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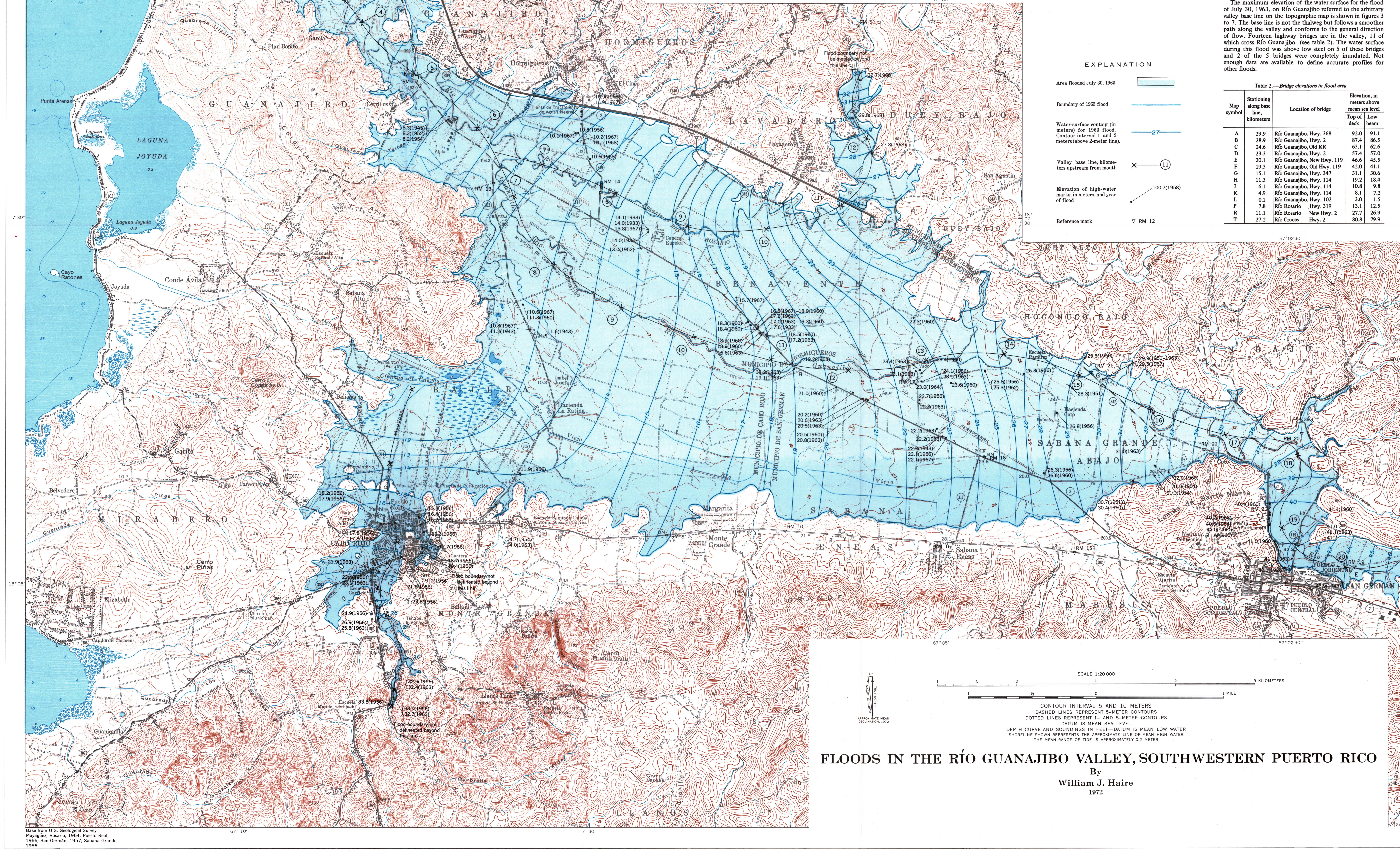

## FLOODS IN THE RÍO GUANAJIBO VALLEY, SOUTHWESTERN PUERTO RICO

This report provides factual and interpretive information that will aid administrators, planners, engineers, and other interested persons concerned with future development in areas subject to flooding in the Río Guanajibo basin. More specifically, the information given here is useful to those responsible for formulating effective floodplain regulations that would minimize flood damage.

This presentation is the result of a compilation of hydrologic data pertaining to floods in the Guanajibo basin and is based principally upon information obtained from residents in the study area. All elevations given are in meters above mean sea level.

The study area lies in the southwestern part of Puerto Rico and encompasses about 90 square miles of land area. The lower part of the basin, from San Germán to the mouth of Río Guanajibo, is used largely for the production of sugarcane and is subject to destructive floods. Parts of the towns of Mayagüez, Cabo Rojo, San Germán, and Sabana Grande are subject to frequent flooding.—see "Flood History."

### RÍO GUANAJIBO BASIN

The Río Guanajibo basin originates in the Cordillera Central of western Puerto Rico. It heads about 6 miles northeast of Sabana Grande at an elevation of about 800 meters. The flow is in a southerly direction to the town of Sabana Grande and then westward and northwestward about 30 kilometers to the outlet into Bahía de Mayagüez on Pasaje de Mona, as shown in figure 1. The total drainage area is 127 square miles.

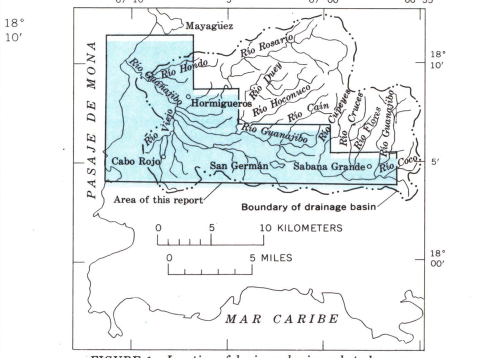


FIGURE 1.—*Location of drainage basin and study area*

The major tributaries of Río Guanajibo also have their source in the mountains and drain the area north of the river. These tributaries are: the Rosario, Duey, Caín, Cupeyes, Cruces, and Coco. The drainage area on the south side of the basin is relatively small and tributaries are few. Río Viejo flows along the south side of the main-stem flood plain and intercepts the runoff from the shorter mountain slopes on that side of the basin.

The average valley slope of the northerly tributary streams is steep, ranging from 0.03 to more than 0.08 meter per meter. The steep slope produces high velocities during periods of flood runoff, which may destroy buildings, pavements, embankments, and sugarcane and thus be more damaging than inundation alone. The average valley slope of Río Guanajibo from Sabana Grande to the mouth, along the base line is 0.03. This approximates the slope of the water surface during the 1963 flood. The area inundated by that flood is delineated on the topographic map.

### FLOOD HISTORY

The flood of August 8, 1899, is the greatest known. The second largest known flood occurred on September 13, 1928. However, elevations of these floods cannot be recovered in sufficient quantity to define flood boundaries. The earliest and largest flood for which adequate elevation data are available occurred on September 23, 1952. Significant floods have occurred at least six times since 1952.

Floods that have inundated sizable areas since 1928 and for which some water-surface elevation data are available occurred in 1943, 1945, 1952, 1954, 1958, 1960, 1963, 1967, and 1968; but records are too fragmentary to determine accurate water-surface profiles for any flood except the flood of July 30, 1963. The 1963 flood is the 7th highest of record. Elevations of all these floods, however, were used to define a stage-frequency relation.

### FLOOD DISCHARGE

The peak discharge of Río Guanajibo for the flood of December 4, 1960, at a location 0.5 mile upstream from Río Caín and 0.6 mile north of San Germán, where the drainage area is 36.8 square miles, was 11,500 cfs (cubic feet per second)—an average of 312 cfs per square mile. The significance of this figure can more readily be understood if it is compared with the possible discharge that could occur as a result of an intense storm over western Puerto Rico similar to that over eastern Puerto Rico in September 1960.

Geological Survey Circular 451 (Barnes and Bogart, 1960) shows that the peak discharges caused by the intense rainfall resulting from passage of Hurricane Donna off the north coast had Myers ratings in excess of 80 percent at 9 sites and exceeded 100 percent Myers rating at four of those sites[1].

The rugged Cordillera Central in western Puerto Rico is very similar hydrologically to the mountains in eastern Puerto Rico. It is conceivable, therefore, that a similar storm over western Puerto Rico could produce stream discharges that also would reach 100 percent Myers rating. This means that for a drainage area of 36.8 square miles, the unit discharge could be as much as 1,700 cfs per square mile, or a peak of 63,000 cfs compared with the known peak discharge of 11,500 cfs.

### FLOOD FREQUENCY

The date of occurrence of a flood of a given magnitude cannot be predicted, but the probable number of such floods during a long period of time can be estimated with reasonable accuracy. The frequency of occurrence is the average interval of time within which a given flood will be equaled or exceeded once. For example, two floods of at least the magnitude of a 50-year flood can be expected to occur in a 100-year period, on the average. Stated differently, a 50-year flood has 1 chance in 50 of being equaled or exceeded in any one year.

The record of floods on Río Guanajibo is fragmentary. Water-surface elevations obtained at the bridge on old Highway 119 near San Germán at base-line kilometer 19.3, however, were used to determine a stage-frequency relation (fig. 2 and table 1). The 1963 flood as delineated on the topographic map would have an average frequency of occurrence of once in 7 years.

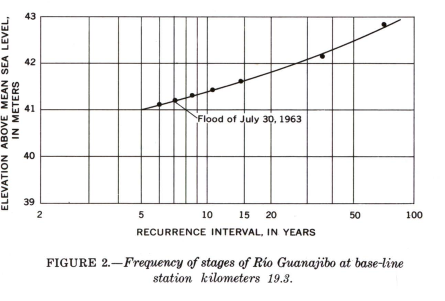


FIGURE 2.—*Frequency of stages of Río Guanajibo at base-line station kilometers 19.3.*

[1]The Myers equation is expressed as follows:

$$Q = C\sqrt{DA}$$

where Q = peak discharge in cfs
C is a coefficient
DA = drainage area in square miles
C = 10,000 is considered to be the 100-percent Myers rating
C = 8,000, the 80-percent Myers rating; etc.

Table 1.—*Date of flood and corresponding water-surface elevation at profile station kilometer 19.3 (see figures 2 and 3).*

| Date of flood | Water-surface elevation, in meters above mean sea level |
|---|---|
| Aug. 8, 1899 | 42.8 |
| Sept. 13, 1928 | 42.1 |
| Aug. 4, 1945 | 41.3 |
| Sept. 23, 1952 | 41.3 |
| Sept. 5–6, 1954 | 41.4 |
| Mar. 6, 1958 | 40.5 |
| Dec. 3–4, 1960 | 41.6 |
| May 17–18, 1963 | 41.1 |
| July 30, 1963 | 41.2 |
| Nov. 27, 1968 | 39.6 |

### INUNDATED AREA

The area inundated by the flood of July 30, 1963, has been delineated on the topographic map. This flood was selected because of the quantity and quality of the data available. Because the floods of 1945, 1952, 1954, and 1960 were very nearly the same elevation as the 1963 flood (see table 1), the 1963 flood as delineated is representative of all five floods. Although the difference in water-surface elevation during flooding may seem small, the difference in the corresponding discharge could be large.

The flood boundary shown on the map was developed from historical data and reflects the channel and flood-plain conditions that existed at that time. No attempt has been made to appraise natural and man-made changes since 1963 nor possible future changes. The inundation pattern of future floods may be affected by new highways and bridges, by new buildings, by relocating or excavating stream channels, or by filling and excavating flood plains.

### WATER-SURFACE CONTOURS

Water-surface contours are imaginary lines of equal water-surface elevation, based on floodmark elevations. Generally they are at right angles to the flow and are parallel to each other, but they become distorted where the valley widens or where obstructions to flow are in the natural path of a flood. Water-surface contours based on floodmarks of the July 30, 1963, flood are shown on the topographic map.

### DEPTH OF FLOODING

Depth of flooding at any point for the flood of July 30, 1963, can be estimated by subtracting the ground elevation at the point from the water-surface elevation indicated by the profile or by the water-surface contour lines. Elevation of the ground and of the water surface at any point can be estimated by interpolation between contour lines. More accurate ground elevations can be obtained by using the elevations of the reference marks shown on the map and described in table 3.

### FLOOD PROFILE

The maximum elevation of the water surface for the flood of July 30, 1963, on Río Guanajibo referred to the arbitrary valley base line on the topographic map is shown in figures 3 to 7. The base line is not the thalweg but follows a smoother path along the valley and conforms to the general direction of flow. Fourteen highway bridges are in the valley, 11 of which cross Río Guanajibo (see table 2). The water surface during this flood was above low steel on 5 of these bridges and 2 of the 5 bridges were completely inundated. Not enough data are available to define accurate profiles for other floods.

### EXPLANATION

| | |
|---|---|
| Area flooded July 30, 1963 | (light blue tint) |
| Boundary of 1963 flood | (blue line) |
| Water-surface contour (in meters) for 1963 flood. Contour interval 1- and 2-meters (above 2-meter line). | —27— |
| Valley base line, kilometers upstream from mouth | ✕——(11) |
| Elevation of high-water marks, in meters, and year of flood | 100.7(1958) |
| Reference mark | ▽ RM 12 |

Table 2.—*Bridge elevations in flood area*

| Map symbol | Stationing along base line, kilometers | Location of bridge | Elevation, in meters above mean sea level: Top of deck | Low beam |
|---|---|---|---|---|
| A | 29.9 | Río Guanajibo, Hwy. 368 | 92.0 | 91.1 |
| B | 28.9 | Río Guanajibo, Hwy. 2 | 87.4 | 86.5 |
| C | 24.6 | Río Guanajibo, Old RR | 63.1 | 62.6 |
| D | 23.3 | Río Guanajibo, Hwy. 2 | 57.4 | 57.0 |
| E | 20.1 | Río Guanajibo, New Hwy. 119 | 46.6 | 45.5 |
| F | 19.3 | Río Guanajibo, Old Hwy. 119 | 42.0 | 41.1 |
| G | 15.1 | Río Guanajibo, Hwy. 347 | 31.1 | 30.6 |
| H | 11.3 | Río Guanajibo, Hwy. 114 | 19.2 | 18.4 |
| J | 6.1 | Río Guanajibo, Hwy. 114 | 10.8 | 9.8 |
| K | 4.9 | Río Guanajibo, Hwy. 114 | 8.1 | 7.2 |
| L | 0.1 | Río Guanajibo, Hwy. 102 | 3.0 | 1.5 |
| P | 7.8 | Río Rosario Hwy. 119 | 13.1 | 12.5 |
| R | 11.1 | Río Rosario New Hwy. 2 | 27.7 | 26.9 |
| T | 27.2 | Río Cruces Hwy. 2 | 80.8 | 79.9 |

Table 3.—*Reference marks established by the U.S. Geological Survey in the Guanajibo valley from the mouth of Río Guanajibo to Terraza La Barca on Highway 368, 2 kilometers southeast of Sabana Grande*

| Reference-mark number (see topographic map) | Elevation above mean sea level, meters | Description |
|---|---|---|
| 8 | 15.58 | At culvert on Highway 102, kilometer 2.63 and 3.2 kilometers east of Cabo Rojo. A brass disk stamped U.S. Geological Survey set in concrete on north side of culvert headwall. |
| 10 | 23.04 | At culvert on Highway 102, kilometer 4.1 and 4.7 kilometers east of Cabo Rojo. A brass disk stamped U.S. Geological Survey set in concrete on south side between two parapets of small culvert. |
| 12 | 7.47 | At culvert on Highway 114, kilometer 4.1 and 2.0 kilometers west of Hormigueros. A brass disk stamped U.S. Geological Survey set in concrete on northwest corner of culvert. |
| 13 | 8.93 | At culvert on Highway 103, kilometer 0.3 and 1.7 kilometers southwest of Hormigueros. A brass disk stamped U.S. Geological Survey set in concrete on southeast side of culvert. |
| 14 | 13.06 | At bridge over Río Rosario on Highway 119, kilometer 1.1 and 1.5 kilometers south of Hormigueros. A brass disk stamped U.S. Geological Survey set in concrete on upstream left abutment. |
| 11 | 37.01 | At small culvert on paved road, kilometer 6.63 and 3.5 kilometers east of Hormigueros. Paved road exits north from new Highway 2 at kilometer 166.2. A brass disk stamped U.S. Geological Survey set in concrete on west side of culvert. |
| 17 | 23.15 | At sugarcane crane on dirt road 600 meters north of junction of Highway 114 (old Highway 2). Dirt road exits Highway 114 at kilometer 11.82. A brass disk stamped U.S. Geological Survey set in concrete on base of north leg of crane at Hacienda El Vado. |
| 18 | 23.87 | At small culvert on Highway 114 (old Highway 2), kilometer 12.75 and 4.0 kilometers west of San Germán. A brass disk stamped U.S. Geological Survey set in concrete on north side of headwall. |
| 16 | 28.74 | At culvert on Highway 102, kilometer 6.17, 100 meters west of junction of Highway 317 and 4 kilometers west of San Germán. A brass disk stamped U.S. Geological Survey set in concrete on northwest corner of headwall. |
| 15 | 32.82 | At culvert on Highway 102, kilometer 7.8 and 2.5 kilometers west of San Germán. A brass disk stamped U.S. Geological Survey set in concrete on top of north parapet of culvert. |
| 21 | 31.15 | At bridge over Río Guanajibo on Highway 347, kilometer 3.9 and 3.4 kilometers west of San Germán. A brass disk stamped U.S. Geological Survey set in concrete on upstream left corner of bridge sidewalk. |
| 22 | 33.85 | At culvert on Highway 347, kilometer 2.1 and 2.0 kilometers northwest of San Germán. A brass disk stamped U.S. Geological Survey set in concrete on south side of upstream headwall. |
| 23 | 40.73 | At small culvert on Highway 347, kilometer 0.92 and 1 kilometer north of San Germán. A brass disk stamped U.S. Geological Survey set in concrete on upstream headwall. |
| 20 | 41.79 | At bridge over Río Caín on new Highway 2, between kilometer posts 173.3 and 173.4 and 2.0 kilometers north of San Germán. A brass disk set in concrete on downstream left abutment. |
| 19 | 46.94 | At bridge over Río Guanajibo on new Highway 119, kilometer 0.4. A brass disk stamped U.S. Geological Survey on sidewalk of upstream right corner of bridge. |
| 24 | 63.14 | At old railroad bridge over Río Guanajibo on dirt road, 4.0 kilometers southwest of Sabana Grande, and at kilometer 1.95 on Highway 329. A brass disk stamped U.S. Geological Survey set in concrete on downstream left abutment. |
| 25 | 80.72 | At bridge over Río Cruces on Highway 2, kilometer 213.3 and 2.0 kilometers west of Sabana Grande. A standard disk stamped U.S. Geological Survey set in concrete on right upstream abutment. |
| 27 | 87.67 | At bridge over Río Guanajibo on Highway 2, kilometer 216.2 and 1.2 kilometers south of Sabana Grande. A brass disk stamped U.S. Geological Survey set in concrete on upstream left abutment. |
| 29 | 100.28 | At concrete bench in front of Terraza La Barca on Highway 368, kilometer 1.8 and 2 kilometers southeast of Sabana Grande. A brass disk stamped U.S. Geological Survey set in concrete on west side of bench. |

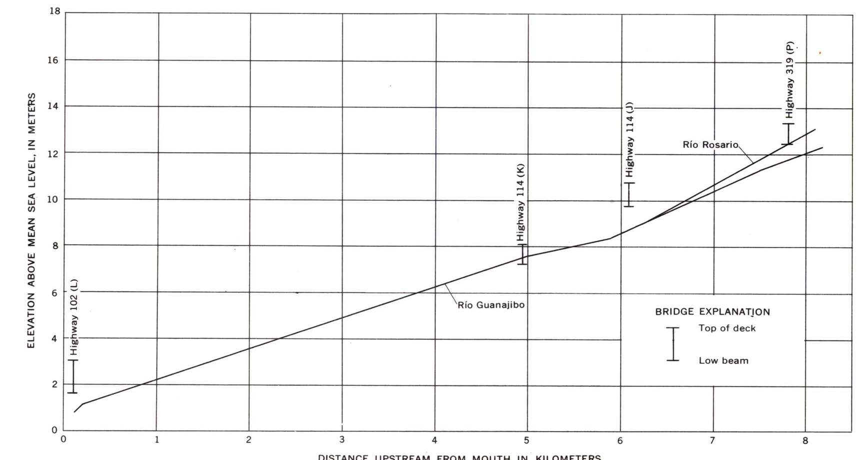


FIGURE 3.—*Profile of Río Guanajibo, base-line stations 0 to 8, flood of July 30, 1963. Letters on bridges refer to table 2.*

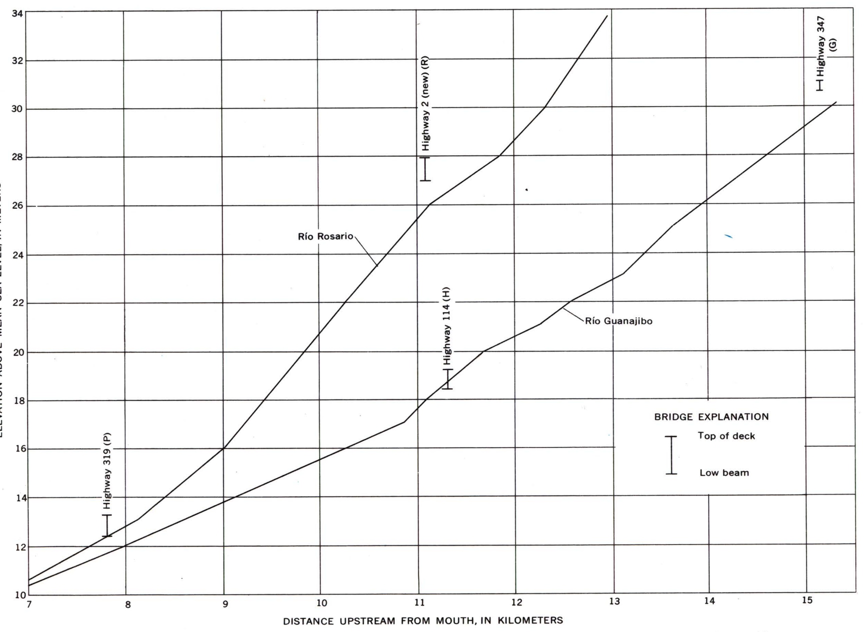


FIGURE 4.—*Profile of Río Guanajibo, base-line stations 7 to 15, flood of July 30, 1963. Letters on bridges refer to table 2.*

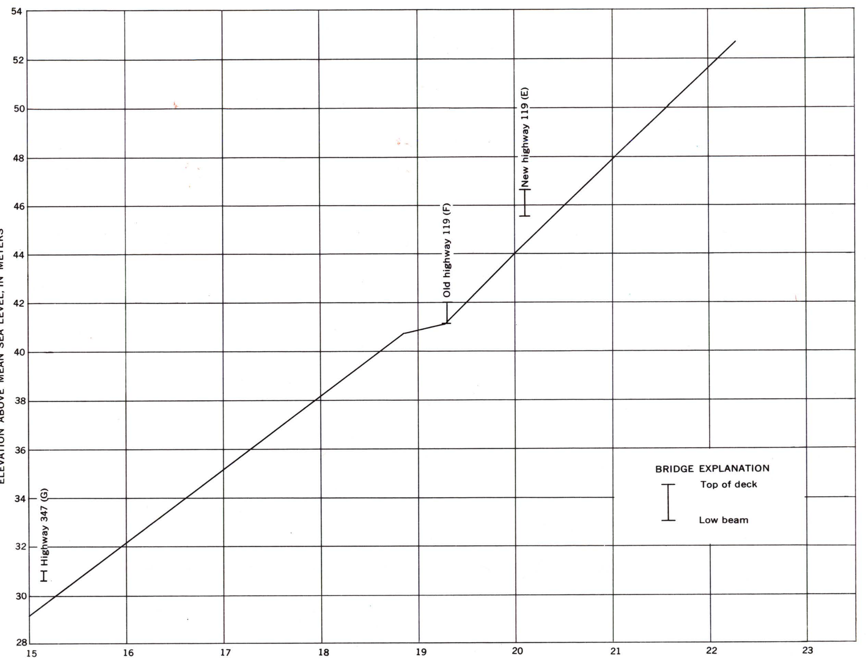


FIGURE 5.—*Profile of Río Guanajibo, base-line stations 15 to 22, flood of July 30, 1963. Letters on bridges refer to table 2.*

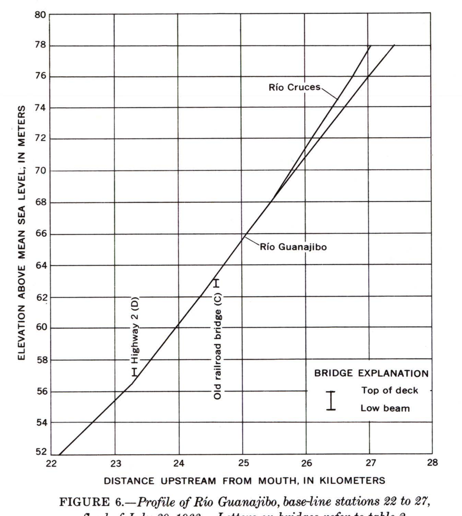


FIGURE 6.—*Profile of Río Guanajibo, base-line stations 22 to 27, flood of July 30, 1963. Letters on bridges refer to table 2.*

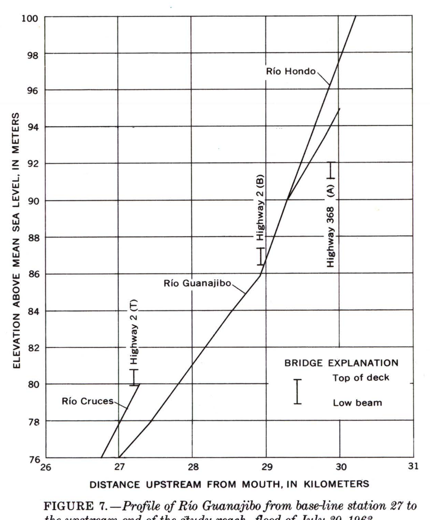


FIGURE 7.—*Profile of Río Guanajibo from base-line station 27 to the upstream end of the study reach, flood of July 30, 1963. Letters on bridges refer to table 2.*

### ACKNOWLEDGMENTS

Selection of the site for this project was made in collaboration with the Area de Prevención de Inundaciónes, Departamento de Obras Públicas de Puerto Rico. Historical flood data were made available by many residents in the Guanajibo basin. The data for the lower part of the basin, from Hormigueros to the mouth of Río Guanajibo, were taken from Geological Survey Hydrologic Atlas HA–288, FLOODS IN THE MAYAGÜEZ AREA OF PUERTO RICO, by I. J. Hickenlooper. HA–288 is one of the same series as this report and is a part of the flood-mapping program in Puerto Rico.

### ADDITIONAL INFORMATION

Supporting data and computations relative to this report are in the files of the U.S. Geological Survey, San Juan, Puerto Rico, and at the Area de Prevención de Inundaciones, Departamento de Obras Públicas de Puerto Rico, Santurce, Puerto Rico.

### REFERENCES

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

Hickenlooper, I. J., 1968, Floods in the Mayaguez area of Puerto Rico: U.S. Geol. Survey Hydrol. Inv. Atlas HA-288.

SCALE 1:20 000

CONTOUR INTERVAL 5 AND 10 METERS
DASHED LINES REPRESENT 5-METER CONTOURS
DOTTED LINES REPRESENT 1- AND 5-METER CONTOURS
DATUM IS MEAN SEA LEVEL
DEPTH CURVE AND SOUNDINGS IN FEET—DATUM IS MEAN LOW WATER
SHORELINE SHOWN REPRESENTS THE APPROXIMATE LINE OF MEAN HIGH WATER
THE MEAN RANGE OF TIDE IS APPROXIMATELY 0.2 METER

APPROXIMATE MEAN DECLINATION, 1972

# FLOODS IN THE RÍO GUANAJIBO VALLEY, SOUTHWESTERN PUERTO RICO

By
William J. Haire
1972

Base from U.S. Geological Survey Mayagüez, Rosario, 1964; Puerto Real, 1966; San Germán, 1957; Sabana Grande, 1956