1945, flood is the highest within memory on Río Cagüitas and on Río Grande de Loíza from Caguas upstream, being about 1 meter higher than the 1960 flood on those reaches.

The flood of September 6, 1960, is the highest known for Lago Loíza and for Río Gurabo and its tributaries. A considerable amount of information is available for the 1960 flood, including peak stage and discharge data obtained by U.S. Geological Survey at many places in eastern Puerto Rico (refer to Barnes and Bogart, 1961).

Flood discharges.—Instantaneous peak stage and peak discharge data were collected at the eight sites within the Río Grande de Loíza basin (fig. 1) for the 1960 flood. These discharges and the annual maximum instantaneous discharges collected at the two gaging stations are listed in table 1.

The peak discharge at the Caguas gaging station (site 3) for the 1945 flood was determined by logarithmic extension of the stage-discharge relation to be about 85,000 cfs. By comparison, for the 1960 flood it was 71,500 cfs.

The peak discharge at the Gurabo gaging station (site 8) for the 1960 flood was estimated to be about 60,000 cfs.

Flood stages.—Since the recording gaging stations at Caguas and Gurabo were established only in 1959, the record of floods is relatively brief. Most of the flood stages used in the study, therefore, came from the special study made after the 1960 flood and from recent interviews with local residents. The interviews provided flood levels and floodmarks for the floods in 1928, 1943, 1945, 1952, 1956, and 1960. Most of the information was in the vicinity of the principal communities, but a useful scattering of information was found in rural areas.

Flood profiles.—Profiles of Río Grande de Loíza and its major tributaries for the flood of September 6, 1960, are shown in figure 4. The flood profiles at Juncos and San Lorenzo for the 1960 and other floods are shown in figures 5 and 6.

The profiles are referenced to arbitrarily chosen base lines indicated on the topographic map. No floodmark elevations are shown on figure 4. These profiles represent the average of floodmark elevations and thus are somewhat smoothed.

Flood frequency.—There are no means of predicting the date a flood of a given magnitude will occur. If a long record of floods is available, however, the average recurrence interval of a selected flood discharge or stage and the chance of its occurrence in any year can be computed. The recurrence interval, or frequency, of a flood of specific magnitude is the average length of time during which that flood will be equaled or exceeded once. For floods greater than the 10-year flood, the reciprocal of the recurrence interval is virtually the chance of occurrence in a given year; thus the 20-year flood will have a 5-percent chance of occurring in any year, and a 50-year flood will have a 2-percent chance.

Discharge-frequency and stage-frequency relations of Río Grande de Loíza and Río Gurabo, based upon data collected at the gaging stations, are shown in figures 7–10. The stage-frequency relations at Juncos and San Lorenzo are shown in figures 11 and 12.

The 1945 and 1960 floods are the greatest since at least 1899, based on historical information. The 1945 flood is the greatest known on Río Cagüitas and on Río Grande de Loíza from Caguas upstream. The 1960 flood is the greatest known on Lago Loíza and on Río Gurabo and its tributaries. The two floods thus mutually are assigned recurrence intervals of 70 and 30 years, respectively, for the gaging stations at Caguas and Gurabo.

The data are insufficient for accurate definition of the discharge-frequency and stage-frequency relations. The illustrations will serve as approximations until additional data permit refinement.

Floodmark information.—The area inundated by the 1960 flood has been delineated principally on the basis of flood-stage information furnished by local residents. Field surveys were conducted to determine the elevation of floodmarks. The delineated area was determined from the water-surface profiles (fig. 4).

Floodmarks are shown at some places on the topographic map that are outside the delineated area of inundation—notably along the north side of Río Gurabo. Most of these marks are near small tributaries or local drainageways. They are valid marks but the boundary of inundation was not determined in their immediate vicinity. The boundary shown on the map thus represents the main valley condition.

Inundated area.—The flood boundaries delineated on the topographic map provide a record of historic facts that reflect channel and flood-plain conditions existing when the 1960 flood occurred. The effect of more recent or future changes in the channel and flood plain, or the possible changes in runoff characteristics resulting from increased urbanization, have not been appraised. The inundation patterns of future floods may be affected by construction of highways on the flood plain, the possible relocation and improvement of stream channels, and other cultural changes. The boundaries are well defined in areas of high population concentration and are poorly defined in intervening reaches of agricultural lands.

Caguas suffered the greatest amount of flooding. A part of the inundated area at Caguas is shown in figure 13. This figure also shows recent development in the flood plain such as the new Gurabo-Caguas highway that did not exist in 1960. Gurabo, Juncos, and San Lorenzo were more fortunate because flooding largely was along the village edges. Río Gurabo completely isolated Pueblito del Río, baseline station 27.0.

The 1945 flood on Río Grande de Loíza reached a stage about 1 meter higher than the 1960 flood. There are insufficient data to delineate the boundaries of the 1945 flood.

Water-surface contours.—The estimated water-surface contours for the 1960 flood are shown on the topographic map. A contour interval of 1 meter is shown below an elevation of 70 meters; a 5-meter interval above.

Depth of flooding.—Depth of flooding during the 1960 flood can be estimated by subtracting the ground elevation from the water-surface elevation, each shown by contours on the map. Intermediate estimates of depth can be determined by interpolation.

Cooperation and acknowledgment.—This report was prepared as part of the floods investigation authorized by a cooperative agreement between the Departamento de Obras Públicas, Commonwealth of Puerto Rico, and the United States Geological Survey. Many of the flood data were provided by the Departamento de Obras Públicas.

Additional information.—Additional information relating to floods in the study area can be obtained from the U.S. Geological Survey in San Juan, Puerto Rico, or from the Sección de Control de Inundaciones, Departamento de Obras Públicas, Santurce, Puerto Rico.

SELECTED REFERENCES

Barnes, H. H., and Bogart, D. B., 1961, Floods of September 6, 1960, in eastern Puerto Rico: U.S. Geol. Survey Circ. 451, 13 p., 12 figs., 5 tables.

Kipple, F. P., and others, 1968, Water records of Puerto Rico, 1958–63: U.S. Geol. Survey local publication, San Juan, P. R., 353 p., 15 figs.

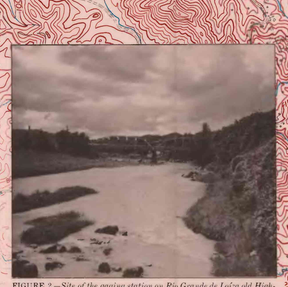


FIGURE 2.—*Site of the gaging station on Río Grande de Loíza old Highway PR-30 at Caguas. The flood crest September 6, 1960, was about 1.5 meters below the low steel of the bridge. About 9,000 cfs of the peak discharge passed over the highway embankment to the left of the bridge.*

Photo courtesy of Mark Hurd Aerial Surveys, Inc., Minneapolis, Minnesota

FIGURE 13.—*Area inundated at Caguas during the flood of September 6, 1960. Scale 1:20,000.*

EXPLANATION

- Area flooded September 6, 1960
- Boundary of 1960 flood
- Water-surface contour for 1960 flood. Contour intervals 1 and 5 meters above mean sea level — 80 —
- Valley base line, kilometers upstream from mouth — 22
- Elevation of high-water marks, in meters, and year of flood — 81.4(1960)

SCALE 1:20 000

CONTOUR INTERVAL 10 METERS
DASHED LINES REPRESENT 5-METER CONTOURS
DOTTED LINES REPRESENT 1-METER CONTOURS
DATUM IS MEAN SEA LEVEL

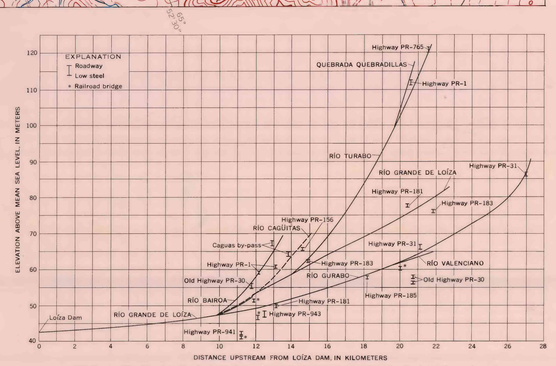


FIGURE 4.—*Profiles of Río Grande de Loíza and its tributaries for the flood of September 6, 1960.*

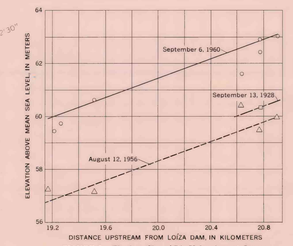


FIGURE 5.—*Flood profiles of Río Valenciano at Juncos.*

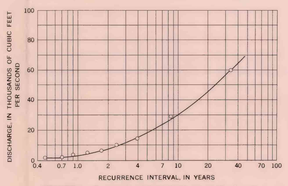


FIGURE 9.—*Frequency of flood discharge of Río Gurabo at Highway PR-181 at Gurabo.*

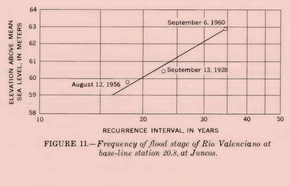


FIGURE 11.—*Frequency of flood stage of Río Valenciano at base-line station 20.5, at Juncos.*

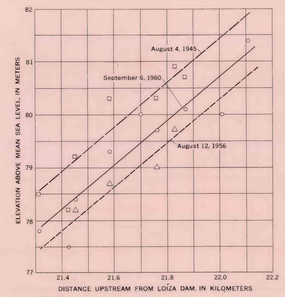


FIGURE 6.—*Flood profiles of Río Grande de Loíza at San Lorenzo.*

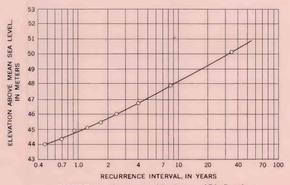


FIGURE 10.—*Frequency of flood stage of Río Gurabo at Highway PR-181 at Gurabo.*

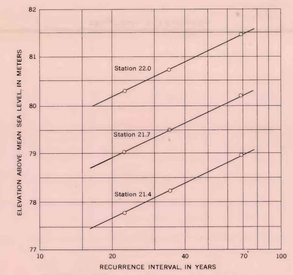


FIGURE 12.—*Frequency of flood stage at Río Grande de Loíza at selected base-line stations at San Lorenzo.*

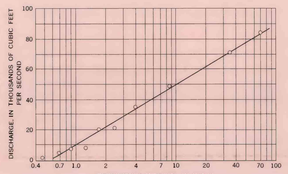


FIGURE 7.—*Frequency of flood discharge of Río Grande de Loíza at old highway PR-30 at Caguas.*

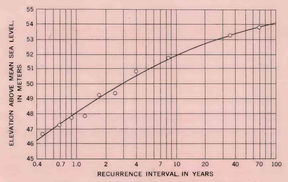


FIGURE 8.—*Frequency of flood stage of Río Grande de Loíza at Highway PR-30 at Caguas.*

Table 1.—*Tabulation of flood discharge*

Measurement site (fig. 1)	Location	Drainage area (sq mi)	Maximum flood		
			Date	Stage (meters above msl)	Discharge (cfs)
1	Río Turabo near La Plata	6.82	Sept. 6, 1960		24,000
2	Quebrada de las Quebradillas near Caguas	6.25	do		8,150
3	Río Grande de Loíza at Caguas (gaging station)	89.7	Aug. 4, 1945	53.8	85,000
			Sept. 6, 1960	53.2	71,500
			Aug. 27, 1961	51.7	48,500
			July 13, 1962	49.3	20,500
			Sept. 27, 1963	47.7	6,900
			July 13, 1964	49.2	20,100
			Aug. 10, 1965	50.8	34,900
			May 27, 1966	47.8	7,090
			June 20, 1967	46.6	1,710
			Nov. 27, 1968	47.2	4,600
4	Río Gurabo near Juncos	23.6	Sept. 6, 1960		28,000
5	Río Valenciano near Las Piedras	6.86	do		28,800
6	Río Valenciano tributary near Las Piedras	.76	do		1,770
7	Río Valenciano at Juncos	15.3	do		37,100
8	Río Gurabo at Gurabo (gaging station)	59.6	Aug. 4, 1945		
			Sept. 6, 1960	50.1	60,000
			Aug. 27, 1961	46.7	14,000
			June 12, 1962	44.9	3,740
			May 26, 1963	44.0	1,580
			July 13, 1964	46.0	9,080
			Aug. 10, 1965	47.9	28,200
			Oct. 17, 1966	45.4	6,400
			Nov. 10, 1967	44.1	1,920
			Aug. 2, 1968	45.1	4,590
9	Río Grande de Loíza at Loíza Dam	207	Sept. 6, 1960		
	Inflow peak discharge				180,000
	Outflow peak discharge				165,000
10	Río Grande de Loíza at Carolina	239	Sept. 6, 1960		197,000

FLOODS AT CAGUAS, GURABO, JUNCOS, AND SAN LORENZO, PUERTO RICO

By
Fred K. Fields
1972

Base from U.S. Geological Survey
Agua Buenas, Gurabo, Caguas, 1957
and Juncos, Humacao, 1958

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