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Puerto Rico Flood Hazard Mitigation Plan

august 1980

DEPARTMENT OF NATURAL RESOURCES

EXHIBIT 8

PUERTO RICO

FLOOD HAZARD MITIGATION PLAN

August 1980

Financial assistance provided in part by the Coastal Zone Management Act of 1972, administered by the Office of Coastal Zone Management, National Oceanic and Atmospheric Administration.

DEPARTMENT OF NATURAL RESOURCES
Area for Planning of Natural Resources.
Coastal Management Program

PUERTO RICO

FLOOD HAZARD MITIGATION PLAN

August 1980

In Response to

September 1979 Disaster Declaration

(FEMA 597 DR Puerto Rico)

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I. INTRODUCTION

Between August 30th and September 6, 1979, Puerto Rico suffered extensive flooding from two violent storms -- Hurricane David and Tropical Storm Frederic. On September 2, 1979, President Carter declared six municipios disaster areas; eventually, the disaster declaration covered 72 of Puerto Rico's 78 municipios. On September 7, 1979, Governor Carlos Romero Barceló signed a Federal/Commonwealth Disaster Assistance Agreement[1] to allow Puerto Rico to receive federal disaster assistance funds. Paragraph nine of this agreement requires Puerto Rico to:

> ...evaluate the natural hazards in the areas in which the proceeds of the grants or loans are to be used..., take appropriate action to mitigate such hazards, including safe land use and construction practices; and to follow up with applicants, within Commonwealth capabilities, to assure that appropriate hazard mitigation actions are taken.[2]

Shortly before Hurricane David and Tropical Storm Frederic struck Puerto Rico, an Executive Order on disaster functions[3] assigned lead agency responsibility for hazard mitigation planning to the Department of Natural Resources (DNR). After the initial emergency operations related to the two storms were completed, DNR, the Federal Emergency Management Agency (FEMA), Civil Defense Agency, and the Planning Board held a series of meetings to initiate hazard mitigation planning. These meetings clarified DNR's role as lead agency and provided the initial direction for the hazard mitigation planning effort.

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[1] FEMA No. 597 DR Puerto Rico. See Appendix A.

[2] The legal basis for this requirement is Section 406 of the Federal Disaster Relief Act of 1974 (P.L. 93-288), which requires as a condition of disaster assistance grants, or loans, that the state or local government agree that:

1) ...the natural hazards in the areas in which the proceeds of the grants or loans are to be used shall be evaluated...
2) ...appropriate actions shall be taken to mitigate such hazards, including safe land use and construction practices, in accordance with standards prescribed or approved by the Administration of DR&R (FDAA) after adequate consultation with the appropriate elected officials of general purpose governments...; and
3) ...the State shall furnish such evidence of compliance with this section as may be required by regulations.

Proposed regulations governing Section 406 were not issued until April 1979. Final regulations were issued November 8, 1979 (44 CFR, Part 205, Subpart M, Hazard Mitigation.)

[3] Administrative Bulletin No. 3669: Governor's Executive Order for Coordination of Executive Functions in Case of Disasters. August 22, 1979.

As lead agency, DNR reassigned several staff members and consultants from other duties to prepare a work program for hazard mitigation planning. Recognizing that this type of effort would require interagency action, the work program called for establishment of a Hazard Mitigation Task Force[1] to include representatives from over 15 federal, commonwealth and municipal agencies. A smaller Hazard Mitigation Work Group[2], with members from three federal and three commonwealth agencies plus several municipios, was also established.

Based on the earlier discussions with other key agencies, DNR proposed two types of hazard mitigation planning: a) the preparation of site-specific plans for selected target areas (potential areas were identified for review with the Task Force.); and b) because flooding from David and Frederic was so widespread, the preparation of a general hazard mitigation plan for all of Puerto Rico (called the "islandwide plan").

At its first meeting on November 7, 1979, the Hazard Mitigation Task Force concurred with this overall approach, suggested a number of changes in the work program, and selected two initial target areas for site-specific plans -- coastal floodplains of Río Grande de Loíza and Río de La Plata. A decision on additional target areas was deferred. At its second meeting on November 29th, the Task Force approved a revised work program, which was subsequently approved by the FEMA New York Regional Office. Following these approvals, DNR began to compile data and evaluate flood hazards for the two target areas and for the islandwide plan. Regular meetings of both the Work Group and the Task Force were scheduled to periodically review this information and to recommend appropriate hazard mitigation actions.

This report -- Puerto Rico Flood Hazard Mitigation Plan -- presents the results of the islandwide investigation.[3] It briefly describes the flood hazard and Puerto Rico's policies for dealing with the hazard, describes on-going actions to reduce future flood losses, and recommends additional actions to be taken in the future.

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[1] See Appendix B.

[2] See Appendix C.

[3] Hazard evaluations and mitigation recommendations that are specific to the target areas are included in the following reports: Hazard Mitigation Plan for Portions of the Coastal Floodplain of Río Grande de Loíza, and Hazard Mitigation Plan for Portions of the Coastal Floodplain of Río de La Plata.

Information included in the plan is derived primarily from the following sources:

- Coastal Flood Hazards and Responses in Puerto Rico: An Overview. Department of Natural Resources, February 1980.
- Hazard Mitigation Plan for Portions of the Coastal Floodplain of Río Grande de Loíza, Department of Natural Resources, May 1980 (Draft).
- Hazard Mitigation Plan for Portions of the Coastal Floodplain of Río de La Plata, Department of Natural Resources, May 1980 (Draft).
- Meetings of the Hazard Mitigation Task Force.
- Meetings of the Hazard Mitigation Work Group.
- Staff work by DNR and other government agencies.

In addition to these major sources, numerous other documents prepared by several commonwealth and federal agencies were also used extensively.

Several actions were taken by government agencies following David and Frederic independent of the actions of DNR and the Task Force. Because these actions are essential to the overall hazard mitigation effort, they are incorporated into the plan, to the extent possible.

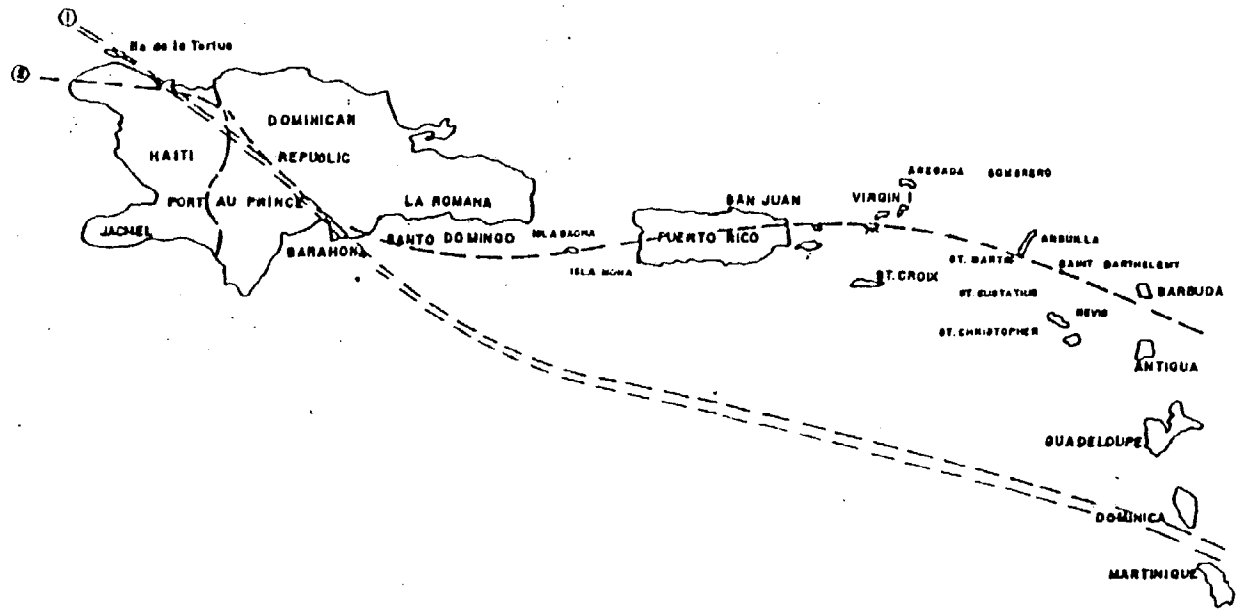
II. DESCRIPTION AND EVALUATION OF FLOOD HAZARDS

A. HURRICANE DAVID AND TROPICAL STORM FREDERIC

During the 1979 hurricane season, Puerto Rico was affected by two major storms within a five-day period. Hurricane David passed 100 miles south of Puerto Rico on August 30th, and Tropical Storm Frederic cut through the center of the island on September 4th (See Figure 1). Danger to Puerto Rico from Hurricane David was at first -- on August 28th -- reported as "unlikely". However, on Wednesday evening, the 29th, David shifted to a slightly more northern track and a hurricane warning was issued for Puerto Rico and the Virgin Islands. Hurricane David -- with 115 mph sustained winds and gale force winds extending 150 miles from the center -- was soon being classify as the most dangerous hurricane to threaten Puerto Rico since Donna in 1960, and even potentially comparable to San Felipe in 1928. Although the storm was originally projected to pass about 60 miles off the south coast, the final path was 100 miles to the south (See Figure 1). This slight shift probably spared Puerto Rico from more serious wind and flood damages; still the entire island felt the effects of the storm.

Heavy rainfall caused floodwaters to rise in some areas by Thursday evening, August 30th. (Rainfall for the 3-day event ranged from 2-10 inches in the north coastal area to 20 inches in the central mountain region.) Severe flooding occurred over the east, south and north sections of Puerto Rico during the early morning and during the day of August 31st. The National Weather Service (NWS) also issued a coastal flood warning at 10:30 p.m. on August 29th, and recommended to Puerto Rico officials that low lying areas in the east and south be evacuated as a precaution against possible storm surges.

The Puerto Rico Civil Defense Agency set up its command center in San Juan to coordinate rescue operations. Evacuation of floodplain residents began on August 30th. In Toa Baja, one of the hardest hit areas, 15,000 residents were evacuated to shelters that night. By Friday, August 31st, the



① HURRICANE DAVID

② TROPICAL STORM FREDERIC

SOURCE: N.W.S. NATIONAL WEATHER SERVICE

FIGURE 1: PATHS OF HURRICANE DAVID AND TROPICAL STORM FREDERIC

death toll reached six[1] with major flooding reported in at least nine towns. Twenty thousand refugees were in shelters Friday afternoon, and 30,000 by nightfall.

The Governor declared a state of emergency on August 31st -- releasing $3 million in emergency aid and activating the National Guard -- and requested a federal disaster declaration. Disaster teams from both the Federal Emergency Management Agency (FEMA) regional office in New York and the Red Cross were flown in. A Presidential disaster declaration, made on Sunday, September 2nd, originally affected only six municipalities where damages had been assessed -- Ponce, Arecibo, Humacao, Arroyo, Barceloneta and Manatí. As damage estimates for other towns were made, additional areas were covered by the disaster declaration.

Initial estimates of damages from Hurricane David, due to both flooding and wind, included over $50 million lost in agricultural production and equipment (including a 50% loss of the coffee crop), over 800 houses destroyed and more than 8,000 damaged, and 25% of the roads blocked by floods, landslides, or fallen trees.

As the cleanup and assistance efforts continued, a second tropical storm moved toward Puerto Rico. Tropical Storm Frederic was upgraded to a hurricane on September 1st, and by Sunday evening September 3rd, a second hurricane watch was issued for Puerto Rico. On Monday, refugee centers began to reopen, and low lying sectors of La Perla in Old San Juan were evacuated, as were some parts of Toa Baja. The National Weather Service warned of severe flooding because of the already saturated condition of the soil, and because flood waters from Hurricane David's rains had not completely receded in some areas.

Hurricane Frederic was originally projected to pass about 100 miles north of Puerto Rico on Tuesday morning, September 4th. Fortunately, as Frederic approached Puerto Rico, its strength diminished and it was downgraded to tropical storm status. However, a slight change in direction brought the

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[1] The final death toll was 7, much less than early reports.

storm over land along the north coast (See Figure 1). Although wind damage was minimal, heavy swells caused beach erosion and damage to roads. Waves of 12 to 15 feet occurred on the east and south coast. Heavy rains continued after the storm passed.

The day after the second storm hit, FEMA announced that damages from Tropical Storm Frederic would be covered under the disaster declaration made following Hurricane David. By September 6th, 15 municipios were included in the disaster declaration, making residents eligible to receive federal disaster relief. Eventually, 72 of Puerto Rico's 78 municipios were declared eligible for federal disaster assistance: 60 eligible for individual and public assistance; 3 for individual assistance only; and 9 for public assistance only (See Appendix D).

Final damage estimates and disaster assistance payments are still to be completed; however, estimates available from the Puerto Rico Civil Defense Agency (CD), Puerto Rico Industrial Development Company, and the Federal Emergency Management Agency provide a relatively complete picture of damages caused by Hurricane David and Tropical Storm Frederic. Approximately 67,000 persons registered for assistance at Emergency Management Centers set up around the island by FEMA and CD. Table 1 details damage estimates and assistance payments to residents, businesses, and public facilities provided by FEMA and other federal and commonwealth agencies whose efforts were coordinated by FEMA.

Civil Defense data gathered after Hurricane David indicated 5,916 houses affected by the storm; 851 were totally destroyed, while the rest were able to be rehabilitated. Housing damages by region were as follows:

Region	Houses Destroyed	Houses Damaged, but Repairable
Arecibo	97	615
Bayamón	234	443
Caguas	164	518
Carolina	132	945
Mayagüez	72	1,021
Ponce	121	1,297
San Juan	31	226
TOTAL	851	5,065

TABLE 1: SUMMARY OF DISASTER ASSISTANCE[1]

PROGRAM	ESTIMATED COST	PROJECTED APPROVALS	APPLICATIONS REC'D/APPRV'D	APPLICATIONS APPROVED ($)	$ DISBURSED
Emergency Conservation Measures	$ 600,000	900	6,201/868	$ 536,845	$ 218,919
Disaster Unemployment Assistance	1,576,000	6,505	11,400/6,505	489,066	667,986
Emergency Food Stamp	127,111	714	2,358/714	132,788	132,788
Small Business Admin., Business Loan	5,000,000	2,200	3,208/1,932	7,268,900	4,551,900
Flood Insurance Claims	15,000,000	1,500	1,843/1,367	4,727,690	4,272,690
Small Business Admin., Home Loans	20,000,000	14,000	25,990/13,186	24,781,000	19,206,500
Individual & Family Grants	87,000,000	61,593	67,760/61,593	65,323,938	65,323,938
Farmers Home Admin.	8,000,000	650	1,947/581	7,050,740	4,609,320
Temporary Housing	5,500,000	(see below)			
Public Assistance	48,073,000	(see below)			

Temporary Housing:

Estimated program cost	$5,500,000
Estimated units required	23,000
Applications received	38,114
Eligible	21,635
Ineligible	14,446
Withdrawn	2,504
Eligible applicants assisted	21,164

Public Assistance:

Estimated total cost	$44,732,458
Debris clearance	561,127
Protective measures	2,004,249
Road systems	18,845,487
Water control facilities	2,703,265
Public buildings	1,757,409
Public utilities	14,633,615
Facil. under construction	674,591
Private non-profit	398,109
Other	3,154,602

[1] Status as of June 15, 1980

Industry suffered very little direct damage. The P.R. Industrial Development Company (PRIDCO) estimated a total cost of $62,985 for repair of damaged industrial facilities. While a few facilities suffered damages over $10,000, most individual projects were less than $1,000 each to repair relatively minor damages from flooding and hurricane winds. These repair projects included replacement of insulation and waterproofing, debris and fallen tree removal, repair of flashing, and repair of submersible pumps. A summary of industrial repairs by region is as follows:

Region	No. of Projects	Estimated Cost
South	1	$15,300
Eastern Metropolitan	7	19,300
North	7	5,300
West	4	15,200
Central Metropolitan	6	7,885
TOTAL	25	$62,985

As noted above, the Department of Agriculture estimated agricultural losses of approximately $50 million. In addition to assistance provided by the federal Farmers Home Administration, the Puerto Rico Department of Agriculture authorized $8.1 million for an agricultural rehabilitation program to reduce the adverse effects of the two storms. The rehabilitation program included no-interest loans, government purchase of crops, and cash bonuses for new coffee plantings. A summary of the assistance provided as of June 15, 1980, is included below:

Program	Estimated Cost	Funds Utilized	Farmers Benefitting
Loans	$3,530,000	$3,312,271	8,367
Fertilizer for Coffee	1,318,000	1,127,792	11,055
Fertilizer for Plantains and Bananas	465,000	478,290	6,272
Fertilizer for Pasture Grass	600,000	450,486	2,579
$5.00 Subsidy Per 100 lbs of Food Concentrate	392,000	385,030	660
Economic Aid and Cover for Vegetable Farms	300,000	173,000	16
Cover for Rice	200,000	-	-
Purchase of Plantains and Bananas	1,192,000	485,225	300
Collection of Coffee	200,000	13,200	4
Production of Small Coffee Trees	150,000	93,300	152
TOTAL	$8,347,000	$6,318,594	29,405

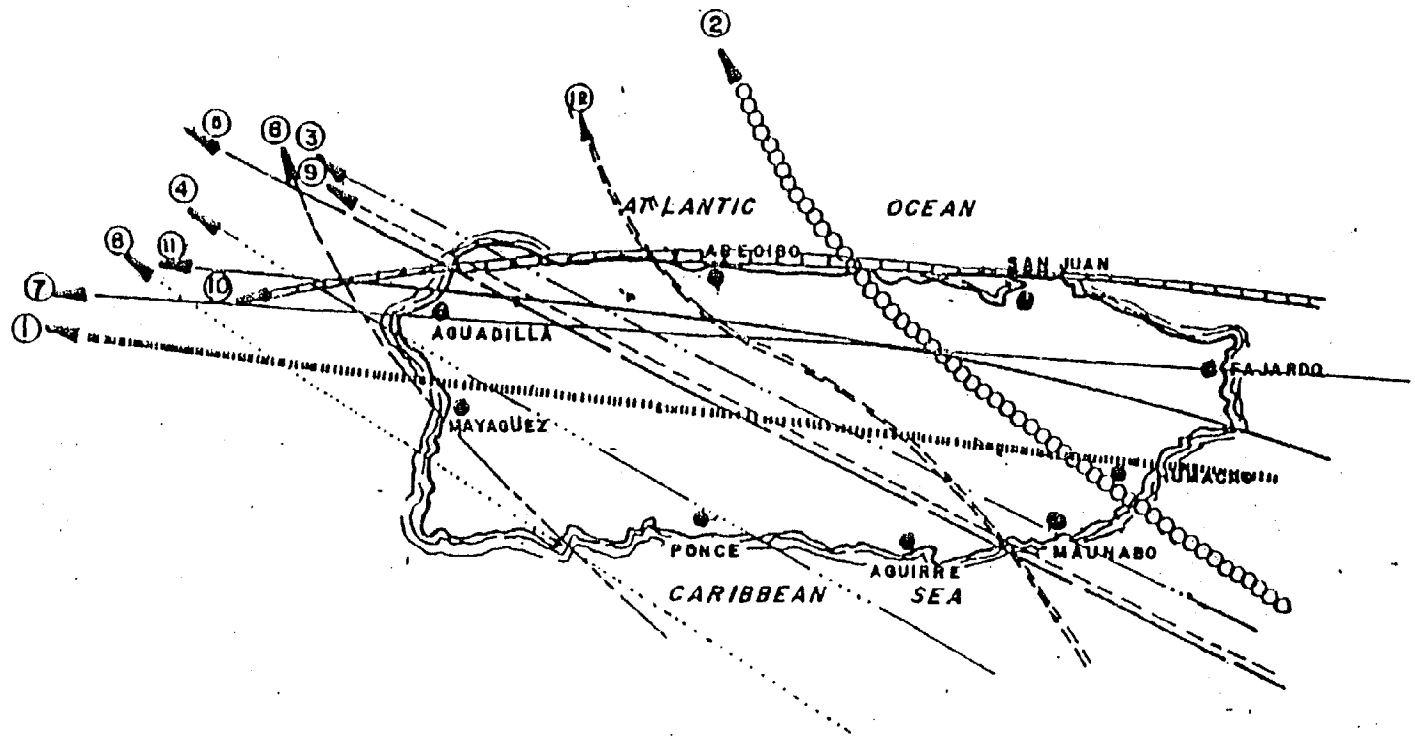
B. HISTORICAL PERSPECTIVE

In assessing the impacts of Hurricane David and Tropical Storm Frederic, it is important to recognize that Puerto Rico escaped the full fury of a major hurricane. The magnitude of flooding varied from only about a one-year to a maximum ten-year flood event throughout the island. The extensive damages resulted from the high winds accompanying David and widespread flooding that affected almost all of Puerto Rico.

Flood hazards in Puerto Rico reflect the island's tropical weather conditions, topography and high population density. Nearly 70 nonnavigable rivers, and streams -- whose banks and drainage areas are dotted with communities -- originate in a central mountain range and rapidly reach the coastal plain. These rivers are narrow, shallow and relatively short (mostly less than 20 miles long), making them highly susceptible to flooding and particularly to flash flooding. Poor drainage and high density of construction in the floodplain, with accompanying high runoff rates, have increased the vulnerability of these areas to flooding. The flooding problem is further aggravated in many urban areas due to inadequate storm drainage systems or poor maintenance of the storm drainage systems and stream channels. Large portions of the coastal floodplain are also subject to storm surge flooding and erosion from hurricanes and other tropical storms that push seawater onshore, and from heavy coastal sea swells generated by winter storms in the North Atlantic.

Minor flooding occurs frequently in Puerto Rico. Much of this smaller scale flooding is the result of only moderately heavy rainfall combined with inadequate drainage. Because minor flooding is so frequent, residents of many areas appear to have accepted flooding as an unavoidable part of life. This attitude seems to also extend to more serious flooding, with many people not taking the threat of dangerous flooding very seriously.

Severe flooding in Puerto Rico can result from: landfalling hurricanes, hurricanes that pass nearby but do not actually hit the island, and non-hurricane storms. Approximately 140 hurricanes have affected Puerto Rico in the past 500 years. They have caused more than 5,000 deaths and hundreds of millions of dollars in property damage. Thirteen hurricanes have actually crossed parts of Puerto Rico since 1876 (See Figure 2). The last landfalling hurricane to cross Puerto Rico was Hurricane Betsy, in 1956.



① SAN FELIPE	SEPTEMBER	13, 1876	
② SAN MAGIN	AUGUST	19, 1891	
③ SAN ROQUE	AUGUST	16, 1893	
④ SAN GIL	AUGUST	31, 1896	
⑤ SAN CIRIACO	AUGUST	8, 1899	
⑥ SAN CIRILO	SEPTEMBER	11, 1901	
⑦ SAN HIPOLITO	AUGUST	22, 1916	
⑧ SAN NICOMEDES II	SEPTEMBER	15, 1926	
⑨ SAN FELIPE II	SEPTEMBER	13, 1928	
⑩ SAN NICOLAS	SEPTEMBER	10, 1931	
⑪ SAN CIPRIAN	SEPTEMBER	26, 1932	
⑫ SANTA CLARA (BETSY)	AUGUST	12, 1956	

SOURCE: NOAA, OFFICE OF HYDROLOGY. "STORM TIDE FREQUENCY ANALYSIS FOR THE COAST OF PUERTO RICO". FRANCIS P. HO, May 1975.

FIGURE 2: LANDFALLING HURRICANES FOR THE PERIOD 1871-1979.

There have been five Presidentially declared flood disasters in Puerto Rico in recent years.

August 1956 - Hurricane Betsy (Santa Clara)

October 1970 (60 municipios) - Tropical Depression

October-November 1974 (52 municipios)

September 1975 (islandwide) - Tropical Storm Eloise

September 1979 (72 municipios) - Hurricane David and Tropical Storm Frederic

Flash flooding, from both hurricanes and other storms, can be predicted with only limited precision. Puerto Rico's relatively small size and the many drainage basins that divide the island prevent geographically detailed predictions of the occurrence of flash flooding. As a result, the warning time available is usually a matter of hours, or even minutes.

The prediction of storm surges affecting the near shore areas is also uncertain. The state-of-the-art for storm surge predictions is less well developed than for flash floods, and only limited study of storm surges has been performed for Puerto Rico.

Although the types of damages incurred from flooding have changed somewhat over the past century -- most noticeable fewer deaths and fewer destroyed buildings -- the potential for property damage and loss of life is greater than it has ever been. This is due mainly to the increased population now living in flood hazard areas. The next major hurricane to directly strike Puerto Rico could cause enormous property damage, economic and social disruption, and substantial loss of life.

III. FLOOD HAZARD MITIGATION POLICIES

A. FORMAL POLICIES

Primary responsibility for the development and implementation of public policies and actions to guide development throughout Puerto Rico, including flood hazard areas, rests with the Puerto Rico Planning Board.

Official Planning Board policies on development in flood hazard areas are contained in the Objectives and Public Policies for Land Use, adopted by by Board in June 1977. These were also incorporated into the Puerto Rico Coastal Management Program by the Department of Natural Resources in July 1978. The principal objectives and public policies relating to flooding are quoted below:[1]

OBJECTIVE

To reduce to a minimum the danger of loss of life and physical damage in the country, as a result of flooding and the action of wave surge -- at the same time identify and promote those land uses and activities compatible with these conditions.

PUBLIC POLICIES

10.00 To protect the population actually residing in floodable areas or in areas affected by the action of wave surge.

10.01 To construct engineering works which will, at a reasonable cost, prevent property damage and risks to the lives of the citizenry actually affected, giving priority to these works above any other flood control measures.

10.02 Where necessary, to take the appropriate measures to relocate these persons.

11.00 To prohibit land development and construction of structures for urban expansion and other activities which are expressly excluded by current regulation in areas affected by floods and wave surge, except when flood control works or protection against wave surge already exist, are under construction or can be provided at a reasonable cost, to protect the property and guarantee the safety of all the people affected in those lands which are not agricultural(ly) productive, do not have important natural resources, and are not environmentally critical.

[1] Official English translation.

12.00 To stimulate agricultural development in floodable areas which have such potential.

13.00 To construct flood control works with an agricultural approach in areas where it is appropriate, and which will result in an increase in agricultural production.

B. ADDITIONAL POLICIES

The official Planning Board policies are the most formal and broadest statement of the commonwealth's position -- but not the only expression of public policy -- regarding development in flood hazard areas. Regulations, programs, and activities of the Planning Board and of other agencies are a less formal, but still integral, part of the total commonwealth policy regarding development in flood hazard areas.

The Hazard Mitigation Task Force found it desirable to formally state several of these informal policies:

1. To continually add to and improve data on the frequency, extent, and magnitude of flood hazards and their effects.
2. To develop flood hazard mitigation plans for high risk areas.
3. To increase the level of public awareness of flood hazards and what actions they can take to prevent or reduce risks to their person and property.
4. To encourage the purchase of flood insurance by those who live in floodable areas.

IV. POLICY IMPLEMENTATION

The remainder of this hazard mitigation plan describes several actions that the Task Force feels should be taken to help implement the policies presented in the previous section. Because structural measures to protect against flooding are expensive and long-term processes, and because they require detailed investigation, this plan emphasizes the use of non-structural measures. Three measures in particular were emphasized by the Task Force as likely to yield significant returns in reduced loss of life and property and lessened social and economic disruption from future floods. They are:

Flood Insurance

Evacuation Plans

Improved Enforcement of Floodplain Regulations

A. SUMMARY OF RECOMMENDATIONS

A summary of the specific recommendations made by the Task Force is presented below. Subsequent sections provide a discussion of the considerations leading to the recommendations.

FLOOD INSURANCE

Flood Insurance for Privately Owned Structures

1. Promote greater knowledge of the flood insurance program and its benefits through a program of increased public awareness.

   a. The Federal Insurance Administration and EDS Federal Corporation should more actively promote the sale of flood insurance in Puerto Rico.

   b. The Puerto Rico Planning Board and Department of Natural Resources should promote greater awareness of the flood insurance program as part of a general flood hazard awareness program. The following measures should be used:

Radio	Public notices in conspicuous places
Television	Banks
Newspapers	Professional and civic organizations
Special Mailings	

2. FIA should take administrative actions to lower the annual cost of a minimum flood insurance policy by extending the term of the policy from one year to two or three years. This action by FIA would make flood insurance more affordable to low income residents with low value properties.

Insurance Renewal by Recipients of Disaster Aid

1. The Government of Puerto Rico should subsidize the cost of renewing minimum flood insurance policies for about 63,000 families currently insured under the Puerto Rico/FEMA Agreement covering beneficiaries of Individual and Family Grants.

2. Before these policies must be renewed, the Puerto Rico Department of Social Services and municipios should undertake an aggressive public awareness campaign, including direct mailing, personal visits to each household or business, or other appropriate measures to explain the danger of not maintaining adequate flood insurance.

Insurance for Public Buildings

1. Government buildings should be insured against flood damages. However, before purchasing flood insurance, an inventory should be taken of public buildings located in floodable areas and of the value of buildings and building contents that should be insured. The costs and benefits to Puerto Rico of insuring these buildings and contents through the NFIP vs. establishing a qualified program of self-insurance should be evaluated.

FLOODPLAIN REGULATIONS

Enforcement of Planning Regulation Number 13

1. Before taking special measures to try and strengthen enforcement of Planning Regulation Number 13, a brief study of current implementation of the regulation should be conducted in order to document the nature and extent of problems with enforcement.

2. Following completion of this study, the Planning Board, Regulation and Permits Administration, Department of Natural Resources and Department of Housing should prepare an Interagency Agreement detailing the responsibilities of each agency for surveillance and enforcement of Planning Regulation Number 13.

3. The Department of Natural Resources and the Department of Housing should make available personnel to assist with surveillance of floodplain activity in accordance with the Interagency Agreement recommended above.

Revision of Planning Regulation Number 13

1. Planning Regulation Number 13 should be revised as needed to clarify its definitions and provisions and to make any other changes indicated by the study of present enforcement.

Better Mapping of Flood Zones

1. The Planning Board should undertake to have all regulated flood zones mapped at a scale of 1:2,000 for urban zones and 1:4,000 for rural zones.

2. The Planning Board should identify the highest priority V-zones and make a request to FIA that Puerto Rico receive high priority for remapping those V-zones.

Safe Construction and Reconstruction

1. To aid professional engineers and architects in designing and constructing safe structures, the Regulation and Permits Administration, in cooperation with the U.S. Army Corps of Engineers, should prepare a manual describing floodproofing techniques acceptable for use in Puerto Rico.

FLOOD FORECASTING AND WARNINGS

1. NOAA should take immediate steps, in coordination with the CoE, U.S. Geological Survey (USGS), FEMA, and DNR, to develop and implement a fully automated flash flood warnings system, consisting of a radio network of event-reporting rain gages, repeater stations, river gages, and computer equipment. The initial cost is estimated at 1.5 to 2.0 million dollars (including $134,000 for the hardware for 56 rain gages and 31 river gages, and computer equipment).

2. The NWS should continue to work closely with Civil Defense Officials to improve data collection and dissemination of flood warnings. In particular, NWS should identify communities most vulnerable to flash floods, and maintain a continuing educational program for Civil Defense personnel on the potential for "worst case" versus "minimum" flood situations.

3. Plans for preparedness literature and films, whether done by NWS or FEMA, should recognize the special and unique needs of Puerto Rico and be designed accordingly.

4. A major NOAA weather radio publicity campaign should be initiated early every year in Puerto Rico.

EVACUATION PLANNING

1. The Civil Defense Agency and the CoE should perform a survey of flood hazard areas and determine, in order of priority, which areas are in the most danger from flooding or isolation during flooding and need detailed emergency evacuation plans.

2. The Civil Defense Agency, through its On-Site Assistance Program, and municipal civil defense directors should prepare evacuation plans for those areas determined to need formal emergency evacuation plans. As much as possible, these plans should be prepared similar to the ones being prepared by the Corps of Engineers for the Río Grande de Loíza and Río de La Plata coastal floodplains.

3. Other agencies, such as DNR, the Geological Survey and the National Weather Service should assist in the preparation of these evacuation plans by providing funding and technical assistance.

RELOCATION

1. A study of relocation needs and the social and economic impacts of relocation should be undertaken by the Department of Housing. The study should use data available from the 1980 census.

2. Federal funding assistance should be sought for the study as well as for subsequent implementation of any specific relocation program.

FLOOD CONTROL STRUCTURES

Construction of Additional Flood Control Structures

1. Puerto Rico should request the Corps of Engineers to conduct flood control studies for all densely developed areas located within regulatory floodways.

Maintenance of Existing Flood Control Structures

1. The Puerto Rico Legislature should provide additional funding to the Department of Natural Resources (flood control section recently transferred from DTPW) for increased maintenance of storm sewer systems, channelized streams and other flood control structures under Commonwealth responsibility. Municipios should likewise increase funding for maintenance of storm sewers and local canals under their jurisdiction.

IMPROVED INFORMATION ON FLOOD HAZARDS AND IMPACTS

1. Commonwealth, federal and private agencies should collect and maintain information on flood damages and disaster assistance by municipios and socioeconomic areas.

2. The Department of Natural Resources should establish a central information repository that will contain and make available most information on flood hazards, flood damages, and emergency and disaster aid.

3. In order to ensure a complete and consistent information base, the Department of Natural Resources should establish and provide to all concerned agencies clear and simple guidance, including development of appropriate forms, regarding the collection of data on flood damages and disaster assistance.

PUBLIC AWARENESS

1. The Department of Natural Resources should establish a Public Awareness Program to coordinate the flood hazard public awareness activities of other agencies, and to prepare and distribute additional materials that are needed.

HAZARD MITIGATION PLANNING

Additional Hazard Mitigation Plans for Target Areas

1. Additional hazard mitigation plans should be prepared for high priority areas, especially for highly developed floodplains.

Hazard Mitigation Planning Following the Next Declared Flood Disaster

1. The present Hazard Mitigation Task Force should be maintained as a functioning group to assist with the preparation of additional hazard mitigation plans and to help with the implementation of recommendations included in this Puerto Rico Hazard Mitigation Plan and in the hazard mitigation plans for target areas.

2. The Department of Natural Resources, with the assistance of the Task Force, should prepare a set of detailed procedures describing each agency's responsibilities for hazard mitigation planning.

3. FEMA should provide more specific guidance, greater technical assistance, and funding assistance for hazard mitigation planning.

Hazard Mitigation Recommendations for Damage Survey Reports

1. Public agencies should be required to implement the hazard mitigation recommendations contained in Damage Survey Reports in order to receive federal disaster funds.

Follow-up to Hazard Mitigation Recommendations Contained in Hazard Mitigation Plans and Damage Survey Reports

1. The Department of Natural Resources should provide follow-up on recommendations and periodically report to the Governor on progress in implementation.

B. FLOOD INSURANCE

The National Flood Insurance Program (NFIP) is administered by the Federal Insurance Administration (FIA), part of the Federal Emergency Management Agency (FEMA). The Planning Board serves as the coordinating agency for the Flood Insurance Program in Puerto Rico. Puerto Rico entered the Emergency Flood Insurance Program in 1972 and the Regular Flood Insurance Program in August 1978 following the revision of Planning Regulation Number 13 by the Planning Board and preparation of Flood Insurance Rate Maps (FIRMs) by FIA. For purposes of the Flood Insurance Program, Puerto Rico is considered a single community by FIA.

Floodplain residents are eligible for subsidized flood insurance on their principal residence up to $35,000 and up to $10,000 on the contents of their home. An additional $150,000 of coverage for the structure and $50,000 for contents are available at actuarial rates. All new construction or substantial improvements after August 1, 1978 are eligible for flood insurance at actuarial rates. The minimum insurance policy available costs $25.00/year and coverage can be divided between the structure and contents.

Flood insurance is obtained through private insurance agencies. Information on the availability of flood insurance can be obtained from insurance agents, the local office of EDS Federal Corporation which handles insurance policies and claims for FIA, or the Flood Insurance Coordinator in the Planning Board. There is also a toll-free number (800-424-9080) operated by FIA in Washington, D.C. which can be called to obtain information, in English and Spanish, on the Flood Insurance Program.

Government buildings (but not infrastructure such as highways and bridges) are also eligible for federal flood insurance. To date, Puerto Rico has not purchased any flood insurance for government buildings.

Prior to David and Frederic, the greatest number of flood insurance policies in force in Puerto Rico was a little over 9,000 following Tropical Storm Eloise in 1975. Many policies were later allowed to lapse, however, and only about 7,000 policies were in force in August 1979.

As of December 31, 1979, 10,037 policies were in force, indicating that almost 3,000 new policies were issued immediately following David and Frederic, and the number of policies increased to about 16,000 by July 1980. In addition, in March 1980, the Government of Puerto Rico entered into an agreement with FIA to purchase flood insurance for about 63,000 persons who received federal disaster assistance under the Individual and Family Grant program administered by FEMA.

Following are several recommendations concerning the National Flood Insurance Program:

Flood Insurance for Privately Owned Structures

Only about 16,000 flood insurance policies have been voluntarily purchased in Puerto Rico. In order to reduce future disaster assistance payments, and to provide relief from flood damages when a disaster declaration is not made, more people who live in floodplains must be covered by flood insurance. The following recommendations will help to meet this goal.

Recommendations

1. Promote greater knowledge of the flood insurance program and its benefits through a program of increased public awareness.

   a. The Federal Insurance Administration and EDS Federal Corporation should more actively promote the sale of flood insurance in Puerto Rico.

   b. The Puerto Rico Planning Board and Department of Natural Resources should promote greater awareness of the flood insurance program as part of a general flood hazard awareness program. The following measures should be used:

      Radio
      Television
      Newspapers
      Special mailings
      Public notices in conspicuous places
      Banks
      Professional and civic organizations

2. FIA should take administrative actions to lower the annual cost of a minimum flood insurance policy by extending the term of the policy from

one year to two or three years. This action by FIA would make flood insurance more affordable to low income residents with low value properties.

Other possibilities for increasing the number of people covered by flood insurance were discussed, but no conclusions were reached. These possibilities are:

- The Government of Puerto Rico purchase a minimum policy for residents of flood hazard areas.
- Make the purchase of flood insurance mandatory for occupants of flood hazard areas.
- Allow the cost of flood insurance to be deducted from Puerto Rico income tax.

Insurance Renewal by Recipients of Disaster Aid

Following flooding from David and Frederic, approximately 63,000 families, who were not covered by flood insurance, received federal disaster assistance under the Individual and Family Grant Program. Federal regulations prohibit this disaster aid unless the recipient has minimal flood insurance coverage.[1] Under an agreement reached between Puerto Rico and FEMA in March 1980, the Government of Puerto Rico purchased flood insurance for these 63,000 families, using $25 withheld from each disaster assistance grant, so that they would be eligible to receive federal disaster assistance. If the policies are not renewed in one year, these families will not be eligible for disaster aid following the next declared disaster. The Department of Social Services has drafted a bill that would provide for government renewal of these policies, but the bill has apparently not been acted on by the Governor's office. To ensure that the families continue to be covered by flood insurance and eligible for future federal disaster aid, the following recommendations are made:

[1] Current policy, however, allows a disaster victim who did not have flood insurance to receive federal disaster assistance, provided that he purchases flood insurance prior to receiving the aid.

Recommendations

1. The Government of Puerto Rico should subsidize the cost of renewing minimum flood insurance policies for about 63,000 families currently insured under the Puerto Rico FEMA Agreement covering beneficiaries of Individual and Family Grants.

2. Before these policies must be renewed, the Puerto Rico Department of Social Services and municipios should undertake an aggressive public awareness campaign, including direct mailing, personal visits to each household or business, or other appropriate measures to explain the danger of not maintaining adequate flood insurance.

Insurance for Public Buildings

Government buildings are not presently covered by flood insurance, even though they are eligible for flood insurance under the NFIP. Puerto Rico also has the option of creating a program of self-insurance to cover flood damage to public buildings.

Recommendation

1. Government buildings should be insured against flood damages. However, before purchasing flood insurance, an inventory should be taken of public buildings located in floodable areas and of the value of buildings and building contents that should be insured. The costs and benefits to Puerto Rico of insuring these buildings and contents through the NFIP vs. establishing a qualified program of self-insurance should be evaluated.

C. FLOODPLAIN REGULATIONS

Law Number 3 of September 27, 1961, as amended, assigns the Planning Board responsibility for developing regulations governing development in floodplains. Floodplain regulations (Planning Regulation Number 13) under this Law were first adopted by the Planning Board in January 1972. Planning Regulation Number 13 was revised by the Planning Board in July 1978, largely to strengthen and clarify the regulation so that Puerto Rico could qualify for the Regular Flood Insurance Program.

Three flood zones are defined in the revised regulation:

- Zone 1 includes those lands located within the regulatory floodway or provisional floodway, lands subject to action of coastal surges, or those prone to erosion or mudslides due to flooding. This area is considered unfit for building, and no new buildings, enlargement of existing buildings or changed use of buildings is allowed.

- Zone 2 includes those lands located between the limits of the floodway or the provisional floodway and the limits of the floodplain. This area is fit for building under certain conditions. New building is permitted if it is properly floodproofed, if the first floor is higher than the regulatory flood, and if obstruction to the flow of water is minimized.

- Zone E includes those areas located within the floodplain or subject to coastal surges that are already occupied by a settlement or town. New buildings are permitted if they minimize obstruction to the flow of water, are properly floodproofed, and the elevation of the first floor is higher than the regulatory flood.

Planning Regulation Number 13 requires that maps be prepared for all areas subject to flooding. Flood zone maps designating Zones 1, 2, and E were adopted by the Planning Board on February 16, 1980.

Planning Regulation No. 13 also requires that any new construction, reconstruction and buildings repairs permitted within each of the three flood zones be performed

with "floodproofing" measures -- techniques enabling these structures to safely resist the effects of flooding or the action of coastal waves. Although Planning Regulation Number 13 requires floodproofing measures, no particular floodproofing techniques are specifically mentioned in it, nor are floodproofing techniques included in Planning Regulation Number 7 -- Building Regulation.

Enforcement of Planning Regulation Number 13 was originally assigned to the Planning Board for issuance of permits, and to the Urban Renewal and Housing Corporation (urban areas) and the Department of Agriculture's Social Programs Administration (rural areas) for surveillance and inspection of floodable zones. When the regulation was amended in 1978, the Regulation and Permits Administration (RPA) was assigned responsibility for issuing permits, and the Department of Housing assigned responsibility for surveillance and inspection. Law Number 80 of July 3, 1979 amended Law Number 3 of 1961 and assigned the responsibility for surveillance of flood zones to the Regulation and Permits Administration with cooperation in surveillance to be provided by the Department of Natural Resources (DNR) in the coastal zone and by the Department of Housing outside the coastal zone.

Enforcement of Planning Regulation Number 13. The Task Force believes that Planning Regulation Number 13 is not being adequately enforced at the present time. Enforcement has been carried out by RPA, but RPA has informed FEMA that it needs additional building inspectors to do an effective job. Although RPA has recently received additional funds so that it may hire more building inspectors, it feels that it will still not have sufficient manpower. In July 1979, Law Number 30 gave DNR (in the coastal zone) the Department of Housing (outside the coastal zone) responsibility to assist RPA with surveillance of flood zones. To date no actions have been taken to involve these two agencies.

Recommendation

1. Before taking special measures to try and strengthen enforcement of Planning Regulation Number 13, a brief study of current implementation of the regulation should be conducted in order to document the nature and extent of problems with enforcement.

2. Following completion of this study, the Planning Board, Regulation and Permits Administration, Department of Natural Resources and Department of Housing should prepare an Interagency Agreement detailing the responsibilities of each agency for surveillance and enforcement of Planning Regulation Number 13.

3. The Department of Natural Resources and the Department of Housing should make available personnel to assist with surveillance of floodplain activity in accordance with the Interagency Agreement recommended above.

Revision of Planning Regulation Number 13. Although Planning Regulation Number 13 was revised in 1978, there have been suggestions that further revisions are needed, particularly to make some of the provisions and definitions clearer and more precise and to make the terminology more compatible with that in the regulations of the NFIP. A revision would not necessarily make the regulation more stringent. Emphasis would be on eliminating any ambiguities and, therefore, possible hindrances to proper enforcement.

Recommendations

1. Planning Regulation Number 13 should be revised as needed to clarify its definitions and provisions and to make any other changes indicated by the study of present enforcement.

Better Mapping of Flood Zones. Until recently, accurate maps of the floodplain zones defined in Planning Regulation Number 13 were not available. On February 16, 1980 the Planning Board adopted maps of the regulated flood zones, including provisional floodways (Zone 1). Final Regulatory Floodways are still being determined in cooperation with FIA, and maps delineating them will be published in the future. These maps are all at a scale of 1:20,000. Suggestions have been made that maps be prepared at a larger scale to aid enforcement of Planning Regulation Number 13.

The V-zones (velocity zones) currently shown on FIA's Flood Insurance Rate Maps (FIRM) understate the area that would be affected by a 100-year flood and the severity of the flooding that would occur. FIA has recognized

this problem and developed a new methodology for revising the V-zones to improve their accuracy. FIA plans to remap all V-zones in the next few years using this new methodology.

Recommendations

1. The Planning Board should undertake to have all regulated flood zones mapped at a scale of 1:2,000 for urban zones and 1:4,000 for rural zones.

2. The Planning Board should identify the highest priority V-zones and make a request to FIA that Puerto Rico receive high priority for remapping those V-zones.

Safe Construction and Reconstruction. Planning Regulation Number 13 requires safe construction and reconstruction in floodplains. However, it does not specify what constitutes safe construction and reconstruction, nor does Planning Regulation Number 7.

Recommendation

1. To aid professional engineers and architects in designing and constructing safe structures, the Regulation and Permits Administration, in cooperation with the U.S. Army Corps of Engineers, should prepare a manual describing floodproofing techniques acceptable for use in Puerto Rico.

D. FLOOD FORECASTING AND WARNINGS

Puerto Rico's relatively small size and the many small drainage basins that divide the island prevent geographically detailed predictions of the occurrence of flash flooding by standard forecasting techniques. As a result, the warning time available is usually a matter of only hours, or even minutes. Many of the techniques that have been developed for use on the U.S. mainland are not transferable to Puerto Rico's climatic and topographic conditions.

The National Weather Service (NWS) is responsible for issuing weather forecasts and flood warnings and provides assistance to communities in establishing flood warning systems. The NWS maintains a weather radar system and a rainfall measurement network with daily readings at about 100 stations plus 20 continuous recording automatic rain gages around the island. Hurricane, flash flood, and other emergency weather warnings are transmitted to the Office of Civil Defense, radio, press and television outlets, as well as being broadcast to the public on NOAA Weather Radio (PBS Bank - VHF 162.4 mz).

The National Weather Service has also established a demonstration program for providing advanced warnings of flash flooding at towns situated along rivers and creeks. Flash Flood Alarm Systems are now installed at three flood-prone towns -- the first on Río Humacao to protect the town of Humacao; the second on Río Guanajibo to protect the towns of San Germán, Hormigueros and parts of Mayagüez; and the third on Río Portugués to protect the Ponce area. The Flash Flood Alarm Program is a cooperative one in that the NWS provides and installs the equipment (valued at approximately $5,000) and performs maintenance for the first two years. The local community is responsible for initial and recurring utility costs, maintenance after the first two years, continuous monitoring of the alarm system display panel, and taking appropriate actions in the event of a flood. NWS has no plans to install additional systems in other towns, but will provide technical assistance if communities wish to act on their own.

The NWS has planned improvements in several areas. One is installation of a new weather radar system at Isla Verde International Airport. This system,

which will be operational by summer 1980, will improve the NWS capability to detect and evaluate heavy rain-producing situations with the potential for flash flooding. The radar system will allow NWS to issue prompt, localized flash flood warnings, as well as hurricane warnings.

A second improvement involves installation of a NOAA weather radio transmitter in Maricao. This transmitter will provide coverage of the western half of the island. (A first radio transmitter was completed last year at Aguas Buenas to cover the eastern half of the island.) This system will broadcast public service weather forecasts, additional warnings, and special bulletins on a 24 hour-a-day basis, in English and Spanish. The transmitter uses a frequency available on special weather radios or ones with a "weather band", but not on the average home radio.

A third improvement will be the installation of an automatic forecasting operations system at Isle Verde Airport that will provide computerized methods for handling weather data. Operational testing will continue through 1980.

Following Hurricane David and Tropical Storm Frederic, the National Weather Service conducted an evaluation[1] of its flood forecasting and warning systems in Puerto Rico. That evaluation examined the possibility of instituting several types of improvements to the existing system. The NWS report also acknowledged that many types of improvements used elsewhere are simply not applicable to Puerto Rico because of weather conditions, topography, limitations on communications systems, and other factors. Nevertheless, NWS has developed recommendations to improve the existing flood forecasting and warnings systems in Puerto Rico. Recommendations that would require cooperation with other federal and commonwealth agencies, and with which the Task Force concurs and endorses, are:

Recommendations

1. NOAA should take immediate steps, in coordination with the CoE, U.S. Geological Survey (USGS), FEMA, and DNR, to develop and implement a

[1] Natural Disaster Survey Report, Hurricanes David and Frederic as They Concerned Puerto Rico and the U.S. Virgin Islands August 26-September 5, 1979, National Weather Service, Southern Region, Fort Worth, Texas, December 1979.

fully automated flash flood warnings system, consisting of a radio network of event-reporting rain gages, repeater stations, river gages, and computer equipment. The initial cost is estimated at 1.5 to 2.0 million dollars (including $134,000 for the hardware for 56 rain gages and 31 river gages, and computer equipment).

(NWS has already submitted an initial proposal to its headquarters office. NWS has set priorities for installation of the system in accordance with work of the Hazard Mitigation Task Force -- specifically first priority to Río Grande de Loíza and Río La Plata -- and has indicated that further priorities will also be identified in cooperation with the Task Force.)

2. The NWS should continue to work closely with Civil Defense Officials to improve data collection and dissemination of flood warnings. In particular, NWS should identify communities most vulnerable to flash floods, and maintain a continuing educational program for Civil Defense personnel on the potential for "worst case" versus "minimum" flood situations.

3. Plans for preparedness literature and films, whether done by NWS or FEMA, should recognize the special and unique needs of Puerto Rico and be designed accordingly.

4. A major NOAA weather radio publicity campaign should be initiated early every year in Puerto Rico.

Other recommendations contained in the NWS report concern specific river basins, and where appropriate, are included in hazard mitigation plans for those particular areas. Still other recommendations would primarily affect NWS's own operations: for example, recommendations to establish new reporting stations in the Virgin Islands and to add a staff position for a flash flood and hurricane warning specialist.

E. EVACUATION PLANNING

The Puerto Rico Civil Defense Agency is designated by Law Number 22 of June 1976 as the agency responsible for coordinating the activities of all Commonwealth and municipal agencies in response to emergencies and disasters, including evacuation from flood-prone areas. Responsibility for actually evacuating people in time of flooding is shared by the Puerto Rico Civil Defense Agency and municipal civil defense organizations.

Few, if any, formal evacuation plans exist. Residents are not informed in advance of evacuation procedures. Evacuation procedures usually consist of radio announcements and the individual warnings of Commonwealth and municipal civil defense workers who drive through flood-prone areas sounding alerts from amplifiers. Information is usually not provided on safe evacuation routes.

Experience indicates that these measures are not totally effective; residents often resist evacuation attempts. Because minor flooding occurs so frequently, residents of many areas appear to accept flooding as an unavoidable part of life. This attitude seems to extend to more serious flooding, with many people making light of or ignoring the threat of dangerous flooding. Other people apparently are reluctant to leave for fear of their houses being looted. In some areas, there was substantial resistance to evacuation during Hurricane David and Tropical Storm Frederic. As a result, many people who could have been safely evacuated before flooding began later needed to be rescued during a time of serious flooding, creating a risk to themselves and their rescuers.

In the event of more severe flooding in a future storm, there is a very real potential for people to resist evacuation, become trapped by floodwaters and suffer serious injury or loss of life. More complete and effective evacuation plans and procedures could help to reduce this problem.

Such formal evacuation planning has not occurred because of a lack of available funding, a lack of expertise concerning preparation of detailed plans, and an apparent lack of awareness of the need to prepare more detailed

formal evacuation plans. As part of this hazard mitigation planning effort, the U.S. Army Corps of Engineers has been asked to prepare emergency evacuation plans for the coastal floodplains of Río Grande de Loíza and Río de La Plata.[1]

Recommendations

1. The Civil Defense Agency and the CoE should perform a survey of flood hazard areas and determine, in order of priority, which areas are in the most danger from flooding or isolation during flooding and need detailed emergency evacuation plans.

2. The Civil Defense Agency, through its On-Site Assistance Program, and municipal civil defense directors should prepare evacuation plans for those areas determined to need formal emergency evacuation plans. As much as possible, these plans should be prepared similar to the ones being prepared by the Corps of Engineers for the Río Grande de Loíza and Río de La Plata coastal floodplains.

3. Other agencies, such as DNR, the Geological Survey, and the National Weather Service should assist in the preparation of these evacuation plans by providing funding and technical assistance.

[1] Discussed in more detail in the hazard mitigation plans for these specific areas.

F. RELOCATION

Locating acceptable building sites in Puerto Rico is difficult because much of the land is either steeply sloped or subject to flooding. Since floodplains provide large areas of level land, there have been extensively developed. Hundreds of thousands of people now live and work within floodplains. It would be neither possible nor desirable to permanently relocate all of these people from the floodplains.

However, some people live in high risk areas -- designated floodways and coastal V-zones are areas of greatest risk -- and are subject to frequent and severe flooding. It may be possible to permanently relocate some of the residences and businesses from these high risk areas.

Permanent relocation is usually an expensive and long-term procedure that may have serious social and economic consequences. Further, since everyone cannot be relocated at once, priorities will have to be established, which may create additional problems. No up-to-date information exists[1] to determine how many people should be considered for relocation and what the social and economic costs and benefits of relocation would be.

Permanent relocation was one of the principal hazard mitigation measures considered by the Task Force. However, lack of precise information concerning number of persons in high risk areas, the costs of relocation, and the social impacts of relocation prevented the Task Force from developing specific recommendations regarding relocation.[2] Social issues are further compounded because many of the developed areas that are candidates for relocation are occupied by low income families who have built illegally on vacant government and private land. In other areas equally at risk are established portions of principal towns.

Recognizing this, the Department of Housing, in late 1979 following David

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[1] The Department of Housing conducted a study of relocation potential in 1964.

[2] Hazard Mitigations Plans for the target areas of Río Grande de Loíza and Río de La Plata contain specific recommendations for relocation of selected businesses and residences.

and Frederic, prepared a draft bill[1] for presentation to the legislature that would authorize the Department of Housing to conduct a socioeconomic study of potential relocation. The proposed study would include selection of the most critical areas, identification of alternate sites, relocation costs, sources of funds, and an analysis of the feasibility of relocation. Estimated cost of the proposed study was $1.6 million. The legislature has not acted on the proposal.

Recommendations

1. A study of relocation needs and the social and economic impacts of relocation should be undertaken by the Department of Housing. The study could use data available from the 1980 census.

2. Federal funding assistance should be sought for the study as well as for subsequent implementation of any specific relocation program.

[1] House Bill No. 3818, April 14, 1980.

G. FLOOD CONTROL STRUCTURES

Puerto Rico has relied on channelization as the principal structural measure for flood protection. Levees have also been built, usually by private developers, to protect some communities. No major flood control reservoirs have been built, although a few small detention basins have been constructed, and two multi-purpose reservoirs are planned that will protect Ponce from flooding. Storm sewers also serve as a flood protection measure.

Among the structural works undertaken in response to damages caused by Hurricane David and Tropical Storm Frederic were channel restoration projects sponsored by the Soil Conservation Service. A summary of these is included below:

SCS CHANNEL RESTORATION PROJECTS
(Funded under Emergency Watershed Protection Program)

Project	Quantity	Estimated Cost	Estimated Completion Date	Measures Installed as of June 20, 1980
1. Coto Santo Domingo Creek Penuelas, P.R.	2,100 Lin.Ft.	$374,840	Oct. 8, 1980	Presently under installation
2. Coto Pueblo Creek Penuelas, P.R.	2,500 Lin.Ft.	37,000	May 13, 1980	4,000 Lin.Ft. $33,300
3. Río Grande de Patillas, P.R.	13,300 Lin.Ft.	116,000	Aug. 2, 1980	Presently under installation
4. Río Yauco Guayanilla, P.R.	7,800	142,000	July 14, 1980	Presently under installation
5. Río Guayanilla Guayanilla, P.R.	3,350 Lin.Ft.	37,000	June 24, 1980	Presently under installation
6. Río Cruces Sabana Grande, P.R.	1,667	9,350	Mar. 26,	1,700 - $9,800

Construction of Additional Flood Control Structures

Flood control structures to protect extensively developed floodplains are expensive. Most flood control studies performed by the Corps of Engineers and the Soil Conservation Service, at the request of Puerto Rico, have not shown a favorable benefit/cost ratio. Nevertheless, detailed flood insurance studies now being completed show a number of densely developed

areas within regulatory floodways. Some protection for these communities must be provided.

Recommendation

1. Puerto Rico should request the Corps of Engineers to conduct flood control studies for all densely developed areas located within regulatory floodways.

Maintenance of Existing Flood Control Structures

Because of inadequate maintenance, many existing flood control structures function at less than their design capacity. Some levees have been breached or reduced in height. Many channelized rivers carry less than their design capacity because they are allowed to become partially blocked with vegetation and debris. The same is true of storm drainage systems, and the inadequate maintenance results in frequent flooding from relatively small storms.

Recommendation

1. The Puerto Rico Legislature should provide additional funding to the Department of Natural Resources (flood control section recently transferred from DTPW) for increased maintenance of storm sewer systems, channelized streams and other flood control structures under commonwealth responsibility. Municipios should likewise increase funding for maintenance of storm sewers and local canals under their jurisdiction.

H. IMPROVED INFORMATION ON FLOOD HAZARDS, AND IMPACTS

During the last few years the information concerning flood hazards and impacts has been greatly improved. A large part of this data increase is due to the preparation of detailed flood insurance studies and floodplain maps. As these studies are completed, the data base on hazards will be further improved. Recent studies[1], however, have shown that there remains a deficiency in readily available data on damages caused by flooding and on technical and financial assistance provided to prevent and to recover from flooding.

Information on damages caused by floods and the types and amounts of aid provided following floods is often available only for Puerto Rico as a whole. Many agencies do not collect and maintain information on a municipio basis. However, to conduct adequate hazard mitigation planning and to properly evaluate the effectiveness of hazard mitigation measures, data must be available broken down to at least the municipio level.

Information on the magnitude, frequency and extent of flood hazards is reasonably available since it is collected and maintained by only a few Puerto Rico and federal agencies located in Puerto Rico. Information on flood damages and emergency and disaster assistance is often not readily accessible since it is maintained by many agencies in Puerto Rico, New York, Washington, D.C. and other locations. It can be difficult and costly to obtain needed data, thereby hampering flood hazard planning and evaluation.

Recommendations

1. Commonwealth, federal and private Agencies should collect and maintain information on flood damages and disaster assistance by municipios and socioeconomic areas.

2. The Department of Natural Resources should establish a central information repository that will contain and make available most information on flood hazards, flood damages, and emergency and disaster aid.

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[1] Coastal Flood Hazards and Responses in Puerto Rico: An Overview, Puerto Rico Department of Natural Resources, February 1980.

Research performed as part of this current hazard mitigation planning effort.

3. In order to ensure a complete and consistent information base, the Department of Natural Resources should establish and provide to all concerned agencies clear and simple guidance, including development of appropriate forms, regarding the collection of data on flood damages and disaster assistance.

I. PUBLIC AWARENESS

Several government agencies presently prepare and distribute limited amounts of public awareness materials. However, the total public awareness effort is relatively small, and there is no coordination among the agencies to make the most effective use of existing programs. The result of these limited and uncoordinated efforts is that the public is not sufficiently informed regarding flood hazards and what they can do to protect their property and lives.

No single agency is responsible for preparing and distributing all flood hazard public awareness materials, nor should a single agency have that responsibility; several agencies should continue to be involved. However, there is presently no formal coordination among these agencies. Lack of coordination means that one agency could duplicate the efforts of another agency; or more likely -- and as is now the case -- not all needed materials are prepared and not all segments of the public are provided with the information they need, when they need it.

Recommendation

1. The Department of Natural Resources should establish a Public Awareness Program to coordinate the flood hazard public awareness activities of other agencies, and to prepare and distribute additional materials that are needed.

J. HAZARD MITIGATION PLANNING

Three types of hazard mitigation planning are now taking place:

- o this general hazard mitigation plan covering all of Puerto Rico
- o hazard mitigation plans for the selected target areas of Río de La Plata and Río Grande de Loíza
- o hazard mitigation recommendations prepared as part of Damage Survey Reports.

Because requirements for hazard mitigation planning are new and not clearly defined, hazard mitigation planning following David and Frederic got off to a slow start. Fortunately, although the flood damages from David and Frederic were extensive, they were not severe, and little or nor disadvantage has resulted from this slow start. However, the next major flood may cause more serious damages and present some special hazard mitigation opportunities if action can be taken quickly.

Additional Hazard Mitigation Plans for Target Areas

Two target area hazard mitigation plans are nearly completed: the coastal floodplains of Río Grande de Loíza and Río de La Plata. Two more are just getting underway: floodplains of Río Guanajibo and Río Guayanilla. Other areas could benefit from similar planning.

Recommendation

1. Additional hazard mitigation plans should be prepared for high priority areas, especially for highly developed floodplains.

Hazard Mitigation Planning Following the Next Declared Flood Disaster

Unfortunately, Puerto Rico is certain to experience additional serious flooding in the coming months, and is very likely to face another flood disaster before too long. The present efforts at hazard mitigation planning are intended to reduce the frequency and severity of flood losses. Nevertheless, when another disaster does occur, further hazard mitigation planning may be found necessary and may be required in order to receive federal aid. To ensure that future hazard mitigation planning proceeds quickly and efficiently, certain actions must be taken now.

Recommendations

1. The present Hazard Mitigation Task Force should be maintained as a functioning group to assist with the preparation of additional hazard mitigation plans and to help with the implementation of recommendations included in this Puerto Rico Hazard Mitigation Plan and in the hazard mitigation plans for target areas.

2. The Department of Natural Resources, with the assistance of the Task Force, should prepare a set of detailed procedures describing each agency's responsibilities for hazard mitigation planning.

3. FEMA should provide more specific guidance, greater technical assistance, and funding assistance for hazard mitigation planning.

Hazard Mitigation Recommendations for Damage Survey Reports

Damage Survey Reports (DSR's) have been prepared for all public buildings and facilities which were damaged by David and Frederic and for which federal assistance for repair and reconstruction has been requested. For some of these facilities, FEMA has also prepared generalized hazard mitigation recommendations -- actions that can be taken to reduce the likelihood of damage from future floods. At present, this process of preparing hazard mitigation recommendations for individual facilities is informal; there is no requirement for Puerto Rico agencies to implement the recommendations.

Recommendation

1. Public agencies should be required to implement the hazard mitigation recommendations contained in Damage Survey Reports in order to receive federal disaster funds.

Follow-up to Hazard Mitigation Recommendations Contained in Hazard Mitigation Plans and Damage Survey Reports

Implementation of the many hazard mitigation recommendations contained in this Puerto Rico Hazard Mitigation Plan, the target area hazard mitigation plans, and the Damage Survey Reports could help to greatly reduce damages

and suffering from future floods. Failure to implement the recommendations could mean continued high damages and possible loss of life as well as possible loss of federal disaster assistance. Realistically, not all recommendations will be fully implemented in the near future, but many can be.

Recommendation

1. The Department of Natural Resources should provide follow-up on recommendations and periodically report to the Governor on progress in implementation.

APPENDICES

APPENDIX A: FEDERAL/COMMONWEALTH DISASTER ASSISTANCE AGREEMENT

FEDERAL EMERGENCY MANAGEMENT AGENCY

REGIONAL OFFICE

26 FEDERAL PLAZA, NEW YORK, NEW YORK 10007

REGION II

IN REPLY REFER TO

September 5, 1979

Honorable Carlos Romero-Barceló
Governor of the Commonwealth of
Puerto Rico
San Juan, Puerto Rico 00903

Dear Governor Romero-Barceló:

1. This letter is the Federal/Commonwealth Disaster Assistance Agreement for a Major Disaster, No. FEMA 597 DR Puerto Rico, under Public Law 93-288, in accordance with Section 2205.44 of the Federal Disaster Assistance Regulations. A copy of the Regulations and Exhibit A, Federal Financial Assistance, and Exhibit B, Commonwealth Certification Officers, are attached hereto and made a part hereof.

2. On September 2, 1979, the President determined that damages resulting from high winds, heavy rains, and flooding beginning on or about August 29, 1979, have caused a major disaster in the Commonwealth of Puerto Rico and you hereby acknowledge receipt of notice of this declaration. You have certified that the Commonwealth of Puerto Rico or other public agencies thereof are expected to expend $5,000,000, for disaster relief purposes for which no Federal reimbursement has been or will be received, in accordance with the table contained in your request, as amended. A copy of your request is attached hereto as Exhibit C, and made a part hereof.

3. Federal assistance will be made available in accordance with Public Law 93-288, Executive Order 11795, and the Regulations attached hereto.

4. The duration of the catastrophe, causing the damage with which this Agreement is concerned, is from August 29, 1979, through September 6, 1979; no project application will be approved for assistance required to alleviate damage as a result of this major disaster occurring at any other times.

5. In the event that funds are to be transferred to the Commonwealth of Puerto Rico for disaster relief purposes; the Commonwealth and its political subdivision, agree to the following: In the event that the Commonwealth of Puerto Rico or its political subdivisions violate any of the con-

ditions imposed upon disaster relief assistance under Public Law 93-288, this Agreement, or applicable Federal Regulations, the Director will notify the Commonwealth that additional financial assistance for the purpose of the project in connection with which the violation occurred will be withheld until such violation has been corrected. Provided, however, that the Director, after such notice to the Commonwealth, is not satisfied with the corrective measures taken to comply with his notification, the Director will notify the Commonwealth that further financial assistance will be withheld for the project for which it has been determined that a violation exists, or for all or any portion of financial assistance which has or is to be made available to the Commonwealth or local governments for the purpose of disaster relief assistance under the provisions of Public Law 93-288, this Agreement, or applicant Federal Regulations.

6. No member of or Delegate to Congress, or Resident Commissioner, shall be admitted to any share or part of this Agreement, or to any benefit to arise thereupon. Provided, however, that this provision shall not be construed to extend to any contract made with a corporation for its general benefit.

7. The Commonwealth Officers authorized to execute certifications and otherwise to act on behalf of the Commonwealth are listed in Exhibit B which is attached hereto and made a part hereof.

8. Federal assistance extended under Public Law 93-288 and this Agreement shall be limited to the following areas of the Commonwealth of Puerto Rico and such additional areas as may be subsequently designated by the Director of the Federal Emergency Management Agency.
The Municipios of:

Arecibo	Humacao
Arroyo	Manatí
Barceloneta	Ponce
Toa Baja	Dorado
Vega Baja	Juana Diaz
Guánica	Jayuya
Guayanilla	Canóvanas
Carolina	

for Individual Assistance only.

9. The state agrees: (1) to review and update as necessary disaster mitigations portions of the Commonwealth Emergency Plan; (2) that, as a condition for any Federal loan or grant, the applicant shall evaluate the natural hazards in the areas in which the proceeds of the grants or loans are to be used and shall take appropriate action to mitigate such hazards, including safe land use and construction practices; and (3) to follow up with applicants, within Commonwealth capabilities, to assure that appropriate hazard mitigation actions are taken.

The Regional Director agrees to make Federal technical advice and assistance available to support these planning efforts and actions.

10. The Commonwealth will establish and maintain an active program under this Agreement of non discrimination in disaster assistance outlined in Part 2205.13, Title 24, CFR. This program will encompass all Commonwealth and local actions pursuant to this Agreement.

11. The Commonwealth will establish and maintain a program under this Agreement to assure that recipients of the FEMA Disaster Assistance comply with 24 CFR, Part 24, Debarment, Suspension and Ineligibility of Contractors and Grantees. This program will encompass all Commonwealth and local contracts pursuant to this Agreement.

12. The Commonwealth will notify all Commonwealth and local agencies and local goverments within the areas defined by this Agreement of the time limitations agreed to herein and the terms and conditions of eligibility for Federal assistance.

13. This Agreement may be amended at any time by written approval of both parties.

Sincerely,

Norman Steinlauf
Acting Regional Director
Federal Emergency Management Agency

Agreed:

Carlos Romero Barceló
Governor

9/7/79
Date

APPENDIX B: HAZARD MITIGATION TASK FORCE

AGENCY	REPRESENTATIVE
Commonwealth:	
Department of Natural Resources	Gabriel Del Toro, Chairman Ruben Freyre
Governors Authorized Representative for (P.R. Telephone Co.)	Juan Negrón
State Civil Defense Agency	Antonio V. Munera
Puerto Rico Planning Board	Boris Oxman
Department of Transportation and Public Works	Rafael Torres García
Department of Education	Heriberto Capella
Puerto Rico Aqueduct and Sewer Authority	José R. Goitía
Department of Housing	Cesáreo Angleró * Francisco Hernández**
Regulations and Permits Administration	Oscar Piñeiro* Telesforo Carrero**
Puerto Rico Industrial Development Co.	John Smith
Municipios:	
Loiza	Felipe Sanjurjo
Carolina	Roberto Bonilla
Canovanas	Miguel Del Valle
Dorado	Manuel J. Canino
Toa Baja	Antonio Rivera
Federal:	
Federal Emergency Management Agency	Curtis Carleton
U.S. Army Corps of Engineers	Emilio Colón
National Weather Service	Robert Calvesbert
U.S. Geological Survey	Karl G. Johnson
U.S. Soil Conservation Service	Oscar Pérez
Housing and Urban Development	Arcadio Torres* Manuel Seone**

*Original representative
**Replacement

APPENDIX C: HAZARD MITIGATION WORK GROUP

AGENCY	REPRESENTATIVE
Department of Natural Resources	Félix I. Aponte, Chairman Ada Sotto
Puerto Rico Planning Board	Rafael Esteva
Department of Transportation and Public Works	René Beauchamp
State Civil Defense	Roberto Martínez Nora Zenoni
Federal Emergency Management Agency	Eduardo García* Ramón Martínez** Rafael Ramírez**
U.S. Army Corps of Engineers	Emilio Colón
National Weather Service	Robert Calvesbert

*Original representative
**Replacement

APPENDIX D: MUNICIPIOS ELIGIBLE FOR DISASTER ASSISTANCE

For Individual and Public Assistance

Adjuntas
Aibonito
Añasco
Arecibo
Arroyo
Barceloneta
Barranquitas
Cabo Rojo
Caguas
Canóvanas
Carolina
Cataño
Cayey
Ceiba
Ciales
Cidra
Coamo
Comerío
Corozal
Culebra
Dorado
Fajardo
Guánica
Guayama
Guayanilla
Gurabo
Hormigueros
Humacao
Jayuya
Juana Díaz
Juncos
Lajas
Lares
Las Piedras
Loíza
Luquillo
Manatí
Maricao
Maunabo
Mayagüez
Morovis
Naguabo
Naranjito
Orocovis
Patillas
Peñuelas
Ponce
Río Grande
Sabana Grande
Salinas
San Germán
San Juan
San Lorenzo
Santa Isabel
Toa Baja
Utuado
Vega Baja
Vieques
Yabucoa
Yauco

For Individual Assistance Only

Aguada
Rincón
San Sebastián

For Public Assistance Only

Aguas Buenas
Bayamón
Florida
Guaynabo
Las Marías
Toa Alta
Trujillo Alto
Vega Alta
Villalba