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106th Congress, 2d Session – – – – – – – – – – – – House Document 106–192

RIO GRANDE DE MANATI AT BARCELONETA, PUERTO RICO FLOOD DAMAGE REDUCTION PROJECT

COMMUNICATION

FROM

THE ASSISTANT SECRETARY (CIVIL WORKS), THE DEPARTMENT OF THE ARMY

TRANSMITTING

NOTIFICATION THAT THE SECRETARY OF THE ARMY SUPPORTS THE AUTHORIZATION AND PLANS TO IMPLEMENT THE FLOOD DAMAGE REDUCTION PROJECT ALONG THE RIO GRANDE DE MANATI AT BARCELONETA, PUERTO RICO

FEBRUARY 8, 2000.—Referred to the Committee on Transportation and Infrastructure and ordered to be printed

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U.S. GOVERNMENT PRINTING OFFICE

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LETTER OF TRANSMITTAL

DEPARTMENT OF THE ARMY
OFFICE OF THE ASSISTANT SECRETARY
CIVIL WORKS
108 ARMY PENTAGON
WASHINGTON DC 20310-0108

REPLY TO
ATTENTION OF

28 MAY 2002

Honorable J. Dennis Hastert
Speaker of the House
of Representatives
Washington, D.C. 20515

Dear Mr. Speaker:

Section 101(a)(28) of the Water Resources Development Act (WRDA) of 1999, authorized construction of a flood damage reduction project along the Rio Grande de Manati at Barceloneta, Puerto Rico. The Secretary of the Army supports the authorization and plans to implement the project through the normal budget process.

The project is described in the report of the Chief of Engineers dated April 21, 1999, which includes other pertinent reports and documents. The views of the Commonwealth of Puerto Rico, and the Departments of the Interior, Commerce, and Housing and Urban Development are set forth in the enclosed report.

Implementation of the project will provide the town of Barceloneta with an estimated 100-year level of flood protection. The project involves constructing about 3.3 miles of levee around the town of Barceloneta, and constructing about 1 mile of pilot channel in the Rio Grande de Manati, east of the town. The levee would have an average height of about 17.7 feet and an average base width of about 125 feet. The project also includes interior drainage facilities to collect, detain, and dispose of runoff from rainfall inside the levee. Two areas totaling about 360 acres in size would store the interior runoff during storms. The project is the national economic development (NED) plan, and no separable fish and wildlife mitigation measures are required for either the construction, or the operation and maintenance of the completed project.

The Army Corps of Engineers developed the project pursuant to the authority provided by Section 205 of the Flood Control Act of 1948, as amended. The Chief of Engineers approved the project for implementation under that authority on November 8, 1994. On May 10, 1999, the Corps and the non-Federal sponsor executed a Project Cooperation Agreement (PCA)

to construct the project under the Section 205 authority. Since they signed the PCA before enactment of WRDA 1999, the Federal share of the total cost of the project is limited to $5 million. At October 1998 price levels, the Corps estimates that the first cost of the project is about $13,490,000. In accordance with Section 205 of the Flood Control Act of 1948, as amended, the Federal share of construction costs would be about $4,609,000, while the non-Federal share would be about $8,785,000. The Federal cost limit of $5 million is reached when the study costs are added.

With the specific authorization of the project by the Congress in WRDA 1999, a new PCA will be required since the construction authority and the cost sharing have changed, and the $5 million Federal cost limit is no longer applicable. In accordance with WRDA 1986, as amended by Section 202(a) of WRDA 1996, the Federal and non-Federal costs are revised to be about $8,785,000 and $4,705,000, respectively. The Puerto Rico Department of Natural and Environmental Resources would be responsible for operating and maintaining the completed project, and would also be required to develop and adopt a comprehensive flood plain management plan for the project area.

The Office of Management and Budget advises that there is no objection to the submission of the report to the Congress. A copy of its letter is enclosed in the report.

Sincerely,

Joseph W. Westphal
Assistant Secretary of the Army
(Civil Works)

Enclosure

COMMENTS OF THE OFFICE OF MANAGEMENT AND BUDGET

EXECUTIVE OFFICE OF THE PRESIDENT
OFFICE OF MANAGEMENT AND BUDGET
WASHINGTON, D.C. 20503

December 9, 1999

The Honorable Joseph W. Westphal
Assistant Secretary of the Army
for Civil Works
Pentagon - Room 2E570
Washington, D.C. 20310-0108

Dear Dr. Westphal:

As required by Executive Order 12322, the Office of Management and Budget has completed its review of your recommendation of January 22, 1999, concerning the flood damage reduction improvements for the Rio Grande de Manati at Barceloneta, Puerto Rico.

Your recommendation for this project is consistent with the policies and programs of the President. The Office of Management and Budget does not object to your submitting the recommendation and report to Congress.

Sincerely,

Kathy Peroff
Deputy Associate Director
Energy and Science

COMMENTS OF THE MUNICIPALITY OF BARCELONETA, PUERTO RICO

GOVERNMENT OF PUERTO RICO
OFFICE OF THE GOVERNOR
PLANNING BOARD

MINILLAS GOVERNMENTAL CENTER, NORTH BLDG.
DE DIEGO AVE, STOP 22
P.O. BOX 41119, SAN JUAN, PUERTO RICO 00940-1119

November 2, 1998

Mr. David B. Sanford, Jr.
Chief, Policy Division
Directorate of Civil Works
Department of the Army
U.S. Corps of Engineers
Washington, D.C. 201314-1000

Dear Mr. Sanford, Jr.:

This is in reference to your letter of October 2, 1998, requesting comments on the Río Grande de Manatí flood control project, at the Municipality of Barceloneta.

We have evaluated the Supplemental Report, Revised July 1998 which includes the authorized project for Río Grande de Manatí. Its design reflects mainly the original concept of a ring levee around the east, north and west side of the urban core of the Municipality.

Few years ago, the Planning Board issued some comments on this project. Among them, the Board is concerned about the lands approximately 2,365 acres to be dedicated for the local drainage or storing the residual flooding caused by interior runoff. These lands described as agricultural lands, 57.5 acres on the east and 179.0 acres on the north, are located within the floodway of Río Grande de Manatí. Once the project be completed, this Board will take the appropriate action to maintain the lands for agricultural use or dedicated to open space. We also concerned about the effective base flood elevation which are lower (one meter) than the estimated 100 year flood stages computed by the U.S. Corps of Engineers study. This also represents a future revision of the Flood Insurance Study for which we requested FEMA to revise it in the near future.

We are in agreement with the proposed plan which represent a great benefit for the redevelopment of the Municipality of Barceloneta. We also encourages to expedite the necessary steps for the approval of the Secretary of the Army.

Cordially yours,

José R. Caballero Mercado

José R. Caballero-Mercado
Chairman

ET/RM/mla

COMMENTS OF THE DEPARTMENT OF THE INTERIOR

United States Department of the Interior

OFFICE OF THE SECRETARY
Washington, D.C. 20240

ER 98/634

NOV 2 1998

Mr. David B. Sanford, Jr.
Chief, Policy Division
Directorate of Civil Works
ATTN: CECW-AR (SA)
7701 Telegraph Road
Alexandria, VA 22315-3861

Dear Mr. Sanford:

The U.S. Department of the Interior has reviewed the Chief of Engineers Proposed Report, Final Detail Project Report and Environmental Assessment for the Rio Grande De Manati, Barceloneta, Puerto Rico.

The Fish and Wildlife Service has been coordinating this project with the Corps for several years. Our major concerns centered around possible impacts to Threatened and Endangered Species particularly the Puerto Rican boa (Epicrates inornatus). The current plan adequately mitigates for impacts to wetlands and avoids impacts to endangered species. If the borrow or disposal sites are changed, however, the Corps should re-initiate Section 7 consultation under the Endangered Species Act.

Thank you for the opportunity to review these materials.

Sincerely,

Willie R. Taylor, Director
Office of Environmental
Policy and Compliance

COMMENTS OF THE DEPARTMENT OF COMMERCE

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Southeast Regional Office
9721 Executive Center Drive N.
St. Petersburg, Florida 33702

October 13, 1998

Directorate of Civil Works
Policy Division, Policy Review Branch
ATTN: CECW-AR
7701 Telegraph Road
Alexandria, Virginia 22315-3861

Dear Sir or Madam:

This responds to the September 14, 1998, Notice of Completion of the Feasibility Study (FS) and Environmental Assessment (EA) for the Rio Grande de Manati flood control project near Barceloneta, Puerto Rico. The recommended plan provides for the construction of a levee around the town of Barceloneta and pilot channels for the Rio Grande.

The National Marine Fisheries Service has reviewed the FS/EA and anticipates that the project will only minimally impact marine and estuarine fishery resources under its purview. Therefore, we have no comments or objections to the project.

Sincerely,

Andreas Mager, Jr.
Assistant Regional Administrator
Habitat Conservation Division

COMMENTS OF THE DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT

U.S. DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT
CARIBBEAN OFFICE , SOUTHEAST/CARIBBEAN
OFFICE OF THE CARIBBEAN COORDINATOR
171 Carlos Chardon Avenue - Suite 301
San Juan, Puerto Rico 00918-0903
http://www.hud.gov

November 18, 1998

Ms. Patricia Luvender,
Policy Review Branch
Policy Division
ATTN: CECW-AR (SA)
Department of The Army
7701 Telegraph Road
Alexandria, Virginia 22315-3861

Dear Ms. Luvender:

SUBJECT: Rio Grande De Manati, Puerto Rico

The proposed report from the Chief of Engineers and the District Engineer has been reviewed for the area known as the Rio Grande de Manati, in the Municipality of Barceloneta, Puerto Rico.

At the present moment we have no comments that would further improve the situation beyond your report. However, as you know this is a serious flood area. Your improvement to this community would surely improve the life and safety of its citizenry. We welcome your involvement.

Should you need additional information on our programs in this area, do not hesitate to contact me at (787) 766-5201.

Sincerely yours

Michael A. Colón,
Senior Community Builder/Coordinator

RIO GRANDE DE MANATI
BARCELONETA, PUERTO RICO

REPORT OF THE CHIEF OF ENGINEERS, DEPARTMENT OF THE ARMY

DEPARTMENT OF THE ARMY
OFFICE OF THE CHIEF OF ENGINEERS
WASHINGTON, D.C. 20314-1000

REPLY TO
ATTENTION OF:

CECW-PE (10-1-7a) 22 JAN 1998

SUBJECT: Rio Grande de Manati, Barceloneta, Puerto Rico

THE SECRETARY OF THE ARMY

1. I submit for transmission to Congress my report on flood damage reduction improvements for Rio Grande de Manati, Barceloneta, Puerto Rico. It is accompanied by the report of the district and division engineers. These reports were prepared pursuant to Section 205 of the Flood Control Act of 1948, as amended (Public Law 80-858) which authorized the Secretary of the Army, acting through the Chief of Engineers, to allot from any appropriations made for flood control for the construction of small projects. At the time this cost shared feasibility study was initiated, the project costs were within the $5,000,000 Federal limitation of section 205. Now that the estimate for the Federal share of the project exceeds the Federal limitation, these reports are being submitted to Congress for specific authorization.

2. The reporting officers recommend a flood damage reduction plan which consists of construction of 5,300 meters (17,400 feet) of levees around the town of Barceloneta and 1,620 meters (5,300 feet) of pilot channels for the Rio Grande de Manati to the east of the town. The eastern section of the ring levee extends for about 3,200 meters (10,500 feet) starting at the north interior drainage structure (Culvert 1) and continues east and southeast crossing Calle Plazuela and Highway 684, continuing mainly toward the south, crossing the river meander twice, and continuing south near the municipal sports complex and around Villa Catalana residential development. The western section of the ring levee starts at Culvert 1, and extends for 2,100 meters (6,900 feet) in a southwestern direction across Highway 681 to end at high ground just across Highway 682. The total length of the ring levee is about 5,300 meters (17,400 feet) with an average height above ground of 5.4 meters (17.7 feet), 1 on 3 side slopes on its east and north sections, 1 on 3.5 side slopes on its west part. The levee has a crest of 3 meters (9.8 feet) and an average base of 38 meters (124.7 feet). For safety purposes and to maintain a clear evacuation route to the south should a larger than design flood occur, the northern 400-meter (1,300 feet) stretch of the levee was designed as an overtopping section. The two portions of the existing Rio Grande de Manati channel cut off by the eastern section of the levee are replaced by two pilot (bypass) channels. The pilot channels are designed to be stable and maintain low flow within its banks. The project also includes the construction of minimum interior drainage facilities to collect and dispose of urban runoff caused by a local rainfall event. The interior drainage facilities are required due to the disruption of the existing storm drainage system and the natural drainage

pattern of the urban area resulting from the construction of the flood control ring levee. Two relatively large areas of mostly agricultural lands, 23.3 hectares (57.5 acres) on the east and 72.4 hectares (179.0 acres) on the north, serve temporarily for storing most of the residual flooding caused by interior runoff. Flood stages on this land for the 1 percent chance of occurrence are reduced from a pre-project elevation of 5.1 meters (16.7 feet) National Geodetic Vertical Datum (NGVD) to a post-project elevation of 2.7 meters (8.9 feet) NGVD. This will allow for its continued use in agriculture. The recommended project requires the construction of one small road ramp over the levee at Highway 682, two road ramps over the levee at Highways 681 and 684, and one agricultural road ramp where the eastern part of the levee precludes access to agricultural lands. Project implementation requires acquisition of seven residential structures, relocation of a boat ramp, and relocation of existing utilities impacted by the levee at four locations.

3. The recommended plan is the national economic development (NED) plan. The recommended plan would provide flood protection against a flood event that has an expected annual exceedance probability of about 1 percent by combining channel construction and levees. The total first cost of the recommended plan is estimated at $13,491,000 at October 1998 price levels, of which $8,785,000 would be Federal and $4,706,000 would be non-Federal. Total average annual costs, based on a Federal interest rate of 6.875 percent and a 50-year period of analysis, are estimated at $1,021,000. These amounts include non-Federal annual operation, maintenance, repair, rehabilitation, and replacement costs. Total average annual flood damage reduction benefits are estimated at $4,243,000, yielding net benefits of $3,222,000, and a benefit to cost ratio of 4.2 to 1. No environmental mitigation is required for the recommended plan.

4. Washington level review indicates that the recommended plan is technically sound, economically justified, and environmentally and socially acceptable. The proposed project complies with applicable U.S. Army Corps of Engineers planning procedures and regulations. Also, the views of interested parties, including Federal, State, and local agencies have been considered.

5. I generally concur in the findings, conclusions, and recommendations of the reporting officers. Accordingly, I recommend that improvements for flood damage reduction for Rio Grande de Manati, Barceloneta, Puerto Rico, be authorized subject to cost sharing as required by Public Law 99-662, as amended by Section 202 of Public Law 104-303. My recommendation is subject to the non-Federal sponsor, the Puerto Rico Department of Natural and Environmental Resources, agreeing to comply with applicable Federal laws and policies, including the following requirements:

a. Provide a minimum of 35 percent, but not to exceed 50 percent, of total project costs as further specified below:

(1) Enter into an agreement that provides 25 percent of design costs prior to the date of execution of the project cooperation agreement;

(2) Provide, during construction, any additional funds needed to cover the non-Federal share of pre-construction design costs;

(3) Provide, during construction, a cash contribution equal to 5 percent of total project costs;

(4) Provide all lands, easements, and rights-of-way, including suitable borrow and dredged or excavated material disposal areas, and perform or assure the performance of all relocations determined by the Federal Government to be necessary for the construction, operation, and maintenance of the project;

(5) Provide or pay to the Federal Government the cost of providing all retaining dikes, wasteweirs, bulkheads, and embankments, including all monitoring features and stilling basins, that may be required at any dredged or excavated material disposal areas required for the construction, operation, and maintenance of the project; and

(6) Provide, during construction, any additional costs as necessary to make its total contribution equal to a minimum of 35 percent of total project costs;

b. For so long as the project remains authorized, operate, maintain, repair, replace, and rehabilitate the completed project or functional portion of the project, at no cost to the Federal Government, in accordance with applicable Federal and State laws and any specific directions prescribed by the Federal Government;

c. Give the Federal Government a right to enter, at reasonable times and in a reasonable manner, upon land that the non-Federal sponsor owns or controls for access to the project for the purpose of inspection and, if necessary, after failure to perform by the non-Federal sponsor, for the purpose of completing, operating, maintaining, repairing, replacing, or rehabilitating the project;

d. Hold and save the United States free from all damages arising from the construction, operation, maintenance, repair, replacement, and rehabilitation of the project and any project-related betterments, except for damages due to the fault or negligence of the United States or its contractors;

e. Keep, and maintain books, records, documents, and other evidence pertaining to costs and expenses incurred pursuant to the project in accordance with the standards for financial

management systems set forth in the Uniform Administrative Requirements for Grants and Cooperative Agreements to State and Local Governments at 32 Code of Federal Regulations (CFR), Section 33.20;

f. Perform, or cause to be performed, any investigations for hazardous substances as are determined necessary to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 42 U.S.C. 9601-9675, that may exist in, on, or under lands, easements, or rights-of-way that the Federal Government determines to be required for the operation, maintenance, repair, replacement, and rehabilitation of the project. However, for lands that the Federal Government determines to be subject to the navigation servitude, only the Federal Government will perform such investigations unless the Federal Government provides the non-Federal sponsor with prior specific written direction, in which case the non-Federal sponsor will perform such investigations in accordance with such written direction;

g. Assume complete financial responsibility, as between the Federal Government and the non-Federal sponsor, for all necessary cleanup and response costs of any CERCLA regulated materials located in, on, or under lands, easements, or rights-of-way that the Federal Government determines to be required for the operation, maintenance, repair, replacement, or rehabilitation of the project;

h. As between the Federal Government and the non-Federal sponsor, the non-Federal sponsor will be considered the operator of the project for the purpose of CERCLA liability. To the maximum extent practicable, operate, maintain, repair, replace, and rehabilitate the project in a manner that will not cause liability to arise under CERCLA;

i. Comply with the applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 (Public Law 91-646) as amended by Title IV of the Surface Transportation and Uniform Relocation Assistance Act of 1987 (Public Law 100-17), and the Uniform Regulations contained in 49 CFR, Part 24, in acquiring lands, easements, and rights-of-way required for the operation, maintenance, repair, replacement, and rehabilitation of the project, including that necessary for relocations, borrowed materials, and dredged or excavated material disposal, and inform all affected persons of applicable benefits, policies, and procedures in connection with said act;

j. Comply with all applicable Federal and State laws and regulations including, but not limited to, Section 601 of the Civil Rights Act of 1964 (Public Law 88-352, 42 U.S.C. 2000d), and Department of Defense Directive 5500.11 issued pursuant thereto, as well as Army Regulation 600-7, entitled "Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted

or Conducted by the Department of the Army," and Section 402 of the Water Resources Development Act of 1986, as amended (33 U.S.C. 701b-12), requiring non-Federal preparation and implementation of floodplain management plans;

k. Provide 35 percent of that portion of total cultural resource preservation, mitigation and data recovery costs of the NED plan attributable to flood controls that are in excess of 1 percent of the total amount authorized to be appropriated for flood control;

l. Participate in and comply with applicable Federal floodplain management and flood insurance programs;

m. Prescribe and enforce regulations to prevent obstruction of or encroachment on the project that would reduce the level of protection it affords or that would hinder operation and maintenance of the project;

n. Not less than once each year, inform affected interests of the extent of the protection afforded by the project;

o. Publicize floodplain information in the area concerned and provide this information to zoning and other regulatory agencies for their use in preventing unwise future development in the floodplain and in adopting such regulations as may be necessary to prevent unwise future development and to ensure compatibility with protection levels provided by the project;

p. Comply with Section 221 of Public Law 91-611, as amended, and Section 103 of Public Law 99-662, as amended, which provides that the Secretary of the Army shall not commence the construction of any water resources project or separable element thereof, until the non-Federal sponsor has entered into a written agreement to furnish its required cooperation for the project or separable element; and

q. Do not use Federal funds to meet the non-Federal sponsor's share of total project costs unless the Federal granting agency verifies in writing that the expenditure of such funds is authorized.

6. The recommendation contained herein reflects the information available at this time and current departmental policies governing formulation of individual projects. It does not reflect program and budgeting priorities inherent in the formulation of a national civil works construction program nor the perspective of higher review levels within the executive branch. Consequently, the recommendation may be modified before it is transmitted to the Congress as a proposal for authorization and implementation funding. However, prior to transmittal to the Congress, the non-Federal sponsor, the Puerto Rico Department of Natural and Environmental Resources; the Commonwealth of Puerto Rico; interested Federal agencies; and other parties will be advised of any modifications and will be afforded an opportunity to comment further.

JOE N. BALLARD
Lieutenant General, U.S. Army
Chief of Engineers

REPORT OF THE DISTRICT ENGINEER

RIO GRANDE DE MANATI, PUERTO RICO
SECTION 205
DETAILED PROJECT REPORT
AND
ENVIRONMENTAL ASSESMENT

A STUDY TO DETERMINE THE FEASABILITY OF
PROVIDING A SMALL FLOOD CONTROL PROJECT
FOR THE RIO GRANDE DE MANATI
IN THE VICINITY OF BARCELONETA, PUERTO RICO

JACKSONVILLE DISTRICT
U.S. ARMY CORPS OF ENGINEERS

MARCH 1994

RIO GRANDE DE MANATI DETAILED PROJECT REPORT

SYLLABUS

This detailed project report describes the flooding and related problems resulting from the overflow of Río Grande de Manatí in the vicinity of the town of Barceloneta, presents the analysis of several different measures to reduce flooding damages, and recommends a plan of action. The report was prepared under the authority provided in Section 205 of the Flood Control Act of 1948 as amended. The study was conducted at the request of the Puerto Rico Department of Natural Resources.

The detailed study area lies in the coastal flood plain of Río Grande de Manatí within the municipalities of Manatí and Barceloneta. This area is located in the north coast of Puerto Rico. Río Grande de Manatí has a drainage area of approximately 447 square kilometers (172 square miles). The southern part of the river basin is mountainous with elevations up to 800 meters above mean sea level (msl). The portion on the northern extreme of the basin is, for the most part, a coastal flood plain with ground elevations fluctuating from about three meters below mean sea level (msl) to about six meters above msl. Río Grande de Manatí main channel has a relatively low hydraulic capacity at the coastal plain. Discharges equal or above the 2-year frequency discharge will exceed the capacity of the river. The excess flows over the banks of the river into the coastal plain producing damages in the communities. Approximately 914 families will be affected by the 100-year flood for existing conditions. Total damages range from about $4.0 million for the 5-year flood to $28.6 million for the SPF with average annual damages being about $3.0 million. Industries, residences, and public facilities are, in that order, the most affected structures.

The recommended flood control plan consists of providing 5,200 meters of levees for flood protection, 1,545 meters of pilot channels, and minimum interior drainage facilities for levee to perform. Interior drainage elements include: 161 acres for ponding area, 5,230 meters of canal, culverts under two highway ramps, and two drainage structures. The plan is designed to protect against the 100-year flood and would reduce 92 percent of the total annual flood damages. This plan maximizes the net national economic development benefits. The total first cost of this plan is about $10.6 million with total annual cost estimated at $942,000. Since total annual benefit is $3,025,000, the implementation of the project would result in a benefit to cost ratio of 3.2/1.0. Pertinent economic data for the recommended plan is based on April 1993 price level and interest rate of 8-percent. Under the current cost-sharing policy, the Federal Government cost would be $4,609,000 while the non-Federal share would amount to $6,013,000.

RIO GRANDE DE MANATI DETAILED PROJECT REPORT

LIST OF APPENDICES

APPENDIX A - HYDROLOGY AND HYDRAULICS

APPENDIX B - GEOTECHNICAL STUDIES

APPENDIX C - DESIGN AND COST ESTIMATES

APPENDIX D - ECONOMIC ANALYSIS

APPENDIX E - REAL ESTATE PLAN

APPENDIX F - COORDINATION

CONVERSION FACTOR TABLE

LENGTH

1 kilometer = 0.6214 mile
1 meter = 3.2808 feet
1 centimeter = 0.3937 inch
1 millimeter = 0.03937 inch

AREA

1 square kilometer = 0.3861 square mile
1 square kilometer = 247.1054 acres
1 hectare = 2.4711 acres
1 square meter = 1.1960 square yards
1 square meter = 10.76 square feet

VOLUME

1 cubic meter = 1.3080 cubic yards
1 cubic meter = 35.3147 cubic feet

VELOCITY

1 meter per second = 3.2808 feet per second

FLOWRATE

1 cubic meter per second = 35.3147 cubic feet per second
1 cubic meter per second = 22.8241 million gallons per day (mgd)
1 liter per second = 0.0353 cubic feet per second

WEIGHT

1 metric ton = 2204.622 lbs.
1 metric ton = 1.1023 short tons

ABBREVIATIONS AND ACRONYMS

DNR	Puerto Rico Department of Natural Resources
PRASA	Puerto Rico Aqueduct and Sewers Authority
PRLA	Puerto Rico Land Authority
FWS	United States Fish and Wildlife Service
EPA	Environmental Protection Agency
ALERT	Automated Local Evaluation in Real Time
FEMA	Federal Emergency Management Agency
FHA	Farmers Home Administration
PRPB	Puerto Rico Planning Board
NED	National Economic Development
NEPA	National Environmental Policy Act
GS	Geological Survey
NFIP	National Flood Insurance Program
NOAA	National Oceanic Atmospheric Administration
FIA	Federal Insurance Administration
EFIP	Emergency Flood Insurance Program
EA	Environmental Assessment
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
PCA	Project Cooperation Agreement
PMP	Project Management Plan
LERRD	Lands, Easements, Rights-of-Ways, Relocations, and Disposal Areas
DPR	Detailed Project Report
SAD	South Atlantic Division
PRHA	Puerto Rico Highway Authority

[First Endorsement]

CESAD-ET-P (CESAJ-PD/15 May 98) (1105-2-10)
Mr. Meyer/bjg/404 562-5224
SUBJECT: Rio Grande de Manati, Barceloneta, Puerto Rico

Commander, South Atlantic Division, U.S. Army Corps of Engineers,
Room 9M15, 60 Forsyth Street, S.W., Atlanta, Georgia 30303-8801
03 SEP 1998

FOR CDR, HQUSACE, ATTN: CECW-ZA, WASH DC 20314-1000

I concur in the recommendation of the District Engineer.

J. Richard Capka
Brigadier General, USA
Commanding

Encl
nc

RIO GRANDE DE MANATI AT BARCELONETA
DETAILED PROJECT REPORT

MAIN REPORT
AND
ENVIRONMENTAL ASSESSMENT

I. INTRODUCTION

This report presents the results of investigations into flooding and related problems resulting from the overflow of Río Grande de Manatí at the town of Barceloneta, Puerto Rico. The report was prepared in response to a letter dated September 11, 1986, from the Puerto Rico Department of Natural Resources (DNR) for assistance in reducing flooding from Río Grande de Manatí at Barceloneta. Funds to initiate this study were allocated on fiscal year 1989.

II. STUDY AUTHORITY

This study was authorized by Section 205 of the Flood Control Act of 1948 as amended, which states:

> *The Secretary of the Army is hereby authorized to allot from any appropriations heretofore or hereafter made for flood control, not to exceed $40,000,000 for any one fiscal year, for the construction of small projects for flood control and related purposes not specifically authorized by Congress, which comes within the provisions of Section 1 of the Flood Control Act of June 22, 1936, when in the opinion of the Chief of Engineers such work is advisable. The amount allotted under this Section for a project shall be sufficient to complete Federal participation in the project. Not more than $5,000,000 shall be allotted for a project at any single locality. The provisions of local cooperations specified in Section 3 of the Flood Control Act of June 22, 1936, as amended, shall apply. The work shall be complete in itself and not commit the United States to any additional improvements to insure its successful operation, except as may result from the normal procedure applying to projects authorized after submission of preliminary examination and survey reports.*

By letter dated September 11, 1986, the DNR made a formal application for a study of the Barceloneta area under the authority cited above (refer to Appendix F). An initial Appraisal Letter Report was completed in November 1987 and a Reconnaissance Report in December 1988. Both reports showed that several alternatives to solve the flooding problem at the town of Barceloneta appeared to be feasible and that further detailed studies were warranted. The Division Engineer, therefore, approved in December 1989 for the preparation of a Detailed Project Report (DPR).

III. STUDY PURPOSE AND SCOPE

The primary purpose of this study is to investigate in detail the frequent flooding and related problems in the town of Barceloneta, determine if feasible means for reducing these problems exist, and recommend the most appropriate course of action within the Federal and Commonwealth guidelines and regulations. The investigations were of sufficient detail to identify those problems being experienced, determine probable future conditions, identify and evaluate possible structural and nonstructural alternative plans for addressing these problems, develop detailed alternative plans for possible implementation, evaluate all adverse and beneficial impacts associated with each alternative plan, determine public support for such plans, and recommend a course of action.

IV. STUDY PROCESS

Section 205 Continuing Authorities studies follow a staged process which includes the four functional planning tasks of problem identification, formulation of alternatives, impact assessment, and evaluation.

A review of previous reports, interviews with local officials, and field observations were made by study team members. The study process concentrated on the formulation and development of alternative plans, assessment of impacts, and relative evaluations. The activities were based on detailed technical analyses including hydrology, hydraulic, and geotechnical investigations; socioeconomic analysis; biological/ecological studies; and cultural resources evaluations.

After the technical studies are completed, the draft report and environmental assessment are prepared and reviewed by the staff of the South Atlantic Division (SAD), Corps of Engineers. Next, the draft report and environmental assessment are reviewed by the Commonwealth and other Federal agencies. The subsequent steps involved with plan implementations are summarized below:

1. Review and approval of the Final Río Grande de Manatí at Barceloneta, Puerto Rico, Section 205 DPR by Commander South Atlantic Division.

2. Allocation of funds by Headquarters, U. S. Army Corps of Engineers (HQUSACE) for preparation of plans and specifications.

3. Preparation of Plans and Specifications.

4. Approval of the project for construction by the Office of the Assistant Secretary of the Army for Civil Works.

5. Execution of the Project Cooperation Agreement (PCA).

6. Sponsor accomplishes required acquisitions, relocations, and certifies project lands.

7. Allocation of funds by the Secretary of the Army for construction.

8. Advertize, award, and construction of the project.

9. Transfer the completed project over to the Sponsor for continued operation and maintenance.

V. SCOPE OF REPORT

A. Study Area

The study area consists of the Río Grande de Manatí basin, which is located in the north central region of Puerto Rico (see Plate 1). The total area covered by the Río Grande de Manatí basin is approximately 447 square kilometers (172 square miles). Though the Río Grande de Manatí basin includes parts of the municipalities of Corozal, Naranjito, Orocovis, Ciales, Morovis, Manatí, Barceloneta, and Arecibo, the main focus of the study is the town of Barceloneta where flooding is a major frequent problem.

B. Study Participants and Coordination

Coordination of this report was accomplished through numerous formal and informal meetings with various Commonwealth and Federal agencies, the mayor of Barceloneta, local legislators, various interested groups, and the residents of the flood plain. Table 1 shows the participating government agencies. The investigation was continuously and thoroughly coordinated with the DNR, which was the primary agency representing the Commonwealth during the planning process.

Several technical Study Management Team meetings were held with various government agencies during the study process. The DNR, the Puerto Rico Planning Board (PRPB), the Puerto Rico Highway Authority (PRHA), the Puerto Rico Land Authority (PRLA), and the Municipality of Barceloneta actively participated in the Study Management Team meetings (refer to Appendix F). The meetings were aimed at the collection of data necessary for the investigation and at the assessment and evaluation of the various flood control alternatives considered. A major objective of the coordination effort was to involve the local governments and citizen representatives as equal partners in the study process.

C. Organization of the Report and Study Process

The results of these investigations are presented in a main report, and environmental assessment (EA), and six appendices. The main report includes the description of the river basin, analysis of the study area's flooding problems, plan formulation and evaluation process, and the conclusions and recommendations of the study. The EA documents the description and analysis of the environmental resources as well as the evaluation of the potential effects that the alternative plans of actimn would have on these resources and the rest of the area's human environment. The EA made reference to inputs and comments from other Federal agencies, particularly the Fish and Wildlife Service (FWS), the Environmental Protection Agency (EPA), the Soil Conservation Service (SCS), and the Geological Survey (GS). The appendices present the supporting data and detailed investigations conducted as part of the study. These include: Appendix A, Hydrology and Hydraulics; Appendix B, Geotechnical Studies; Appendix C, Design and Cost Estimates; Appendix D, Economic Analysis; Appendix E, Real Estate Plan; and Appendix F, Coordination.

TABLE 1

RIO GRANDE DE MANATI DETAILED PROJECT REPORT

PARTICIPATING GOVERNMENT AGENCIES

Federal	Commonwealth	Local
Department of the Interior	Office of the Governor	Municipality of Barceloneta
U.S. Geological Survey		Office of the Mayor of Barceloneta
U.S. Fish & Wildlife Service	Legislature of Puerto Rico	Office of Planning
National Park Service	House of Representatives	Department of Public Works
	Senate	Civil Defense
Department of Transportation		
Federal Highway Administration	Office of the Resident Commissioner	
Environmental Protection Agency	Puerto Rico Planning Board	
Department of Housing & Urban Development	Environmental Quality Board	
	Regulations and Permits Administration	
Department of Agriculture		
Soil Conservation Service	Department of Transportation and Public Works	
Farmers Home Administration		
Department of Commerce	Department of Natural Resources	
National Weather Service		
Office of Coastal Zone Management	Civil Defense	
National Marine Fisheries Service		
	Highway Authority	
Federal Emergency Management Agency		
	Aqueducts and Sewers Authority	
	Electric Power Authority	
	Puerto Rico Ports Authority	
	Puerto Rico Land Authority	
	Puerto Rico Land Administration	
	State Historic Preservation Officer	
	Institute of Puerto Rican Culture	
	Department of Agriculture	
	Office of the Budget and Management	
	Department of Sports and Recreation	
	Department of Housing	
	Department of Social Services	
	Department of Education	
	Department of Labor and Human Resources	
	Puerto Rico Industrial Development Company	
	Police Department	
	Puerto Rico Telephone Company	

VI. DESCRIPTION OF THE STUDY AREA

A. Physiography

1. The river basin. The Río Granda de Manatí interior basin is situated on the northern slopes of the Cordillera Central (the central mountain range of Puerto Rico), refer to Plate 1. The Río Grande de Manatí originates at an elevation of about 800 meters (2,625 feet) above mean sea level, and flows in a slightly northwesterly direction through a belt of limestone hills typified by the karst terrain, a deep and narrow canyon-like valley, and across an alluvial flood plain before finally emptying into the Atlantic Ocean. The main stream is about 90 kilometers (55.9 miles) long. Major tributaries to the Río Grande de Manatí are the Río Cialitos, Río Toro Negro, Río Sana Muerto, and Río Orocovis. These rivers flow in the northeast and/or north direction and enter the Río Grande de Manatí from the west. The drainage area of the interior basin at the town of Ciales is 347.5 square kilometers (134 square miles), while the drainage area at Highway 2 bridge is 422.5 square kilometers (163 square miles). The total area covered by the Río Grande de Manatí watershed is approximately 447 square kilometers (172 square miles).

The coastal alluvial flood plain at the lower end of the basin extends for about 25 kilometers and averages approximately 2 kilometers in width. Practically all the land in this plain is subject to periodic flooding. The detailed study area is shown in Figure 1 and Photos 1, 2, and 3.

2. Waterworks. There are two small water supply reservoirs at the upper part of the Río Grande de Manatí watershed: Guineo Reservoir, on the upper Río Toro Negro, and Matrullas Reservoir, on the Río Matrullas, which impound runoff from about 15.5 square kilometers (6 square miles), refer to Plate 1. Part of this runoff is diverted from both reservoirs by means of channels and tunnels to the Río Jacaguas, which flows south towards the Caribbean Sea. The diverted flow is used for irrigation in the southerly coastal plain of the island. The combined capacity of the two reservoirs at crest elevations is about 5.86 million cubic meters (4,750 acre-feet). Because regulation by the two dams is not complete and because the area affected by diversion is less than 4 percent of the drainage area at Highway 2, the effect of the reservoir on floods in the area to be protected is not significant.

3. Soils. The soils in the Río Grande de Manatí basin consist of deposits of sand, clay, and gravel in the coastal plain and limestone overlain by strata of clay slates and sands in the mountain areas. Soils in the upper basin have a low permeability and high runoff potential. The many meanders of the Río Grande de Manatí in the coastal flood plain denotes the existence of fine-grained alluvial soils in the area.

4. Climate. The climate of the area is characterized by dependable rainfall and tropical temperatures, tempered by the trade winds. Daily temperature ranges are relatively small, with a mean annual temperature of 18° centigrade (65° Fahrenheit) in the upper basin and 24° centigrade (76° Fahrenheit) in the coast. Mean annual precipitation in the upper basin is 191 centimeters (75 inches) and 150 centimeters (59 inches) in the coastal area.

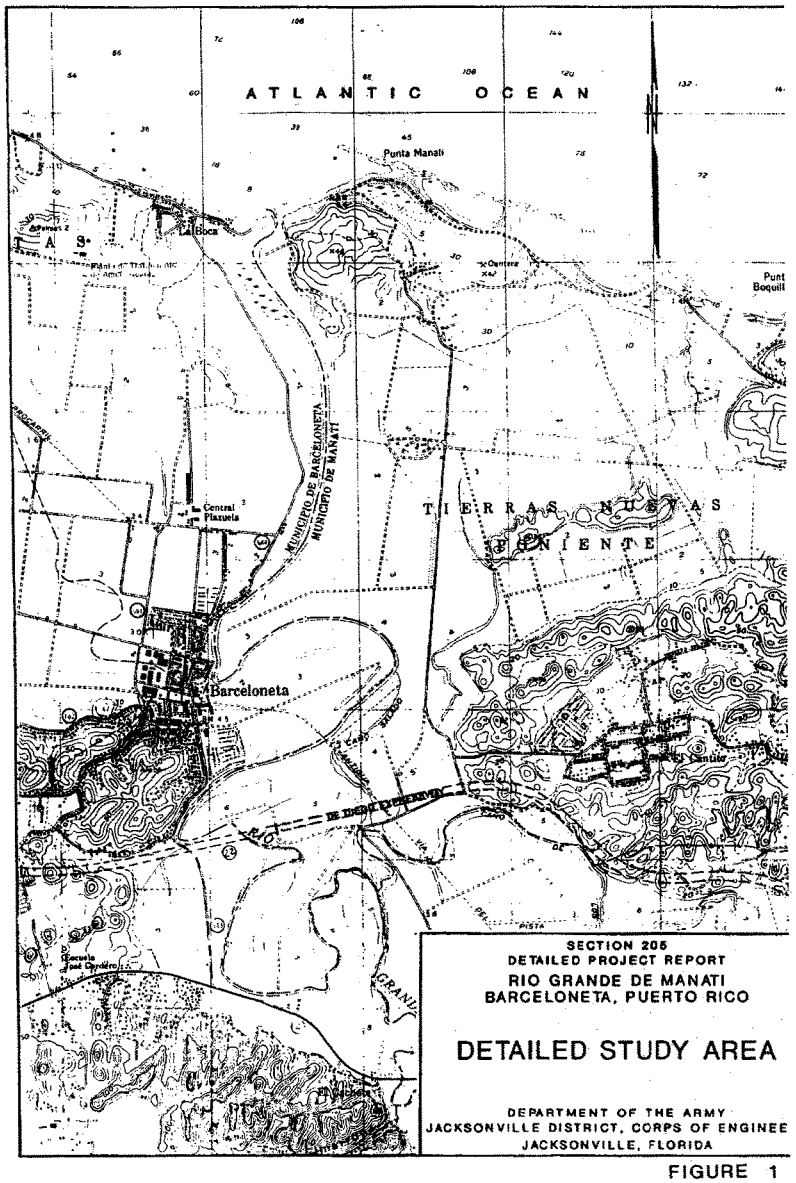

ATLANTIC OCEAN
Punta Manati
La Boca
Central Plazuela
MUNICIPIO DE BARCELONETA
MUNICIPIO DE MANATI
TIERRAS NUEVAS PONIENTE
Barceloneta
SECTION 205
DETAILED PROJECT REPORT
RIO GRANDE DE MANATI
BARCELONETA, PUERTO RICO
DETAILED STUDY AREA
DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEE
JACKSONVILLE, FLORIDA

FIGURE 1

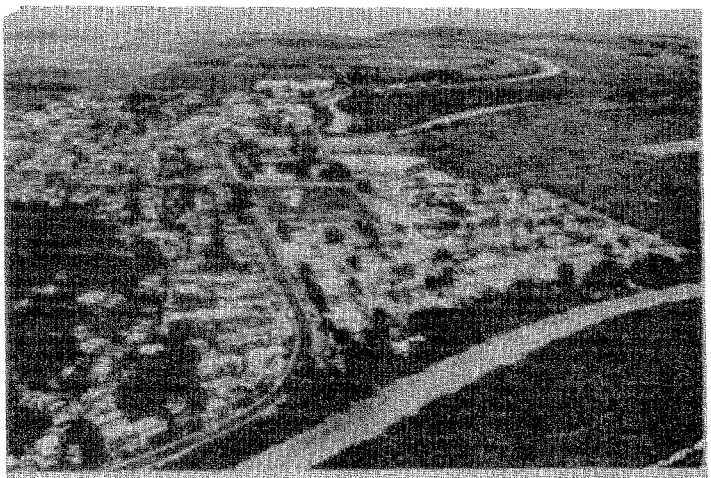


PHOTO OF TOWN OF BARCELONETA LOOKING NORTH

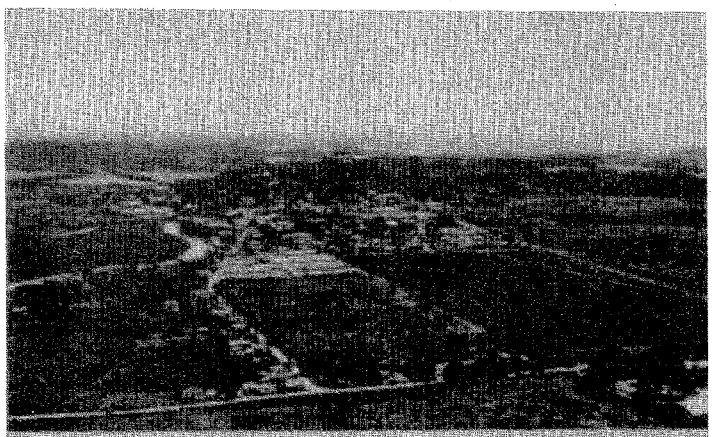


PHOTO OF TOWN OF BARCELONETA LOOKING SOUTH

PHOTO 3. LOWER RIO GRANDE DE MANATI

B. Natural Resources

1. Water resources. There are abundant surface and ground water resources in the study area. The low flow of the Río Grande de Manatí near Barceloneta is estimated at approximately 2.5 cubic meters per second (87 cfs) with 90 percent probability. The mean annual flow is about 329.2 million cubic meters (267,000 acre-feet). Lack of flow control structures limit surface water supply developments.

2. Environmental resources. The entire area has been significantly influenced and largely altered by man; however, the intermixture of marine, estuarine, riverine, flood plain, and karst features provide a variety of habitats. The most important natural feature in the vicinity of the study area is the Caño Tiburones swamp which occupies approximately 6,000 acres between the Río Grande de Arecibo and the Río Grande de Manatí. Wetlands are common throughout the flood plain, especially on the Toa, Coloso, Bajura, and Almirante soil series. The significance of fish and wildlife habitats in and along the Río Grande de Manatí and the extent and functions and values of wetlands in the project area are discussed in the EA.

3. Cultural resources. The Río Grande de Manatí flood plain has been exploited throughout Puerto Rico's prehistoric and historic periods, and the area is rich in significant archaeological and historic resources. There are at least three known indian burial sites within the coastal flood plain. The river was a source of gold during the early 16th century. Numerous sugar processing haciendas were established in the 19th and 20th centuries throughout the entire Río Grande de Manatí coastal valley.

An archaeological reconnaissance report of the study area identified six potentially significant archaeological sites near the area of effect for the proposed project. Of the six sites, five did not met the criteria of eligibility for inclusion on the National Register, or were determined to be outside the area of effect for the proposed project. The other site was documented as the foundations of a small sugar processing mill that is considered to be a potentially eligible site for the National Register of Historic Places. For the most part, the study area corridors have been disturbed by the processes of urbanization; and recent land fills were encountered over much of the proposed project area.

All cultural resources work will be conducted in compliance with the National Historic Preservation Act of 1966, as amended (P.L. 89-655); and the Archaeological and Historic Preservation Act, as amended (P.L. 93-291).

C. Socioeconomic Characteristics

1. Demographics. The Municipality of Barceloneta was established in 1881. It covers an area of 62.7 square kilometers (24.2 square miles). The terrain is characterized by an extensive coastal flood plain in the north and a series of karst hills to the south.

The town of Barceloneta, which is the main urban center of the municipality, is a relatively small, densely populated community located in the western margin of Río Grande de Manatí (refer to Figure 1 and Photos 1 and 2). Highways 2, 22, and 140 lead into the town. Flooding and karst hills terrain have considerably inhibited the urban expansion of the town. According to the U. S. Department of Commerce 1990 Census of Population for Puerto Rico, the town has a population of approximately 5,000 persons.

2. Employment and labor force. Available information on labor and income indicates that manufacturing is the most important economic activity in the study area. The area referred to as Cruce Dávila, approximately 3 kilometers southwest of the town and which is outside of the floodable area, has one of the world's largest concentration of pharmaceutical plants. There are 17 plants employing over 3,400 persons. The area has potential for additional industrial development because of the new Highway 22, connecting San Juan and Arecibo, providing direct access to the town of Barceloneta, the availability of water, tax exemption provisions of Section 936, and highly skilful labor force.

D. Land Use

The Río Grande de Manatí basin covers an area of about 98,437 acres. About 61,280 acres are in crops and pastures; 34,346 acres are forest; and 2,811 acres are in urban or semiurban uses. The Río Grande de Manatí channel, its estuary and its tributaries, numerous drainage and irrigation canals, wetlands, highways and roads, and karst terrain cover the rest of the area.

Plate 2 shows existing and ongoing urban development within the town of Barceloneta that is affected by floods. Area 1 includes the oldest portion of town, municipal government facilities, and commercial center. Area 2 includes recent commercial areas. Area 3 includes an industrial area. Areas 4 and 5 include public housing developments. Areas 6 and 7 include public schools. Areas 8, 9, 10, and 11 include various recreation facilities. Areas 12, 13, 14, 15, and 16 include private residential areas, and Area 15 consists of a municipal low income housing project consisting of 88 single family units completed in July 1993. The development was immediately sold out to applicants in waiting list. Area 17 includes the municipal public works facilities. Area 18 includes an ongoing municipal housing project subsidized and financed by the Farmer's Home Administration consisting of 236 single family units. This housing development is expected to be completed by 1995.

Flood plain regulations, PRPB Regulation 13, have limited the urban expansion of the town. As shown in Plate 2, all lands to the east and north of the town are classified as Zone 1 or floodway, in which no new development may occur. Most of the lands west of the town are classified as Zone 2 or floodway fringe, in which development may occur with adequate flood proofing measures which avoid damages to developments.

Plate 2 also shows the main and secondary highways providing access to and from the town of Barceloneta. Highway 140 provides access from the south, connecting the town with San Juan, Arecibo, and the industrial area by primary roads Highway 22 and Highway 2; Highway 682 provides access from the west; Highway 681 provides access from developments along the north coastal area; and

Highway 684 provides access from developments near the river mouth and the Puerto Rico Aqueducts and Sewers Authority (PRASA) regional wastewater plant.

Practically all the lands in the coastal flood plain east of the river are dedicated to agriculture, particularly for improved pasture and sugar cane cultivation. Excellent soils, availability of water, and leveled lands provide a potential for more extensive and intensive agricultural activity in the flood plain. Over the years there have been various attempts to cultivate flood plain lands west of the river in the vicinity of Caño Tiburones, particularly for cultivation of sugar cane and pineapple. Recently, attempts to cultivate rice in this land that is mostly below or near sea level have been unsuccessful mainly because of the expense of continued pumping of groundwater through a system of drainage canals, environmental concerns, salt water intrusion, and inferior soils. All agricultural lands along the periphery of the town and most of the flood plain belong to the Puerto Rico Land Authority, a state entity in charge of administrating and preserving lands for agriculture, while vacant lands in the process of being developed, west of the urban core, belong to the Municipality of Barceloneta.

E. Future Conditions

1. Population and labor force. Considerable population and economic growth in the study area, particularly in the town of Barceloneta, are expected to occur. The completion of the De Diego Expressway (Highway 22) and improvement of secondary roads would contribute significantly to this growth. The diversification of the agricultural sector, the location of new industries, and the expansion of the services sector would stimulate further development of the area. According to projections of the PRPB, the population of the Municipality of Barceloneta is projected to increase from 18,942 in 1990 to 20,947 persons by the year 2000 or about 11 percent.

2. Land use. According to the PRPB Land Use Plan for the Year 1992, the land proposed for future urban expansion is mostly located south of the town of Barceloneta and to some extent west of Highway 681 near the industrial part of the town. Plate 3 shows the proposed future urban development within the town of Barceloneta. The proposed developments around the town of Barceloneta will take advantage of the existing infrastructure, utilizing the excellent network of highways, power, water, sewer, telephone, etc. Area 1 includes an ongoing municipal housing project subsidized and financed by the Farmer's Home Administration consisting of 236 single family units. All the necessary permits and financing have been approved and the land has been cleared for construction. The land to be developed will be filled above the existing FEMA 100-year flood elevation. Area 2 includes a municipal proposal for a sports complex, housing for the elderly, and a low income housing development of 125 single family units. Area 2 is scheduled for development before 1996. Flood plain regulations, PRPB Regulation 13, will continue to limit the urban expansion of the town.

No additional new highways are planned for the near future, only the maintenance and improvement of the existing ones. Practically all the lands in the flood plain east of the river and north of the town will continue to be dedicated to agriculture, particularly for improved pasture and sugar cane.

VII. PROBLEMS, NEEDS, AND OPPORTUNITIES

A. Flooding

1. General. The Río Grande de Manatí is a potential danger to the lives of the residents of the study area and is a source of frequent flood damages. Floods can occur anytime during the year; however, they are most frequent during the period of May through December. Large peak discharges result from storm rainfall, generally associated with hurricanes, tropical depressions, and northern cold fronts over or near the island. Cloudburst storms can occur anytime during the year, and because of the steep slopes in the upper basin, flash floods are another common type of event affecting this area.

There are two principal floodable areas within the basin. At the upper basin the town of Orocovis, which is a short and narrow plateau. The more significant floodable area is the broad and flat coastal area in the vicinity of the town of Barceloneta. This report addresses the flooding problem in the town of Barceloneta. Floods larger than the 2-year event inundate all the highways and roads in the coastal flood plain.

2. Historical floods. Since the turn of the aentury, there have been at least 15 damaging floods on the Río Grande de Manatí. The most damaging and largest flood of record occurred on September 13, 1928, although higher stages, at least in the coastal area, occurred in August 1899. Both events were associated with the passage of hurricanes.

In accordance with the *U. S. Geological Survey Flood of October 5-10, 1970, Puerto Rico, Water Resources Bulletin 12, 1972*, the flood of record on the Río Grande de Manatí in recent times occurred on October 9, 1970. This flood had an estimated recurrent interval of about 10 years. The discharge associated with this flood was estimated at 2,315 cms (81,743 cfs) and stages in the vicinity of Highway 2 reached 10.15 meters (33.3 feet) above mean sea level. However, this previous flood of record was exceeded twice during 1985.

Other large floods in the Río Grande de Manatí that caused at least minimum flood damage occurred in; September 1932, August 1945, August 1956, May 1959, September 1960, August 1961, December 1965, November 1969, October 1970, September 1975, August 1979, May and October 1985, November 1988, October 1989, and January 1992. The dates of some of these events, elevations above mean sea level (msl), and their peak discharges in cubic meters per second (cms) as determined by the GS at the Highway 2 gaging stations are shown on Table 2.

3. Recent floods. The town of Barceloneta was severely flooded twice during 1985. The May 17-18, 1985, flood affected the entire town of Barceloneta. The town of Barceloneta was declared a disaster area by the President (see Photos 4, 5, 6, and 7). According to records from the town of Barceloneta and the GS, flood stages for the May and October 1985 floods, throughout most of the town were above 1 meter. Damages recorded by the local Civil Defense for public buildings and facilities, residential developments, and commercial establishments exceeded $7.4 million for each flood. The following paragraphs describe both flood events that had an estimated flood frequency of about 10 years.

TABLE 2

RIO GRANDE DE MANATI DETAILED PROJECT REPORT

FLOOD DATA FOR RIO GRANDE DE MANATI
AT HIGHWAY 2, USGS STATION 50038100

Date of Record	Discharge in cms	Water Surface Elevation in meters above msl
May 3, 1959	2,152	9.85
September 6, 1960	1,756	9.73
December 11, 1965	2,005	9.80
November 9, 1969	1,929	10.00
October 9, 1970	2,315	10.15
May 18, 1985	2,549	10.23
October 7, 1985	2,754	10.30
October 23, 1989	2,320	9.42

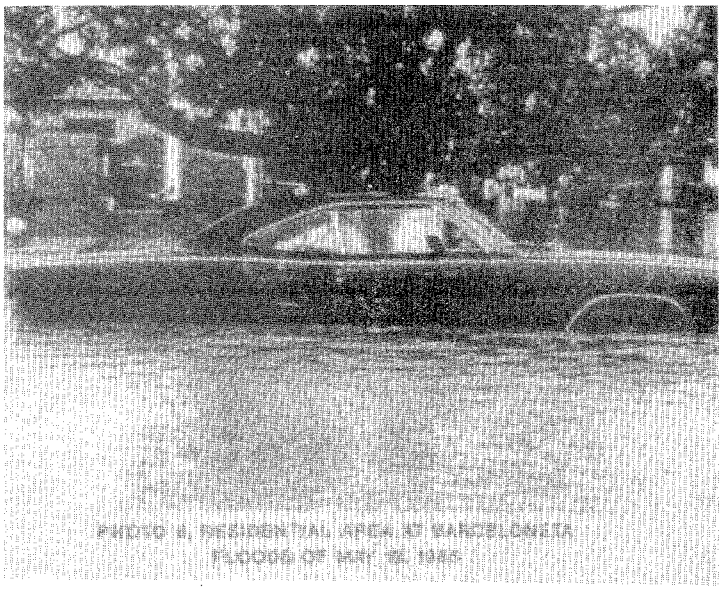


PHOTO @ PRESIDENTIAL AREA AT MARCELO NETA
FLOODS OF MAY 26, 1995

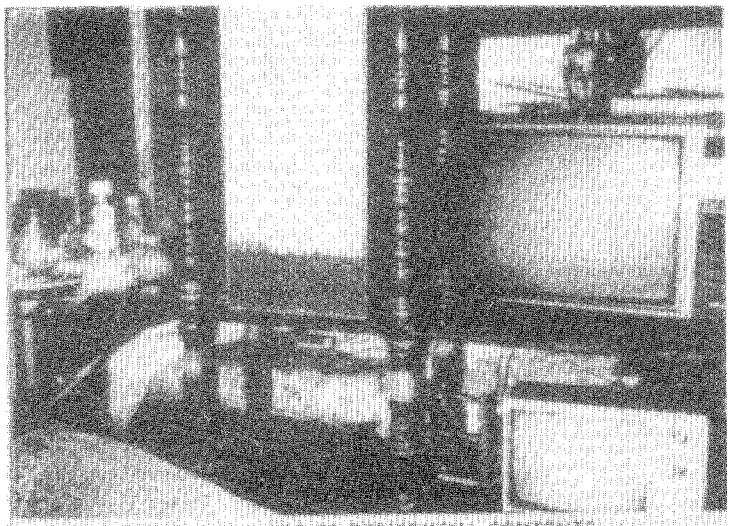


PHOTO 3. DAMAGE TO RESIDENTIAL CONTENTS
FLOODS OF MAY 16, 1969

Severe flooding affected most of the north and north-central parts of Puerto Rico during May 17-18, 1985, as a result of intense precipitation that began on May 15 and continued through May 19. The rains were produced by a nearly stationary low-pressure system that moved from the northwest on May 15. During the next five days, almost continuous precipitation of varying intensity was recorded throughout most of the south-central and eastern part of Puerto Rico. Precipitation totals for the 5 days of the storm ranged from 20 centimeters (8 inches) to 64 centimeters (25 inches). The most intense rainfall occurred over an area extending west of a north-south line at the town of Orocovis toward Mayagüez (refer to Plate 1). A second cell of less intense rainfall affected the Río Grande de Loíza basin, in the eastern part of the island. The recorded precipitation total for the 5-day period May 15-19 was 64.03 centimeters (25.21) inches at Jayuya. Flood stages at the town of Barceloneta were greater and inundated about the same area as the 1970 flood. Undefined conditions appear to have caused backwater effects in several areas along the Río Grande de Manatí flood plain.

Another intense precipitation induced by a nearly stationary tropical depression occurred over most of southern Puerto Rico during October 6-7, 1985. As much as 58.42 centimeters (23 inches) of rainfall occurred north of the towns of Ponce and Coamo during a 24-hour period (refer to Plate 1). The rainfall was equally distributed between the afternoon of October 6 and the early hours of October 7. Less intense precipitation occurred on October 5. Similarly less intense precipitation occurred on October 8 after the very intense storm of October 7. Precipitation totals for the 4-day period (October 5-8) were as high as 77.88 centimeters (30.66 inches). The urban area of Barceloneta was flooded for the second time in 1985. Preliminary high-water marks surveyed in the center of the town showed that the October 1985 flood was about 0.3 meters (1 foot) higher than the May 1985 flood.

4. Floodable area and property subject to flooding. The flooding condition of the study area due to the Río Grande de Manatí presented on this report is the result of a detailed hydraulic and hydrologic investigation performed as part of this study. The areas flooded under the existing conditions are shown in Plate 4. It is estimated that the 100-year flood would affect over 5,680 acres of land in the coastal valley, most of which are agricultural fieldq and wetlands. The number of structures affected by the potential floods of Río Grande de Manatí, within the detailed study area, is summarized on Table 3. Some 1,084 structures, mostly residential, are affected by floods. The fourteen industries affected by floods include, companies engaged in manufacturing sophisticated high technology electronic equipment for communications, and companies engaged in manufacturing fine ladies undergarment. Appendix E, Economic Analysis, provides a detailed description of the property subject to flooding.

5. Hurricane tides. Historically, the study area has never suffered flood damages from hurricane or storm tides. According to the report *Storm Tide Frequency Analysis for the North Coast of Puerto Rico*, prepared by NOAA in August 1983, the 100-year storm will produce an average maximum tide of 1.6 meters (5.3 feet) above mean sea level about 2 kilometers north of the town of Barceloneta; the 500-year storm will produce an average maximum tide of 2.3 meters (7.6 feet) above mean sea level.

TABLE 3

RIO GRANDE DE MANATI DETAILED PROJECT REPORT

NUMBER OF STRUCTURES SUBJECT TO FLOODING
IN THE DETAILED STUDY AREA

	LAND USES				
Flood	Residential	Commercial	Public	Nonprofit	Industrial
5-Year	131	8	8	1	9
10-Year	420	81	53	10	14
25-Year	745	91	53	10	14
50-Year	914	91	54	11	14
100-Year	914	91	54	11	14
SPF	914	91	54	11	14

Source: Field Survey U.S. Army Corps of Engineers.

6. Potential flood damages. Under existing conditions, the 100-year flood would produce damage of $25.4 million, while the Standard Project Flood (SPF) would produce damage reaching $28.6 million. Average annual damages for existing development are estimated to be $3.0 million. Most of the damage is sustained by the residential and industrial areas. Table 4 shows damage estimates for existing conditions by flood frequencies and land use categories. These damages were developed by a detailed economic analysis of the study area. Methods used on the development of economic data such as inventories and assessment of structural and contents values are presented in Appendix E, Economic Analysis.

7. Flood warning system. The Puerto Rico Department of Natural Resources recently established the Automated Local Evaluation in Real Time (ALERT), a flash flood warning system installed in 18 of the largest watersheds in Puerto Rico. ALERT consists of a network of rain gages together with stage-discharge sensors throughout the island providing real time rainfall-runoff data which is transmitted by a satellite telemetry system that allows monitoring the behavior of selected streams with data updates every five minutes. The ALERT system is jointly operated by the Department of Natural Resources, the National Weather Service, the Geological Survey Water Resources Division, and the Civil Defense.

In the Río Grande de Manatí basin the ALERT network consists of a total of about 9 rain sensors and 5 stage-discharge sensors. The Río Grande de Manatí ALERT system is very effective in providing advanced flood warning for the densely populated areas within its lower flood plain. The actual warning time under ideal conditions would be less than two hours. Two hours before the floods reaches the town of Barceloneta, the Civil Defense and other relief agencies would be notified by ALERT to proceed with the evacuation of residents in the flood prone areas. The complicated process would save many lives, but leaves no time and no additional resources for taking any measures to protect and save structures contents.

B. Water Supply

There are substantial water resources potential in the Río Grande de Manatí watershed. A 1980 Corps of Engineers study identified a mayor potential water supply reservoir site in the upper part of the watershed with an estimated firm yield of 360,000 cubic meters per day (94.1 million gallons per day). On the other hand, PRASA is considering the option of tapping 150,000 cubic meters per day (40 million gallons per day) through a surface diversion and transporting the water through a pipeline into the San Juan Metropolitan Area. Also, recent ground water studies by the Geological Survey, in the Barceloneta area, identified a major artesian aquifer. A major constraint on water withdrawals from the lower Río Grande de Manatí is the inland movement of the salt water wedge with a reduction of flow.

According to GS, future development of fresh water supplies in the alluvial valley is limited to areas south of Highway 2. Large scale ground water development in the Río Grande de Manatí valley is limited to wells tapping the deep artesian aquifer.

TABLE 4

RIO GRANDE DE MANATI DETAILED PROJECT REPORT

POTENTIAL FLOOD DAMAGE ESTIMATES FOR
EXISTING CONDITIONS WITHOUT PROJECT
($1,000 OF 1993)

Flood Frequency	Residential	Commercial	Public	Non Profit	Industry	Others	Total
5-Year	632	39	79	2	2,549	668	3,969
10-Year	1,772	400	400	12	7,009	751	10,344
25-Year	5,160	1,491	1,024	59	11,477	993	20,204
50-Year	6,332	1,600	1,088	68	11,477	1,097	21,662
100-Year	8,860	2,468	1,247	141	11,478	1,220	25,414
SPF	11,243	3,074	1,366	185	11,478	1,256	28,602

Expected annual damages: $3,043,000

C. Water Quality

According to GS, the water from Río Grande de Manatí is of good quality and suitable for most purposes. Analyses of samples collected since 1969 at the gaging station on Highway 2 indicate that fecal contamination, perhaps from dairy farms, may be the most serious water quality problem. The suspended sediment load of Río Grande de Manatí was estimated by GS studies at approximately 100,000 tons per year. On the other hand, according to GS studies, in some neglected areas ground water is affected by one or a combination of problems including salt water intrusion, presence of bacteria, and traces of organic compounds.

D. Salt Water Intrusion

Most of the Río Grande de Manatí north of Highway 2 lies within the estuary part of the river. According to the GS, tidal effects have been observed up to river mile 5.3, but actual inland advance of the salt water wedge has been detected only to river mile 4.2. Fifty percent of the time the wedge lies at least 3.5 miles upstream from the mouth. At zero discharge the maximum inland extent of the wedge would be 6.8 miles upstream. The position of the salt water wedge also affects to some extent all canals and streams connected to the river along the estuary reach.

E. Erosion and Sedimentation

The central mountain range of Puerto Rico is comprised of igneous and sedimentary rocks. The intensive processes of chemical weathering which characterize the humid tropical climate have produced moderate and deep soil profiles, which might fail during prolonged period of rainfall. The most common movements experienced in this physiographic province are localized landslides of soil and rock. There is no evidence of problems related to debris flows reaching Highway 2 during past historical floods. At flood stage, the Río Grande de Manatí carries some sediments which are mainly deposited at the river mouth, about 2 kilometers downstream of the proposed project. River sediments form a perennial sandbar at the mouth. There is evidence that the sandbar is blown out to the ocean after every flood (refer to Photo 3). Cultivated land in the steep upland areas and the development of more land for residential and industrial uses are the two most intensive sources of erosion in the basin. In general terms, a shift from cropland acreage to grassland farming in upland areas would tend to reduce the erosion rate.

F. Land Use

The topographic characteristics and flood plain management regulative restrictions of the study area have considerably limited the growth of the town of Barceloneta, which is the major urban center within the municipality. The Atlantic Ocean and floodway zoning to the north, the river and floodway zoning to the east, floodway fringe zoning to the west, and the karst topography to the south are physical barriers that limit the growth of the town. Urban growth has occurred on very small valleys between hay-stack-like karst hills adjacent to the town and other built-up areas, on the floodway fringe, along the periphery of Highway 2 and along Highway 681 just west of the urban core, and on some areas separated from the traditional urban core (Cruce Dávila and Garrochales).

As population increases in the future, the demand for additional lands for residential development would significantly increase. The PRPB intends to accommodate this demand for future development by increased densification in the already developed areas and by permitting developments in some of the floodway fringe (PRPB Zone 2 west of urban core) and in some uplands away from the urban core. Development of upland areas would require considerable investment in land leveling and new infrastructure. Development of upland areas may result in a significant increase of erosion and sedimentation, particularly toward the main channels of Río Grande de Manatí.

G. Recreational Opportunities

The municipal and Commonwealth governments have considerably expanded the sports and recreation facilities of the detailed study area during the last five years. They include basketball, volleyball, and tennis courts; baseball and softball fields; one boat ramp at the river; track and field facilities; the ANCON linear park along the existing west bank of the river; and neighborhood passive parks and play grounds.

With the expected increase in population, the recreational demand of the area would be much higher in the future, particularly with respect to regional parks. In order to cope with the future recreational demands, the Municipality of Barceloneta is proposing the construction of a sports and recreation complex at a 40 acres track, along Highway 681, on the western edge of the town. Area 2, shown in Plate 3, depicts the location of the proposed municipal sports and recreation complex.

The Municipality of Barceloneta has verbally expressed their interest to include recreation facilities on project lands as part of the recommended flood control project. A 3.1 mile levee leisure/interpretive walk, active and passive recreation facilities at the 11 acre track of agricultural lands made unaccessible by the east levee located east of the urban core, and a boat ramp with fishing pier near Highway 684 road ramp were proposed at one time. However, since the cost of the recommended flood control project already exceedq the maximum Federal participation of $5 million, there would be no Federal cost sharing for recreation facilities. The local sponsor has not requested that a locally financed recreation plan be included in the recommended plan. Therefore, the recommended project does not include recreation facilities.

H. Hazardous and Toxic Wastes

There are no known Hazardous and Toxic Waste (HTW) sites within the proposed project area. The lower Río Grande de Manatí flood plain has been used exclusively for agricultural purposes. A negative HTW survey was conducted, on February 1992, during the Detailed Project Report phase.

I. Flood Plain Development

Executive Order 11988 ties together the need to protect lives and property with the need to restore and preserve all natural and beneficial flood plain values. The objective of the order is to avoid to the extent possible the long and short term adverse impacts associated with the occupancy and

modification of flood plains and to avoid direct and indirect support of development wherever there is a practicable alternative. The test of what is practicable depends upon the situation and includes consideration of many pertinent factors such as environment, project cost, and present design and construction technology.

The order is based in part on the National Environmental Policy Act (NEPA) of 1969, and it adds new prominence to the environmental aspects of flood plain management. Consideration must be given, therefore, to natural and beneficial flood plain values and to the public benefits to be derived from their restoration or preservation.

Section 2(a)(2) of the order requires that if an agency has determined to, or proposes to, conduct, support, or allow an action to be located in a flood plain, the agency shall:

1. Consider alternatives to avoid effects and incompatible development in the flood plains.

2. Design or modify its action in order to minimize potential harm to or within the flood plain.

3. Prepare and circulate a notice containing an explanation of why the action is proposed to be located in the flood plain.

All plans considered and evaluated during the reconnaissance and detailed project report phases have been carefully formulated to obtain the most practical and feasible alternative in accordance with the flood plain preservation requirements dictated by Executive Order 11988. The proposed project minimizes impacts to flood plain values. Ongoing and proposed development within the town (refer to Plate 3) would occur without a project. Therefore, the project does not promote development of land in the flood plain.

K. Prime and Unique Farmlands

The Farmland Protection Policy Act, implemented under the Department of Agriculture's final rule effective 6 August 1984, requires the U. S. Army Corps of Engineers to coordinate with the Soil Conservation Service for identification of prime and unique farmland which might be impacted by the proposed project. It is within the Corps' discretion to proceed with a project that would result in conversion of farmland to nonagricultural uses once the potential impacts of the proposed action have been examined and other alternatives to lessen the adverse effects have been considered. The final rule also requires that the project, to a practicable extent, be compatible with state and local programs for the protection of farmlands.

All plans considered and evaluated during the reconnaissance and detailed project report phases have been formulated in accordance with the prime and unique farmlands preservation requirements of the Farmland Protection Policy Act. The proposed project minimizes impacts to prime and unique farmlands.

VIII. PLAN FORMULATION RATIONALE

A. General

Plan formulation involved the identification, analysis, and evaluation of alternative flood control management plans that addressed the planning objectives within a set of constraints, assumptions, and criteria. Several alternatives or ways to reduce flood damages to the communities located in the detailed study area are available. However, those alternatives for flood control that were believed to be detrimental to the valuable environmental and cultural resources of the area, not practical or not cost effective were eliminated from further analysis during the initial plan identification phase.

This report analyzes flood control alternatives along Río Grande de Manatí at the town of Barceloneta and investigates various nonstructural alternatives and some structural alternatives previously identified during the initial phase of this study along various alignments and for various levels of protection.

During the initial phase, from February 1987 to December 1988, the most attractive alternative consisted of 4,600 meters of earthen levees, 1,200 meters long pilot channel, minimum interior drainage facilities, and two road ramps. This alternative is similar to Preliminary Plan 3.

The plan formulation process had evolved considerably since the DPR study began in March 1990. The evolution of the plan formulation process was mainly due to: examining alternative alignments with and without relocation of residential and public facilities scattered in the northeast section of town, examining alternatives to minimize residual interior flooding, examining alternatives to accommodate the ongoing urban expansion on the southwest portion of town, examining alternatives to minimize land enhancement, examining alternative east alignments to minimize impacts to the floodway, examining alternative alignments to minimize impacts to cultural resources.

During the preliminary plan formulation, undertaken between May 1990 and February 1991, the same concept recommended in the reconnaissance phase was maintained. For better identification and reference, the levee was divided in two portions, the east levee from Culvert 1 to road ramp at Highway 140, and the west levee from Culvert 1 to road ramp at Highway 682. The alternatives considered in the reconnaissance phase as well as the DPR phase preliminary plans maintained a west levee alignment about 150 meters west of Highway 681.

As a result of cultural investigations, a portion of the east levee alignment was shifted to avoid an important burial site. Detailed hydraulic analysis determined that the length of the pilot channel could be reduced to 785 meters. Geotechnical investigations determined that the southeast portion of the east levee could not be built without rerouting the river with a 760 meters long pilot channel. Economic analysis determined that it was cost effective to protect 28 residences, located near Highway 684 ramp, as compared to relocating them. The levee was therefore shifted eastward in that area. Hydraulic analysis required shifting other portions of the east levee alignment closer to town in order to minimize increasing flood stages in the floodway by more than a foot.

In February 1991 the DNR, the PRPB, and the Municipality of Barceloneta announced during a technical Study Management Team meeting that the western levee alignment was excluding vacant land in the process of being developed consistent with FEMA and PRPB Regulation 13 (requiring flood proofing) and that the proposed levee would dislocate the continuity of urban development and the provision of public services in that area. Also, it was realized at that time that the levee cannot tie-in to the ongoing developments because permits for those developments were based on building up or flood proofing the area by placing compacted fill above the FEMA 100-year flood elevation, which is about 1 meter lower than the 100-year stages determined under this study. Therefore, the sponsor and the Municipality of Barceloneta requested that the alignment be shifted about 300 meters west to accommodate ongoing urban development in the town. The shifting of the alignment required additional geotechnical, environmental, and cultural investigations that added time and cost to the study. The revised alignment is 600 meters longer. However, the annual benefits accrued by protecting 325 additional residences ($90,000), offset the additional annual cost increase of $72,000 due to the longer levee alignment.

During the plan formulation process the levee alignment was optimized to minimize enhancing the agricultural lands within the levee. That is, the agricultural lands within the levee should be for the purpose of residual interior flooding management. The local sponsor expressed that at the time of signature of the PCA, they intend to restrict the use of the lands in question either through a special zoning from the Puerto Rico Planning Board or through a written agreement with the land owner, the Puerto Rico Land Authority, to the effect that the land in question will remain in agricultural use for the life of the project.

B. Planning Objectives

An analysis of the study area's problems, needs, and opportunities relating to water and land related resources resulted in the identification of six planning objectives. Of foremost importance is the solution of the flooding problem that affects Barceloneta and threatens the lives and properties of its residents. The specific objectives identified for this study are:

1. Safeguard the lives of about 5,000 residents in Barceloneta.

2. Reduce property losses in the town of Barceloneta due to flooding.

3. Minimize disruption of economic and social activities.

4. Enhance opportunities for redevelopment throughout the study area.

5. Restore, enhance, and/or preserve environmental resources.

6. Protect, preserve, or minimize impacts on significant historical and cultural resources of the study area.

C. Planning Constraints

The planning constraints that limit or influence the type of measures that were considered in this study include:

1. The scope of the study is limited to the flood prone area in the town of Barceloneta.

2. Physical constraints related to the proximity of the urban development to the river main channel.

3. Floodway encroachment by levees that may increase flood stages in the Río Grande de Manatí flood plain.

4. The need to construct long highway ramps over high levees may require highway relocation or changes in levee alignment to meet with DOT design requirements.

5. Ground elevation of ongoing developments under construction were based on existing FEMA maps that are 1 meter lower than the without project conditions. Therefore, project levees cannot tie into ongoing developments.

6. The very high local runoff coming from the hills south of the town that may influence the size and location of interior drainage facilities.

7. The large number of archeological and historical sites that could be found within the study area.

8. Formulate plans in accordance with the flood plain preservation requirements of Executive Order 11988, and Farmland Protection Policy Act.

D. Planning Assumptions and Criteria

Several engineering and economic assumptions and criteria were established to guide the plan formulation and evaluation process.

1. Engineering

a. Each plan must be complete in itself.

b. High discharges, high velocities, and short time to peak require that degree of protection and type of design minimize potential for catastrophic results should project works fail.

c. The design flood is to be based on most probable future hydrologic conditions.

d. Proposed plans should minimize residual flooding and damages.

e. A pilot (bypass) channel was considered for Río Grande de Manatí at areas were the levee cutoff the existing channel.

f. Earthen levees were designed to have an alignment which would provide flood protection to the existing and ongoing urban developments, minimize real estate requirements while affording sufficient undeveloped area for temporary storage of local runoff in order to reduce interior residual flooding and eliminate the need for expensive pumping stations.

g. Riprap and/or gabions armoring was considered for levees and channels side slopes in areas where high flow velocities are expected.

2. Economic and financial

a. Each plan must be justified in itself, and each separate element of a plan must be incrementally justified.

b. For purpose of optimization of net National Economic Development (NED), benefits not only are different plans examined, but similar plans are examined for different degree of protection.

c. Total beneficial contributions of the each plan considered must exceed the total adverse impacts, and one plan must maximize net NED benefits.

d. The study year is taken as 1993, the base year as 1998, and the end of the planning period as the year 2048.

e. The structure values for future condition remain unchanged from those for existing condition for the computation of annual damages; however, a factor of 3.4 percent affluency is applied to the existing residential contents value to estimate the value for future condition. The affluency factor is based on economic data published by the PRPB (Statistical Appendix to the Governor's Economic Report for 1992). The maximum value of residential contents is limited to 50 percent of the structure value.

E. Without Project Conditions

The without project conditions scenario would be equivalent to the no action plan, which envisions no flood control works within the detailed study area. Potential flood hazard to the life, health, and property of the residents in the area would remain as the most critical water-related problems. Persistent disruption of productive economic activities resulting from flooding in the area would impair further economic development. Relocation of all the activities in the area seem unlikely because nowhere else are similar locations and agglomeration economies available.

In terms of economic development, the future growth of the study area would depend on the success of the Commonwealth and municipal government programs to induce higher capital investment in agriculture, manufacturing, and trade. Some factors that impact on future economic development in the area are the new local Industrial Incentives Act, the reduction in interest rates, the stability of crude oil prices, and the preservation of tax benefits under Section 936 of the U. S. Internal Revenue Code.

The apparel, pharmaceutical, and high technology industry is expected to remain as the most important source of income and employment in the study area. The construction sector is also expected to make a significant contribution to future economic development. The construction of new housing developments, shopping malls, fast food centers, and the expansion of existing facilities and infrastructure would contribute to the growth of the area.

The town of Barceloneta constitutes the growth center of the study area. The PRPB adopted an urban expansion plan for the Municipality of Barceloneta that delineated the vacant areas proposed for future urban development within the municipality. Three distinct areas were identified, two areas are located south of the town of Barceloneta and one is located west of Highway 681 near the industrial park of the town. These areas will develop with and without a flood control project. The without-project condition serves as a benchmark to assess and evaluate the candidate flood-control plans.

IX. FORMULATION OF PLANS

A. Relevant Measures

Four nonstructural measures and four structural measures were identified to fully or partially address the planning objectives identified in a previous section. The nonstructural measures considered are flood plain management, flood insurance, temporary and permanent flood plain evacuation, and channel maintenance. Structural measures considered included channel improvements, channel diversion, reservoirs, floodwalls, and levees. Measures considered are described in the following paragraphs:

1. Nonstructural measures

a. Flood plain management. The most important and relevant nonstructural measure that the Commonwealth of Puerto Rico has to manage on development in the study area's flood-prone areas is the PRPB Regulation 13. This regulation, which predates FEMA flood plain regulations and which in 1987 was revised to make it consistent with FEMA, regulates all new developments and expansion of, or improvements to, existing developments in flood-prone areas. However, the present FEMA 100-year base flood elevation in the town of Barceloneta is about 1 meter lower than the 100-year flood stages computed for this study. The PRPB had been advised of the need to update the present flood insurance study and a request should be initiated by the PRPB (local NFIP coordinator) to revise the flood maps.

For a developer to receive a construction permit in a flood-prone area he must establish through a hydrologic/hydraulic study that his project is above the 100-year flood event or that it will not raise water stages in the vicinity by more than 0.3 meters. According to the PRPB, during the last 3 years they have denied several permits for new developments in the study area's flood plain because they do not comply with PRPB Regulation 13. Flood plain management regulations are assumed to be in effect under all plans. Flood plain management, however, will have very limited effect in reducing potential flood damages to existing development.

b. Flood insurance program. The National Flood Insurance Program (NFIP) is administered by the Federal Flood Insurance Administration (FIA), which is part of the FEMA. The PRPB serves as the local coordinating agency for the Flood Insurance Program in Puerto Rico. Puerto Rico entered the Emergency Flood Insurance Program (EFIP) in 1972 and entered the Regular Flood Insurance Program in 1978. For purposes of the Flood Insurance Program, Puerto Rico is considered a single community by the FIA.

Flood insurance would not reduce or eliminate the flooding problem but it would serve to reimburse property owners for losses incurred. The measure, however, seems to have been of very limited acceptance in Puerto Rico, for despite frequent and significant flood damage, approximately only two percent of the families living in urban areas, not necessarily subject to flooding, have acquired the insurance. Only during recent years some financial institutions have required home buyers to purchase flood insurance as a condition for loan approval. Though in most cases flood insurance is voluntary, it is expected to be in effect under all plans considered.

c. Temporary and permanent flood plain evacuation. Temporary evacuation of persons and personal property from flood-prone areas could be accomplished when a flood threat exists. Temporary evacuation can be very effective when operated in conjunction with a reliable flood warning system and where movable, damageable objects are concerned.

The ALERT system described in Section VII.A.7. is currently in operation for the Río Grande de Manatí basin. The system would work in conjunction with an evacuation plan to non-floodable areas. This measure would contribute to minimize the threat to the lives of the residents of the lower flood plain area and would provide advanced flood warning for urban areas in the basin.

Permanent evacuation of the flood plain areas could be used to reduce flood damage potential. Such a measure involves land purchase, physical removal of buildings and infrastructure, and relocation of population. Lands acquired in this manner could be used for parks or other purposes that would not interfere with flood flows or receive material damage from floods. The permanent relocation of hundreds of concrete housing units and hundreds of commercial establishments in a highly urbanized area is to a large extent impractical and would have very little acceptance. Therefore, permanent evacuation is not considered any further.

d. Stream cleanup program. This measure primarily consists of removal of trash, debris, and sediments from the existing stream channel. Experience with cleanup programs in other rivers in Puerto Rico suggest that such works have the effect of restoring the natural capacity of the rivers. The cleanup programs have proved to be very effective in alleviating the effects of small periodic flooding; however, they do not contribute to solving the flooding problem associated with intermediate and large floods. These floods are a continuous menace in the study area.

2. Structural measures

a. Flood proofing. Flood proofing is primarily structural changes and adjustments which allow flood waters to rise around or within a building with little or no damaging effects to the building. However, flood proofing techniques do not eliminate residual nuisance damages, loss of access, loss of business, possible utility and community interruptions, and potential danger to public health and safety.

b. Channel improvements. Widening and deepening the present channel of Río Grande de Manatí and route realinement practically throughout the flood plain would provide flood relief in the study area at a very high cost.

During the reconnaissance phase, a plan was considered consisting of a 6 kilometers long channel, one drop structure, levees and inflow structures along the channel improvements to provide flood protection against the 100-year flood. An improved outlet to the ocean required jetties to stabilize it and protect it from coastal sand movements. Salt water intrusion also needed to be controlled. The implementation of this plan would cause considerable environmental impacts. This plan would induce development in the flood plain and violates the flood plain preservation requirements of Executive Order 11988 and the prime and unique farmlands preservation requirements of the Farmland Protection Policy Act. The cost such a flood control channel was estimated at over $32 million. This measure was dropped from further consideration.

c. Floodwalls and levees. These measures preclude flood waters from entering damage-susceptible areas. They are considered in detail because of the physical and environmental conditions of the study area, and also because they appear as practicable, acceptable, and efficient control measures to solve the flood problems in the study area. The physical conditions of the study area are; the urban development is located to one side of the flood plain, there is available open space and flat terrain, the availability of low undeveloped lands that can accommodate interior residual flooding and eliminate the need for costly pumping stations, and levee construction materials are readily available.

Levees or floodwalls, in conjunction with limited channel realignment at two locations where the river is too close to the urban area, could provide considerable protection in the town of Barceloneta. A ring levee would be required at the town of Barceloneta. A ring levee around the town of Barceloneta would disrupt the existing storm drainage system and the natural drainage pattern of the urban area. Interior drainage works would be necessary as part of the ring levee measures.

d. Reservoirs. Reservoirs reduce flood levels by holding back peak flood flows until downstream condition permit release. They can also be effective in fulfilling other water needs such as water supply and recreation. Since the potential reservoir sites will not provide sufficient flood storage capacity and the existing reservoirs are too small and located too far upstream to provide any significant reduction of floods, no further analysis of flood storage at these reservoirs was considered. On the other hand, the high cost of designing and constructing a flood control reservoir, presently estimated at over $50 million, undoubtedly would make the project not economically feasible.

B. Description and Evaluation of Preliminary Plans

During the initial plan identification phase of this study, several non-structural and structural measures were considered. The structural measures included the construction of reinforced concrete floodwalls, earthen levees, pilot channels, drainage structures, and acquisition of residential structures combined into four preliminary plans to provide protection against the SPF. The most feasible plan identified during the initial plan identification phase was modified in accordance to input received during the initial technical meeting and the plan was examined in more detail as final levee plans of the Detailed Project Report phase.

At the time preliminary plans were examined they did not include interior drainage channels and other features later discussed for the final plans. Also, preliminary plans do not considered protecting the ongoing developments west of the town. Implementation of preliminary plans would also have required relocating 236 houses currently under development. Cost of this action is not included in the cost figures.

1. Plan 1. This plan consisted of a combination of 3,400 meters of levees around the town of Barceloneta, a 1,200 meters long pilot channel, four road ramps, and interior drainage facilities. The plan, shown on Figure 2, provides flood protection against the 100-year flood. This plan required the acquisition of 67 residential structures and relocation of 9 buildings at the Municipal Public Works and Civil Defense facilities, all estimated at about $5.4 million. Since levee is adjacent to developed areas in the northern part of the town, the lack of sufficient agricultural lands to be used for residual interior flooding management resulted in high residual damages that required construction of a $3.0 million pumping station. The estimated first cost for this plan, at November 1990 price levels, was $15.1 million. This plan was eliminated from further analysis due to its high acquisition and relocation cost, high pumping station cost, reduced inundation reduction benefits due to some residual flooding at urban areas, higher operations and maintenance cost, and not being acceptable to the local community.

2. Plan 2. As shown on Figure 3, this plan consisted of a combination of about 600 meters of floodwall and about 4,100 meters of earthen levees around the town of Barceloneta, two road ramps, relocation of a 600 meters portion of Highway 681, and minimum interior drainage facilities. This plan provided sufficient agricultural lands, north and east of the town, to be used for residual interior flooding management. The plan provides flood protection against the 100-year flood. Given the foundations conditions encountered, the constructibility of a floodwall at the edge of the existing river bank will be a major problem for the implementation of this plan. The plan also required the acquisition of 32 residential structures. The aesthetics impacts of a floodwall in such a panoramic and picturesque section of town would be unacceptable to the municipal government and the local residents. Incremental costs associated with the construction of the floodwall, about $600,000, were found not to be justified when compared with Plan 3. The estimated first cost for this plan, at November 1990 price levels, was about $10.0 million. This plan was eliminated from further analysis due to its high floodwall cost and constructibility problems.

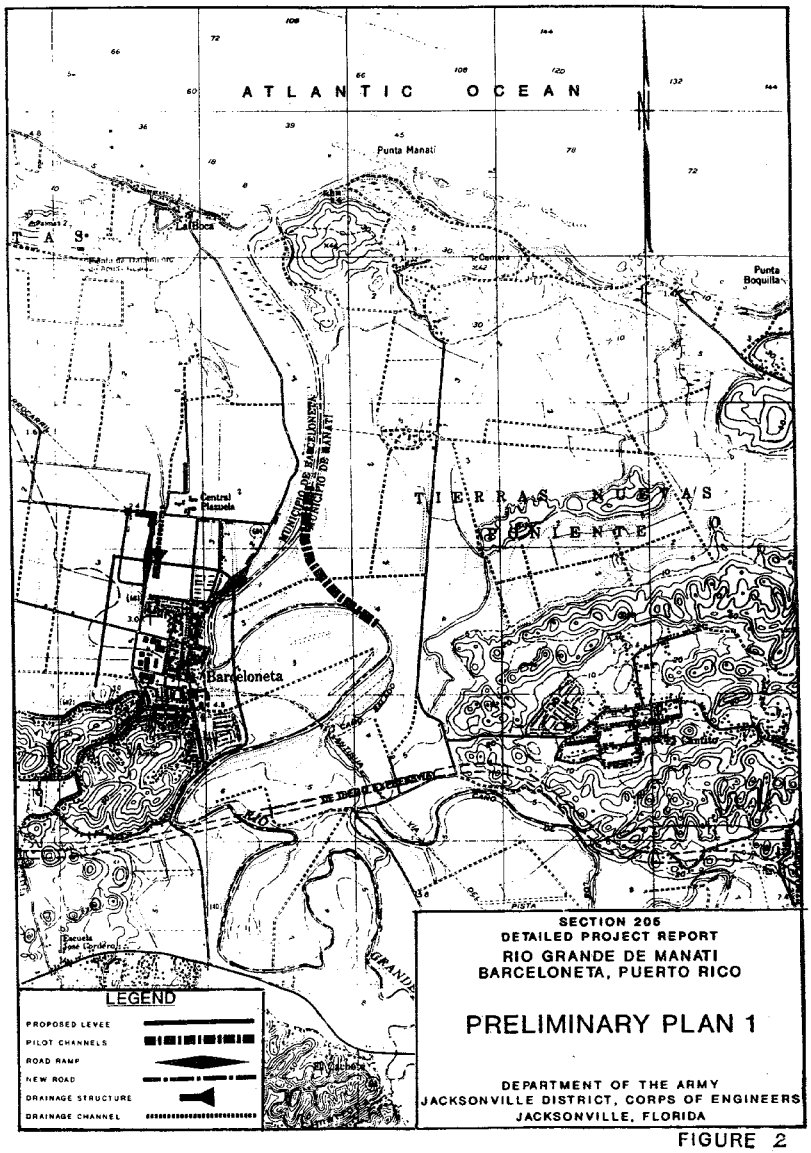

ATLANTIC OCEAN
Punta Manati
La Boca
Punta Boquilla
Central Planada
Barceloneta
TIERRAS NUEVAS
ORIENTE
RIO
GRANDE
LEGEND
PROPOSED LEVEE
PILOT CHANNELS
ROAD RAMP
NEW ROAD
DRAINAGE STRUCTURE
DRAINAGE CHANNEL
SECTION 205
DETAILED PROJECT REPORT
RIO GRANDE DE MANATI
BARCELONETA, PUERTO RICO
PRELIMINARY PLAN 1
DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

FIGURE 2

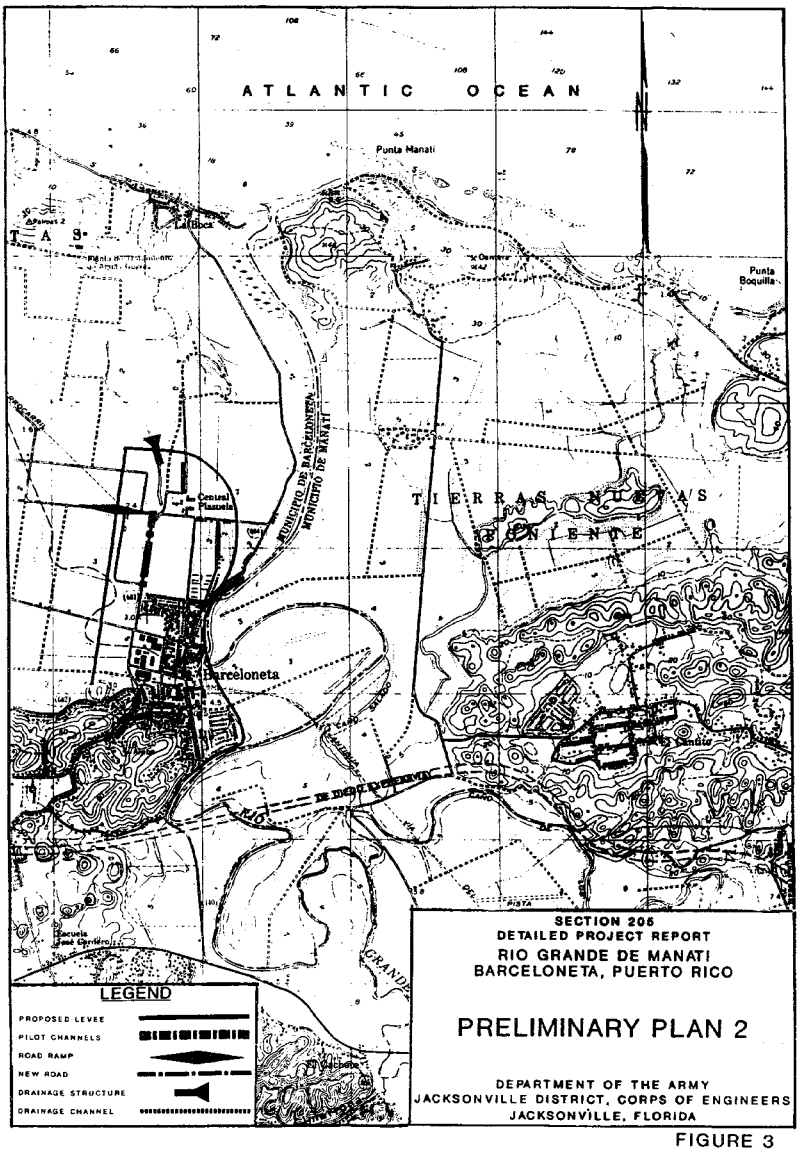

ATLANTIC OCEAN
Punta Manati
Punta Boquilla
Central Plazuela
Barceloneta
MUNICIPIO DE BARCELONETA
MUNICIPIO DE MANATI
TIERRAS NUEVAS
PONIENTE
LEGEND
PROPOSED LEVEE
PILOT CHANNELS
ROAD RAMP
NEW ROAD
DRAINAGE STRUCTURE
DRAINAGE CHANNEL
SECTION 205
DETAILED PROJECT REPORT
RIO GRANDE DE MANATI
BARCELONETA, PUERTO RICO
PRELIMINARY PLAN 2
DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

FIGURE 3

3. Plan 3. As shown on Figure 4, this plan consisted of a combination of 4,600 meters of earthen levees around the town of Barceloneta, a 1,200 meters long pilot channel, two road ramps, relocation of a 600 meters portion of Highway 681, and a drainage structure. The plan also required the acquisition of 32 residential structures. This plan provided sufficient agricultural lands, north and east of the town, to be used for residual interior flooding management. This plan provides flood protection against the 100-year flood. This plan replaces the concrete floodwall included in Plan 2 with an earthen levee away from the edge of town along the east bank of the river, cutting through the river oxbow, and a pilot channel to restore the river channel cut by the levee. During the initial plan identification phase, this plan demonstrated to be the most practical and cost effective flood control alternative for the town of Barceloneta. The estimated first cost for this plan, at November 1990 price levels, was about $9.4 million. This plan was selected for further investigation during the Detailed Project Report phase.

4. Plan 4. As shown on Figure 5, this plan consisted of a combination of earthen levees, following the same alignment as Plan 3, around the town of Barceloneta, a 2,800 meters long pilot channel, two road ramps, relocation of a 600 meters portion of Highway 681, and an interior drainage structure. The plan also required the acquisition of 32 residential structures. The plan provides flood protection against the 100-year flood. The additional length of the pilot channel increased project cost by about $2.0 million without providing any additional inundation reduction benefits. The estimated first cost for this plan, at November 1990 price levels, was about $11.4 million. This plan was eliminated from further analysis due to its high pilot channel cost, larger requirement for disposal areas, and its greater environmental impact.

X. DESCRIPTION AND ANALYSIS OF FINAL PLANS

A. General

Preliminary Plan 3 combining levees, pilot (bypass) channels, was examined for three levels of protection, 50-year, 100-year and the SPF, into three final levee plans. Interior areas protected by the levees were analyzed for minimum drainage facilities and for drainage facilities with a 2-year, 5-year, and 25-year level of design. Plate 5 shows the alignment and features of the final plans.

For purpose of description, the proposed levee is divided into an east and west portion. The east and west portions includes levees sections to east and west of Culvert 1. There is a north and a south pilot channel.

The final alignment of levees has the following significant variation from those considered in the preliminary plans:

1. Design engineers determined that the southeast portion of the east levee could not be built without rerouting a portion of the river with a 760 meters long pilot channel in that area.

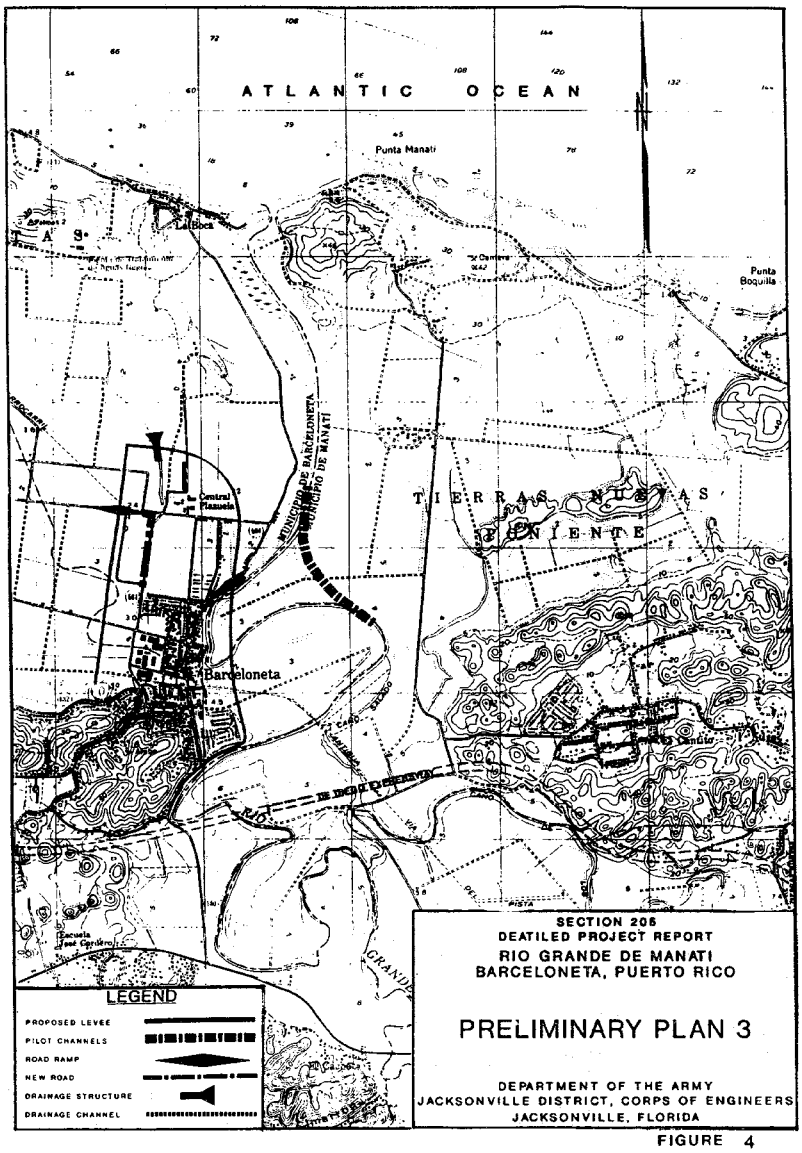

ATLANTIC OCEAN
Punta Manati
La Boca
Punta Boquilla
Central Manuelo
Barceloneta
TIERRAS NUEVAS PONIENTE
LEGEND
PROPOSED LEVEE
PILOT CHANNELS
ROAD RAMP
NEW ROAD
DRAINAGE STRUCTURE
DRAINAGE CHANNEL
SECTION 205
DEATILED PROJECT REPORT
RIO GRANDE DE MANATI
BARCELONETA, PUERTO RICO
PRELIMINARY PLAN 3
DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

FIGURE 4

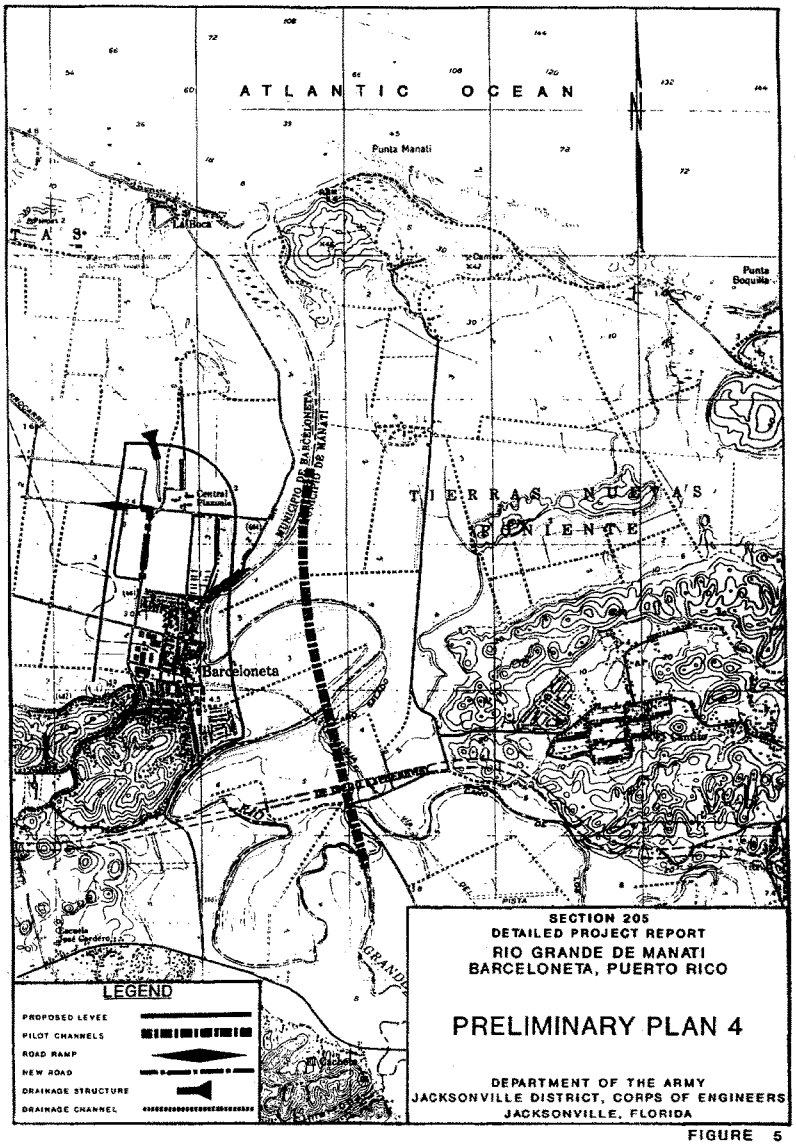

ATLANTIC OCEAN
Punta Manati
Punta Boquilla
Barceloneta
TIERRAS NUEVAS
PONIENTE
LEGEND
PROPOSED LEVEE
PILOT CHANNELS
ROAD RAMP
NEW ROAD
DRAINAGE STRUCTURE
DRAINAGE CHANNEL
SECTION 205
DETAILED PROJECT REPORT
RIO GRANDE DE MANATI
BARCELONETA, PUERTO RICO
PRELIMINARY PLAN 4
DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

FIGURE 5

2. The length of the original downstream pilot channel was reduced from 1,200 meters to 785 meters.

3. The east levee alignment was shifted to protect some 67 residences left without flood protection in the original alignment. With-project flood stages near these houses will be higher. The cost of acquiring these structures was estimated at over $5.4 million, much more than the cost of modifying the east levee alignment to protect them.

4. The southern section of the west levee was shifted 300 meters towards to the west to accommodate an ongoing low income families residential development being built by the Municipality of Barceloneta and financed by the Farmer's Home Administration. The proposed development is consistent with FEMA regulations and the PRPB regulation 13.

5. A portion of the southern alignment of the east levee was modified to avoid an archaeological burial site.

6. The northern part of the west levee alignment was modified to provide enough distance to elevate Highway 681 over the west levee without having to relocate about 600 meters of Highway 681.

7. Additional small highway ramps were required at Highway 682 and Highway 140 where the levee ties into high ground, and an agricultural road ramp on the east levee to provide access and avoid severance costs to over 250 acres of prime agricultural lands.

B. Description of Levee Plans

1. Plan 1. This levee plan considers the construction of 5,200 meters of earthen levees around the town of Barceloneta and two pilot channels, about 1,545 meters long, in the Río Grande de Manatí. This plan would protect the urban area against the 50-year flood. The east levee extends for about 3,000 meters starting at the north interior drainage structure (Culvert 1) and continues east and southeast crossing Calle Plazuela and Highway 684, continuing mainly towards the south crossing the river meander twice, and continuing south near the sport complex and around Villa Catalana residential development. The west levee would start at Culvert 1, and would extend for about 2,200 meters in a south western direction across Highway 681 to end at high ground just across Highway 682. The total length of the levee would be about 5.2 kilometers, with an average height above ground of about 4.7 meters, 1 on 3 side slopes on the east and north levees, 1 on 3.5 side slopes along the west levee, a levee crest of 4.0 meters, and an average levee base of 34.1 meters. The general alignment and important features of this plan are similar to the recommended plan (Plan 2) and are shown on Plate 5.

The two portions of the existing Río Grande de Manatí channel cutoff by the east levee would be replaced by two pilot (bypass) channels with a total length of about 1,545 meters. The pilot channels are designed to be stable and maintain low flow within its banks. The south pilot channel is located about 50 meters south of the existing river channel near the south eastern end of the project. The existing river channel would be filled to built

the levee and drainage channel. The south pilot channel would have a trapezoidal cross section with 1 on 4 side slopes and a 15 meters bottom width at elevation -1.1 meters NGVD. The south pilot channel and the levee near the pilot channel would be revetted with riprap with bedding stone. The north pilot channel is located about 750 meters east of the existing channel. The existing river channel would be filled, elevation 1.0 meters NGVD, and a small drainage channel would be cut along the filled old channel. The north pilot channel would have a trapezoidal cross section with 1 on 4 side slopes and a 15 meters bottom width at elevation -2.2 meters NGVD. Portions of the north pilot channel would be revetted with riprap and bedding stone.

This plan would require the construction of two small road ramps over the levee at Highways 140 and 682 where the levee ties into high ground, two large road ramps over the levee at Highways 681 and 684, and one small gravel road ramp where the east levee preclude access to agricultural lands. Plan implementation would require acquisition of six residential structures, relocation of a boat ramp, and relocation of existing utility lines impacted by the levee at four locations.

The total first cost of this plan, at April 1993 price levels, would be $9.5 million. The annual costs of this plan would reach $893,000, and it would result in a 3.2/1.0 benefit-to-cost ratio. Net National economic development under this plan would be about $1,950,000.

2. Plan 2. This plan considers the same project features as described for Plan 1, but it would provide a 100-year level of protection levee. The proposed 100-year levee would have an average height above ground of about 5.4 meters, 1 on 3 side slopes on the east and north levees, 1 on 3.5 side slopes on the west levee, a levee crest of 4.0 meters, and an average levee base of about 38.0 meters. The general alignment and important features of this plan are those of the recommended plan and are shown on Plate 5.

The total first cost of this plan, at April 1993 price levels, would be $10.6 million. The annual costs of this plan wmuld reach $987,000, and it would result in a 3.1/1.0 benefit-to-cost ratio with a Net National Economic Development of about $2,047,000.

3. Plan 3. This plan considers the same project features as described for Plan 1, but it would provide a SPF level of protection levee. The proposed SPF levee would have an average height above ground of about 6.2 meters, 1 on 3 side slopes on the east and north levees, 1 on 3.5 side slopes on the west levee, a levee crest of 4.0 meters, and an average levee base of about 44 meters. The general alignment and important features of thiq plan are similar to the recommended plan (Plan 2) and are shown on Plate 5.

The total first cost of this plan would be $12.7 million. The annual costs of this plan would reach $1,181,000, and it would result in a 2.7/1.0 benefit-to-cost ratio. Net National Economic Development benefits under this plan would amount to about $1,991,000.

C. Description of Interior Drainage Alternatives.

These consist of a series of channels, culverts, and structures providing interior drainage for the collection and disposal of interior runoff trapped inside the levees. Regarding interior drainage facilities, the following alternatives were considered for optimization of level of design:

1. Alternative Interior Drainage 1. A ring levee around the town of Barceloneta would required at least a minimum interior drainage facilities due to the disruption of the existing storm drainage system of town and the natural drainage pattern of lands by the construction of levees. This plan considers minimum interior drainage facilities to collect and dispose of urban runoff caused by a local rainfall event to economically minimize residual flooding.

Minimum interior drainage facilities would consist of 5,230 meters of drainage channels along the protected side of the levee, drainage channels culverts under two highway ramps, and two drainage structures. Flood stages within the levee for the 100-year will be reduced from a pre-project elevation of 5.1 meters NGVD to a post-project elevation of 2.7 meters NGVD. The drainage channels would be constructed with a triangular cross section with an average depth of flow of 1.5 meters and an average top width of 9.0 meters. The drainage channels would collect and direct storm water into the drainage structures. Some 236.5 acres of mostly agricultural lands located to the north and east of town would still be subject to interior flooding. The interior drainage structures would consist of corrugated metal pipe culverts with flap gates, to prevent backflow, and concrete headwalls. Corrugated metal pipe culverts for interior drainage would be provided under Highway 681 ramp and the agricultural road access ramp. The total first cost of this plan, at November 1991 price levels, would be $0.7 million. The total annual cost of this plan would reach $65,700. This is the least expensive interior drainage alternative, that would be required to restore the natural existing drainage characteristics of the area.

2. Alternative Interior Drainage 2. This plan considers a 2-year level of design interior drainage facilities to collect and dispose of urban runoff caused by a local rainfall event.

The proposed 2-year interior drainage facilities would consist of 4,840 meters of drainage channels along the protected side of the levee, drainage channels culverts under two highway ramps, two ponding areas and two drainage structures. The drainage channels along the east and north levees would be of trapezoidal cross section with a bottom width of 2.0 meters and an average depth of flow of 2.0 meters. The drainage channels along the west levee would be of trapezoidal cross section with a bottom width of 35.0 meters and an average depth of flow of 2.0 meters. The drainage channels would collect and direct storm water into the ponding areas and from there into the drainage structures. A 39.5 acres excavated ponding area at agricultural lands, north of Calle Plazuela, was included in this plan. Some 236.5 acres of mostly agricultural lands located to the north and east of town would still be subject to interior flooding. The interior drainage structures would consist of corrugated metal pipe culverts with flap gates, to prevent backflow, and concrete headwalls. The total first cost of this plan, at November 1991 price levels, would be $2.6 million. The annual costs of this plan would reach $232,600.

3. Alternative Interior Drainage 3. This plan considers a 5-year level of design interior drainage system. A 57.2 acres excavated ponding area at agricultural lands, north of Calle Plazuela, was included in this plan. Some 236.5 acres of mostly agricultural lands located to the north and east of town would still be subject to interior flooding. The total first cost of this plan, at November 1991 price levels, would be $3.7 million. The annual costs of this plan would reach $324,500.

4. Alternative Interior Drainage 4. This plan considers a 25-year level of design interior drainage system. An 87 acres excavated ponding area at agricultural lands, north of Calle Plazuela, was included in this plan. Some 236.5 acres of mostly agricultural lands located to the north and east of town would still be subject to interior flooding. The total first cost of this plan, at November 1991 price levels, would be $6.2 million. The annual costs of this plan would reach $564,200.

D. Analysis of Final Plans

1. General. The purpose of this analysis is to arrive at a recommended plan on the basis of the contributions of the final plans to the planning objectives and the trade-offs among the plans. Table 5 is a summary of the significant impacts for each levee plan considered in detail with minimum interior drainage facilities. The table includes NED benefits as well as environmental, social, cultural, and regional impacts. This table contains pertinent data to evaluate the final plans on the basis of their contribution to the system of accounts. Interior drainage alternatives 2, 3, and 4 are eliminated, from further analysis, since they do not provide additional net benefits they are not incrementally justified.

The construction of a road ramp at Highway 684 will affect one significant historic period archaeological site. The site has been determined to be significant only for its information potential, and archaeological data recovery will collect information adequately to mitigate adverse effects. Mitigation costs are estimated at $45,000, and will not exceed 1 percent of the Federal flood control cost.

The construction of a flood control project would take 140 acres of agricultural land for levees, channels, and highway ramps. Construction of levees would require about 700,000 cubic meters of fill which would come from two nearby commercial quarries (see Plate B-2, Appendix B). The construction of channels would require the excavation of about 197,000 cubic meters of material. About 50 percent of the excavated material would be deposited at channels cutoff from the river and at the 6 acres disposal area located along the flood side of the west levee and the rest would be utilized for the construction of levees.

2. Plan 1. This plan would significantly reduce the flooding problem in the town of Barceloneta, affected by overbanking of Río Grande de Manatí. Flood damages would be reduced by 85 percent. The construction of levees under this plan would require the acquisition of 3 structures with severe access alone Highway 684 that would also remain in the floodway, and 3 additional structures where the levee ties to high ground. The plan would require raising Highways 140, 681, 682 and 684 at levee crossings.

TABLE 5

RIO GRANDE DE MANATI DETAILED PROJECT REPORT

SUMMARY SYSTEM OF ACCOUNTS FOR FINAL PLANS
(All $ Figures in $1,000 of April 1993)

	PLAN 1	PLAN 2	PLAN 3	NO ACTION
I. National Economic Development Effects				
A. Value of Increased Output of Goods and Services (Annual)				
Inundation Reduction Benefits	2,796	2,981	3,107	----
Total Beneficial Effects (Annual)	2,796	2,981	3,107	----
B. Value of Resources Required for the Plan				
Total First Cost	9,544	10,577	12,722	----
Interest During Construction	640	718	879	----
Total Investment Cost	10,184	11,295	13,601	----
Annual Investment Cost	856	950	1,144	----
Annual Operations and Maintenance	33	37	45	----
Total Annual Cost	889	987	1,189	----
Net Beneficial Effects (Annual)	1,907	1,994	1,918	----
Total Benefit to Cost Ratio	3.1	3.0	2.6	----
II. Environmental Effects				
A. Cultural	One significant archaeological site will be impacted by the construction of Highway 684 ramp. Proper mitigation will be provided.	Same as Plan 1.	Same as Plan 1.	None.

TABLE 5 (Cont.)

RIO GRANDE DE MANATI DETAILED PROJECT REPORT

SUMMARY SYSTEM OF ACCOUNTS FOR FINAL PLANS
(All $ Figures in $1,000 of April 1993)

	PLAN 1	PLAN 2	PLAN 3	NO ACTION
B. Flora and Wetlands	Destruction of vegetation along river edge. Impact to 7 acres of palustrine wetlands along the levee alignment will be replaced with some 22 acres from new channels with a net gain of about 15 acres of palutrine wetlands.	Same as Plan 1, with a net gain of about 14 acres of palustrine wetlands.	Same as Plan 1, with a net gain of about 14 acres of palustrine wetlands.	No net gain or loss of palustrine wetlands.
C. Fauna Avian and Fisheries	Temporary destruction and disruption of aquatic fauna and fisheries because of construction of pilot channels.	Same as Plan 1, because size of pilot channels are the same.	Same as Plan 1, because size of pilot channels are the same.	None.
D. Threatened and Endangered Species	No impact to endangered species.	Same as Plan 1.	Same as Plan 1.	Same as Plan 1.
E. Noise	Temporary noise level expected to increase during construction.	Same as Plan 1.	Same as Plan 1.	None.
F. Water Quality	No impact to water quality.	Same as Plan 1.	Same as Plan 1.	Same as Plan 1.
G. Water Supply	No impact to surface waters.	Same as Plan 1.	Same as Plan 1.	Same as Plan 1.
H. Ground Water	Channel excavation is not expected to affect the aquifer.	Same as Plan 1.	Same as Plan 1.	Same as Plan 1.

TABLE 5 (Cont.)

RIO GRANDE DE MANATI DETAILED PROJECT REPORT

SUMMARY SYSTEM OF ACCOUNTS FOR FINAL PLANS
(All $ Figures in $1,000 of April 1993)

	PLAN 1	PLAN 2	PLAN 3	NO ACTION
I. Land Use	Will require about 136 acres of land for construction and affect 236.5 acres by interior residual flood. With-project 100 year flood stages will increase by almost one foot on agricultural lands east of the levee.	Will require about 142 acres of land for construction and affect 236.5 acres by interior residual flood. With-project 100 year flood stages will increase by almost one foot on agricultural lands east of the levee.	Will require about 153 acres of land for construction and affect 236.5 acres by interior residual flood. With-project 100 year flood stages will increase by almost one foot on agricultural lands east of the levee.	None.
J. Excavated Materials	The pilot channel excavated would produce 249,900 cubic yards while the interior drainage channel excavation would result in 36,400 cubic yards. About half or 143,000 cubic yards of this material would be used for construction of levee while the rest would be deposited at 6.8 acres of upland site. There is no contaminated sediment in the excavated material.	Same as Plan 1.	Same as Plan 1.	None.

TABLE 5 (Cont.)

RIO GRANDE DE MANATI DETAILED PROJECT REPORT

SUMMARY SYSTEM OF ACCOUNTS FOR FINAL PLANS
(All $ Figures in $1,000 of April 1993)

	PLAN 1	PLAN 2	PLAN 3	NO ACTION
III. Regional Development				
A. Income (Annual)				
Regional Income	5,858	6,291	6,727	None.
Regional Costs	221	248	304	None.
Net Regional Benefits	5,637	6,043	6,423	None.
B. Employment (Annual)				
Direct and Indirect Increase of Jobs Resulting from Plan Implementation (man-years)	117	126	136	None.
C. Urban Development	Provides for densification of existing urban area and maximizes use of infrastructure.	Same as Plan 1.	Same as Plan 1.	None.
IV. Social Well-Being				
A. Life, Health, and Safety of Residents	Will protect about 3,200 persons. Will require the relocation of 6 families.	Same as Plan 1.	Same as Plan 1.	None.
B. Cohesiveness	Prevents disruption of family life in the study area.	Same as Plan 1.	Same as Plan 1.	None.
C. Urbanization	Provides for flood protection to ongoing development of lands.	Same as Plan 1.	Same as Plan 1.	Same as Plan 1.
D. Reduction in Property Losses (in %)	85%	92%	95%	None.
E. Residual Flooding (in $1,000 annual)	475	290	164	3,000

The plan would provide protection for 0.96 square kilometers (237 acres) of existing urban developments, 0.40 square kilometers (100 acres) of lands in the process of urban expansion, and 0.96 square kilometers (237.5 acres) of mostly agricultural lands which would serve for residual interior flooding management when there is substantial rainfall.

There would be temporary adverse impacts on air quality, water quality, and aquatic life from clearing and excavating during the construction of levees, pilot channel, and transportation of fill material. Other than the use of some 136 acres of land for construction of levee, no other major significant permanent environmental adverse impacts are expected to result from the implementation of this plan.

3. Plan 2. This plan which protects against the 100-year flood would substantially reduce the flooding problem in the urban area of the town of Barceloneta. This plan would have essentially the same impacts as Plan 1, except that the temporary and permanent environmental adverse impacts would be more extensive because of the larger levee footprint (142 acres). The reduction of flood damages is 92 percent.

4. Plan 3. This plan which protects against the SPF would have the same features and impacts as Plan 2, except that the permanent environmental adverse impacts would be more extensive because of the larger levee footprint (153 acres). This plan would eliminate 95 percent of potential flood damages.

5. No action plan. The no-action plan supposes continued suffering by thousands of residents in the town of Barceloneta. In the case of the Río Grande de Manatí, a "no-action" plan would require acceptance of about $3.0 million in average annual damages to existing properties. This would not be acceptable to the residents of the study area. The "no-action" plan would result in a physical deterioration of the study area and would seriously undermine its potential for further economic development. Inhabitants of the area would continue to suffer social and economic stresses associated with frequent flooding. Continuous government relief would be necessary to help the victims of the frequent flooding of the area.

XI. RECOMMENDED PLAN OF IMPROVEMENTS

A. Description of Components

1. General. The recommended plan consist of providing a ring levee, two pilot channels, minimum interior drainage facilities, relocation of one boat ramp, four highway ramps, and one agricultural ramp for flood protection for the town of Barceloneta. The recommended plan would provide 100-year flood protection for the flood prone areas of the town of Barceloneta due to overflows from Río Grande de Manatí. Agricultural lands would still be flooded by interior runoff which for all conditions is less severe than under existing conditions. The alignment and most important structural features of the recommended plan are shown on Plate 5.

The recommended plan considers the construction of 5,200 meters of levees around the town of Barceloneta and 1,545 meters of pilot channels in the Río Grande de Manatí. The east levee extends for about 3,000 meters starting at the north interior drainage structure (Culvert 1) and continues east and southeast crossing Calle Plazuela and Highway 684, continuing mainly towards the south crossing the river meander twice, and continuing south near sport complex and around Villa Catalana residential development. The west levee would start at Culvert 1, and would extend for 2,100 meters in a south western direction across Highway 681 to end at high ground just across Highway 682. The total length of the levee would be about 5.2 kilometers, with an average height above ground of 5.4 meters, 1 on 3 side slopes on the east and north levees, 1 on 3.5 side slopes on the west levee, a levee crest of 4.0 meters, and an average levee base of 38 meters. For purpose of safety and to maintain clear an evacuation route to the south should larger than design flood occur, the northern 500 meters stretch of levee was designed as an overtopping section.

The two portions of the existing Río Grande de Manatí channel cutoff by the east levee would be replaced by pilot (bypass) channels. The pilot channels are designed to be stable and maintain low flow within its banks. The south pilot channel is located about 50 meters south of the existing river channel near the south eastern end of the project. The existing river channel would be filled to built the levee and drainage channel. The south pilot channel would have a trapezoidal cross section with 1 on 4 side slopes and a 15 meters bottom width at elevation -1.1 meters NGVD. The south pilot channel and the levee near the pilot channel would be revetted with riprap with bedding stone. The north pilot channel is located about 750 meterq east of the existing channel. The existing river channel would be filled, elevation 1.0 meters NGVD, to built the drainage channel. The north pilot channel would have a trapezoidal cross section with 1 on 4 side slopes and a 15 meters bottom width at elevation -2.2 meters NGVD. The north pilot channel would be revetted with riprap and bedding.

The recommended plan considers the construction of a minimum interior drainage facilities to collect and dispose of urban runmff caused by a local rainfall event. The interior drainage facilities are required due to the disruption of the existing storm drainage system and the natural drainage pattern of the urban area by the construction of flood control levees. The proposed minimum drainage facilities would consist of 5,230 meters of drainage channels along the protected side of the levee, drainage channels culverts under two highway ramps, and two drainage structures on the levees. The drainage channels would be constructed with a triangular cross section with an average depth of flow of 1.5 meters and an average top width of 9.0 meters. The drainage channels would collect and direct storm water into the drainage structures. Corrugated metal pipe culverts for interior drainage would be provided under Highway 681 ramp and the agricultural road access ramp. The drainage structures, Culvert 1 and Culvert 2, consist of corrugated metal pipe culverts with flap gates and concrete headwalls. Two large areas of mostly agricultural lands, 57.5 acres on the east and 179.0 acres on the north, would serve for stmring most of the residual flooding caused by interior runoff (refer to Plate A-2). Flood stages on this land, however, for the 100-year will be reduced from a pre-project elevation of 5.1 meters NGVD to a post-project elevation of 2.7 meters NGVD. This would allow for its continued use in agriculture.

The recommended plan would require the construction of two small road ramps over the levee at Highways 140 and 682, two large road ramps over the levee at Highways 681 and 684, and one agricultural road ramp where the east levee preclude access to agricultural lands. Plan implementation would require acquisition of six residential structures, relocation of a boat ramp, and relocation existing utilities impacted by the levee at four locations.

The total first cost of this plan, at April 1993 price levels, would be $10.6 million. The annual costs of this plan would reach $942,000, and it would result in a 3.2 benefit-to-cost ratio. Net benefits for this plan are $2,086,000.

2. Design considerations

a. Access during construction. Existing town streets, state highways and agricultural roads in the vicinity of the project would provide adequate access for construction and future maintenance.

b. Construction methods. Excavation of materials for the pilot channels and interior drainage channels would be accomplished by bulldozer, front-end loader, or other similar types of equipment. Suitable material from the pilot channels and interior drainage channels would be used for the construction of levees and filling the river oxbow being cut-off by the levee. Excess material and material unsuitable for construction would be hauled to the nearby disposal area along the flood side of the west levee.

c. Real estate requirements. It is estimated that construction of the levees and drainage channel would require 76.2 acres, the road ramps would require 23 acres, 21 acres of severance land, while the construction of the pilot channels would require another 24.3 acres, and the disposal area 6.8 acres.

d. Operation and maintenance. The local sponsor would be responsible for maintenance of the proposed project upon completion of the construction contract. The contractor would be responsible for all maintenance during the construction contract. The annual operations and maintenance for flood control features was estimated at $37,000 a year.

B. Economics of Recommended Plan

1. General. The tangible economic justification of the recommended plan was determined by comparing the average annual charges with the estimated average annual equivalent benefits anticipated to accrue over the economic life of the project. A discount rate of 8.0 percent was used to discount cost and benefits over a project life of 50 years.

2. Cost estimate. Construction cost estimates for the proposed project, showing quantities and unit prices costs, are presented in Table C-1, Appendix C, Design and Cost Estimates. Estimates of first costs were based on April 1993 price levels and a construction period of 24 months. Table 6 summarizes each feature cost, the total first cost, interest during construction, total investment cost, operation and maintenance cost, and total annual cost.

TABLE 6

RIO GRANDE DE MANATI DETAILED PROJECT REPORT

COSTS ESTIMATES OF RECOMMENDED PLAN
($1,000 of April 1993)

	ECONOMIC COST	FINANCIAL COST
Roads and Ramps	1,011	1,011
Utilities	370	370
Channels and Canals	1,430	1,430
Levees	4,840	4,840
TOTAL CONSTRUCTION COST	7,651	7,651
Real Estate	1,410	1,410
P. L. 91-646	---	203
Cultural Resources Preservation	---	45
Planning, Engineering, and Design	525	525
Construction Management	788	788
TOTAL FIRST COSTS	10,374	10,622
Interest During Construction	696	
TOTAL INVESTMENT COSTS	11,070	
Interest and Amortization	905	
Annual Operation and Maintenance Cost	37	
TOTAL ANNUAL COST	942	

NOTES: Figures include appropriate contingency costs.
Detailed estimates are shown in Appendix C, Design and Cost Estimates.
Discounted at current interest rate of 8 percent.
The economic cost is related to the economic analysis on Table 7.
The financial cost is related to the project cost sharing on Table 8.

3. Benefits. Tangible benefits to be derived as a result of the proposed project result from urban inundation reduction and employment benefits. Annual agricultural inundation reduction benefits were calculated but they were so insignificant (less than $3,000) that it was decided not to include them in the economic analysis. On the other hand, relatively small employment benefits were included to assist the local sponsor in explaining one important local benefits of the project. The base year for project analysis was 1998.

C. Summary of Impacts

Table 7 summarizes the economic impacts of the recommended plan for the project as a whole. Detailed cost estimates are presented in Appendix C, Design and Cost Estimates, while details on benefits associated with the plans are discussed in Appendix E, Economic Analysis. The benefit to cost ratio for the overall plan is 3.2/1.0. Net NED benefits are about $2.1 million annually. Implementation of project would produce directly and indirectly net regional annual income of $5,223,000 and 168 temporary man years and 127 permanent jobs. Most of these jobs would be associated with the intensification of commercial or industrial facilities and housing in the enhanced study area.

The construction of a road ramp at Highway 684 will affect one significant historic period archaeological site. The site has been determined to be significant only for its information potential, and archaeological data recovery will collect information adequately to mitigate adverse effects. Mitigation costs are estimated at $45,000, and will not exceed 1 percent of the Federal flood control cost.

D. Implementation Responsibilities

1. Federal responsibility. The Federal Government would design and prepare detailed plans, and construct the project (exclusive those items specifically required of non-Federal interests), this being subject to approval of this report, future funding, and upon completion of a contractual agreement for local cooperation as required by Section 221 of the 1970 Flood Control Act, and upon completion of contribution of the Federal Government under current cost sharing policy would be the maximum authorized $5.0 million.

2. Non-Federal responsibility. The local sponsor would be required to provide all lands, easements, and rights-of-way; alterations or acquisition of structures; alterations and relocations to highway bridges and public utilities; to hold and save the Federal Government from damages due to the construction works; and to properly maintain, replace, repair, rehabilitate and operate all works after completion of the project, including establishing and enforcing regulations, to assure the flood control project accomplishes its objectives. In addition, the local sponsor is responsible for a cash contribution to cover the flood control cost in excess of $5.0 million. This later figure includes cost of reconnaissance and detailed project report.

3. Cost sharing. Table 8 shows cost sharing of total first cost of the project as established in the Water Resources Development Act of 1986. The non-Federal costs, required from the local sponsor, would be those associated with easements, rights-of-way, acquisition of structures, relocation of utilities, and modifications to roads. These costs would amount to $2,994,000 and represent 28.2 percent of the total flood control cost of the project. As required by law, the non-Federal sponsor would also have to contribute the minimum 5 percent in cash of the total flood control cost of the project, that

TABLE 7

RIO GRANDE DE MANATI DETAILED PROJECT REPORT

SUMMARY OF ECONOMICS FOR RECOMMENDED PLAN
($1,000 of April 1993)

TOTAL FIRST COST	10,374
Interest During Construction	696
TOTAL INVESTMENT COST	11,070
Interest and Amortization	905
Annual Operation and Maintenance:	37
TOTAL ANNUAL COST	942
Annualized Benefits : Inundation Reduction	2,982
: Employment	43
TOTAL ANNUAL BENEFITS	3,025
Net NED Benefits	2,083
BENEFIT-TO-COST RATIO	3.2

TABLE 8

RIO GRANDE DE MANATI DETAILED PROJECT REPORT

RECOMMENDED PLAN
COST SHARING OF TOTAL FIRST COST
($1,000 of April 1993)

Total First Cost	10,622
Non-Federal Cost:	
Lands and Damages	1,613
Road and Ramps	1,011
Relocation of Utilities	370
5% of Flood Control Cost Minimum Cash	531
Additional Cash Contribution because project cost surpasses $5 million Federal limit	2,488
TOTAL NON-FEDERAL SHARE	6,013
FEDERAL SHARE	4,609*

*Difference with limit of $5.0 million for Section 205 studies account for cost of reconnaissance and detailed project reports.

is, another $531,000 in addition to the lands, easements, right-of-ways, acquisition of structures, relocation of utilities, and bridge replacements. In this project the local sponsor would also have to contribute an additional $2,488,000 in cash because the cost of the project goes beyond the $5.0 million Federal limit. Already some $391,000 in Federal funds have been expended in the reconnaissance and detailed project reports. The Federal contribution for the flood control project to include plans and specifications would therefore be $4,609,000, while the non-Federal contribution would total $6,013,000.

The local sponsor shall perform environmental investigations to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), 42 USC 9601-9675, on land necessary for construction, operation, and maintenance. All actual costs incurred by the local sponsor which are properly allowable and allocable for the performance of any such environmental investigations shall be included in the total project cost and cost shared as a construction cost in accordance with Section 103 of Public Law 99-662. If any project lands are found to contain hazardous substances regulated under CERCLA, the local sponsor should promptly notify the Federal Government. Any costs incurred with the clean up of hazardous materials located on project lands and response cost covered under CERCLA are considered a non-Federal responsibility.

4. Institutional arrangements. The Department of Natural Resources (DNR) of the Commonwealth of Puerto Rico would be the local sponsor and cooperating agency for the project. The DNR would organize a coordinating committee of representatives of the Department of Transportation and Public Works, the Puerto Rico Aqueduct and Sewer Authority, the Puerto Rico Electric Power Authority, the Puerto Rico Land Authority, the Municipality of Barceloneta, the Puerto Rico Planning Board, the Puerto Rico Environmental Quality Board, the Office of the Budget and Management, and residents of the study area.

5. Steps to plan implementation. Submission of this report by the District Engineer constitutes the first step in a chain of events that must take place before a flood control project can become a reality. It may be modified at any stage of review, and only if it successfully passes each stage will it ultimately be constructed. These events are:

a. Review and approval of the Río Grande de Manatí Detailed Project Report and the environmental assessment by South Atlantic Division, Washington Level Review Center, and Office of the Chief of Engineers.

b. Fulfillment of the required measures of local cooperation, including cost sharing and lands, easements, rights-of-way, acquisitions and relocations.

c. Completion of the necessary additional detailed topographic surveys, cultural investigations, geotechnical explorations, preparation of plans and specifications, and an estimate of the construction cost by the District Engineer and acquisition of permits, followed by an invitation for bids and awarding of the construction contracts.

d. Allocation of funds by Chief of Engineers for construction.

E. Coordination

The study was developed and worked out in close coordination with the Puerto Rico Department of Natural Resources, the local sponsor; the Puerto Rico Planning Board; the State Historic Preservation Officer; the Municipality of Barceloneta; the U. S. Fish and Wildlife Service; the U. S. Geological Survey; and the Environmental Protection Agency.

The local sponsor will read and will concur with the findings of the report and will provide a Letter of Intent supportine the report's conclusions and recommendations. The Draft Project Management Plan (PMP) and Project Cost Agreement (PCA) will be discussed with the local sponsor. The Letter of Intent, PMP, and PCA will be included in the final report.

F. Financial Analysis

During several coordination meetings with the local sponsor, the Corps field office has discussed and explained the recommended plan for a flood control project for Río Grande de Manatí at Barceloneta under the continuing authority of Section 205. The local sponsor understands their responsibilities for contributing with all lands, easements and right-of-ways, relocation of utilities, and the acquisition of buildings and structures necessary for the implementation of the recommended plan. The local sponsor understands the Federal requirement for contributing a minimum of 5 percent cash of the total flood control first aosts. The local sponsor understands that the maximum Federal share for the project including study cost is limited tm $5.0 million.

Options for financing the local share and assessing the financial feasibility of the project were also discussed. The local sponsor has expressed their support for the recommended plan and their intent to comply with all requirements as outlined in the report. Also, they have presented their plan to finance the local share in the project by annual appropriations from the Commonwealth legislature for the capital improvement program for flood control works managed by the Puerto Rico Department of Natural Resources. These funds will be combined with funds obtained from selling of Commonwealth of Puerto Rico bonds for infrastructure development. The funds, now being programmed by the sponsor, will cover their share of the total first cost for construction of the project in accordance with the detailed project report and latest PMP.

G. Ability to Pay

The application of the ability to pay criteria does not change the project cost allocation.

XII. CONCLUSIONS

The Río Grande de Manatí Detailed Project Report shows that flooding is a major problem threatening life, property, and economic development in the town of Barceloneta, Puerto Rico. It is economically justified and considered necessary to develop and construct a flood control project along the Río Grande de Manatí at the town of Barceloneta.

The recommended plan provides for a combination of channel construction and levees along the Río Grande de Manatí to protect over 914 families against the 100-year flood. The recommended plan proposes the following works; the construction of about 1,545 meters of pilot channels and about 5,200 meters of earthen levees.

I have given consideration to all significant aspects in the overall public interest, including engineering feasibility, economic, social and environmental effects. The recommended plan described in the report provides the optimum and most practical solution for flood protection along the Río Grande de Manatí in the vicinity of the town of Barceloneta within the framework of the formulation concepts.

XIII. RECOMMENDATIONS

I recommend that the recommended plan for flood damage reduction along Río Grande de Manatí at Barceloneta be approved under the authority contained in Section 205 of the 1948 Flood Control Act, as amended, with such modifications as in the discretion of the Chief of Engineers may be advisable, be authorized for implementation as a Federal project, with such modifications as advisable at the discretion of the Chief of Engineers, for a total first cost to the United States estimated at $4,609,000 and a benefit-to-cost ratio of 3.1 to 1.0 provided that, except as otherwise stated in these recommendations, the exact amount of non-Federal contributions shall be determined by the Chief of Engineers following polices satisfactory to the President and the United States Congress prior to project implementation, in accordance with the following requirements to which non-Federal interests must agree prior to implementation:

1. Provide all lands, easements, and rights-of-way, including suitable borrow and material disposal areas necessary for construction, operation and maintenance of the Project;

2. Accomplish all necessary alterations and relocations to public roads, railroads, bridges (except existing railroad bridges), pipelines, cables, and other facilities, required for construction, operation and maintenance of the Project;

3. Provide a cash contribution of 5 percent of the total project first cost assigned to structural flood control;

4. In no instance shall the Government's share of total project cost, including all preauthorization planning (reconnaissance report, detailed project report, etc.), exceed $5,000,000. The local sponsor shall pay all project costs in excess of the Federal cost limitation of $5,000,000 (including cost of reconnaissance and DPR).

5. Operate and maintain the Project after completion, including accomplishment of any needed repairs, replacements or rehabilitation of any Project components in accordance with directions of the Federal Government;

6. Hold and save the United States free from damages due to the construction, operation and maintenance of the Project, except for damages due to the fault or negligence of the United States or its contractors;

7. Prior to initiation of construction, enact ordinances and promulgate regulations to prevent construction and encroachment on the levees and channels and other project works that would reduce their flood carrying capacity or hinder maintenance and operation, and control development in the project area to prevent an undue increase in the flood damage potential;

8. Prevent future encroachments which might interfere with proper functioning of the Project;

9. Participate in and comply with applicable Federal flood plain management and flood insurance programs;

10. Publicize flood plain information in the area concerned and provide this information to zoning and other regulatory agencies for their guidance and leadership in preventing unwise future development in the flood plain and in adopting such regulations as may be necessary to prevent unwise future development and to ensure compatibility with the protection levels provided by the Project;

11. No less than once a year inform affected interests of the limitations of the protection afforded by the Project;

12. Assume complete financial responsibility for the cleanup of hazardous materials located on project lands and regulated under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), and be responsible for operating, maintaining, repairing, replacing, and rehabilitating the project in a manner so that liability will not arise under CERCLA;

13. After the time of entering the Project Cooperation Agreement, perform any environmental investigations as determined necessary to identify the existence and extent of any hazardous substances regulated under CERCLA on any lands needed for project construction, operation and maintenance;

14. Comply with the requirements of Section 221 of the Flood Control Act of 1970, Public Law 91-611, as amended, in executing a written agreement with the Federal Government to furnish its required cooperation for the Project;

15. Comply with Section 601 of the Title VI of the Civil Rights Acts of 1964 (Public Law 88-352) and Department of Defense Directive 5500.11 issued pursuant thereto and published as part 300 of Title 32, Code of Federal Regulations, as well a Army Regulation 600-7 entitled "Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army.";

16. Comply with the applicable provisions of the Uniform Relocations Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, approved January 2, 1971, in acquiring lands, easements, and rights-of-way for construction and subsequent operation and maintenance of the project, and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act;

This recommendation is made with the provision that, prior to implementation, local interest enter into a Project Cooperation Agreement with the Department of the Army to provide the items of non-Federal responsibility stipulated above.

The recommendations contained herein reflect the information available at this time and current Departmental policies governing formulation of individual projects. They do not reflect program and budgeting priorities inherent in the formulation of a national civil works construction program nor the perspective of higher review levels within the Executive Branch. Consequently, the recommendations may be modified before it is approved and funded by the Chief of Engineers.

TERRENCE C. SALT
Colonel, Corps of Engineers
Commanding

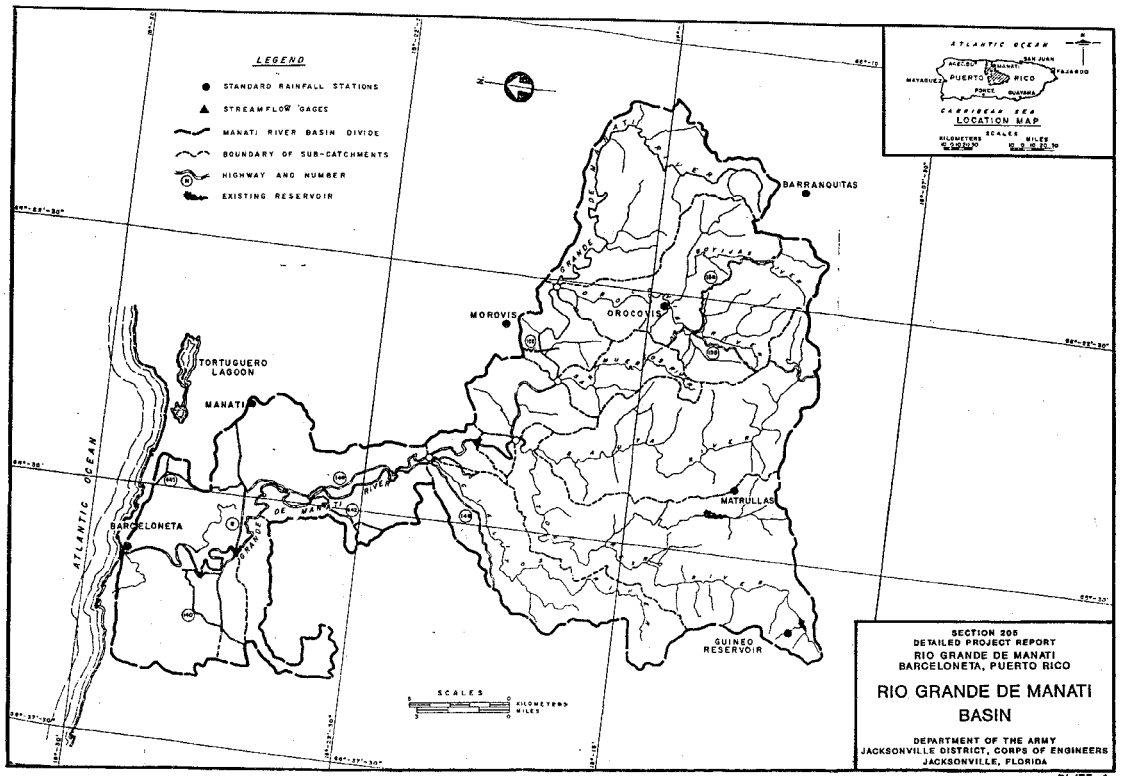
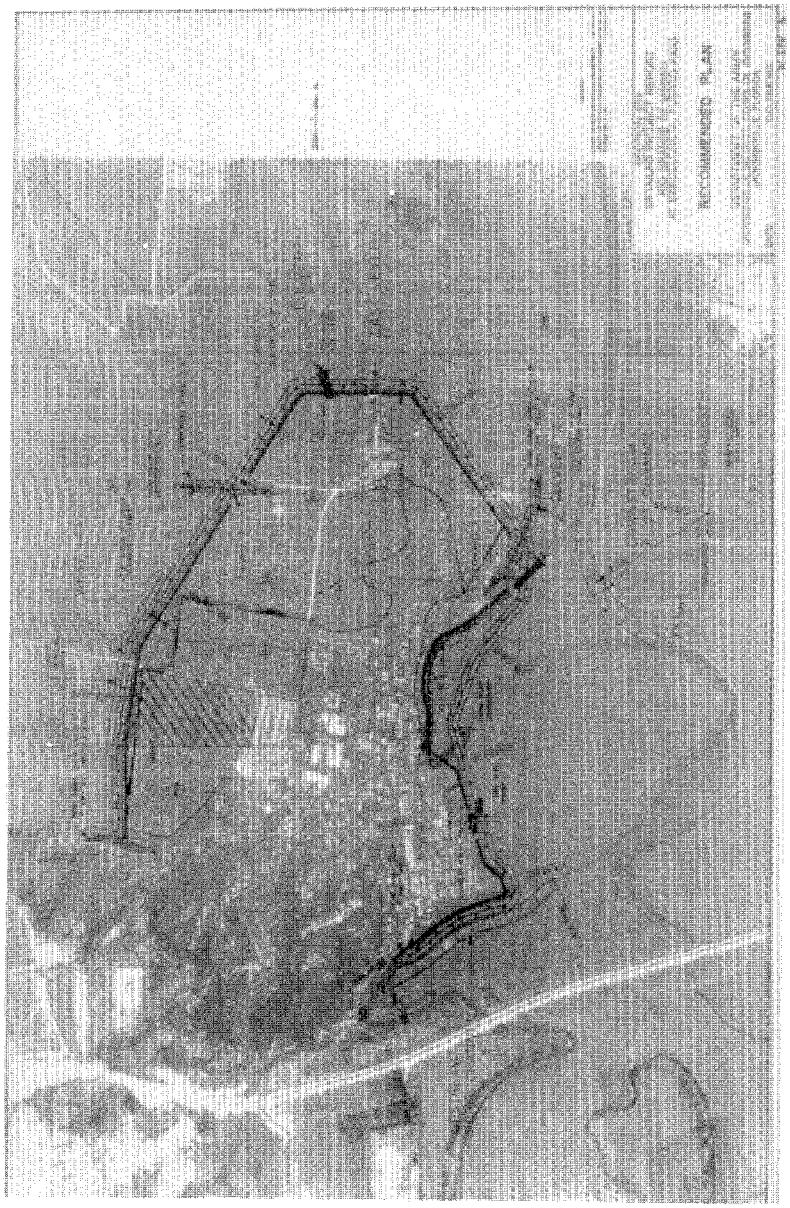

LEGEND
STANDARD RAINFALL STATIONS
STREAMFLOW GAGES
MANATI RIVER BASIN DIVIDE
BOUNDARY OF SUB-CATCHMENTS
HIGHWAY AND NUMBER
EXISTING RESERVOIR
ATLANTIC OCEAN
CARIBBEAN SEA
LOCATION MAP
PUERTO RICO
SAN JUAN
MAYAGUEZ
PONCE
GUAYAMA
FAJARDO
ARECIBO
BARRANQUITAS
MOROVIS
OROCOVIS
TORTUGUERO LAGOON
MANATI
BARCELONETA
MATRULLAS
GUINEO RESERVOIR
RIO GRANDE DE MANATI
RIO DE LA PLATA
SCALES
KILOMETERS
MILES
SECTION 205
DETAILED PROJECT REPORT
RIO GRANDE DE MANATI
BARCELONETA, PUERTO RICO
RIO GRANDE DE MANATI
BASIN
DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

PLATE 1

EXISTING DEVELOPMENTS
AND HIGHWAYS



RIO GRANDE DE MANATI
BARCELONETA, PUERTO RICO

SUPPLEMENTAL REPORT

JACKSONVILLE DISTRICT
U.S. ARMY CORPS OF ENGINEERS

MAY 1998
(REVISED JULY 1998)

SUPPLEMENTAL REPORT

RIO GRANDE DE MANATI
BARCELONETA, PUERTO RICO

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1 Most Important Structural Features of Recommended Project

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(Enclosures follow Figures.)

Enclosure

1 Letter of Support from Local Sponsor

2 MCACES Report

SUPPLEMENTAL REPORT
RIO GRANDE DE MANATI AT BARCELONETA
PUERTO RICO

I. INTRODUCTION

The Río Grande de Manatí at Barceloneta Detailed Project Report (DPR) and Environmental Assessment (EA) were completed in March 1994 under Section 205 of the Flood Control Act as amended. The final report and EA were approved by the Office of the Chief of Engineers on November 8, 1994. The DPR presents the results of investigations into flooding and related problems resulting from the overflow of Río Grande de Manatí at the town of Barceloneta, Puerto Rico. The DPR was prepared in response to a letter dated September 11, 1986, from the Puerto Rico Department of Natural and Environmental Resources (DNER) for assistance in reducing flooding from Río Grande de Manatí at Barceloneta. Funds to initiate the Plans and Specifications (P&S) were allocated in fiscal year 1995. P&S were completed and approved in September 1997.

This Supplemental Report presents a revised cost estimate, an updated economic analysis, and an environmental resources update as of October 1997. It evaluates the authorized project and the refined detailed design developed for Río Grande de Manatí at Barceloneta during the preparation of Plans and Specifications during 1995-1997. A Supplemental Report is required because more than three years have elapsed since approval of the Detailed Project Report and the local sponsor, DNER, is actively pursuing individual congressional authorization for construction of the flood damage reduction project under the General Investigations program. The approved DPR as updated by this supplemental report with respect to economics of project and cost sharing will become the decision document for the proposed change in authority for construction.

II. AUTHORIZED PROJECT

A. Project Authority. The Río Grande de Manatí at Barceloneta Detailed Project Report was authorized by the continuing authority of Section 205 of the Flood Control Act of 1948 as amended. It has been extensively coordinated with the local sponsor, the Puerto Rico Department of Natural and Environmental Resources; the Municipality of Barceloneta; the residents of the area; and the local and federal resource agencies.

Subsequent to completion of DPR and initiation of P&S, under Section 205 of the Continuing Authority Program, the Committee on Public Works and Transportation of the U.S. House of Representatives adopted a resolution on September 28, 1994, authorizing a General Investigations study. **No funds have been appropriated to do this General Investigations study. This Supplemental Report should close the Congressional Resolution for the study.** Since the flooding problem and damages in Barceloneta are so severe and frequent, in order to avoid delays in implementing a flood control project, at the request of the Sponsor, DNER, initiation of the P&S proceeded under the Continuing Authorities Program.

B. Description of the Study and Project Area. The Río Grande de Manatí basin is located in the north central region of Puerto Rico. The Río Grande de Manatí originates at an elevation of about 800 meters (2,625 feet) above mean sea level, and flows in a slightly northwesterly direction through a belt of limestone hills typified by the karst terrain, a deep and narrow canyon-like valley, and across an alluvial flood plain before finally emptying into the Atlantic Ocean. The main stream is about 90 kilometers (55.9 miles) long. The total watershed area is approximately 447 square kilometers (172 square miles). The coastal alluvial flood plain at the lower end of the basin extends for about 25 kilometers and averages approximately 2 kilometers in width. Practically all the land in this coastal plain is subject to periodic flooding. The focus of this report is the town of Barceloneta, in the coastal flood where riverine flooding is a major frequent problem. The Municipality of Barceloneta covers an area of 62.7 square kilometers and has a population of approximately 39,000 as of 1996.

C. Description of the Recommended Project. The scope and design of the project has not changed since DPR was completed. The recommended project, **which is the NED plan,** consists of a ring levee, two pilot channels, minimum interior drainage facilities, relocation of one boat ramp, three highway ramps, and one agricultural ramp to provide flood protection for the town of Barceloneta. The recommended project would provide 100-year flood protection for the flood prone areas of the town of Barceloneta. The alignment and most important structural features of the recommended project are shown on Figure 1.

The recommended project includes the construction of 5,300 meters of levees around the town of Barceloneta and 1,620 meters of pilot channels for the Río Grande de Manatí to the east of the town. The eastern section of the ring levee extends for about 3,200 meters starting at the north interior drainage structure (Culvert 1) and continues east and southeast crossing Calle Plazuela and Highway 684, continuing mainly towards the south crossing the river meander twice, and continuing south near the municipal sports complex and around Villa Catalana residential development. The western section of the ring levee starts at Culvert 1, and extends for 2,100 meters in a south western direction across Highway 681 to end at high ground just across Highway 682. The total length of the ring levee is about 5.3 kilometers, with an average height above ground of 5.4 meters, 1 on 3 side slopes on its east and north sections, 1 on 3.5 side slopes on its west part. The levee has a crest of 3.0 meters, and an average base of 38 meters. For purpose of safety and to maintain clear an evacuation route to the south should larger than design flood occur, the northern 400 meters stretch of the levee was designed as an overtopping section.

The two portions of the existing Río Grande de Manatí channel cut off by the eastern section of the levee are replaced by pilot (bypass) channels. The pilot channels are designed to be stable and maintain low flow within its banks. The south pilot channel is located about 50 meters south of the existing river channel near the south eastern end of the project. The existing river channel would be filled to build the levee and drainage channel. The south pilot channel would have a trapezoidal cross section with 1 on 3 side slopes and a 15 meters bottom width at elevation -1.1 meters NGVD. The north slope of the south pilot channel and the levee slope adjacent to the pilot channel would be protected with gabions. The north pilot channel is located about 750 meters east of the existing channel. The existing river channel would be filled to elevation 1.0 meters NGVD. The north pilot channel would have a trapezoidal cross section with 1 on 3 side slope and a 15-meter bottom width at elevation -2.2 meters NGVD.

The recommended project includes the construction of a minimum interior drainage facilities to collect and dispose of urban runoff caused by a local rainfall event. The interior drainage facilities are required due to the disruption of the existing storm drainage system and the natural drainage pattern of the urban area resulting from the construction of the flood control ring levee. The proposed minimum drainage facilities consist of 5,230 meters of drainage channels along the protected side of the levee, drainage channels culverts under two highway ramps, and two drainage structures on the levees. The drainage channels would be constructed with a triangular cross section with an average depth of flow of 1.5 meters and an average top width of 9.0 meters. The drainage channels would collect and direct storm waters into the drainage structures. Corrugated metal pipe culverts for interior drainage are provided under Highway 681 ramp and the agricultural road access ramp. The drainage structures, Culvert 1 and Culvert 2, consist of corrugated aluminum pipe culverts with flap gates and concrete headwalls. Two relatively large areas of mostly agricultural lands, 57.5 acres on the east and 179.0 acres on the north, serve temporarily for storing most of the residual flooding caused by interior runoff. Flood stages on this land, however, for the 100-year is reduced from a pre-project elevation of 5.1 meters NGVD to a post-project elevation of 2.7 meters NGVD. This would allow for its continued use in agriculture.

The recommended project also requires the construction of one small road ramp over the levee at Highways 682, two road ramps over the levee at Highways 681 and 684, and one agricultural road ramp where the eastern part of the levee precludes access to agricultural lands. Project implementation requires acquisition of **seven** residential structures, relocation of a boat ramp, and relocation of existing utilities impacted by the levee at four locations.

The total first cost of this project, at October 1997 price level, is $13.4 million. The total annual costs **is $1,053,000, while the total annual benefit is $4,243,000. The project** results in net benefits of $3,170,000 and a 4.0/1.0 benefit to cost ratio.

D. Items of Local Cooperation. A Project Cooperation Agreement (PCA) will be executed between the Federal Government and the non-Federal sponsor as a legal and binding document identifying the sponsor's duties and obligations for the project. The PCA cannot be executed until construction funds have been appropriated. The items of local cooperation are those required under the General Investigations Program.

Should this project be specifically authorized by Congress, it would be subject to cost sharing as required by Public Law 99-662, the Water Resources Development Act of 1986, as amended by Section 202 of Public Law 104-103, the Water Resources Development Act of 1996 and the non-Federal sponsor agreeing to comply with applicable Federal laws and policies, including the following requirements:

(1) Provide a minimum of 35 percent, but not to exceed 50 percent, of total project costs **allocated to structural flood control for the NED plan** as further specified below:

(a) Enter into an agreement which provides, prior to construction, 25 percent of preconstruction engineering and design (PED) costs;

(b) Provide during construction any additional funds needed to cover the non-Federal share of PED costs;

(c) Provide, during construction, a cash contribution equal to 5 percent of total project costs;

(d) Provide all lands, easements, and rights-of-way, including suitable borrow and dredged or excavated material disposal areas, and perform or assure the performance of all relocations determined by the Federal Government to be necessary for the construction, operation, and maintenance of the project;

(e) Provide or pay to the Federal Government the cost of providing all retaining dikes, wasteweirs, bulkheads, and embankments, including all monitoring features and stilling basins, that may be required at any dredged or excavated material disposal areas required for the construction, operation, and maintenance of the project; and

(f) Provide during construction any additional costs as necessary to make its total contribution equal to 35 percent of total project costs.

(2) Provide all lands, easements, and rights-of-way, and suitable borrow and dredged or excavated material disposal areas, and perform or ensure the performance of all relocations determined by the Federal Government to be necessary for the construction, operation, and maintenance of the project;

(3) Provide all improvements required on lands, easements, and rights-of-way to enable the proper disposal of dredged or excavated material associated with the construction, operation, maintenance, repair, replacement, or rehabilitation of the project. Such improvements may include, but are not limited to, retaining dikes, wasteweirs, bulkheads, embankments, monitoring features, stilling basins, and dewatering pumps;

(4) Provide during construction any additional amounts as are necessary to make its total contribution equal to 35 percent of total project costs assigned to structural flood control;

(5) For so long as the project remains authorized, pay 100 percent of costs to operate, maintain, repair, replace, and rehabilitate the completed project or functional portion of the project prescribed by the Federal Government;

(6) Give the Federal Government a right to enter, at reasonable times and in a reasonable manner, upon property that the non-Federal sponsor now or hereafter owns or controls for access to the project for the purpose of inspection, and, if necessary after failure to perform by the non-Federal sponsor, for the purpose of completing, operating, maintaining, repairing, replacing, or rehabilitating the project. No completion, operation, maintenance, repair, replacement, or rehabilitation by the Federal Government shall operate to relieve the non-Federal sponsor of responsibility to meet the non-Federal sponsor's obligations, or to preclude the Federal Government from pursuing any other remedy at law or equity to ensure faithful performance;

(7) Hold and save the United States free from all damages arising from the construction, operation, maintenance, repair, replacement, and rehabilitation of the project and any project-related betterments, except for damages due to the fault or negligence of the United States or its contractors;

(8) Keep, and maintain books, record, documents, and other evidence pertaining to costs and expenses incurred pursuant to the project in accordance with the standards for financial management systems set forth in the Uniform Administrative Requirements for Grants and Cooperative Agreements to State and Local Governments at 32 Code of Federal Regulations (CFR) Section 33.20;

(9) Perform, or cause to be performed, any investigations for hazardous substances as are determined to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 42 U.S.C. 9601-9675, that may exist in, on, or under lands, easements, or rights-of-way that the Federal Government determines to be required for the operation, maintenance, repair, replacement, and rehabilitation of the project. However, for the lands that the Federal Government determines to be subject to the navigational servitude, only the Federal Government shall perform such investigations unless the Federal Government provides the non-Federal sponsor with prior specific written direction, in which case the non-Federal sponsor shall perform such investigations in accordance with such written direction;

(10) Assume complete financial responsibility, as between the Federal Government and the non-Federal sponsor, for all necessary cleanup and response costs of any CERCLA regulated materials located in, on, or under lands, easements, or rights-of-way that the Federal Government determines to be required for the operation, maintenance, repair, replacement, or rehabilitation;

(11) As between the Federal Government and the non-Federal sponsor, the non-Federal sponsor shall be considered the operator of the project for the purpose of CERCLA liability. To the maximum extent practical, operate, maintain, repair, replace, and rehabilitate the project in a manner that will not cause liability to arise under CERCLA;

(12) Comply with the applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, as amended by Title IV of the Surface Transportation and Uniform Relocation Assistance Act of 1987 (Public Law 100-17), and the Uniform Regulations contained in 49 CFR Part 24, in acquiring lands, easements, and rights-of-way required for the operation, maintenance, repair, replacement, and rehabilitation of the project, including those necessary for relocations, borrow materials, and dredged or excavated material disposal, and inform all affected persons of applicable benefits, policies, and procedures in connection with said act;

(13) Comply with all applicable Federal and Commonwealth laws and regulations including, but not limited to, Section 601 of the Civil Rights Act of 1964, Public Law 88-352 (42 U.S.C. 2000d), and the Department of Defense Directive 5500.11 issued pursuant thereto, as well as Army Regulation 600-7, entitled "Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army;" **and Section 402 of the Water Resources Development Act of 1986, as amended (33 U.S.C. 701b-12), requiring non-Federal preparation and implementation of flood plain management plans;**

(14) Provide 35 percent of that portion of total cultural resource preservation, mitigation and data recovery costs attributable to flood control that are in excess of 1 percent of the total amount authorized to be appropriated for flood control;

(15) **Participates in and comply with applicable Federal flood plain management and flood insurance programs;**

(16) Within 1 year after the date of signing a project cooperation agreement, prepare a floodplain management plan designed to reduce the impact of future flood events in the project area. The plan shall be prepared in accordance to guidelines developed by the Federal Government and must be implemented not later than 1 year after the completion of construction of the project;

(17) Prescribe and enforce regulations to prevent obstruction of or encroachment on the project that would reduce the level of protection it affords or that would hinder operation and maintenance of the project;

(18) Not less than once each year, inform affected interests of the extent of the protection afforded by the project; and

(19) Publicize floodplain information in the area concerned and provide this information to zoning and other regulatory agencies for their use in preventing unwise development in the floodplain and in adopting such regulations as may be necessary to prevent unwise future development and to ensure compatibility with protection levels provided by the project.

E. Project Sponsor. The Puerto Rico Department of Natural and Environmental Resources (DNER) as the local sponsor and representative of the Commonwealth of Puerto Rico has, in letter dated May 1998, restated its strong support for the proposed flood control project (refer to enclosure 1). The DNER has the institutional responsibility for the planning, programming, and the construction of flood control measures for the Commonwealth of Puerto Rico. It receives annual appropriation from the local legislature for this mission from the island's capital investment program. The source of funding for this program is recurrent general income to the Commonwealth and the issuance of capital improvement bonds.

F. Coordination. The flood control project as well as its refinements made during the Plans and Specifications Phase were developed and worked out in close coordination with the Puerto Rico Department of Natural and Environmental Resources, the local sponsor; the Puerto Rico Planning Board; the Puerto Rico Highway and Transportation Authority; the Puerto Rico Land Authority; the Puerto Rico Electric Power Authority, the Puerto Rico

Aqueduct and Sewer Authority; the State Historic Preservation Officer; the Puerto Rico Environmental Quality Board; the Municipality of Barceloneta; the U. S. Fish and Wildlife Service; the U. S. Geological Survey; and the Environmental Protection Agency; and the residents of Barceloneta.

The DNER and the local legislature are programming annual appropriations of funds to cover their share of total first cost for construction of the project in accordance with the latest Project Management Plan (PMP). The DNER has been coordinating with all other local agencies for land acquisition, roads and utilities relocations since the completion of the Detailed Project Report.

III. CHANGES IN APPROVED PROJECT

A. Differences from Detailed Project Report. There are no significant and relevant physical, engineering, and environmental impacts between project approved in the DPR of 1994 and project presented in this supplemental report of 1998 for Río Grande de Manatí at Barceloneta, Puerto Rico.

B. **Environmental Update. The feasibility-phase study for the project ended in a Detailed Project Report and Environmental Assessment (EA). After coordination of the EA with Federal and Puerto Rico agencies, the Finding of No Significant Impact (FONSI) was signed on March 24, 1994. In October, 1994, the Puerto Rico Environmental Quality Board (PREQB) issued a "Certification of Environmental Document" for the EA, signaling that the document had met all Commonwealth environmental evaluation requirements. At that time EQB accepted an application for a Water Quality Certificate (WQC). The WQC was issued on August 15, 1995. It has no expiration date. Other environmental commitments carried forward from the EA include (1) carrying out a survey for Puerto Rican boas on proposed quarry (borrow) sites; and (2) archeological data recovery in the one identified National Register eligible historic site. The boa survey is underway. No quarrying will occur in identified boa habitat. The archeological data recovery will occur prior to construction, as provided for in the EA, and coordinated with SHPO. There have been no substantive changes in the project, thus all existing concurrences are still valid, and all prior commitments have been or will be met.**

C. Changes in Project Costs and Benefits. Tables 1 and 2 show 1993 and 1997 costs and benefits associated with project approved in DPR. **The 3.4 percent affluency factor to residential contents utilized in determining inundation flood benefits in the DPR was not included in the updated benefits of this Supplemental Report.** Total first cost of project increased from $10,622,000 to 13,364,000 between 1993 and 1997 (Enclosure 2 shows the detailed MCASES for the 1997 cost estimate). Total benefits and net benefits increased $4,243,000 and $3,190,000, respectively. The benefit cost ratio increased from 3.2 to 4.0 for the approved project.

TABLE 1

SUPPLEMENTAL REPORT
RIO GRANDE DE MANATI AT BARCELONETA

COST ESTIMATES OF RECOMMENDED PLAN
($1,000 of 1993 and 1997)

COST ITEM	1993	1997
Roads and Ramps	$ 1,011	$ 1,222
Utilities	370	152
Channel and Canals	1,430	1,973
Levees	4,840	6,137
TOTAL CONSTRUCTION COST	**$ 7,651**	**$ 9,484**
Real Estate	$ 1,410	$ 1,528
P.L. 91-646	203	219
Cultural Resources Preservation	45	45
Planning, Engineering, and Design	525	950
Construction Management	788	1,138
TOTAL FIRST COSTS	**$10,622**	**$13,364**
Interest During Construction	696	588
TOTAL INVESTMENT COSTS	**$11,318**	**$13,952**

TABLE 2

SUPPLEMENTAL REPORT
RIO GRANDE DE MANATI AT BARCELONETA

SUMMARY OF ANNUAL COSTS AND BENEFITS OF RECOMMENDED PLAN ($1,000 of 1993 and 1997)

	1993	1997
ANNUAL COST*		
Interest and Amortization	$ 905	$1,032
Annual O&M	37	20
TOTAL	**$ 942**	**$1,053**
ANNUAL BENEFITS		
Inundation Reduction	2,982	4,199
Employment	43	44
TOTAL	**$3,025**	**$4,243**
Net NED Benefits	2,083	3,190
BENEFIT TO COST RATIO	3.2	4.03

**Does not include cost for PL 91-646 and cultural resources preservation.*

The increase in the cost is a reflection of refined cost estimates for the project features and cost inflation for construction. The increase in benefits results from higher **replacement costs** for structures and contents and more intensive use of some facilities that in 1993 were **underutilized.** The increase in values for structures and content were developed for each land classification separately (residential, commercial, public, etc.); and a replacement value adjusted for depreciation for each structure of the different uses was developed using **construction costs data from local construction companies and** recent applicable comparable appraisals and sales **of properties in the area which include data on costs of replacement. Value of land is excluded from the replacement cost.** This data were obtained from various sources: **construction companies in the Barceloneta area** and the P. R. Property Registry Cadastre Sales data, the P.R. Appraisers Comparable Sales Data System Report (1997), and the MunicipalRevenue Collection Center data. This data compared with the real rate of growth of economic indicators published by the P. R. Planning Board for Internal Gross Product and expenditures in housing at constant prices which reflects an estimated increase of approximately 3.2 percent for the 1994-1997 period. However, most of the increase in average annual damages resulted from the **intensification of** use of some 49,500 square feet of industrial space that were **underutilized** in 1993. **Damage to the structures as such were included in the 1993 DPR.** The structures are now being utilized by the expansion of General Instruments Corp. and Playtex Apparel, Inc. under a long term agreement with the local Economic Development Administration. According to information provided by the plants managers, these plants have very expensive

manufacturing machinery and equipment and maintain a relatively large inventory of materials for processing. **The intensification of use the industrial building is consistent with Puerto Rico Planning Board Regulation 13, which establishes guidelines and procedures for managing flood plain areas. This Regulation is consistent with FEMA flood plain management policies and guidelines.**

IV. COST SHARING

Table 3 shows cost sharing of total first cost of the project, as established by Public Law 99-662, the Water Resources Development Act of 1986, as amended by Section 202 of Public Law 104-303, the Water Resources Act of 1996. **P&S costs incurred as part of Section 205 will be treated as PED costs and will be included in the authorized project costs for cost sharing purposes.** The non-Federal costs required from the local sponsor would be those associated with relocations ($1,374,000); lands, easements, and rights-of-way ($1,747,000); a minimum of 5 percent cash of flood control first costs ($668,000); plus additional cash of $888,000 to reach the minimum of 35 percent contribution of the total first cost for flood control. Thus, the total non-Federal cost share would be $4,677,000 and the Federal cost share would be $ 8,687,000.

TABLE 3

SUPPLEMENTAL REPORT
RIO GRANDE DE MANATI AT BARCELONETA

COST SHARING OF TOTAL FIRST COST
($1,000 of October 1997)

ITEMIZED ELEMENTS	TOTAL	FEDERAL	NON-FEDERAL
Levees and Channels *	$10,198	$10,198	
Roads, Utilities, and Relocations	1,374		$ 1,374
Lands and Damages	1,747		1,747
Cultural Resources Preservation	45	45	
Total First Cost	$13,364		
5% of Flood Control Cost Contribution		-668	+668
Subtotal		$ 9,575	$ 3,789
35% Minimum Contribution			4,677
50% Maximum Contribution			6,682
Contribution Adjustment (to reach 35% minimum)		888	888
Total	**$13,364**	**$ 8,687**	**$ 4,677**

* *Includes costs associated with Channels ($1,973K), Levees ($6,137K), PED ($950K), and CM ($1,138) as shown in MCACES.*

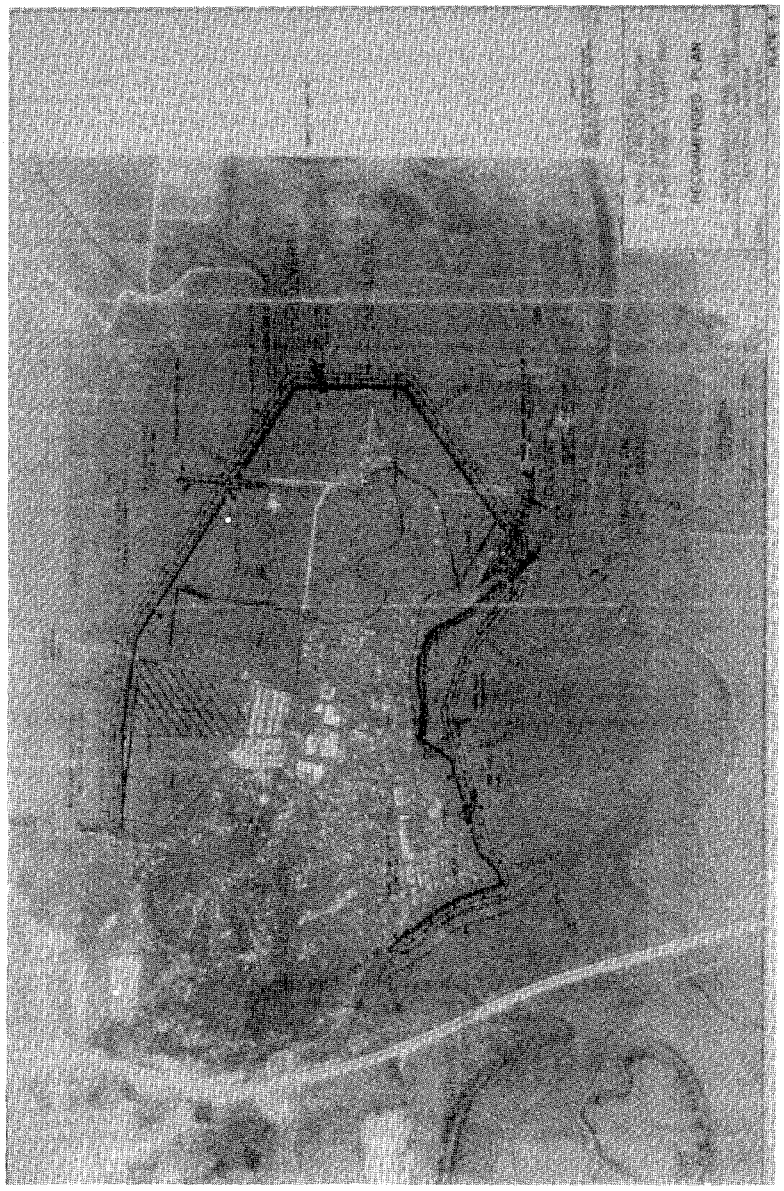
V. CONCLUSION

The Río Grande de Manatí at Barceloneta Supplemental Report demonstrates that flooding is a major problem threatening the life, property, and economic development of the residents of Barceloneta, Puerto Rico. The report confirms that there are no significant changes in the recommended project and that it is still economically justified and needed to solve a serious flooding problem in town of Barceloneta.

VI. RECOMMENDATIONS

The reevaluation of the engineering, economics, and environmental impacts of the Río Grande de Manatí at Barceloneta flood control project as refined by the detailed investigations conducted during the preparation of Plans and Specifications and have found that the project continues to be economically justified. Project refinements made during the development of the Plans and Specifications for Río Grande de Manatí at Barceloneta are within the original project scope. The project is environmentally acceptable.

The recommendation contained herein reflects the information available at this time and current departmental policies governing formulation of individual projects. It does not reflect program and budgeting priorities inherent in the formulation of a national civil works construction program nor the perspective of higher review levels within the executive branch. Consequently, the recommendations may be modified before it is transmitted to Congress as a proposal for authorization and implementation funding. However, prior to transmittal to Congress, the sponsor, the Commonwealth of Puerto Rico; interested Federal agencies; and other parties will be advised of any modifications and will be afforded an opportunity to comment further.



GOVERNMENT OF PUERTO RICO
Department of Natural
and Environmental Resources

) Box 9066600
. de Tierra Station
n P.R. 00906-5600
(787) 724-8774
(787) 723-4255

5 MAY 1996

Col. Joe R. Miller
Jacksonville District
Deputy District Engineer
U.S. Army Corps of Engineers
P.O. Box 4970
Jacksonville, Florida 32232-0019

Dear Colonel Miller:

RE: RIO GRANDE DE MANATI FLOOD CONTROL PROJECT AT BARCELONETA, PUERTO RICO

We have reviewed the Supplemental Report to the Río Grande de Manatí Detailed Project Report (DPR) for flood control at Barceloneta. This is to restate our support to the conclusions and recommendations of the DPR as well as the Supplemental Report.

We fully understand the revised cost sharing in accordance with the federal policy established in the Water Resources Development Act of 1996 and we intend to fulfill all the items of local cooperation described in the Supplemental Report.

Our Department will secure by annual appropriations from the Puerto Rico Legislature the local share funding necessary for project implementation.

Cordially,

Daniel Pagán Rosa
Secretary

JAA/RAH/JGL/jaa

RIO MANATI AT BARCELONETA
DETAILED PROJECT REPORT
FOR LEVEE PROTECTION OF
BARCELONETA, PUERTO RICO

Designed By: JACKSONVILLE DISTRICT
Estimated By: M. Perez

Prepared By: M. Perez

Preparation Date: 09/16/97
Effective Date of Pricing: 10/01/97
Est Construction Time: 540 Days

Sales Tax: 0.00%

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The project consists of excavating an 800 meter and a 760 meter long pilot channels in the downstream and upstream portions of the river respectively. Both pilot channels would be constructed with a 15 meter bottom width and side slopes of 3H on 1V. Geotechnical assuption is that 50% of the excavated material is suitable for levee construction, the unsuitable material would be used to backfill a segment of the original river meander which will be isolated by placement of the East Levee.

An interior drainage system consisting of shallow canals would be constructed on the inside perimeter of the levee system. It was estimated that 50% of the material excavated from these drainage canals is suitable for levee construction; the other 50% of unsuitable material will be hauled to the onsite disposal area.

In addition to the excavation a main ring levee will be constructed to satisfy the hydraulic requirements associated with the 100 year flood event. The ring levee will consist of two main segments (East Levee and West Levee). The total levee length is about 5,200 meters and a required embankment volume of 917,000 cy. Most of the required fill will be obtained from three offsite sources located west of Barceloneta.

Other project features includes drainage culvert structures, slope protection, road relocations, ramp construction, and other related construction.

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** PROJECT OWNER SUMMARY - Con/Non (Rounded to 1000's) **

	QUANTY	UOM	CONTRACT	CONTINGN	TOTAL COST	UNIT
A CONSTRUCTION COSTS			8,980,000	505,000	9,484,000	
B NON-CONSTRUCTION COSTS			3,429,000	451,000	3,880,000	
TOTAL RIO MANATI AT BARCELONETA			12,409,000	956,000	13,364,000	

** PROJECT OWNER SUMMARY - Feature (Rounded to 1000's) **

	QUANTY UOM	CONTRACT	CONTINGN	TOTAL COST	UNIT
A CONSTRUCTION COSTS					
A.02 RELOCATIONS		1,256,000	118,000	1,375,000	
A.09 CHANNELS AND CANALS		1,879,000	94,000	1,973,000	
A.11 LEVEES AND FLOODWALLS		5,844,000	292,000	6,137,000	
TOTAL CONSTRUCTION COSTS		8,980,000	505,000	9,484,000	
B NON-CONSTRUCTION COSTS					
B.01 LANDS AND DAMAGES		1,398,000	349,000	1,747,000	
B.18 CULTURAL RESOURCE PRESERVATION		43,000	2,000	45,000	
B.30 PLANNING, ENGINEERING & DESIGN		905,000	45,000	950,000	
B.31 CONSTRUCTION MANAGEMENT		1,084,000	54,000	1,138,000	
TOTAL NON-CONSTRUCTION COSTS		3,429,000	451,000	3,880,000	
TOTAL RIO MANATI AT BARCELONETA		12,409,000	956,000	13,364,000	

	QUANTY UOM	CONTRACT	CONTINGN	TOTAL COST	UNIT
A CONSTRUCTION COSTS					
A.02 RELOCATIONS					
A.02.01 Roads, Construction Activities		1,111,000	111,000	1,222,000	
A.02.02 Cemeteries, Utilities & Struct.		145,000	7,000	152,000	
TOTAL RELOCATIONS		1,256,000	118,000	1,375,000	
A.09 CHANNELS AND CANALS					
A.09.01 CHANNELS		1,879,000	94,000	1,973,000	
TOTAL CHANNELS AND CANALS		1,879,000	94,000	1,973,000	
A.11 LEVEES AND FLOODWALLS					
A.11.01 LEVEES		5,844,000	292,000	6,137,000	
TOTAL LEVEES AND FLOODWALLS		5,844,000	292,000	6,137,000	
TOTAL CONSTRUCTION COSTS		8,980,000	505,000	9,484,000	
B NON-CONSTRUCTION COSTS					
B.01 LANDS AND DAMAGES					
B.01. 1 Real Estate		1,222,000	306,000	1,528,000	
B.01. 2 PL 91-646		175,000	44,000	219,000	
TOTAL LANDS AND DAMAGES		1,398,000	349,000	1,747,000	
B.18 CULTURAL RESOURCE PRESERVATION					
B.18. 1 Cultural Resource Preservation		43,000	2,000	45,000	
TOTAL CULTURAL RESOURCE PRESERVATION		43,000	2,000	45,000	
B.30 PLANNING, ENGINEERING & DESIGN					
B.30. 1 PLANNING, ENGINEERING & DESIGN		905,000	45,000	950,000	
TOTAL PLANNING, ENGINEERING & DESIGN		905,000	45,000	950,000	

** PROJECT OWNER SUMMARY - Sub Feat (Rounded to 1000's) **

	QUANTY UOM	CONTRACT	CONTINGN	TOTAL COST	UNIT
B.31 CONSTRUCTION MANAGEMENT					
B.31. 1 Construction Management		1,084,000	54,000	1,138,000	
TOTAL CONSTRUCTION MANAGEMENT		1,084,000	54,000	1,138,000	
TOTAL NON-CONSTRUCTION COSTS		3,429,000	451,000	3,880,000	
TOTAL RIO MANATI AT BARCELONETA		12,409,000	956,000	13,364,000	

	QUANTY UOM	CONTRACT	CONTINGN	TOTAL COST	UNIT
A CONSTRUCTION COSTS					
A.02 RELOCATIONS					
A.02.01 Roads, Construction Activities					
A.02.01.01 Mob, Demob and Prep Work		71,000	7,000	79,000	
A.02.01.13 Traffic Control		60,000	6,000	66,000	
A.02.01.19 Construct Roadbed to Subgrade		400,000	40,000	439,000	
A.02.01.39 Road Surfacing		525,000	53,000	578,000	
A.02.01.99 Assoc General Items		55,000	5,000	60,000	
TOTAL Roads, Construction Activities		1,111,000	111,000	1,222,000	
A.02.02 Cemeteries, Utilities & Struct.					
A.02.02.01 Mobilization, Demob & Prep Work		8,000	0	8,000	
A.02.02.18 Utilities		136,000	7,000	142,000	
A.02.02.47 Structures		2,000	0	2,000	
TOTAL Cemeteries, Utilities & Struct.		145,000	7,000	152,000	
TOTAL RELOCATIONS		1,256,000	118,000	1,375,000	
A.09 CHANNELS AND CANALS					
A.09.01 CHANNELS					
A.09.01.01 Mob, Demob and Prep Work		83,000	4,000	87,000	
A.09.01.30 Bank Stabilization		616,000	31,000	647,000	
A.09.01.31 Earthwork		1,156,000	58,000	1,214,000	
A.09.01.99 Associated General Items		24,000	1,000	25,000	
TOTAL CHANNELS		1,879,000	94,000	1,973,000	
TOTAL CHANNELS AND CANALS		1,879,000	94,000	1,973,000	
A.11 LEVEES AND FLOODWALLS					
A.11.01 LEVEES					
A.11.01.01 Mob, Demob and Prep Work		259,000	13,000	272,000	
A.11.01.02 Drainage		623,000	31,000	654,000	
A.11.01.30 Bank Stabilization		563,000	28,000	591,000	
A.11.01.31 Earthwork		4,247,000	212,000	4,459,000	
A.11.01.99 Associated General Items		152,000	8,000	160,000	

		QUANTY	UOM	CONTRACT	CONTINGN	TOTAL COST	UNIT
	TOTAL LEVEES			5,844,000	292,000	6,137,000	
	TOTAL LEVEES AND FLOODWALLS			5,844,000	292,000	6,137,000	
	TOTAL CONSTRUCTION COSTS			8,980,000	505,000	9,484,000	
B	NON-CONSTRUCTION COSTS						
B.01	LANDS AND DAMAGES						
B.01. 1	Real Estate			1,222,000	306,000	1,528,000	
B.01. 2	PL 91-646			175,000	44,000	219,000	
	TOTAL LANDS AND DAMAGES			1,398,000	349,000	1,747,000	
B.18	CULTURAL RESOURCE PRESERVATION						
B.18. 1	Cultural Resource Preservation			43,000	2,000	45,000	
	TOTAL CULTURAL RESOURCE PRESERVATION			43,000	2,000	45,000	
B.30	PLANNING, ENGINEERING & DESIGN						
B.30. 1	PLANNING, ENGINEERING & DESIGN			905,000	45,000	950,000	
	TOTAL PLANNING, ENGINEERING & DESIGN			905,000	45,000	950,000	
B.31	CONSTRUCTION MANAGEMENT						
B.31. 1	Construction Management			1,084,000	54,000	1,138,000	
	TOTAL CONSTRUCTION MANAGEMENT			1,084,000	54,000	1,138,000	
	TOTAL NON-CONSTRUCTION COSTS			3,429,000	451,000	3,880,000	
	TOTAL RIO MANATI AT BARCELONETA			12,409,000	956,000	13,364,000	

DETAILED PROJECT REPORT

RIO GRANDE DE MANATI
AT BARCELONETA, PUERTO RICO

ENVIRONMENTAL ASSESSMENT
SECTION 205 FLOOD CONTROL STUDY

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Environmental Assessment
Rio Grande de Manati at Barceloneta, Puerto Rico
Section 205 Flood Protection Study

1.00 SUMMARY

The U. S. Army Corps of Engineers responded to a request by the Puerto Rico Department of Natural Resources to study means to alleviate flooding hazards and damages now experienced by the town of Barceloneta in northern Puerto Rico from the Rio Grande de Manati. We analyzed four preliminary plans and three final alternative plans and the following environmental issues: (a) potential impacts on intermittent wetlands in the project area; (b) impacts on the Rio Grande de Manati water quality, area recreation uses, fish and wildlife values, and agricultural resources; (c) archeological and historical resources; and (d) the Hacienda La Esperanza Natural Reserve, adjacent to the study area.

Major study conclusions were the following:

(a) Protection of the residents of Barceloneta from standard project flood (SPF) hazards to human life and health and from damages to property is feasible through employment of a levee with internal drainage works around the town, and diversion of the river course.

(b) Although the proposed project would take 6.7 acres of intermittent wetlands, the project would create 21.7 acres of similar wetlands, with a net gain of 15 acres.

(c) Diversion of the Rio Grande de Manati into newly constructed channels would not produce significant environmental impacts because of the present nature of the river in the study area. No opportunities for enhancement of the river environmental quality are presented by the project.

(d) Of 11 archaeological sites in the study area, one, eligible for listing on the National Register of Historic Places, would be affected by the proposed project. Mitigation, including in-depth archival study, archaeological excavation, and architectural documentation will be performed.

Potential impacts on cultural resources were mitigated by first avoiding impacts to a significant site by realigning the levee to avoid adverse impact; secondly by field investigations that determined that all but one remaining affected sites are not significant to the point of eligibility for listing in the National Register of Historic Places; and thirdly by including appropriate data retrieval and preservation during preconstruction engineering and design.

The recommended action will be subject to Puerto Rico Department of Natural Resources water quality certification under Section 401 of the Clean Water Act. A preliminary Section 404(b)(1) Evaluation is annexed to this environmental assessment (EA). However, this report is not to be submitted to Congress for authorization and the proposed project is not eligible for ection 404(r) exemption. It is fully intended that the proposed action will

conform to Commonwealth standards for certification, so that certification may be obtained from the Commonwealth prior to construction.

2.00 PURPOSE OF AND NEED FOR ACTION.

2.01 When flooding, the Rio Grande de Manati is a potential danger to the lives of residents in the town of Barceloneta in northern Puerto Rico and is a source of frequent property damages. Floods can occur anytime during the year, but they are most frequent during the period from May through December. Large peak discharges may result from storm rainfall generally associated with the passage of hurricanes, tropical depressions, and northern cold fronts over or near the island. Cloudburst storms can occur anytime during the year, and because of the steep slopes in the basin, flash floods commonly affect the Barceloneta area.

At least 15 damaging floods have occurred on the Rio Grande de Manati during the twentieth century. In recent times the May 17-18, 1985, flood affected the entire town of Barceloneta. Town officials reported that flood stages throughout most of the western and northern sections of the town were above one meter, and damages to public buildings and facilities, residential developments, and commercial establishments exceeded $1.2 million. The President declared the town a disaster area.

The urban area of Barceloneta was inundated for the second time during October 5-8, 1985. The flood at that time was about 0.3 meter (1 foot) higher than the May 1985 flood.

Average annual flood damages to development in Barceloneta are estimated to be $395,000. Properties subject to damage are listed in table 3 of the main report. They include dwellings, commercial and industrial establishments, schools, and public buildings and works.

2.02 AUTHORITY FOR STUDY. This study of the feasibility of flood protection measures within the Federal interest was made under authority of Section 205 of the Flood Control Act of 1948 as amended.

3.00 ALTERNATIVES INCLUDING RECOMMENDED ACTION.

3.01 Planning objectives determined for this study are discussed in Section VI of the main report and are listed below:

1. Safeguard the lives of about 6,000 residents in Barceloneta.
2. Reduce property losses due to flooding in the town of Barceloneta.
3. Minimize flood-caused disruption of economic and social activities.
4. Enhance opportunities for redevelopment throughout the study area.
5. Restore and/or preserve environmental resources.

6. Protect, preserve, or minimize impacts on significant historical and cultural resources of the study area.

7. Enhance recreational opportunities in the study area.

3.02 We considered four nonstructural measures and four structural measures to fully or partially address the planning objectives. Nonstructural measures are flood plain management, flood insurance, temporary and permanent flood plain evacuation, and channel maintenance. For the most part, the nonstructural measures are being used and will continue to be useful in meeting some of the planning objectives.

3.03 Structural measures that were considered include flood proofing, channel improvements, flood walls, levees and reservoirs. These are discussed in following paragraphs.

Flood proofing consists of structural changes that allow flood waters to rise around or within a building with little or no damage to structural integrity of the flood-proofed building or to property. Flood proofing does not eliminate residual nuisance damages, loss of access, loss of business, possible utility and community interruptions, and potential danger to public health and safety.

Flood-control reservoirs can reduce flood levels by holding peak flood waters until downstream conditions permit release. They can also meet other needs and demands such as water supply, recreation, and, in some cases, environmental enhancement. Potential reservoir sites and existing reservoirs discussed in Section VI of the main report (for water supply rather than flood control), will not provide sufficient flood storage capacity to meet study objectives. The cost of designing and constructing a flood control reservoir is believed to exceed the value of benefits that could be realized. Existing reservoirs are too small and located too far upstream to provide any significant reduction of floods in the Barceloneta area.

3.04 Preliminary Plans. During reconnaissance phase we combined structural and non-structural measures into four preliminary plans to provide protection against the standard project flood (SPF). Structural measures included construction of reinforced concrete floodwalls, earthen levees, pilot channels that redirected river flow, drainage structures, and acquisition of residential structures. The most feasible preliminary plan was selected for study in the Detailed Project Report phase. It was subsequently modified in the light of information received during the initial public meeting and ongoing scoping. The four feasible alternative plans included 2 alternative levee alignments, alternative internal drainage plans, and alternative pilot channel configurations.

3.05 Preliminary Plan 1. The elements of this plan include 3,400 meters of earthen levees, an interior drainage canal around the town of Barceloneta and a drainage structure (culvert) at the northern perimeter. Additionally, a pilot channel would divert river flow from the 3.2-km (2.0-mile) northern river bend into a 1,200-m (0.75-mile), nearly straight channel. The plan, epresented in figure 2 (main report), would protect Barceloneta from the

standard project flood. However, 67 residential structures would have to be acquired under this plan, and the Municipal Public Works and Civil Defense facilities would have to be relocated, all at a cost of about $5.4 million. The lack of sufficient vacant land for ponding areas would create high residual damages and would reduce project benefits. The estimated first cost for this plan, at November 1990 price levels, is about $12.8 million. The plan was eliminated from further analysis because of its high cost and low benefits.

3.06 Preliminary Plan 2. This alternative plan would include about 600 meters of flood wall and about 4,100 meters of earthen levees and an internal drainage canal around Barceloneta (figure 3). Additionally, the plan would require a drainage structure, 2 road ramps, and relocation of a 600-meter length of Highway 681. Extension of the levee northward would provide ponding areas north and east of the town. This plan would provide standard project flood (SPF) protection to the town of Barceloneta, but construction of the flood wall at the edge of the existing river bank would present serious challenges and would require taking 30 residential structures. Furthermore, the aesthetic impacts of a concrete flood wall in a picturesque section of town would be unacceptable. The estimated first cost for this plan, at November 1990 price levels, was about $9.7 million. For these reasons the plan was eliminated.

3.07 Preliminary Plan 3. In this plan the levee configuration of Plan 2 is modified and the flood wall is eliminated by aligning the levee away from the edge of town (figure 4). The plan includes 4,600 meters of earthen levees, a 1,200-meter-long pilot channel, two road ramps, relocation of a 600-meter portion of Highway 681, and minimum interior drainage structures. The estimated first cost for this plan, at November 1990 prices, was about $9.2 million. This plan was selected for further investigation during the Detailed Project Report phase.

3.08 Preliminary Plan 4. This plan (figure 5) features the same levee and drainage configurations as Plan 3. Nine km (5.6 miles) of meandering river channel would be by-passed by provision of a 2.8-km (1.7 mile) nearly straight channel. The channel would be protected against the effects of higher water velocities with gabions for about the upper one-third of its length. The lengthened pilot channel would increase project cost by about $2.0 million without providing any additional benefits. This plan was not further considered due to its high pilot channel cost, larger requirement for disposal areas, and its greater impact on the human environment.

3.09 Final Plans. We selected a modified Plan 3 levee alignment and pilot channel for analysis at three alternative levels of protection: the 50-year, 100-year and Standard Project Flood (SPF). We also analyzed alternative interior drainage features to achieve 2-year, 5-year, and 25-year levels of protection. Plate 5 shows the recommended levee alignment and plan features.

The recommended plan (Plate 5) differs from the preliminary plans in the following ways (for convenience, the proposed levee west of Culvert 1 is called the west levee; east of Culvert 1 is the east levee):

1. Because the area between the south edge of Barceloneta and the river is so narrow, the river must be rerouted in order to build the south portion of the east levee, and a 760-meters-long, south pilot channel is required.

2.The length of the north (downstream) pilot channel is reduced from 1,200 meters to 785 meters.

3. The east levee alignment was modified to protect 67 residences and the public facilities otherwise left without flood protection. The estimated cost of acquiring the structures, $5.4 million, is much more than the estimated cost of the modified east levee.

4. We avoided having to relocate about 600 meters of Highway 681 by modifying the west levee alignment to provide the distance needed for a highway ramp over the levee.

5. Realignment of the west levee provided protection for a new, low-income-families subdivision being built by the Municipality of Barceloneta.

6. We modified a portion of the southern alignment of the east levee to avoid a significant archaeological site.

7. Small highway ramps are required at Highway 682 and Highway 140, and an agricultural road ramp is provided over the east levee for access to prime agricultural lands that would be cut off by the proposed levee.

3.10 The final levee alignment is shown on Plate 5. It consists of 5,200 meters of earthen levees around the town of Barceloneta and two pilot channels about 1,545 meters long in the Rio Grande de Manati. The east levee would extend for about 3,000 meters from the north interior drainage structure (Culvert 1), turning southeast, crossing Calle Plazuela and Highway 684, crossing the river twice, and turning around the sport complex and the Villa Catalana residential development. The west levee would extend southwestward for about 2,200 meters across Highway 681 and end at high ground near Highway 682.

The river channel at the southeastern end of the project would be filled to build the levee and drainage channel, and a pilot (bypass) channel would be constructed about 50 meters south of the existing river channel to replace the river reach. This 760-meter south pilot channel would have a trapezoidal cross section with 1 on 4 side slopes and a 15-meter bottom width at elevation -1.1 meters NGVD. The south pilot channel and the adjacent levee side would be revetted with riprap and bedding stone.

East of the town of Barceloneta 1.9 km (0.6 mile) of river would be by-passed and the flow directed into the 785-meter north pilot channel. The north pilot channel would have a trapezoidal cross section with 1 on 4 side slopes and a 15-meter-wide (49 feet) bottom at elevation -2.2 meters NGVD. Portions of the north pilot channel would be revetted with riprap and bedding stone.

Two small road ramps would be required over the levee at Highways 140 and 682; wo large road ramps would be required over the levee at Highways 681 and 684.

A gravel, farm road ramp would be provided over the levee for access to the agricultural land inside the large river bend.

This alignment would require acquisition of six residential structures and relocation of a boat ramp and of utility lines.

Adjacent to Barceloneta 1,000 m (0.6 mile) of the by-passed river channel would be filled to one meter NGVD, leaving a shallow, 10-acre drainageway for conveyance of rainwater from the site through the east culvert to the river. Fill material to be placed in the river channel would be of alluvial clay and sandy clay sub-soil excavated for construction of pilot channels and drainage canals. The drainageway would be top-dressed with topsoil.

3.11 Plan 1. This plan follows the final levee alignment described in section 3.10 and shown in Plate 5. and it would provide for protection of the urban area against the 50-year flood. The earthen ring-levee that would be built around Barceloneta would have an average height above ground of 4.7 meters, an average base width of 34.1 meters, and a crest width of 4.0 meters. The east levee would have 1 on 3 side slopes, and the west levee would have 1 on 3.5 side slopes.

3.12 Plan 2. This plan would have the project features common to each of the three finally considered plans (Plate 5), but would provide protection against the 100-year flood. The 100-year-protection levee would have an average height above ground of 5.4 meters and an average base width of about 38 meters. The crest width would be 4.0 meters and side slopes would be 1 on 3 on the east levee and 1 on 3.5 on the west levee.

3.13 Plan 3. Protection against the SPF would be provided by means of a levee averaging 6.2 meters in height above ground-level with a base width of about 44 meters. The crest width would be 4.0 meters, and the side slopes would 1 on 3 on the east levee and 1 on 3.5 on the west levee.

3.14 Internal Drainage Alternatives. The flood control levee would interfere with the existing urban drainage pattern and storm drainage system. Therefore, facilities for collecting and draining urban runoff from local rainfall events must be must be provided as part of the flood control project. Considered alternative interior drainage plans ranged from a minimum plan to a 25-year level of protection. These are described in Section X.C. of the main report. They call for drainage canals along the protected side of the levee, culverts under the ramps, ponding areas within the levee perimeter, and a culvert drainage structure to release interior flood waters to the outside of the levee. The various alternative plans differ in dimensions and configurations of the drainage canal and the structures. They range from a minimum channel with a triangular cross section, an average top width of 9 meters, and an average depth of flow of 1.5 meters, to a 25-year-level channel trapezoidal in shape with bottom widths ranging from 2.0 meters to 35.0 meters and an average depth of flow of 2.0 meters. A 57.2-acre excavated ponding area located in vacant lands north of Calle Plazuela was included in the latter plan (Central Plazuela is labeled in figures 1-5).. In selecting the interior drainage plan we considered only the quantity of flood damage reductions achievable by the alternative plans.

3.15 The Recommended Plan. The recommended plan (Plate 5) would provide a 100-year level of protection for areas of the town of Barceloneta subject to flooding from overflow from the Rio Grande de Manati (Plan 2), and would provide minimum interior drainage facilities. Proper performance of the interior drainage facilities require reservation of vacant agricultural lands in the northern part of the protected area: 150 acres northwest of the Central Plazuela and 11 acres northeast of there (Central Plazuela is labeled in figures 1-5).

The levee alignment is shown on Plate 5. The levee would be constructed with some of the material excavated from project channels, and the remainder from a commercial quarry located west of the project area. About 50 percent of the 88,000 cubic yards to be excavated from the channels would be suitable for levee construction; the rest would be placed in the onsite disposal area along the outside of the west levee. The disposal area would be about 900 meters long by 30 meters wide and cover 6.8 acres.

The project consists of 5,200 meters of earthen levees around the town of Barceloneta and two pilot channels about 1,545 meters long in the Rio Grande de Manati. The east levee would extend for about 3,000 meters from the north interior drainage structure (Culvert 1), turning southeast, crossing Calle Plazuela and Highway 684, crossing the river twice, and turning around the sport complex and the Villa Catalana residential development. The west levee would extend southwestward for about 2,200 meters across Highway 681 and end at high ground near Highway 682.

The river channel at the southeastern end of the project would be filled to build the levee and drainage channel, and a pilot (bypass) channel would be constructed about 50 meters south of the existing river to replace the river reach. This 760-meter south pilot channel would have a trapezoidal cross section with 1 on 4 side slopes and a 15-meter bottom width at elevation -1.1 meters NGVD. The south pilot channel and the adjacent levee side would be armored with riprap and bedding stone.

East of the town of Barceloneta 1.9 km (0.6 mile) of river would be by-passed and the flow directed into the north pilot channel. The 785-meter north pilot channel would have a trapezoidal cross section with 1 on 4 side slopes and a 15-meter-wide (49 feet) bottom at elevation -2.2 meters NGVD. Portions of the north pilot channel would be armored with riprap and bedding stone.

Two small road ramps would be required over the levee at Highways 140 and 682; two large road ramps would be required over the levee at Highways 681 and 684. A gravel, farm road ramp would be provided over the levee for access to the agricultural land inside the large river bend.

This alignment would require acquisition of six residential structures and relocation of a boat ramp and of utility lines.

Adjacent to Barceloneta 1,000 m (0.6 mile) of the by-passed river channel would be filled to one meter NGVD, leaving a shallow, 10-acre drainageway for conveyance of rainwater from the site through the east culvert to the river. Fill material to be placed in river channels would be of alluvial clay and

sandy clay sub-soil excavated from project channels. The drainageway would be top-dressed with topsoil.

The 100-year-protection levee would have an average height above ground of 5.4 meters and an average base width of about 38 meters. The crest width would be 4.0 meters and side slopes would be 1 on 3 on the east levee and 1 on 3.5 on the west levee.

Interior drainage facilities would include 5,230 meters of drainage canals. The canals would have a tri- gular cross section 9.0 meters wide at the top and have an average depth o -low of 1.5 meters. Corrugated metal culverts would pass water under the road ramps. The drainage structures, Culvert 1 and Culvert 2, would be corrugated metal pipe culverts with flap gates and concrete headwalls.

4.00 AFFECTED ENVIRONMENT.

4.01 The study area surrounds the town of Barceloneta, west of the Rio Grande de Manati, and extends from the town east as far as the eastern-most river bend at Barceloneta, west about one-half mile, south about one mile, and north about one-half mile (figure 5). Environmental resources outside of the study area and not affected by the recommended plan include the Cambalache National Forest, the Caño Tiburones Natural Reserve and the coastal barrier resource, Punta Manati.

Significant environmental resources that could be affected by considered alternatives include 11 archaeological sites of which 6 were thought to have potential significance, 50 acres of abandoned or grazed agricultural land, 62 acres of actively cultivated sugarcane, the Hacienda La Esperanza Natural Reserve east of the river, about 6.7 acres of palustrine, intermittently flooded wetlands at the north culvert and at the eastern road ramps and culvert, and a total of 4,170 meters (2.6 miles) of linear riparian habitat on the near-vertical river banks in river reaches that would be filled. The river in the study area is not considered significant habitat for reasons discussed below.

4.02 The major part of the study area surface is classified as flood plain alluvium, composed of gravel, sand, silt and clay (Gomez-Gomez, 1984). It contains volcanic rock fragments, quartz grains, and silicified and non-silicified volcanic rock pebbles. This type of surficial deposit typifies the northern two-thirds of Barceloneta northward to the Tiburones Swamp, the study area east of the river, and that included within the river bend at Barceloneta (main report Plate 2). The recommended project would be in this area. The level to gently rolling plain has been cultivated to pineapple or sugar cane, now abandoned, west of the river. Surface erosion has produced swales and depressions where rain water stands; these are considered as intermittently flooded wetlands that intergrade with higher ground, ridges and hummocks.

4.03 Soils in the alluvial flood plain are Toa and Coloso with occasional inclusions of Vivi. Toa soils occur only where the ground is relatively higher and well-drained, but Coloso soils are found both in wet and in dryer locations and in transition zones between wet and dry areas.

Drainageways and ponding areas typically have Coloso soils. The latter usually support such facultative wetland plant species as the following:

Typha domingensis (cattail)
Paspalum millegrana (paspalum grass)
Panicum aquaticum (water grass)
Cyperus sp. (sedges)

Plants of the drier, Toa locations, include Panicum maximum (guinea grass), Paspalum virgatum (talquezeal), Digitaria decumbens (pangola grass), and Psidium guajava (guava). Both types of soils have been cultivated and are used to pasture cattle.

West of the river from the southern third of Barceloneta southward, Aymamon limestone makes up the surface deposits. This limestone is generally very pure and fine-grained. Solution of the limestone typically develops a karst topography of steep-sided peaks and ridges with intervening plains of medium and fine-grained quartz sand (Gomez-Gomez, 1984). The end of the levee for the final plans abuts high ground at the northern edge of this area.

4.04 Cultural Resources. The Rio Grande de Manati flood plain has been extensively exploited throughout Puerto Rico's prehistoric and historic periods, and the area is rich in significant archaeological and historic resources. In letters dated August 17, 1987 and April 25, 1990, the Puerto Rico State Historic Preservation Officer (SHPO) recommended that a reconnaissance-level cultural resources survey be conducted to identify significant prehistoric or historic properties which will be affected by the project.

A cultural resources reconnaissance survey was performed in 1990 along alignments of Preliminary Plans 1, 2, and 3 (A Cultural Resources Reconnaissance within the Proposed Flood Control Project Area on Rio Grande de Manati at Barceloneta, Puerto Rico, by Garrow and Associates, Inc. 1990). Archival and background data were collected during the survey, utilizing information from the SHPO and the National Register of Historic Places. Field investigations included oral interviews, pedestrian archaeological reconnaissance, shovel testing, and preliminary architectural assessments. Six potentially significant archaeological sites (Site No. 1, 3, 4, 5, 6, 10) were identified, and additional assessment work was recommended to define site boundaries and determine National Register eligibility. In April 1993, Jacksonville District staff archaeologists conducted reconnaissance level cultural resources survey on those portions of the Selected Plan alignment that were not investigated during the 1990 survey. No potentially significant historic properties were identified during the 1993 survey.

The Jacksonville District staff also conducted archaeological testing to assess the significance and define the boundaries of the 6 sites recommended for additional investigations. Of the 6 sites, 5 were determined to not meet the criteria of eligibility for inclusion on the National Register, or were determined to be outside the area of effect for the proposed project. The remaining site is National Register eligible and will be affected. The site was originally recorded as a nineteenth and early twentieth century

residential site with brick foundation and intact archaeological midden. Through archaeological testing and archival research, it has been determined that this was the site of a small sugar processing mill.

4.05 Agricultural Resources. West of the river all lands within the project area outside of urbanized areas are abandoned or used for pasture. Sugarcane was the main agricultural crop until the Monserrate sugar mill closed in 1965. Now active sugarcane cultivation is conducted east of the river. The north pilot channel is to be located in an area of active sugarcane cultivation known as the "Predio Barceloneta y Vega," jointly managed by the Puerto Rico Land Authority, the Puerto Rico Sugar Corporation and the Puerto Rico Conservation Trust. This is considered prime agricultural land.

4.06 The River. The Rio Grande de Manati originates at an elevation of about 800 meters (2,625 feet) above mean sea level on the northern slope of the Cordillera Central (the central mountain range of Puerto Rico). It flows over a length of 90 kilometers (55.9 miles) and drains a watershed of 447 square kilometers (172 square miles). At Barceloneta the river flows slowly in a meandering channel and contains a salt-water wedge moving tidally along the bottom.

Summer flows in the project area during March to October are 70-80 cfs (95% probability), ranging up to 180 cfs in October-January (Gomez-Gomez, 1984). Under existing, without-project conditions, suspended sediment concentrations reported at flows of less than 100 cfs range from 30 to 200 pounds per acre-foot (ibid.) (11 to 74 parts per million). Flow around 200 cfs carries 200-250 pounds per acre-foot (74-93 ppm), with extreme measurements reported from 30-500 pounds (11-185 ppm) (ibid.). The mean annual suspended-sediment discharge at Highway 2 is estimated at approximately 100,000 tons per year.

In the study area the river is classified SC, Coastal Water intended for uses where the human body may come in indirect contact with the water (such as fishing, boating, etc.), and for use in propagation and preservation of desirable species. Curtis et al, (1991) reported that Río Grande de Manati water quality constituents measured during normal and below-normal flow conditions at Highway 2 near Manati in 1989 and 1990 complied with water quality standards for Class SC waters. However, during above-normal flow in October of 1989, fecal coliform and turbidity standards were violated. Gomez-Gomez (1984) cites as probable major sources of fecal contamination dairy cattle within the valley and sewage out-falls from towns in the upper basin. The latter author points out that fecal coliform concentrations are not in themselves indicators of the presence of pathogens, but cautions that should the snail (Biomphalaria glabarata) host of the bilharzia pathogen, Schistosoma mansoni, be introduced into the valley, e.g., on the hooves of cattle, the pathogen could rapidly propagate if conditions are favorable.

The organic pollution promotes algae blooms which cause dissolved oxygen concentrations in the lower river to reach 8.0 mg/l during summer days (111 percent saturation at 27 degrees C) and to plummet to zero at night. Benthos in the soft, muddy bottom silt of the slowly flowing river would be those tolerant of near-anaerobic conditions and salt-water; we have not sampled the benthos. Stable fish populations are unable to survive in these conditions,

and above the mouth of the river in the study area there is no fishery and the water is not used for human-contact recreation.

4.07 Riparian Wetlands: Land in the study area is cultivated or developed to the river's edge. The riparian habitat is therefore only a narrow strip overhanging the river and extending down into the water.

Benthos in the habitat are largely confined to the banks near the surface, where adequate concentrations of dissolved oxygen are dependably present, and where the fresh water is not affected by a salt water wedge that extends up the river. Aquatic insect larvae (Odonata, Diptera, Coleoptera), snails, leeches and oligochaete worms may be found in the near-surface, vegetated river banks.

4.08 Palustrine Wetlands: Wetlands apart from the river channel are limited to drainageways and ponding areas. Plants occurring in these palustrine, intermittently flooded areas are listed above (section 4.03). These sites support amphibians that breed in rain pools and provide forage for snowy egrets (Egretta thula), little blue herons (Egretta caerulea), green-backed herons (Butorides striatus), and other wading birds (USFWS, 1992). Benthos in these sites would be those that develop quickly in temporarily flooded sites, such as mosquito and fly larvae.

4.09 Special Sites and Areas. Cambalache Commonwealth Forest is about 3 miles west of the study area. Part of the Commonwealth Forest System, the forest is located on the north coast off Highways 2 and 682. It conserves examples of mature secondary coastal forest and provides recreational and educational opportunities to Barceloneta residents. It is outside the Rio Grande de Manati flood plain and will not be affected in any way by the recommended plan, but it provides additional recreation area used on weekends by residents of Barceloneta (Puerto Rico Department of Natural Resources 1976).

Caño Tiburones Marsh, located about 3 miles west-northwest of the study area, is noted for its high botanical and wildlife diversity. This brackish, coastal marsh extends westward from the municipality of Barceloneta line to the Arecibo Delta at the Vigía pump station, about 1 km northeast of the Arecibo River mouth. Although it has been extensively altered, first by clearing of its original forest (mangrove and swamp bloodwood), then by manmade gravity drainage and pumpage, followed by muck soil shrinkage and sinking, it is still believed to shelter nesting populations of three locally threatened species of native ducks. It is a popular bird-watching and waterfowl hunting area, and is habitat to several rare native aquatic plants (Cardona and Rivera 1988; P.R. DNR Natural Heritage Program, 1991). The Marsh is outside of the Rio Grande de Manati drainage basin and is not expected to be affected in any way by the recommended plan.

Punta Manati, a sand spit connected to the shore about 0.8 mile east-northeast of the mouth of the Rio Grande de Manati, is proposed for listing in the Coastal Barrier Resource system. It is about 1.5 miles north-northeast of the study area and is outside any influence of the recommended project.

Hacienda La Esperanza Natural Reserve. The north pilot channel is planned to cut through lands in Hacienda La Esperanza Natural Reserve that are in active sugarcane cultivation. The lands are jointly managed by the Puerto Rico Land Authority, Puerto Rico Sugar Corporation and the Puerto Rico Conservation Trust.

4.10 Endangered Species, Threatened Species. Coordination with the U.S. Fish and Wildlife Service has resulted in agreement between the USFWS and the U.S. Army Corps of Engineers that the Puerto Rico boa (Epicrates inornatus) may be present in the disposal area once considered under preliminary plans, but not under the recommended plan, and in the vicinity of the commercial quarry from which borrow material would be taken. The quarry has been used recently for fill for the new residential development west of Barceloneta.

4.11 Hazardous and Toxic Waste (HTW). Review of study area maps and photographs indicates that urbanized or modified areas with potential for HTW contamination are negligible. The predominant land use is agricultural and poses little or no HTW threat. Although light industry occurs in the basin, there appear to be no landfills, industrial waste treatment plants or other facilities likely to generate serious HTW problems.

An on-site HTW survey of the Rio Grande de Manati project area was performed in February 1992. The inspection revealed no HTW sites in the project area. Unless new information contrary to this finding is revealed, no additional HTW work is needed for this study.

5.00 ENVIRONMENTAL CONSEQUENCES.

Impacts of finally considered alternative plans are summarized and compared in Table 1. Impacts are discussed in the following paragraphs.

5.01 Cultural Resources Impacts. The Selected Plan will affect one significant historic period archaeological site, the site of a small sugar processing mill. The site has been determined to be significant only for its information potential, and archaeological data recovery will collect information adequately to mitigate adverse effects. Archaeological data recovery will include in-depth archival study, archaeological excavation, and architectural documentation of building foundations. Mitigation costs are estimated at $45,000, and will not exceed 1 percent of total project costs. All cultural resources work will be conducted in compliance with the National Historic Preservation Act of 1966, as amended (PL 89-655); and the Archeological and Historic Preservation Act, as amended (PL 93-291).

ALTERNATIVES	SOCIOECONOMIC	AESTHETIC	HISTORIC-ARCHEOLOGICAL	PRIME FARMLAND +/- AREA	CONSERVATION TRUST LAND	PALUSTRINE WETLANDS +/- AREA	RIPARIAN WETLANDS +/- LENGTH	NET RIVER METER AFFECTED
--Final Plans--								
Plan M-1	Leaves 30 wood structures in floodplain			-8.7 hectares (-21.4 acres) taken	-33.7 hectares (-84.3 acres) taken/cut off	+5.2 hectares (+12.8 acres)	-850 meters (-0.5 miles)	Cuts off 2.4 km (1.5 miles)
Plan M-2	Leaves 30 wood structures in floodplain			-8.7 hectares (-21.4 acres) taken	-33.7 hectares (-84.3 acres) taken/cut off	+4.4 hectares (+10.8 acres)	-850 meters (-0.5 miles)	Cuts off 2.4 km (1.5 miles)
Plan M-3	Leaves 30 wood structures in floodplain			-8.7 hectares (-21.4 acres) taken	-33.7 hectares (-84.3 acres) taken/cut off	+4.7 hectares (+11.6 acres)	-850 meters (-0.5 miles)	Cuts off 2.4 km (1.5 miles)
Plan M-2-F	Takes 4 residences; leaves 4 in floodplain			-8.7 hectares (-21.4 acres) taken	-33.7 hectares (-84.3 acres) taken/cut off	+4.4 hectares (+10.8 acres)	-850 meters (-0.5 miles)	Cuts off 2.4 km (1.5 miles)
Plan M-3-F	Takes 3 residences; leaves 4 in floodplain			-8.7 hectares (-21.4 acres) taken	-33.7 hectares (-84.3 acres) taken/cut off	+4.4 hectares (+10.8 acres)	-850 meters (-0.5 miles)	Cuts off 2.4 km (1.5 miles)

Table 1. Rio Grande de Manati at Barceloneta: Summary of Impacts of Alternatives

5.02 Agricultural Impacts. The north pilot channel will cross an actively cultivated sugarcane area, the "Predio Barceloneta y Vega," and will replace about 13.5 acres. The east levee berm and drainage channel will cover about 8 acres. The total area of farm land that will be taken out of production, about 21 acres, is classified prime farmland by the U.S. Department of Agriculture Soil Conservation Service. An additional 62 acres of sugarcane within the river bend will be cut off by the levee. It is part of the "Predio Barceloneta y Vega," managed jointly by the Puerto Rico Land Authority, the Puerto Rico Sugar Corporation and the Puerto Rico Conservation Trust. Access to the cut off land would be provided by a road ramp from the Barceloneta area.

5,03 Palustrine Wetlands Impacts. At the north culvert site 1.3 acres of palustrine wetlands in an improved natural drainageway will be covered by the levee, interior drainage canal and right-of-way. At the east culvert site 5.4 acres of palustrine wetlands in a groundwater seepage area adjacent to the river will be covered by levee, road ramps and interior drainage canal. At these sites as well as around the entire inner perimeter of the levee the interior drainage canal will produce 11.6 acres of palustrine wetlands, and 10.1 acres will be created on the filled river segment next to Barceloneta. The net effect of the recommended plan on palustrine wetlands will be the addition of 15 acres of palustrine wetlands of approximately the same quality and function as those presently on site.

5.04 Riparian Wetlands Impacts. Riparian sites to be filled are the near-vertical banks of the Rio Grande de Manati. Because agricultural cultivation and urban development are carried to the river's edge, and the steep channel sides offer only a very narrow expanse, up to 2 meters, this habitat is reported in lineal and, secondarily, in areal units. Construction of the levee, drainage canal and right-of-way at the upstream (south) end of the project will require filling the river reach there, covering 785 meters of steep riparian habitat on each bank. A pilot channel will be constructed to replace the river reach at that location, but the 1-on-3-sloped channel banks will be riprapped. The result will be a loss of 1570 meters of lineal riparian habitat at the upstream end.

A similar pilot channel, 785 meters long, will be constructed in the downstream extremity of the project with a loss of 600 meters of lineal riparian habitat at the sites where the channel ties into the river.

East of the town of Barceloneta 2.4 km (1.5 miles) of river will be by-passed and the flow directed into the downstream pilot channel. Adjacent to Barceloneta 1,000 m (0.6 mile) of the by-passed river channel will be filled to one meter elevation, leaving a shallow, 10-acre drainageway for conveyance of rainwater from the site through the east culvert to the river. Fill material to be placed in river channels will be of alluvial clay and sandy clay sub-soil from excavation of the pilot channels and the interior drainage canal. The drainageway would be top-dressed with topsoil. As a result, about 2,000 meters (1.2 mile) of riparian habitat clinging to steep channel sides will be covered (1,000 m x 2 = 2,000 m of 2 channel sides, combined). The drainageway will function similarly to the way the drainageways in the area

now function, supporting intermittently flooded palustrine wetlands and contributing to the net gain in wetlands described above. The remainder of the by-passed river (1448 m; 0.9 mile) will be left as a slough-like backwater connected to the flowing river. The backwater slough may become filled with sediment over time.

A summary of respective acreage impacted by the recommended plan follows:

PALUSTRINE (PERSISTENT, TEMPORARILY FLOODED) WETLANDS

Levee: 404 wetlands

At north outlet: cover.....(1.3 acres)
At east outlet: cover.....(5.4 acres)

SUBTOTAL PALUSTRINE WETLANDS LOSS.....(6.7 acres)

Palustrine Wetlands Replacement:

Drainageway replacement of river segment.....10.1 acres
Added by internal drainage canal.....11.6 acres

NET PALUSTRINE WETLANDS GAIN.....15.0 acres

RIPARIAN (RIVER BANK) WETLANDS

Channels and Levee:

Barceloneta*: fill 1,000 m x 2* = (2,000 m) loss

D/S* pilot channel: channelize 300 m x 2 = (600 m) loss
U/S* pilot channel: channelize and
fill 785 m x 2 = (1,570 m), = (1,570 m) loss

TOTAL RIVER BANK WETLANDS LOSS.....(4,170 m) loss

* Barceloneta: the river reach to be filled adjacent to Barceloneta--it will be filled to 1 meter elevation, and a drainage-way will be constructed over the filled channel, thus replacing riparian wetlands with palustrine; multiplier accounts for 2 channel banks; D/S = downstream; U/S = upstream.

The impacted palustrine areas' value is that of temporary rain-pool breeding areas for amphibians and hunting grounds for their predators, wading birds. This habitat function will be more than replaced by the 1-meter-elevation, 10-acre drainageway over the filled river reach and by the interior drainage canal, although the canal would be maintained to ensure drainage capability. No amphibians listed under the Endangered Species Act or by the Commonwealth of Puerto Rico are present in the habitat.

The 4,170 meters of steep, riparian habitat to be lost represent maximally about 2 acres, and the net gain in palustrine habitat totals 15 acres. Although no net loss of wetlands values seems likely, there appears to be no

meaningful basis for calculating the relative habitat values between the impacted palustrine areas and the linear riparian habitats. Although the riparian habitat is relatively permanent and may provide the stable habitat necessary for aquatic insects to complete their life cycles, such habitat is common, and additional, compensatory mitigation is not proposed.

The effect of creating the backwater slough will be neutral to positive. The cutoff portion will receive less pollution than the river receives, because pollutants from the river would have to circulate into the nonflowing slough. In the process the nutrients are subject to uptake by planktonic algae, by their predators, and to settling after death of the flora and fauna. The more the bottom is built up by sedimentation, the less river pollutants will enter the slough, and the salt water wedge will be excluded. The slough will never have less than zero dissolved oxygen, which is the river condition now. The slough will eventually flood and recede with rainfall and runoff, and it will become habitat for breeding amphibians. The amphibians will be preyed upon by wading birds which will use more area as the slough becomes shallower.

Design features to improve the backwater slough habitat were considered but deemed unnecessary, since the slough will be a rather useful habitat, growing more useful in time. Should clean fill become available, its deposition in the slough channel near the river would prevent salt water intrusion and hasten the improvement of the slough toward shallow fresh water used by amphibians and invertebrates. During this project the slough will be invaded by aquatic vascular vegetation and become additional palustrine wetland.

5.05 River Impacts. Water quality will not be adversely impacted, and Commonwealth water quality standards will be met. Contaminants will not be introduced by fill material that may become suspended or dissolved in river water. As flow is introduced into the pilot channels some sediment from the removed plug may be expected to be carried in suspension for a short time. No biological resources sensitive to suspended and settling sediment are present. River bottom sediments will not be dredged; at points of river diversion, the existing channel will be riprapped.

5.06 Endangered Species Impacts. Potential impacts associated with the preliminary plan disposal area would be avoided by using the proposed 6.8-acre disposal area, approximately 30 meters wide on the outside flank of the southern 900 meters of the western levee (Plate 5). The first considered alternative disposal area, south of Barceloneta, may contain Puerto Rican boa habitat along its north, east and south edges. The area is east of the Sabana Hoyos, an important karst habitat that may well shelter the boa, but the area will not be used for disposal under the recommended plan. The borrow area is an actively used quarry west of the proposed project area. The use of this area was coordinated with the U.S. Fish and Wildlife Service under the Endangered Species Act.

5.07 Cumulative Impacts. The Puerto Rico Highway Authority is constructing a new highway, Highway 22, through the Rio Grande de Manati (figure 1). A traffic interchange has been constructed south of Barceloneta. The interchange will provide a link between existing Highway 2, Highway 22, and the town of Barceloneta. The highway project and the planned flood protection

project would not adversely affect each other, but the highway project is likely to stimulate moderate population growth in the study area. As a result, future flood protection benefits may increase.

5.08 Air Quality Impacts. Fugitive dust from vehicular traffic and earth moving will be unavoidable but insignificant. There are no air quality issues in the study area.

5.09 Noise Impacts. Part of the construction area would be adjacent to parts of the town of Barceloneta. Although engines on construction equipment will be equipped with required mufflers and air pollution control devices, individuals may experience annoyance with construction noise levels. Probably the most intrusive noises will occur during the driving of sheet pile near town. Reverse travel (back-up) warning alarms on the vehicles will be a frequent sound during construction. Overall, the impacts would be short-term and unavoidable. They can be mitigated by scheduling the driving of piling during daylight hours.

5.10 Man-made Resources Impacts. Where the levee and channels would be constructed across roads, road ramps and temporary detours would be provided. No significant impacts on these and other man-made resources are known.

5.11 Community Cohesion Impacts. The recommended plan requires that two residences at the southwest levee junction with high ground, and probably four where the Highway 684 ramp is constructed, would have to be relocated. The residences would have to be taken by fee simple purchase, and the occupants would be assisted to relocate. From an overall community viewpoint, these impacts at the extremes of the urban area do not appear to have significant import to community cohesion.

5.12 Public Facilities and Service. No impacts have been identified other than those to the roads that will be furnished with ramps over the levee and drainage channel.

5.13 Employment Impacts. Except for possible temporary employment with construction crews, there would be no impacts. Commuters will be able to travel via detours and road ramps.

5.14 Tax Value. About 21 acres of sugarcane plantation would become project land and lose their agricultural value. Six residences would have to be taken, and the owners would be fairly compensated.

5.15 Displacement of People, Businesses and Farms. The north pilot channel would cross land now in sugarcane cultivation but owned by the Puerto Rico Conservation Trust as part of the Hacienda La Esperanza Natural Reserve. Access to the cut off land within the river bend would be provided by a road ramp from Barceloneta. Six families would have to be relocated (section 5.11, above).

5.16 Community Growth. Insofar as the project provides dependable flood protection to the urban area, the community's potential for economic and

quality-of-life improvement would be enhanced. There would be no adverse impacts to the potential for community growth.

5.17 Regional Growth. The flood protection project in conjunction with Highway 22 and the interchange with Highway 2 could provide some stimulus to regional growth. There would be no adverse effects on the community growth potential.

5.18 Coastal Zone Management Program. The studied project was evaluated in accordance with Puerto Rico Planning Board Guidelines for Federal Projects in the Coastal Zone of Puerto Rico, pursuant to Puerto Rico's approved Coastal Zone Management Plan, adopted in 1978 and incorporated into the Puerto Rico Comprehensive Land Use Plan in 1979. The studied project was determined by the Corps, in accordance with the above guidelines, to be consistent with this Plan.

6.00 UNAVOIDABLE ADVERSE ENVIRONMENTAL EFFECTS.

About 21 acres of prime farmland cultivated in sugarcane will be removed from production by construction of the north pilot channel and the levee. Additionally, 62 acres of prime farmland in sugarcane would be cut off and provided access by means of a ramp over the levee from Barceloneta. Residential property values would have to be acquired by flood easement or fee simple purchase, and residents would be assisted to relocate.

7.00 RELATIONSHIP BETWEEN SHORT-TERM USES OF MAN'S ENVIRONMENT AND THE MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY.

The recommended action would enhance and preserve urban quality and the constructed environment, and it would protect historic and cultural resources. The recommended plan would have the least identified impacts on natural depletable resources such as petroleum and other mineral resources. Construction of the north pilot channel would hasten the river's long-term process of cutting a channel in approximately the same place.

8.00 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES.

The only irreversible and irretrievable commitment of resources is the use of petroleum products during construction.

9.00 COMMITMENTS TO BE CARRIED OUT DURING DESIGN AND CONSTRUCTION.

1. The drainage-way to be created over the filled river site inside the levee at Barceloneta will be dressed with topsoil.

2. The pilot channels will be riprapped to prevent erosion.

3. Archaeological-historical data will be recovered at the single, significant historical site to be affected. All work will be conducted in compliance with the National Historic Preservation Act of 1966, as amended (PL 89-655) and the Archaeological and Historic Preservation Act, as amended (PL 93-291).

10.00 SUMMARY OF COMPLIANCE WITH APPLICABLE ENVIRONMENTAL REQUIREMENTS.

10.01. Archeological and Historic Preservation Act, as amended. 16 U.S.C. 469 et seq., as amended by PL 96-515, December 12, 1980. The Act provides for the preservation of historical and archaeological data which might otherwise be lost or destroyed as the result of flooding or by any alteration of the terrain caused as a result of any Federal construction project. Before any Federal agency undertakes such an activity it must give written notice to the Secretary of the Interior and the State Historic Preservation Officer. Recovery, protection, and/or preservation of such data may be required. Executive Order No. 11593, 13 May 1971.

Archaeological-historical data will be recovered at the single, significant historical site to be affected. All work will be conducted in compliance with the National Historic Preservation Act of 1966, as amended (PL 89-655) and the Archaeological and Historic Preservation Act, as amended (PL 93-291).

10.02. Clean Air Act, as amended. 42 U.S.C. 7401 et seq. Any official of a Federal agency having jurisdiction over any property or facility constituting an emissions source shall be subject to and comply with Federal, state, interstate or local requirements respecting control and abatement of pollution. All Federal projects, licenses, permits, financial assistance and other activities must conform to EPA approved or promulgated state implementation plans. The assurance of such conformity is an affirmative responsibility of the head of the Federal agency involved. Sections 118, 176(c), and 309, 42 U.S.C. Executive Order 12088, Federal Compliance with Pollution Control Standards, 13 October 1978.

The only project-related sources of such emissions would be the motorized construction equipment. All vehicles, generators, pumps and construction related engines will conform to Puerto Rican emissions standards. The study area is not in a non-attainment air quality area.

10.03. Clean Water Act (Federal Water Pollution Control Act), as amended. 33 U.S.C. 1251 et seq. (PL 92-500). Any official of a Federal agency having jurisdiction over any property or facility or engaged in any activity that may result in the discharge or runoff of pollutants shall be subject to, and shall comply with federal, state, interstate and local requirements, both substantive and procedural, respecting control and abatement of pollution. Federal agencies are not exempt from the requirement to obtain certification from the state or interstate agency for any discharge into navigable waters (except as provided in Section 404(r)). Executive Order 12088, 13 October 1978. EPA guidelines, 33 U.S.C. 1344b. CEQ Memorandum 17 Nov 80, guidance to apply Sec. 404(r) to a Federal project.

Construction activities will be controlled through contract specifications and on-site inspections so as to comply with all federal, Commonwealth and local requirements for environmental quality control. The recommended action will be subject to Puerto Rico Department of Natural Resources water quality certification under the Clean Water Act. Such water quality certification requires (1) a complete evaluation of the effects of the proposed discharge

consistent with Section 404(b)(1) of the Act; and (2) a public notice, with opportunity for public hearings for the proposed discharge, including or referencing the Preliminary Section 404(b)(1) evaluation included in the feasibility report. A preliminary Section 404(b)(1) Evaluation is annexed to this environmental assessment. However, this report is not to be submitted to Congress for authorization and is not eligible for Section 404(r) exemption. It is fully intended that the proposed action will conform to Commonwealth standards for certification, so that certification may be obtained from the Commonwealth prior to construction.

10.04. Coastal Zone Management Act of 1972, as amended. 16 U.S.C. 1451 et seq. Any activity that a Federal agency conducts or supports that directly affects the coastal zone, and any development project in the coastal zone, shall be, to the maximum extent practicable, consistent with approved state management programs. NOAA Regulations, 15 CFR Part 930 revised 15 June 1979, 44 F.R. 37142.

Certification by the Commonwealth of Puerto Rico that the recommended work is consistent with Puerto Rico's Coastal Zone Management Plan will be required. It may be issued after Commonwealth agencies' review and approval of the draft report and EA. U.S. Army Corps of Engineers certification of compliance with the Puerto Rico Coastal Management Program appears as attachment C to this EA.

10.05. Endangered Species Act of 1973, as amended. 16 U.S.C. 1531 et seq. Federal agencies shall, in consultation with and with the assistance of the Secretary (Interior or Commerce), utilize their authorities in furtherance of the purposes of the Act by carrying out programs for the conservation of listed endangered and threatened species and by taking such action as necessary to insure that actions they authorize, fund, or carry out are not likely to jeopardize the continued existence of such endangered or threatened species or result in the destruction or modification of habitat of such species which the Secretary, after consultation as appropriate with the affected States, has determined to be critical. USDI and USDC, NOAA, Rules on Endangered Species Exemption Applications, 50 CFR Parts 451, 45 F.R. 8264 (8 Feb 80), and 50 CFR Parts 450, 451, 452 and 453, 45 F.R. 23354 and 49083.

The recommended plan is being coordinated with the U.S. Fish and Wildlife Service by separate correspondence during coordination of this draft report and EA, and with the Puerto Rico Department of Natural Resources. The PRDNR response is invited as part of the agency's comment on the environmental assessment (EA). No effect is expected upon species listed under the Act, nor on locally protected species.

10.06. Estuary Protection Act. 16 U.S.C. 1221 et seq. (PL 9454, 3 August 1968). In planning for use or development of water and land resources, all Federal Agencies shall give consideration to estuaries and their natural resources, and their importance for commercial and industrial developments. All project plans and reports affecting estuaries and their natural resources that are submitted to Congress shall contain a discussion by the Secretary of the Interior concerning the estuaries and their resources and effects of the project on them and his recommendation thereon. No implementing directives.

Comment from the Secretary of the Interior is solicited through review of the draft report and Environmental Assessment. The Rio Grande de Manati may be considered estuarine in the study area, inasmuch as a salt water wedge extends up the river into the study area.

10.07. Federal Water Project Recreation Act, as amended. 16 U.S.C. 4601-12 et seq. Any Federal navigation, flood control, hydroelectric, or multiple-purpose project planning shall include full consideration of opportunities afforded by the project for outdoor recreation and fish and wildlife enhancement. No implementing directives.

Opportunities for outdoor recreation were considered and a plan was provided to the local sponsor. The principles of the Federal Water Project Recreation Act. (P.L. 89-72) as amended, have been fulfilled by complying with the recreation cost sharing criteria as outlined in Section 2 (a), paragraph (2).

10.08. Fish and Wildlife Coordination Act, as amended. 16 U.S.C. 661 et seq. For any proposal or Federal work affecting any stream or other body of water, the Federal agency proposing such work must first consult with the Fish and Wildlife Service and state wildlife agency with a view to preventing losses and damages to wildlife resources and to providing for development and improvement of wildlife resources. Reports of the Secretary of the Interior and state wildlife agency shall be an integral part of any report to Congress. No implementing directives.

A Fish and Wildlife Coordination Act Report prepared by the U.S. Fish and Wildlife Service is included with the EA. The Feasibility Report and EA have been submitted to the Secretary of the Interior and to the Secretary of the Puerto Rico Department of Natural Resources for comment.

10.09. Land and Water Conservation Fund Act of 1965, as amended. 16 U.S.C. 4601-4 et seq. No financial assistance may be given under any other Federal program for any project with respect to which such assistance to a state has been given or promised under this statute. No property acquired or developed with assistance from the Land and Water Conservation Fund shall, without the approval of the Secretary of the Interior, be converted to other than outdoor recreation uses. No implementing directives.

No properties affected by this act are involved in the recommended project area.

10.10. Marine Protection, Research, and Sanctuaries Act of 1972, as amended. 33 U.S.C. 1401 et seq. In connection with Federal projects involving dredged material, the Secretary of the Army may issue permits for the ocean discharge of dredged material, applying the same criteria which apply to EPA issuance of permits for ocean dumping of other material. Executive Order 12088, Federal Compliance with Pollution Control Standards, 13 Oct 78.

Ocean disposal of dredged material is not proposed.

10.11. National Environmental Policy Act of 1969, as amended. 42 U.S.C. 4321 et seq. PL 91-190, as amended. All Federal agencies shall include a detailed

Environmental Impact Statement (EIS) in every recommendation or report on proposals for legislation and other major Federal actions significantly affecting the quality of the human environment. Prior to making an EIS, the responsible Federal official shall consult with and obtain comments from any Federal agency which has jurisdiction by law or special expertise with respect to any environmental impact involved. The EIS and comments and views of appropriate Federal state and local agencies which are authorized to develop and enforce environmental standards shall be available to the President, CEQ and the public, and shall accompany the proposal through the existing agency review process. Executive Order 11593, 13 May 71; E.O. 11988, 24 May 77; E.O. 1990, 24 May 1977; E.L. 11991, 24 May 77; E.L. 12088, 13 Oct 78; E.L. 12114, 4 Jan 79; CEQ Regulations 40 CFR Parts 1500-1508, 29 Nov 78; CEQ Memorandum 30 Aug 76.

In consultation with the Puerto Rico Government and the U.S. Fish and Wildlife Service we have determined that the proposed major Federal action will not significantly affect the human environment. The draft Detail Project Report and EA have been submitted to the responsible Federal, Commonwealth and local officials for comment. Their responses will be reviewed and considered during the process of project finalization and prior to making a Finding of No Significant Impact and that an EIS is not required.

10.12. National Historic Preservation Act of 1966, as amended. 16 U.S.C. 470 et seq., as amended by PL 102-575, 2 Nov 92. The head of any Federal agency having direct or indirect jurisdiction over a proposed Federal or Federally assisted undertaking shall, prior to approving expenditure of any Federal funds on that undertaking, take into account its effect on any district, site, building, structure, or object that is included, or is eligible for inclusion, in the National Register of Historic Places. The head of the Federal agency shall afford the Advisory Council on Historic Preservation a reasonable opportunity to comment with regard to such undertaking. Advisory Council on Historic Preservation Regulations, 36 CFR Part 800, 44 F.R. 6068, 30 Jan 79.

Consideration of effects on such resources are addressed in the body of the EA, and comments have been received from the State Historic Preservation Officer. The Advisory Council on Historic Preservation has been asked to comment on the draft Detail Project Report and EA. Impacts to known archaeological and other cultural resources have been avoided, except for one, which will be documented for mitigation, and unknown resources that may potentially be present will be protected through monitoring during project construction.

10.13. Coastal Barrier Resources Act. The Act prohibits certain types of development on designated coastal barrier islands or portions thereof (CBRA units) and requires that a project located in a CBRA unit be subjected to comments by the Secretary of the Interior.

The study area is not in a designated CBRA unit.

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Gomez-Gomez, Fernando, 1984. Water Resources of the Lower Rio Grande de Manati Valley, Puerto Rico. U.S. Geological Survey Water Resources Investigations Report 83-4199.

U.S. Fish and Wildlife Service, 1992. Final Planning Aid and Coordination Act Report Rio Grande de Manati Flood Control Project. Appended.

ATTACHMENT A

U.S. FISH AND WILDLIFE COORDINATION ACT REPORT

RIO GRANDE DE MANATI AT BARCELONETA, PUERTO RICO

SECTION 205 STUDY FOR FLOOD PROTECTION

Final Planning Aid and Coordination Act Report
Rio Grande de Manati Flood Control Project

Prepared by:
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INTRODUCTION:

The Rio Grande de Manati drains a total of 204 square miles. The upper drainage drains through an area of volcanic origin while the lower drainage meanders through limestone Karst topography. The river opens into a coastal plan just below the town of Barceloneta. A sand bar usually blocks the mouth of the river during the winter months, an estuarine marsh is located just behind the sand bar. The Matrullas, Guineo, Yahueca, and Prieto reservoirs are located in the upper drainage. Rainfall in the area averages some 54 inches near the coast and 61 inches six miles inland. The months with the most rainfall are October through December these are also the months of greatest discharge for the river. Gauge station data at the Highway 2 bridge near the town of Barceloneta indicates a maximum height of 33.3 feet, and a maximum discharge of 119,000 cfs. The mean annual flow is some 267,000 acre feet. The river overflows its banks on the average of once every 2 years with major floods resulting once every 7 years. This gives a flood probability of 13% for any given year, resulting in the frequent flooding of the town of Barceloneta. From 1899-1980, 12 major floods have occurred in the Rio Grande de Manati river valley. A typical flood can inundate the valley with at least 3 feet of water.

The proposed flood control project plans for the construction of a levee around the town, a north pilot channel to eliminate a meander, and a second, south pilot channel to move the river away from the town. Several culverts, road crossings and three

ponding areas within the levee are also proposed.

Sugarcane was the main agricultural crop in the project area until 1965 when the Monserrate sugar mill closed. Most of the sugarcane fields were either abandoned, used for pasture or pineapple production. Over 70 percent of the land belongs to the Puerto Rico Land Authority, or the Puerto Rico Conservation Trust. At the time of this survey the majority of the lands west of the Rio Grande de Manati were in an abandoned state. They are being used for pasture. All the lands within the project boundaries are currently abandoned or pasture. East of the river the areas are still in active sugarcane production, with some fields being used for hay.

SOILS:

The principal soil series in the project area are Coloso and Toa. Both of these soils originate from fine alluvial sediments. Alluvial deposits in the river valley maybe as much as 300 feet thick. Toa soils are deep and well drained. Coloso soils are somewhat poorly drained. Both are typical floodplain soils and both are known to have hydric inclusions of Bajura soils. Some Coloso soils have been extensively drained for agricultural purposes for over a century.

WETLANDS:

The majority of wetlands in the Barceloneta area are either directly related to the Rio Grande de Manati, or form part of the

basin mangrove forests that are common along the north coast of Puerto Rico. Wetlands within the project site are limited to riverine wetlands along the banks of the river and small patches of herbaceous wetlands found in the abandoned fields. These habaceous wetlands are slowly forming as drainage canals and ditches block up from lack of maintenance. As a result, the naturally occurring swales in the landscape are reverting back to wetlands. These wetlands can be best classified as seasonal and depend on annual flooding to maintain their wetland characteristics. Flooding and ponding for prolonged periods is the driving force in these wetlands. Typical vegetation found along the river banks include wild cane Arundo donax and Gynerium saggittatum, guinea grass Panicum maximum, elephant grass Pennisetum purpureum, and saw grass Cladium jamaicense.

Many of the ditches and drainages in the project site have become sedimented and as a result they have become colonized by wetland plants. Dominant species include cattails Typha domingensis, sedges Cyperus spp., and Job's tears Coix lacryma-jobi.

Project descriptions:

1) Southern Pilot Channel: This channel will be cut through active sugarcane fields in Toa soils. The river channel currently cuts at the base of a hill just below Road 140. There are several houses and part of a residential development just above the river. The southern pilot channel will join the existing river channel below an abandoned metal bridge. In

conjunction with the pilot channel, a levee will be built along the existing river channel completely eliminating all riverine vegetation.

2) North Pilot Channel: This channel will eliminate a major bend in the river. The river currently bends southwest towards the town and then runs north paralleling the town. The pilot channel will eliminate this bend and join the natural channel north of the town. The pilot channel will cut through existing sugarcane fields, known as the "Predio Barceloneta y Vega". These fields are still in cultivation and will be isolated by the channel. These sugarcane fields form part of the Hacienda Esperanza Natural Reserve and are jointly managed by the Puerto Rico Land Authority, Puerto Rico Sugar Corporation and the Puerto Rico Conservation Trust (Figure 1).

3) Western Levee: The southern levee turns 90 degrees at the corner of the residential development. It moves away from the river channel and parallels the town. The levee will run through fallow fields belonging to the Puerto Rico Land Authority, which are currently being used as pasture. As it moves away from the river, the vegetation is dominated by guinea grass, tan-tan Leucaena leucacephala, Sesbania spp., and african tulip tree Spathodea campanulata. Many of these are fast growing colonizing species. The levee will cut across some small patches of wetlands just before crossing the river. These herbaceous wetlands are located in swales and are comprised of elephant

grass, cane, and saw grass. After the river crossing, the levee crosses the "Predio Barceloneta y Vega". It will run directly through the active cane fields. With the construction of the North Pilot Channel and the levee, these fields will essentially be eliminated.

4) The levee crosses the river just north of the town and then takes a northwesterly route. The levee runs just north of the now defunct Plazuela sugar mill and then turns south to join the karst hills at Road 682. Along this transect the levee will cross several small wetland areas. The fields in the area are not in active cultivation. Many are being invaded by African tulip trees and tan-tan. The drainage canals in these fields have become blocked and as a result, wetland hydrology has returned in some isolated spots. Wetland vegetation includes cattails, sedges, Paspalum millegrana, and Panicum aquaticum,

Site Inspections:

Site 1) Open field east of the Sixto Escobar Stadium. The levee and drainage ditch will run parallel to the town in this area. The levee will run north, parallel to a residential area (Photos 1&2). Several home owners have expanded their yards out into the fields and might be impacted by the drainage channel. The land belongs to the Puerto Rico Land Authority, it was once in sugarcane but its now in pasture. Several horses were seen in the northern portion while cattle are using the southern portion (Photo 3). Vegetation is predominantly upland and consists of

plush grass Chloris spp., wire grass Eleusine indica, hairy grass Paspalum paniculatum, guinea grass and African tulip trees. The levee and drainage channel will cross several small patches of wetlands at the northern portion of the fields just before crossing the river (Photo 4). The small pockets of wetlands form in swales, and contain wild cane and elephant grass (Photo 5).

Site 2) "Predio Barceloneta y Vega": This area is currently in active sugar cane production (Photo 6&7). The North Pilot Channel and the levee will both impact this area. At the time of the inspection the sugar cane was being harvested (Photo 8). Some wetland vegetation exists along the river banks in a fringe about 2 meters wide. In the northern portion of the site the levee and drainage channel will cross the river. A culvert is proposed for this site to provide drainage into the Rio Grande de Manati. This area has some small banana plantations. The river banks on the town side have been severely eroded and have been armored with gabions (Photo 9).

Site 3) Plazuela sugar mill: This mill is no longer in use and the buildings house the Municipal Public Works Department. The surrounding fields were once in sugarcane production but are now in an abandoned state (Photo 10). All of the old irrigation and drainage ditches are either filled or clogged with vegetation (Photo 11). Some fields now flood frequently enough to support wetland vegetation. These fields are mostly Coloso soils which are known to have a hydric component (Photo 12). The levee will

run just north of the mill and then curve south to join Road 682. An existing drainage will cross the levee via a culvert. As the levee heads south it again crosses through abandoned fields (Photo 13) that have small pockets of wetlands.

Site 4) South Pilot Channel: In this area the town and Road 140 are situated on a karst rise. The river flows directly beneath at the foot of the karst (Photo 14). The new pilot channel will move the river southeast, away from the road and town of Barceloneta. The levee will start at this point and will parallel the pilot channel before veering north to parallel the town. The flood control measures will impact active sugarcane fields and abandoned fields (Photo 15). The new PR highway 22 is just 2 miles south of the proposed channel and levee. Road construction was underway during the time of the inspection.

Site 5) Disposal and Borrow sites: Several sites have been chosen for borrow material and disposal. Because of the construction of PR-22 several of the designated sites are already being used. The karst hill located east of town has an active quarry (Photo 16). This quarry is providing material for highway construction. The second borrow site is located in karst formations between Roads 682 and 140, this site has numerous residences located nearby. The designated disposal site is located east of the Imbery community and is just several hundred meters south of the ongoing highway construction. Its comprised of an empty field (Photo 17), currently being used for cattle grazing. There are

some isolated karst hills towards the east of the site. Communications with PR Highway officials indicate that there are some plans for the site, although definitive plans were not available.

Fish and Wildlife Resources:

The pilot channels, levee, and drainage channel will all be traversing either sugarcane fields, or abandoned fields reverting to a more natural state. There are some small herbaceous wetland areas that will be eliminated by the project as well as riverine wetlands. Although these wetlands currently have relatively low habitat value they do provide foraging for snowy egrets (Egretta thula), little blue herons (Egretta caerulea), green-backed herons (Butorides striatus), and other wading birds.

The borrow and disposal sites are located in karst hills. Karsts are known for their high levels of endemic flora. They are also the primary habitat of the Puerto Rico boa (Epicrates inornatus). At the time of the site inspection dead boa specimen was found along Road 140. It was apparently killed by a vehicle while trying to cross. Highway construction has already impacted several of the karst hills in the area. Once the exact sites are determined for borrow and disposal, a detailed survey of those sites should be carried out for endangered plant species and PR boas.

Recommendations:

The Corps should consider maintaining and managing the proposed ponding areas for mitigation. These ponding areas do not appear in the plans provided to the Service dated January 23, 1992. However the ponding areas appeared in previous plans. By providing enough depth to maintain some standing water these area could become excellent herbaceous wetlands. The use of weirs just before the culverts could allow water retention during normal flows. Overflow into the culverts could be easily controlled. This would mitigate for the wetlands lost due to construction and by the town's expansion once flood protection is provided.

The Corps will have to negotiate with the Puerto Rico Conservation Trust and Commonwealth Government concerning impacts to the Esperanza Natural Reserve. Some form of access will have to be provided for the fields islolated by the levee and north pilot channel.

References

1) Gómez, Fernando, 1984, Water Resources of the Lower Rio Grande de Manatí Valley, Puerto Rico. US Geological Survey Water Resources Report 83-4199

2) Puerto Rico Department of Natural Resources, 1979. Suplemento Técnico para la Designación de la Reserva Natural Hacienda La Esperanza, Manatí, Puerto Rico

3) Puerto Rico Department of Natural Resources, Coastal Zone Management Program, 1986. Documento de Designacion, Reserva Natural Hacienda La Esperanza

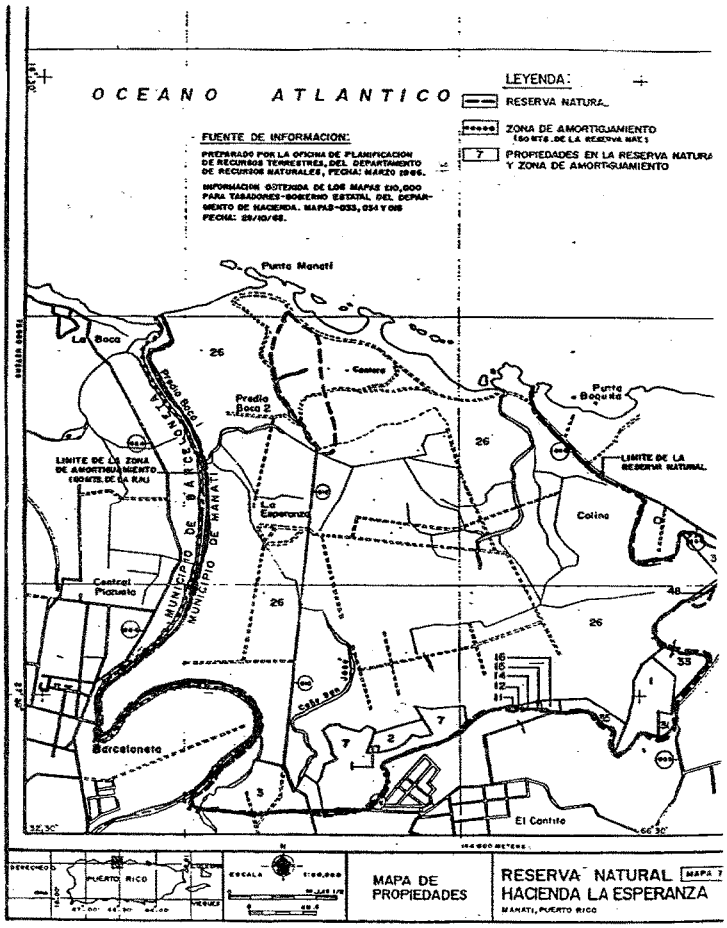
OCEANO ATLANTICO
LEYENDA:
RESERVA NATURAL
ZONA DE AMORTIGUAMIENTO
PROPIEDADES EN LA RESERVA NATURAL Y ZONA DE AMORTIGUAMIENTO
FUENTE DE INFORMACION:
Punta Manati
La Boca
Predio Boca 2
Punta Boquilla
LIMITE DE LA ZONA DE AMORTIGUAMIENTO
LIMITE DE LA RESERVA NATURAL
La Esperanza
Colina
Central Pozuelo
MUNICIPIO DE BARCELONETA
MUNICIPIO DE MANATI
Barceloneta
El Contio
MAPA DE PROPIEDADES
RESERVA NATURAL
HACIENDA LA ESPERANZA
MANATI, PUERTO RICO

Figure #1

Photo 1) Levee route looking south to PR highway 2. Town is to the left of the photo, vegetation is mostly guinea grass.

Photo 2) Levee route looking north. Town is to the left. Vegetation is guinea grass, tan-tan and vines. A small patch of elephant grass is visible by the whitish inflorecense in the center of the photo

Photo 3) Levee route looking south, area is being used by cattle.

Photo 4) Site where levee will cross the Rio Grande de Manati. Notice wetland vegetation on either bank. The river here turns sharply and parallels the town. This bend will be eliminated by the North Pilot Channel.

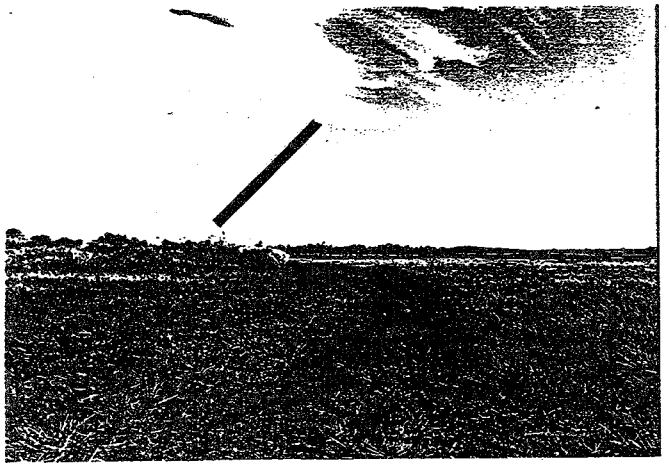

Photo 4) Small patch of wetlands found in swale. Wetland vegetation is visible to the left of the photo.

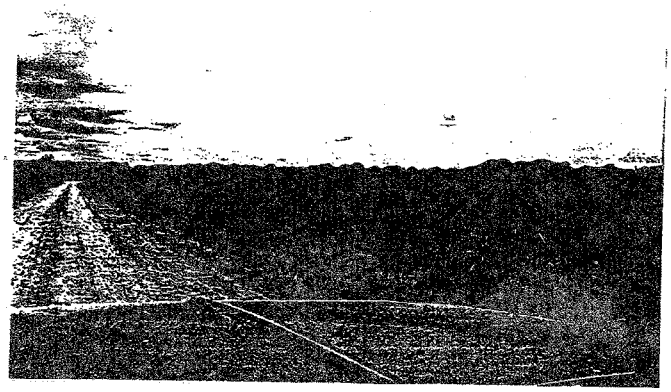

Photo 6) Active sugarcane field in "Predio Barceloneta y Vega". This area is part of the Hacienda Esperanza Natural Reserve.

Photo 7) North Pilot Channel route through cane fields in "Predio Barceloneta y Vega.

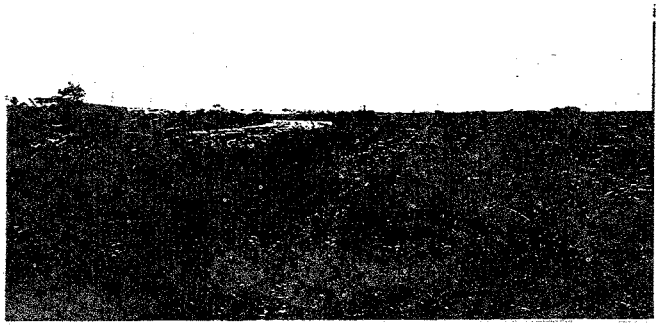

Photo 8) Sugarcane field that has just been harvested. Cane fields run up to the river bank leaving just a narrow fringe of riverine vegetation.

Photo 9) Gabion reinforcement of river bank along Road 684 north of the town of Barceloneta.

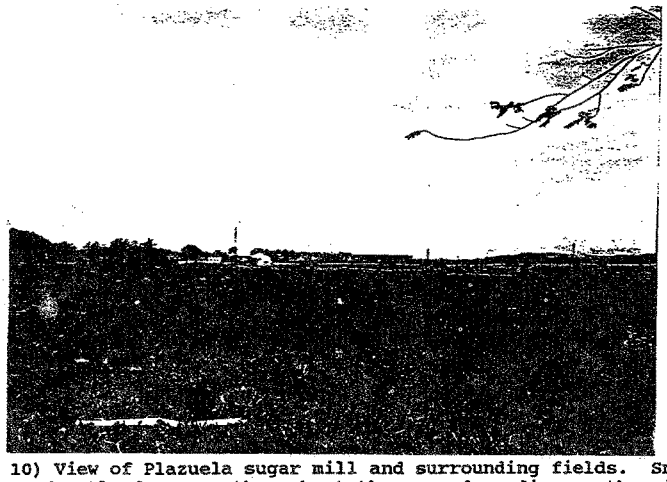

Photo 10) View of Plazuela sugar mill and surrounding fields. Small patches of wetlands occur throughout the area depending on the micro topography.

Photo 11) Remains of drainage ditch. Cattails and sedges now dominate the site. Water overflows the ditch and the hydrophitic vegetation is expanding.

Photo 12) View of levee route north of the Plazuela sugar mill. The has been completely abandoned although there are some cattle on the property.

Photo 13) Southern levee route close to Road 682. A small wetland area can be seen in the center of the photo. Wetland vegetation is greener than surrounding vegetation.

Photo 14) Levee route looking towards Road 682. Fields are abandoned, cattails are growing in old drainage, African tulip tree is the dominant tree species.

Photo 15) View of area to be impacted by South Pilot channel. Foreground is pasture, background active sugarcane fields.

Photo 16) View of the levee route just before it joins Road 682. The proposed Borrow site #1 can be seen in the background .

Photo 17) View of the proposed disposal site.

ATTACHMENT B

PRELIMINARY SECTION 404(b)(1) EVALUATION
CLEAN WATER ACT

SECTION 205 FLOOD PROTECTION STUDY
RIO GRANDE DE MANATI AT BARCELONETA, PUERTO RICO

I. Project Description

a. Location: Northcentral coastal area of Puerto Rico, Municipality of Barceloneta.

b. General Description: The principal features include a levee around the town of Barceloneta, two pilot channels in the Rio Grande de Manati, a drainage canal with an average 1.5-meter-deep flow on the protected side of the levee, and two flap-gate culverts. Other features include gabion or riprap protection for the levee adjacent to the south pilot channel, riprap in the pilot channels, four road ramps, and relocation of six families. Fill material will be excavated from project channels, and excess will be deposited along the outside of the west levee. Some levee material will be taken from a commercial quarry west of the project site.

c. Authority and Purpose: A study of the feasibility of flood protection measures within the Federal interest was made under authority of Section 205 of the Flood Control Act of 1948 as amended.

d. General Description of Fill Material:

(1) General Characteristics of Material: Alluvial clay and sandy clay.

(2) Quantity of Material: 917,000 cubic yards.

(3) Source of Material: Channels excavated for the project and a commercial quarry..

e. Description of proposed discharge sites

(1) Location: Drainageway at north culvert and an area of periodic groundwater seepage at the east culvert and road ramps (Plate 5). River channel at upstream end of project and in the river channel adjacent to the town of Barceloneta.

(2) Size, (3) Type of Sites, and (4) Types of Habitat: 6.7 acres of drainageway (palustrine) wet areas unconfined in cultivated or grazed land; 4,170 meters of linear riparian wetlands confined to steep river banks.

(5) Timing and Duration of Discharge: Timing will be at the mutual convenience of the project sponsor and the U.S. Army Corps of Engineers, and duration of construction will be about one year.

f. Description of Disposal Methods: Disposal will be by conventional earth-moving equipment such as dump trucks, pans, bulldozers, drag-line.

II. Factual Determinations:

a. Physical Substrate Determinations:

(1) Substrate Elevation and Slope:

Palustrine sites: At the north culvert site 1.3 acres of intermittently flooded wetlands in an improved natural drainageway will be covered by the levee, interior drainage canal and right-of-way. The levee would be built to an average height of about 4.7 meters (15 feet) and the channel would have an average depth of flow of about 1.5 meters (5 feet) and about 9 meters (30 feet) top-width. The levee and channel side slopes will be 1 on 3. The culvert through the levee will permit continued drainage as at present.

At the east culvert site 5.4 acres of palustrine wetlands in a groundwater seepage area adjacent to the river will be covered by levee, road ramps and internal drainage canal. Levee and channel dimensions will be similar to those described for the north culvert site.

Riparian sites: Riparian sites to be filled are the near-vertical banks of the Rio Manati. Because the steep channel sides offer only a very narrow expanse, this habitat is reported in lineal units. Adjacent to the town of Barceloneta the river channel will be filled to one meter elevation, leaving a shallow drainage-way for conveyance of rainwater from the site through the east culvert to the river. Fill material to be placed in river channels will be of alluvial clay and sandy clay sub-soil excavated for construction of the project channels. The drainageway would be top-dressed with topsoil. As a result about 2,000 meters (1.2 miles) of riparian habitat clinging to the two steep channel sides will be covered. The drainage-way will function similarly to the way the drainageways in the area now function, supporting temporarily flooded palustrine wetlands, replacing the riparian wetlands for no net wetland loss. The remainder of the by-passed river (1448 m; 0.9 mile) will be left as a slough-like backwater connected to the flowing river.

Construction of the levee, drainage canal and right-of-way at the upstream (south) end of the project will require filling the river reach there, covering 785 meters of steep riparian habitat on each bank. A pilot channel will be constructed to replace the river reach at that location, but the banks of the 1 on 3 side slopes will be riprapped. The result will be a net loss of 1,570 meters of lineal riparian habitat at the upstream site.

A similar pilot channel will be constructed in the downstream extremity of the project with a net loss of 600 meters of lineal riparian habitat at the points where the newly created channel connects with the river. The pilot channel's 1 on 3-sloped banks will be riprapped.

The net tally of these activities is:

(i) 6.7 acres of palustrine habitat will be covered by levee and channel, and 21.7 acres of palustrine wetlands will be created by excavation of the interior drainage canal;

(ii) 2.4 km (1.5 mile) of river will be by-passed and replaced with a 785-m (0.5 mile) downstream pilot channel; 1,000 m (0.6 mile) of by-passed river will be filled and replaced with a 10.1-acre, 1-m-elevation drainage-way; 860 m (0.5 mile) of former river will be left as a slough-like backwater connected to the flowing river; 785 m of river channel will be replaced with an upstream pilot channel;

(iii) linear riparian habitat that will be filled and not replaced totals 4,170 meters (2.6 miles).

This tally represents replacement of 6.7 acres of palustrine wetlands with 11.6 acres of drainage canal and 10.1 acres of drainageway on the filled river segment, representing 15 acres net gain in palustrine wetlands. A total of 4,170 m (about two acres) of linear riparian habitat will not be replaced because of the net gain in wetlands the project would produce.

(2) Sediment Type:

Palustrine Sites and Riparian Sites: Levee construction material and fill material to be placed in river channels will be of alluvial clay and sandy clay sub-soil excavated for project channel construction. The levee and right-of-way would be top-dressed with topsoil.

(3) Fill Material Movement:

Palustrine and Riparian Sites: Erosion control measures will be employed as needed to control erosion of the levee sides; these may include grass seeding and mulching. If other temporary soil-holding devices or measures are necessary, they will be used. Siltation and sedimentation from the levee will thus be minimized and insignificant.

(4) Physical Effects on Benthos:

Palustrine Sites: Benthos in these sites would be those that develop quickly in temporarily flooded sites, such as mosquito and fly larvae. These may be expected to occur presently in existing sites in the area, and the net gain of 15 acres of intermittently flooded wetlands would have no significant effect upon such populations.

Riparian Sites: Near the surface in the river bank vegetation aquatic insect larvae (Odonata, Diptera, Coleoptera), snails, leeches and oligochaete worms may be found. Benthos in the soft, muddy silt of the bottom of the slowly flowing river would be those tolerant of near-anaerobic conditions and salt-water. The benthos, which we have not sampled, will be buried by the fill.

(5) Other Effects: None.

(6) Actions Taken to Minimize Impacts:

Erosion control of newly placed fill will confine adverse impacts to the fill area, insofar as possible.

b. Water Circulation, Fluctuation and Salinity Determinations:

(1) Water:

(a) Salinity: The Rio Grande de Manati is estuarine within the study area. A salt-water wedge has been detected in the river upstream as far as about 0.2 mile north of the upstream limit of the project (Gomez-Gomez, 1984). The position of the upstream extremity of the salt wedge is correlated with the river's flow rate and elevation relative to sea level. "The maximum possible inland extent of the wedge, if all flow was diverted at Highway 2, would be limited to the upstream distance at which the river bed lies below sea level. This point was defined as river mile 6.8 above the mouth" (Gomez-Gomez, 1984). Implementation of the recommended plan will not reduce normal flow rate nor alter the river's elevation, and the new downstream pilot channel would cause a small increase in normal river flow rate. The salt wedge could not move farther upstream during low flows, and during normal flow rates the wedge may not extend as far upstream. No net change in the salinity gradients in the river will occur as a result of the recommended plan.

(b) Water Chemistry: The recommended plan will not affect water chemistry except for the salinity effects discussed above.

(2) Current Patterns and Circulation:

(a) Current patterns and flow: The Rio Manati at Barceloneta flows slowly in a meandering channel, is tidally influenced, and contains a salt-water wedge moving tidally along the bottom. Under the recommended plan the river channel would be displaced southward at the upstream end of the project; the flow pattern would be unchanged. Downstream, a 1.9 km (1.2 mile) segment would be by-passed and a new, 760-m (0.5-mile) pilot channel would be constructed. A 1,000-m (0.6-mile) segment of the by-passed river would be filled to 1 meter elevation, resulting in a 10-acre drainageway (palustrine habitat). Storm water that now enters the segment to be filled will drain into the river near the downstream end of the downstream pilot channel. The remaining 860 meters (0.5 mile) of the by-passed river segment will be left as a slough-like backwater connected to the flowing river; this slough-like channel may eventually fill with sediment. The effects on the salt water wedge of shortening the river by one mile are discussed above (II b(1)(a) Salinity).

(b) Velocity: Little effect; some increase through the new, downstream pilot channel.

(c) Stratification: No effect

(d) Hydrologic Regime: River flood waters would be excluded from the levee-protected area, and flood waters outside of the levee would be higher by

0.7 m to 1.2 m. This condition would affect cultivated (pineapple and sugarcane) and grazed lands in the flood plain. Other man-made features, e.g, the towns of Garrochales, Imbrey and El Cantito, and the Hacienda La Esperanza site are located on high ground that would not be affected by the higher river flood waters.

(3) Normal Water Level Fluctuations:

Normal (other than flood) water fluctuations would not be affected by the recommended plan.

(4) Salinity Gradients:

Effects on salinity gradients are discussed above (II b(1)(a) Salinity).

(5) Actions That Will Be Taken to Minimize Impacts:

The pilot channels will be stabilized before the river flow is diverted into them. Fill at the point of diversion will be armored.

c. Suspended Particulate/Turbidity Determinations:

(1) Expected Changes in Suspended Particulates and Turbidity Levels in Vicinity of Disposal Site: At points where the river channel will be filled to divert the river, the new pilot channel will first be dug and graded to the desired dimensions. The new river bed will be stabilized before the final cut is made and the river flow diverted through the new channel. The pilot channel will be armored with riprap and bedding stone. Since summer flows in the project area during March to October are 70-80 cfs (95% probability), ranging up to 180 cfs in October-January (Gomez-Gomez, 1984), little solid material will be picked up and carried in suspension. Under existing, without-project conditions, suspended sediment concentrations reported at flows of less than 100 cfs range from 30 to 200 pounds per acre-foot (ibid.) (11 to 74 parts per million). Flow around 200 cfs carries 200-250 pounds per acre-foot (74-93 ppm), with extreme measurements reported from 30-500 pounds (11-185 ppm) (ibid.). The annual mean suspended-sediment discharge at Highway 2 is estimated at approximately 100,000 tons per year. No project-induced changes are anticipated.

(2) Effects (degree and duration) on Chemical and Physical Properties of the Water Column: The fill material will be taken from nearby surface quarries and will be of the same parent material as the substrate in the fill areas. It will contain essentially no organic material nor minerals in a chemically reduced state that would exert a biochemical oxygen demand on the water. No toxic metals nor organics, pathogens nor viruses would be present in such forms as to become biologically available to organisms in the water or substrate.

(a) Light Penetration: The measures discussed in the preceding paragraphs are considered effective in preventing turbidity plumes of such severity as to cause adverse impacts in the dark, slowly flowing water.

(b) Dissolved Oxygen: No effects.

(c) Toxic Metals and Organics: None will be present in fill material, nor have any been detected in river water.

(d) Pathogens: None in fill material.

(e) Aesthetics: At the south end of the project, where the river would be channelized and separated from the town by a grassy, 5-meters-high levee with 1 on 3 side slopes, the view of the river from street level would be obstructed.

(3) Effects on Biota:

(a) Primary Production, Photosynthesis: Net effects due to the planned work will consist of temporary reduction in wetland production while newly created areas of riparian and palustrine wetlands develop, and permanent removal of 21 acres of sugarcane farmlands from production by covering with the project works and road ramps. Long-term effects on wetlands functions would be negligible, since there will be no net loss of wetlands.

(b) Suspension/Filter Feeders: None are known in the river.

(c) Sight feeders: No effect on such sight-feeders as may be present during periods of adequate dissolved oxygen concentration.

(4) Actions Taken to Minimize Impacts:

Impacts on wetlands were minimized by aligning the levee in the least damaging configuration. Construction will be planned in the least damaging sequence, e.g., constructing pilot channels and stabilizing them before diverting flow into them.

d. Contaminant Determinations:

(1)-(4) Fill material will introduce no contaminants; material will be taken from the clean, project area, not in areas of dumping. The sites are sufficiently removed from sources of pollution to provide assurance that the proposed discharge material is not a carrier of contaminants. The discharge material will be of the same parent material as the receiving sites, and there is no likelihood of the presence of minerals or other harmful substances that could be released into the aquatic environment. These factors ensure that there will be no adverse effects on plankton, benthos, nekton, or other components of the aquatic food web.

(5) Effects on Special Aquatic Sites:

There are no designated sites within the area of influence of the study area, other than the palustrine and riparian wetlands discussed above. The Hacienda Esperanza Natural Reserve is non-aquatic.

(6) Threatened or Endangered Species:

The Corps of Engineers in consultation with the U.S. Fish and Wildlife Service has determined that species listed under the Endangered Species Act that may be affected by implementation of the studied project would likely be confined to disposal and borrow areas considered during preliminary planning, but the disposal area will not be used in the recommended plan. The borrow area is a commercial quarry west of the proposed project. Coordination with the U.S. Fish and Wildlife Service under the Endangered Species Act is being conducted concurrently with public coordination of this report.

(7) Other Wildlife:

Wildlife associated with the temporarily flooded systems inside the protected area--birds and amphibians--will suffer temporary disruption of intermittent habitat value during construction. The interior drainage canal will provide a net gain in such habitat.

(8) Actions to Minimize Impacts:

Construction activities will be controlled to avoid unnecessary and unplanned damages to plant life and wetlands by vehicle operations, cutting, erosion and fuel and oil spills. The disposal and borrow areas will be surveyed to ensure that endangered or threatened plants or animals will not be adversely affected.

f. Proposed Disposal Site Determinations:

(1) Mixing Zone Determination:

Palustrine Sites: Palustrine sites that will be covered by fill for levee construction and be replaced by the interior drainage canal are now temporarily flooded to a few inches during periods of rainfall and up to one meter (3.3 ft) during river flooding. There will be no mixing zone impact. Net discharges of rain waters will be unchanged.

Riverine and Riparian Sites: Sites of river channel fill will be cut off from river flow, so there will be no mixing of fines from fill with river waters.

(2) Determination of Compliance with Applicable Water Quality Standards:

Water quality will not be adversely impacted, and Commonwealth water quality standards will be met. Contaminants will not be introduced by fill material that may become suspended or dissolved in river water. As flow is introduced into the pilot channels some sediment from the removed plug may be expected to be carried in suspension for a short time. No biological resources sensitive to suspended and settling sediment are present. River bottom sediments will not be dredged; at points of river diversion the existing channel will be filled and the bottom sediments covered.

(3) Potential Effects on Human Use Characteristics:

(a) Municipal and Private Water Supply: Such water supplies are drawn from wells drilled into the alluvium and limestones down to a depth of 200 feet below sea level in areas south of Highway 2 (Gomez-Gomez, 1984). Additionally, industrial wells have been drilled into a freshwater artesian aquifer at a depth of approximately 1,100 to 1,700 feet below land surface in the valley (ibid.). The planned works will not affect recharge of these aquifers nor their waters.

(b) Recreational and Commercial Fisheries: There are no such fisheries of significance in the study area, but in the estuary at the mouth of the river, such fisheries are practiced. The planned work will not impact the estuarine area.

(c) Water Related Recreation: No such resource is utilized in the study area. The river is slowly flowing and turbid, and boat launching is done only in the estuary.

(d) Aesthetics: At the south end of the project, where the river would be channelized and separated from the town by a grassy, 5-meters-high levee with 1 on 3 side slopes, the view of the river from street level would be obstructed.

(e) Parks, National and Historical Monuments, National Seashores, Wilderness Areas, Research Sites, and Similar Preserves: The downstream pilot channel will take 21 acres of the Hacienda La Esperanza Natural Preserve now in sugarcane cultivation. Access by ramp to the 62 acres that the levee would cut off will be provided.

g. Determination of Cumulative Effects on the Aquatic Ecosys m:

No additional effects beyond the direct effects of project construction and functioning will occur to the Rio Manati aquatic ecosystem, nor to palustrine wetlands in the area. All effects are described in the foregoing parts of this evaluation.

h. Determination of Secondary Effects on the Aquatic Ecosystem:

Implementation of the recommended plan will not reduce normal flow rate nor alter the river's elevation, and the new downstream pilot channel would cause a small increase in normal river flow rate. The salt wedge could not move farther upstream during low flows, and during normal flow rates the wedge may not extend as far upstream. No net change in the salinity gradients in the river will occur as a result of the recommended plan. Flooding outside the levee may be deeper by a few centimeters, but developments are located on elevated land features and would not be affected.

III. Findings of Compliance With the Restrictions on Discharge:

1. No significant adaptations of the guidelines were made relative to this evaluation.

2. Availability of alternatives which would have less adverse impact on the aquatic ecosystem (alternatives considered that are available and practical and why the selected alternative would have least significant impacts) have been considered and documented in the main report and the environmental impact statement.

3. The planned use of clean fill to fill a section of the river and to construct the levee in the upstream river reach of the study area would not violate any applicable water quality standards. Filling the palustrine sites for levee construction would violate no applicable water quality standards.

4. Filling the disposal site, riverine reaches and palustrine sites, and quarrying fill from the commercial quarries for project construction, while employing aforementioned precautions, will not harm any species listed under the Endangered Species Act nor their critical habitat, nor violate any protective measures developed by the Commonwealth of Puerto Rico.

5. The proposed disposal of dredged material will not result in significant adverse effects on human health and welfare, including municipal and private water supplies, recreation and commercial fishing, plankton, fish, shellfish, wildlife, and special aquatic sites. Life stages of aquatic life and other wildlife will not be adversely affected. Significant adverse effects on aquatic ecosystem diversity, productivity and stability, and on recreational, aesthetic and economic values will not occur.

6. Appropriate steps to minimize potential adverse impacts of the discharge on aquatic systems include construction and stabilization of pilot channels before the river is re-routed and protection of fill against excessive erosion that could cause deposition of fill on wetland substrates.

7. On the basis of the guidelines and with the inclusion of appropriate practical conditions to minimize pollution or adverse effects to the aquatic ecosystem, discharge of fill on the proposed sites is specified as in compliance.

ATTACHMENT C

CERTIFICATION OF COMPLIANCE WITH THE
PUERTO RICO COASTAL MANAGEMENT PROGRAM

Name of Federal Agency: U.S. Army Corps of Engineers
Jacksonville District

Federal Program Catalog Number: N/A

Type of Action: Civil Works, Construction (Flood Control)

Name of Applicant: U.S. Army Corps of Engineers, Jacksonville District

Address: P.O. Box 4970, Jacksonville, Fl. 32232-0019

Physical Description of Project Location: (Please refer to the attached Feasibility Report and Environmental Impact Statement): Rio Grande de Manati flood plain at Barceloneta, Municipality of Barceloneta, Puerto Rico.

Type of construction proposed: Construction of an earthen ring-levee around the town of Barceloneta, road ramps, an interior drainage canal and two pilot channels, placement of two drainage culverts and filling of river channel segments replaced with pilot channels, for the purpose of flood protection to urban development.

Natural, artificial, historic or cultural systems likely to be affected by the project: Effects are described in Section 4.00 of the Environmental Impact Statement. A portion of the Rio Grande de Manati adjacent to the town of Barceloneta would be cut off, partly filled and replaced with a pilot channel. Another river segment at the upstream extremity of the project would be filled and replaced with a pilot channel. Temporarily flooded drainageway wetlands would be filled and replaced with an interior drainage canal for a net gain in total wetland area. Sugarcane farmland would be cut off and taken out of production. One historical site eligible for listing in the National Register of Historic Places will be affected by the project and will be documented for mitigation.

Other permits, approvals and endorsements from Federal and Puerto Rican Government Agencies required: Refer to the EIS, Compliance with Environmental Requirements.

1. Water Quality Certificate (EQB): Yes, to be applied for.
2. Regulation and Permits Administration: No
3. Department of Natural Resources: Yes. Review and approval of the EIS.
7. State Historic Preservation Office: Yes. Approval.
8. U.S. Army Corps of Engineers: Not applicable.
9. U.S. Coast Guard: No
10. Endangered Species Concurrence, Determination of No Impact: National Marine Fisheries Service: No.
Fish and Wildlife Service: Biological opinion of no effect received.

CERTIFICATE: The U.S. Army Corps of Engineers certifies that the Rio Grande de Manati at Barceloneta Flood Control Project is consistent with the Puerto Rico Coastal Zone Management Program to the maximum extent practical.

RIO GRANDE DE MANATI DETAILED PROJECT REPORT
SECTION 205 FLOOD PROTECTION STUDY

FINDING OF NO SIGNIFICANT IMPACT

I have reviewed the plans and the Environmental Assessment of the considered action. Based on information analyzed in the Environmental Assessment, reflecting data obtained from site examination and from cooperating Federal and State agencies having jurisdiction by law and/or special expertise, and from the interested public, I conclude that the considered action will have no significant impact on the quality of the human environment.

Reasons for this conclusion are, in summary:

a. Impacts to wetlands have been minimized by appropriate levee alignment, and remaining impacts have been mitigated in full by project features. No important fish and wildlife habitat will be adversely affected.

b. Impacts to known archaeological and other cultural resources have been avoided, except for one, which will be documented for mitigation, and unknown resources that may potentially be present will be protected through monitoring during project construction.

c. No hazardous nor toxic materials are in the study area, and water quality will not be impacted.

d, There will be no adverse impacts to endangered or threatened species because of precautions to be taken in use of a commercial quarry for borrow material.

In consideration of the information summarized, I find that the considered action does not require an Environmental Impact Statement.

March 24, 1994
date

TERRENCE C. SALT
Colonel, Corps of Engineers
Commanding

RIO GRANDE DE MANATI AT BARCELONETA, P.R.
DETAILED PROJECT REPORT

APPENDIX A
HYDROLOGY AND HYDRAULICS

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I. INTRODUCTION:

This appendix presents the basic hydrologic data and analyses used to define the hydraulics of the Lower Rio Grande de Manati in the vicinity of the town of Barceloneta under existing and with-project conditions. Shown on Figure A-1 is the river basin located in north-central Puerto Rico. The study reach extends from the coast upstream to Puerto Rico Highway-2 (PR-2), a distance of 6.35 kilometers. The detailed study area is shown on Figure A-2.

II. DRAINAGE BASIN INFORMATION:

A. Watershed Description.

Rio Grande de Manati drains a basin on the northern slopes of the Cordillera Central (the central mountain range of Puerto Rico). The river flows northwest from its origin. Most of Rio Manati is a steep mountain stream, except near the coast where the river flows across a flat-wide flood plain. The Rio Grande de Manati is 90 kilometers long and drains an area of approximately 447 square kilometers. There are two small water supply reservoirs at the upper part of the watershed: Guineo Reservoir, on the upper Rio Toro Negro, and Matrullas Reservoir, on the Rio Matrullas, which impound runoff from about 15.5 square kilometers. Part of the runoff of this area is diverted to the southern coast. However, since this area is less than 4 percent of the drainage area at PR-2, the effect of the reservoirs on floods in the study area is not significant. The communities of Ciales, Manati, and Barceloneta are the main population centers along Rio Manati's course.

B. Topography.

The Rio Grande de Manati drainage area is predominately mountainous with elevations ranging up to 1,200 meters above sea level. Near the ocean the Rio Grande de Manati basin widens to a relatively flat coastal flood plain. The coastal alluvial flood plain at the lower end of the basin extends for about 25 kilometers and averages approximately 2 kilometers in width. Invert elevations for the Rio Grande de Manati range from 800 meters upstream to -3 meters at the coast.

C. Tributaries.

The principal tributaries to the Rio Grande De Manati are: Rio Orocovis (71 square kilometers), Rio Toro Negro (90 square kilometers), Rio Cialitos (50 square kilometers), Rio

Bauta (75 square kilometers). All major tributaries join Rio Manati upstream of the study area.

D. Soils.

A report titled "Soil Survey of Manati Area Northern Puerto Rico" published by the U.S. Soil Conservation Service (SCS), illustrates on aerial photographic maps the various soil associations within the Rio Manati Basin. The soils on the coastal plain are deposits of sandy, clayey, and loamy materials. These soils are associated into numerous combinations. However, the soils of the coastal plain are typically deep, gently sloping to level, and well drained. The soils on the uplands are loamy and clayey with rock outcroppings. As with the coastal soils, the SCS combines these soils into many groups. In general the upland soils are moderately deep, very steep, and well drained. The soils in the Rio Grande de Manati basin were hydrologically classified between "C" and "D" which represents higher than average runoff.

E. Available Hydrologic Data.

The U.S. Geological Survey (USGS), in cooperation with local and other Federal agencies obtain a large amount of water resources data in the Commonwealth of Puerto Rico. The USGS currently operates five stream flow and water quality stations in the Rio Grande de Manati basin. The gage identification numbers and the period of flow records are as follows:

1. 500038100 Rio Grande de Manati at Highway 2 near Manati, Puerto Rico (1959-1988 & historical flows for 1899, 1922, and 1932; missing years 1964 & 1967).

2. 500035000 Rio Grande de Manati at Highway 145 at Ciales, Puerto Rico (1960-1988 & historical flows for 1899, 1922, and 1932)

3. 50031200 Rio Grande de Manati near Morovis, Puerto Rico (1965-1988).

4. 500032590 Lago De Matrullas at Dam site, Puerto Rico (1988).

5. 50032290 Lago el Guineo at Dam site, Puerto Rico (1988).

F. Flood History.

The flood of August 8, 1899 is the greatest known flood on the Rio Grande de Manati. On this date rain from Hurricane San Ciriaco caused widespread damage throughout the Rio Grande de Manati basin. The second highest flood of record occurred on September 13, 1928 when Hurricane San Felipe tracked over Puerto Rico. Most recently two floods in 1985 have caused extensive property damages. Table A-1 provides annual peak discharge records for Rio Grande de Manati measured at the USGS gages 50035000 at Ciales, Puerto Rico and 50038100 at PR-2.

G. Flood Frequency.

Hydrologic data, such as the annual peak discharges shown in Table A-1, when treated as random variables can statistically estimate flood frequencies of the Rio Grande de Manati. Analysis of the peak flow data for the continuous period, as listed in Table A-1, provides better estimates with higher confidence when combined with the historic data for the years 1899, 1928, and 1932. A log-Pearson Type III frequency analysis was performed in accordance with the guidelines of the Water Resources Council in Bulletin No. 17B, "Guidelines for Determining Flood Flow Frequency", U.S. Department of Interior, 1982. The resulting flood frequency curves and confidence limits are shown on Figures 3 and 4.

H. Rainfall.

The National Weather Service (NWS) operates several rainfall gauges in the Rio Grande de Manati basin as well as the many others in Puerto Rico. TECHNICAL PAPER NO. 42 (TP-42) by the NWS uses the rainfall at various gauges producing generalized estimates of probable maximum precipitation and rainfall-frequency data for Puerto Rico and the U.S. Virgin Islands. Contained in the report are isopluvial maps of precipitation contours for selected frequencies. The maps show rainfall increases moving toward the central mountainous region of Puerto Rico. In this study Rio Grande de Manati basin was subdivided into 10 subareas. Point rainfalls for several frequencies and durations were obtained for the entire basin using TP-42. Necessary adjustments for aerial distribution, partial duration series and expected probability were made. Table A-2 presents the point rainfall data used in the study.

I. Standard Project Storm and Probable Maximum Precipitation

The Standard Project Storm (SPS) is defined as the most severe flood-producing rainfall depth-area-duration relationship and ishohyetal pattern of any storm that is considered reasonably characteristic of the region. For the Rio Grande de Manati basin the SPS was assumed to be 50 percent of the probable maximum precipitation shown in the TP-42. The Probable maximum precipitation is defined as the greatest depth of precipitation for a given duration that is physically possible over a given size storm area at a particular geographical location at a certain time of the year.

III. HYDROLOGY:

A. HEC-1.

The U.S. Army Corps of Engineers HEC-1 computer program was used to calculate the runoff volumes and peak discharges for this study. HEC-1 estimates surface runoff resulting from synthetic or natural rainstorm events. Two important choices are methods for losses and routing. Rainfall runoff for the Rio Grande de Manati Basin was computed using the SCS curve number methodology. The SCS method calculates losses from curve numbers which are related to soil type, land use, and antecedent moisture conditions. Flood hydrographs were routed in the model by the modified Plus method for reservoirs and the kinematic wave method for channel reaches.

B. Formation of HEC-1 Model.

The following procedures were used to produce the results of the HEC-1 model:

1. Drainage Area.

Drainage boundaries were delineated in the USGS quadrangle topographic maps, with a scale of 1 to 50,000, to determine the drainage area of the Rio Grande de Manati. The watershed was divided into sub-basins according to basin area characteristics. Some of the foothill areas above the town of Manati are of karstic rock outcroppings. The Karstic areas contribute very little to the peak flows of the Rio Grande de Manati floods and were ignored from the hydrologic computations.

2. Curve Numbers.

The SCS curve numbers were calculated for each subarea considering the soil types, soil covers, land uses, and Antecedent Moisture Conditions (AMC). Dry conditions (AMC I) were used for frequencies up to 10 percent chance flood. Average moisture conditions (AMC II) were considered for frequencies up to a 2 percent chance flood and wet conditions (AMC III) for larger floods. Estimated curve numbers for various subareas and AMC conditions are listed in Table A-3.

3. Lag Time.

Lag times were computed for each sub basin by dividing each stream into several reaches. Manning's equation was used to calculate velocities and travel times for various channel cross sections. Travel times were multiplied by 0.6 to obtain SCS lags for each sub basin. Calculated lag times for various subareas are provided in Table A-3.

4. Discharges for Existing Conditions.

Using TP-42 rainfall data and calculated basin variables shown in Table A-3, peak discharges and runoff volumes for Rio Grande de Manati were estimated by HEC-1. A summary of HEC-1 peak discharges for the Rio Grande de Manati at the Ciales gage and PR Highway 2 are presented in Table A-4. Figure A-5 shows the hydrographs for various frequency floods at PR-2. In addition, HEC-1 peak discharges were plotted on the frequency-discharge curves in Figures 3 & 4 for Rio Grande de Manati at Ciales and PR-2, respectively. The peak flows computed by HEC-1 for various frequencies compare well with the frequency curves obtained from the gage data.

The hydrographs estimated by HEC-1, representing total flood volumes, were adopted to route the frequency floods through the wide floodplain in the study area.

Peak discharges used in the Federal Emergency Management Agency (FEMA) report at Ciales and PR-2 gage locations are shown in Figures A-3 and A-4 for comparison. The present study compares well with FEMA estimates at the Ciales gage. Figure A-4 indicates that FEMA estimates fell below the 95 percent confidence limit line of the frequency curve and resulted in significantly lower stages in the study area. The FEMA report, published in 1982, considered that the records available at the PR-2 gage were not adequate for a frequency analysis; however, data is now available through water year 1992 and the frequency analysis compares well with the synthetic storm analysis.

5. **Future Condition Discharges.**

According to projections of the Puerto Rico Planning Board, the population of the town of Barceloneta is projected to increase from 7,200 persons in 1985 to 8,200 persons by the year 2000. Such a small increase of development in a portion of the watershed will have negligible effects on the hydrology of the entire Rio Grande de Manati basin. The future condition discharges on Rio Grande de Manati are estimated to be the same as the existing condition discharges. Interior areas of the town of Barceloneta were adjusted for future development and increased runoff curve numbers are shown in Table A-9.

IV. HYDRAULICS:

A. Hydraulic Design Criteria.

1. **General.**

Hydraulic design criteria and procedures used herein are in accordance with standard engineering practice and applicable provisions of Corps Engineering Manuals and the Waterways Experimental Station "Hydraulic Design Criteria" relative to design and construction of Civil Works Projects. Engineering criteria adopted to meet special local condition are in accordance with that previously approved for similar projects.

The town of Barceloneta is located on the bank of a coastal flood plain immediately adjacent to Rio Grande de Manati. Although most of the Rio Manati basin is mountainous with steep slopes, the project area, at Barceloneta is in a wide coastal plain with shallow slopes. This reach of the flood plain is characterized by a relatively small meandering channel with heavy vegetation in overbank areas. Large storm events quickly exceed the dominant discharge channel and pass through a broad floodway on its way to the coast. The town starts to experience flooding when flows in the Rio Grande de Manati exceed the bank full capacity.

Proposed project design features consist of a ring levee around the town to prevent flooding from high stages in the flood plain. Interior drainage features would be added to convey discharge runoff from protected areas to the floodway.

2. **Water Surface Elevations.**

Existing and proposed conditions were analyzed using the Dynamic Wave Operational Model (DWOPER) and Hydrologic Engineering Center program entitled HEC-2. DWOPER is a dynamic wave routing model based on an implicit finite difference solution of the complex one-dimensional St. Venant equation. The program uses unsteady

state flow conditions and takes in consideration the storage in the basin. HEC-2 uses the standard-step backwater computation approach for computing water surface elevations.

a. **Existing Conditions.**

(1). Formation of DWOPER Model.

The Dynamic Wave Operational Model (DWOPER) was used to estimate flood levels for the Rio Grande de Manati study area. DWOPER is a dynamic wave routing model based on an implicit finite difference solution of the complete one-dimensional St. Venant equation. Input to the model are river cross sections, HEC-1 generated inflow hydrographs at selected junctions and basic hydraulic parameters such as Manning's roughness ("n") and contraction and expansion coefficients.

The river cross sections for the study area were obtained from aerial topographic maps prepared in 1978 to a scale of 1 to 5000. In addition, the channel cross sections surveyed in the detailed study area were incorporated in the analysis. Sixteen cross sections were used to define the flow path of the study reach.

Rio Manati has two other outlets to the ocean in addition to the main channel. HEC-2 analyses were performed on the three outlets to determine a combined stage-discharge rating curve at the junction of the three branches. Critical depths were assumed at the three ocean outlets. The combined stage-discharge rating curve was used as the downstream boundary condition for the DWOPER model. The low land area available in Cano Tiburones was treated as a tributary stream in the DWOPER model.

(2). Model Verification.

A flood atlas prepared for the October 1985 flood by USGS showed several high water marks in the study area for a peak discharge of 2,754 cubic meters per second (cms) at PR-2. The "n" values were estimated for the DWOPER model based on the simulation of the 1985 flood. The estimated "n" values ranged from 0.06 to 0.15. Figure A-6 shows the comparison between the simulated flood profile and high water marks. The model results were very similar to the high water profile.

(3). Flood Stages.

Existing condition flood stages were computed by DWOPER model using HEC-1 flood hydrographs for various frequencies ranging from 50 percent chance flood to 1 percent chance

flood event and the Standard Project Flood (SPF). Table A-5 lists the existing condition flood stages at several cross sections in the study area for various frequencies. The existing condition flood profiles for various frequencies are shown in Figure A-7.

Computer modeling of the existing flood plain showed that most of the flood flow is conveyed through the overbank areas of the flood plain. The existing channel is small and is overtopped by storm events with a frequency of 1 in 2 years. Plate A-1 shows the flooded areas for the 100 and SPF events under existing conditions with cross section locations.

b. Post Project Conditions.

(1). Flood Protection.

The proposed plan consists of a levee around the town of Barceloneta to protect against flood waters from Rio Grande de Manati. The existing conditions model was modified to simulate the floodway with a 100 year levee in place around Barceloneta. Analyses showed that water surface elevations in the flood plain area would rise about one meter above pre-project conditions. The one meter rise was considered acceptable because of the steep increase of ground elevation in the area. The levee plan provides up to and including a 1 in 100 year level of protection for the town of Barceloneta. Figures A-7 and A-8 shows the water surface profiles for existing and with project conditions for the Rio Grande de Manati.

(2). Interior Drainage Features.

The plan also includes a small drainage collection system along the protected side of the levee for the town of Barceloneta. The water surface elevations for the interior system were computed using HEC-2.

B. Canal Characteristics.

1. Side Slopes.

Side slopes of the pilot channel segments and the side slopes for the interior drainage ditches were based on the soil conditions in the area. Stable channel side slopes would be achieved by shaping channel banks at a slope of one vertical to three horizontal.

2. Cross Section.

The cross section locations and spacing for existing conditions analyses were selected to best represent the topographic

conditions of each reach being modeled. Cross sectional information was taken from topographical mapping of the area with a contour interval of one meter. A total of sixteen cross sections were used to define the flow path of the study reach. These cross sections range from the ocean to just upstream of Hwy 2. For the area within the proposed levee a total of ten cross sections were used. Plate A-2 shows the location of selected cross sections for the interior area.

3. Transitions.

Smooth transitions would be provided at all change in channel geometry.

4. Roughness Coefficients.

The existing condition roughness values were computed and calibrated using historical flooding data. This was compared to the density of vegetation in the area as could be determined from site investigations, pictures, and flow-way limits outlined on USGS quadrangle maps. The selected values ranges from 0.035 to 0.15 for the overbank areas and 0.035 to 0.055 in the channel.

5. Channel Freeboard.

The selected plan does not utilize channels to provide flood control. The pilot channel segments in the flood plain are designed to reconnect the existing channels and to minimize the impact of the project on storms which produce the dominant discharge (bank-full capacity). The interior drainage ditches would be provided as a collector ditch system with minimum conveyance. No channel freeboard was considered in design of the pilot channels in the flood plain or the interior drainage ditches.

C. Levees.

A levee would be required around the town of Barceloneta to exclude the flows up to and including the 1 in 100 year frequency from Rio Grande de Manati.

1. Alignment.

The levee alignment was chosen to avoid existing homes and businesses. The proposed levee alignment provides two large areas which will be reserved for ponding of interior runoff. The alignment also provides for limiting encroachment into the existing floodway.

2. **Side Slopes.**

Side slopes of the levee were based on existing soil conditions, type of material used in construction, and stability analysis. The side slopes on the flood side and protected side of the east side levee would be 1 vertical to 3.0 horizontal and for the west side levee it would be 1 vertical to 3.5 horizontal.

3. **Levee Crest Elevation.**

The levee crest elevations were designed by increasing manning's "n" value and using a higher discharge. This design follows the overtopping criteria in ETL 1110-2-299. An overtopping area is provided at the farthest point downstream (north) to ensure that flanking of the levee does not occur during higher than design frequencies. Plate A-2 shows the plan view of the levee with the overtopping section located 100 meters along the west side levee and 400 meters along the east side levee from culverts No. 1.

D. **Bridges.**

There will be road ramps over the proposed levee at highways 681, 682, 684 and 140. The road ramp at Hwy 681 will have a culvert for interior drainage. There will also be a road ramp and a crossover for a farm located on the east side of Barceloneta. There will be two culverts for interior drainage at the road ramp for the farm. The road ramps at all these locations are needed to maintain existing traffic patterns. A boat ramp and its access road will be relocated near culverts No. 2. Plate A-2 shows the ramps and crossover locations.

E. **Spoil Areas.**

Designated upland areas will be used for spoil disposal. The locations of spoil areas would not interfere with existing or proposed flow patterns.

F. **Sediment Potential.**

Computer modeling of the existing flood plain showed that most flood flow is conveyed through the overbank areas of the flood plain. The existing channel is small and is overtopped by storm events with a 50% chance of exceedance (1 in 2-years frequency). The fast nature of storm hydrographs and the slope of the basin combine to produce peak stages within 18 hours of commencement of runoff. Base flow is small. The existing natural dominant discharge channel is very small relative to the total conveyance required at design storm rates. Tropical vegetation and farm vegetation covers the entire floodplain and reduces sediment potential.

A comparison of pre- and post project flow conditions for the design storm showed that project levees would result in an increase in average velocities in the floodway from 1.1 meters per second (mps) to 1.2 mps. This would occur only in the immediate area of the floodway protected by the project levees at Barceloneta. Soils in the flood plain are a mixture of course sand, silt and clay with tropical vegetation as ground cover. This condition should result in minimal movement of sediments for velocities beyond 1.8 mps for the short flow durations.

Sieve analyses of samples taken at United States Geological Survey suspended sediment sampling station 50038110 showed sample particle sizes less than 0.062 mm ranged from 75 to 100 percent of the sample for the highest rates of flow recorded. This is due to the majority of flood flows passes over the flood plain instead of the existing natural channel. Under flood stage conditions sand and gravel size particles are deposited before they reach the project area.

The bulk of the sediment load is silt and clay particle sizes which would have little chance of forming large deposits which would significantly alter roughness or flow characteristics in the flood plain. Sand and gravel size particles would settle out at the upper reaches of the flood plain.

Sediment transport in the floodway is not expected to increase or decrease due to this project. The project levee would not significantly alter the current sedimentation regime within the basin.

V. HYDRAULIC DESIGNS.

A. Channels.

1. Flood Plain of Rio Grande de Manati.

The existing Rio Manati channel does not provide in-bank conveyance for discharges greater than the 1 in 2 year flow. Less frequency flood flows exceed the banks and are conveyed overland to the coast as sheet flow. The project levee alignment would fill in two short reaches of the small existing Rio Grande de Manati channel. Conveyance of low flows in Rio Grande de Manati would be maintained by constructing new channel sections around those reaches filled in by the levee. The size of the channels sections, called pilot channels, were determined by averaging the conveyance of the existing channel sections to be filled in. Backwater profiles were complied to insure that adverse hydraulic conditions, such as excessive erosion, would not occur. The left descending bank of the upstream pilot channel will have rip-rap protection. Plate A-2 shows the location of the upstream and downstream pilot channel

segments. Table A-11 shows the hydraulic design data for the pilot channels.

2. Interior Drainage System.

All interior drainage ditches and channels were designed to provide collection and conveyance of flow to the outlet culverts which would discharge to the flood plain. The interior drainage system will consist of small collector channels (ditches) to direct flows to the outlet culvert structures in the levee. Those channels would have minimal flood control value and are to provide continuous positive drainage to the outlet culverts. The channels will have a "V" shape with side slopes shaped to 1 vertical to 3 horizontal. Plate A-2 shows the alignment of the channels and Table A-12 shows the hydraulic design data.

B. Culvert Structures.

Two culvert structures, designated C-1 and C-2, will be used to as the drainage outlet for the town of Barceloneta. The interior culverts, designated C-1A and C-2B, will be used to convey flow under the new road ramps. Plate A-2 shows the location of the culverts and Table A-13 shows the hydraulic design data.

Culverts C-1 and C-2 will discharge interior drainage flows to the flood plain area. The culverts will be furnished with flap gates to prevent reverse flow when stages in the flood plain exceed interior water surface levels within the collector ditches. Culverts were design to pass design discharges with one foot of head loss. Those discharges would be passed with tailwater conditions corresponding to the stages in the flood plain expected from a 1- in 10-year storm event. Rip-rap will be placed around the culverts and the apron lengths were designed to reduce culvert barrel velocities to non erosive values.

C. Levees.

1. Levee Height Design.

The existing condition DWOPER model was modified to represent the with-project conditions. Table A-6 lists Rio Grande de Manati water levels computed with- and with-out the proposed project modifications. Figure A-8 compares the water surface profiles with- and with-out the project levee for 50%, 10%, and 1% chance flood events.

2. Overtopping Analysis.

Overtopping analyses were performed on the Rio Grande de Manati levee according to ETL 1110-2-299 dated 22 August 1986. The overtopping water surface profiles were computed by considering the uncertainties in "n" values and the

availability of the downstream storage areas in the future. The "n" values of both channels and overbanks were increased by 20 percent. The storage areas of the downstream tributary, Cano Tiburones, were removed from the overtopping analysis since the availability of the storage areas in the future is uncertain.

Stage-discharge rating curves were plotted at several cross sections for the design "n" values and increased "n" values to design the levee heights. An overtopping section was provided at the north end of the levee. The levee height at the overtopping section was set to coincide with the computed overtopping water surface profile. This levee height is also equivalent to passing a higher overtopping discharge with normal "n" values. Minimum levee heights at other cross sections were determined by considering overtopping discharges with normal "n" values and normal design discharges with higher "n" values. A levee superiority of 0.15 meters was used for the entire levee except at the overtopping section. Table A-7 summarizes the results of the overtopping analysis. Computed levee heights ranged from 1.08 meters to 1.37 meters, as listed in Table A-7, above the normal one percent chance flood levels to cover the uncertainties in the design parameters.

3. Overtopping Section.

An overtopping area is provided at the farthest point downstream (north) to ensure that flanking of the levee does not occur during a storm event higher than the design frequency. Plate A-2 shows the plan view of the levee and Table A-14 shows the hydraulic design data.

D. Interior Flood Hydrology.

The project levee protects the town of Barceloneta from the Rio Grande de Manati floods. Outlet culverts, detention areas and collector channels along the levee are required for interior drainage. Minimum facilities were chosen based on the designs for various frequency floods.

Peak discharges and flood volumes required for the interior flood hydrology under future conditions development were determined by using HEC-1 computer program. The contributing drainage areas, bounded by the project levee, were delineated in a USGS quadrangle map. The watershed was divided into several subareas as shown in Figure A-9. The rainfall data for the basin was obtained from TP-42 as listed in Table A-8. Dry soil conditions (AMC I) were used for frequencies up to 10 percent chance flood. Average moisture conditions (AMC II) were considered for frequencies up to a 2 percent chance flood and wet conditions (AMC III)

for larger floods. Estimated subarea parameters such as SCS curve numbers and lag times are listed in Table A-9. Computed peak discharges for various frequencies at several locations are listed in the residual flooding table.

Computed flood hydrographs were routed through detention areas and flap-gated outlet culverts by EXTRAN, a dynamic flow routing model. EXTRAN is a part of the Environmental Protection Agency's Storm Water Management Model. This model can simulate branched or looped networks and can compute backwater effects caused by varying tailwater conditions. Channels, pipes, orifices, weirs, flap gates, detention basins, and pumps can be used in EXTRAN. The Interior Flood Hydrology program (HEC-IFH), released for general use in May 1992, was not available for the analysis. Coincident tailwater flooding conditions were used to analyze 50%, 20%, and 10% chance interior flood events. A 10 percent chance tailwater stage hydrograph was assumed to analyze the other large interior flood hydrographs. The estimated peak flood levels in the detention areas, unexcavated low lands upstream of the interior drainage culverts and with the proposed developments in place, are listed in Table A-10.

Flood durations were computed for various frequencies for pre- and post-project conditions and listed in Table A-16.

1. Performance.

a. Overtopping Analyses.

The levee will exclude flows up to and including the 100 year frequency. Overtopping would be initiated in the planned overtopping section near C-1 for floods exceeding the 100-year event.

b. Residual Flooding.

A levee, designed to protect a one percent chance flood event from Rio Grande de Manati, was determined to be the most beneficial alternative. The levee provides protection to the town from Rio Grande de Manati flooding from the east, north and west directions.

Residual flooding was computed using flows higher than the capacity of the system and the interior flood analysis was revised to account for the proposed developments. The sub-basin parameters reflect the future condition hydrology. Table A-10 was revised to indicate peak water surface elevations with the proposed developments in place. Figures 10 and 11 indicate a comparison of the water surface profiles, with and without the proposed developments, for the 2-year and SPF events. The

analysis indicated that for the 2-year event there was very little change in the water surface profile and the average channel velocity. For the SPF event the area between the levee and proposed developments would indicate a rise in the water surface elevation of about two feet and the average channel velocity would be about 1.2 meters per second. At Culvert 1 the total ponding areas for the 2-year and SPF events were 107 and 179 acres, respectively. Plate A-2 was also revised to indicate the developed areas and the limits of the residual ponding area. The flooded area assumes no flooding from Rio Grande de Manati. Once the levee is overtopped from the flood plain the flooding will be the same as for existing conditions. This has an average depth of about 0.8 meters. Flood stages within the levee near Barceloneta for the 1 in 100 year event will be reduced from a pre-project elevation of 5.1 meters, NGVD to 2.7 meters, NGVD under post-project conditions.

c. **People at Risk.**

The most heavily developed areas of Barceloneta are located at the south end of town. This area is closest to the high ground to which the levee would terminate. Levee failure would first occur at the overtopping section which is located at the north and least developed end of town. Highway 140 is the most direct route to high ground and would serve as the main evacuation route. The topography of the area within the levee would force level pool flooding from the overtopping section toward the south. Flooding depths along the evacuation route would be a maximum of one meter at the peak stage. Velocities within the levee from overtopping would be associated with "filling" and are expected to be low.

TABLE A-1

ANNUAL PEAK DISCHARGES
FOR RIO GRANDE DE MANATI

WATER YEAR	GAGE 50035000 AT CIALES		GAGE 50038100 AT HWY-2	
	DATE	PEAK DISCHARGE CMS	DATE	PEAK DISCHARGE CMS
1899	* AUGUST 8	5,890		
1928	* SEPTEMBER 13	4,049		
1932	* SEPTEMBER 27	3,766		
1959			MAY 3	2,152
1960	SEPTEMBER 6	3,172	SEPTEMBER 6	1,756
1961	DECEMBER 4	623	AUGUST 27	1,501
1962	MAY 20	413	MAY 20	447
1963	MAY 17	779	MAY 17	320
1964	NOVEMBER 2	182		
1965	MAY 5	368	OCTOBER 15	142
1966	DECEMBER 9	1,192	DECEMBER 11	2,005
1967	DECEMBER 6	223		
1968	SEPTEMBER 19	212	OCTOBER 24	170
1969	APRIL 21	702	NOVEMBER 28	481
1970	NOVEMBER 9	1,600	NOVEMBER 9	1,929
1971	OCTOBER 9	3,540	OCTOBER 9	2,315
1972	MARCH 30	564	MARCH 30	187
1973	APRIL 20	289	APRIL 21	201
1974	MARCH 9	225	OCTOBER 16	48
1975	SEPTEMBER 16	2,042	SEPTEMBER 16	607
1976	SEPTEMBER 30	148	APRIL 30	155
1977	OCTOBER 14	320	OCTOBER 15	197
1978	APRIL 10	572	APRIL 10	328
1979	AUGUST 30	1,025	AUGUST 31	977
1980	NOVEMBER 25	793	MAY 28	343
1981	MAY 5	328	MAY 6	314
1982	DECEMBER 13	745	DECEMBER 13	879
1983	APRIL 21	824	APRIL 21	855
1984	SEPTEMBER 11	535	SEPTEMBER 11	242
1985	MAY 18	2,104	MAY 18	2,549
1986	OCTOBER 7	2,132	OCTOBER 7	2,754
1987	APRIL 12	714	APRIL 12	934
1988	NOVEMBER 27	1,031	NOVEMBER 27	1,218
1989	SEPTEMBER 18	750	SEPTEMBER 18	1,252
1990	OCTOBER 23	408	OCTOBER 23	872
1991		388		439
1992		1,079		385

* Estimated at Cialas gage by USCOE
Floodpain Information, Manatee River, PR, 1967, p. A-12.
Assumed same peak flow at HWY-2 gage.

TABLE A-2

RIO MANATI BASIN POINT RAINFALL*
FOR VARIOUS FREQUENCIES AND DURATIONS

DURATION	PERCENT CHANCE STORM EVENTS						
	50	20	10	4	2	1	SPS
15 MIN	35	47	55	65	73	81	81
1 HR	61	82	96	114	128	143	143
2 HR	76	105	124	149	169	190	230
3 HR	84	116	138	167	191	214	298
6 HR	99	140	169	207	238	270	419
12 HR	122	172	206	252	289	327	521
24 HR	137	196	238	294	338	385	635

*Rainfall in millimeters

TABLE A-3

RIO MANATI SUB-BASIN PARAMETERS

BASIN NO.	DRAINAGE AREA (SQ. KM.)	CURVE NUMBER			LAG TIME (HOURS)
		AMC I	AMC II	AMC III	
1	58.78	63	80	91	1.63
2	70.59	63	80	91	0.98
3	50.85	63	80	91	0.72
4	75.26	63	80	91	1.41
5	90.14	63	80	91	1.28
6	49.94	63	80	91	0.74
7	4.28	63	80	91	0.20
8	3.94	63	80	91	0.24
9	18.69	63	80	91	1.81
10	24.11	63	80	91	2.22
	TOTAL AREA =446.58				

TABLE A-4

SUMMARY OF HEC-1 PEAK DISCHARGES*
FOR RIO GRANDE DE MANATI

PERCENT CHANCE FLOOD EVENT	RIO MANATI GAGE 50035000 (AT CIALES)	RIO MANATI GAGE 50038100 (AT HWY 2)
50	594	722
20	1535	1893
10	2255	2771
4	4353	5366
2	5064	6288
1	6244	7816
SPF	7795	9877

*DISCHARGE VALUES IN CMS

TABLE A-5

RIO MANATI EXISTING CONDITION WATER SURFACE ELEVATIONS

CROSS SECTION NO.	DISTANCE FROM MOUTH (KM)	WATER SURFACE ELEVATION (METERS, NGVD)						
		PERCENT CHANCE FLOOD EVENTS						
		50	20	10	4	2	1	SPF
0.1	0.60	1.30	2.06	2.48	3.62	3.96	4.48	5.40
1	0.87	1.48	2.15	2.55	3.67	4.01	4.53	5.47
4	1.59	1.82	2.44	2.81	3.89	4.23	4.78	5.76
6	2.04	2.35	3.02	3.35	4.26	4.57	5.11	6.10
8	2.39	2.97	3.62	3.98	4.84	5.09	5.52	6.41
10	2.77	3.33	4.16	4.55	5.36	5.60	5.99	6.74
12	3.15	3.51	4.52	4.95	5.84	6.08	6.47	7.14
14	3.59	3.70	4.89	5.36	6.31	6.57	6.98	7.62
16	4.01	4.55	5.76	6.18	7.14	7.40	7.80	8.41
18	4.42	5.34	6.57	7.01	7.92	8.38	8.83	9.69
20	4.84	6.17	7.29	7.79	8.94	9.25	9.75	10.46
22	5.20	6.69	7.82	8.31	9.47	9.79	10.28	11.01
24	5.55	7.09	8.28	8.78	9.93	10.25	10.74	11.45
26	5.95	7.49	8.83	9.35	10.50	10.82	11.31	12.00
28	6.31	8.32	10.02	10.45	11.41	11.70	12.15	12.76
29	6.35	8.66	10.23	10.66	11.59	11.87	12.30	12.90

TABLE A-6

RIO MANATI WATER SURFACE ELEVATIONS
EXISTING AND WITH-PROJECT CONDITIONS

CROSS SECT. NO.	DISTANCE FROM MOUTH KM	CONDITION	WATER SURFACE ELEVATIONS (METERS, NGVD)						
			PERCENT CHANCE FLOOD EVENTS						
			50	20	10	4	2	1	SPF
0.1	0.60	Existing	1.30	2.06	2.48	3.62	3.96	4.48	5.40
0.1	0.60	With Project	1.31	2.07	2.51	3.63	3.96	4.52	5.40
1	0.87	Existing	1.48	2.15	2.55	3.67	4.01	4.53	5.47
1	0.87	With Project	1.50	2.29	2.67	3.82	4.01	4.73	5.63
4	1.59	Existing	1.82	2.44	2.81	3.89	4.23	4.78	5.76
4	1.59	With Project	1.91	2.63	3.02	4.10	4.32	5.08	6.01
6	2.04	Existing	2.35	3.02	3.35	4.26	4.57	5.11	6.10
6	2.04	With Project	2.70	3.51	3.91	4.98	5.29	5.82	6.75
8	2.39	Existing	2.97	3.62	3.98	4.84	5.09	5.52	6.41
8	2.39	With Project	3.21	4.02	4.55	5.66	5.96	6.46	7.33
10	2.77	Existing	3.33	4.16	4.55	5.36	5.60	5.99	6.74
10	2.77	With Project	3.58	4.58	5.07	6.13	6.33	6.87	7.67
12	3.15	Existing	3.51	4.52	4.95	5.84	6.08	6.47	7.14
12	3.15	With Project	3.81	4.91	5.37	6.42	6.67	7.21	8.01
14	3.59	Existing	3.70	4.89	5.36	6.31	6.57	6.98	7.62
14	3.59	With Project	4.10	5.23	5.69	6.72	6.99	7.53	8.35
16	4.01	Existing	4.55	5.76	6.18	7.14	7.40	7.80	8.41
16	4.01	With Project	4.82	6.06	6.35	7.39	7.68	8.15	8.89
18	4.42	Existing	5.34	6.57	7.01	7.92	8.38	8.83	9.69
18	4.42	With Project	5.79	6.85	7.11	8.22	8.55	9.04	9.85
20	4.84	Existing	6.17	7.29	7.79	8.94	9.25	9.75	10.46
20	4.84	With Project	6.21	7.31	7.81	8.89	9.32	9.84	10.61
22	5.20	Existing	6.69	7.82	8.31	9.47	9.79	10.28	11.01
22	5.20	With Project	6.71	7.83	8.32	9.48	9.82	10.33	11.11
24	5.55	Existing	7.09	8.28	8.78	9.93	10.25	10.74	11.45
24	5.55	With Project	7.10	8.29	8.78	9.94	10.27	10.77	11.51
26	5.95	Existing	7.49	8.83	9.35	10.50	10.82	11.31	12.00
26	5.95	With Project	7.50	8.83	9.35	10.51	10.83	11.32	12.04
28	6.31	Existing	8.32	10.02	10.45	11.41	11.70	12.15	12.76
28	6.31	With Project	8.32	10.02	10.45	11.41	11.70	12.15	12.78
29	6.35	Existing	8.66	10.23	10.66	11.59	11.87	12.30	12.90
29	6.35	With Project	8.66	10.23	10.66	11.59	11.87	12.30	12.92

TABLE A–7

RIO MANATI LEVEE HEIGHT
DESIGN FOR ONE PERCENT CHANCE FLOOD EVENT

LEVEE LOCATION	CROSS SECT. NO.	WATER SURFACE ELEVATION METERS, NGVD			HEIGHT REQUIRED ABOVE NORMAL ONE PERCENT CHANCE FLOOD LEVEL IN METERS			TOP OF LEVEE METERS NGVD
		DESIGN WATER LEVEL FOR NORMAL CONDITION	DESIGN DISCHARGE WITH 20% HIGHER N VALUE AND CANO TIBURONES STORAGE REMOVED	NORMAL N VALUE WITH HIGHER DISCHARGE DETERMINED AT OVERTOPPING SECTION	MINIMUM	LEVEE SUPERI–ORITY	TOTAL	
SW END		5.35	6.48	6.48	1.13	0.15	1.28	6.63
NORTH END		5.35	6.48	6.48	1.13	0.15	1.28	6.63
OVERTOPPING SECTION		5.35	6.48	6.48	1.13	0.00	1.13	6.48
	6	5.82	6.86	7.04	1.22	0.15	1.37	7.19
	8	6.46	7.10	7.64	1.18	0.15	1.33	7.79
	10	6.85	7.36	7.98	1.13	0.15	1.28	8.13
	12	7.21	7.75	8.30	1.09	0.15	1.24	8.45
	14	7.58	8.04	8.66	1.08	0.15	1.23	8.81
SOUTH END	16	8.15	8.46	9.08	0.93	0.15	1.08	9.23

TABLE A-8

RAINFALL FOR INTERIOR FLOOD HYDROLOGY*

DURATION	PERCENT CHANCE STORM EVENTS						
	50	20	10	4	2	1	SPS
5 MIN	15	19	23	26	29	32	35
15 MIN	28	37	41	51	57	64	68
1 HR	48	62	76	91	103	114	121
2 HR	62	81	97	116	128	140	184
3 HR	67	90	109	130	146	163	267
6 HR	80	114	140	170	196	218	381
12 HR	98	142	173	213	241	272	445
24 HR	117	170	206	254	287	325	508

*Rainfall in millimeters

TABLE A-9

SUB-BASIN PARAMETERS FOR INTERIOR FLOOD HYDROLOGY

BASIN IDENTIFICATION	DRAINAGE AREA (SQ. KM.)	LAG TIME (HOURS)	CURVE NUMBER AMC I	AMC II	AMC III
E1	0.33	0.66	73	87	95
E2	0.21	0.23			
E3	0.11	0.10			
C1	0.32	0.79			
C2	0.35	0.50			
W1	0.53	0.53			
W2	0.27	0.41			
W3	0.27	0.68			
W4	0.32	0.70			
W5	0.14	0.10	*	*	91
TOTAL	2.85				

Note : * Wet area-AMC III condition used for all frequencies

TABLE A-10

PERFORMANCE OF THE INTERIOR DETENTION AREAS

PERCENT CHANCE FLOOD EVENTS	PEAK WATER SURFACE ELEVATIONS METERS, NGVD	
	NORTH AREA UPSTREAM OF CULVERT 1	EAST AREA UPSTREAM OF CULVERT 2
50	1.88	1.56
20	2.10	2.06
10	2.22	2.37
4	2.46	3.05
2	2.54	3.22
1	2.66	3.44
SPF	3.09	3.89

TABLE A-11
Hydraulic Design Data For Pilot Channel
Rio Grande De Manati

STATION	LOCATION	APPROX. NATURAL GRADE METERS	CHANNEL INVERT M-NGVD	CHANNEL BOTTOM WIDTH METERS	SIDE SLOPES (V TO H)	TYPE OF CHANNEL
0 + 00	Begin Downstream	3	-2.2	15	1 to 3	Earth
2 + 00	Pilot Channel	4.3	-2.2	15	1 to 3	Earth
4 + 00		4.8	-2.2	15	1 to 3	Earth
6 + 00		4.9	-2.2	15	1 to 3	Earth
7 + 85	End Pilot Channel	4	-2.2	15	1 to 3	Earth
0 + 00	Begin Upstream	4.2	-1.1	15	1 to 3	Earth/Gabion
1 + 60	Pilot Channel	4	-1.1	15	1 to 3	Earth/Gabion
3 + 60		4	-1.1	15	1 to 3	Earth/Gabion
5 + 60		5	-1.1	15	1 to 3	Earth/Gabion
7 + 60	End Pilot Channel	5	-1.1	15	1 to 3	Earth/Gabion

TABLE A-12
HYDRAULIC DESIGN DATA FOR INTERIOR CHANNELS
RIO GRANDE DE MANATI
CITY OF BARCELONETA

CHANNEL STATION	COMMENTS	EXISTING GR. ELEV. M-NGVD	CHANNEL INVERT M-NGVD	BOTTOM WIDTH	CHANNEL S.S.
		CHANNEL 1			
0 + 00	CULVERT 1	1	-0.50	V-TYPE	1V on 3H
2 + 00	CHANNEL SLOPE	1.5	-0.30	V-TYPE	1V on 3H
4 + 00	S=0.1%	1.7	-0.10	V-TYPE	1V on 3H
5 + 50	CULVERT 1A	1.8	0.05	V-TYPE	1V on 3H
6 + 00		1.8	0.10	V-TYPE	1V on 3H
8 + 00		2	0.30	V-TYPE	1V on 3H
10 + 00		2.5	0.50	V-TYPE	1V on 3H
12 + 00		2	0.70	V-TYPE	1V on 3H
14 + 00		2.4	0.90	V-TYPE	1V on 3H
16 + 00		2.3	1.10	V-TYPE	1V on 3H
18 + 00		2.1	1.30	V-TYPE	1V on 3H
19 + 80	END OF CHANNEL	2.1	1.48	V-TYPE	1V on 3H
		CHANNEL 2			
0 + 00	CULVERT 1	1	0.00	V-TYPE	1V on 3H
2 + 00	CHANNEL SLOPE	1	0.20	V-TYPE	1V on 3H
4 + 00	S=0.1%	1.3	0.40	V-TYPE	1V on 3H
6 + 00		1.4	0.60	V-TYPE	1V on 3H
8 + 00		1.9	0.80	V-TYPE	1V on 3H
9 + 00		1.9	0.90	V-TYPE	1V on 3H
10 + 00		2.2	1.00	V-TYPE	1V on 3H
		CHANNEL 3			
0 + 00	CULVERT 2	1.5	1.00	V-TYPE	1V on 3H
0 + 50	CHANNEL SLOPE	1.9	1.05	V-TYPE	1V on 3H
1 + 00	S=0.1%	1.9	1.10	V-TYPE	1V on 3H
		CHANNEL 4			
0 + 00	CULVERT 2	1.5	0.50	V-TYPE	1V on 3H
2 + 00	CHANNEL SLOPE	2.2	0.90	V-TYPE	1V on 3H
4 + 00	S=0.2%	2	1.30	V-TYPE	1V on 3H
6 + 00		3	1.70	V-TYPE	1V on 3H
8 + 00		3	2.10	V-TYPE	1V on 3H
10 + 00		4	2.50	V-TYPE	1V on 3H
12 + 00		4	2.90	V-TYPE	1V on 3H
12 + 50	CULVERT 2B	4	3.00	V-TYPE	1V on 3H
14 + 00		5	3.30	V-TYPE	1V on 3H
16 + 00		5	3.70	V-TYPE	1V on 3H
18 + 00		5	4.10	V-TYPE	1V on 3H
19 + 50	END OF CHANNEL	5	4.40	V-TYPE	1V on 3H

TABLE A-13
HYDRAULIC DESIGN DATA FOR CULVERTS
RIO GRANDE DE MANATI
CITY OF BARCELONETA

CULVERT DESINNATION CHANNEL STATION	C-1 0+00	C-1A 5+50	C-2 0+00	C-2B 12+50
Natural Grade Elevation	1.5	1.9	1.5	4.0
Levee Crown Elevation	6.5	---	7.8	---
Design Conditions				
Discharge	8.0	1.4	3.0	7.6
Headwater	1.8	1.9	2.5	4.0
Tailwater	1.7	1.7	2.4	3.8
Culvert Diameter Size	1.8	1.2	1.5	1.8
Number of Culverts	4.0	1.0	2.0	2.0
Length	60	50	60	50
Invert	-1.0	0.2	-0.5	1.2
Type Control	Flapgate	None	Flapgate	None
Channel Sections				
Upstream Bottom Width	9.00		7.00	
Upstream Bottom Ele.	-1.30		-1.00	
Upstream Side Slope	3.0		3.0	
Downstream Bottom Width	9.00		7.00	
Downstream Bottom Ele.	-1.30		-1.00	
Downstream Side Slope	3.00		3.00	
Riprap Requirements				
Upstream Length	3.00		3.00	
Upstream Elevation	1.00		1.00	
Downstream Length	6.00		6.00	
Downstream Elevation	2.00		2.00	

Note: All measurements are in meters.
All elevations are in meters, NGVD.
Approach channels for culverts should be 30 meters long and then transition to natural grade at 1 on 10 slope.

TABLE A-14
HYDRAULIC DESIGN DATA FOR LEVEES
RIO GRANDE DE MANATI
CITY OF BARCELONETA

STATION	COMMENTS	EXISTING GR. ELEV. M-NGVD	TOP OF LEVEE M-NGVD	TOP WIDTH OF LEVEE METERS	LEVEE S.S.
WEST SIDE LEVEE					
0 + 00	CULVERT 1	1	6.48	4	1V on 3.5H
1 + 00	OVERTOPPING SEC	1.5	6.48	4	1V on 3.5H
1 + 10		1.5	6.63	4	1V on 3.5H
2 + 00		1.5	6.63	4	1V on 3.5H
4 + 00		1.7	6.63	4	1V on 3.5H
6 + 00		1.8	6.63	4	1V on 3.5H
8 + 00		1.8	6.63	4	1V on 3.5H
10 + 00		2	6.63	4	1V on 3.5H
12 + 00		2.5	6.63	4	1V on 3.5H
14 + 00		2	6.63	4	1V on 3.5H
16 + 00		2.4	6.63	4	1V on 3.5H
18 + 00		2.3	6.63	4	1V on 3.5H
20 + 00	END OF LEVEE	2.1	6.63	4	1V on 3.5H
EAST SIDE LEVEE					
0 + 00	CULVERT 1	1	6.48	4	1V on 3H
2 + 00	OVERTOPPING SEC	1	6.48	4	1V on 3H
4 + 00	OVERTOPPING SEC	1.3	6.48	4	1V on 3H
4 + 10		1.4	7.19	4	1V on 3H
6 + 00		1.9	7.40	4	1V on 3H
8 + 00		1.9	7.60	4	1V on 3H
10 + 00		1.9	7.79	4	1V on 3H
12 + 00	CULVERT 2	1.9	7.95	4	1V on 3H
14 + 00		1.9	8.13	4	1V on 3H
16 + 00		1.9	8.30	4	1V on 3H
18 + 00		1.9	8.45	4	1V on 3H
20 + 00		1.9	8.60	4	1V on 3H
22 + 00		1.9	8.70	4	1V on 3H
24 + 00		1.9	8.81	4	1V on 3H
26 + 00		1.9	8.95	4	1V on 3H
28 + 00		1.9	9.10	4	1V on 3H
30 + 00	END OF LEVEE	2.2	9.23	4	1V on 3H

TABLE A-15
RESIDUAL FLOOD ELEVATIONS
RIO GRANDE DE MANATI
CITY OF BARCELONETA

Frequency	Discharge (CMS)	Cross-Section	Water Surface (M-MSL)	Discharge (CMS)	Cross-Section	Water Surface (M-MSL)
2-Yr	7.3	0.00	1.90	7.3	2500.00	2.80
5-Yr	15.0		2.10	15.0		3.00
25-Yr	34.1		2.46	34.1		3.40
50-Yr	38.8		2.54	38.8		3.50
100-Yr	45.2		2.70	45.2		3.60
SPF	51.0		3.10	51.0		3.60
2-Yr	7.3	500.00	2.40	7.3	3000.00	3.00
5-Yr	15.0		2.40	15.0		3.20
25-Yr	34.1		2.60	34.1		3.70
50-Yr	38.8		2.70	38.8		3.80
100-Yr	45.2		2.80	45.2		3.80
SPF	51.0		3.10	51.0		3.90
2-Yr	7.3	1000.00	2.40	5.6	3500.00	3.00
5-Yr	15.0		2.50	11.9		3.30
25-Yr	34.1		2.70	27.0		3.80
50-Yr	38.8		2.70	30.8		3.90
100-Yr	45.2		2.80	35.9		4.00
SPF	51.0		3.10	40.4		4.10
2-Yr	7.3	1500.00	2.50	5.6	4000.00	3.10
5-Yr	15.0		2.60	11.9		3.40
25-Yr	34.1		2.80	27.0		3.90
50-Yr	38.8		2.80	30.8		4.00
100-Yr	45.2		2.90	35.9		4.10
SPF	51.0		3.20	40.4		4.20
2-Yr	7.3	2000.00	2.60	5.6	4100.00	3.10
5-Yr	15.0		2.90	11.9		3.40
25-Yr	34.1		3.20	27.0		3.90
50-Yr	38.8		3.30	30.8		4.00
100-Yr	45.2		3.30	35.9		4.10
SPF	51.0		3.30	40.4		4.20

Note: Water surface at cross section 0.00 are the peak elevations in the detention area.
Water surface elevations were computed with developed areas.

TABLE A–16
FLOOD DURATIONS IN THE PONDING AREA UPSTREAM OF CULVERT 1
RIO GRANDE DE MANATI
CITY OF BARCELONETA

STAGE METERS	FLOOD DURATION IN HOURS													
	PERCENT CHANCE FLOOD EVENT													
	50		20		10		4		2		1		SPF	
	EXISTING	WITH PROJECT	EXISTING	WITH PROJECT	EXISTING	WITH PROJECT	EXISTING	WITH PROJECT	EXISTING	WITH PROJECT	EXISTING	WITH PROJECT	EXISTING	WITH PROJECT
3.05	0.0	0.0	0.0	0.0	3.7	0.0	9.3	0.0	9.9	0.0	11.5	0.0	15.5	6.1
2.74	0.0	0.0	4.0	0.0	6.7	0.0	10.1	0.0	10.9	0.0	12.8	0.0	17.1	16.0
2.44	0.0	0.0	7.7	0.0	8.5	0.0	11.2	4.0	12.0	8.8	14.4	14.1	18.4	20.8
2.13	6.7	0.0	9.3	0.0	10.1	7.5	12.5	16.0	13.3	17.6	16.0	19.2	20.0	25.3
1.83	8.8	0.0	10.9	14.1	11.5	17.1	14.1	19.7	14.9	20.8	17.6	22.1	21.1	28.8
1.52	10.7	7.2	12.5	16.5	12.8	18.4	16.0	21.1	16.3	22.1	19.2	23.7	22.4	30.7
1.22	12.5	12.3	13.9	17.6	14.1	19.2	17.3	21.9	17.9	22.9	20.8	25.1	23.7	31.5
0.91	14.7	15.2	15.5	18.1	15.5	19.7	19.2	22.7	19.5	24.5	22.4	26.4	25.1	32.3

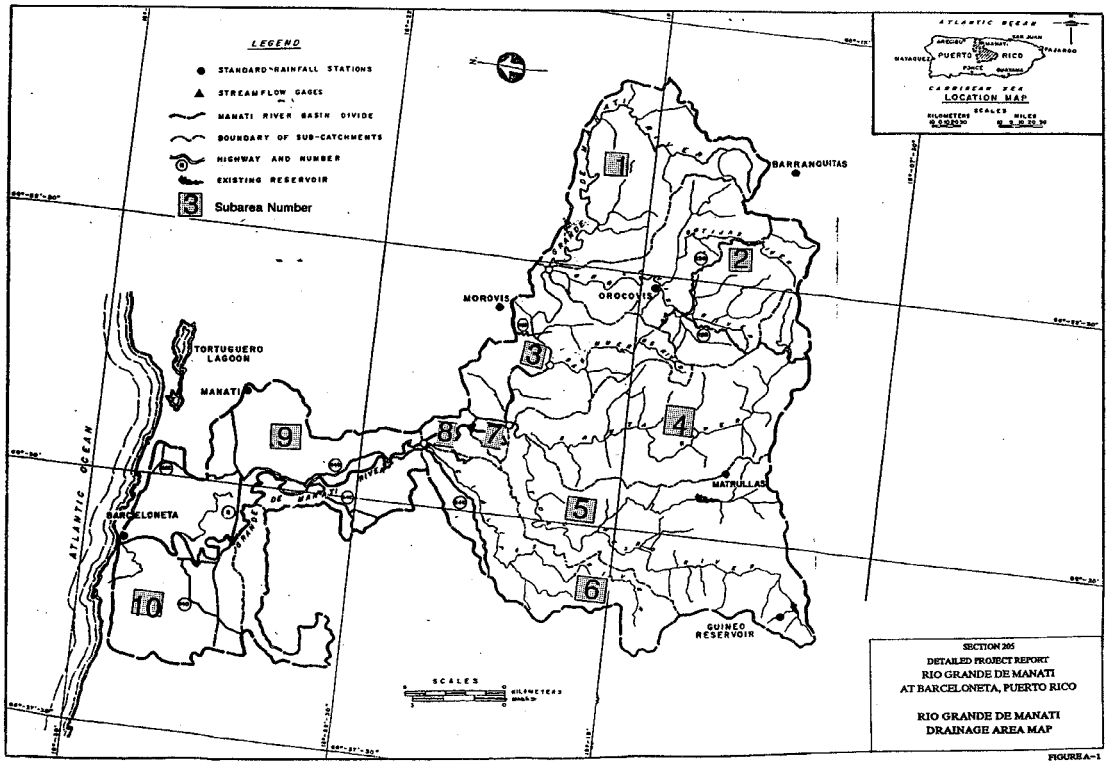
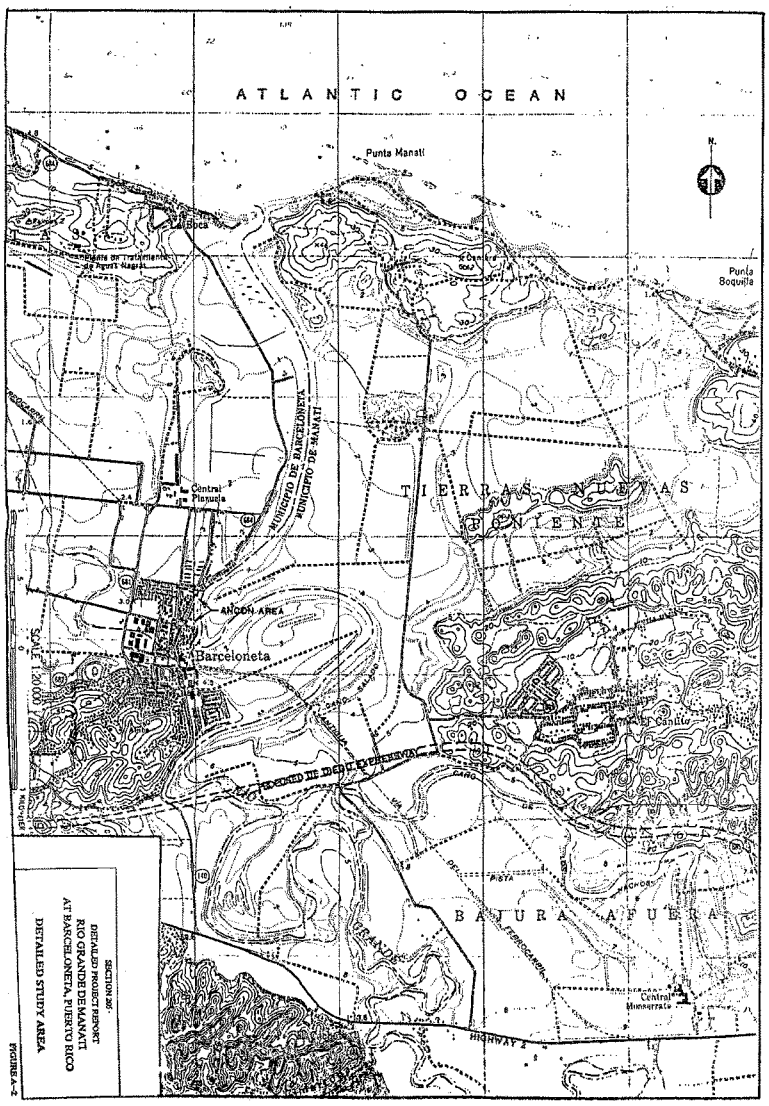
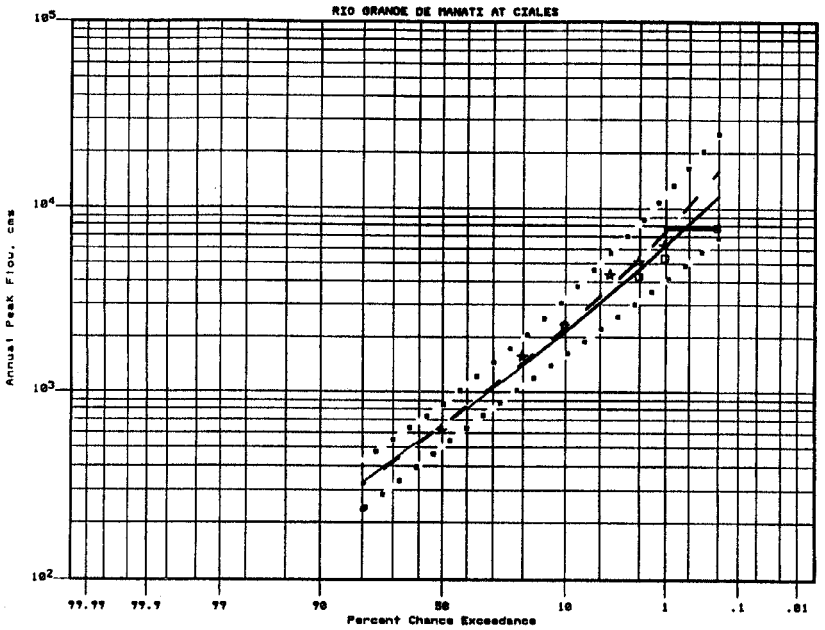

LEGEND
STANDARD RAINFALL STATIONS
STREAMFLOW GAGES
MANATI RIVER BASIN DIVIDE
BOUNDARY OF SUB-CATCHMENTS
HIGHWAY AND NUMBER
EXISTING RESERVOIR
Subarea Number
ATLANTIC OCEAN
CARIBBEAN SEA
PUERTO RICO
LOCATION MAP
SCALES
BARRANQUITAS
COROCOVIS
MOROVIS
TORTUGUERO LAGOON
MANATI
BARCELONETA
MATRULLAS
GUINEO RESERVOIR
SECTION 205
DETAILED PROJECT REPORT
RIO GRANDE DE MANATI
AT BARCELONETA, PUERTO RICO
RIO GRANDE DE MANATI
DRAINAGE AREA MAP

FIGURE A-1

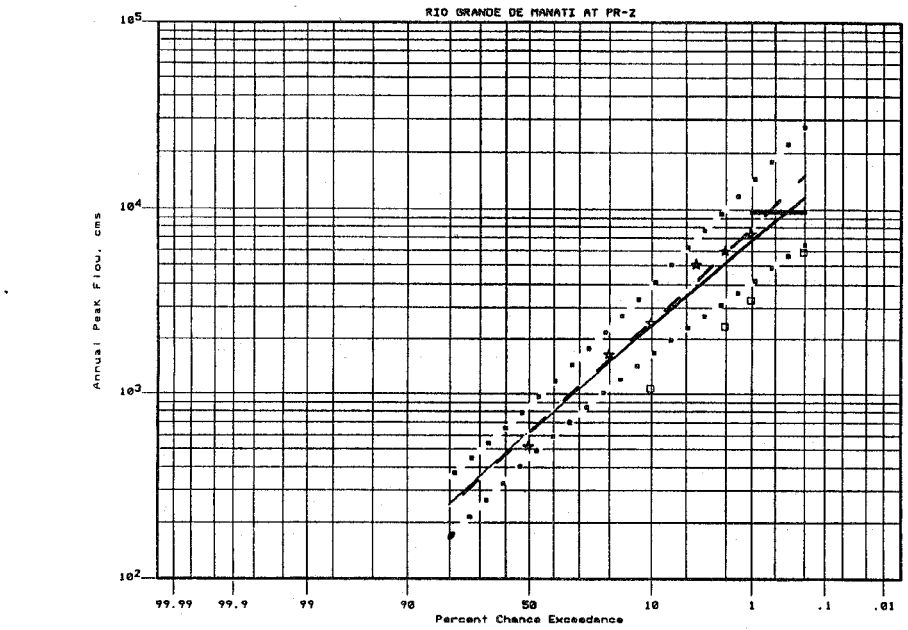

ATLANTIC OCEAN
Punta Manati
Punta Boquilla
Central Palmas
MUNICIPIO DE BARCELONETA
MUNICIPIO DE MANATI
TIERRAS NUEVAS
PONIENTE
ANCON AREA
Barceloneta
Canita
Central Monserrate
BAJURA AFUERA
HIGHWAY 2
SCALE 1:20,000
DETAILED PROJECT REPORT
RIO GRANDE DE MANATI
AT BARCELONETA, PUERTO RICO
DETAILED STUDY AREA
SECTION 205
FIGURE A-2



SECTION 205
DETAILED PROJECT REPORT
RIO GRANDE DE MANATI
AT BARCELONETA, PUERTO RICO

FLOOD FLOW FREQUENCY CURVE AT CIALES (USGS GAGE 50035000)

FIGURE A-3



SECTION 205
DETAILED PROJECT REPORT
RIO GRANDE DE MANATI
AT BARCELONETA, PUERTO RICO

FLOOD FLOW FREQUENCY CURVE AT PR–2 (USGS GAGE 50038100)

FIGURE A–4

FLOOD HYDROGRAPH FOR VARIOUS FREQUENCIES
RIO MANATI AT PR HWY-2

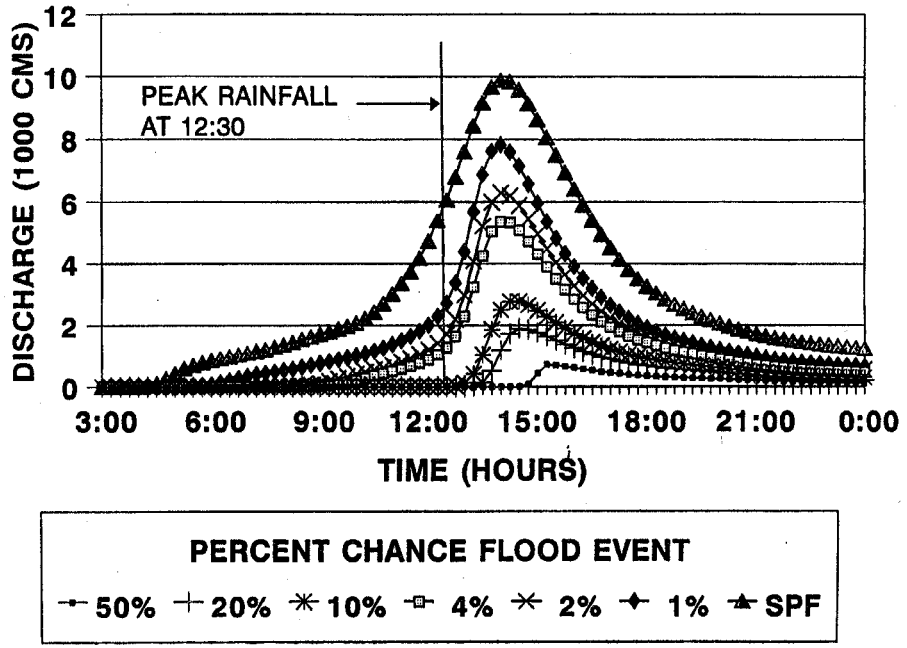
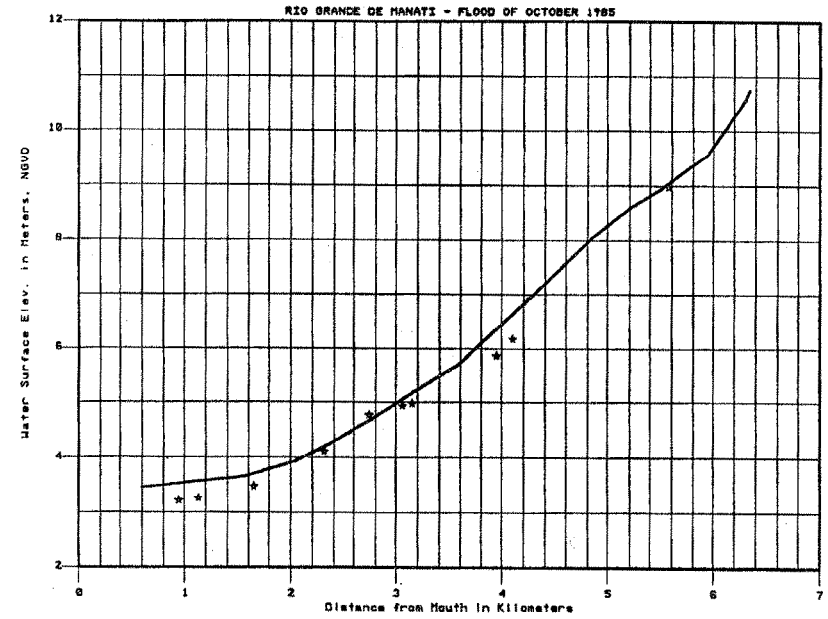


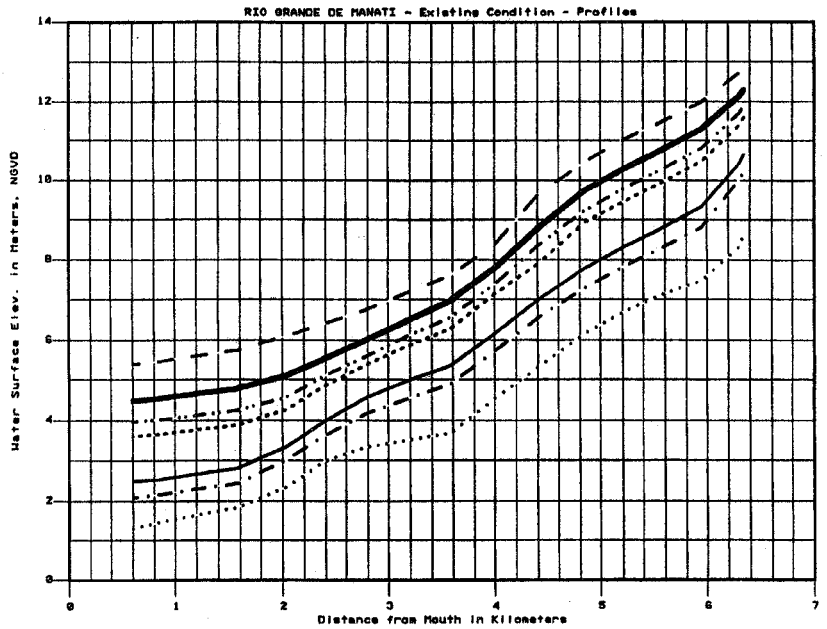
FIGURE A-5



SECTION 205
DETAILED PROJECT REPORT
RIO GRANDE DE MANATI
AT BARCELONETA, PUERTO RICO

SIMULATION OF OCTOBER 1985 FLOOD

FIGURE A–6



SECTION 205

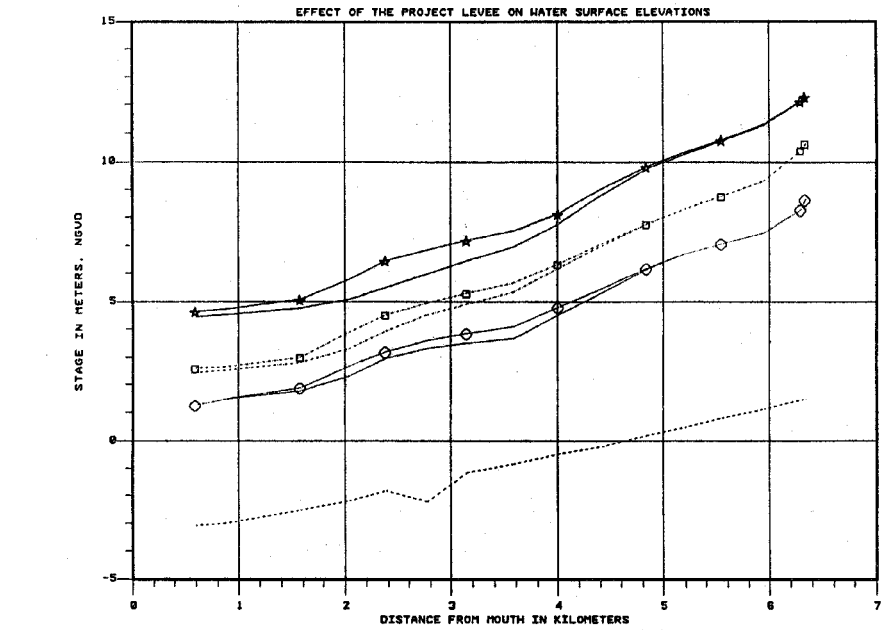
DETAILED PROJECT REPORT

RIO GRANDE DE MANATI

AT BARCELONETA, PUERTO RICO

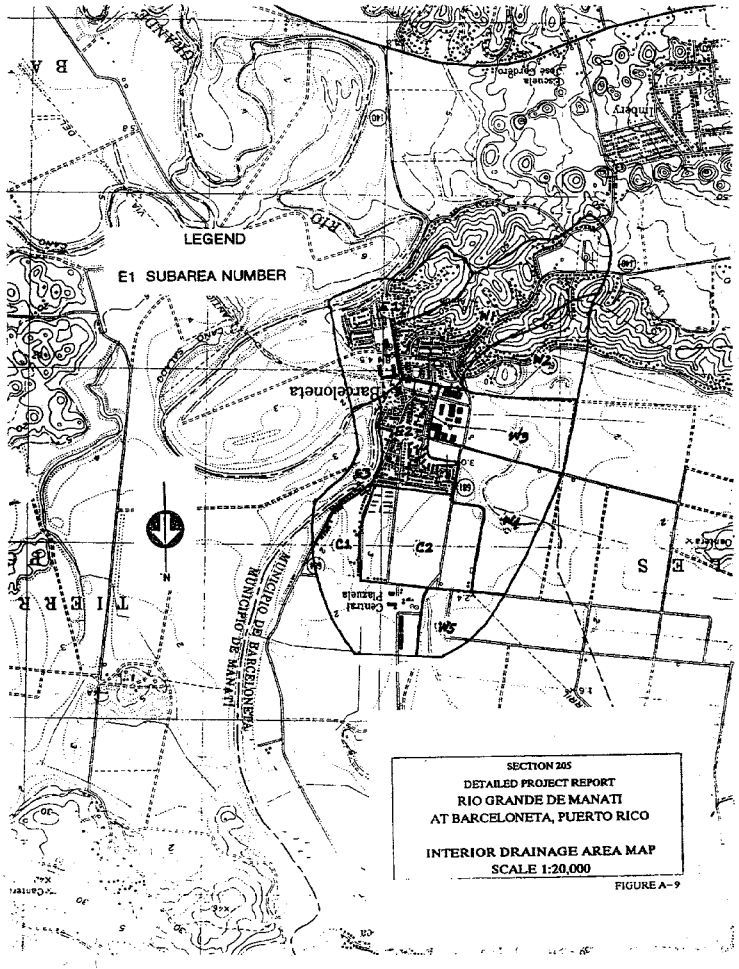
EXISTING CONDITION FLOOD PROFILES

FIGURE A-7



SECTION 205 DPR
RIO GRANDE DE MANATI
AT BARCELONETA, PUERTO RICO
EFFECT OF THE PROJECT LEVEE ON
WATER SURFACE PROFILES

FIGURE A-8


LEGEND
E1 SUBAREA NUMBER
Barceloneta
MUNICIPIO DE BARCELONETA
MUNICIPIO DE MANATI
TIERRAS
SECTION 205
DETAILED PROJECT REPORT
RIO GRANDE DE MANATI
AT BARCELONETA, PUERTO RICO
INTERIOR DRAINAGE AREA MAP
SCALE 1:20,000
FIGURE A-9

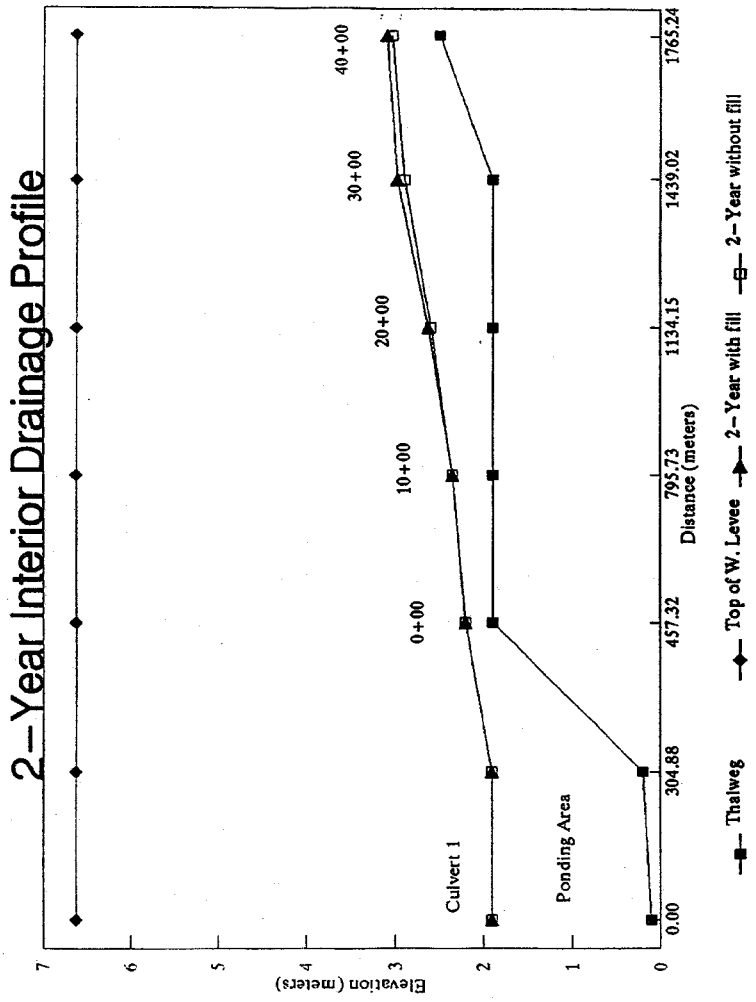

2–Year Interior Drainage Profile
Elevation (meters)
7
6
5
4
3
2
1
0
0+00
10+00
20+00
30+00
40+00
Culvert 1
Ponding Area
0.00
304.88
457.32
795.73
1134.15
1439.02
1765.24
Distance (meters)
Thalweg
Top of W. Levee
2–Year with fill
2–Year without fill

FIGURE 10

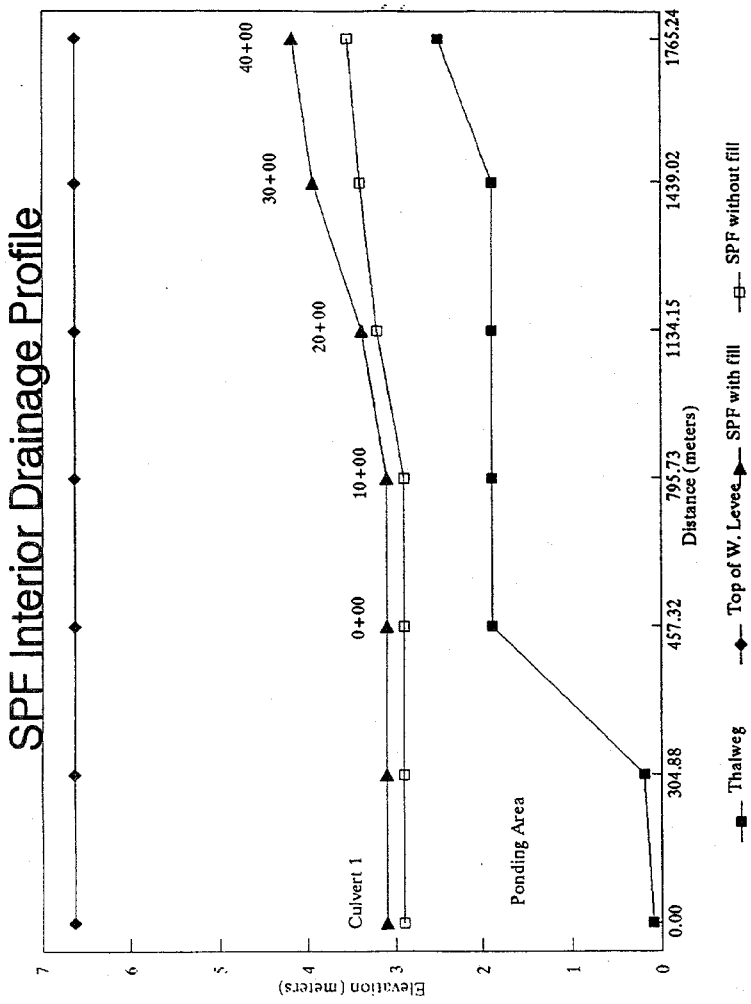
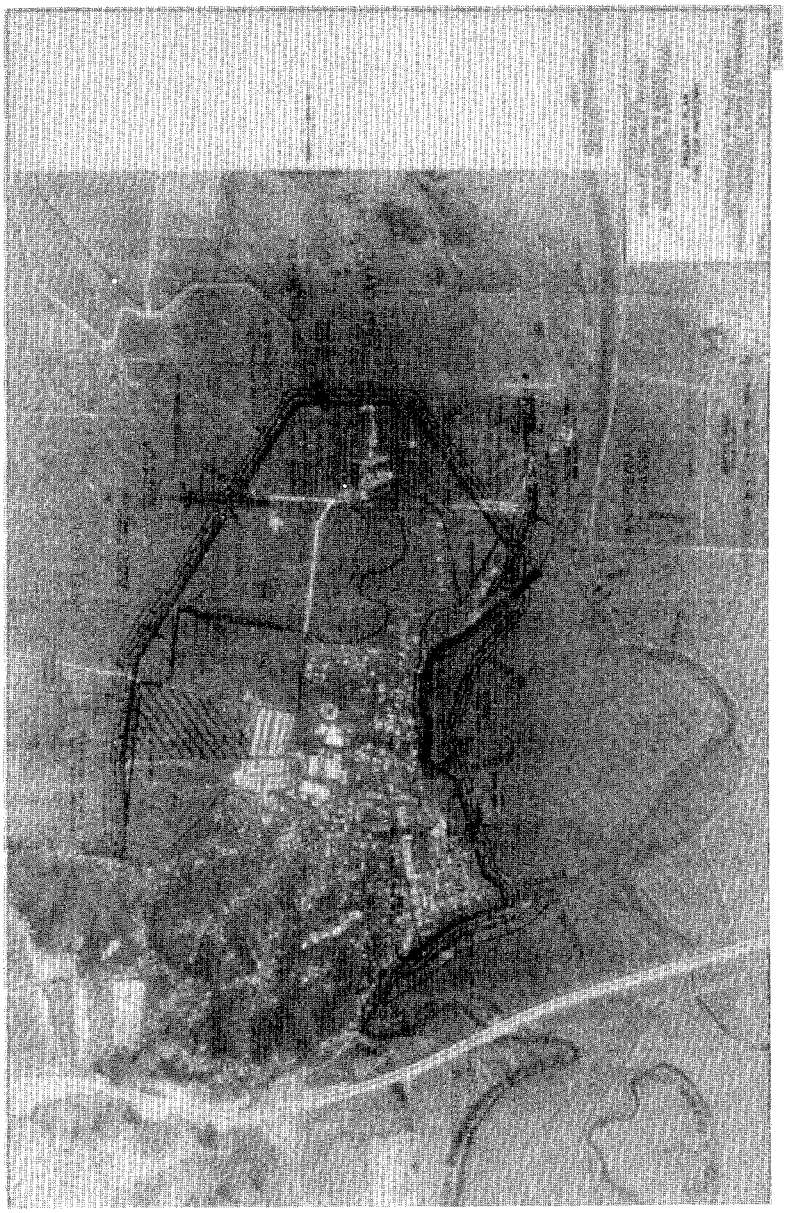

SPF Interior Drainage Profile
Elevation (meters)
0
1
2
3
4
5
6
7
0.00
304.88
457.32
795.73
1134.15
1439.02
1765.24
Distance (meters)
0+00
10+00
20+00
30+00
40+00
Culvert 1
Ponding Area
Thalweg
Top of W. Levee
SPF with fill
SPF without fill

FIGURE 11



APPENDIX B
GEOTECHNICAL REPORT

TABLE OF CONTENTS

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E. SLOPE PROTECTION		
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General		204

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Geologic Profiles	B-103 to B-105
Slope Stability Analysis	B-106 to B-109

A. Scope. This appendix presents geotechnical explorations, laboratory tests, and design analyses performed to determine the geotechnical conditions for Rio Grande de Manati, Barceloneta, Puerto Rico. The project area is broken into two sections for analyses (see plate B-1). The west section includes the levee alignment and interior drainage from the southwest corner of the project to the north culvert. The east section runs from the north culvert southeast to the southeast corner of the project.

B. Investigations Performed.

1. Core Borings. Twenty (20) core borings (CB-MB-1 through CB-MB-20) were drilled in May 1990 along a general alignment for the proposed flood control improvements. Eleven (11) additional core borings (CB-MB-21 through CB-MB-31) were drilled in April 1993. The unconsolidated materials were sampled to a depth of 25.5 feet (7.77 meters) by standard penetration tests (1 3/8-inch I.D. X 2-inch O.D. standard split spoon driven with 140-pound hammer falling 30-inches). Plates B-1 and B-2 show the boring locations, and plates B-3 through B-62 show the core boring logs.

2. Test Pits. Two (2) test pits (TP-MB-1 and TP-MB-2) were excavated in April 1993. Plate B-2 shows the test pit locations.

3. Laboratory Testing. Sieve analyses, Atterberg Limits, standard proctor compaction tests, consolidation tests, unconfined compression tests, and triaxial compression tests were performed on selected samples. Laboratory test data and gradation curves are shown on plates B-64 through B-102.

C. Materials Encountered.

1. Levee Foundation. The materials encountered in the borings generally consisted of silty gravel, silty sand, clayey sand, poorly graded sand, high and low plasticity silt, lean clay, fat clay, organic silt and clay, and peat. Borings CB-MB-12, CB-MB-13, and CB-MB-14 show large deposits of high plasticity clay near the location of the levee and the road ramp of Highway 681. Borings CB-MB-13 and CB-MB-14 show a layer of peat and organic silt ranging from 1 to 6 feet at a depth of 19.0 feet. Plates B-103 through B-105 show the geologic profiles.

2. Borrow Area. The San Juan planning group has selected two borrow sites. Both sites are west of the project area and Borrow Site #1 is currently being used to provide material for nearby highway projects. In May 1991 surface samples were collected at both borrow areas and gradation curves were provided to Geotechnical Branch. Additional samples were obtained during explorations in April 1993. Based on laboratory tests, the material consists primarily of gravelly sand with some silt and is suitable for levee construction.

Based on available subsurface data, it was estimated 50 percent of the material excavated from the pilot channels, north interior drainage ditch, and 70 to 100 percent of the material excavated from the east interior drainage ditch could be used for levee material. It was estimated no material could be used from the west interior drainage ditch excavation.

Processing of excavated material may be required to provide suitable levee material and would consist of removal of stones larger than six inches, clearing and grubbing to remove vegetation and organic top soil, etc., and for wet clays, disking and drying. Levee embankment materials should be thoroughly mixed, then placed in approximately horizontal layers of 1 foot in thickness for gravels and sands and 8 inches when fine grained materials (silts, clays, clayey sands, etc.) are being placed. All levee fill material should be compacted to not less than 95 percent standard proctor density.

3. Groundwater. The groundwater level data shown on the core borings in this Appendix has been evaluated and is not considered representative in the area where impervious materials have been encountered. Due to the impervious clay encountered in many core borings, the standard 24 hour time period specified for recovering the water level in core borings is insufficient to allow the water in the borings to stabilize. Prior to plans and specifications, additional core borings will be drilled and water levels will be monitored for sufficient time to allow the water level to reach equilibrium. When this additional information is obtained, the dewatering requirements will be determined. Dewatering, if needed, will probably consist of pumping from sumps.

D. Slope Stability. Slope stability analyses were performed for levee-foundation sections at borings CB-MB-13, CB-MB-14, and CB-MB-28, for the west section, at CB-MB-4 for the north and east section, and at CB-MB-1 for the section next to the pilot channel. Computer analyses were performed using shear strengths based on soil consistency and standard penetration with the UTEXAS-3 computer program using the Spencer's Method option. Due to a short duration of flooding conditions, steady seepage and slope saturation with rapid drawdown cases were unlikely to occur and therefore were not analyzed. Slopes were analyzed for end of construction and long term stability using both circular and wedge failures. Earthquake loadings were analyzed, but were not allowed to control the design of the channel or levees since the failure of the levee or channel slope during an earthquake would not result in a catastrophic failure, loss of life, or significant loss of property. Also, since the probability of having an earthquake during a time of high water is minimal (EM 1110-2-1913), earthquake loading is not a critical loading condition.

The west levee was assumed to be built out of borrow material or gravelly sand with some silt (GM). The soil profile indicates some of the excavated material from the east pilot channel and the interior drainage ditch may be used for levee fill. The remainder must come from borrow areas. The east levee was analyzed with clayey sand (SC) as fill material. The west section slopes between the north culvert and the Highway 681 ramp were found stable at 1 vertical to 3.5 horizontal. The remaining west section slopes were found stable at 1 vertical to 3 horizontal. The east section slopes were found stable at 1 vertical to 3 horizontal. All other slopes including the drainage ditches and diversion channels were found stable at 1 vertical to 3 horizontal. Analyses for the south pilot channel were based on a minimum 20 foot exterior berm and a minimum 10 foot interior berm. The east and north sections were analyzed with a minimum 15 foot interior berm. The west section was analyzed with a minimum 20 foot berm. Levee slope stability analyses are shown on plates B-106 through B-109.

E. Slope Protection. Riprap and bedding stone will be required in order to protect the canal bottoms and slopes in the immediate vicinity of the structures. Riprap protection will also be required on the north slope of the south pilot channel and the levee slope paralleling the pilot channel. All other levee and channel slopes and channel bottoms require grass protection.

1. Riprap. Riprap design is based on EM 1110-2-1601. A design velocity of 5 feet per second was used in the riprap design. The riprap stone should have a minimum unit weight of 160 pcf (saturated surface dry). The thickness of the riprap blanket will be a minimum of 18 inches. The riprap stone should be well graded within the following limits:

Limits of Stone Weight (pounds)

Max	Min	% Lighter by Weight
280	110	100
80	55	50
42	18	15

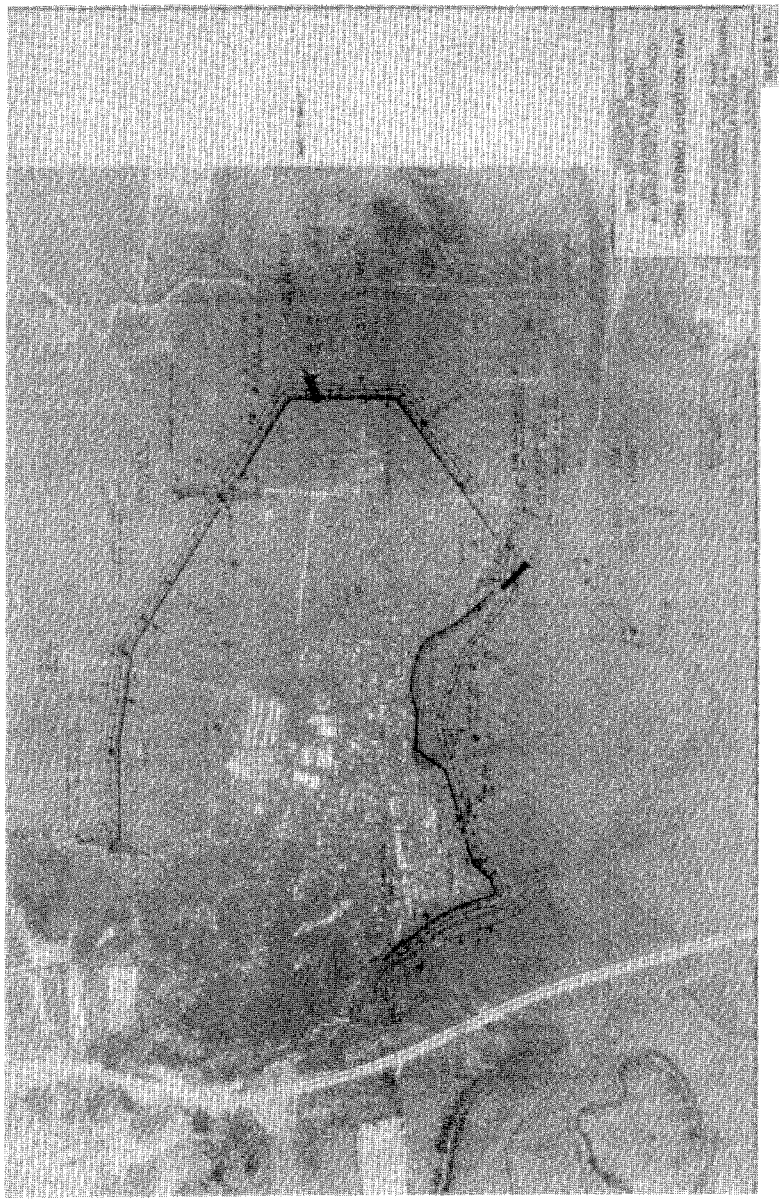
2. Bedding stone. The bedding stone should have a minimum unit weight of 140 pcf (saturated surface dry). The thickness of the bedding stone should be a minimum of 9 inches. The bedding stone should be well graded within the following limits:

Stone Size (inches) or Sieve Number	% Finer by Weight
1.5 in	100
0.5 in	55 - 85
#4	35 - 55
#10	15 - 35
#40	0 - 5

F. Levee Settlement. Initial calculations for settlement show that the levees located on the high plasticity clay will settle. Settlement was calculated using values for the coefficient of consolidation (Cc) and void ratio based on consolidation test results. Overbuilding of the west section by 1.5 feet and the north and east section by 1.0 foot is required to compensate for the average anticipated settlement. Installation of settlement gages will be required to measure the settlement and to provide basis for payment of placement of additional material due to settlement.

G. Foundation Conditions. Based on available subsurface data, no foundation problems are anticipated for the east culvert, north culvert, and five road ramps. Settlements of 3 inches for the east culvert and 8 inches for the north culvert were calculated. Settlement of ramps will be equal to or less than that of the levee settlement for that particular section.

H. Future Subsurface Investigations. Prior to the completion of plans and specifications, additional borings will be obtained to define the subsurface conditions more completely along the levee alignment, pilot channels, road ramps, culverts, and borrow areas. Sufficient field and laboratory tests will be performed to adequately predict the behavior of the materials encountered when subjected to conditions imposed by the proposed improvements. This includes the shear strength parameters for slope stability, dewatering requirements, and consolidation parameters for settlement calculations. The estimated costs for drilling and testing is $45,000.



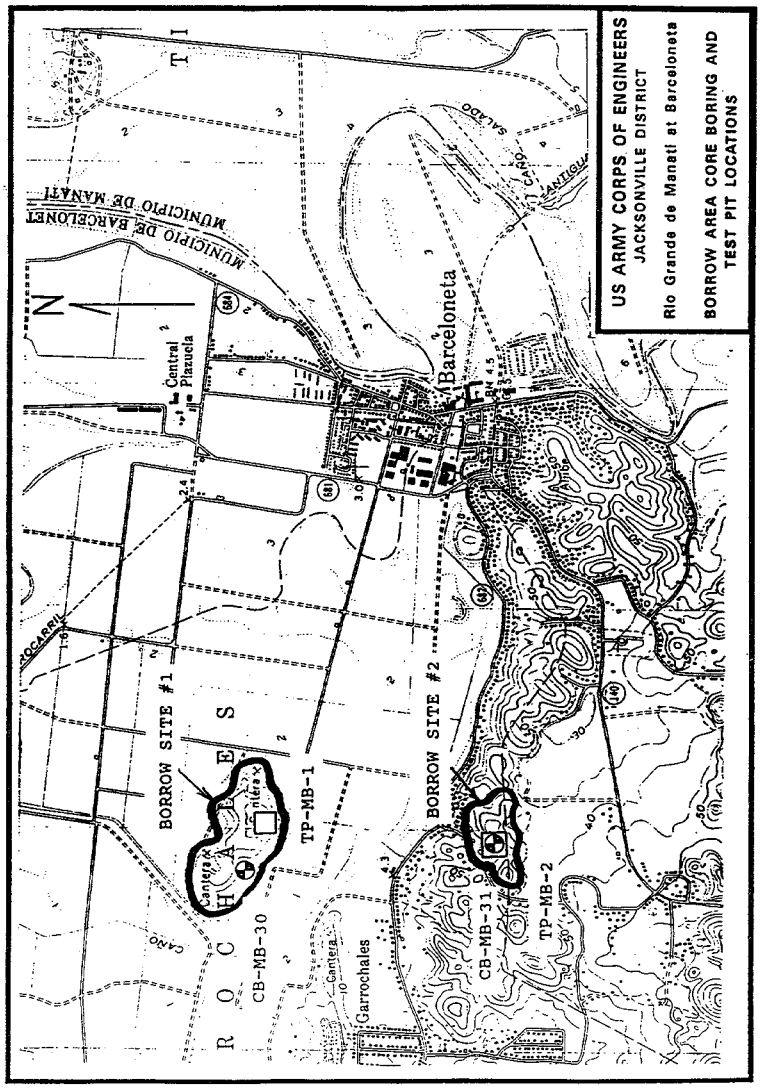

US ARMY CORPS OF ENGINEERS
JACKSONVILLE DISTRICT
Rio Grande de Manati at Barceloneta
BORROW AREA CORE BORING AND TEST PIT LOCATIONS
MUNICIPIO DE BARCELONETA
MUNICIPIO DE MANATI
N
Barceloneta
Central Plazuela
BORROW SITE #1
BORROW SITE #2
TP-MB-1
TP-MB-2
CB-MB-30
CB-MB-31
Garrochales
Cantera
ROCAS

PLATE B-2

Hole No. CB-MB- 1

DRILLING LOG	DIVISION SOUTH ATLANTIC	INSTALLATION JACKSONVILLE DISTRICT	SHEET 1 OF 2 SHEETS
1. PROJECT RIO MANATI AT BARCELONETA		11. SIZE AND TYPE OF BIT	
2. LOCATION (Coordinates or Stations) X= 463,818 Y= 223,840		12. DATUM FOR ELEVATION SHOWN (TBM or MSL) MSL	
3. DRILLING AGENCY GEOCONSULT		13. MANUFACTURER'S DESIGNATION OF DRILL CME- 55	
4. HOLE NO. (As shown on drawing title and file number) CB-MB- 1		14. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: DISTURBED 17	UNDISTURBED
5. NAME OF DRILLER R. González		15. TOTAL NUMBER CORE BOXES	
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.		16. ELEVATION GROUND WATER 1.12 feet	
7. THICKNESS OF OVERBURDEN		17. DATE HOLE STARTED 5-8-90 COMPLETED 5-8-90	
8. DEPTH DRILLED INTO ROCK ——		18. ELEVATION TOP OF HOLE 21.12 feet	
9. TOTAL DEPTH OF HOLE 25.5 feet		19. TOTAL CORE RECOVERY FOR BORING 70.53 %	
		20. SIGNATURE OF INSPECTOR Kermit Schmidt, PE	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Descriptions) d	% CORE RECOV-ERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
21.12	0.0					BIT OR BARREL bls/6"
			TOP SOIL, clay, stiff, silty, grayish brown, some sand, thin roots, occ. pebbles. (CL)	78	1	140# hammer with 30" drop on 1-3/8" ID x 2" OD std. spl. spoon 3 5 7
18.12	3.0			67	2	5 7 7
			CLAY, stiff, silty, grayish brown, little sand, occ. roots and pebbles (CL)	67	3	6 6 6
15.12	6.0		with sand, fine to medium grained	78	4	5 4 3
			SILT, sandy, medium, reddish brown, some clay, partly very sandy (ML)	56	5	2 2 2
12.12	9.0			67	6	3 3 3
			SAND, fine to coarse grained brown, some gravel, fine to medium grained, silty clay (SP)	57	7	4 4 4
10.62	10.5					
			CLAY, soft, light brown, some silt, little sand very dark brown mottled, occ. pebbles (CL)	100	8	1 1 1
9.12	12.0					
			SILT, very soft, sandy gray, some clay, occ. thin roots, reddish brown mottled. (ML)	100	9	1 1 1
				78	10	2 2 2
			some gray sand, fine grained	72	11	2 2 9
4.62	16.5					
			SAND, fine to coarse grained, brown and gray, some gravel, fine grained, sub-angular, little silt (SP)	56	12	5 8 10
				56	13	11 12 14
1.62	19.5					
▽			silty, little clay	78	14	9 10 11
0.12	21.0					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT RIO MANATI AT BARCELONETA HOLE NO. CB-MB- 1

Plate B-3

DRILLING LOG (Cont Sheet) 21.12 feet Hole No. CB-MB-1

PROJECT RIO MANATI AT BARCELONETA | INSTALLATION JACKSONVILLE DISTRICT | SHEET 2 OF 2 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
0.12	21.0					
-1.38	22.5			56	15	11 12 12
-2.88	24.0		GRAVEL, fine to medium grained, sub-angular to sub-rounded, gray, some sand, little silt (GP)	67	16	10 11 11
-4.38	25.5		SAND, fine to coarse grained, gray, some gravel, sub-rounded, little silt (SP)	67	17	14 14 14
			END 25.5 feet			

NOTES:

A. Soil classifications above are visual classifications using the Unified Soil Classification System.

B. After the visual classification was performed, Atterberg Limits and Water Contents were obtained from the requested samples and the results and final USCS classifications are shown below. Laboratory classification takes precedence over visual classification.

CB-MB-1		4	LL=31% PL=19% PI=12% (CL)
CB-MB-1		5	LL=33% PL=24% PI=9% (ML)

ENG FORM 1836-A JUN 67 (ER 1110-1-1801) GPO 1969 OF-626-603 | PROJECT RIO MANATI AT BARCELONETA | HOLE NO. CB-MB-1

Plate B-4

Hole No. CB-HB- 2

DRILLING LOG	DIVISION SOUTH ATLANTIC	INSTALLATION JACKSONVILLE DISTRICT	SHEET 1 OF 2 SHEETS
1. PROJECT: RIO HANATI AT BARCELONETA		10. SIZE AND TYPE OF BIT	
2. LOCATION (Coordinates or Grid): X= 464,530 Y= 224,490		11. DATUM FOR ELEVATION SHOWN (TBM or MSL): MSL	
3. DRILLING AGENCY: GEOCONSULT		12. MANUFACTURER'S DESIGNATION OF DRILL: CME- 45	
4. HOLE NO. (As shown on drawing title and file number): CB-HB- 2		13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: DISTURBED 17 / UNDISTURBED	
5. NAME OF DRILLER: T. Cabán		14. TOTAL NUMBER CORE BOXES	
6. DIRECTION OF HOLE: [X] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.		15. ELEVATION GROUND WATER: 6.64 feet	
7. THICKNESS OF OVERBURDEN: ft.		16. DATE HOLE: STARTED 5-9-90 / COMPLETED 5-9-90	
8. DEPTH DRILLED INTO ROCK: ----		17. ELEVATION TOP OF HOLE: 16.64 feet	
9. TOTAL DEPTH OF HOLE: 25.5 feet		18. TOTAL CORE RECOVERY FOR BORING: 76.29 %	
		19. SIGNATURE OF INSPECTOR: Kermit Schmidt, PE	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
16.64	0.0					BIT OR BARREL bls/6"
15.54	1.5		TOP SOIL, clay, very very stiff, grayish brown, silty, little sand occ. roots (CL)	56	1	140# hammer with 30" drop on 1-3/8" ID x 2" OD std. spl. spoon 4 8 8
9.14	7.5		CLAY, very stiff, grayish brown, little sand and silt, occ. pebbles, very dark brown mottled (CH)	56	2	10 12 16
				56	3	13 12 10
				50	4	6 7 6
				39	5	7 7 7
7.64	9.0		little to some sand	17	6	9 7 8
▽ 6.14	10.5		brown and gray, medium	89	7	2 2 2
			stiff	100	8	4 6 5
				89	9	2 4 4
1.64	15.0			89	10	4 5 6
			grayish brown mottled, medium	100	11	2 2 4
				89	12	5 5 5
-2.86	19.5			100	13	3 2 5
-4.36	21.0		SILT, very soft, brown, some very fine sand and clay (ML)	100	14	2 1 1

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE.

PROJECT RIO HANATI AT BARCELONETA | HOLE NO. CB-HB-2

Plate B-5

DRILLING LOG (Cont Sheet) | ELEVATION TOP OF HOLE 16.64 feet | Hole No. CB-MB-2

PROJECT: RIO HANATI AT BARCELONETA | INSTALLATION: JACKSONVILLE DISTRICT | SHEET 2 OF 2 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOV-ERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
-4.36	21.0					
			sandy, some clay	78	-15	1/1/2
-5.86	22.5		CLAY, stiff, brown and gray, little sand and silt, occ. rust colored oxidized veins. (CH)	89	16	3/5/5
			dark gray and olive	100	17	5/6/7
-8.86	25.5		END 25.5 feet			

NOTES:

A. Soil classifications above are visual classifications using the Unified Soil Classification System.

B. After the visual classification was performed, Atterberg Limits and Water Contents were obtained from the requested samples and the results and final USCS classifications are shown below. Laboratory classification takes precedence over visual classification.

CB-MB-2		8	LL=54% PL=26% PI=28% (CH)

ENG FORM 1836-A (ER 1110-1-1801) | PROJECT: RIO HANATI AT BARCELONETA | HOLE NO: CB-MB-2

Plate B-6

Hole No. CB-HB- 3

DRILLING LOG	Division SOUTH ATLANTIC	Installation JACKSONVILLE DISTRICT	Sheet 1 of 2 sheets

1. Project: RIO MANATI AT BARCELONETA		10. Size and type of bit	
2. Location (Coordinates or Station): X= 464,569 Y= 225,316		11. Datum for elevation shown (MSL or USC&GS): MSL	
3. Drilling agency: GEOCONSULT		12. Manufacturer's designation of drill: CME- 45	
4. Hole No. (As shown on drawing title and file number): CB-HB- 3		13. Total no. of overburden samples taken: Disturbed 17	Undisturbed
5. Name of driller: T. Cabán		14. Total number core boxes	
6. Direction of hole: ☒ Vertical ☐ Inclined ____ deg. from vert.		15. Elevation ground water: 5.65 feet	
7. Thickness of overburden		16. Date hole: Started 5-8-90	Completed 5-8-90
8. Depth drilled into rock: ——		17. Elevation top of hole: 13.65 feet	
9. Total depth of hole: 25.5 feet		18. Total core recovery for boring: 82.76 %	
		19. Signature of inspector: Kermit Schmidt, PE	

Elevation (a)	Depth (b)	Legend (c)	Classification of materials (Description) (d)	% Core Recovery (e)	Run or Sample No. (f)	Remarks (Drilling time, water loss, depth of weathering, etc., if significant) (g)
13.65	0.0					BIT OR BARREL bls/6"
12.15	1.5		TOP SOIL, clay, silty, brown little sand, occ. pebbles, thin roots. (CL)	39	1	140# hammer with 30" drop on 1-3/8" ID x 2" OD std. spl. spoon 6 5 6
10.65	3.0		CLAY, stiff, brown, some sand, occ. pebbles, thin roots (CL)	56	2	8 5 6
7.65	6.0		partly sandy.	67	3	5 7 4
				33	4	4 4 5
▽ 4.65	9.0		SAND, fine to coarse grained, brown, some gravel, fine grained, occ. silty clay lumps (SP)	78	5	3 4 3
				78	6	3 3 3
3.15	10.5		CLAY, medium, brown, some silt, little sand occ. roots, gray mottled (CH)	56	7	2 PUSH 1
2.15	11.5		SILT, medium, sandy, gray some clay (ML)	100	8	1 3 4
			SAND, fine grained, some silt, occ. pebbles. (SM)	100	9	3 3 3
-1.35	15.0		fine to coarse grained, little gravel, fine grained, sub-angular	100	10	6 10 11
			sand, fine to coarse grained, gray, some gravel, fine to medium grained, little silt.	100	11	5 6 7
				100	12	6 8 5
				100	13	15 12 10
-7.35	21.0			100	14	10 9 6

ENG FORM 1836 MAR 71 — PREVIOUS EDITIONS ARE OBSOLETE.

Project: RIO MANATI AT BARCELONETA — Hole No. CB-HB- 3

Plate B-7

DRILLING LOG (Cont Sheet)	ELEVATION TOP OF HOLE 13.65 feet	Hole No. CB-MB-3
PROJECT RIO MANATI AT BARCELONETA	INSTALLATION JACKSONVILLE DISTRICT	SHEET 2 OF 2 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
-7.35	21.0					
			more gravely	100	15	3 7 12
-8.85	22.5					
			some silt	100	16	11 12 13
				100	17	14 6 5
-11.85	25.5					

END 25.5 feet

NOTES:

A. Soil classifications above are visual classifications using the Unified Soil Classification System.

B. After the visual classification was performed, Atterberg Limits and Water Contents were obtained from the requested samples, and the results and final USCS classifications are shown below. Laboratory classification takes precedence over visual classification.

CB-MB-3		3	LL=32% PL=21% PI=11% (CL)

ENG FORM 1836-A JUN 67 (ER 1110-1-1801) GPO 1969 OF - 626-665

PROJECT RIO MANATI AT BARCELONETA HOLE NO. CB-MB-3

Plate B-8

Hole No. CB-HB- 4

DRILLING LOG	DIVISION SOUTH ATLANTIC	INSTALLATION JACKSONVILLE DISTRICT	SHEET 1 OF 2 SHEETS
1. PROJECT RIO MANATI AT BARCELONETA		10. SIZE AND TYPE OF BIT	
2. LOCATION (Coordinates or Stations) X= 464,569 Y= 226,107		11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MSL	
3. DRILLING AGENCY GEOCONSULT		12. MANUFACTURER'S DESIGNATION OF DRILL CME-45	
4. HOLE NO. (As shown on drawing title and file number) CB-HB-4		13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 17	UNDISTURBED
5. NAME OF DRILLER T. Cabán		14. TOTAL NUMBER CORE BOXES	
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.		15. ELEVATION GROUND WATER 0.70 feet	
7. THICKNESS OF OVERBURDEN ----		16. DATE HOLE STARTED 5-8-90 COMPLETED 5-8-90	
8. DEPTH DRILLED INTO ROCK ----		17. ELEVATION TOP OF HOLE 7.70 feet	
9. TOTAL DEPTH OF HOLE 25.5 feet		18. TOTAL CORE RECOVERY FOR BORING 74.29 %	
		19. SIGNATURE OF INSPECTOR Kermit Schmidt, PE	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
7.70	0.0					BIT OR BARREL bls/6"
			TOP SOIL, clay, stiff, brown, some sand and silt, occ. pebbles and thin roots (CL)	39	1	140# hammer with 30" drop on 1-3/8" ID x 2" OD std. spl. spoon 2 5 5
4.20	3.5		gray mottled	28	2	8 6 4
			CLAY, medium, brown and gray, silty, little sand, occ. roots (CL)	28	3	3 3 1
1.70	6.0			33	4	3 2 2
▽ -1.30	9.0		clay, very soft, slightly organic, silty, dark gray, little sand	56	5	1 1 1
				56	6	2 1 1
			very soft, trace shell fragments, partly sandy	100	7	PUSH PUSH PUSH
-4.30	12.0			100	8	PUSH 1 2
			SAND, very fine grained clayey, dark gray, some silt, occ. brown mottled (SC)	100	9	PUSH PUSH 2
-5.80	13.5		Sand, fine to medium grained, gray, some silt, trace clay	56	10	2 5 5
-7.30	15.0		sand, fine to medium grained, gray, little silt, trace gravel, fine grained, sub-angular	89	11	12 9 5
				89	12	3 1 2
				100	13	1 1 1
-12.80	20.5			89	14	1 1 1
-13.30	21.0					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT RIO MANATI AT. BARCELONETA HOLE NO. CB-HB-4

Plate B-9

DRILLING LOG (Cont Sheet) | ELEVATION TOP OF HOLE 7.70' feet | Hole No. CB-MB- 4

PROJECT RIO MANATI AT BARCELONETA | DISTRICT JACKSONVILLE DISTRICT | SHEET 2 OF 2 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	SIZE OF SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc. - if significant) g
-13.30	21.0					
-14.80	22.5		CLAY, very soft, gray, slightly organic, little sand, decayed fibrous matter, shelly (CL)	100	15	2 / 1 / 1
-16.30	24.0		SAND, fine grained, silty trace fibrous matter, gray, shelly (SM)	100	16	4 / 4 / 8
-17.80	25.5		sand, fine to coarse, little silt, gray trace gravel, fine grained, sub-angular, shelly	100	17	7 / 12 / 11
			END 25.5 feet			

NOTES:

A. Soil classifications above are visual classifications using the Unified Soil Classifications System.

B. After the visual classification was performed, Atterberg Limits and Water Contents were obtained from the requested samples and the results and final USCS classifications are shown below. Laboratory classification takes precedence over visual classification.

CB-MB-4		4	LL=48% PL=24% PI=24% (CL)
CB-MB-4		7	LL=56% PL=32% PI=24% (CH)

ENG FORM 1836-A (ER 1110-1-1801) | PROJECT RIO MANATI AT BARCELONETA | HOLE NO. CB-MB- 4

Plate B-10

Hole No. CB-HB- 5

DRILLING LOG	DIVISION SOUTH ATLANTIC	INSTALLATION JACKSONVILLE DISTRICT	SHEET 1 OF 2 SHEETS
1. PROJECT RIO HANATI AT BARCELONETA		10. SIZE AND TYPE OF BIT	
2. LOCATION (Coordinates or Station) X= 464,569 Y= 227,025		11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MSL	
3. DRILLING AGENCY GEOCONSULT		12. MANUFACTURER'S DESIGNATION OF DRILL CME- 55	
4. HOLE NO. (As shown on drawing title and file number) CB-HB-5		13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 17	UNDISTURBED
5. NAME OF DRILLER H. González		14. TOTAL NUMBER CORE BOXES	
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.		15. ELEVATION GROUND WATER -0.99 feet	
7. THICKNESS OF OVERBURDEN ——		16. DATE HOLE STARTED 5-9-90 COMPLETED 5-9-90	
8. DEPTH DRILLED INTO ROCK ——		17. ELEVATION TOP OF HOLE 11.01 feet	
9. TOTAL DEPTH OF HOLE 25.5 feet		18. TOTAL CORE RECOVERY FOR BORING 91.88	
		19. SIGNATURE OF INSPECTOR Kermit Schmidt, PE	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOV-ERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., of significance) g
11.01	0.0					BIT OR BARREL bls/6"
			TOP SOIL, clay, stiff, brown, some silt, little sand, occ. pebbles and thin roots (CL)	83	1	140# hammer with 30" drop on 1-3/8" ID x 2" OD std. spl. spoon 3 3 4
8.01	3.0		very stiff	100	2	8 9 11
			CLAY, very stiff, brown and dark brown, little sand and silt, occ. pebbles (CH)	100	3	12 12 14
				89	4	14 14 15
3.51	7.5			100	5	13 12 11
			CLAY, stiff, silty yellowish brown, some sand, occ. pebbles, very	100	6	3 4 5
2.01	9.0		dark brown mottled (CL)			
			soft to medium	100	7	2 2 2
0.51	10.5					
▽			CLAY, medium, yellowish brown, little sand and silt, occ. pebbles, very dark brown mottled (CH)	100	8	2 2 2
				100	9	3 3 1
				100	10	2 2 3
				100	11	3 3 3
				100	12	3 3 3
				100	13	3 3 3
-8.99	20.0		olive gray	100	14	2 1 1
-9.99	21.0		SILT, very soft, olive gray, sandy some clay (ML)			

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE.

PROJECT RIO HANATI AT BARCELONETA HOLE NO. CB-HB- 5

Plate B-11

DRILLING LOG (Cont Sheet) | ELEVATION TOP OF HOLE 11.01 feet | Hole No. CB-MB-5

PROJECT: RIO MANATI AT BARCELONETA | DISTRICT/AREA OFFICE: JACKSONVILLE DISTRICT | SHEET 2 OF 2 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOV. ERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
-9.99	21.0					
-11.49	22.5		CLAY, soft, gray, little sand and silt. (CH)	67	15	
			olive gray	56	16	
-14.49	25.5			67	17	

END 25.5 feet

NOTES:

A. Soil classifications above are visual classifications using the Unified Soil Classifications System.

B. After the visual classification was performed, Atterberg Limits and Water Contents were obtained from the requested samples and the results and final USCS classifications are shown below. Laboratory classification takes precedence over visual classification.

CB-MB-5		2	LL=59% PL=23% PI=35% (CH)
CB-MB-5		4	LL=52% PL=26% PI=26% (CH)

ENG FORM 1836-A (ER 1110-1-1801) | PROJECT: RIO MANATI AT BARCELONETA | HOLE NO: CB-MB-5

Plate B-12

Hole No. CB-MB- 6

DRILLING LOG	DIVISION SOUTH ATLANTIC	INSTALLATION JACKSONVILLE DISTRICT	SHEET 1 OF 2 SHEETS

1. PROJECT: RIO MANATI AT BARCELONETA
2. LOCATION: X= 464,678 Y= 227,796
3. DRILLING AGENCY: GEOCONSULT
4. HOLE NO.: CB-MB-6
5. NAME OF DRILLER: H. González
6. DIRECTION OF HOLE: [X] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN: ____
8. DEPTH DRILLED INTO ROCK: ____
9. TOTAL DEPTH OF HOLE: 25.5 feet
10. DATE HOLE: STARTED 5-16-90 COMPLETED 5-16-90
11. ELEVATION GROUND WATER: -16.03 feet
12. MANUFACTURER'S DESIGNATION OF DRILL: CME-55
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 17 UNDISTURBED
14. TOTAL NUMBER CORE BOXES
15. ELEVATION GROUND WATER: -16.03 feet
16. DATE HOLE: STARTED 5-16-90 COMPLETED 5-16-90
17. ELEVATION TOP OF HOLE: 5.97 feet
18. TOTAL CORE RECOVERY FOR BORING: 69.65
19. SIGNATURE OF INSPECTOR: Kermit Schmidt, PE

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
5.97	0.0'					BIT OR BARREL bls/6"
			TOP SOIL, clay, stiff, brown, some silt, little sand, thin roots, occ. pebbles. (CL)	56	1	140# hammer with 30" drop on 1-3/8" ID x 2" OD std. spl. spoon 6 7 7
2.97	3.0'		brown and dark grayish brown	39	2	7 6 6
			CLAY, medium, brown and gray, little sand and silt, occ. very dark brown mottled (CH)	56	3	4 4 3
			olive gray and brown, slightly organic	50	4	3 2 2
-1.53	7.5'		very soft	72	5	1 1 1
-3.03	9.0'		CLAY, soft, silty, gray, some sand occ. shell fragments (CL)	56	6	1 2 4
-4.53	10.5'		SAND, fine to coarse grained, gray, some gravel, fine to medium grained, sub-angular, little silt (SP)	83	7	5 7 9
-6.02	12.0'		trace silty clay lumps, brown	72	8	11 11 12
-7.53	13.5'		silty	89	9	3 4 7
-9.03	15.0'		little silt	72	10	6 10 10
			sand, fine to coarse grained, gray some gravel, fine grained, sub-angular, little silt.	72	11	8 11 10
				89	12	8 9 7
-13.53	19.5'			89	13	4 6 8
-15.03	21.0'		GRAVEL, fine to medium grained, gray, sand, fine to coarse grained, silty, trace clay. (GM)	89	14	6 9 12

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT RIO MANATI AT BARCELONETA HOLE NO. CB-MB-6

Plate B-13

DRILLING LOG (Cont Sheet) | ELEVATION TOP OF HOLE 5.97 feet | Hole No. CB-MB-6

PROJECT RIO MANATI AT BARCELONETA | INSTALLATION JACKSONVILLE DISTRICT | SHEET 2 OF 2 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	SOIL OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
-15.03	21.0					
▽ -16.53	22.5		SAND, fine to coarse grained, gray, silty, some gravel, fine grained, trace clay (SM)	50	~15	11 11 14
			occ. shell fragments	78	16	12 12 9
-19.53	25.5			72	17	8 5 4
			END 25.5 feet			

NOTES:

A. Soil classifications above are visual classifications using the Unified Soil Classifications System.

B. After the visual classification was performed, Atterberg Limits and Water Contents were obtained from the requested samples and the results and final USCS classifications are shown below. Laboratory classifications takes precedence over visual classification.

CB-MB-6		4	LL=61% PL=24% PI=37% (CH)

ENG FORM 1836-A (ER 1110-1-1801) | PROJECT RIO MANATI AT BARCELONETA | HOLE NO. CB-MB-6

Plate B-14

Hole No. CB-HB- 7

DRILLING LOG	DIVISION: SOUTH ATLANTIC	INSTALLATION: JACKSONVILLE DISTRICT	SHEET 1 of 2 SHEETS
1. PROJECT: RIO HANATI AT BARCELONETA		10. SIZE AND TYPE OF BIT	
2. LOCATION: X=464,678 Y=228,623		11. DATUM FOR ELEVATION SHOWN: MSL	
3. DRILLING AGENCY: GEOCONSULT		12. MANUFACTURER'S DESIGNATION OF DRILL: CME-55	
4. HOLE NO.: CB-HB-7		13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: DISTURBED 17 / UNDISTURBED	
5. NAME OF DRILLER: H. González		14. TOTAL NUMBER CORE BOXES	
6. DIRECTION OF HOLE: ☒ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.		15. ELEVATION GROUND WATER: 6.27 feet	
7. THICKNESS OF OVERBURDEN		16. DATE HOLE: STARTED 5-7-90 / COMPLETED 5-7-90	
8. DEPTH DRILLED INTO ROCK: ----		17. ELEVATION TOP OF HOLE: 10.27 feet	
9. TOTAL DEPTH OF HOLE: 25.5 feet		18. TOTAL CORE RECOVERY FOR BORING: 60.47 %	
		19. SIGNATURE OF INSPECTOR: Kermit Schmidt, PE	

ELEVATION	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS (Description)	% CORE RECOVERY	BOS OR SAMPLE NO.	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant)	
10.27	0.0					BIT OR BARREL bls/6"	
			TOP SOIL, clay, stiff, brown, silty, little sand, roots (CL)	67	1	140# hammer with 30" drop on 1-3/8" ID x 2" OD std. spl. spoon	3 4 4
				100	2		4 6 7
▽ 5.77	4.5			100	3		5 5 5
			CLAY, stiff, silty, brown, some sand, occ. pebbles, occ. dark brown mottled (CL)	78	4		4 4 4
			soft to medium	100	5		2 2 2
1.27	9.0		gray mottled	67	6		2 3 3
-0.23	10.5		SILT, very soft, clayey, slightly organic; gray, some sand, brown mottled (ML)	33	7	PUSH PUSH	1
			SAND, fine to coarse grained, gray, some gravel, fine grained, sub-angular, little silt, trace clay (SM)	100	8		3 5 8
-1.73	12.0			78	9		6 7 6
-3.23	13.5		very silty	100	10		6 6 6
-4.73	15.0		silty	22	11		2 2 4
-6.23	16.5		CLAY, soft, very sandy, some silt and gravel medium grain (CL)	22	12		2 2 2
-7.73	18.0		GRAVEL, fine grain, gray, sand, fine grain, silty trace clay (GM)	17	13		2 2 2
			SAND, fine to coarse grained, clayey, gray some silt, occ. shell fragments (SC)	22	14		2 2 2
-10.73	21.0						

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT: RIO HANATI AT BARCELONETA HOLE NO. CB-HB-7

Plate B-15

DRILLING LOG (Cont Sheet)	ELEVATION TOP OF HOLE 10.27 feet	Hole No. CB-MB- 7
PROJECT RIO MANATI AT BARCELONETA	INSTALLATION JACKSONVILLE DISTRICT	SHEET 2 OF 2 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
-10.73	21.0					
-12.23	22.5			22	15	2 2 2
-13.73	24.0		SAND, fine to coarse grained, gray, little silt, trace clay, occ. shell fragments (SP)	22	16	4 5 5
-15.23	25.5		shelly	78	17	9 9 9

END 25.5 feet

NOTES:

A. Soil classifications above are visual classifications using the Unified Soil Classifiction System.

B. After the visual classification was performed, Atterberg Limits and Water Contents were obtained from the requested samples and the results and final USCS classifications are shown below. Laboratory classification takes precedence over visual classification.

CB-MB-7	5	LL=46% PL=23% PI=23% (CL)

ENG FORM 1836-A JUN 67 (ER 1110-1-1801) GPO 1968 OF-626-603

PROJECT RIO MANATI AT BARCELONETA HOLE NO. CB-MB-7

Plate B-16

Hole No. CB-HB- 8

DRILLING LOG	DIVISION SOUTH ATLANTIC	INSTALLATION JACKSONVILLE DISTRICT	SHEET 1 OF 2 SHEETS

1. PROJECT	RIO MANATI AT BARCELONETA
2. LOCATION (Coordinates or Station)	X= 464,563 Y= 229,403
3. DRILLING AGENCY	GEOCONSULT
4. HOLE NO. (As shown on drawing title and file number)	CB-HB-8
5. NAME OF DRILLER	T. Cabán
6. DIRECTION OF HOLE	☒ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN	----
8. DEPTH DRILLED INTO ROCK	----
9. TOTAL DEPTH OF HOLE	25.5 feet
10. SIZE AND TYPE OF BIT	
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	MSL
12. MANUFACTURER'S DESIGNATION OF DRILL	CME-45
13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN	DISTURBED 17 / UNDISTURBED
14. TOTAL NUMBER CORE BOXES	
15. ELEVATION GROUND WATER	0.23 feet
16. DATE HOLE	STARTED 5-7-90 / COMPLETED 5-7-90
17. ELEVATION TOP OF HOLE	8.23 feet
18. TOTAL CORE RECOVERY FOR BORING	94.82 %
19. SIGNATURE OF INSPECTOR	Kermit Schmidt, PE

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
8.23	0.0					BIT OR BARREL bls/6"
6.73	1.5		TOP SOIL, clay, very stiff, brown, silty, little sand, occ. pebbles, many thin roots (CL)	89	1	140# hammer with 30" drop on 1-3/8" ID x 2" OD std. spl. spoon 9 7 9
5.23	3.0		occ. roots	89	2	4 7 9
3.73	4.5		stiff	100	3	6 5 6
2.23	6.0		CLAY; medium, yellowish brown, little sand and silt, occ. thin roots, dark brown mottled (CH)	100	4	6 3 2
0.73	7.5		CLAY, very soft, gray, silty, slightly organic, little sand (CL)	100	5	PUSH PUSH PUSH
			SAND, fine to coarse grained, gray, some gravel, fine grained, little silt (SP)	100	6	3 4 5
				100	7	4 5 6
				100	8	7 10 12
				89	9	10 8 5
				89	10	9 13 13
				89	11	13 7 5
-9.77	18.0			89	12	6 8 8
-11.27	19.5		GRAVEL, fine to medium grained, gray, sand, fine to coarse grained, some silt, little clay (GM)	89	13	8 5 5
-12.77	21.0		SAND, coarse grained, gray, some gravel, fine grained, little silt. (SP)	100	14	11 5 3

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE.

PROJECT RIO MANATI AT BARCELONETA HOLE NO. CB-HB-8

Plate B-17

DRILLING LOG (Cont Sheet) | ELEVATION TOP OF HOLE: 8.23 feet | Hole No. CB-MB-8

PROJECT: RIO MANATI AT BARCELONETA | INSTALLATION: JACKSONVILLE DISTRICT | SHEET 2 of 2 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	SIZE OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
-12.77	21.0					
				89	15	8 8 10
				100	16	3 6 7
				100	17	6 8 8
-17.27	25.5		END 25.5 feet			

NOTES:

A. Soil classifications above are visual classifications using the Unified Soil Classifications System.

B. After the visual classification was performed, Atterberg Limits and Water Contents were obtained from the requested samples and the results and final USCS classifications are shown below. Laboratory classification takes precedence over visual classification.

CB-MB-8		5	LL=51% PL=23% PI=28% (CH)

ENG FORM 1836-A JUN 67 (ER 1110-1-1801) GPO 1986 O-626-669

PROJECT: RIO MANATI AT BARCELONETA | HOLE NO. CB-MB-8

Plate B-18

Hole No. CB-HB-9

DRILLING LOG	Division: SOUTH ATLANTIC	Installation: JACKSONVILLE DISTRICT	Sheet 1 of 2 Sheets
1. Project: RIO MANATI AT BARCELONETA		10. Size and Type of Bit	
2. Location (Coordinates or Station): X= 464,098 Y= 230,230		11. Datum for Elevation Shown (ft or m): MSL	
3. Drilling Agency: GEOCONSULT		12. Manufacturer's Designation of Drill: CME- 45	
4. Hole No. (As shown on drawing title and file number): CB-HB- 9		13. Total No. of Overburden Samples Taken: Disturbed 17 / Undisturbed	
5. Name of Driller: T. Cabán		14. Total Number Core Boxes	
6. Direction of Hole: ☒ Vertical ☐ Inclined ____ Deg. From Vert.		15. Elevation Ground Water: -2.92 feet	
7. Thickness of Overburden		16. Date Hole: Started 5-7-90 Completed 5-7-90	
8. Depth Drilled Into Rock: ----		17. Elevation Top of Hole: 6.08 feet	
9. Total Depth of Hole: 25.5 feet		18. Total Core Recovery for Boring: 85.35 %	
		19. Signature of Inspector: Kermit Schmidt, PE	

Elevation (a)	Depth (b)	Legend (c)	Classification of Materials (Description) (d)	% Core Recovery (e)	Box or Sample No. (f)	Remarks (Drilling time, water loss, depth of weathering, etc., if significant) (g)
6.08	0.0					BIT OR BARREL bls/6"
4.58	1.5		TOP SOIL, clay, stiff, brown, some silt, little sand, occ. roots (CL)	44	1	140# hammer with 30" drop on 1-3/8" ID x 2" OD std. spl. spoon 5 5 5
1.58	4.5		CLAY, stiff, brown and gray, little sand and silt, occ. roots, very dark brown mottled. (CH)	56	2	4 4 4
				28	3	4 2 2
0.58	5.5		SILT, very soft, sandy, gray, some clay, slightly organic (ML)	78	4	2 PUSH 1
			SAND, fine grained, gray, some silt, trace clay (SM)	100	5	PUSH 3 7
▽ -4.42	10.9			100	6	2 1 2
				100	7	5 7 9
			little gravel, fine grained	100	8	8 9 8
				100	9	4 5 6
-8.92	15.0			100	10	10 8 7
-10.42	16.5		fine to coarse grained	100	11	8 29 44
-11.92	18.0		silty, some fine gravel, fine grained	100	12	39 24 14
				89	13	20 19 19
-14.92	21.0			89	14	1 4 9

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE.

Project: RIO MANATI AT BARCELONETA | Hole No. CB-HB-9

Plate B-19

DRILLING LOG (Cont Sheet) ELEVATION TOP OF HOLE 6.08 feet Hole No. CB-MB- 9

PROJECT RIO MANATI AT BARCELONETA | INSTALLATION JACKSONVILLE DISTRICT | SHEET 2 OF 2 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOV. ERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling rate, water loss, depth of weathering, etc., if significant) g	
-14.92	21.0						
				89	15		10
-16.42	22.5						10
							16
			SAND, coarse to fine grained, little silt, gray, occ. shell fragments (SP)	78	16		20
-17.92	24.0						26
							30
				100	17		10
-19.42	25.5		some silt				43
							38
			END 25.5 feet				
			NOTES:				
			A. Soil classifications above are visual classifications using the Unified Soil Classification System.				
			B. After the visual classification was performed, Atterberg Limits and Water Contents were obtained from the requested samples and the results and final USCS classifications are shown below. Laboratory classification takes precedence over visual classification.				
			CB-MB-9		3	LL=64% PL=29% PI=35% (CH)	

ENG FORM 1836-A (ER 1110-1-1801) PROJECT RIO MANATI AT BARCELONETA HOLE NO. CB-MB-9

Plate B-20

Hole No. CB-NB- 10

DRILLING LOG	DIVISION SOUTH ATLANTIC	INSTALLATION JACKSONVILLE DISTRICT	SHEET 1 OF 2 SHEETS
1. PROJECT: RIO MANATI AT BARCELONETA		10. SIZE AND TYPE OF BIT	
2. LOCATION (Coordinates or Station): X= 463,343 Y= 230,574		11. DATUM FOR ELEVATION SHOWN (TBM or MSL): MSL	
3. DRILLING AGENCY: GEOCONSULT		12. MANUFACTURER'S DESIGNATION OF DRILL: CME-45	
4. HOLE NO. (As shown on drawing title and file number): CB-NB- 10		13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: DISTURBED 17 / UNDISTURBED	
5. NAME OF DRILLER: T. Cabán		14. TOTAL NUMBER CORE BOXES	
6. DIRECTION OF HOLE: [X] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.		15. ELEVATION GROUND WATER: -6.81 feet	
7. THICKNESS OF OVERBURDEN		16. DATE HOLE: STARTED 5-2-90 / COMPLETED 5-2-90	
8. DEPTH DRILLED INTO ROCK		17. ELEVATION TOP OF HOLE: 2.19 feet	
9. TOTAL DEPTH OF HOLE: 25.5 feet		18. TOTAL CORE RECOVERY FOR BORING: 73.71 %	
		19. SIGNATURE OF INSPECTOR: Kermit Schmidt, PE	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
2.19	0.0					BIT OR BARREL bls/6"
0.69	1.5		TOP SOIL, clay, stiff brown, some silt, little sand, occ. pebbles, thin roots (CL)	78	1	140# hammer with 30" drop on 1-3/8" ID x 2" OD std. spl. spoon. 5 / 5 / 7
-0.81	3.0		CLAY, stiff to very stiff, brown and gray, little sand and silt, occ. very dark brown mottled (CH)	33	2	7 / 8 / 7
			yellowish brown mottled	100	3	7 / 6 / 5
				56	4	7 / 7 / 7
				6	5	5 / 3 / 4
▽				78	6	3 / 3 / 2
				56	7	1 / 2 / 3
				100	8	PUSH / PUSH / 3
-11.31	13.5			100	9	PUSH / 2 / 3
			CLAY, very soft, dark gray, slightly organic, silty, little sand, occ brown mottled (CH)	56	10	2 / 1 / 1
-14.31	16.5			56	11	PUSH / PUSH / PUSH
-15.81	18.0		SILT, soft, clayey, gray, slightly organic, some sand, occ. brown mottled (ML)	78	12	PUSH / 2 / 2
			SAND, fine grained, gray, little silt (SP)	89	13	9 / 11 / 12
-18.81	21.0			89	14	8 / 7 / 5

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT RIO MANATI AT BARCELONETA HOLE NO. CB-NB- 10

Plate B-21

DRILLING LOG (Cont Sheet)	ELEVATION TOP OF HOLE 2.19 feet	Hole No. CB-MB- 10
PROJECT RIO MANATI AT BARCELONETA	INSTALLATION JACKSONVILLE DISTRICT	SHEET 2 OF 2 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
-18.81	21.0					
-20.31	22.5			89	15	2 3 5
			little gravel, fine grained	100	16	3 4 10
-23.31	25.5			89	17	4 6 9

END 25.5 feet

NOTES:

A. Soil classifications above are visual classifications using the Unified Soil Classifications System.

B. After the visual classification was performed, Atterberg Limits and Water Contents were obtained from the requested samples and the results and final USCS classifications are shown below. Laboratory classification takes precedence over visual classification.

CB-MB-10		10	LL=51% PL=23% PI=28% (CH)
CB-MB-10		11	LL=56% PL=24% PI=32% (CH)

ENG FORM 1836-A (ER 1110-1-1801) GPO 1969 OF-836-001 | PROJECT RIO MANATI AT BARCELONETA | HOLE NO. CB-MB-

Plate B-22

Hole No. CB-HB-11

DRILLING LOG	DIVISION SOUTH ATLANTIC	INSTALLATION JACKSONVILLE DISTRICT	SHEET 1 OF 2 SHEETS
1. PROJECT RIO HANATI AT BARCELONETA		10. SIZE AND TYPE OF BIT	
2. LOCATION (Coordinates or Station) X=462,708 Y= 230,679		11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MSL	
3. DRILLING AGENCY GEOCONSULT		12. MANUFACTURER'S DESIGNATION OF DRILL CME- 45	
4. HOLE NO. (As shown on drawing title and file number) CB-HB- 11		13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: DISTURBED 17	UNDISTURBED
5. NAME OF DRILLER T. Cabán		14. TOTAL NUMBER CORE BOXES	
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.		15. ELEVATION GROUND WATER 3.62 feet	
7. THICKNESS OF OVERBURDEN ---		16. DATE HOLE: STARTED 5-1-90 COMPLETED 5-1-90	
8. DEPTH DRILLED INTO ROCK ---		17. ELEVATION TOP OF HOLE 7.62 feet	
9. TOTAL DEPTH OF HOLE 25.5 feet		18. TOTAL CORE RECOVERY FOR BORING 75.59 %	
		19. SIGNATURE OF INSPECTOR Kermit Schmidt, PE	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	SPT OR SAMPLE NO. f	REMARKS (Drilling rate, water loss, depth of weathering, etc., if significant) g
7.62	0.0					BIT OR BARREL bls/6"
6.12	1.5		TOP SOIL, clay, stiff, yellowish brown and dark grayishbrown, little sand and silt, occ. roots (CH)	89	1	140# hammer with 30" drop on 1-3/8" ID x 2" OD std. spl. spoon 7 5 6
4.62	3.0		CLAY, stiff yellowish brown and gray, little sand and silt, occ. pebbles (CH)	78	2	6 5 4
3.12	4.5		clay, soft, dark gray, some silt, slightly organic, little sand occ. olive brown mottled	78	3	3 2 2
▽			SAND, very silty, fine grained, gray, some clay,	89	4	PUSH PUSH PUSH
			sand, fine grained, some silt toward bottom of sample (SM)	100	5	3 4 4
			Sand, fine grained, silty gray, trace clay	89	6	3 3 2
-2.88	10.5			22	7	PUSH 1 1
-4.38	12.0		some silt	89	8	2 2 2
-5.88	13.5		very silty, trace clay	22	9	1 1 PUSH
-7.38	15.0		SILT, very soft, sandy, gray, some clay (ML)	28	10	1 PUSH PUSH
-8.88	16.5		little clay	89	11	1 1 1
-11.88	19.5		some sand, little clay	78	12	2 1 1
				89	13	1 2 1
-13.38	21.0		SAND, fine to coarse grained, silty, some gravel, fine to medium grained, trace clay (SP)	89	14	10 10 10

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT RIO HANATI AT BARCELONETA HOLE NO. CB-HB-11

Plate B-23

DRILLING LOG (Cont Sheet) | ELEVATION TOP OF HOLE 7.62 feet | Hole No. CB-MB-11

PROJECT RIO MANATI AT BARCELONETA | ORGANIZATION JACKSONVILLE DISTRICT | SHEET 2 OF 2 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOV-ERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
-13.38	21.0		some silt	89	15	12 8 11
				89	16	8 8 8
-16.38	24.0		gravelly, fine grained	78	17	10 9 13
-17.88	25.5		END 25.5 feet			

NOTES:

A. Soil classifications above are visual classifications using the Unified Soil Classifications System.

ENG FORM 1836-A (ER 1110-1-1801) | PROJECT RIO MANATI AT BARCELONETA | HOLE NO. CB-MB-11

Plate B-24

Hole No. CB-MB-12

DRILLING LOG	DIVISION SOUTH ATLANTIC	INSTALLATION JACKSONVILLE DISTRICT	SHEET 1 OF 2 SHEETS
1. PROJECT RIO MANATI AT BARCELONETA		10. SIZE AND TYPE OF BIT	
2. LOCATION (Coordinates or Station) X= 461,939 Y= 230,764		11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MSL	
3. DRILLING AGENCY CEOCONSULT		12. MANUFACTURER'S DESIGNATION OF DRILL CME-45	
4. HOLE NO. (As shown on drawing title and file number) CB-MB-12		13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: DISTURBED 17; UNDISTURBED	
5. NAME OF DRILLER T. Cabán		14. TOTAL NUMBER CORE BOXES	
6. DIRECTION OF HOLE [X] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.		15. ELEVATION GROUND WATER -3.28 feet	
7. THICKNESS OF OVERBURDEN ____		16. DATE HOLE STARTED 5-2-90 COMPLETED 5-2-90	
8. DEPTH DRILLED INTO ROCK ____		17. ELEVATION TOP OF HOLE 4.72 feet	
9. TOTAL DEPTH OF HOLE 25.5 feet		18. TOTAL CORE RECOVERY FOR BORING 60.94 %	
		19. SIGNATURE OF INSPECTOR Kermit Schmidt, PE	

ELEVATION	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS (Description)	% CORE RECOVERY	BOX OR SAMPLE NO.	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant)	
4.72	0.0					BIT OR BARREL	
						blst6"	
3.22	1.5		TOP SOIL, clay, stiff, grayish brown, little sand and silt, occ. very dark brown mottled (CH)	17	1	140# hammer with 30" drop on 1-3/8" ID x 2" OD std. spl. spoon	4 6 7
1.72	3.0		CLAY, very stiff, yellwoish brown, little sand and silt, occ. very dark brown mottled (CH)	22	2		9 9 9
-1.28	6.0		brown and grayish brown	33	3		7 6 5
				56	4		2 3 4
-2.78	7.5		occ. rust colored oxidized nodules	44	5		7 5 4
-4.28	9.0		very soft, brown and gray.	100	6		2 1 1
			grayish brown.	56	7		1 PUSH PUSH
				56	8		1 PUSH PUSH
-8.78	13.5			100	9		2 1 1
-10.28	15.0		olive gray, slightly organic	78	10		PUSH PUSH PUSH
-13.28	18.0		CLAY, very soft, gray, very silty, slightly organic, partly sandy (CL)	28	11		PUSH PUSH 1
				100	12		2 2 2
-14.78	19.5		SILT, very soft, gray, slightly organic, sandy, some clay (ML)	89	13		PUSH PUSH PUSH
-16.28	21.0		partly very sandy	56	14		1 2 2

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT RIO MANATI AT BARCELONETA HOLE NO. CB-MB-12

Plate B-25

DRILLING LOG (Cont Sheet) | ELEVATION TOP OF HOLE 4.72 feet | Hole No. CB-MB-12

PROJECT RIO MANATI AT BARCELONETA | INSTALLATION JACKSONVILLE DISTRICT | SHEET 2 OF 2 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Unified) d	% CORE RECOV. e	BOR OR SAMPLE NO. f	REMARKS (Drilling rate, water loss, depth of weathering, etc., if significant) g
-16.28	21.0					
-17.78	22.5		SAND, fine grained, silty gray, trace clay (SM)	89	15	4 4 4
-19.28	24.0		SILT, medium, sandy, gray, little clay. (ML)	56	16	1 4 3
-20.78	25.5		SAND, fine gravel, silty, gray, trace clay (SM)	56	17	4 5 10
			END 25.5 feet			

NOTES:

A. Soil classifications above are visual classifications using the Unified Soil Classifications System.

B. After the visual classification was performed, Atterberg Limits and Water Contents were obtained from the requested samples and the results and final USCS classifications are shown below.

CB-MB-12		7	LL=66% PL=26% PI=40 (CH)

ENG FORM 1836-A (ER 1110-1-1801) | PROJECT RIO MANATI AT BARCELONETA | HOLE NO. CB-MB-12

Plate B-26.

Hole No. CB-MB-13

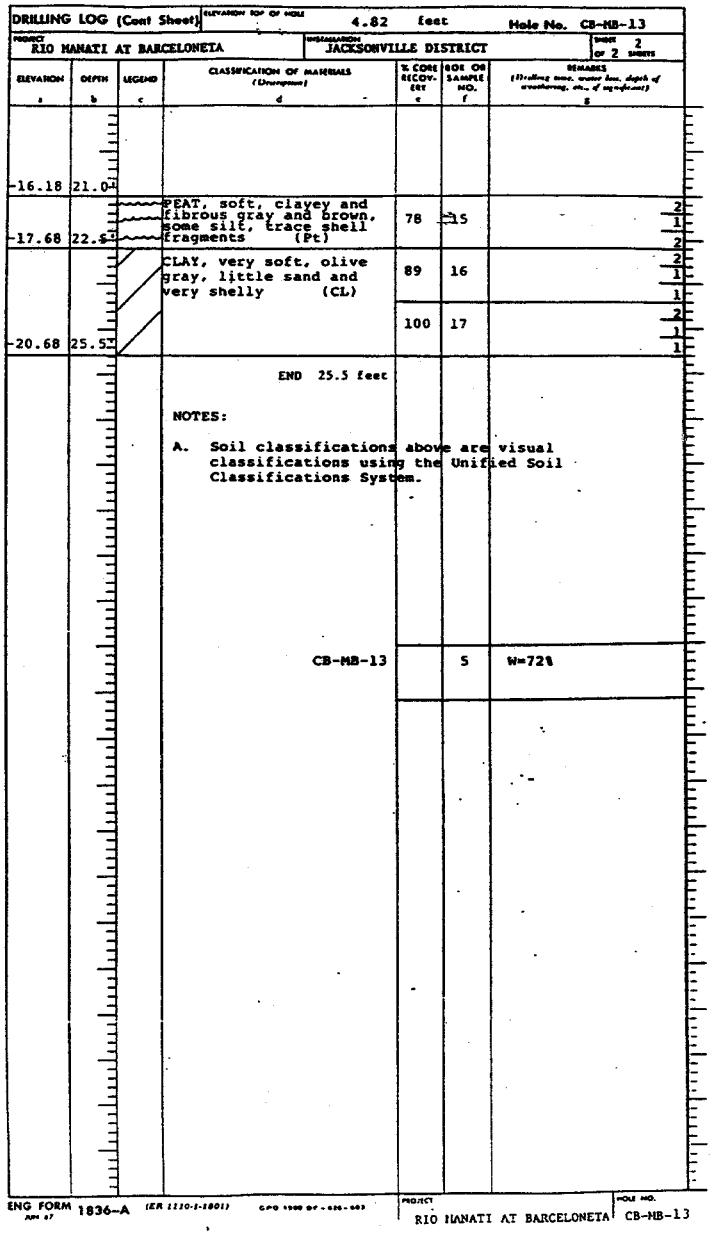
DRILLING LOG	DIVISION SOUTH ATLANTIC	INSTALLATION JACKSONVILLE DISTRICT	SHEET 1 OF 2 SHEETS

1. PROJECT: RIO MANATI AT BARCELONETA
2. LOCATION (Coordinates or Station): X= 461,890 Y= 230,433
3. DRILLING AGENCY: GEOCONSULT
4. HOLE NO. (As shown on drawing title and file number): CB-MB-13
5. NAME OF DRILLER: T. Cabán
6. DIRECTION OF HOLE: [X] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN: ____
8. DEPTH DRILLED INTO ROCK: ____
9. TOTAL DEPTH OF HOLE: 25.5 feet
10. SIZE AND TYPE OF BIT:
11. DATUM FOR ELEVATION SHOWN (TBM or MSL): MSL
12. MANUFACTURER'S DESIGNATION OF DRILL: CME-45
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 17 / UNDISTURBED
14. TOTAL NUMBER CORE BOXES:
15. ELEVATION GROUND WATER: -3.18 feet
16. DATE HOLE: STARTED 5-3-90 / COMPLETED 5-3-90
17. ELEVATION TOP OF HOLE: 4.82 feet
18. TOTAL CORE RECOVERY FOR BORING: 72.0 %
19. SIGNATURE OF INSPECTOR: Kermit Schmidt, PE

ELEVATION	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS (Description)	% CORE RECOV. (RQD)	BOX OR SAMPLE NO.	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant)
4.82	0.0'					BIT OR BARREL bls/6"
3.32	1.5'		TOP SOIL, clay, stiff, brown, little sand and silt, occ. roots (CH)	33	1	140# hammer with 30" drop on 1-3/8" ID x 2" OD std. spl. spoon 3 3 3
1.82	3.0'		CLAY, stiff, yellowish brown, little sand and silt, occ. pebbles, gray and very dark brown mottled (CH)	100	2	5 5 4
0.32	4.5'		gray and brownish yellow	83	3	4 3 3
-1.18	6.0'		medium	50	4	4 3 3
-2.68	7.5'		soft	100	5	2 1 1
-4.18	9.0'		gray and dark grayish brown, slightly organic	56	6	2 1 2
			gray and brown	56	7	1 2 1
-7.18	12.0'			50	8	2 2 2
-8.68	13.5'		silty, some sand	89	9	1 1 1
			some silt, little sand	50	10	PUSH 2 1
				56	11	1 1 1
				56	12	1 1 1
				89	13	1 1 1
-16.18	21.0'			89	14	1 1 2

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT RIO MANATI AT BARCELONETA HOLE NO. CB-MB-13

Plate B-27



DRILLING LOG (Cont Sheet) | ELEVATION TOP OF HOLE 4.82 feet | Hole No. CB-MB-13

PROJECT: RIO MANATI AT BARCELONETA | ORGANIZATION: JACKSONVILLE DISTRICT | SHEET 2 OF 2 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	SOIL OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
-16.18	21.0					
-17.68	22.5		PEAT, soft, clayey and fibrous gray and brown, some silt, trace shell fragments (Pt)	78	15	2 1 2
-20.68	25.5		CLAY, very soft, olive gray, little sand and very shelly (CL)	89	16	2 1 1
				100	17	2 1 1
			END 25.5 feet			
			NOTES:			
			A. Soil classifications above are visual classifications using the Unified Soil Classifications System.			
			CB-MB-13		S	W=72%

ENG FORM 1836-A (ER 1110-1-1801) | PROJECT: RIO MANATI AT BARCELONETA | HOLE NO. CB-MB-13

Plate B-28

Hole No. CB-HB-14

DRILLING LOG	DIVISION: SOUTH ATLANTIC	INSTALLATION: JACKSONVILLE DISTRICT	SHEET 1 OF 2 SHEETS

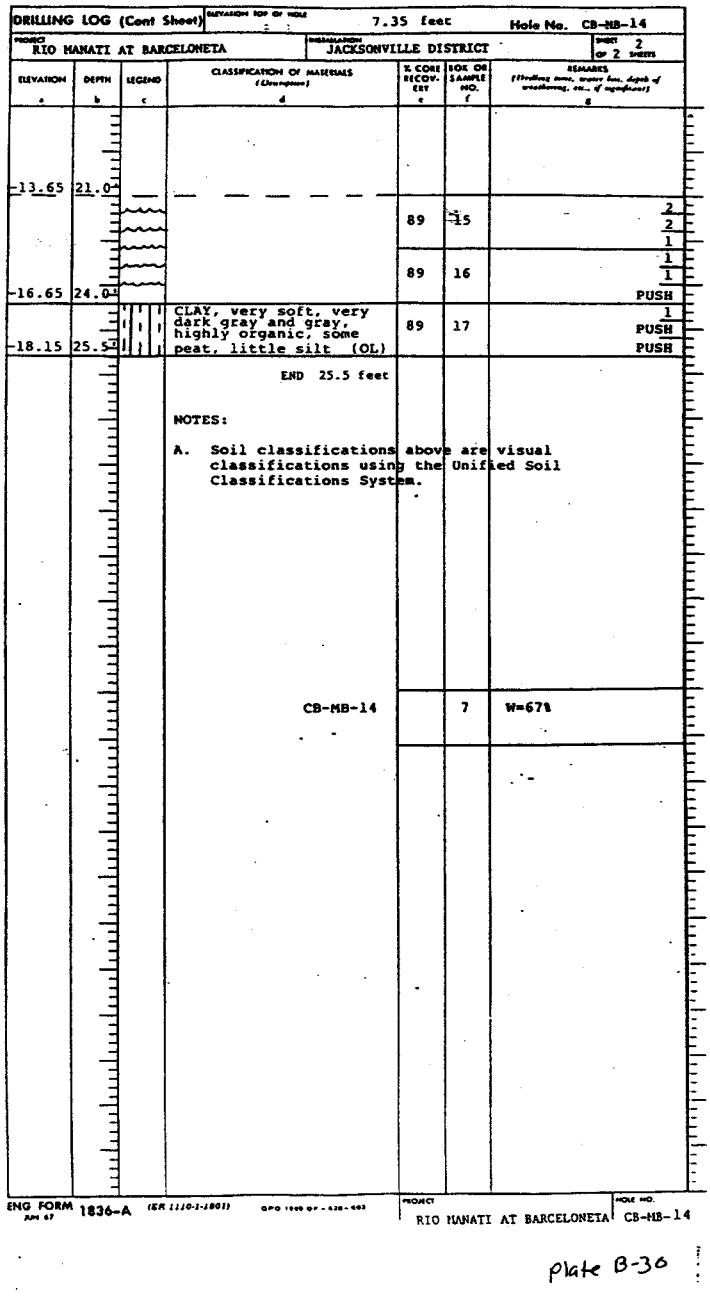
1. PROJECT: RIO MANATI AT BARCELONETA	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station): X= 461,758 Y= 229,649	11. DATUM FOR ELEVATION SHOWN (TBM or MSL): MSL
3. DRILLING AGENCY: GEOCONSULT	12. MANUFACTURER'S DESIGNATION OF DRILL: CME-45
4. HOLE NO. (As shown on drawing title and file number): CB-HB-14	13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: DISTURBED 17; UNDISTURBED
5. NAME OF DRILLER: T. Cabán	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE: ☒ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER: -0.65 feet
7. THICKNESS OF OVERBURDEN: ——	16. DATE HOLE: STARTED 5-3-90; COMPLETED 5-3-90
8. DEPTH DRILLED INTO ROCK: ——	17. ELEVATION TOP OF HOLE: 7.35 feet
9. TOTAL DEPTH OF HOLE: 25.5 feet	18. TOTAL CORE RECOVERY FOR BORING: 75.0 %
	19. SIGNATURE OF INSPECTOR: Kermit Schmidt, PE

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
7.35	0.0					BIT OR BARREL
						blS/6"
5.85	1.5		TOP SOIL, clay, medium, brown, little sand and silt, occ. roots (CH)	89	1	140# hammer with 30" drop on 1-3/8" ID x 2" OD std. spl. spoon 2 2 4
4.35	3.0		CLAY, stiff, yellowish brown and gray, little sand and silt, occ. pebbles (CH)	56	2	4 5 5
			soft to medium	56	3	1 1 3
				50	4	2 2 2
-0.15	7.5			56	5	2 1 2
▽ -1.65	9.0		brown, olive gray and dark gray, slightly organic	100	6	1 1 1
-3.15	10.5		olive gray, very soft, trace fibrous matter.	100	7	2 1 PUSH
-4.65	12.0		SILT, very soft, olive gray, sandy some clay (ML)	39	8	2 2 PUSH
-6.15	13.5		CLAY, very soft, olive gray, little sand and silt, trace fibrous matter (CH)	78	9	PUSH 2 1
			little fibrous matter	100	10	PUSH 1 1
				56	11	PUSH PUSH PUSH
				72	12	PUSH PUSH PUSH
-12.15	19.5		little fibrous matter	100	13	1 1 1
-13.65	21.0		PEAT, soft, fibrous and silty, dark brown, little clay (Pt)	56	14	1 1 2

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE.

PROJECT: RIO MANATI AT BARCELONETA | HOLE NO. CB-HB-14

Plate B-29



DRILLING LOG (Cont Sheet) — ELEVATION TOP OF HOLE: 7.35 feet — Hole No. CB-MB-14

PROJECT: RIO MANATI AT BARCELONETA — DISTRICT: JACKSONVILLE DISTRICT — SHEET 2 OF 2 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOV-ERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
-13.65	21.0					
				89	15	2 2 1
				89	16	1 1 PUSH
-16.65	24.0					
			CLAY, very soft, very dark gray and gray, highly organic, some peat, little silt (OL)	89	17	1 PUSH
-18.15	25.5					PUSH
			END 25.5 feet			
			NOTES:			
			A. Soil classifications above are visual classifications using the Unified Soil Classifications System.			
			CB-MB-14		7	W=67%

ENG FORM 1836-A JUN 67 (ER 1110-1-1801) GPO 1968 O-320-403

PROJECT: RIO MANATI AT BARCELONETA — HOLE NO. CB-MB-14

Plate B-30

Hole No. CB-HB-15

DRILLING LOG	DIVISION SOUTH ATLANTIC	INSTALLATION JACKSONVILLE DISTRICT	SHEET 1 of 2 SHEETS
1. PROJECT RIO MANATI AT BARCELONETA		10. SIZE AND TYPE OF BIT	
2. LOCATION (Coordinates or Stations) X= 461,578 Y= 228,518		11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MSL	
3. DRILLING AGENCY GEOCONSULT		12. MANUFACTURER'S DESIGNATION OF DRILL CME-45	
4. HOLE NO. (As shown on drawing title and file number) CB-HB- 15		13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: DISTURBED 17 / UNDISTURBED	
5. NAME OF DRILLER T. Cabán		14. TOTAL NUMBER CORE BOXES	
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.		15. ELEVATION GROUND WATER 2.82 feet	
7. THICKNESS OF OVERBURDEN		16. DATE HOLE STARTED 5-4-90 COMPLETED 5-4-90	
8. DEPTH DRILLED INTO ROCK —		17. ELEVATION TOP OF HOLE 8.82 feet	
9. TOTAL DEPTH OF HOLE 25.5 feet		18. TOTAL CORE RECOVERY FOR BORING 84.06 %	
		19. SIGNATURE OF INSPECTOR Kermit Schmidt, PE	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
8.82	0.0					BIT OR BARREL bls/6"
7.32	1.5		TOP SOIL, clay, stiff, dark grayish brown and yellowish brown, little sand and silt, roots (CH)	50	1	140# hammer with 30" drop on 1-3/8" ID x 2" OD std. spl. spoon 4 4 5
4.32	4.5		CLAY, stiff, yellowish brown and gray, little sand and silt, occ. roots and pebbles, dark brown mottled (CH)	56	2	7 6 6
				56	3	7 6 4
2.82 ▽	6.0		medium, brownish yellow, some silt, occ. pebbles	33	4	4 3 2
-1.68	10.5		yellowish brown, gray and dark gray	100	5	2 3 3
				100	6	4 4 5
				100	7	2 2 2
-3.18	12.0		CLAY, medium, silty, yellowish brown and gray, some sand, occ. pebbles (CL)	100	8	3 3 3
-6.18	15.0		SILT, medium, yellowish brown, sandy, some clay, gray mottled. (ML)	100	9	4 3 3
				56	10	PUSH PUSH 4
-10.68	19.5		CLAY, very soft, dark olive gray, slightly organic, little sand and silt (CH)	100	11	1 1 1
				100	12	PUSH 2 1
				100	13	2 1 2
-12.18	21.0		CLAY, soft, very silty, dark gray, little fibrous matter, partly sandy (CL)	84	14	2 2 1

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE

PROJECT RIO MANATI AT BARCELONETA | HOLE NO. CB-HB- 15

Plate B-31

DRILLING LOG (Cont Sheet)	ELEVATION TOP OF HOLE 8.82 feet	Hole No. CB-MB-15
PROJECT RIO MANATI AT BARCELONETA	INSTALLATION JACKSONVILLE DISTRICT	SHEET 2 OF 2 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
-12.18	21.0					
			SAND, fine to coarse grained, gray, little silt, occ. gravel, fine grained, sub-rounded (SP)	89	15	3 / 1 / 1
				100	16	3 / 8 / 10
-16.68	25.5			100	17	4 / 10 / 15
			END 25.5 feet			
			NOTES: A. Soil classifications above are visual classifications using the Unified Soil Classifications System.			
			CB-MB-15		4	W=40%

ENG FORM 1836-A JUN 67 (ER 1110-1-1801) GPO 1969 OF - 820-893

PROJECT RIO MANATI AT BARCELONETA HOLE NO. CB-MB-15

Plate B-32

Hole No. CB-HB-16

DRILLING LOG	DIVISION SOUTH ATLANTIC
INSTALLATION	JACKSONVILLE DISTRICT
SHEET 1 OF 2 SHEETS	
1. PROJECT	RIO MANATI AT BARCELONETA
2. LOCATION (Coordinates or Station)	X= 461,414 Y= 227,468
3. DRILLING AGENCY	GEOCONSULT
4. HOLE NO. (As shown on drawing title and file number)	CB-HB- 16
5. NAME OF DRILLER	T. Cabán
6. DIRECTION OF HOLE	☒ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN	
8. DEPTH DRILLED INTO ROCK	
9. TOTAL DEPTH OF HOLE	25.5 feet
10. SIZE AND TYPE OF BIT	
11. DATUM FOR ELEVATION SHOWN (TBM or MSL)	MSL
12. MANUFACTURER'S DESIGNATION OF DRILL	CME- 45
13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN	DISTURBED 17 / UNDISTURBED
14. TOTAL NUMBER CORE BOXES	
15. ELEVATION GROUND WATER	2.35 feet
16. DATE HOLE	STARTED 5-4-90 / COMPLETED 5-4-90
17. ELEVATION TOP OF HOLE	10.35 feet
18. TOTAL CORE RECOVERY FOR BORING	73.29 %
19. SIGNATURE OF INSPECTOR	Kermit Schmidt, PE

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
10.35	0.0					BIT OR BARREL bls/6"
			TOP SOIL, clay, stiff, yellowish brown, little sand and silt, thin roots, occ. pebbles, gray mottled (CH)	22	1	140# hammer with 30" drop on 1-3/8" ID x 2" OD std. spl. spoon 4 4 3
7.35	3.0		very poor recovery	11	2	7 7 6
			CLAY, very stiff, brown and gray, little sand and silt, occ. dark brown mottled (CH)	100	3	7 7 9
				56	4	6 5 6
				50	5	7 6 4
▽				100	6	1 2 2
0.35	10.0			17	7	2 1 3
			SAND, fine to coarse grained, gray, silty some gravel, fine grained, sub-angular, little clay, brown mottled (SM)	100	8	6 4 3
-1.65	12.0					
			SILT, soft, sandy, gray some clay, partly very sandy, slightly organic (ML)	100	9	2 1 2
-4.65	15.0			100	10	4 2 3
			SAND, fine to coarse grained, gray, little silt, trace gravel, fine grained, trace clay (SP)	78	11	3 3 5
				56	12	4 3 3
				100	13	7 5 18
-10.65	21.0			78	14	10 13 13

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE

PROJECT RIO MANATI AT BARCELONETA | HOLE NO. CB-HB-16

Plate B-33

DRILLING LOG (Cont Sheet) | ELEVATION TOP OF HOLE 10.38 feet | Hole No. CB-HB-16

PROJECT RIO MANATI AT BARCELONETA | INSTALLATION JACKSONVILLE DISTRICT | SHEET 2 OF 2 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
-10.65	21.0					
				78	15	9 / 14 / 18
				100	16	16 / 14 / 14
-13.62	24.0					
				100	17	35 / 22 / 16
-15.15	25.5		gravelly			
			END 25.5 feet			
			CB-HB-16		3	W=34%

NOTES:

A. Soil classifications above are visual classifications using the Unified Soil Classifications System.

ENG FORM 1836-A JAN 67 (ER 1110-1-1801) GPO 1969 OF - 520-601 | PROJECT RIO MANATI AT BARCELONETA | HOLE NO. CB-HB-16

Plate B-34

Hole No. CB-MB-17

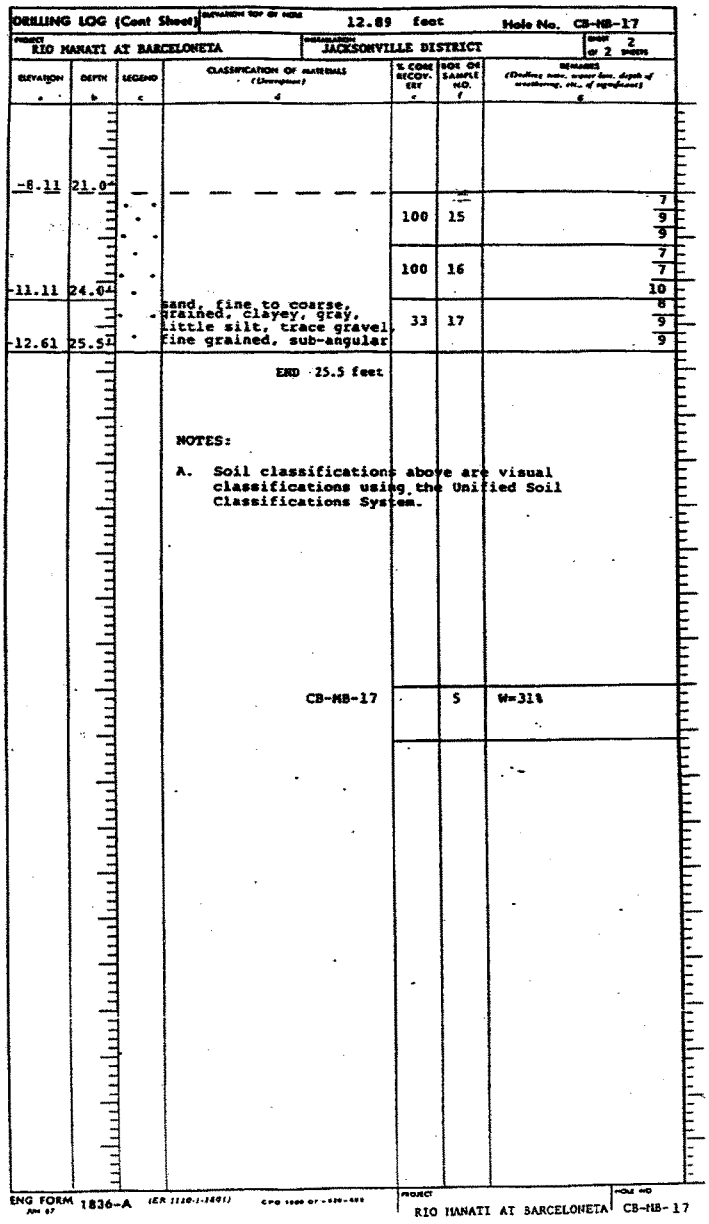
DRILLING LOG	DIVISION SOUTH ATLANTIC	INSTALLATION JACKSONVILLE DISTRICT	SHEET 1 OF 2 SHEETS

1. PROJECT RIO MANATI AT BARCELONETA	10. SIZE AND TYPE OF BIT
2. LOCATION (Coordinates or Station) X=461,234 Y= 226,402	11. DATUM FOR ELEVATION SHOWN (TBM or MSL) MSL
3. DRILLING AGENCY GEOCONSULT	12. MANUFACTURER'S DESIGNATION OF DRILL CME- 45
4. HOLE NO. (As shown on drawing title and file number) CB-MB- 17	13. TOTAL NO. OF OVER-BURDEN SAMPLES TAKEN: DISTURBED 17; UNDISTURBED
5. NAME OF DRILLER H. González	14. TOTAL NUMBER CORE BOXES
6. DIRECTION OF HOLE [X] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.	15. ELEVATION GROUND WATER 3.89 feet
7. THICKNESS OF OVERBURDEN	16. DATE HOLE: STARTED 5-7-90; COMPLETED 5-7-90
8. DEPTH DRILLED INTO ROCK —	17. ELEVATION TOP OF HOLE 12.89 feet
9. TOTAL DEPTH OF HOLE 25.5 feet	18. TOTAL CORE RECOVERY FOR BORING 84.35 %
	19. SIGNATURE OF INSPECTOR Kermit Schmidt, PE

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
12.89	0.0'					BIT OR BARREL bls/6"
11.39	1.5'		TOP SOIL, clay, medium, some, silt, dark grayish brown, little sand, occ. roots. (CL)	67	1	140# hammer with 30" drop on 1-3/8" ID x 2" OD std. spl. spoon 1 2 4
9.89	3.0'		very stiff	78	2	6 8 10
8.39	4.5'		CLAY, very stiff, dark grayish brown, little sand and silt, occ. thin roots (CH)	78	3	9 8 7
6.89	6.0'		gray, mottled, stiff	56	4	6 6 5
3.89 ▽	9.0'		CLAY, medium, grayish brown, silty, some sand, occ. pebbles, gray mottled, partly sandy (CL)	100	5	3 3 3
				100	6	2 2 2
0.89	12.0'		soft to medium	100	7	1 2 2
				100	8	1 1 1
-0.61	13.5'		dark olive gray	100	9	2 2 2
-2.11	15.0'		very soft, more silty	100	10	PUSH PUSH 1
-3.61	16.5'		SILT, very soft, gray, sandy, little clay, partly very sandy. (ML)	100	11	1 1 1
-5.11	18.0'		SAND, fine grained, gray, silty, little clay (SP)	100	12	1 1 1
-6.61	19.5'		fine to coarse grained, little silt	33	13	7 9 10
-8.11	21.0'		little gravel, fine grained	89	14	8 9 9

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT RIO MANATI AT BARCELONETA HOLE NO. CB-MB- 17

Plate B-35



DRILLING LOG (Cont Sheet) | ELEVATION TOP OF HOLE 12.89 feet | Hole No. CB-MB-17

PROJECT RIO MANATI AT BARCELONETA | INSTALLATION JACKSONVILLE DISTRICT | SHEET 2 OF 2 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling rate, water loss, depth of weathering, etc., if significant) g
-8.11	21.0					
				100	15	7 / 9 / 9
				100	16	7 / 7 / 10
-11.11	24.0					
			Sand, fine to coarse, grained, clayey, gray, little silt, trace gravel, fine grained, sub-angular	33	17	8 / 9 / 9
-12.61	25.5					
			END 25.5 feet			
			NOTES:			
			A. Soil classifications above are visual classifications using the Unified Soil Classifications System.			
			CB-MB-17		S	W=31%

ENG FORM 1836-A (ER 1110-1-1801) | PROJECT RIO MANATI AT BARCELONETA | HOLE NO CB-MB-17

Plate B-36

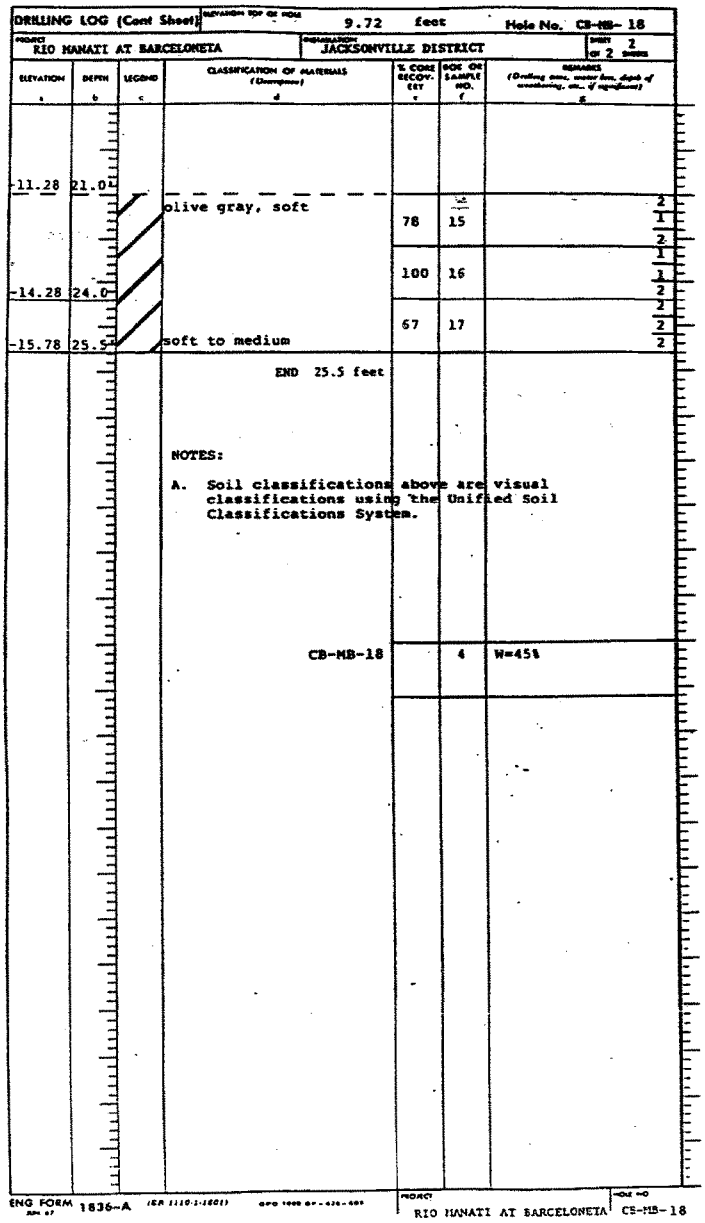
Hole No. CB-MB-18

DRILLING LOG	DIVISION SOUTH ATLANTIC	INSTALLATION JACKSONVILLE DISTRICT	SHEET 1 OF 2 SHEETS
1. PROJECT RIO MANATI AT BARCELONETA		10. SIZE AND TYPE OF BIT	
2. LOCATION X= 463,136 Y= 228,091		11. DATUM FOR ELEVATION SHOWN MSL	
3. DRILLING AGENCY GEOCONSULT		12. MANUFACTURER'S DESIGNATION OF DRILL CME- 55	
4. HOLE NO. CB-MB- 18		13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: DISTURBED 17	UNDISTURBED
5. NAME OF DRILLER H. González		14. TOTAL NUMBER CORE BOXES	
6. DIRECTION OF HOLE ☒ VERTICAL ☐ INCLINED ____ DEG. FROM VERT.		15. ELEVATION GROUND WATER 4.72 feet	
7. THICKNESS OF OVERBURDEN		16. DATE HOLE STARTED 5-4-90	COMPLETED 5-4-90
8. DEPTH DRILLED INTO ROCK —		17. ELEVATION TOP OF HOLE 9.72 feet	
9. TOTAL DEPTH OF HOLE 25.5 feet		18. TOTAL CORE RECOVERY FOR BORING 78.0 %	
		19. SIGNATURE OF INSPECTOR Kermit Schmidt, PE	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
9.72	0.0					BIT OR BARREL
						bls/6"
			TOP SOIL, clay, stiff, brown and dark grayish brown, some silt, little sand, occ. pebbles, roots (CL)	67	1	140# hammer with 30" drop on 1-3/8" ID x 2" OD std. spl. spoon 3 4 6
6.72	3.0			78	2	5 7 7
▽ 3.72	6.0		CLAY, medium, yellowish brown, some silt, little sand, occ. pebbles, grayish brown mottled (CH)	100	3	3 3 3
				100	4	2 2 2
			yellowish brown and gray, stiff.	100	5	3 4 4
				67	6	2 4 5
				56	7	2 3 4
-2.28	12.0			78	8	4 5 5
			medium	100	9	2 2 3
-5.28	15.0			78	10	2 3 3
			medium to stiff	56	11	3 4 4
-8.28	18.0			78	12	2 3 3
-9.78	19.5		SILT, soft, sandy, yellowish brown and gray, little clay. (ML)	67	13	2 2 3
-11.28	21.0		CLAY, very soft, gray, slightly organic, little sand and silt (CH)	56	14	1 1 1

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE. PROJECT RIO MANATI AT BARCELONETA HOLE NO. CB-MB- 18

Plate B-37



DRILLING LOG (Cont Sheet) | ELEVATION TOP OF HOLE 9.72 feet | Hole No. CB-MB- 18

PROJECT: RIO MANATI AT BARCELONETA | DISTRICT: JACKSONVILLE DISTRICT | SHEET 2 OF 2 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOV-ERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling rate, water loss, depth of weathering, etc., if significant) g
-11.28	21.0		olive gray, soft	78	15	2 1 2
				100	16	1 1 2
-14.28	24.0			67	17	2 2 2
-15.78	25.5		soft to medium			
			END 25.5 feet			
			NOTES: A. Soil classifications above are visual classifications using the Unified Soil Classifications System.			
			CB-MB-18		4	W=45%

ENG FORM 1836-A (ER 1110-1-1801) | PROJECT: RIO MANATI AT BARCELONETA | HOLE NO. CB-MB-18

Plate B-38

Hole No. CB-MB-19

DRILLING LOG	DIVISION SOUTH ATLANTIC	INSTALLATION JACKSONVILLE DISTRICT	SHEET 1 of 2 SHEETS
1. PROJECT: RIO MANATI AT BARCELONETA		10. SIZE AND TYPE OF BIT:	
2. LOCATION (Coordinates or Station): X=466,672 Y= 227,389		11. DATUM FOR ELEVATION SHOWN (TBM or MSL): MSL	
3. DRILLING AGENCY: GEOCONSULT		12. MANUFACTURER'S DESIGNATION OF DRILL: CME-45	
4. HOLE NO. (As shown on drawing title and file number): CB-MB-19		13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: DISTURBED 17 / UNDISTURBED	
5. NAME OF DRILLER: T. Cabán		14. TOTAL NUMBER CORE BOXES	
6. DIRECTION OF HOLE: [X] VERTICAL [ ] INCLINED ____ DEG. FROM VERT.		15. ELEVATION GROUND WATER: 8.55 feet	
7. THICKNESS OF OVERBURDEN		16. DATE HOLE: STARTED 5-9-90 / COMPLETED 5-9-90	
8. DEPTH DRILLED INTO ROCK: ____		17. ELEVATION TOP OF HOLE: 13.55 feet	
9. TOTAL DEPTH OF HOLE: 25.5 feet		18. TOTAL CORE RECOVERY FOR BORING: 78.65 %	
		19. SIGNATURE OF INSPECTOR: Kermit Schmidt, PE	

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
13.55	0.0					BIT OR BARREL bls/6"
			TOP SOIL, clay, stiff, brown and grayish brown, some silt, little sand, thin roots (CL)	56	1	140# hammer with 30" drop on 1-3/8" ID x 2" OD std. spl. spoon 5 5 5
10.55	3.0			56	2	5 5 5
			CLAY, medium, brown, silty, little sand, occ. thin roots, gray and dark brown mottled (CL)	56	3	5 4 1
7.55	6.0		brown and gray, stiff	78	4	3 2 1
6.05	7.5		olive gray, sligthly organic	56	5	PUSH PUSH PUSH
			SILT, very soft, gray, very sandy, some clay, occ. shell fragments (ML)	56	6	PUSH PUSH PUSH
3.05	10.5			56	7	PUSH PUSH PUSH
1.55	12.0		SAND, fine grained, very silty, gray, little clay, occ. shell fragments (SM)	78	8	PUSH PUSH PUSH
0.05	13.5		CLAY, very soft, dark gray, slightly organic, silty, some sand, fine to medium grained, shells (CL)	100	9	1 1 2
-1.45	15.0		sandy, little gravel, fine grained	89	10	2 PUSH 2
			SAND, fine to coarse grained, gray very clayey, some silt, trace gravel, fine grained, sub-rounded, occ. shells (SC)	78	11	PUSH 3 8
-2.95	16.5			100	12	7 2 1
-4.45	18.0		some clay	78	13	PUSH 2 2
			CLAY, soft, olive gray and gray, slightly organic, little sand and silt, occ. gravel, fine grained (CH)	100	14	2 2 2
-7.45	21.0					

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE.

PROJECT RIO MANATI AT BARCELONETA HOLE NO. CB-MB-19

Plate B-39

DRILLING LOG (Cont Sheet) | ELEVATION TOP OF HOLE 13.55 feet | Hole No. CB-MB-19

PROJECT RIO MANATI AT BARCELONETA | INSTALLATION JACKSONVILLE DISTRICT | SHEET 2 OF 2 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOV-ERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling rate, water loss, depth of weathering, etc., if significant) g
-7.45	21.0					
-8.95	22.5			100	15	3 2 2
-10.45	24.0		PEAT, medium, dark brown and very dark gray, clayey and fibrous, little silt (Pt)	100	16	3 3 3
-11.95	25.5		CLAY, medium, organic, olive gray and very dark gray, some peat, little sand and silt, occ. shells (OH)	100	17	2 3 2
			END 25.5 feet			

NOTES:

A. Soil classifications above are visual classifications using the Unified Soil Classifications System.

CB-MB-19		4	W=49%

ENG FORM 1836-A (ER 1110-1-1801) | PROJECT RIO MANATI AT BARCELONETA | HOLE NO. CB-MB-19

Data B-40

Hole No. CB-HB- 20

DRILLING LOG	DIVISION: SOUTH ATLANTIC	INSTALLATION: JACKSONVILLE DISTRICT	SHEET 1 OF 2 SHEETS

1. PROJECT: RIO MANATI AT BARCELONETA
2. LOCATION (Coordinates or Grid): X= 466,114 Y= 228,327
3. DRILLING AGENCY: GEOCONSULT
4. HOLE NO. (As shown on drawing title and file number): CB-MB- 20
5. NAME OF DRILLER: H. González
6. DIRECTION OF HOLE: ☒ VERTICAL ☐ INCLINED _____ DEG. FROM VERT.
7. THICKNESS OF OVERBURDEN: ——
8. DEPTH DRILLED INTO ROCK: ——
9. TOTAL DEPTH OF HOLE: 25.5 feet
10. SIZE AND TYPE OF BIT:
11. DATUM FOR ELEVATION SHOWN (TBM or MSL): MSL
12. MANUFACTURER'S DESIGNATION OF DRILL: CME- 55
13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: DISTURBED 17 UNDISTURBED
14. TOTAL NUMBER CORE BOXES:
15. ELEVATION GROUND WATER: 4.43 feet
16. DATE HOLE: STARTED 5-9-90 COMPLETED 5-9-90
17. ELEVATION TOP OF HOLE: 12.43 feet
18. TOTAL CORE RECOVERY FOR BORING: 85.06 %
19. SIGNATURE OF INSPECTOR: Kermit Schmidt, PE

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	g. CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
12.43	0.0					BIT OR BARREL bls/6"
10.93	1.5		TOP SOIL, clay, medium, brown, silty, some sand, thin roots, occ. gray mottled (CL)	56	1	140# hammer with 30" drop on 1-3/8" ID x 2" OD std. spl. spoon 2 3 4
9.43	3.0		stiff	67	2	4 6 7
6.43	6.0		CLAY, stiff, brown, silty, some sand, occ. thin roots (CL)	100	3	4 4 5
				100	4	4 4 5
4.93	7.5		soft to medium	78	5	3 2 2
3.43	9.0		sandy	100	6	2 2 2
1.93	10.5		brown and gray	22	7	2 2 1
-0.43	12.0		SAND, fine grained, olive gray, silty, little clay (SM)	100	8	1 1 1
-1.07	13.5		CLAY, very soft, olive gray, some sand, little silt (CH)	100	9	1 1 1
-2.57	15.0		SAND, fine grained, olive gray, very silty, little clay, occ. fibrous matter (SM)	100	10	1 3 8
			sand, fine to coarse grained, gravel, fine to medium grained, sub-rounded, little silt	78	11	7 8 9
				89	12	9 9 9
				78	13	9 9 10
-8.57	21.0			78	14	10 10 11

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE.

PROJECT: RIO MANATI AT BARCELONETA HOLE NO: CB-HB-20

Plate B-41

DRILLING LOG (Cont Sheet)	ELEVATION TOP OF HOLE 12.43 feet	Hole No. CB-MB-20
PROJECT RIO MANATI AT BARCELONETA	INSTALLATION JACKSONVILLE DISTRICT	SHEET 2 OF 2 SHEETS

ELEVATION a	DEPTH b	LEGEND c	CLASSIFICATION OF MATERIALS (Description) d	% CORE RECOVERY e	BOX OR SAMPLE NO. f	REMARKS (Drilling time, water loss, depth of weathering, etc., if significant) g
-8.57	21.0					
				100	15	11 12 12
				100	16	5 5 10
				100	17	3 3 3
-13.07	25.5					
			END 25.5 feet			
			CB-MB-20		4	W=31%

NOTES:

A. Soil classifications above are visual classifications using the Unified Soil Classifications System.

ENG FORM 1836-A (ER 1110-1-1801) GPO 1960 OF-478-801

PROJECT RIO MANATI AT BARCELONETA HOLE NO. CB-MB-20

Plate B-42

Hole No.CB-MB-21

DRILLING LOG | DIVISION: South Atlantic | INSTALLATION: JACKSONVILLE DISTRICT | SHEET 1 OF 2

1. PROJECT: RIO DE MANATI AT BARCELONETA, P. R.
2. LOCATION (Coordinates or Station): X=483,700 E, Y=223,147 N
3. DRILLING AGENCY: GEOCONSULT, INC.
4. HOLE NO. (As shown on drawing title and file number): CB-MB-21
5. NAME OF DRILLER: HIPOLITO GONZALEZ
6. DIRECTION OF HOLE: ☒ VERTICAL ☐ INCLINED
7. THICKNESS OF BURDEN: ft.
8. DEPTH DRILLED INTO ROCK: 0 ft.
9. TOTAL DEPTH OF HOLE: 25.5 ft.
10. SIZE AND TYPE OF BIT: See Remarks
11. DATUM FOR ELEVATION SHOWN (TBM or MSL): MSL
12. MANUFACTURER'S DESIGNATION OF DRILL: CME-45B
13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: disturbed: 17 undisturbed: 0
14. TOTAL NUMBER OF CORE BOXES: 1
15. ELEVATION GROUND WATER: -0.4
16. DATE HOLE STARTED: 13 April COMPLETED: 13 April 1993
17. ELEVATION TOP OF HOLE: 20.5
18. TOTAL CORE RECOVERY FOR BORING: 84.6 %
19. SIGNATURE OF GEOLOGIST: ALAN RANDOLPH CRUMLEY

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS (Description)	CORE REC %	SAMPLE NUMBER	REMARKS Bit or Barrel	BLOWS/6"
20.5	0.0					20.5	
			CLAY, silty, very stiff, little fine gravel, occassional roots, dark brown (CL)	88	1	Split spoon	2 3 5
						19.0	
				67	2	Split spoon	3 5 6
17.5	3.0					17.5	
			SILT, sandy, very stiff, little clay, dark brown (ML)	56	3	Split spoon	9 8 5
						16.0	
			some clay	83	4	Split spoon	5 4 5
						14.5	
				83	5	Split spoon	7 8 10
						13.0	
				94	6	Split spoon	6 6 6
						11.5	
				83	7	Split spoon	4 5 7
10.0	10.5					10.0	
			CLAY, silty, very stiff, little fine sand, dark brown (CL)	94	8	Split spoon	8 6 8
						8.5	
			very stiff	58	9	Split spoon	5 7 10
						7.0	
			stiff	100	10	Split spoon	8 8 7
						5.5	
			stiff	44	11	Split spoon	2 3 3
						4.0	
			medium	100	12	Split spoon	3 2 3
						2.5	
			stiff	89	13	Split spoon	3 4 4
						1.0	
			soft	100	14	Split spoon	1 1 1
						-.5	
			medium consistency	100	15	Split spoon	2 4 4
-2.0	22.5					-2.0	

(continued)

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PROJECT: RIO DE MANATI AT BARCELONETA, P. R. | HOLE NUMBER: CB-MB-21

Plate B-43

Hole No.CB-MB-21

DRILLING LOG (Cont. Sheet) | ELEVATION TOP OF HOLE 20.5± ft. | SHEET 2 OF 2

PROJECT: RIO DE MANATI AT BARCELONETA, P. R.

INSTALLATION: JACKSONVILLE DISTRICT

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS (Description)	CORE REC %	SAMPLE NUMBER	REMARKS Bit or Barrel	BLOWS/.5'
-2.0	22.5					-2.0	
			SAND, clayey, fine to medium grain size, trace silt, very dark gray (SC)	100	16	Split spoon	8 6 10
						-3.5	
				100	17	Split spoon	3 5 6
-5.0	25.5					-5.0	

Soils are classified visually in accordance with the Unified Soil Classification System.

After the visual classification was performed, Atterberg limits and water contents were obtained from some of the samples; the results and final Unified classification take precedence over the visual classification.

The following laboratory tests were performed as indicated below:

Sample #6: Sieve analysis
w=19%
Sample #12 Sieve analysis
w=36%
LL=49%
PL=33%
PI=16% (ML)

140# hammer with 30" drop used in 1.5" standard split spoon sampler (1 3/8" ID x 2" OD)

Groundwater level was measured the day after completion of drilling.

25 30 40 45 50

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PROJECT: RIO DE MANATI AT BARCELONETA, P. R. | HOLE NUMBER: CB-MB-21

Plate A-44

Hole No.CB-MB-22

DRILLING LOG | DIVISION: South Atlantic | INSTALLATION: JACKSONVILLE DISTRICT | SHEET 1 OF 2

1. PROJECT: RIO DE MANATI AT BARCELONETA, P. R.
2. LOCATION (Coordinates or Station): X=484,832 E, Y=223,822 N
3. DRILLING AGENCY: GEOCONSULT, INC.
4. HOLE NO. (As shown on drawing title and file number): CB-MB-22
5. NAME OF DRILLER: HIPOLITO GONZALEZ
6. DIRECTION OF HOLE: ☒ VERTICAL ☐ INCLINED
7. THICKNESS OF BURDEN: ft.
8. DEPTH DRILLED INTO ROCK: 0 ft.
9. TOTAL DEPTH OF HOLE: 25.5 ft.
10. SIZE AND TYPE OF BIT: See Remarks
11. DATUM FOR ELEVATION SHOWN (TBM or MSL): MSL
12. MANUFACTURER'S DESIGNATION OF DRILL: CME-45B
13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: disturbed: 17 undisturbed: 0
14. TOTAL NUMBER OF CORE BOXES: 1
15. ELEVATION GROUND WATER: 7.1
16. DATE HOLE STARTED: 14 April COMPLETED: 14 April 1993
17. ELEVATION TOP OF HOLE: 13.12
18. TOTAL CORE RECOVERY FOR BORING: 75.5%
19. SIGNATURE OF GEOLOGIST: ALAN RANDOLPH CRUMLEY

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS (Description)	CORE REC %	SAMPLE NUMBER	REMARKS Bit or Barrel	BLOWS/6"
13.1	0.0					13.1	
			SILT, sandy, very stiff, little clay, brown (ML)	100	1	Split spoon	3 5 7
						11.6	
				87	2	Split spoon	5 5 5
						10.1	
				100	3	Split spoon	6 7 5
8.6	4.5					8.6	
			CLAY, silty, little fine sand, very stiff, brown (CL)	78	4	Split spoon	2 3 4
						7.1	
			stiff	88	5	Split spoon	5 3 2
						5.6	
			soft	100	6	Split spoon	2 1 1
4.1	9.0					4.1	
			CLAY, sandy, trace silt, soft, grayish brown (CL)	56	7	Split spoon	1 1 1
						2.6	
			very soft, brown to grayish brown	88	8	Split spoon	1 1 1
1.1	12.0					1.1	
			CLAY, soft, fat, very dark gray (CH)	100	9	Split spoon	0 1 1
-.4	13.5					-.4	
			SAND, fine to medium grain size, some silt, very dark gray (SM)	100	10	Split spoon	3 4 4
						-1.9	
			some silt, sand is fine grain size	100	11	Split spoon	3 2 1
						-3.4	
			little silt, sand is fine grain size	100	12	Split spoon	2 1 5
						-4.9	
			trace clay lumps, sand is medium grain size	56	13	Split spoon	11 7 8
						-6.4	
			without traces of clay, medium to coarse grain size, trace fine gravel, color changes to grayish brown	56	14	Split spoon	8 13 11
						-7.9	
			same as above, traces of silty sand lumps	33	15	Split spoon	10 12 9
						-9.4	
				(continued)			

0 5 10 15 20

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PROJECT: RIO DE MANATI AT BARCELONETA, P. R. | HOLE NUMBER: CB-MB-22

Plate B-45

Hole No.CB-MB-22

DRILLING LOG (Cont. Sheet) | ELEVATION TOP OF HOLE 13.12 ft. | SHEET 2 OF 2

PROJECT: RIO DE MANATI AT BARCELONETA, P. R. | INSTALLATION: JACKSONVILLE DISTRICT

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS (Description)	CORE REC %	SAMPLE NUMBER	REMARKS Bit or Barrel	BLOWS/.5
-9.4	22.5					-9.4	
			see previous page	28	16	Split spoon	11 9 8
						-10.9	
			trace clay, color changes to very dark gray	33	17	Split spoon	12 10 10
-12.4	25.5					-12.4	

At 12' depth, "0" blows means weight of hammer, without blows.

Soils are classified visually in accordance with the Unified Soil Classification System.

After the visual classification was performed, Atterberg limits and water contents were obtained from some of the samples; the results and final Unified soil classification take precedence over the visual classification.

The following laboratory tests were performed as indicated below:
Sample #5: Sieve analysis
w=34%
LL=43%
PL=31%
PI=12% (ML)

140# hammer with 30" drop used in 1.5" standard split spoon sampler (1 3/8" ID x 2" OD)

Groundwater elevation was measured the day after completion of drilling.

25 30 35 40 45 50

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PROJECT: RIO DE MANATI AT BARCELONETA, P. R. | HOLE NUMBER: CB-MB-22

Plate B-46

Hole No.CB-MB-23

DRILLING LOG | DIVISION: South Atlantic | INSTALLATION: JACKSONVILLE DISTRICT | SHEET 1 OF 2

1. PROJECT: RIO DE MANATI AT BARCELONETA, P. R.	10. SIZE AND TYPE OF BIT: See Remarks
2. LOCATION (Coordinates or Station): X=465,184 E, Y=228,090 N	11. DATUM FOR ELEVATION SHOWN (TBM or MSL): MLW
3. DRILLING AGENCY: GEOCONSULT, INC.	12. MANUFACTURER'S DESIGNATION OF DRILL: CME-45B
4. HOLE NO. (As shown on drawing title and file number): CB-MB-23	13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: disturbed: 17 undisturbed: 0
5. NAME OF DRILLER: HIPOLITO GONZALEZ	14. TOTAL NUMBER OF CORE BOXES: 1
6. DIRECTION OF HOLE: ☒ VERTICAL ☐ INCLINED	15. ELEVATION GROUND WATER: 4.2
7. THICKNESS OF BURDEN: 11.	16. DATE HOLE STARTED: 17 April COMPLETED: 17 April 1993
8. DEPTH DRILLED INTO ROCK: 0 ft.	17. ELEVATION TOP OF HOLE: 8.2
9. TOTAL DEPTH OF HOLE: 25.5 ft.	18. TOTAL CORE RECOVERY FOR BORING: 76.8 %
	19. SIGNATURE OF GEOLOGIST: ALAN RANDOLPH CRUMLEY

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS (Description)	CORE REC %	SAMPLE NUMBER	REMARKS Bit or Barrel	BLOWS/.5'
8.2	0.0					8.2	
			CLAY, silty, medium, little fine sand, brown (CL)	94	1	Split spoon 6.7	2 3 3
				83	2	Split spoon 5.2	2 3 2
			soft	88	3	Split spoon 3.7	2 1 2
			grayish brown and very soft to 10.5'	100	4	Split spoon 2.2	1 1 1
				67	5	Split spoon .7	1 1 1
				100	6	* = 1 blow in 18 inches = 1/18 Split spoon -.8	1/18 * *
				100	7	Split spoon -2.3	1 1 1
-2.3	10.5						
			SAND, clayey, some silt, fine to medium grain size, some shell fragments, very dark gray (SC)	100	8	Split spoon -3.8	10 5 7
				44	9	Split spoon -5.3	8 8 9
			SAND, well graded, fine to coarse grain size, some fine gravel, very dark gray (SW)	100	10	Split spoon -6.8	8 8 8
				56	11	Split spoon -8.3	7 7 6
				67	12	Split spoon -9.8	7 6 7
			fine to coarse gravel sizes	56	13	Split spoon -11.3	4 5 6
			same as above	88	14	Split spoon -12.8	6 3 1
-12.8	21.0						
			SAND, clayey, little silt, medium to coarse grain size, trace fine gravel, very dark gray (SC)	88	15	Split spoon -14.3	7 3 2
-14.3	22.5						

(continued)

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PROJECT: RIO DE MANATI AT BARCELONETA, P. R. | HOLE NUMBER: CB-MB-23

Plate B-47

Hole No.CB-MB-23

DRILLING LOG (Cont. Sheet) | ELEVATION TOP OF HOLE 8.2 ft. | SHEET 2 OF 2

PROJECT: RIO DE MANATI AT BARCELONETA, P. R. | INSTALLATION: JACKSONVILLE DISTRICT

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS (Description)	CORE REC %	SAMPLE NUMBER	REMARKS Bit or Barrel	BLOWS/.5'
-14.3	22.5					-14.3	
			CLAY, silty, trace fine sand, soft to medium, very dark gray (CH)	28	16	Split spoon	1 1 1
						-15.8	
				44	17	Split spoon	1 1 1
-17.3	25.5					-17.3	

Soils are classified visually in accordance with the Unified Soil Classification System.

After the visual classification was performed, Atterberg limits and water contents were obtained from some of the samples; the results and final Unified classification take precedence over the visual classification.

The following laboratory tests were performed as indicated below:
Sample #5: Sieve analysis
w=64%
LL=53%
PL=35%
PI=18% (MH)

140# hammer with 30" drop used in 1.5" standard split spoon sampler (1 3/8" ID x 2" OD)

Groundwater elevation was measured the day after completion of drilling.

ENG FORM 1838 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE.

PROJECT: RIO DE MANATI AT BARCELONETA, P. R. | HOLE NUMBER: CB-MB-23

Plate B-48

Hole No.CB-MB-24

DRILLING LOG | DIVISION: South Atlantic | INSTALLATION: JACKSONVILLE DISTRICT | SHEET 1 OF 2

1. PROJECT: RIO DE MANATI AT BARCELONETA, P. R.
2. LOCATION (Coordinates or Station): X=485,114 E, Y=228,562 N
3. DRILLING AGENCY: GEOCONSULT, INC.
4. HOLE NO. (As shown on drawing title and file number): CB-MB-24
5. NAME OF DRILLER: HIPOLITO GONZALEZ
6. DIRECTION OF HOLE: ☒ VERTICAL ☐ INCLINED
7. THICKNESS OF BURDEN: ft.
8. DEPTH DRILLED INTO ROCK: 0 ft.
9. TOTAL DEPTH OF HOLE: 25.5 ft.
10. SIZE AND TYPE OF BIT: See Remarks
11. DATUM FOR ELEVATION SHOWN (TBM or MSL): MSL
12. MANUFACTURER'S DESIGNATION OF DRILL: CME-45B
13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: disturbed: 17 undisturbed: 0
14. TOTAL NUMBER OF CORE BOXES: 1
15. ELEVATION GROUND WATER: 0.97
16. DATE HOLE STARTED: 13 April COMPLETED: 13 April 1993
17. ELEVATION TOP OF HOLE: 8.97
18. TOTAL CORE RECOVERY FOR BORING: 79.1 %
19. SIGNATURE OF GEOLOGIST: ALAN RANDOLPH CRUMLEY

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS (Description)	CORE REC. %	SAMPLE NUMBER	REMARKS Bit or Barrel	BLOWS/.5'
9.0	0.0					9.0	
			CLAY, silty, very stiff, trace fine sand, occ. roots, dark brown (CL)	94	1	Split spoon 7.5	2 4 5
			stiff	100	2	Split spoon 6.0	3 5 6
			soft, brown	88	3	Split spoon 4.5	2 2 2
			very soft, grayish brown	100	4	Split spoon 3.0	1 1 1
3.0	6.0		SILT, some fine sand, very dark gray (ML)	100	5	Split spoon 1.5	1 1 1
1.5	7.5		SAND, clayey, some fine well rounded gravel, occassional shell fragments, very dark gray (SC)	100	6	Split spoon 0.0	1 4 3
0.0	9.0		SAND, coarse, trace to little shell fragments, trace fine gravel, very dark gray (SP)	56	7	Split spoon -1.5	20 6 6
				44	8	Split spoon -3.0	5 5 5
			some fine gravel	50	9	Split spoon -4.5	25 9 5
				67	10	Split spoon -6.0	20 9 10
				100	11	Split spoon -7.5	18 13 12
			trace clay lumps	67	12	Split spoon -9.0	20 15 3
			no traces of clay	78	13	Split spoon -10.5	18 12 10
				88	14	Split spoon -12.0	15 16 12
				67	15	Split spoon -13.5	16 12 10

(continued)

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PROJECT: RIO DE MANATI AT BARCELONETA, P. R. | HOLE NUMBER: CB-MB-24

Plate B-49

Hole No.CB-MB-24

DRILLING LOG (Cont. Sheet) | ELEVATION TOP OF HOLE 8.97 ft. | SHEET 2 OF 2

PROJECT: RIO DE MANATI AT BARCELONETA, P. R. | INSTALLATION: JACKSONVILLE DISTRICT

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS (Description)	CORE REC %	SAMPLE NUMBER	REMARKS Bit or Barrel	BLOWS/6"
-13.5	22.5					-13.5	
			trace clay lumps	88	16	Split spoon	25 10 9
						-15.0	
			no traces of clay, sand becomes fine to medium grain size	58	17	Split spoon	10 11 9
-16.5	25.5					-16.5	

Soils are classified visually in accordance with the Unified Soil Classification System.

After the visual classification was performed, Atterberg limits and water contents were obtained from some of the samples; the results and final Unified soil classification take precedence over the visual classification.

The following laboratory tests were performed as indicated below:
Sample #3: Sieve analysis
w=42%
LL=50%
PL=36%
PI=14% (MH)

140# hammer with 30" drop used in 1.5" standard split spoon sampler (1 3/8" ID x 2" OD)

Groundwater elevation was measured the day after completion of drilling.

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE.

PROJECT: RIO DE MANATI AT BARCELONETA, P. R. | HOLE NUMBER: CB-MB-24

Plate A-50

Hole No.CB-MB-25

DRILLING LOG | DIVISION: South Atlantic | INSTALLATION: JACKSONVILLE DISTRICT | SHEET 1 OF 2

1. PROJECT: RIO DE MANATI AT BARCELONETA, P. R.
2. LOCATION (Coordinates or Station): X=481,436 E, Y=228,387 N
3. DRILLING AGENCY: GEOCONSULT, INC.
4. HOLE NO. (As shown on drawing title and file number): CB-MB-25
5. NAME OF DRILLER: HIPOLITO GONZALEZ
6. DIRECTION OF HOLE: ☒ VERTICAL ☐ INCLINED
7. THICKNESS OF BURDEN: ft.
8. DEPTH DRILLED INTO ROCK: 0 ft.
9. TOTAL DEPTH OF HOLE: 25.5 ft.
10. SIZE AND TYPE OF BIT: See Remarks
11. DATUM FOR ELEVATION SHOWN (TBM or MSL): MSL
12. MANUFACTURER'S DESIGNATION OF DRILL: CME-45B
13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: disturbed: 17 undisturbed: 0
14. TOTAL NUMBER OF CORE BOXES: 1
15. ELEVATION GROUND WATER: -4.79
16. DATE HOLE: STARTED 12 April COMPLETED 12 April 1993
17. ELEVATION TOP OF HOLE: 8.21
18. TOTAL CORE RECOVERY FOR BORING: 87.3 %
19. SIGNATURE OF GEOLOGIST: ALAN RANDOLPH CRUMLEY

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS (Description)	CORE REC %	SAMPLE NUMBER	REMARKS Bit or Barrel	BLOWS/.5'
8.2	0.0						
			CLAY, silty, trace fine sand, very stiff, occ. roots, light brown mottled gray (CL)	100	1	Split spoon 6.7	2 3 4
				100	2	Split spoon 5.2	2 3 5
			same as above, stiff, occ. rock fragments, light brown mottled gray	88	3	Split spoon 3.7	3 2 3
			no roots evident below 4.5 feet	100	4	Split spoon 2.2	2 2 4
			stiff	100	5	Split spoon .7	4 5 6
			medium	94	6	Split spoon -.8	1 2 2
-2.3	10.5		soft to medium	50	7	Split spoon -2.3	1 1 1
			SAND, clayey, fine grain size, trace silt, very soft, peat traces, very dark gray (SC)	100	8	Split spoon -3.8	1 1 1
-5.3	13.5		medium grain size, occ. shell fragments, traces of decomposed wood and peat	100	9	Split spoon -5.3	1 1 2
			SAND, medium grain size, silty, trace clay, very dark gray and brown (SM)	100	10	Split spoon -6.8	1 1 1
						w = 1 blow in 18 inches = 1/18	1/18
				100	11	Split spoon -8.3	w w
-9.8	18.0		becomes more clayey towards bottom of sample	100	12	WH = weight of hammer Split spoon -9.8	WH WH WH
			CLAY, silty, trace fine sand, very soft, very dark gray, slightly organic (CL)	100	13	WH = weight of hammer Split spoon -11.3	WH 1 2
-12.8	21.0		slightly organic, soft, trace fine sand, very dark gray and black	88	14	Split spoon -12.8	2 3 2
-14.3	22.5		PEAT, some slightly organic clay, occ. shell fragments, black (Pt)	67	15	Split spoon -14.3	3 2 3
				(continued)			

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PROJECT: RIO DE MANATI AT BARCELONETA, P. R. | HOLE NUMBER: CB-MB-25

Plate B-51

Hole No.CB-MB-25

DRILLING LOG (Cont. Sheet) | ELEVATION TOP OF HOLE: 8.21 ft. | SHEET 2 OF 2

PROJECT: RIO DE MANATI AT BARCELONETA, P. R. | INSTALLATION: JACKSONVILLE DISTRICT

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS (Description)	CORE REC. %	SAMPLE NUMBER	REMARKS Bit or Barrel	BLOWS/.5'
-14.3	22.5					-14.3	
-15.8	24.0		ORGANIC CLAY AND PEAT, soft, black (OH)	6	[illegible]	Split spoon -15.8	3 3 3
-17.3	25.5		SAND, some clay, medium to coarse grain size, slightly organic, trace shell fragments (SC)	88	17	Split spoon -17.3	1 1 2

Soils are classified visually in accordance with the Unified Soil Classification System.

After the visual classification was performed, Atterberg limits and water contents were obtained from some of the samples; the results and final Unified soil classification take precedence over the visual classification.

The following laboratory tests were performed as indicated below:

Sample #3: Sieve analysis
w=38%
LL=58%
PL=43%
PI=15% (MH)

Sample #6: Sieve analysis
w=43%

140# hammer with 30" drop used in 1.5" standard split spoon sampler (1 3/8" ID x 2" OD)

Groundwater elevation was -0.4 feet the day after completion of drilling. Groundwater level on 26 April 1993 was 3'10" below top of hole (elevation +4.38 feet).

-25 -30 -3' -40 -45 -50

ENG FORM 1838 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE.

PROJECT: RIO DE MANATI AT BARCELONETA, P. R. | HOLE NUMBER: CB-MB-25

Plate B-52

Hole No.CB-MB-26

DRILLING LOG | DIVISION: South Atlantic | INSTALLATION: JACKSONVILLE DISTRICT | SHEET 1 OF 2

1. PROJECT: RIO DE MANATI AT BARCELONETA, P. R.	10. SIZE AND TYPE OF BIT: See Remarks
2. LOCATION (Coordinates or Station): X=460,881 E, Y=228,332 N	11. DATUM FOR ELEVATION SHOWN (TBM or MSL): MSL
3. DRILLING AGENCY: GEOCONSULT, INC.	12. MANUFACTURER'S DESIGNATION OF DRILL: CME-45B
4. HOLE NO. (As shown on drawing title and file number): CB-MB-26	13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: disturbed: 17 undisturbed: 0
5. NAME OF DRILLER: HIPOLITO GONZALEZ	14. TOTAL NUMBER OF CORE BOXES: 1
6. DIRECTION OF HOLE: ☒ VERTICAL ☐ INCLINED	15. ELEVATION GROUND WATER: 2.3
7. THICKNESS OF BURDEN: ft.	16. DATE HOLE STARTED: 15 April COMPLETED: 15 April 1993
8. DEPTH DRILLED INTO ROCK: 0 ft.	17. ELEVATION TOP OF HOLE: 10.33
9. TOTAL DEPTH OF HOLE: 25.5 ft.	18. TOTAL CORE RECOVERY FOR BORING: 94.1 %
	19. SIGNATURE OF GEOLOGIST: ALAN RANDOLPH CRUMLEY

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS (Description)	CORE REC %	SAMPLE NUMBER	REMARKS Bit or Barrel	BLOWS/6"
10.3	0.0					10.3	
			CLAY, silty, little fine sand, very stiff, occ. very small roots, dark brown (CL)	88	1	Split spoon	4 5 5
						8.8	
			brown, very stiff	100	2	Split spoon	3 6 6
						7.3	
			brown, very stiff	100	3	Split spoon	6 7 8
						5.8	
			light brown and light gray, stiff	94	4	Split spoon	3 3 3
						4.3	
			stiff	100	5	Split spoon	3 3 4
						2.8	
			medium, without roots, light brown mottled gray	100	6	Split spoon	2 1 2
						1.3	
			medium	100	7	Split spoon	2 2 2
						-.2	
			soft	100	8	Split spoon	1 1 1
						-1.7	
			very soft	100	9	Split spoon	1 1 1
						-3.2	
			soft, light bluish gray	100	10	Split spoon	2 2 3
-4.7	15.0					-4.7	
			CLAY, organic, soft, peat traces, gray and black (OH)	100	11	Split spoon	2 2 2
						-6.2	
			black, peat traces, soft	100	12	Split spoon	2 2 2
						-7.7	
			soft, some peat	100	13	Split spoon	3 3 2
						-9.2	
			soft, light bluish gray	100	14	Split spoon	3 2 3
						-10.7	
			soft	83	15	Split spoon	3 3 2
-12.2	22.5					-12.2	

(continued)

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PROJECT: RIO DE MANATI AT BARCELONETA, P. R. | HOLE NUMBER: CB-MB-26

Plate B-53

Hole No.CB-MB-26

DRILLING LOG (Cont. Sheet)

ELEVATION TOP OF HOLE: 10.33 ft.

SHEET 2 OF 2

PROJECT: RIO DE MANATI AT BARCELONETA, P. R.

INSTALLATION: JACKSONVILLE DISTRICT

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS (Description)	CORE REC %	SAMPLE NUMBER	REMARKS Bit or Barrel	BLOWS/6"
-12.2	22.5					-12.2	
			PEAT, soft, black, some organic clay (Pt)	67	16	Split spoon	3 3 2
						-13.7	
			some shell fragments, light gray	67	17	Split spoon	2 2 3
-15.2	25.5					-15.2	

Soils are classified visually in accordance with the Unified Soil Classification System.

After the visual classification was performed, Atterberg limits and water contents were obtained from some of the samples; the results and final Unified soil classification take precedence over the visual classification.

The following laboratory tests were performed as indicated below:

Sample # 4: Sieve analysis
w=37%
LL=62%
PL=46%
PI=16% (MH)

140# hammer with 30" drop used in 1.5" standard split spoon sampler (1 3/8" ID x 2" OD)

Groundwater elevation was +2.3 feet the day after completion of drilling. Groundwater level on 28 April 1993 was 6'7" below top of hole (elevation +3.75 feet).

25 30 40 45 50

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PROJECT: RIO DE MANATI AT BARCELONETA, P. R.

HOLE NUMBER: CB-MB-26

Hole No.CB-MB-27

DRILLING LOG | DIVISION: South Atlantic | INSTALLATION: JACKSONVILLE DISTRICT | SHEET 1 OF 2

1. PROJECT: RIO DE MANATI AT BARCELONETA, P. R.
2. LOCATION (Coordinates or Station): X=480,074 E, Y=227,434 N
3. DRILLING AGENCY: GEOCONSULT, INC.
4. HOLE NO. (As shown on drawing title and file number): CB-MB-27
5. NAME OF DRILLER: HIPOLITO GONZALEZ
6. DIRECTION OF HOLE: ☒ VERTICAL ☐ INCLINED
7. THICKNESS OF BURDEN: ft.
8. DEPTH DRILLED INTO ROCK: 0 ft.
9. TOTAL DEPTH OF HOLE: 25.5 ft.
10. SIZE AND TYPE OF BIT: See Remarks
11. DATUM FOR ELEVATION SHOWN (TBM or MSL): MSL
12. MANUFACTURER'S DESIGNATION OF DRILL: CME-45B
13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: disturbed: 17 undisturbed: 0
14. TOTAL NUMBER OF CORE BOXES: 1
15. ELEVATION GROUND WATER: 6.7
16. DATE HOLE STARTED: 15 April COMPLETED: 15 April 1993
17. ELEVATION TOP OF HOLE: 11.87
18. TOTAL CORE RECOVERY FOR BORING: 95.4 %
19. SIGNATURE OF GEOLOGIST: ALAN RANDOLPH CRUMLEY

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS (Description)	CORE REC %	SAMPLE NUMBER	REMARKS Bit or Barrel	BLOWS/.5'
11.7	0.0					11.7	
			CLAY, silty, little fine sand, very stiff, occ. very small roots, dark brown (CL)	100	1	Split spoon	3, 4, 5
						10.2	
			very stiff, light brown	88	2	Split spoon	3, 4, 3
						8.7	
			very stiff, trace fine sand, mottled light grayish brown	94	3	Split spoon	3, 4, 4
						7.2	
			stiff, brown	83	4	Split spoon	2, 1, 1
						5.7	
			stiff, gray mottled	100	5	Split spoon	2, 2, 3
						4.2	
			medium	78	6	Split spoon	3, 3, 3
						2.7	
			soft	100	7	Split spoon	2, 1, 1
						1.2	
			same silty clay as above, but mixed with black organic silt and peat, about 40% of sample is organic, soft	78	8	Split spoon	1, 1, 1
						-.3	
			some peat, soft, black	100	9	Split spoon	1, 2, 2
						-1.8	
			soft	100	10	Split spoon	1, 1, 2
						-3.3	
			very soft	100	11	Split spoon	2, 1, 1
-4.8	16.5					-4.8	
			SILT, organic, very soft, black and gray (OL)	100	12	Split spoon	2, 1, 2
						-6.3	
			soft	100	13	Split spoon	2, 2, 2
						-7.8	
			occ. shell fragments	100	14	Split spoon	2, 2, 3
-9.3	21.0					-9.3	
			SILT, sandy, trace to little shell fragments, black and gray (ML)	100	15	Split spoon	3, 3, 3
						-10.8	
						(continued)	

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PROJECT: RIO DE MANATI AT BARCELONETA, P. R. | HOLE NUMBER: CB-MB-27

Plate B-55

Hole No.CB-MB-27

DRILLING LOG (Cont. Sheet) | ELEVATION TOP OF HOLE 11.87 ft. | SHEET 2 OF 2

PROJECT: RIO DE MANATI AT BARCELONETA, P. R. | INSTALLATION: JACKSONVILLE DISTRICT

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS (Description)	CORE REC %	SAMPLE NUMBER	REMARKS Bit or Barrel	BLOWS/.5"
-10.8	22.5					-10.8	
			numerous shell fragments, about 3/4" in size, 5% of sample, embedded in sandy silt matrix, gray and black	100	16	Split spoon	3 2 3
						-12.3	
			some small (1/4") shell fragments, light gray and gray	100	17	Split spoon	2 3 2
-13.8	25.5					-13.8	

Soils are classified visually in accordance with the Unified Soil Classification System.

After the visual classification was performed, Atterberg limits and water contents were obtained from some of the samples; the results and Unified soil classification take precedence over the visual classification.

The following laboratory tests were performed as indicated below:
Sample #2 Sieve analysis
w=34%
LL=60%
PL=45%
PI=15% (MH)

140# hammer with 30" drop used in 1.5" standard split spoon sampler (1 3/8" ID x 2" OD)

Groundwater elevation was +6.7 feet the day after drilling. Groundwater level on 28 April was 4'10" below top of hole (elevation +6.84 feet).

25 30 40 45 50

ENG FORM 1836 MAR 71 PREVIOUS EDITIONS ARE OBSOLETE.

PROJECT: RIO DE MANATI AT BARCELONETA, P. R. | HOLE NUMBER: CB-MB-27

A-Le A-54

Hole No.CB-MB-28

DRILLING LOG | DIVISION: South Atlantic | INSTALLATION: JACKSONVILLE DISTRICT | SHEET 1 OF 2

1. PROJECT: RIO DE MANATI AT BARCELONETA, P. R.
2. LOCATION (Coordinates or Station): X=459,854 E, Y=226,152 N
3. DRILLING AGENCY: GEOCONSULT, INC.
4. HOLE NO. (As shown on drawing title and file number): CB-MB-28
5. NAME OF DRILLER: HIPOLITO GONZALEZ
6. DIRECTION OF HOLE: ☒ VERTICAL ☐ INCLINED
7. THICKNESS OF BURDEN: ft.
8. DEPTH DRILLED INTO ROCK: 0 ft.
9. TOTAL DEPTH OF HOLE: 25.5 ft.
10. SIZE AND TYPE OF BIT: See Remarks
11. DATUM FOR ELEVATION SHOWN (TBM or MSL): MSL
12. MANUFACTURER'S DESIGNATION OF DRILL: CME-45B
13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: disturbed: 17 undisturbed: 0
14. TOTAL NUMBER OF CORE BOXES: 1
15. ELEVATION GROUND WATER: 3.0
16. DATE HOLE: STARTED 16 April COMPLETED 16 April 1993
17. ELEVATION TOP OF HOLE: 8.03
18. TOTAL CORE RECOVERY FOR BORING: 87.9 %
19. SIGNATURE OF GEOLOGIST: ALAN RANDOLPH CRUMLEY

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS (Description)	CORE REC %	SAMPLE NUMBER	REMARKS Bit or Barrel	BLOWS/.5'
8.0	0.0					8.0	
			CLAY, silty, little fine sand, very stiff, dark brown (CL)	94	1	Split spoon	2, 3, 4
						6.5	
			very stiff	88	2	Split spoon	4, 8, 7
						5.0	
			very stiff	100	3	Split spoon	5, 5, 7
						3.5	
			medium to stiff	100	4	Split spoon	2, 1, 3
						2.0	
			medium	100	5	Split spoon	2, 1, 2
						.5	
			same clay as above, but mixed with peat and organic clay	100	6	Split spoon	2, 2, 2
-1.0	9.0					-1.0	
			CLAY, organic, little peat, soft, dark gray (OH)	88	7	Split spoon	1, 1, 2
						-2.5	
			soft	100	8	Split spoon	1, 1, 1
						-4.0	
			some peat (about 40% of sample)	100	9	Split spoon	1, 1, 1
						-5.5	
			soft	100	10	Split spoon (# = 1 blow in 18" = 1/18)	1/18, #, #
						-7.0	
			soft	100	11	Split spoon	1, 1, 2
						-8.5	
			occ. decayed wood particles, very soft	100	12	Split spoon	1, 2, 1
						-10.0	
			soft	100	13	Split spoon	4, 6, 9
-11.5	19.5					-11.5	
			SILT, clayey, embedded limestone fragments over entire sample, very soft, brown (ML)	100	14	Split spoon	14, 36, 21
-13.0	21.0					-13.0	
			CLAY, silty, embedded limestone throughout sample (about 40%), soft, olive green (CL)	33	15	Split spoon	10, 12, 10
						-14.5	
			(continued)				

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PROJECT: RIO DE MANATI AT BARCELONETA, P. R. | HOLE NUMBER: CB-MB-28

Plate B-57

Hole No.CB-MB-28

DRILLING LOG (Cont. Sheet) | ELEVATION TOP OF HOLE 8.03 ft. | SHEET 2 OF 2

PROJECT: RIO DE MANATI AT BARCELONETA, P. R. | INSTALLATION: JACKSONVILLE DISTRICT

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS (Description)	CORE REC %	SAMPLE NUMBER	REMARKS Bit or Barrel	BLOWS/6"
-14.5	22.5					-14.5	
			see previous page	56	16	Split spoon	11
							12
-16.0	24.0					-16.0	15
			SILT, sandy, very soft, one large 1 1/2" limestone fragment (ML)	33	17	Split spoon	10
							11
-17.5	25.5					-17.5	12

Soils are classified visually in accordance with the Unified Soil Classification System.

After the visual classification was performed, Alterberg limits and water contents were obtained from some of the samples; the results and final Unified soil classification take precedence over the visual classification.

The following laboratory tests were performed as indicated below:

Sample #3 Sieve analysis
w=37%
LL=54%
PL=40%
PI=14% (MH)

Sample #9 Sieve analysis
w=103%
LL=51%
PL=35%
PI=16% (OH)

140# hammer with 30" drop used in 1.5" standard split spoon sampler (1 3/8" ID x 2" OD)

Groundwater level was measured the day after completion of drilling.

25 30 35 40 45 50

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PROJECT: RIO DE MANATI AT BARCELONETA, P. R. | HOLE NUMBER: CB-MB-28

Plate B-58

Hole No.CB-MB-29

DRILLING LOG — DIVISION: South Atlantic — INSTALLATION: JACKSONVILLE DISTRICT — SHEET 1 OF 2

1. PROJECT: RIO DE MANATI AT BARCELONETA, P. R.	10. SIZE AND TYPE OF BIT: See Remarks
2. LOCATION (Coordinates or Station): X=459,791 E, Y=224,885 N	11. DATUM FOR ELEVATION SHOWN (TBM or MSL): MSL
3. DRILLING AGENCY: GEOCONSULT, INC.	12. MANUFACTURER'S DESIGNATION OF DRILL: CME-458
4. HOLE NO. (As shown on drawing title and file number): CB-MB-29	13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: disturbed: 17 undisturbed: 0
5. NAME OF DRILLER: HIPOLITO GONZALEZ	14. TOTAL NUMBER OF CORE BOXES: 1
6. DIRECTION OF HOLE: ☒ VERTICAL ☐ INCLINED	15. ELEVATION GROUND WATER: 7.3
7. THICKNESS OF BURDEN: ft.	16. DATE HOLE STARTED: 17 April COMPLETED: 17 April 1993
8. DEPTH DRILLED INTO ROCK: 0 ft.	17. ELEVATION TOP OF HOLE: 12.30
9. TOTAL DEPTH OF HOLE: 25.5 ft.	18. TOTAL CORE RECOVERY FOR BORING: 83.0 %
	19. SIGNATURE OF GEOLOGIST: ALAN RANDOLPH CRUMLEY

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS (Description)	CORE REC %	SAMPLE NUMBER	REMARKS Bit or Barrel	BLOWS/.5
12.3	0.0					12.3	
			CLAY, silty, little fine sand, very stiff, occassional fine roots, dark brown (CL)	94	1	Split spoon 10.8	2, 4, 8
			very stiff	100	2	Split spoon 9.3	3, 3, 4
			stiff, brown	100	3	Split spoon 7.8	2, 3, 3
			stiff, light brown	100	4	Split spoon 6.3	3, 4, 7
			very stiff	100	5	Split spoon 4.8	7, 9, 11
3.3	9.0		stiff	100	6	Split spoon 3.3	1, 3, 5
			CLAY, sandy, occassional weathered limestone fragments, stiff but friable, dark orange (CL)	100	7	Split spoon 1.8	7, 14, 20
.3	12.0		stiff but friable	67	8	Split spoon .3	15, 7, 8
-1.2	13.5		SAND, clayey, fine to medium, dark orange, similar to previous samples but with increased sand content (SC)	88	9	Split spoon -1.2	5, 7, 14
			CLAY, silty, some fine sand, hard, yellowish brown, some weathered limestone fragments (CL)	67	10	Split spoon -2.7	16, 30, 30
				100	11	Split spoon -4.2	15, 27, 40
			stiff but friable due to sand	67	12	Split spoon -5.7	15, 45, 50
				88	13	Split spoon -7.2	12, 50/5, augered
-8.7	21.0		same as above, silty clay with embedded limestone fragments, soft, about 30% limestone content	94	14	Split spoon -8.7	26, 28, 17
			SAND, silty, some limestone (about 35-40% of samples), light brown (SM)	56	15	Split spoon -10.2	6, 9, 9
			(continued)				

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PROJECT: RIO DE MANATI AT BARCELONETA, P. R. — HOLE NUMBER: CB-MB-29

Plate B-59

Hole No.CB-MB-29

DRILLING LOG (Cont. Sheet) | ELEVATION TOP OF HOLE 12.30 ft. | SHEET 2 OF 2

PROJECT: RIO DE MANATI AT BARCELONETA, P. R. | INSTALLATION: JACKSONVILLE DISTRICT

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS (Description)	CORE REC %	SAMPLE NUMBER	REMARKS Bit or Barrel	BLOWS/.5'
-10.2	22.5					-10.2	
			trace clay	78	-18	Split spoon	9 10 15
						-11.7	
			no traces of clay	67	17	Split spoon	12 11 10
-13.2	25.5					-13.2	

Soils are classified visually in accordance with the Unified Soil Classification System.

After the visual classification was performed, Allerberg limits and water contents were obtained from some of the samples; the results and final Unified soil classification take precedence over the visual classification.

The following laboratory tests were performed as indicated below:

Sample #3 Sieve analysis
w=39%
LL=64%
PL=38%
PI=26% (MH)

140# hammer with 30" drop used in 1.5" standard split spoon sampler (1 3/8" ID x 2" OD)

Groundwater level was measured the day after completion of drilling.

22 25 27 30 32 37 40 42 45 47 50

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PROJECT: RIO DE MANATI AT BARCELONETA, P. R. | HOLE NUMBER: CB-MB-29

Plate B-60

Hole No.CB-MB-30

DRILLING LOG | DIVISION: South Atlantic | INSTALLATION: JACKSONVILLE DISTRICT | SHEET 1 OF 1

1. PROJECT: RIO DE MANATI AT BARCELONETA, P. R.
2. LOCATION (Coordinates or Station): X=456,568 E, Y=228,544 N
3. DRILLING AGENCY: GEOCONSULT, INC.
4. HOLE NO. (As shown on drawing title and file number): CB-MB-30
5. NAME OF DRILLER: HIPOLITO GONZALEZ
6. DIRECTION OF HOLE: ☒ VERTICAL ☐ INCLINED
7. THICKNESS OF BURDEN: ft.
8. DEPTH DRILLED INTO ROCK: 0 ft.
9. TOTAL DEPTH OF HOLE: 19.5 ft.
10. SIZE AND TYPE OF BIT: See Remarks
11. DATUM FOR ELEVATION SHOWN (TBM or MSL): MSL
12. MANUFACTURER'S DESIGNATION OF DRILL: CME-45B
13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: disturbed: 12 undisturbed: 0
14. TOTAL NUMBER OF CORE BOXES: 1
15. ELEVATION GROUND WATER: Not found
16. DATE HOLE STARTED: 15 April COMPLETED: 15 April 1993
17. ELEVATION TOP OF HOLE: 66.10
18. TOTAL CORE RECOVERY FOR BORING: 69.2 %
19. SIGNATURE OF GEOLOGIST: ALAN RANDOLPH CRUMLEY

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS (Description)	CORE REC %	SAMPLE NUMBER	REMARKS Bit or Barrel	BLOWS/.5
66.1	0.0					66.1	
			SILT, sandy, some limestone rock fragments, yellowish and yellowish red (this is soft limestone broken by sampler into these constituents), sampled as (ML)	94	1	Split spoon	13 12 17
			yellow			64.6	
			friable with medium pressure, some limestone fragments	100	2	Split spoon	18 20 25
						63.1	
				88	3	Split spoon	20 40 20
						61.6	
				17	4	Split spoon	50/3 augered augered
60.1	6.0					60.1	
			LIMESTONE, soft, subrounded to subangular, light yellow, no recovery (sample was obtained from auger flights, thus it is subrounded or angular)	0		-no recovery- Split spoon	50/1 augered augered
58.6	7.5					58.6	
			SILT, sandy, some limestone rock fragments, light yellow, about 40% of sample is recrystallized limestone (ML)	88	5	Split spoon	12 13 17
			limestone does not appear recrystallized, soft rock			57.1	
			samples are all whitish yellow or very pale yellow to end of boring	88	6	Split spoon	20 18 38
						55.6	
				78	7	Split spoon	15 28 28
						54.1	
			includes recrystallized limestone, hard	100	8	Split spoon	36 10 30
						52.6	
				56	9	Split spoon	50 50/5 augered
						51.1	
				100	10	Split spoon	45 26 20
						49.6	
				44	11	Split spoon	40 50/4 augered
						46.1	
				88	12	Split spoon	28 30 50/4
46.6	19.5					46.6	
			Soils are classified visually in accordance with the Unified Soil Classification System. After the visual classification was performed, Atterberg limits and water contents were obtained from some of the samples; the results and final Unified soil classification take precedence over the visual classification. The following laboratory tests were performed as indicated below: Sample #2: Sieve analysis, w=7%; Atterberg limits on -40 portion indicate that sample is non-plastic. Sample #9: Sieve analysis, w=5%			140# hammer with 30" drop used in 1.5" standard split spoon sampler (1 3/8" ID x 2" OD) No water found to bottom of hole.	

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PROJECT: RIO DE MANATI AT BARCELONETA, P. R. | HOLE NUMBER: CB-MB-30

Plate B-61

Hole No.CB-MB-31

DRILLING LOG | DIVISION: South Atlantic | INSTALLATION: JACKSONVILLE DISTRICT | SHEET 1 OF 1

1. PROJECT: RIO DE MANATI AT BARCELONETA, P. R.	10. SIZE AND TYPE OF BIT: See Remarks
2. LOCATION (Coordinates or Station): X=456,966 E, Y=224,981 N	11. DATUM FOR ELEVATION SHOWN (TBM or MSL): MSL
3. DRILLING AGENCY: GEOCONSULT, INC.	12. MANUFACTURER'S DESIGNATION OF DRILL: CME-45B
4. HOLE NO. (As shown on drawing title and file number): CB-MB-31	13. TOTAL NO. OF OVERBURDEN SAMPLES TAKEN: disturbed: 13 undisturbed: 0
5. NAME OF DRILLER: HIPOLITO GONZALEZ	14. TOTAL NUMBER OF CORE BOXES: 1
6. DIRECTION OF HOLE: ☒ VERTICAL ☐ INCLINED	15. ELEVATION GROUND WATER: Not found
7. THICKNESS OF BURDEN: ft.	16. DATE HOLE: STARTED 18 April; COMPLETED 18 April 1993
8. DEPTH DRILLED INTO ROCK: 0 ft.	17. ELEVATION TOP OF HOLE: 176.51
9. TOTAL DEPTH OF HOLE: 19.5 ft.	18. TOTAL CORE RECOVERY FOR BORING: 78.2 %
	19. SIGNATURE OF GEOLOGIST: ALAN RANDOLPH CRUMLEY

ELEV.	DEPTH	LEGEND	CLASSIFICATION OF MATERIALS (Description)	CORE REC %	SAMPLE NUMBER	REMARKS Bit or Barrel	BLOWS/.5'
176.5	0.0					176.5	
			SILT, sandy, some limestone rock fragments (about 1" size), white and yellow with black specks throughout, sampled as (ML)	44	1	Split spoon	10
			yellow			175.0	50/3
							augered
				22	2	Split spoon	50/4
						173.5	augered
							augered
			black specks throughout sample	94	3	Split spoon	15
						172.0	30
							25
			yellow	100	4	Split spoon	11
						170.5	12
							16
				94	5	Split spoon	17
						169.0	20
							17
			black specks throughout sample	88	6	Split spoon	15
			yellow to end of boring			167.5	28
							15
				94	7	Split spoon	8
			Note: All samples recovered 30 to 50% rock fragments and appear to be broken by sampler.			166.0	11
							17
				22	8	Split spoon	15
						164.5	24
							18
				88	9	Split spoon	10
						163.0	10
							10
				94	10	Split spoon	7
						161.5	13
							7
			Soils are classified visually in accordance with the Unified Soil Classification System.	78	11	Split spoon	11
						160.0	15
			After the visual classification was performed, Atterberg limits and water contents were obtained from some of the samples; the results and final Unified soil classification take precedence over the visual classification.				11
				100	12	Split spoon	9
						158.5	10
							14
				94	13	Split spoon	15
157.0	19.5					157.0	30
							24
			The following laboratory tests were performed as indicated below:			140# hammer with 30" drop used in 1.5" standard split spoon sampler (1 3/8" ID x 2" OD)	
			Sample #4: w=11% ; Atterberg limits on -40 portion indicate that sample is non-plastic			No water found to end of boring.	

0 5 10 15 20

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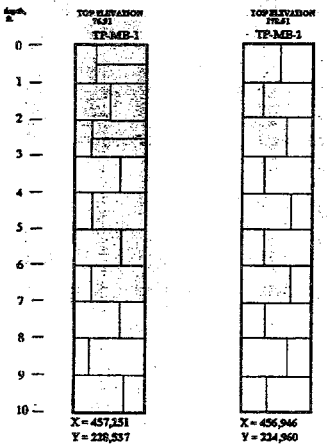
PROJECT: RIO DE MANATI AT BARCELONETA, P. R. | HOLE NUMBER: CB-MB-31



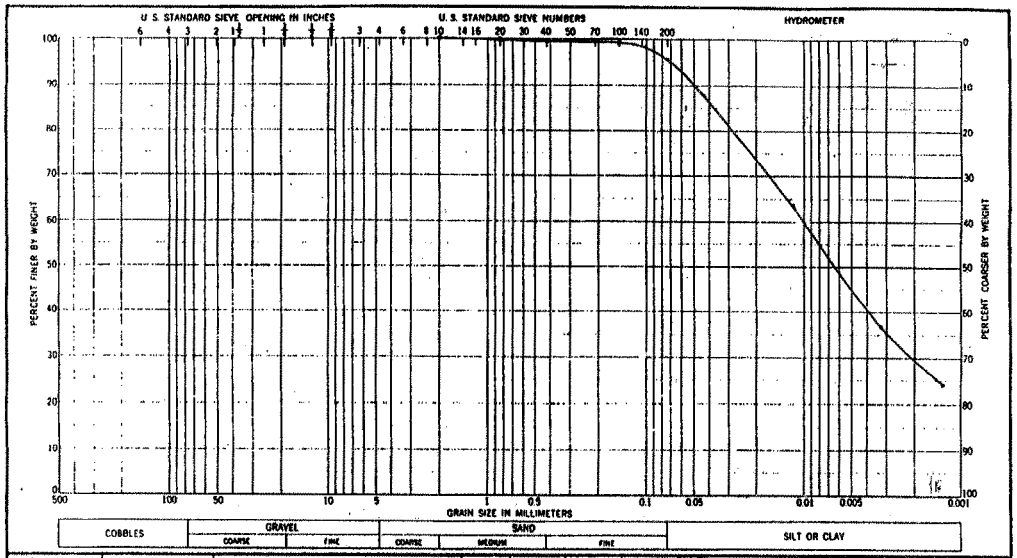
GEOCONSULT

LIMESTONE, MODERATELY WEATHERED, PITS AND VUGS THROUGHOUT ENTIRE DEPTH OF TEST PIT, HARD TO MODERATELY HARD, BROKEN INTO LIMESTONE GRAVEL, SOME SILT, AND FINE TO MEDIUM SAND, LIGHT YELLOW.

TEST PITS
RIO GRANDE MAYAGÜEZ-BARCELONETA
U.S. CORPS OF ENGINEERS

Plate B-63

W.O. NO. 6252
REQ. NO. RM-CW-90-258



Sample No	Depth	Classification	Nat w %	LL	PL	PI
-	6.0-8.5'	Gray, inorganic silt high LL (MH), w/ a trace of sand and organic matter.	64.1	66	34	32

Project Rio Manti
Lab. No. 258/832*
Area Barceloneta Project
Boring No. CB-MB-4
Date 24 Oct 90

GRADATION CURVES

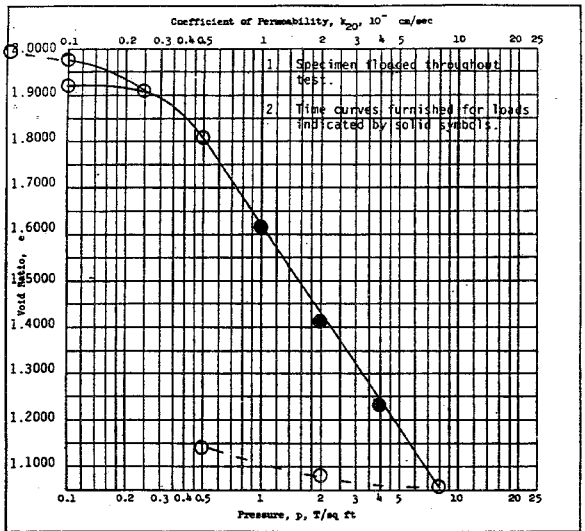
ENG FORM 1 MAY 63 2087

*Unconfined Compression, Q, $\bar{R}$ Triaxial & Consolidation Tests.

Plate B-64

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER NO. 6252
Req. No. RH-CW-90-258



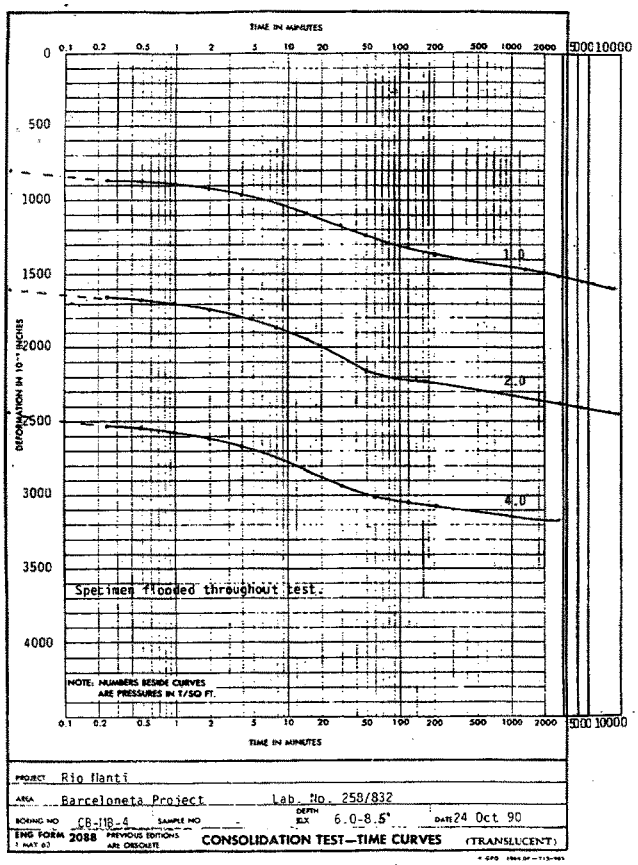
Type of Specimen	undisturbed		Before Test			After Test	
Diam 4.00 in.	Ht 1.26 in.		Water Content, w_o	71.5 %		w_f	42.6 %
Overburden Pressure, Po	T/sq ft		Void Ratio, e_o	1.994		e_f	1.146
Preconsol. Pressure, Pc	T/sq ft		Saturation, S_o	96.4 %		S_f	100.0 %
Compression Index, C_c			Dry Density, γ_d	56.1 lb/ft^3			
Classification Gray, inorganic silt high LL(MH) w/ a trace of sand & organic matter.			k_{20} at e_o =	× 10^{-} cm/sec			
LL 66	G_s 2.69		Project Rio Manti				
PL 34	D_{10} < 0.002mm		Lab. No. 258/832				
Remarks See gradation curve and additional information on ENG Form 2087.			Area Barceloneta Project				
			Boring No. CB-MB-4		Sample No. -		
			Depth 6.0-8.5'		Date 24 Oct 90		
			CONSOLIDATION TEST REPORT				

ENG FORM 2090 (MAY 83) PREVIOUS EDITIONS ARE OBSOLETE

Plate B-65

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER NO. 6252
Req. No. RM-CW-90-258



PROJECT Rio Hanti

AREA Barceloneta Project Lab. No. 258/832

BORING NO CB-HB-4 SAMPLE NO - DEPTH ELEV 6.0-8.5' DATE 24 Oct 90

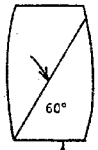
ENG FORM 2088 1 MAY 63 PREVIOUS EDITIONS ARE OBSOLETE

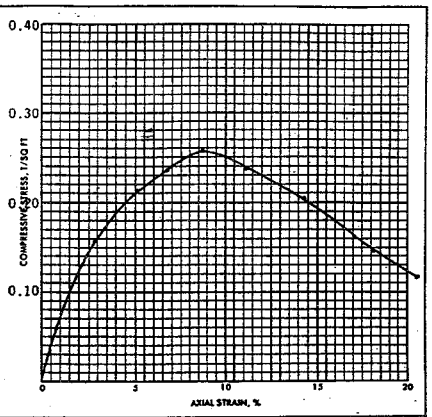
CONSOLIDATION TEST—TIME CURVES (TRANSLUCENT)

Plate B-66

W.O. NO. 6252
REQ. NO. RM-CW-90-258

FAILURE SKETCHES





☐ CONTROLLED STRESS
☒ CONTROLLED STRAIN

TEST NO.			1			
TYPE OF SPECIMEN			undisturbed			
INITIAL	WATER CONTENT	w_o	70.2 %	%	%	%
	VOID RATIO	e_o	1.934			
	SATURATION	S_o	97.6 %	%	%	%
	DRY DENSITY, LB/CU FT	γ_d	57.2			
TIME TO FAILURE, MIN		t_f	12.0			
UNCONFINED COMPRESSIVE STRENGTH, T/SQ FT		q_u	0.26			
UNDRAINED SHEAR STRENGTH, T/SQ FT		s_u	0.13			
rate of strain, %/min		S_r	0.73			
INITIAL SPECIMEN DIAMETER, IN		D_o	1.38			
INITIAL SPECIMEN HEIGHT, IN.		H_o	3.07			

CLASSIFICATION Gray, inorganic silt high LL (MH), w/ a trace of sand & organic matter

LL	PL	PI	G$_s$
66	34	32	2.69

REMARKS See gradation and additional information on ENG Form 2087.

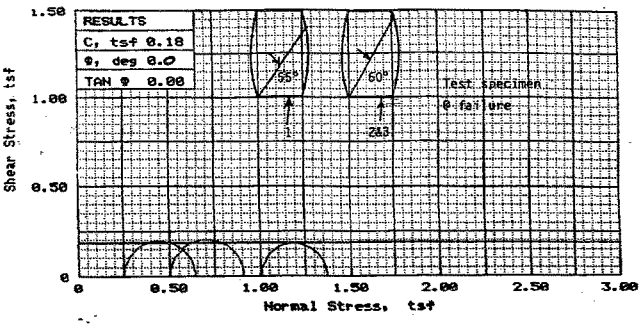
PROJECT Rio Manti
Lab. No. 258/832
AREA Barceloneta Project
BORING NO. CB-MB-4 SAMPLE NO.
DEPTH 6.0-8.5' DATE 25 Oct 90

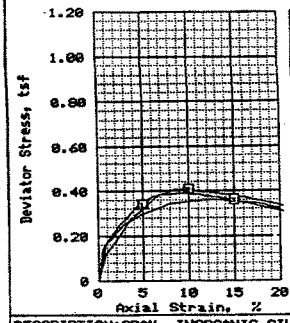
UNCONFINED COMPRESSION TEST REPORT

ENG FORM 3659 1 JUN 65 (TRANSLUCENT) PLATE XI-2

Plate B-67

SOUTH ATLANTIC DIVISION LABORATORY, CORPS OF ENGINEERS - MARIETTA, GEORGIA
Work Order No. 6252
Requisition No. RM-CM-90-258





SPECIMEN NO.		1	2	3
INITIAL	WATER CONTENT, %	69.4	70.6	71.8
	DRY DENSITY, pcf	56.9	57.7	56.3
	SATURATION, %	95.8	99.3	96.5
	VOID RATIO	1.958	1.911	1.988
	DIAMETER, in	1.38	1.38	1.38
	HEIGHT, in	3.07	3.07	3.07
@ TESTING	WATER CONTENT, %	69.4	70.6	71.8
	DRY DENSITY, pcf	56.9	57.7	56.3
	SATURATION, %	95.8	99.3	96.5
	VOID RATIO	1.958	1.911	1.988
	DIAMETER, in	1.38	1.38	1.38
	HEIGHT, in	3.07	3.07	3.07
BACK PRESSURE, tsf		0.00	0.00	0.00
INIT. EFF. STR., tsf		0.25	0.50	1.01
MAX. DEV. STRESS, tsf		0.39	0.41	0.36
PORE PRESSURE, tsf				
TIME TO FAILURE, min.		13	12	15
RATE, %/min.		0.75	0.72	0.87
ULT. DEV. STRESS, tsf		0.36	0.38	0.35

DESCRIPTION: GRAY, INORGANIC SILT HIGH LL (MH), WITH A TRACE OF SAND AND ORGANIC MATTER.

LL= 66	PL= 34	PI= 32	Gs= 2.69	CONTROLLED STRAIN TEST

TYPE OF SPECIMEN: UNDISTURBED — TYPE OF TEST Q

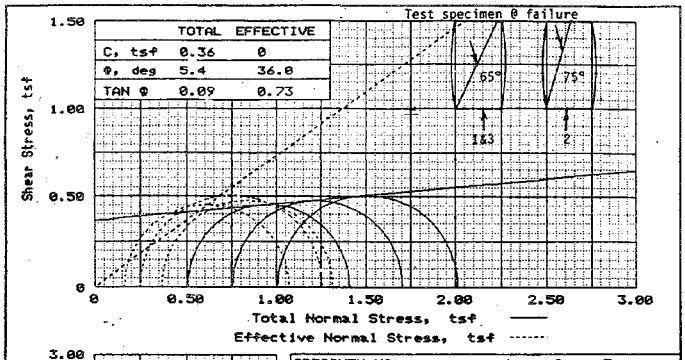
REMARKS: SEE GRADATION CURVE ON ENG FORM 2087.

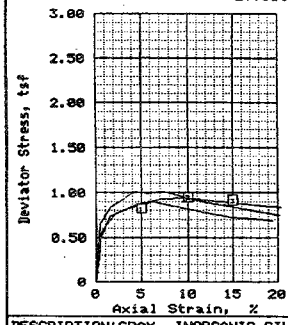
PROJECT: RIO MANTI
AREA: BARCELONETA PROJECT
LAB NO. 258/832
BORING NO. CB-MB-4
SAMPLE NO. ---
DEPTH/ELEV: 6.0-8.5'
LABORATORY: CESAD-EN-FL DATE 22 OCTOBER 90

TRIAXIAL COMPRESSION TEST

Plate B-68

SOUTH ATLANTIC DIVISION LABORATORY, CORPS OF ENGINEERS - MARIETTA, GEORGIA
Requisition No. RM-CW-90-258 Work Order No. 6252





SPECIMEN NO.		1	2	3
INITIAL	WATER CONTENT, %	71.3	68.4	72.8
	DRY DENSITY, pcf	55.4	57.2	54.8
	SATURATION, %	94.4	94.9	94.9
	VOID RATIO	2.038	1.938	2.062
	DIAMETER, in	1.38	1.38	1.38
	HEIGHT, in	3.08	3.08	3.08
@ TESTING	WATER CONTENT, %	63.5	57.6	58.2
	DRY DENSITY, pcf	62.8	65.9	65.5
	SATURATION, %	100.0	100.0	100.0
	VOID RATIO	1.708	1.549	1.565
	DIAMETER, in	1.33	1.31	1.30
	HEIGHT, in	2.97	2.94	2.91
BACK PRESSURE, tsf		5.04	5.04	5.04
INIT. EFF. STR., tsf		0.50	0.76	1.01
MAX. DEV. STRESS, tsf		0.90	0.95	1.01
PORE PRESSURE, tsf		0.34	0.39	0.76
TIME TO FAILURE, min.		65	98	70
RATE, %/min.		0.10	0.11	0.11
ULT. DEV. STRESS, tsf		0.73	0.84	0.89

DESCRIPTION: GRAY, INORGANIC SILT HIGH LL (MH), WITH A TRACE OF SAND AND ORGANIC MATTER.

LL= 66	PL= 34	PI= 32	Gs= 2.69	CONTROLLED STRAIN TEST
TYPE OF SPECIMEN: UNDISTURBED				TYPE OF TEST: R w/pore pressures

REMARKS: SEE GRADATION CURVE AND ADDITIONAL INFORMATION ON ENG FORM 2087.

PROJECT: RIO MANTI
AREA: BARCELONETA PROJECT
LAB NO. 258/832
BORING NO. CB-MB-4
SAMPLE NO.
DEPTH/~~ELEV~~ 6.0-8.5'
LABORATORY: CESAD-EN-FL DATE 11 OCT, 1990
pg 1 of 2 TRIAXIAL COMPRESSION TEST

Plate B-69

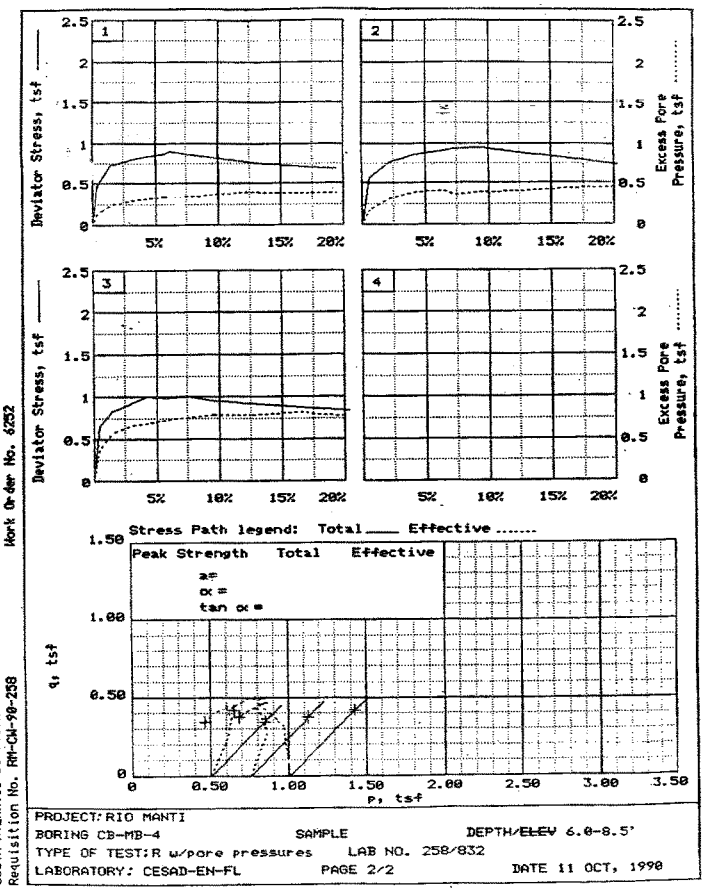
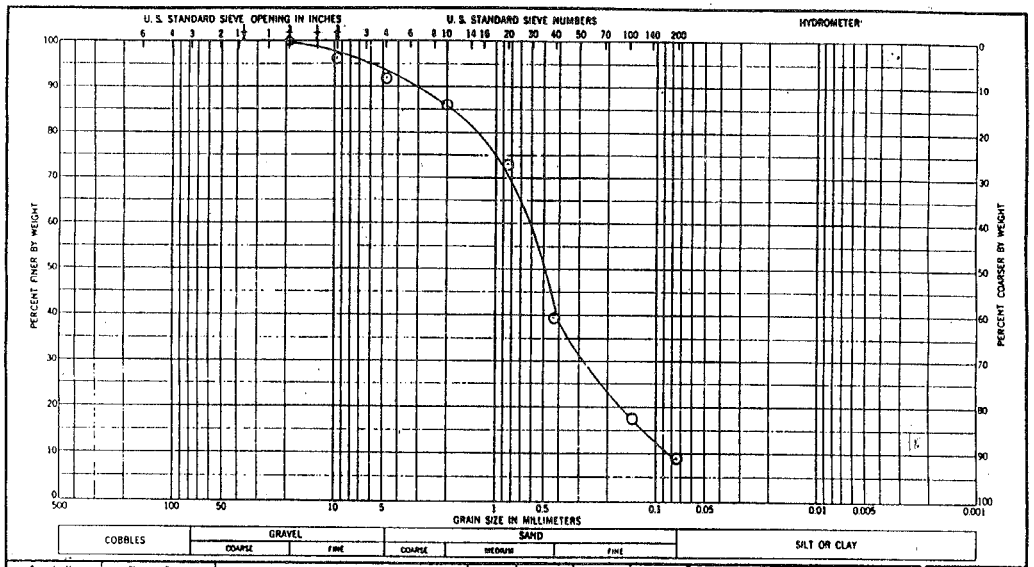

SOUTH ATLANTIC DIVISION LABORATORY, CORPS OF ENGINEERS - MARIETTA, GEORGIA
Requisition No. RM-CM-90-258
Work Order No. 6252
1
2
3
4
Deviator Stress, tsf ——
Excess Pore Pressure, tsf .....
5%
10%
15%
20%
Stress Path legend: Total —— Effective .....
Peak Strength Total Effective
a=
α =
tan α =
q, tsf
p, tsf
PROJECT: RIO MANTI
BORING CB-MB-4 SAMPLE DEPTH/ELEV 6.0-8.5'
TYPE OF TEST: R w/pore pressures LAB NO. 258/832
LABORATORY: CESAD-EN-FL PAGE 2/2 DATE 11 OCT, 1990

Plate B-70



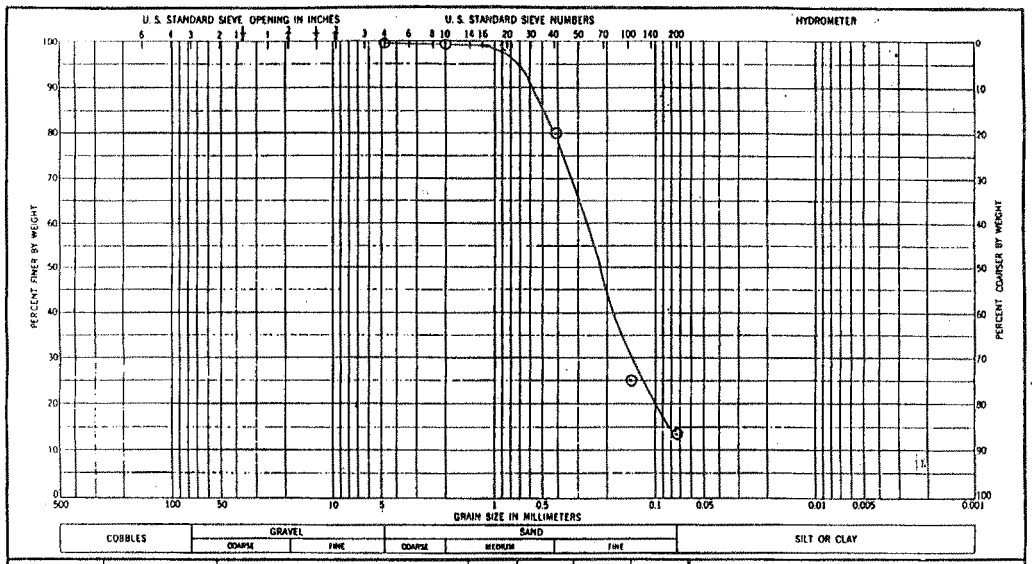
Sample No	Elev or Depth	Classification	Nat w %	LL	PL	PI
7	9 - 10.5'	Sand, fine to coarse grain, gray, some fine to medium gravel, sub-angular, little silt (SP)				

GRADATION CURVES

Project: Río Manatí at Barceloneta
Assignment #6
Area: Barceloneta, Puerto Rico
Boring No.: CB-MB-6
Date: 6-8-90

Plate B-71

ENG FORM 1 MAY 63 2087



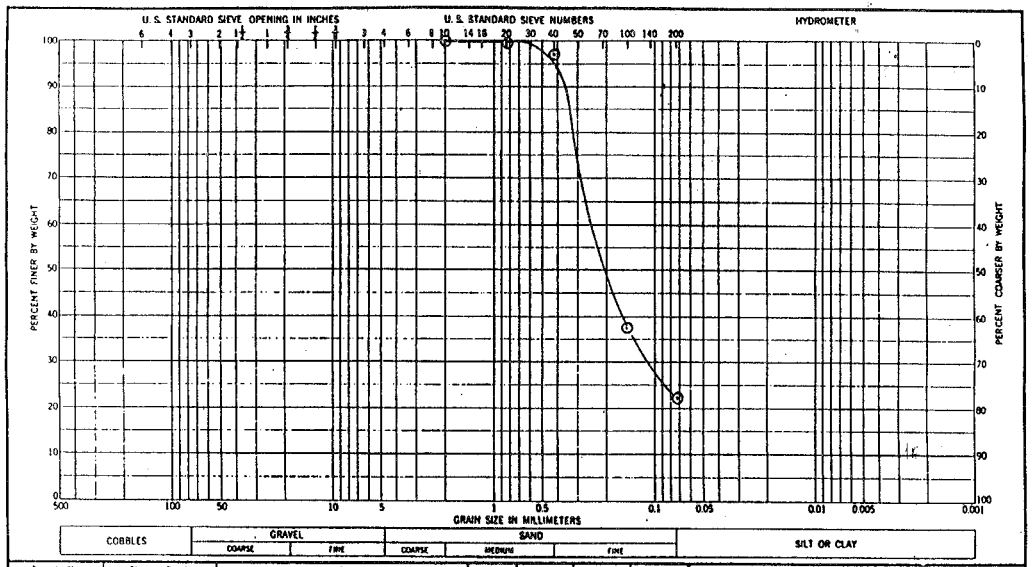
Sample No	Elev or Depth	Classification	Nat w %	LL	PL	PI
5	6 - 7.5'	Sand, fine grain, gray, some silt, trace clay (SM)				

GRADATION CURVES

Project: Río Manatí at Barceloneta
Assignment #6
Area: Barceloneta, Puerto Rico
Boring No.: CB-MB-9
Date: 6-8-90

Plate B-22

ENG FORM MAY 83 2087



Sample No	Elev or Depth	Classification	Nat w %	LL	PL	PI
5	6' - 7.5'	Sand, very silty, fine grain, gray, some clay (SM)				

GRADATION CURVES

Project: Río Manatí de Barceloneta Assignment #6
Area: Barceloneta, Puerto Rico
Boring No.: CB-MB-11
Date: 6-8-90

Plate B-73

ENG FORM 1 MAY 63 2087

W.O. NO. 6252
REQ. NO. RM-CW-90-258

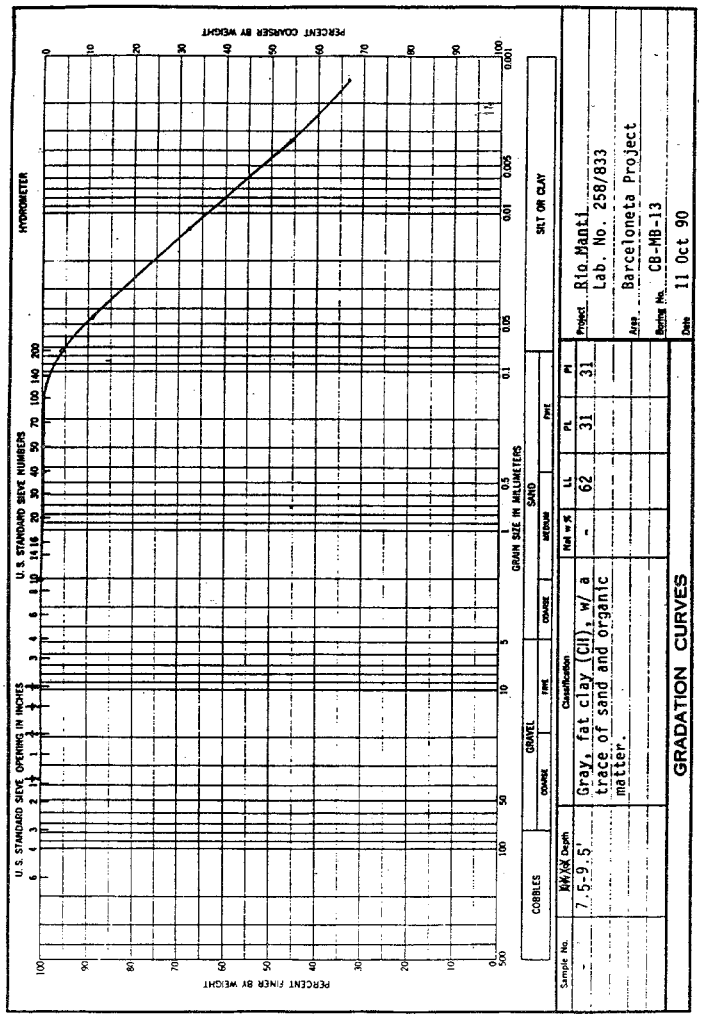
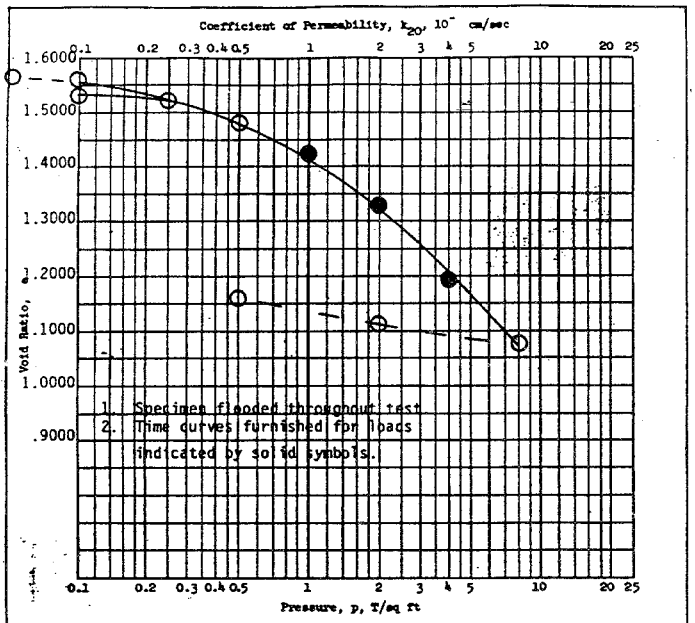


Plate B-74

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER NO. 6252
Req. No. RM-CW-90-258



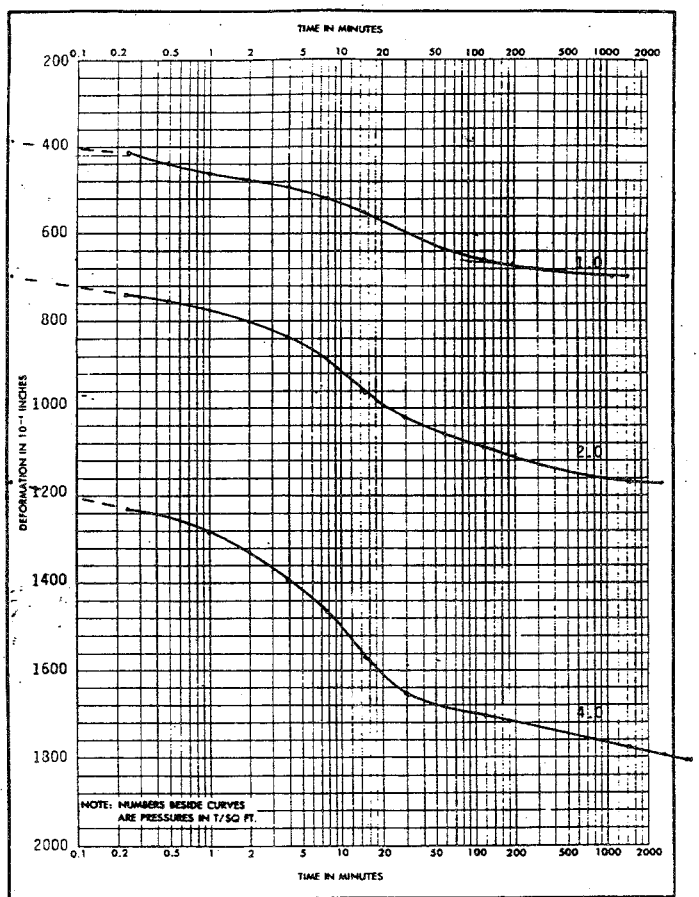
Type of Specimen: undisturbed		Before Test		After Test	
Diam 3.99 in.	Ht 1.25 in.	Water Content, w_o	56.4 %	w_f	41.6 %
Overburden Pressure, p_o T/sq ft		Void Ratio, e_o	1.567	e_f	1.156
Preconsol. Pressure, p_c T/sq ft		Saturation, S_o	100.0 %	S_f	100.0 %
Compression Index, C_c		Dry Density, γ_d	67.6 lb/ft^3		
Classification: Gray, fat clay (CH) w/ a trace of sand & organic matter.		k_{20} at e_o =	x 10^{-} cm/sec		
LL 62	G_s 2.78	Project Rio Manti			
PL 31	D_{10} <0.002mm	Lab. No. 258/833			
Remarks: See gradation curve and additional information on ENG Form 2087.		Area Barceloneta Project			
		Boring No. CB-MB-13	Sample No. -		
		Depth 7.5-9.5	Date 11 Oct 90		
		CONSOLIDATION TEST REPORT			

ENG FORM 1 MAY 63 2090 PREVIOUS EDITIONS ARE OBSOLETE.

Plate B-75

DEPARTMENT OF THE ARMY, SOUTH ATLANTIC DIVISION LABORATORY
CORPS OF ENGINEERS, 611 SOUTH COBB DRIVE, MARIETTA, GA. 30060

WORK ORDER NO. 6252
Req. No. RM-CW-90-258



PROJECT Rio Manti
AREA Barceloneta Project Lab. No. 258/833
BORING NO. CB-MB-13 SAMPLE NO. - DEPTH 7.5-9.5' DATE 11 Oct 90

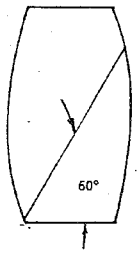
ENG FORM 2088 1 MAY 63 PREVIOUS EDITIONS ARE OBSOLETE

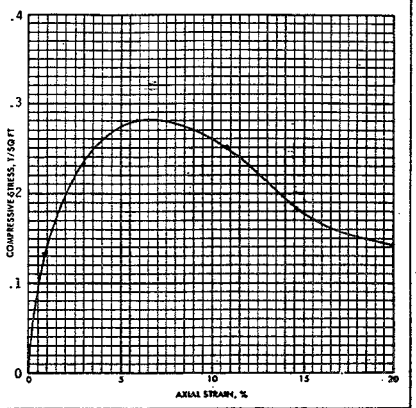
CONSOLIDATION TEST—TIME CURVES (TRANSLUCENT)

Plate B-76

W.O. NO. 6252
REQ. NO. RM-CW-90-258

FAILURE SKETCHES





☐ CONTROLLED STRESS

☒ CONTROLLED STRAIN

TEST NO.			1			
TYPE OF SPECIMEN			undisturbed			
INITIAL	WATER CONTENT	w_o	56.2 %	%	%	%
	VOID RATIO	e_o	1.563			
	SATURATION	S_o	100.0 %	%	%	%
	DRY DENSITY, LB/CU FT	γ_d	67.7			
TIME TO FAILURE, MIN		t_f	8			
UNCONFINED COMPRESSIVE STRENGTH, T/SQ FT		q_u	0.28			
UNDRAINED SHEAR STRENGTH, T/SQ FT		s_u	0.14			
~~AVERAGE RATE~~ Rate of Strain, %/min		S_r	0.73			
INITIAL SPECIMEN DIAMETER, IN		D_o	1.38			
INITIAL SPECIMEN HEIGHT, IN.		H_o	3.07			

CLASSIFICATION Gray, fat clay (CH), w/ a trace of sand & orgainc matter.

LL	PL	PI	G_s
62	31	31	2.78

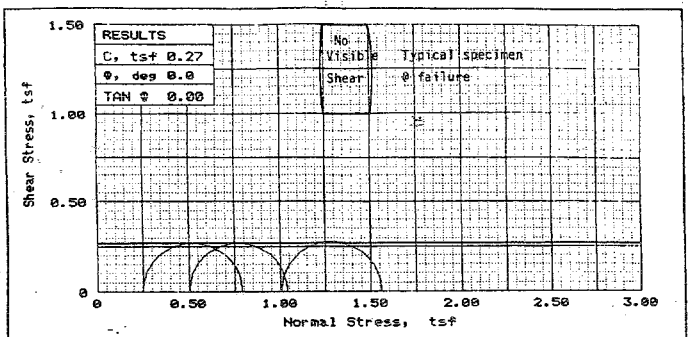
REMARKS See gradation curve and additional information on ENG Form 2087 previously reported.

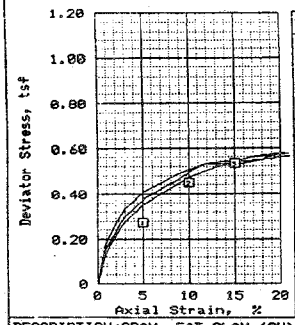
PROJECT Rio Manti
Lab. No. 258/833
AREA Barceloneta Project
BORING NO. CB-MB-13 SAMPLE NO. -
DEPTH 7.5-9.5' DATE 22 Oct 90

UNCONFINED COMPRESSION TEST REPORT

ENG FORM 1 MAR 65 3659 (EM 1110-2-1906) (TRANSLUCENT) PLATE XI-2

Plate B-77





SPECIMEN NO.		1	2	3
INITIAL	WATER CONTENT, %	61.4	61.1	58.8
	DRY DENSITY, pcf	64.0	64.3	65.9
	SATURATION, %	99.8	100.0	100.0
	VOID RATIO	1.710	1.699	1.635
	DIAMETER, in	1.38	1.38	1.38
	HEIGHT, in	3.08	3.08	3.08
@ TESTING	WATER CONTENT, %	61.4	61.1	58.8
	DRY DENSITY, pcf	64.0	64.3	65.9
	SATURATION, %	99.8	100.0	100.0
	VOID RATIO	1.710	1.699	1.635
	DIAMETER, in	1.38	1.38	1.38
	HEIGHT, in	3.08	3.08	3.08
BACK PRESSURE, tsf		0.00	0.00	0.00
INIT. EFF. STR., tsf		0.25	0.50	1.01
MAX. DEV. STRESS, tsf		0.54	0.54	0.55
PORE PRESSURE, tsf				
TIME TO FAILURE, min.		20	16	20
RATE, %/min.		0.75	0.74	0.77
ULT. DEV. STRESS, tsf		0.54	0.53	0.55

DESCRIPTION: GRAY, FAT CLAY (CH), WITH A TRACE OF SAND AND ORGANIC MATTER.

LL= 62	PL= 31	PI= 31	Gs= 2.78	CONTROLLED STRAIN TEST
TYPE OF SPECIMEN: UNDISTURBED				TYPE OF TEST: Q

REMARKS: SEE GRADATION CURVE AND ADDITIONAL INFORMATION ON ENG FORM 2087.

PROJECT: RIO MANTI

AREA: BARCELONETA PROJECT

LAB NO. 258/833

BORING NO. CB-MB-13

SAMPLE NO.

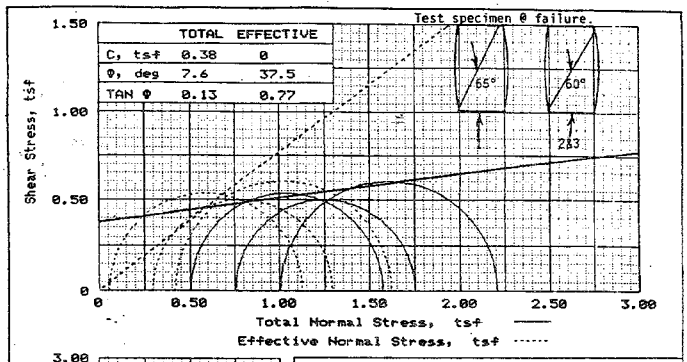
DEPTH/~~ELEV~~ 7.5-9.5'

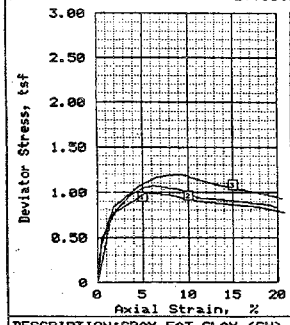
LABORATORY: CESAD-EN-FL DATE 19 OCT, 1990

TRIAXIAL COMPRESSION TEST

SOUTH ATLANTIC DIVISION LABORATORY, CORPS OF ENGINEERS - MARIETTA, GEORGIA
Work Order No. 6252
Requisition No. RM-CW-90-258

Plate B-78





SPECIMEN NO.		1	2	3
INITIAL	WATER CONTENT, %	55.0	56.3	57.8
	DRY DENSITY, pcf	68.6	67.7	66.6
	SATURATION, %	100.0	100.0	100.0
	VOID RATIO	1.529	1.564	1.606
	DIAMETER, in	1.38	1.38	1.38
	HEIGHT, in	3.08	3.08	3.08
@ TESTING	WATER CONTENT, %	51.2	52.8	52.6
	DRY DENSITY, pcf	71.6	70.3	70.5
	SATURATION, %	100.0	100.0	100.0
	VOID RATIO	1.424	1.467	1.462
	DIAMETER, in	1.36	1.36	1.35
	HEIGHT, in	3.04	3.04	3.02
BACK PRESSURE, tsf		5.04	5.04	5.04
INIT. EFF. STR., tsf		0.50	0.76	1.01
MAX. DEV. STRESS, tsf		1.07	1.08	1.20
PORE PRESSURE, tsf		0.45	0.46	0.59
TIME TO FAILURE, min.		65	50	90
RATE, %/min.		0.09	0.11	0.10
ULT. DEV. STRESS, tsf		0.91	0.87	1.05

DESCRIPTION: GRAY FAT CLAY (CH), WITH A TRACE OF SAND AND ORGANIC MATTER.

LL= 62	PL= 31	PI= 31	Gs= 2.78	CONTROLLED STRAIN TEST

TYPE OF SPECIMEN: UNDISTURBED — TYPE OF TEST: R w/pore pressures

REMARKS: SEE GRADATION CURVE AND ADDITIONAL INFORMATION ON ENG FORM 2087 PREVIOUSLY SUBMITTED.

PROJECT: RIO MANTI

AREA: BARCELONETA PROJECT — LAB NO. 258/833

BORING NO. CB-MB-13

SAMPLE NO. —

DEPTH/~~ELEV~~ 7.5-9.5'

LABORATORY: CESAD-EN-FL DATE 17 OCT, 1990

pg. 1 of 2 TRIAXIAL COMPRESSION TEST

SOUTH ATLANTIC DIVISION LABORATORY, CORPS OF ENGINEERS - MARIETTA, GEORGIA
Work Order No. 6252
Requisition No. RM-CW-90-258

Plate B-79

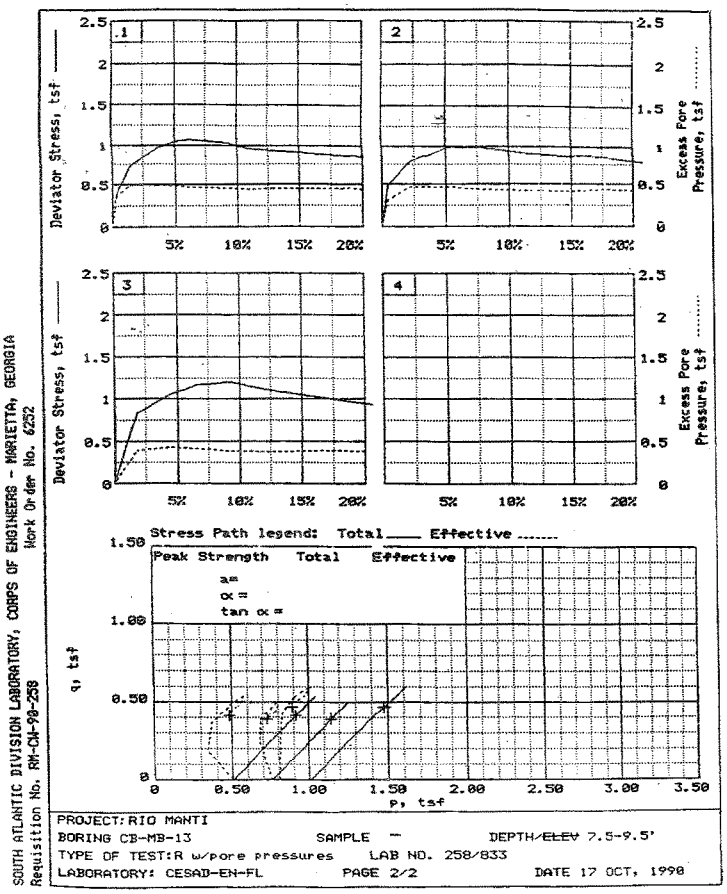

SOUTH ATLANTIC DIVISION LABORATORY, CORPS OF ENGINEERS - MARIETTA, GEORGIA
Requisition No. RM-CM-90-258
Work Order No. 6252
Deviator Stress, tsf
Excess Pore Pressure, tsf
1
2
3
4
5%
10%
15%
20%
Stress Path legend: Total Effective
Peak Strength Total Effective
a=
α =
tan α =
q, tsf
p, tsf
PROJECT: RIO MANTI
BORING CB-MB-13 SAMPLE - DEPTH/ELEV 7.5-9.5'
TYPE OF TEST: R w/pore pressures LAB NO. 258/833
LABORATORY: CESAD-EN-FL PAGE 2/2 DATE 17 OCT, 1990

Plate B-80

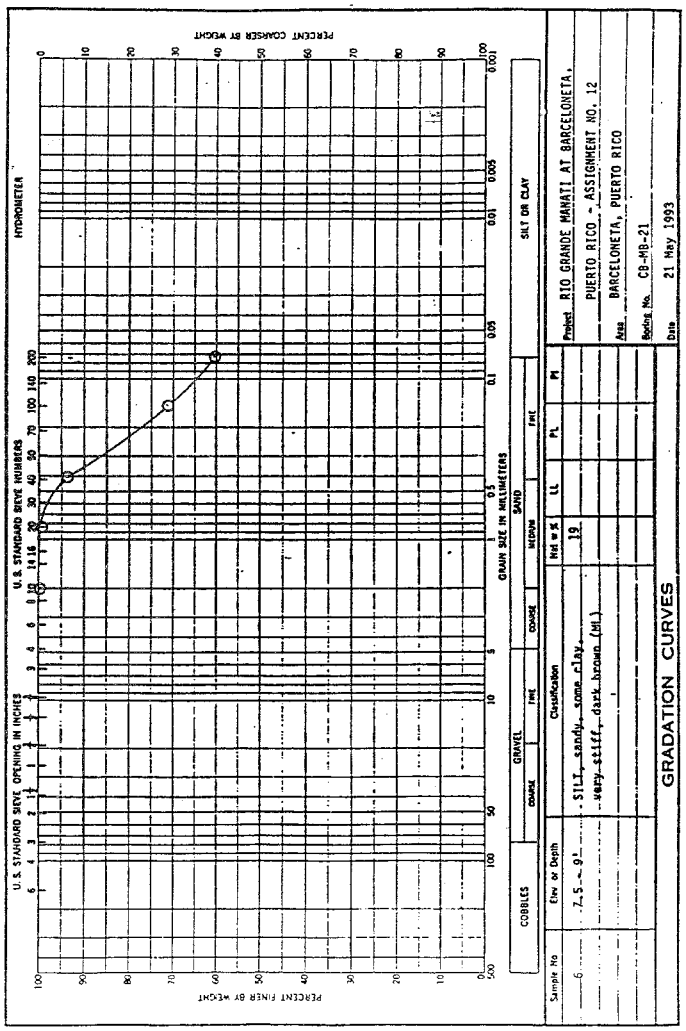
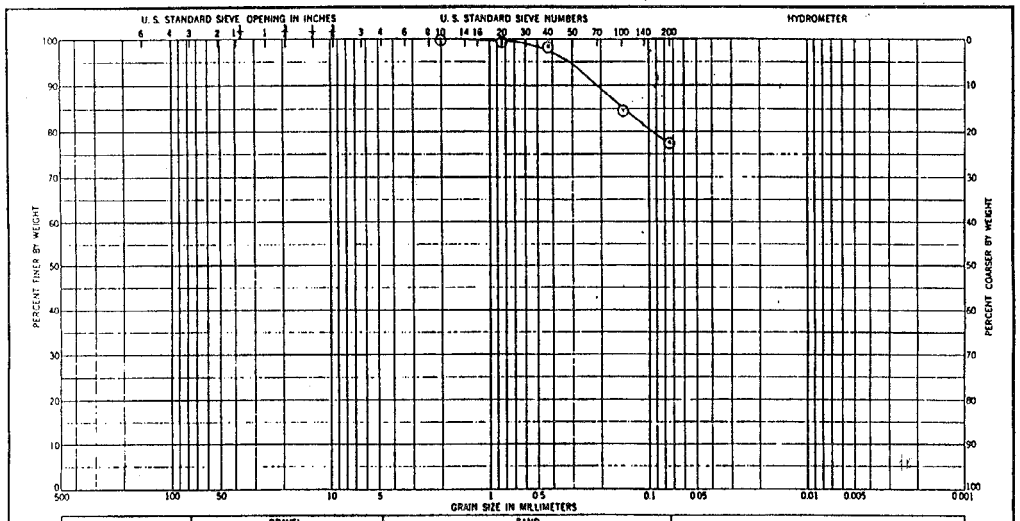

HYDROMETER
U.S. STANDARD SIEVE NUMBERS
U.S. STANDARD SIEVE OPENING IN INCHES
PERCENT COARSER BY WEIGHT
PERCENT FINER BY WEIGHT
GRAIN SIZE IN MILLIMETERS
COBBLES
GRAVEL
SAND
SILT OR CLAY
COARSE
FINE
MEDIUM
Sample No
Elev or Depth
Classification
Nat w %
LL
PL
PI
6
7.5 - 9'
SILT, sandy, some clay,
very stiff, dark brown (ML)
19
Project RIO GRANDE MANATI AT BARCELONETA,
PUERTO RICO - ASSIGNMENT NO. 12
Area BARCELONETA, PUERTO RICO
Boring No. CB-MB-21
Date 21 May 1993
GRADATION CURVES
ENG FORM 2087 1 MAY 83

Plate B-81



Sample No	Elev or Depth	Classification	Nat w %	LL	PL	PI
12	16.5 - 18'	SILT, clayey, little fine sand, medium, dark brown (ML)	36	49	33	16

GRADATION CURVES

Project: RIO GRANDE DE MANATI AT BARCELONETA, PUERTO RICO - ASSIGNMENT 12
Area: BARCELONETA, PUERTO RICO
Boring No.: CB-MB-21
Date: 21 May 1993

Plate B-82

ENG FORM (MAY 63) 2087

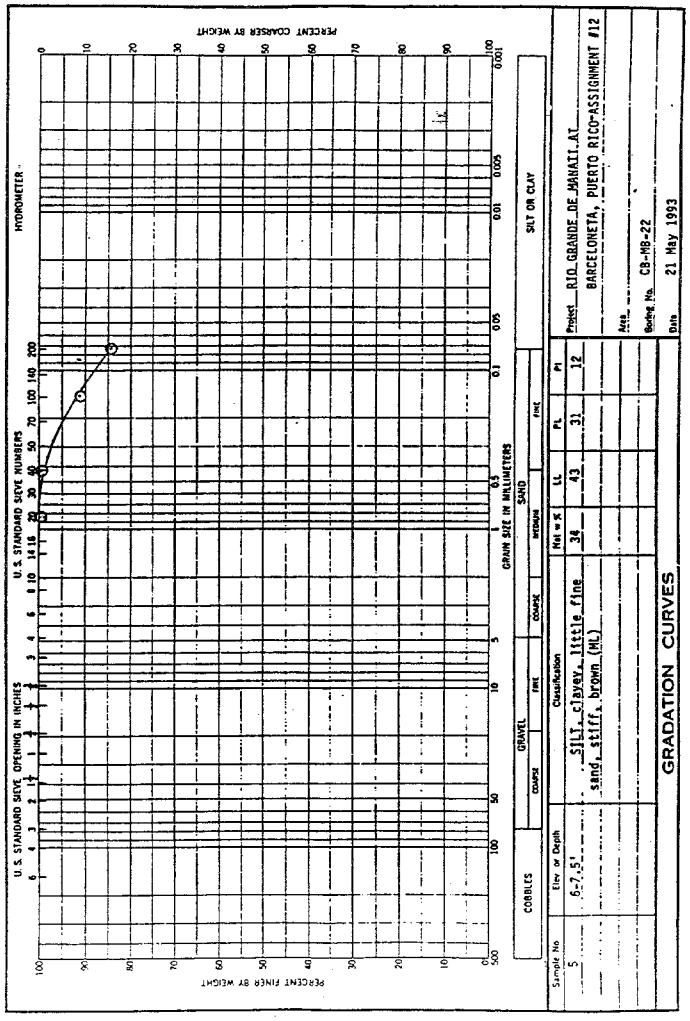
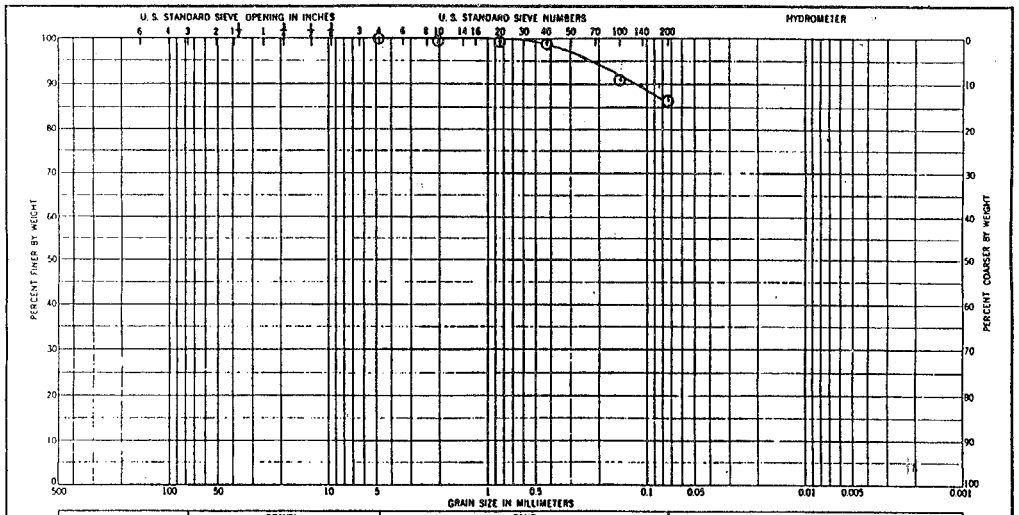

HYDROMETER
U. S. STANDARD SIEVE OPENING IN INCHES
U. S. STANDARD SIEVE NUMBERS
PERCENT FINER BY WEIGHT
PERCENT COARSER BY WEIGHT
GRAIN SIZE IN MILLIMETERS
COBBLES
GRAVEL
SAND
SILT OR CLAY
Sample No
Elev or Depth
Classification
Wat = %
LL
PL
PI
5
6-7.5'
Silt, clayey, little fine sand, stiff, brown (ML)
34
43
31
12
Project RIO GRANDE DE MANATI AL
BARCELONETA, PUERTO RICO-ASSIGNMENT #12
Area
Boring No. CB-MB-22
Date 21 May 1993
GRADATION CURVES
ENG FORM 2087

Plate B-83



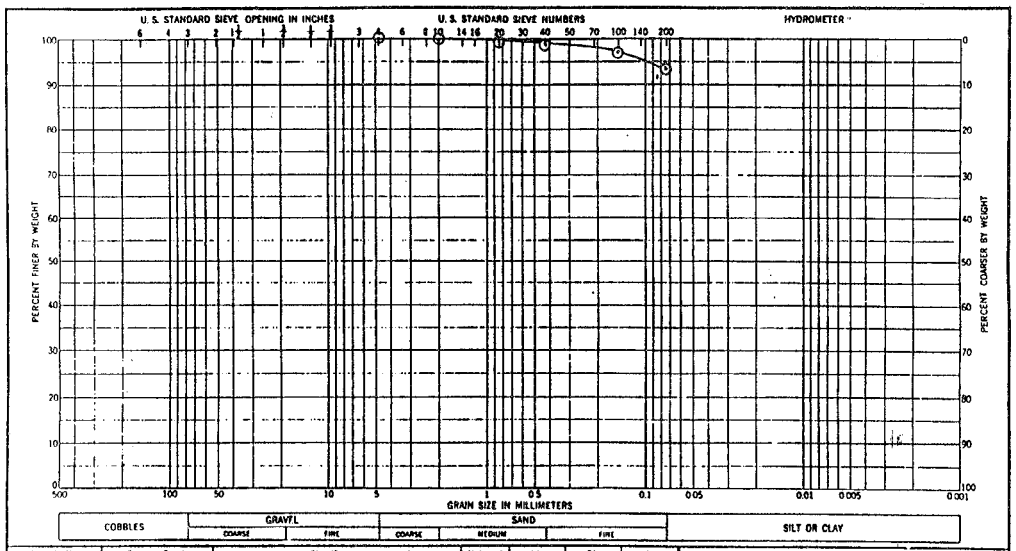
Sample No	Elev or Depth	Classification	Nat w %	LL	PL	PI
5	6-7.5'	SILT, clayey, little fine sand, very soft, grayish brown (MH)	64	53	35	18

GRADATION CURVES

Project: RIO GRANDE DE MANATI AT BARCELONETA, PUERTO RICO-ASSIGNMENT #12
Area:
Boring No.: CB-MB-23
Date: 21 May 1993

Plate B-84

ENG FORM 1 MAY 63 2087



Sample No	Elev or Depth	Classification	Nat w %	LL	PL	PI
3	3-4.5'	SILT, clayey, trace fine sand, occ. roots, soft, brown (MH)	42	50	36	14

GRADATION CURVES

Project RIO GRANDE MANATI AT BARCELONETA, PUERTO RICO - ASSIGNMENT #12

Area BARCELONETA, PUERTO RICO

Boring No. CB-MB-24

Date

Plate B85

ENG FORM 1 MAY 83 2087

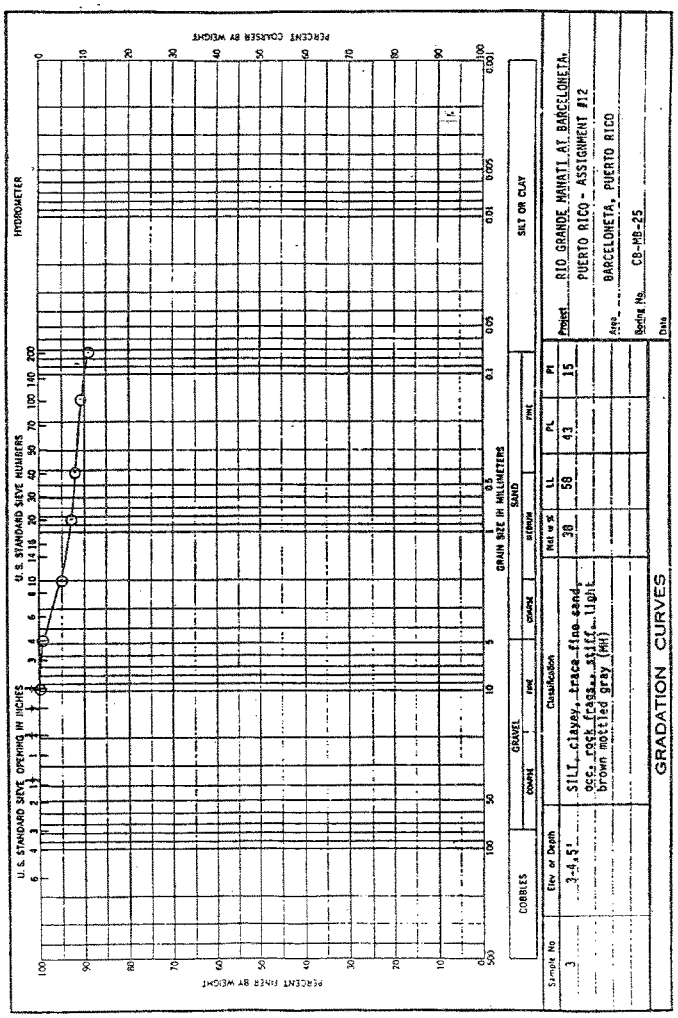
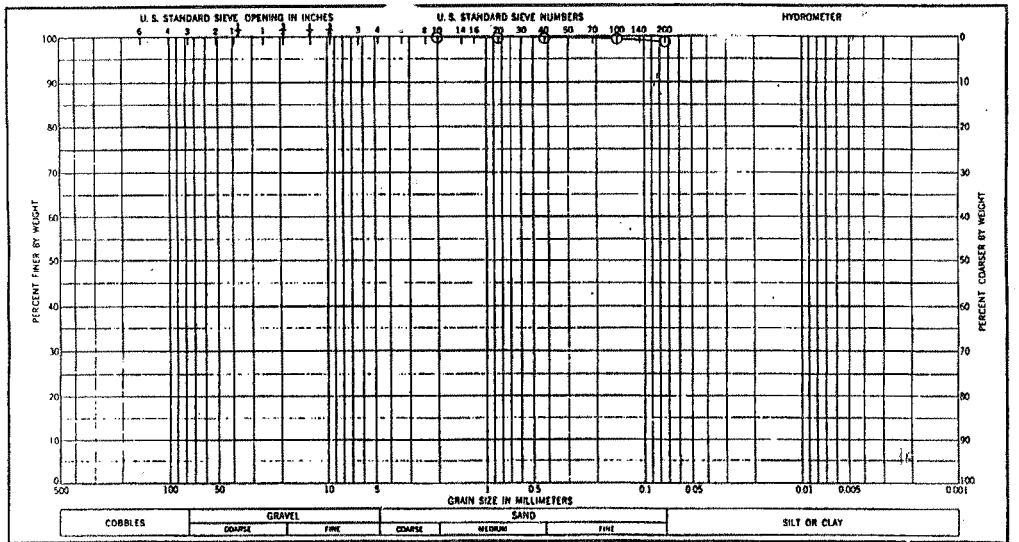

HYDROMETER
U. S. STANDARD SIEVE OPENING IN INCHES
U. S. STANDARD SIEVE NUMBERS
PERCENT FINER BY WEIGHT
PERCENT COARSER BY WEIGHT
GRAIN SIZE IN MILLIMETERS
COBBLES
GRAVEL
SAND
SILT OR CLAY
Sample No
Elev. or Depth
Classification
Nat w %
LL
PL
PI
3
3-4.5'
SILT, clayey, trace fine sand, occ. rock frags., stiff, light brown mottled grey (ML)
38
58
43
15
Project RIO GRANDE MAMATI AT BARCELONETA, PUERTO RICO - ASSIGNMENT #12
Area BARCELONETA, PUERTO RICO
Boring No. CB-MB-25
Date
GRADATION CURVES
ENG FORM 1 MAY 63 2087

Plate B-86

HYDROMETER
U.S. STANDARD SIEVE NUMBERS
U.S. STANDARD SIEVE OPENING IN INCHES
PERCENT FINER BY WEIGHT
PERCENT COARSER BY WEIGHT
GRAIN SIZE IN MILLIMETERS
COBBLES
GRAVEL
SAND
SILT OR CLAY
Sample No.
Elev or Depth
Classification
Nat w %
LL
PL
PI
6
7.5-9'
SILTy clayey, trace fine sand, occ. rock frags, medium light brown mottled gray
43
Project RIO GRANDE MANATI AT BARCELONETA
PUERTO RICO - ASSIGNMENT #12
Area BARCELONETA, PUERTO RICO
Boring No. CB-MB-25
Date 21 May 1993
GRADATION CURVES
FORM 1 MAY 83 2087
ENG

Plate B-87



Sample No	Elev or Depth	Classification	Nat w %	LL	PL	PI
4	4.5-6'	SILT, clayey, little fine sand, stiff dark brown (MH)	37	62	46	16

GRADATION CURVES

Project: RIO GRANDE MANATI AT BARCELONETA, PUERTO RICO - ASSIGNMENT #12

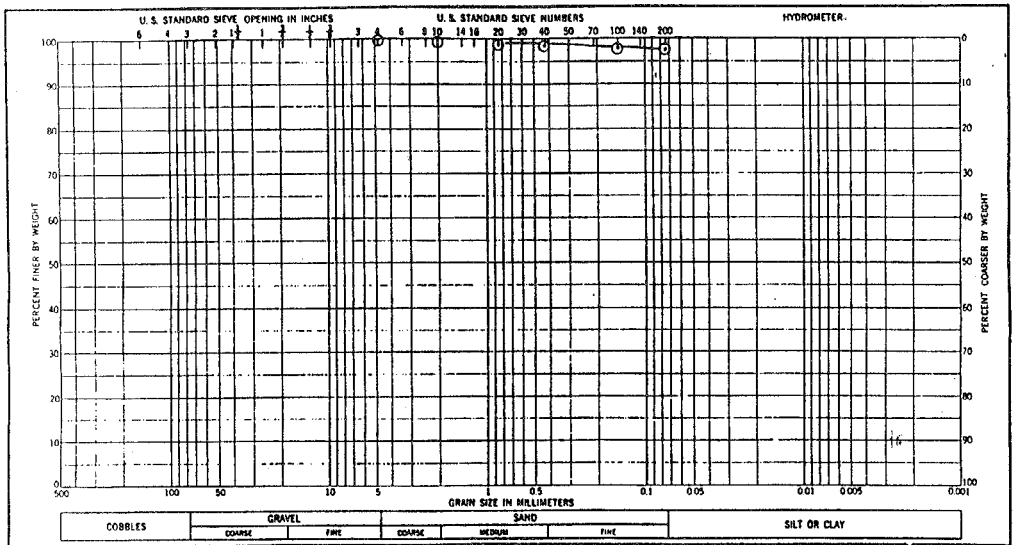
Area: BARCELONETA, PUERTO RICO

Boring No.: CB-MB-26

Date: 21 May 1993

Plate 9-88

ENG FORM 1 MAY 83 2087



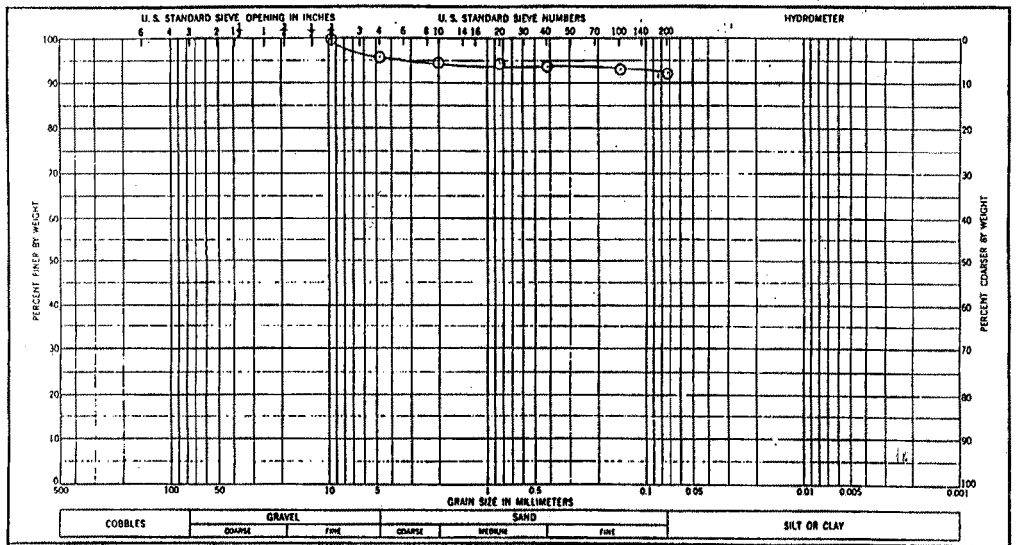
Sample No	Elev or Depth	Classification	Nat w %	LL	PL	PI
2	1.5-3'	SILT, clayey, little fine sand, occ. very small roots, very stiff, light brown (MH)	34	60	45	15

GRADATION CURVES

Project: RIO GRANDE MANATI AT BARCELONETA, PUERTO RICO - ASSIGNMENT #12
Area: BARCELONETA, PUERTO RICO
Boring No.: CB-MB-27
Date: 21 May 1993

Plate B-89

ENG FORM 1 MAY 63 2087



Sample No	Elev or Depth	Classification	Nat w %	LL	PL	PI
3	3-4.5'	SILT, clayey, little fine sand, very stiff, dark brown (MH)	37	54	40	14

Project RIO GRANDE MANATI AT BARCELONETA, PUERTO RICO - ASSIGNMENT # 12

Area BARCELONETA, PUERTO RICO

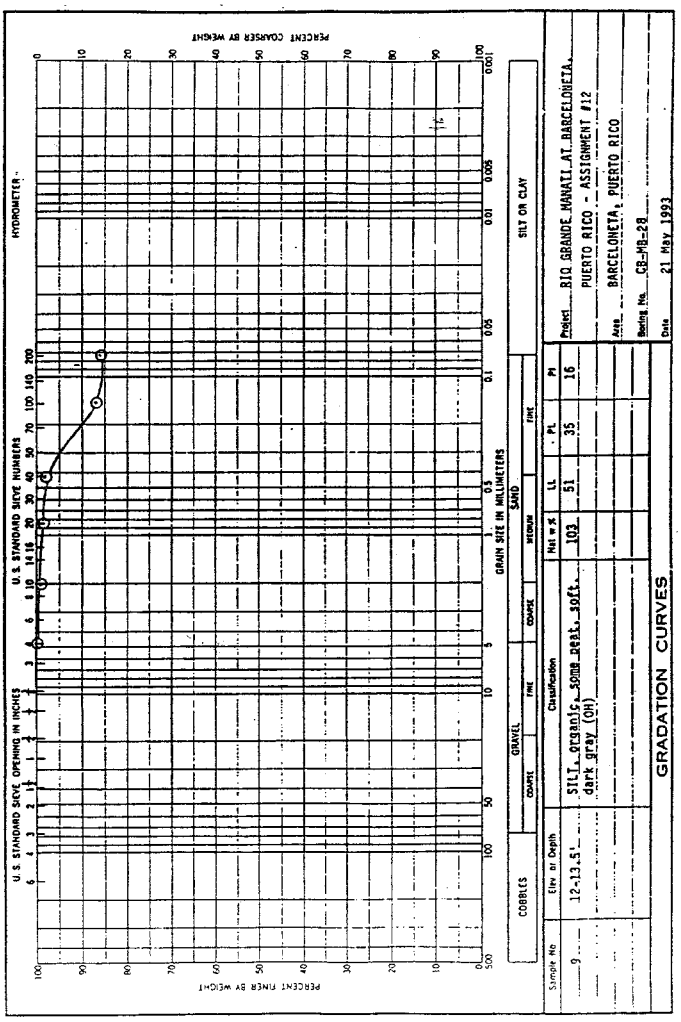
Boring No. CB-MB-28

Date 21 May 1993

GRADATION CURVES

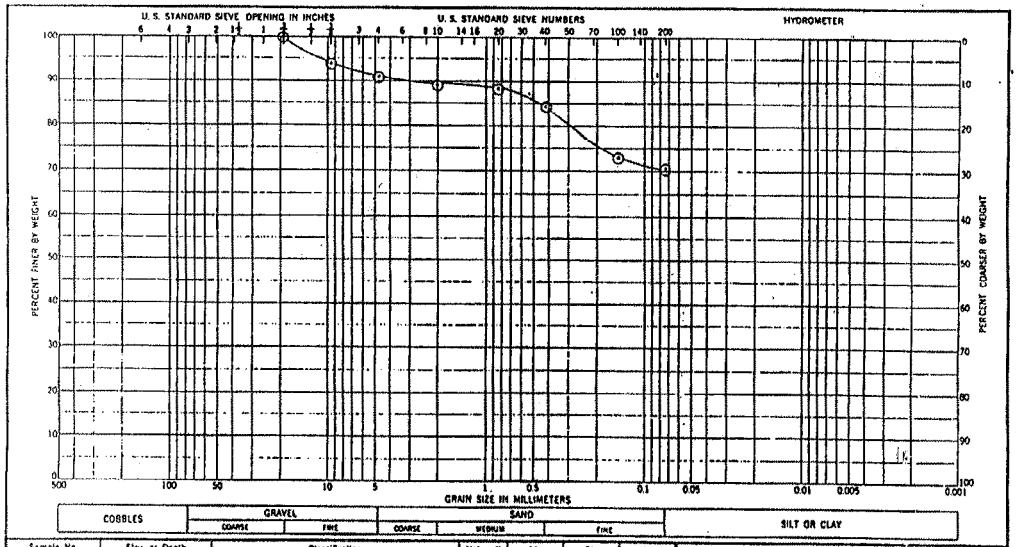
ENG FORM 1 MAY 63 2087

Plate 10-90



ENG FORM 1 MAY 83 2087

Plate B-91



Sample No	Elev or Depth	Classification	Nat w %	LL	PL	PI
3	3-4.5'	SILT, clayey, little fine sand, occ. fine sand, stiff, brown (MH)	39	64	38	26

GRADATION CURVES

Project RIO GRANDE MANATI AT BARCELONETA, PUERTO RICO - ASSIGNMENT #12

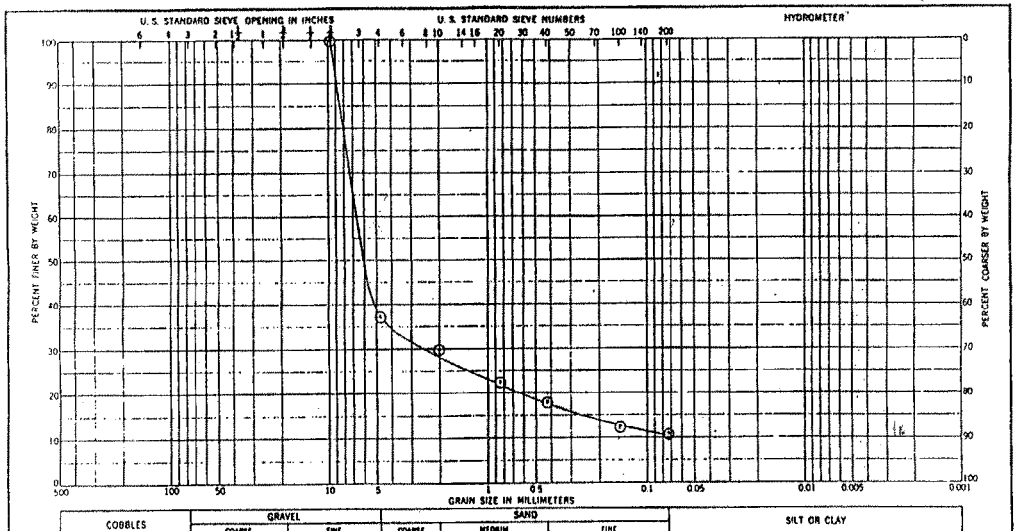
Area BARCELONETA, PUERTO RICO

Boring No CB-MB-29

Date 21 May 1993

Plate B-92

ENG FORM (MAY 63) 2087



Sample No	Elev or Depth	Classification	Nat w %	LL	PL	PI
2	1.5-3'	GRAVEL, sandy, little silt, fine, yellowish and yellowish red (material; soft limestone broken by sampler into soil constituents) (GP-GM)	7			NP

GRADATION CURVES

Project RIO GRANDE MANATI AT BARCELONETA, PUERTO RICO - ASSIGNMENT #12
Area BARCELONETA, PUERTO RICO
Boring No. CB-MB-30
Date 21 May 1993

Plate B-93

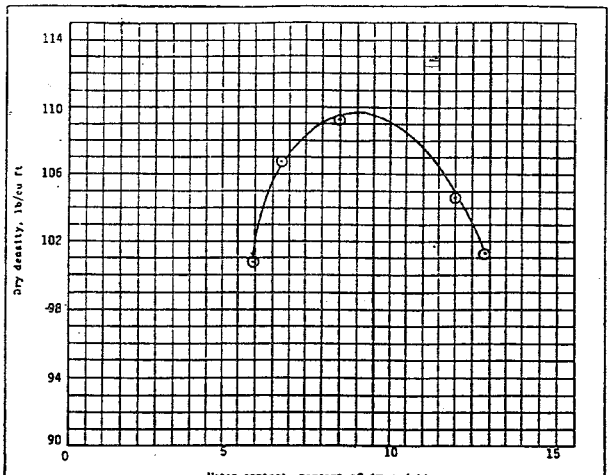
ENG FORM (MAY 63) 2087

ENG FORM 2087

Plate B-94

ENG FORM 2087 (MAY 93)

Plate B-95



STANDARD compaction test

25 blows per each of 3 layers, with 5.5 lb rammer and

12 inch drop. 6 inch diameter mold

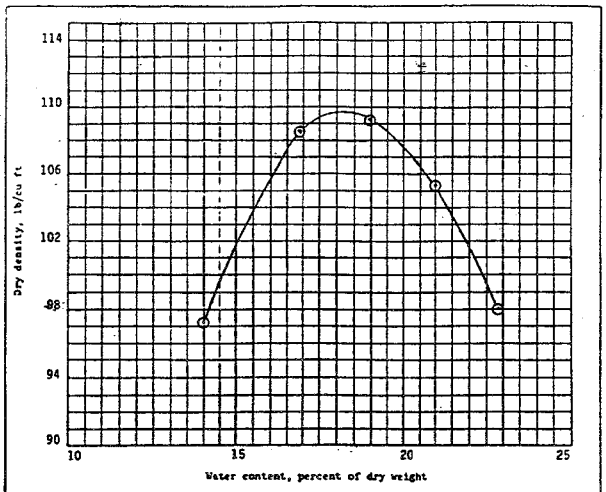
Sample No.	Elev or Depth	Classification	G	LL	PL	% > No. 4	% > 3/4 in.
1	*	Weathered limestone broken into gravel frags, some silt and trace sand.					

Sample No.	1			
Natural water content, percent				
Optimum water content, percent	9			
Max dry density, lb/cu ft	109.8			

Remarks	Project RIO GRANDE DE MANATI AT BARCELONETA, PR
*SAMPLE IS A COMPOSITE OF	ASSIGNMENT #12
THE SOILS EXCAVATED FROM	Area BARCELONETA, PUERTO RIC
THIS TEST PIT.	Boring No. TP-MB-1 Date 23 APRIL 1993
	COMPACTION TEST REPORT

EMC FORM 1 JUN 65 2091 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

Plate B-96



STANDARD compaction test

25 blows per each of 3 layers, with 5.5 lb rammer and

12 inch drop. 6 inch diameter mold

Sample No.	Elev or Depth	Classification	G	LL	PL	% > No. 4	% > 3/4 in.
1	*	Weathered limestone broken into gravel frags. some silt and trace sand.					

Sample No.	1			
Natural water content, percent				
Optimum water content, percent	18.2			
Max dry density, lb/cu ft	109.8			

Remarks * SAMPLE IS A COMPOSITE OF THE SOILS EXCAVATED FROM THIS TEST PIT.

Project RIO GRANDE DE MANATI AT BARCELONETA, PR
ASSIGNMENT #12

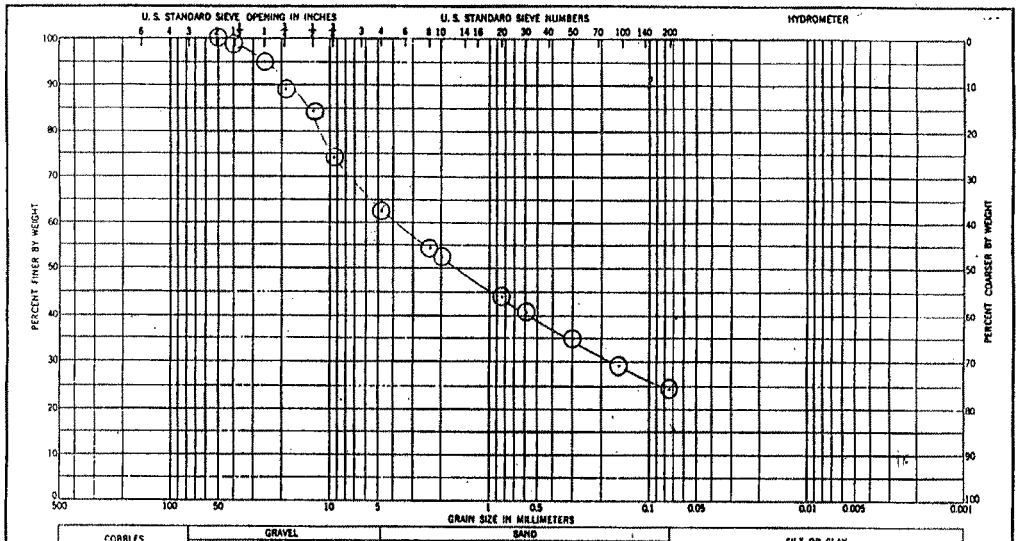
Area BARCELONETA, PUERTO RICO

Boring No. TP-MB-2 Date 22 APRIL 1993

COMPACTION TEST REPORT

ENG FORM 1 JUN 63 2091 PREVIOUS EDITIONS ARE OBSOLETE. (TRANSLUCENT)

Plate B-97



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
1	SITE #1	Tan, Non plastic gravelly SAND with some silt.				

Project BARCELONETA

Area

Boring No.

Date 4/30/91

GRADATION CURVES

Pit # B-18

ENG FORM 1 MAY 63 2087

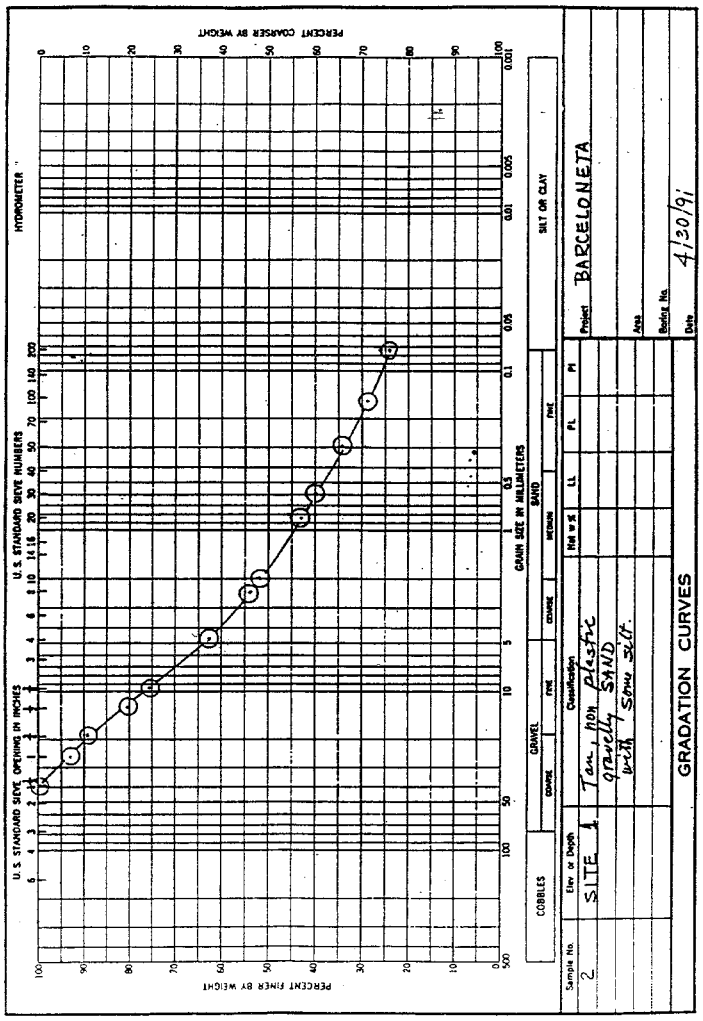
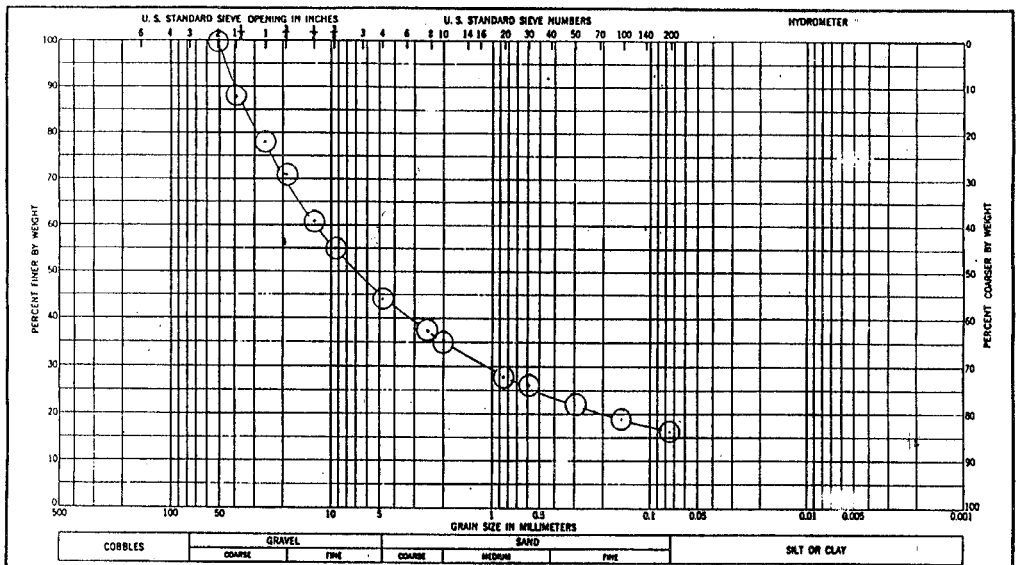

HYDROMETER
U.S. STANDARD SIEVE NUMBERS
U.S. STANDARD SIEVE OPENING IN INCHES
PERCENT COARSER BY WEIGHT
PERCENT FINER BY WEIGHT
GRAIN SIZE IN MILLIMETERS
COBBLES
GRAVEL
SAND
SILT OR CLAY
Sample No.
Elev or Depth
Classification
2
SITE 1
Project BARCELONETA
Date 4/30/91
GRADATION CURVES
ENG FORM 2087

Plate B-99



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
3	SITE 1	Tan GRAVEL with Some sand and little Silt. Non plastic.				

Project BARCELONETA

Area

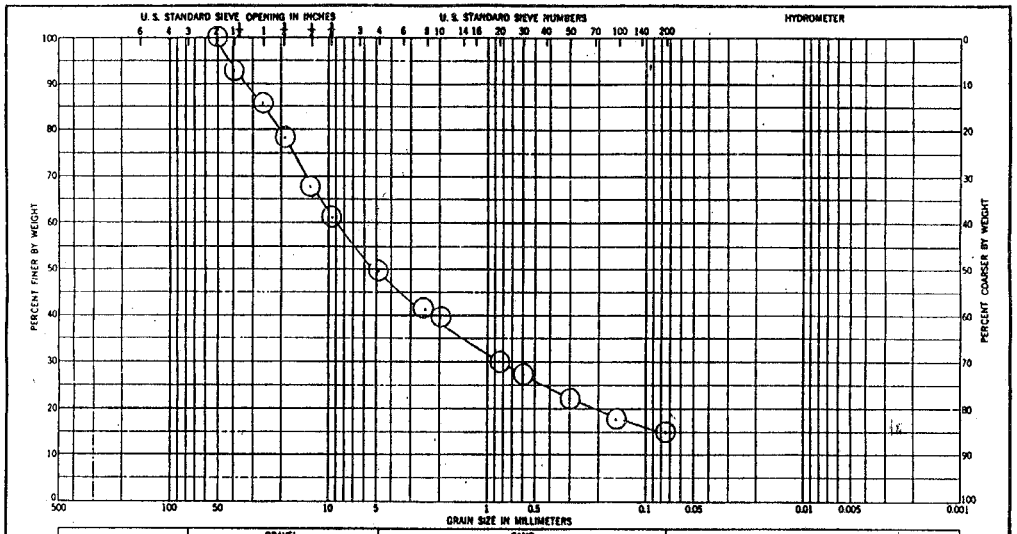
Boring No.

Date 4/30/91

GRADATION CURVES

ENG FORM 2087

plate B-100



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
1	SITE 2	Light tan GRAVEL with some sand and little silt.				

Project: BARCELONETA
Area:
Boring No.
Date: 5/1/91

GRADATION CURVES

Plate B-101

ENG FORM 1 MAY 63 2087

HYDROMETER
U. S. STANDARD SIEVE OPENING IN INCHES
U. S. STANDARD SIEVE NUMBERS
PERCENT COARSER BY WEIGHT
PERCENT FINER BY WEIGHT
GRAIN SIZE IN MILLIMETERS
COBBLES
GRAVEL
SAND
SILT OR CLAY
Sample No.
Elev. or Depth
Classification
Nat. w %
LL
PL
PI
2
SITE 2
Tan Gravel with Sand and little silt
Project BARCELONETA
Area
Boring No.
Date 4/30/91
GRADATION CURVES
ENG FORM 2087 1 MAY 63

Plate B-102

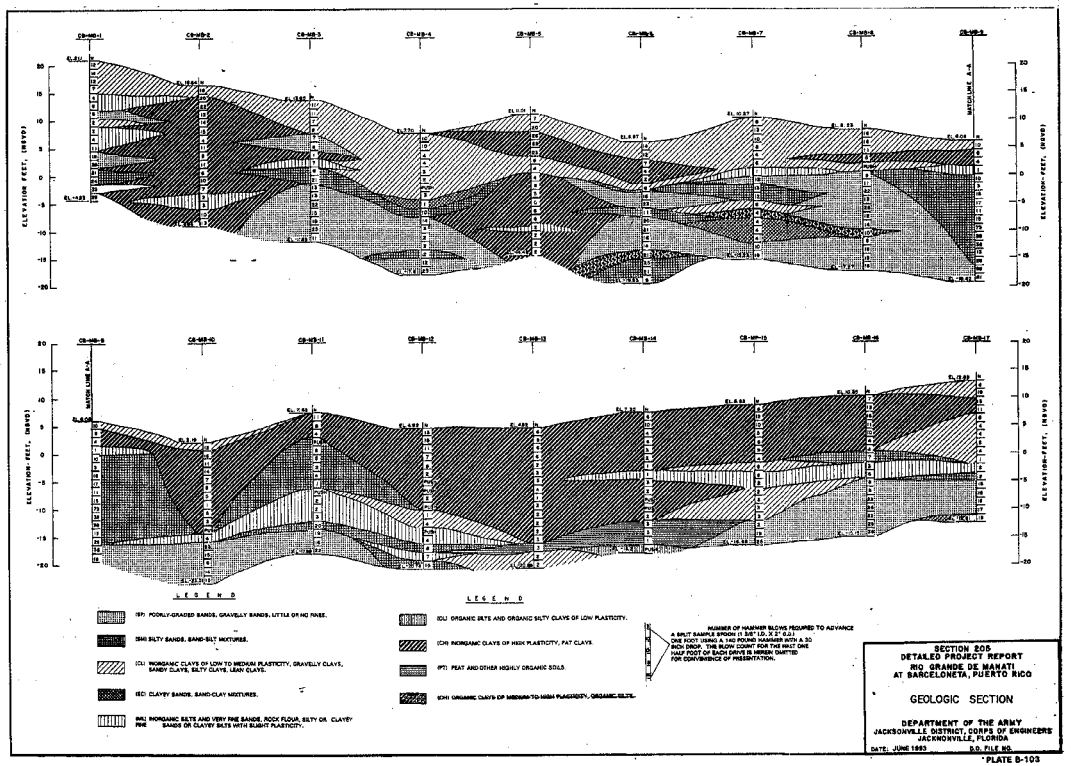
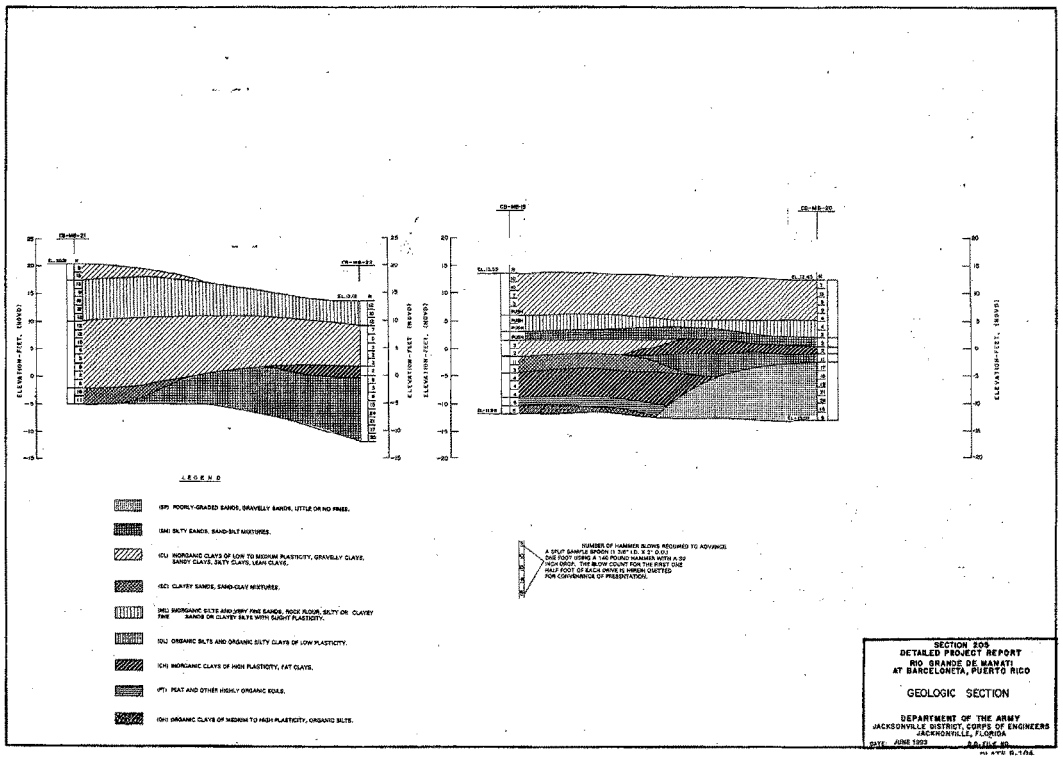
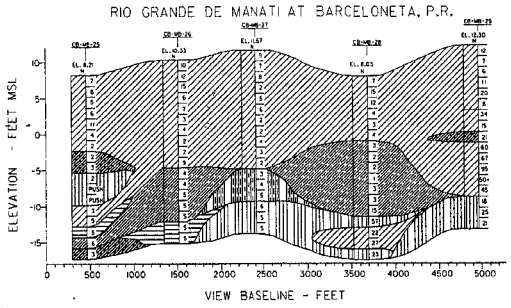

ELEVATION FEET, (NGVD)
LEGEND
(SP) POORLY-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES.
(SM) SILTY SANDS, SAND-SILT MIXTURES.
(CL) INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS.
(SC) CLAYEY SANDS, SAND-CLAY MIXTURES.
(ML) INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY.
(OL) ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY.
(CH) INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS.
(PT) PEAT AND OTHER HIGHLY ORGANIC SOILS.
(OH) ORGANIC CLAYS OF MEDIUM-TO-HIGH PLASTICITY, ORGANIC SILTS.
NUMBER OF HAMMER BLOWS REQUIRED TO ADVANCE A SPLIT SAMPLE SPOON (1 3/8" I.D., 2" O.D.) ONE FOOT USING A 140 POUND HAMMER WITH A 30 INCH DROP. THE BLOW COUNT FOR THE NEXT ONE HALF FOOT OF EACH DRIVE IS WHERE OMITTED FOR CONVENIENCE OF PRESENTATION.
SECTION 205
DETAILED PROJECT REPORT
RIO GRANDE DE MANATI
AT BARCELONETA, PUERTO RICO
GEOLOGIC SECTION
DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA
DATE: JUNE 1983
S.D. FILE NO.

PLATE B-103


CB-MB-21
CB-MB-22
CB-MB-19
CB-MB-20
ELEVATION-FEET, (NGVD)
LEGEND
(SP) POORLY-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES.
(SM) SILTY SANDS, SAND-SILT MIXTURES.
(CL) INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS.
(SC) CLAYEY SANDS, SAND-CLAY MIXTURES.
(ML) INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY.
(OL) ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY.
(CH) INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS.
(PT) PEAT AND OTHER HIGHLY ORGANIC SOILS.
(OH) ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS.
NUMBER OF HAMMER BLOWS REQUIRED TO ADVANCE A SPLIT SAMPLE SPOON (1 3/8" I.D. X 2' O.D.) ONE FOOT USING A 140 POUND HAMMER WITH A 30" HIGH DROP. THE BLOW COUNT FOR THE FIRST ONE HALF FOOT OF EACH DRIVE IS WHEN OMITTED FOR CONVENIENCE OF PRESENTATION.
SECTION 205
DETAILED PROJECT REPORT
RIO GRANDE DE MANATI
AT BARCELONETA, PUERTO RICO
GEOLOGIC SECTION
DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA
DATE: JUNE 1993
A-E FILE NO.



LEGEND

(SM) SILTY SANDS, SAND-SILT MIXTURES.

(CL) INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS.

(SC) CLAYEY SANDS, SAND-CLAY MIXTURES.

(ML) INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY.

(OL) ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY.

(PT) PEAT AND OTHER HIGHLY ORGANIC SOILS.

(OH) ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS.

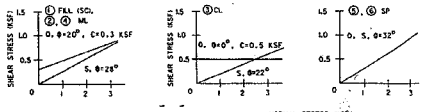
NUMBER OF HAMMER BLOWS REQUIRED TO ADVANCE A SPLIT SAMPLE SPOON (1⅜" I.D. X 2.0") ONE FOOT USING A 140 POUND HAMMER WITH A 30 INCH DROP. THE BLOW COUNT FOR THE FIRST ONE HALF FOOT OF EACH DRIVE IS NORMALLY OMITTED FOR CONVENIENCE OF PRESENTATION.

SECTION 205
DETAILED PROJECT REPORT
RIO GRANDE DE MANATI
AT BARCELONETA, PUERTO RICO

GEOLOGIC SECTION

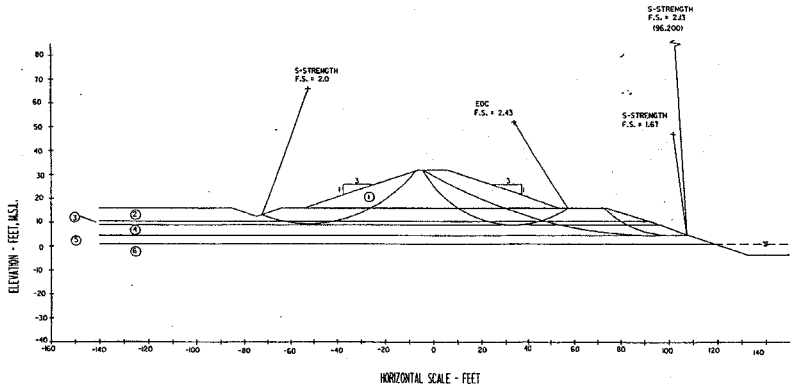
DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
JACKSONVILLE, FLORIDA

DATED: JUNE 1993 C.O. FILE NO. XXX-XX-XXX



COMPOSITE STRENGTH ENVELOPES

ASSUMED DESIGN DATA							
MTL. NO.	MTL.	UNIT WT. (PCF) γ_m	UNIT WT. (PCF) γ_s	O STRENGTH Φ' (DEG)	O STRENGTH C (KSF)	S STRENGTH Φ (DEG)	S STRENGTH C (KSF)
①	LEVEE SC	110	115	20	0.3	28	0
②	ML	100	110	20	0.3	28	0
③	CL		105	0	0.5	22	0
④	ML		110	20	0.3	28	0
⑤	SP		125	32	0	32	0
⑥	SP		120	32	0	32	0



NOTES:

1. CIRCULAR ANALYSIS AND WEDGE ANALYSIS WERE PERFORMED USING UTEXAS COMPUTER PROGRAM. CRITICAL FAILURE SURFACE LOCATION IS SHOWN WHICH PRODUCED THE LOWEST F.S.
2. CORE BORING CB-MB-1 WAS USED FOR THIS ANALYSIS.

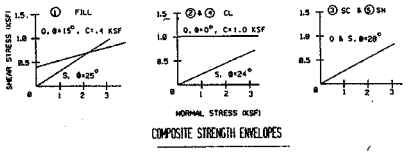
SECTION 205
DETAILED PROJECT REPORT
RIO GRANDE DE MANATI
AT BARCELONETA, PUERTO RICO

SLOPE STABILITY

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS

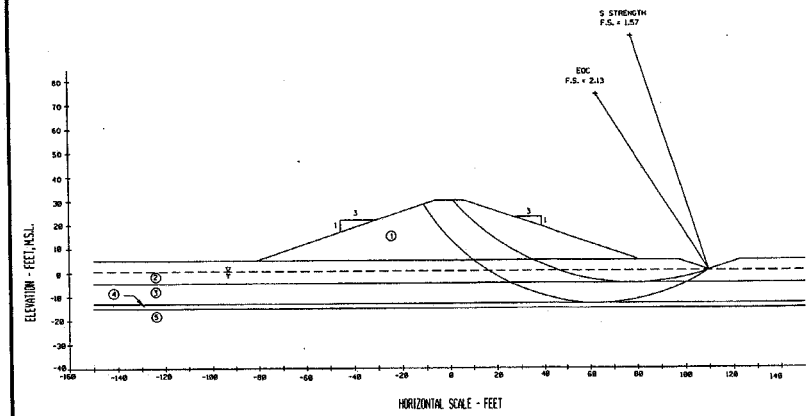
JUNE 1993 D.O. FILE NO.

Plate B-106



COMPOSITE STRENGTH ENVELOPES

ASSUMED DESIGN DATA							
MTL. NO.	MTL.	UNIT WT. (PCF)		Q STRENGTH		S STRENGTH	
		γ_m	γ_s	Φ (DEG)	C (KSF)	Φ (DEG)	C (KSF)
①	LEVEE SC	118		15	0.4	25	0
②	CL	100	125	0	1.0	24	0
③	SC		110	28	0	28	0
④	CL		110	0	1.0	24	C'_r
⑤	SM		110	28	0	28	Φ'_r



NOTES:

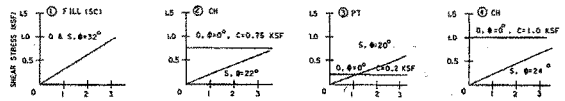
1. CIRCULAR ANALYSIS WAS PERFORMED USING UTEXAS COMPUTER PROGRAM. CRITICAL FAILURE SURFACE LOCATION IS SHOWN WHICH PRODUCED THE LOWEST F.S.
2. CORE BORING CB-MB-4 WAS USED FOR THIS ANALYSIS.

SECTION 205
DETAILED PROJECT REPORT
RIO GRANDE DE MANATI
AT BARCELONETA, PUERTO RICO

SLOPE STABILITY

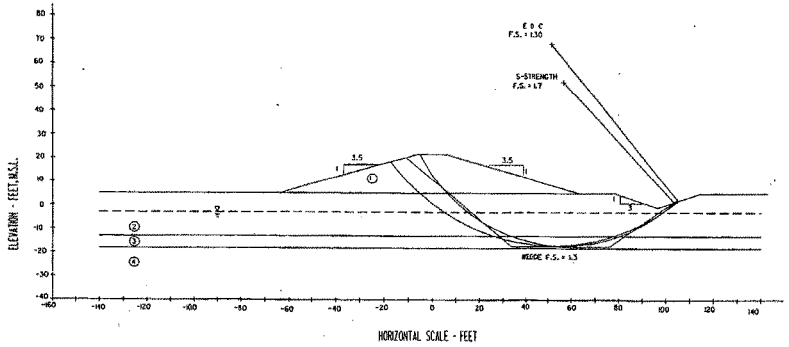
DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS

JUNE 1995 D.D. FILE NO.



COMPOSITE STRENGTH ENVELOPES

ASSUMED DESIGN DATA							
MTL. NO.	MTL.	UNIT WT. (PCF)		Ø STRENGTH		S STRENGTH	
		γ_m	γ_s	Ø (DEG)	C (KSF)	Ø (DEG)	C (KSF)
①	EVEE SC	110	115	32	0	32	0
②	CH	90	100	0	0.75	22	0
③	PT		85	0	0.2	20	0
④	CL		120	0	1.0	24	0



NOTES:

1. CIRCULAR ANALYSIS AND WEDGE ANALYSIS WERE PERFORMED USING UTEXAS COMPUTER PROGRAM. CRITICAL FAILURE SURFACE LOCATION IS SHOWN WHICH PRODUCED THE LOWEST F.S.
2. CORE BORINGS CB-MD-13 AND CB-MD-14 WERE USED FOR THIS SECTION.

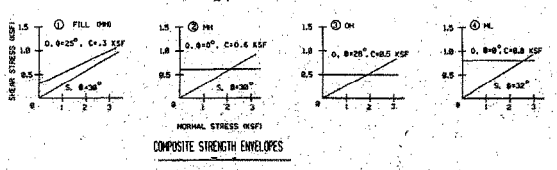
SECTION 205
DETAILED PROJECT REPORT
RIO GRANDE DE MANATI
AT BARCELONETA, PUERTO RICO

SLOPE STABILITY

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS

JUNE 1983 — D.O. FILE NO.

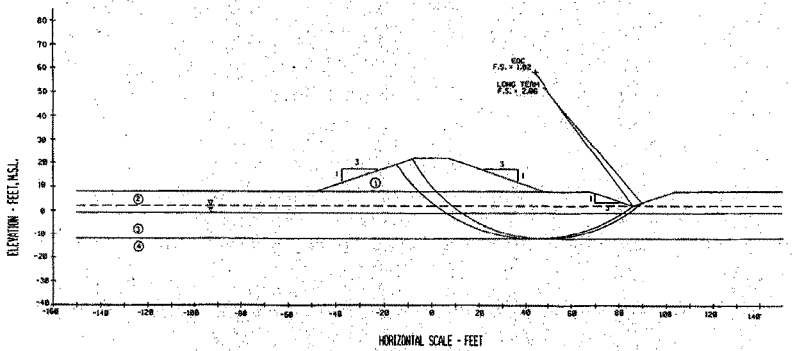
Plate B-108



COMPOSITE STRENGTH ENVELOPES

ASSUMED DESIGN DATA

MTL. NO.	MTL.	UNIT WT.(PCF) γ_m	γ_m	G STRENGTH θ (DEG)	G STRENGTH C (KSF)	R STRENGTH θ (DEG)	R STRENGTH C (KSF)	S STRENGTH θ (DEG)	S STRENGTH C (KSF)
①	LEVEE FILL SM	110	120	25	0.3	27	0.15	30	0
②	MH	115	120	0	0.6	15	0.3	30	0
③	OH		105	0	0.5	12	0.25	24	0
④	ML		125	0	0.8	16	0.4	32	0



NOTES:

1. CIRCULAR ANALYSIS AND WEDGE ANALYSIS WERE PERFORMED USING UTEXAS COMPUTER PROGRAM. CRITICAL FAILURE SURFACE LOCATION IS SHOWN WHICH PRODUCED THE LOWEST F.S.
2. CORE BORING CB-MB-28 WAS USED FOR THIS ANALYSIS.

SECTION 205
DETAILED PROJECT REPORT
RIO GRANDE DE MANATI
AT BARCELONETA, PUERTO RICO

SLOPE STABILITY

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS

JUNE 1983 — SAD FILE NO.

Plate B-109

RIO GRANDE DE MANATI @ BARCELONETA, P.R.
DETAILED PROJECT REPORT

APPENDIX C
DESIGN AND COST ESTIMATES

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APPENDIX C
DESIGN AND COST ESTIMATES

A. INTRODUCTION

1. General. This Appendix presents a discussion of applicable design considerations and construction methods utilized to establish a basis for the cost estimates. General requirements for real estate and operation and maintenance are also presented.

B. DESIGN AND CONSTRUCTION

2. Channels.

a. Downstream Pilot Channel. A 785 meter length pilot channel would be constructed east of the town of Barceloneta within the existing floodway in order to maintain flows in the original Rio Grande de Manati. The pilot channel is required because placement of the east levee adjacent to the town cuts off a portion of the existing river meander. The pilot channel would be designed to mimic the hydraulic capacity of the existing river section and would be constructed with a 15 meter bottom width at a design invert of elevation -2.2 meters producing an average channel depth of 5.6 meters. Channel side slopes would be 1V on 3H, and the channel would be constructed with a 500 meter (1640 foot) radius to provide a smooth transition between the adjoining meanders. The channel would be located sufficiently floodside of the east levee in order to avoid the need for erosion protection of the levee toe and slope. Geotechnical assumption is that 50% of the estimated 169,000 cubic yards of excavated material is suitable for levee construction. Construction of the downstream pilot channel would likely be the first order of work with all excavated material hauled to the future recreation site where it would be stockpiled and sorted based on suitability. Material unsuitable for levee construction would be used to backfill the adjacent reach of the original river meander which would be isolated by placement of the east levee.

b. Upstream Pilot Channel. A 760 meter length pilot channel would be constructed within the floodway southeast of the town of Barceloneta in order to maintain flows in the Rio Grande de Manati. The pilot channel would be required due to placement of approximately 450 meters of east levee within the existing riverbed. The upstream pilot channel would also be designed to mimic the hydraulic capacity of the existing river section and would be constructed with a 15 meter bottom width at a design invert of elevation -1.1 meters producing an average channel depth of 4.4 meters. Channel side slopes would be 1V on 3H. Predicted erosive velocities would require that bank protection be provided

along the entire length of the channel side slope adjacent to the levee. Geotechnical assumption is that 50% of the estimated 87,700 cubic yards of excavated material would be suitable for levee construction and could be used to construct a portion of the west levee. The remaining unsuitable material would be used to backfill the cut-off river meander as described in paragraph 1.

c. Interior Drainage Channels. A minimal interior drainage system consisting of four shallow channels would be constructed on the inside perimeter of the levee system and would route drainage flows to the two culvert outlet structures. Each channel would consist of a typical v-section with 1V on 3H side slopes constructed to an average depth of 1.5 meters below existing ground. The suitability of material excavated from the channel vary from 0 percent useability along the west channel (Channel 1) to upwards of 70 percent for the eastern channels (Channel 3 and 4). Material unsuitable for levee construction would be hauled to the onsite disposal area.

3. Main Ring Levee

a. General. The main earth levee protecting the town of Barceloneta would be constructed to satisfy the hydraulic requirements associated with the 100-year flood event in the Rio Grande de Manati basin. The ring levee would consist of two main segments (east and west) with a total length of approximately 5,200 meters and a required embankment volume of about 917,000 cubic yards. Starting at the southeast corner of Barceloneta [across from HWY 140 @ elevation 9.23 meters(NGVD)], the levee would basically encircle the developed areas of town to the north before tieing into high ground again at its southwest terminus [south of HWY 682 @ elevation 6.63 meters(NGVD)]. Levee heights varying between 1.15 and 1.37 meters above design water surface and geotechnical settlement factors varying from 0.28 to 0.46 meters were used in computing the design and as-built levee crest elevations respectively. An approximate 100 meter portion of the west levee segment, starting at the north culvert outlet and heading west, would be constructed as an overtopping section with a design elevation of 6.48 meters(NGVD). Also, an approximate 400 meter portion of the east levee segment, starting at the north culvert outlet and heading east, would be constructed as an overtopping section with a design elevation of 6.48 meters(NGVD). Refer to Plate C-1 for a plan view and description of the levee and its segments.

b. East Segment. The east levee segment would start at the north culvert outlet, culvert 1. The levee alinement would then turn southeast crossing Calle Plazuela and HWY 684; crossing Rio Manati twice; then essentially paralleling HWY 684 until terminating at HWY 140. The length of this segment is estimated to be 3000 meters with a required embankment volume of 637,000 cubic yards. The final 450 meters of the levee would be

constructed mostly within the existing riverbed in order to avoid relocating the row of residential structures adjacent to the river. In general, an attempt has been made to align the levee closely to the town in order to not infringe on the natural floodway. The levee would be constructed with 1V on 3H side slopes, a 4 meter crown width, and to an average height 5.3 meters above natural ground. Approximately eighty-five percent of the required levee fill would be obtained from an offsite borrow area with the balance of material available from the pilot and interior drainage channel excavations. Minimum berm separation between the levee toe and top of bank for the interior drainage channel would be 4.6 meters (15 feet). The berm width increases to 7.6 meters (25 feet) for the upstream pilot channel. A geotechnical overbuild factor of 0.28 meters (11 inches) has been applied to the design levee section in order to account for post construction settlement.

c. West Segment. The west segment begins at the north outlet culvert structure and extends along the west perimeter of proposed development for the town of Barceloneta. Final tie to high ground would be approximately 30 meters south of HWY 682 amidst a row of houses. Alignment of the levee across HWY 681 would be determined by the minimum westward offset required to provide a safe rampdown of HWY 681 prior to reaching the ninety degree turn onto the north-south segment of the highway. Total length of the segment is estimated at 2000 meters with a required embankment volume of 280,000 cubic yards. The levee would be built with 1V on 3.5H side slopes, with a 4 meter crown width, and to an average height 5.5 meters above natural ground. It is assumed that all (100%) of the required levee fill would be obtained from an offsite borrow area. Minimum berm separation between the levee toe and the top of bank for the interior drainage channel would be 6.1 meters (20 feet). A geotechnical overbuild factor of 0.46 meters (1.5 feet) has been applied to the design levee section in order to account for post construction settlement.

4. Drainage Culvert Structures. Culverts would be placed at four different locations within the project area. Culverts 1 and 2 would be sets of flap-gated culverts placed within existing channels in order to facilitate interior drainage through the levee and out of the protected area. Culvert 1A and 2B would be individual open-end culverts placed within the proposed interior drainage channels in order to convey flows beneath road embankments. Designs and costs for the flap-gated culverts are based on CMP barrels with bituminous coating. Tie down straps may be required due to head differentials across the culvert. For Culverts 1 and 2 only, riprap and bedding stone would be placed along the embankment face about the barrels and for about 3 meters along the approach channels and 6 meters along the discharge channels.

5. Bank Protection. Bank protection would be provided along areas of the channel and levee alignments where erosive velocities are predicted. As discussed above, the primary use of erosion protection would be along the channel side slope and adjacent levee face associated with the upstream pilot channel reach. Riprap would also be utilized as standard practice in protecting the intake and discharge areas for the proposed culvert structures. Geotechnical design specifies blanket thicknesses of 0.46 meters (18 inches) and 0.23 meters (9 inches) respectively for the riprap and filter stone layers.

6. Borrow and Disposal Areas.

a. Borrow Area. An existing borrow area owned by the Puerto Rico Land Authority located west of Barceloneta in the Garrochales area is proposed as the primary source of project borrow (see Appendix B for location). Due to the relatively poor quality of material obtained from onsite excavations, it is estimated that approximately 880,000 cubic yards of material (including road embankments) would be required from offsite borrow. An additional borrow area (Site 2) currently in use has been located between Barceloneta and Garrochales and would be used, if necessary, to supplement the existing borrow area (Site 1).

b. Disposal Area. A 6.8 acre corridor approximately 30 meters wide and 900 meters in length parallel and floodside of the west levee is proposed as the onsite disposal area. The disposal area extends from approximately west levee Sta. 10+00 to 19+00 and will accommodate a minimum 50,000 cubic yards of material when placed in adjacent and gapped pile configuration. Increased capacity within the area is possible if Geotechnical Branch determines later that the disposal material is suitable for overbuilding the floodside levee slope.

C. RELOCATIONS

7. General. The project sponsor would be required to assume the costs for all relocations and alterations. The recommended plan presented in this report would require the relocation of five roads as discussed in the following paragraphs. Any relocation of utilities, electric transmission lines, or telephone lines would be the responsibility of the local sponsor. For cost estimating purposes, the number and type of utilities relocations have been identified by preliminary field investigation. More detailed survey information and coordination with the project sponsor and utility owners would be required prior to construction.

8. Highway Bridges. The recommended plan will not require the removal and/or replacement of any existing highway bridges.

9. Road Relocations.

a. Public Roads. Road modifications would be designed in accordance with the Department of Transportation and Public Works Highway Design Manual. Designs and costs for the road rampings were based on providing vertical grade transitions dictated by speed and geometric parameters necessary to maintain safe stopping distances. Road relocations would consist of raising and ramping four local roads where the proposed ring levee crosses these routes. The locations of the crossings are indicated on Plate C-1. A design speed of 40 miles per hour (MPH) was used for HWY 684, 35 MPH for HWY 681, and 25 MPH for the HWY 682 and HWY 140 crossings. Grade transitions for all the rampings are a maximum 6 percent. Maintaining traffic flow during construction will be accomplished by several methods. A temporary paved bypass road is proposed to pass traffic around the HWY 681 and HWY 140 ramping locations. Construction of the HWY 140 bypass road will be hampered by adjacent residences (west side) and the proximity of the river (east side). It is anticipated that additional fill extending into the river bed or perhaps a widening of the levee crest at this location will be necessary in order to build the bypass road. Shifting the East Levee tie point approximately 80 meters southward should also be considered since the HWY 140 embankment does eventually reach an elevation greater than the 100-year levee crest (elevation 9.27 meters). In order to not impact residential structures adjacent to the existing alinements, offset alinements are proposed for the HWY 684 and HWY 682 rampings. However, the existing alinements will remain intact and serve both as temporary bypass routes during construction and as permanent non-thru access (blocked by levee) to the residences after construction.

b. Private Roads. Placement of the East Levee will prevent vehicular access to two tracts of farmland east of the levee and within the floodplain. To maintain access, one private farm road at approximately levee STA 22+50 will have to be ramped over the levee. The ramp will be designed so that the floodside portion of the ramp is constructed mostly parallel to the levee centerline so that extension into the floodway is minimized. The ramp will be unpaved, with a 5 meter top width and 1V on 3H embankment slope, and designed for a maximum 20 MPH and maximum 8 percent vertical grade. Placement of the downstream pilot channel will eliminate access from the east to the large tract of farmlands located between the east levee and the pilot channel. Continued access to these lands will be provided by constructing a private river crossing adjacent to the East Levee at

approximately STA 19+50. The crossing will be designed as a earthen berm extension to the existing levee and will be constructed at elevation 3.5 meters, with a 7.5 meter crest width, and a 1V on 5H side slope extending to the river bottom. The span length across the river will be approximately 40 meters. The crossing will be unpaved and guardrail will be placed along the outer edge to protect traffic from entering the river.

10. Buildings. Based on available topographic and aerial survey data, it is estimated that two residential structures at the southwest levee juncture would need to be relocated in order to construct the project. More detailed surveys would be needed at the levee start and end junctures with high ground to determine the actual number of structures that would be impacted by levee construction. Ramping of HWY 684 over the East Levee would also impact the several adjacent residences north of Calle Plazuela. These residences, however, would already qualify for relocation because the with-project stages in their area would be higher than the existing with-out project stages by 1 foot or greater.

11. Utilities. All utilities located within the area of project construction would require either temporary or permanent relocation. These utilities include overhead electric and telephone lines and poles identified at four separate locations where they cross the proposed levees. Lump sum cost estimates for each of the above relocations are included in the project cost summary. The cost estimates assume that two replacement poles and reconnection of lines would be required at each location. Further delineation of these and additional utilities, if any, will be determined by future topographic surveys and site visits.

12. Public Boat Ramp. The placement of the east levee and filling of the cut-off river meander along the eastern edge of town would require the relocation of an existing public boat ramp. The boat ramp will be relocated to the river reach just downstream of Culvert 2 but prior to the juncture with the pilot channel. Design of the new ramp will closely adhere to the existing facility and will include an unpaved ramp (approximately 1V on 4H grade), a concrete slab apron at the foot of the ramp depending on bottom conditions and an improved (but unpaved) access road leading from PR 684. A parking lot will not be provided but vehicular parking can be accommodated along the access road right-of-way.

D. OPERATIONS AND MAINTENANCE

13. General. The project sponsor would be responsible for operation and maintenance of the improvements and features proposed in this report upon completion of the construction project. The contractor would be responsible for all maintenance during the construction contract. Operation and maintenance of the project facilities would be performed in accordance with instructions prepared and incorporated in the "Operation and Maintenance Manual" which would be furnished to the project sponsor.

E. COST ESTIMATES

14. General. The estimate of first cost for construction of the recommended plan, including quantities, unit costs, contingencies and reasons for contingencies is presented in Table C-1.

TABLE C-1
PROJECT COST ESTIMATE
RIO GRANDE DE MANATI @ BARCELONETA, P.R.
DETAILED PROJECT REPORT
APRIL 1993 PRICE LEVEL

Rio Manati at Barceloneta
Barceloneta, Puerto Rico
Levee Protection

		Estimated Cost	Contingency	Total Cost
02.--.--	RELOCATIONS			
02.01.--	ROADS, CONSTRUCTION ACTIVITIES	871,000	140,000	1,011,000
02.03.--	CEMETERIES, UTILITIES AND STRUCTURES	309,000	61,000	370,000
09.--.--	CHANNELS AND CANALS			
09.01.--	CHANNELS	1,224,000	206,000	1,430,000
11.--.--	LEVEES AND FLOODWALLS			
11.01.--	LEVEES	4,159,000	681,000	4,840,000
	CONSTRUCTION COSTS	$6,563,000	$1,088,000	$7,651,000
01.--.--	LANDS AND DAMAGES	1,290,000	323,000	1,613,000
30.--.--	PLANNING, ENGINEERING AND DESIGN	450,000	75,000	525,000
31.--.--	CONSTRUCTION MANAGEMENT	676,000	112,000	788,000
Levee Protection		$8,979,000	$1,598,000	$10,577,000

APRIL 1993 PRICE LEVEL

Rio Manati at Barceloneta
Levee Protection

ACCOUNT CODE	ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT	% CONTINGENCY		CONTINGENCY REASON
02.01.--	ROADS, CONSTRUCTION ACTIVITIES							
02.01.01	Mobilization, Demobilization and Preparatory Work:	1	JOB	LS	41,000	20	8,200	1
02.01.13	Traffic Control:							
	PR-140 Road							
	Maint. of Traffic, Signs, Barr., Etc.	2	MO	2,600	5,200	20	1,040	2,3
	Detour Road	1	JOB	LS	98,380	15	14,757	2,3,4
	PR-684 Road, North							
	Maint. of Traffic, Signs, Barr., Etc.	4	MO	2,600	10,400	20	2,080	2,3
	PR-681 Road							
	Maint. of Traffic, Signs, Barr., Etc.	4	MO	2,600	10,400	20	2,080	2,3
	Detour Road	1	JOB	LS	54,300	15	8,145	2,3,4
	PR-682 Road							
	Maint. of Traffic, Signs, Barr., Etc.	2	MO	2,600	5,200	20	1,040	2,3
02.01.19	Construct Roadbed to Subgrade:							
	PR-140 Road							
	Clear and Grubb	1	ACR	1,000	1,000	20	200	2,3
	Remove Existing Pavement	1070	SY	3.00	3,210	20	642	2,3
	Ramp Fill	1100	CY	3.60	3,960	15	594	2,3,4
	Seed & Mulch	675	SY	0.40	270	20	54	2,3

TABLE C-1 (2)

APRIL 1993 PRICE LEVEL

Rio Manati at Barceloneta
Levee Protection

ACCOUNT CODE	ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT	% CONTINGENCY	CONTINGENCY	CONTINGENCY REASON
02.01.--	ROADS, CONSTRUCTION ACTIVITIES (Continued)							
02.01.19	Construct Roadbed to Subgrade:							
	PR-684 Road, North							
	Clear and Grubb	3	ACR	1,000	3,000	20	600	2,3
	Ramp Fill	33,290	CY	3.60	119,844	15	17,977	2,3,4
	Seed & Mulch	9,470	SY	0.40	3,788	20	758	2,3
	PR-681 Road							
	Clear and Grubb	2	ACR	1,000	2,000	20	400	2,3
	Remove Existing Pavement	3,510	SY	3.00	10,530	20	2,106	2,3
	Ramp Fill	23,200	CY	3.60	83,520	15	12,528	2,3,4
	Seed & Mulch	7,380	SY	0.40	2,952	20	590	2,3
	PR-682 Road							
	Clear and Grubb	1	ACR	1,000	1,000	20	200	2,3
	Ramp Fill	7,500	CY	3.60	27,000	15	4,050	2,3,4
	Seed & Mulch	3,000	SY	0.40	1,200	20	240	2,3
	Farm Road Ramp & Crossover							
	Embankment	2,550	CY	3.60	9,180	20	1,836	2,3,4
	Culvert 28 (72" CMP)	240	LF	160.00	38,400	20	7,680	2,3,4
	Excavation for Culverts	3,500	CY	3.00	10,500	20	2,100	2,3,4
	Limestone Pavement	250	CY	24.00	6,000	20	1,200	2,3,4
	Embankment	3,000	CY	3.60	10,800	20	2,160	2,3,4
	Guardrail	130	LF	20.00	2,600	20	520	2,3,4
	Limestone Pavement	65	CY	24.00	1,560	20	312	2,3,4
02.01.39	Road Surfacing:							
	PR-140 Road							
	New Pavement	1,070	SY	16.00	17,120	15	2,568	2,3,4
	Pavement Markings	500	LF	0.50	250	15	38	2,3,4
	Guardrail	280	LF	20.00	5,600	15	840	2,3,4
	PR-684 Road, North							
	New Pavement	5,420	SY	16.00	89,920	15	13,488	2,3,4
	Pavement Markings	2,110	LF	0.50	1,055	15	158	2,3,4
	Guardrail	2,190	LF	20.00	43,800	15	6,570	2,3,4

APRIL 1993 PRICE LEVEL

Rio Manati at Barceloneta
Levee Protection

ACCOUNT CODE	ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT	% CONTINGENCY		CONTINGENCY REASON
02.01.--	ROADS, CONSTRUCTION ACTIVITIES (Continued)							
02.01.03	Road Surfacing:							
	PR-681 Road							
	New Pavement	3,510	SY	16.00	56,160	15	8,424	2,3,4
	Pavement Markings	1,320	LF	0.50	660	15	99	2,3,4
	Guardrail	2,000	LF	20.00	40,000	15	6,000	2,3,4
	PR-682 Road							
	New Pavement	1,840	SY	16.00	29,440	15	4,416	2,3,4
	Pavement Markings	690	LF	0.50	345	15	52	2,3,4
	Guardrail	970	LF	20.00	19,400	15	2,910	2,3,4
	Subtotal, Construction Costs:				$871,000			
	Contingencies @ Average of 16.1 %						$140,000	
02.01.--	Roads, Construction Activities Total:						$1,011,000	

REASONS FOR CONTINGENCIES

1. PLACE WHERE MOBILIZATION COMES FROM IS UNKNOWN.
2. GOOD LEVEL OF DESIGN PROVIDED.
3. ACCURACY IN QUANTITIES TAKE-OFF.
4. DETAILED UNIT COST ANALYSIS PERFORMED.

TABLE C-1 (4)

APRIL 1993 PRICE LEVEL

Rio Manati at Barceloneta
Levee Protection

ACCOUNT CODE	ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT	% CONTINGENCY	CONTINGENCY REASON
02.03.--	CEMETERIES,UTILITIES AND STRUCTURES, COSTRUCTION ACTIVITIES						
02.03.01	Mobilization, Demobilization and Preparatory Work:	1	JOB	LS	15,000	20 3,000	1
02.03.18	Utilities:						
	Relocation of Poles, Cables, etc	1	JOB	LS	253,170	20 50,634	2,3
	Manhole Extension	1	JOB	LS	30,000	20 6,000	2,3,4
02.03.19	Construct Boat Ramp:						
	Clear and Grubb	0.5	ACR	1,000	500	20 100	2,3
	Ramp Excavation	105	CY	3.00	315	20 63	2,3
	Reinforced Concrete Slab	14	CY	100.00	1,400	15 210	2,3,4
	Bedding Stone	14	CY	30.00	420	20 84	2,3
	Limestone Base	275	CY	24.00	6,600	15 990	2,3,4
	Compacted Fill	570	CY	3.60	2,052	20 410	2,3
	Subtotal, Construction Costs:				$309,000		
	Contingencies @ Average of 19.7 %					$61,000	
02.03.--	Total					$370,000	

REASONS FOR CONTINGENCIES

1. PLACE WHERE MOBILIZATION COMES FROM IS UNKNOWN.
2. GOOD LEVEL OF DESIGN PROVIDED.
3. ACCURACY IN QUANTITIES TAKE-OFF.
4. DETAILED UNIT COST ANALYSIS PERFORMED.

TABLE C-1 (S)

APRIL 1993 PRICE LEVEL

Rio Manati at Barceloneta
Levee Protection

ACCOUNT CODE	ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT	% CONTINGENCY	CONTINGENCY REASON
09.01.--	CHANNELS						
09.01.01	Mobilization, Demobilization and Preparatory Work:	1	JOB	LS	58,000	20 11,600	1
09.01.31	Earthwork						
	Downstream Pilot Channel						
	Excavation	169,100	CY	1.40	236,740	15 35,511	2,3,4
	Hauling to East Levee	84,550	CY	1.00	84,550	15 12,683	2,3,4
	Hauling to Fill Oxbow	84,550	CY	1.00	84,550	15 12,683	2,3,4
	Upstream Pilot Channel						
	Excavation	87,700	CY	1.40	122,780	15 18,417	2,3,4
	Hauling to West Levee	43,850	CY	2.80	122,780	15 18,417	2,3,4
	Hauling to Fill Oxbow	35,450	CY	2.80	99,260	15 14,889	2,3,4
	Hauling to Disposal Area	8,400	CY	3.00	25,200	15 3,780	2,3,4
09.01.99	Associated General Items						
	Downstream Pilot Channel						
	Clear and Grubb	12.4	ACR	1,000	12,400	20 2,480	2,3
	Upstream Pilot Channel						
	Clear and Grubb	9.1	ACR	1,000	9,100	20 1,820	2,3
	18" Riprap	7,340	CY	35.00	256,900	20 51,380	2,3
	9" Bedding	3,720	CY	30.00	111,600	20 22,320	2,3
	Subtotal, Construction Costs:				$1,224,000		
	Contingencies @ Average of 16.8 %					$206,000	
09.01.-*	Channels Total:					$1,430,000	

REASONS FOR CONTINGENCIES

1. PLACE WHERE MOBILIZATION COMES FROM IS UNKNOWN.
2. GOOD LEVEL OF DESIGN PROVIDED.
3. ACCURACY IN QUANTITIES TAKE-OFF.
4. DETAILED UNIT COST ANALYSIS PERFORMED.

TABLE C-1 (6)

APRIL 1993 PRICE LEVEL

Rio Manati at Barceloneta
Levee Protection

ACCOUNT CODE	ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT	% CONTINGENCY		CONTINGENCY REASON
11.01.--	LEVEES							
11.01.01	Mobilization, Demobilization and Preparatory Work:	1	JOB	LS	198,000	20	39,600	1
11.01.02	Drainage:							
	Drainage Canals							
	Channel 1							
	Clear & Grubb	11.1	ACR	1,000	11,100	20	2,220	2,3
	Excavation	18,500	CY	1.50	27,750	15	4,163	2,3,4
	Hauling to D/A	18,500	CY	1.00	18,500	15	2,775	2,3,4
	Seed & Mulch	4.4	ACR	1,200	5,280	20	1,056	2,3
	Channel 2							
	Clear & Grubb	4.8	ACR	1,000	4,800	20	960	2,3
	Excavation	3,420	CY	1.50	5,130	15	770	2,3,4
	Hauling to D/A	1,710	CY	1.85	3,164	15	479	2,3,4
	Seed & Mulch	1.4	ACR	2,000	2,800	20	560	2,3
	Channel 3							
	Clear & Grubb	0.6	ACR	1,000	600	20	120	2,3
	Excavation	1,130	CY	1.50	1,695	15	254	2,3,4
	Hauling to D/A	565	CY	3.60	2,034	15	305	2,3,4
	Seed & Mulch	0.3	ACR	2,000	600	20	120	2,3
	Channel 4							
	Clear & Grubb	10.1	ACR	1,000	10,100	20	2,020	2,3
	Excavation	13,300	CY	1.00	13,300	15	1,995	2,3,4
	Hauling to D/A	6,650	CY	1.75	11,638	15	1,746	2,3,4
	Seed & Mulch	3.4	ACR	2,000	6,800	20	1,360	2,3
	Culverts							
	Culvert 1	1	JOB	LS	241,000	20	48,200	2,3,4
	Culvert 2	1	JOB	LS	96,600	20	19,320	2,3,4
	Culvert 1A	1	JOB	LS	22,400	20	4,480	2,3,4

TABLE C-1 (7)

APRIL 1993 PRICE LEVEL

Rio Manati at Barceloneta
Levee Protection

ACCOUNT CODE	ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT	%	CONTINGENCY	CONTINGENCY REASON
11.01.--	LEVEES (cont)							
11.01.31	Earthwork:							
	East Levee							
	Compact Fill from Channel 2, 3 and 4	8,930	CY	1.00	8,930	15	1,340	2,3,4
	Compact Fill from D/S Pilot Channel	84,550	CY	1.00	84,550	15	12,683	2,3,4
	Compact Fill Hauled from Borrow Area	543,525	CY	3.70	2,011,043	15	301,656	2,3,4
	West Levee							
	Compact Fill Hauled from Borrow Area	236,150	CY	3.55	838,333	15	125,750	2,3,4
	Compact Fill Hauled from U/S Pilot Channe	43,850	CY	1.00	43,850	20	8,770	2,3
	Oxbow							
	Filling East Oxbow	120,000	CY	1.00	120,000	20	24,000	2,3
11.01.99	Associated General Items:							
	East Levee							
	Clear & Grubb	36	ACR	1,000	36,000	20	7,200	2,3
	18" Riprap	4,150	CY	35.00	145,250	20	29,050	2,3
	9" Bedding	2,095	CY	30.00	62,850	20	12,570	2,3
	Grassing	30	ACR	2,000	60,000	20	12,000	2,3
	West Levee							
	Clear & Grubb	25	ACR	1,000	25,000	20	5,000	2,3
	Grassing	20	ACR	2,000	40,000	20	8,000	2,3
	Subtotal, Construction Costs:				$4,159,000			
	Contingencies @ Average of 16.4 %						$681,000	
11.01.--	Levees Total:						4,840,000	

REASONS FOR CONTINGENCIES

1. PLACE WHERE MOBILIZATION COMES FROM IS UNKNOWN.
2. GOOD LEVEL OF DESIGN PROVIDED.
3. ACCURACY IN QUANTITIES TAKE-OFF.
4. DETAILED UNIT COST ANALYSIS PERFORMED.

APRIL 1993 PRICE LEVEL

Rio Manati at Barceloneta
Levee Protection

ACCOUNT CODE	ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT	%	CONTINGENCY	CONTINGENCY REASON
01.-.-.-	LANDS AND DAMAGES							
01.A.-.-	Project Planning	1	JOB	LS	25,000	25	6,250	1
01.B.-.-	Acquisitions							
01.B.2.-	By Local Sponsor	1	JOB	LS	60,000	25	15,000	1
01.B.4.-	Review of Local Sponsor	1	JOB	LS	12,000	25	3,000	1
01.C.-.-	Condemnations							
01.C.2.-	By Local Sponsor	1	JOB	LS	40,000	25	10,000	1
01.C.4.-	Review of Local Sponsor	1	JOB	LS	4,000	25	1,000	1
01.E.-.-	Appraisals							
01.E.2.-	By Local Sponsor	1	JOB	LS	30,000	25	7,500	1
01.E.4.-	Review of Local Sponsor	1	JOB	LS	9,000	25	2,250	1
01.F.-.-	PL 91-646 Assistance							
01.F.2.-	By Local Sponsor	1	JOB	LS	7,000	25	1,750	1
01.F.4.-	Review of Local Sponsor	1	JOB	LS	2,800	25	700	1
01.G.-.-	Temporary Permits							
01.G.2.-	By Local Sponsor	1	JOB	LS	3,000	25	750	1
01.G.4.-	Review of Local Sponsor	1	JOB	LS	800	25	200	1
01.G.6.-	Damage Claims	1	JOB	LS	2,000	25	500	1
01.R.-.-	Real Estate Payments							
01.R.1.-	Land Payments (By Local Sponsor)	1	JOB	LS	930,000	25	232,500	1
01.R.2.-	PL 91-646 Assist.P'mts (By Local Sponsor)	1	JOB	LS	162,000	25	40,500	1
29.-.-.-	Local Cooperation Agreement (PCA)							
29.A.1.-	Draft PCA (Real Estate Activities)	1	JOB	LS	2,000	25	500	1
Subtotal Costs:					$1,290,000			
Contingencies @ Average of 25.0 %							$323,000	
							$1,613,000	

REASONS FOR CONTINGENCIES

1. CESAJ-RE-S STANDARD CONTINGENCY PERCENTAGE

TABLE C-1 (9)

PROJECT PLAN

APPENDIX D
ECONOMIC ANALYSIS

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RIO GRANDE DE MANATI AT BARCELONETA
DETAILED PROJECT REPORT

Appendix D
Economic Analysis

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RIO GRANDE DE MANATI AT BARCELONETA
DETAILED PROJECT REPORT

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Economic Analysis

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RIO GRANDE DE MANATI AT BARCELONETA
DETAILED PROJECT REPORT

Appendix D
Economic Analysis

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RIO GRANDE DE MANATI AT BARCELONETA
DETAILED PROJECT REPORT
ECONOMIC APPENDIX

I. INTRODUCTION

A. General

The Río Grande de Manatí Detailed Project Report is being conducted under Section 205, of the Flood Control Act of 1948, as amended. The study was requested by the Puerto Rico Department of Natural Resources, the local sponsor, in a letter dated September 11, 1986.

This appendix describes the social and economic conditions pertaining to the detailed Río Grande de Manatí study area and provides economic and demographic information useful in describing and analyzing the resources within that area, within the Municipality of Barceloneta, and with respect to formulation and evaluation of flood control plans. A description of the estimated flood damages induced by the river under existing and future conditions, as well as the benefits to be derived from the implementation of alternative flood control plans for the area are discussed.

B. Socioeconomic Profile

The study area of this report is the town of Barceloneta, the main urban area of the Municipality of Barceloneta, which is located in the northern part of Puerto Rico some 34 miles west of San Juan. With an area of about 24 square miles, the Municipality of Barceloneta is one of the smallest in Puerto Rico, and so is the town with an estimated population of 5,000. Most of the town, however, is in the flood plain and is subject to frequent and large floods. The economic base of the municipality revolves around a strong and growing manufacturing sector which is denominated by one of the largest concentrations of pharmaceutical plants in the world. Nevertheless, as the figures below indicate, the municipality shows an index of economic growth lower than that of the island as a whole:

Index of Economic Growth

	1985	1990	% Changes
Barceloneta	125.0	140.0	12.5
Puerto Rico	127.0	146.0	15.0

1. Population. According to the 1990 Census figures, the population of the Municipality of Barceloneta grew in about 11 percent or to 20,947 persons as compared to the 18,942 inhabitants in 1980. However, as Figure D-1 shows, the 1990 population was about the same as in 1970, and for the study area or the town it practically has remained the same during the past twenty years. It is only during the past few years that new residential developments are occurring in the urban part of the town probably reflecting growing job opportunities and the

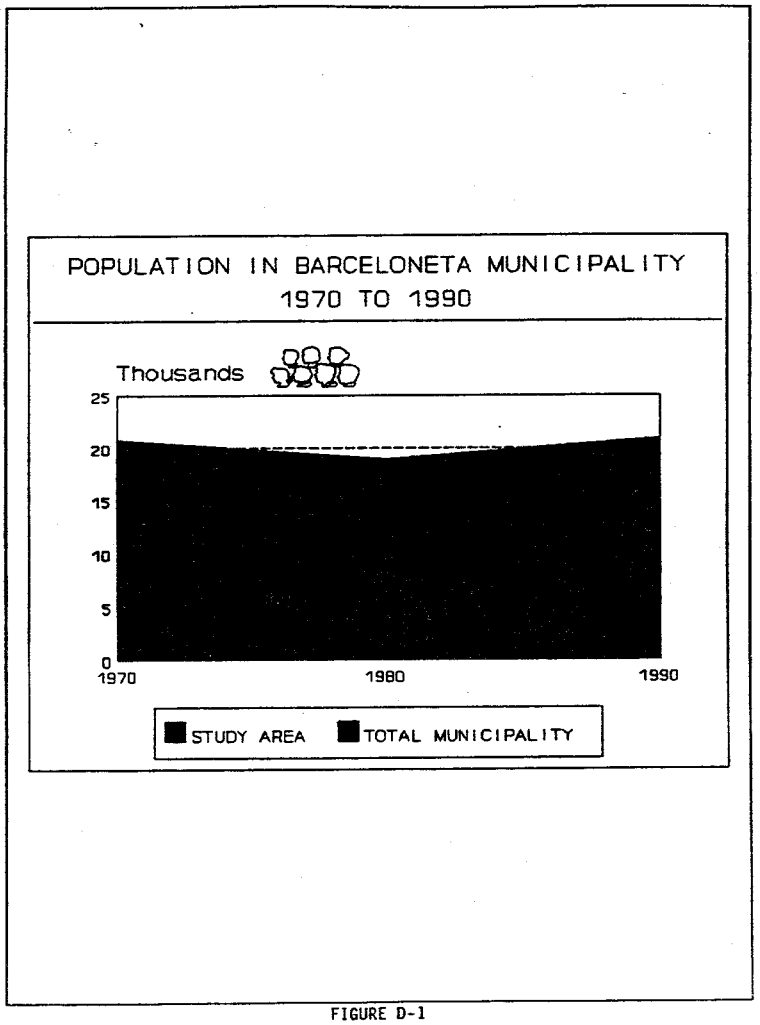
POPULATION IN BARCELONETA MUNICIPALITY
1970 TO 1990
Thousands
25
20
15
10
5
0
1970
1980
1990
STUDY AREA
TOTAL MUNICIPALITY

FIGURE D-1

substantial improvement in accessibility of the town resulting from the construction of the new toll highway connecting San Juan with the city of Arecibo and only a few miles south of the town of Barceloneta.

Table D-1 shows the 1990 distribution of population by age group. Median age for the population was estimated at 29.0 About 27.8 percent of the population is 19 years of age or younger, 61.9 percent is between 20 and 64 years old, and 10.3 percent is 65 years and older.

2. Labor force and employment. In 1990 there were in the municipality 15,019 persons 16 years of age and older. Of this, some 45.1 percent or 6,781 were in the labor force. The number of employed persons reached 4,833. Therefore, the unemployment rate was about 29 percent. Table D-2 shows the distribution of the labor force by principal economic sector. Most of the employed persons of the municipality concentrated in activities relating to manufacturing, commerce, professional and related services, and government. When figures in Table D-2 were compared with those relating to total job opportunities in the municipality as shown in Figure D-2, it can be seen that a substantial number of employees in the municipality are from other municipality. This is particularly true for the manufacturing sector. Table D-3 shows the distribution of the employed people by principal occupational categories. About 1,900 are within the managerial and professional occupation. This includes executive, administrative, as well as technical and sales people in the different economic sectors. Some 1,542 are classified as operators and laborers. Most of these are in the manufacturing activity. There are 638 persons in services occupations and another 657 in activities relating to precision production, craft, and repair occupation. There are only 95 employees in farming and related activities.

3. Manufacturing. This sector is the most important for Barceloneta's economy comprising about 72 percent of its total employment. According to the 1990 County Business' Patents ,17 manufacturing plants in the pharmaceutical and high technology and traditional products are operating in the municipality. The manufacturing activity is concentrated in the production of:

- Chemicals and allied products
- Measuring, analyzing and controlling instruments
- Apparel
- Electronic and other electrical equipment and components, except computer equipment
- Stone, clay, glass, and concrete products
- Food and kindred products
- Textile mill products

Some companies with facilities in the municipality include Sharp & Dohme; Pfizer; Abbot, Inc., Bristol Myers and Eastman Kodak. In the town of Barceloneta the structures where the plants are located are mostly owned by the government and rented through the Puerto Rico Industrial Development Company (PRIDCO), one of the prime movers of industrial development in the island. A total of 14 structures are located in the industrial park.

TABLE D-1

RIO GRANDE DE MANATI DETAILED PROJECT REPORT
1990 POPULATION DISTRIBUTION BY AGE GROUP

AGE	NUMBER	PERCENTAGE
Less than 5	1,732	8.3
5-9	1,799	8.6
10-14	1,969	9.4
15-19	1,997	9.5
20-24	1,357	8.4
25-44	5,717	27.3
45-54	2,219	10.4
55-59	852	4.1
60-64	741	3.5
65 and more	2,164	10.3

Median Age: 29 years

Source: 1990 Census of Population and Housing for Puerto Rico.

TABLE D-2

RIO GRANDE DE MANATI DETAILED PROJECT REPORT
1990 DISTRIBUTION OF EMPLOYED PEOPLE
BY MAJOR ECONOMIC SECTOR

INDUSTRY	EMPLOYMENT	PERCENTAGE
Agriculture and Related	105	2.1
Construction	606	12.0
Manufacturing	1,544	30.7
Transportation, Communications and Public Utilities	218	4.3
Commerce	778	15.5
Finance, Insurance, and Real Estate	219	4.4
Business and Repair Services	134	2.7
Personal Services	44	.9
Entertainment and Related Services	20	.4
Proffessional and Related Services	732	14.5
Public Administration	633	12.6
Total	5,033	100.0

Source: 1990 Census of Population and Housing for Puerto Rico.

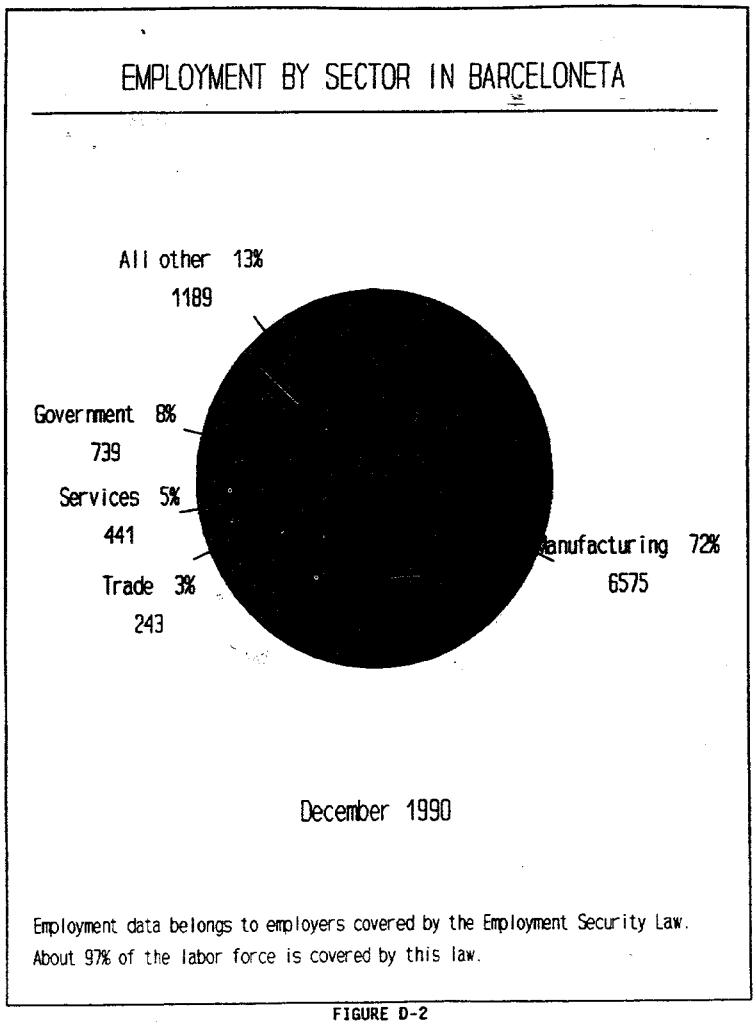
EMPLOYMENT BY SECTOR IN BARCELONETA
All other 13%
1189
Government 8%
739
Services 5%
441
Trade 3%
243
anufacturing 72%
6575
December 1990
Employment data belongs to employers covered by the Employment Security Law.
About 97% of the labor force is covered by this law.

FIGURE D-2

TABLE D-3

RIO GRANDE DE MANATI DETAILED PROJECT REPORT
1990 DISTRIBUTION OF EMPLOYED PEOPLE
BY MAJOR OCCUPATIONAL GROUP

OCCUPATIONAL CATEGORY	NUMBER OF EMPLOYEES	PERCENTAGE
Managerial and Professional	1,901	37.8
Service Occupations	638	12.7
Farming and Related	95	1.9
Precision Production	657	13.0
Operators and Laborers	1,542	30.6
Others	200	4.0
Total	5,033	100.0

Source: 1990 Census of Population and Housing for Puerto Rico.

4. Trade. According to the 1990 County Business Patterns there are 189 retail and 29 wholesale commercial establishments in the municipality with an estimated payroll of $1.6 million annually.

5. Education. In terms of education, according to the 1990 Population Census, there are 225 children of 3 years old and over were enrolled on pre-school institutions; 2,752 in elementary schools; 1,367 in high schools; and 831 in college.

6. Housing. In 1990 the total housing units in Barceloneta were 6,406 of which 79 percent (5,061) were owner-occupied. This represents a 5 percent rate of increase in the decade. The estimated number of owner and renter-occupied units in 1980 were 4,340 and 404, respectively.

Another characteristic of the housing stock is that 94 percent of the total housing inventory in 1980 was considered adequate housing, as classified by the U. S. Census of Housing. This substantial number of standard units is due mainly to federal policies and grant programs which gave priority to urban renewal of existing housing. Removal of substandard urban-pocket zones and major renovation of the urban center is observed in spite of the flooding problem. Estimates for 1990 sustain this trend.

The 6,046 total housing units were occupied with an average of 3.3 persons per unit, a downward trend since the 1980's which was 3.66. Projections by the Puerto Rico Department of Housing and the Puerto Rico Planning Board show that the trend will continue to decline. This may be in part because the problem of overcrowding in existing housing units has been reduced. The percentage of units with more than one person per room fell from 17.9 percent of the occupied inventory in 1980 to 12.6 percent in 1990. Single family housing makes up to 85 percent of the housing inventory, while attached structures and apartments increased in 10 percent during the decade.

According to the Puerto Rico Department of Housing, Comprehensive Housing Affordability Strategy Report (1992-1996), the existing need for housing in Barceloneta is estimated at 608 units; when future demand is taken into consideration this figure reaches over 2,600 by the year 2010.

7. Income distribution and poverty. Table D-4 shows the 1990 distribution of household by income groups. There were 1,079 families with annual income less than $1,999, while there were 188 families with annual income of $40,000 or more. Median household income was estimated at $7,173. About 62 percent of the household had annual income below the poverty level. Most of the households are recipients of the food stamps program.

8. Infrastructure. Public utilities for power and domestic water supply provide the necessary services to the area.

The transportation network between Barceloneta and the other municipalities in the north coast, is being improved with the construction of the final segment of toll Highway 22. This new highway, located only a few miles south of the study area, will be an expressway between San Juan city and the municipalities in the north coast.

TABLE D-4

RIO GRANDE DE MANATI DETAILED PROJECT REPORT
1990 DISTRIBUTION OF HOUSEHOLDS BY INCOME GROUP

INCOME GROUP	NUMBER
Less than 1,999	1,079
2,000 to 3,999	1,007
4,000 to 7,499	1,413
7,500 to 9,999	659
10,000 to 14,999	931
15,000 to 19,999	585
20,000 to 29,999	473
30,000 to 39,999	209
40,000 to 49,9099	130
50,000 to 59,999	24
60,000 to 74,999	34
75,000 or more	0

Source: 1990 Census of Population and Housing for Puerto Rico.

9. Land use and availability without project conditions. One of the most important elements in the development of the municipality is the availability and value of land, most specially flood-free land. This resource is limited and there is a highly competitive demand for its use by the residential, commercial, institutional and agricultural sectors. The growth of the housing sector and housing market is one of the most affected by the scarcity of land.

In order to balance and meet the future urban expansion, the Puerto Rico Planning Board adopted an Urban Expansion Plan for the municipality in 1978 and revised it during 1990. The plan includes proposed vacant lands for future urban development mostly located to the south of the town and to the west of Highway 681 near the industrial park zone. However, the present pressure for expansion has been very high due to the location of 17 industries in Barceloneta and high return migration from the mainland. This situation has pressed the administration of the municipal government to acquire and begin developing some of the land for housing use since the need is high in the community. During 1989-1991 the Villa Barcelona I development was completed. This is a middle-low cost housing consisting of 89 units. During 1992-1993 an additional tract of land on the west side of the Villa Barcelona I was also acquired. This consists of approximately 10 acres of land acquired by the municipality to develop Villa Barcelona II, an expansion of 236 lots and housing units. This expansion is occurring at vacant lands and involves costly site preparation. Therefore, it is expected that the PRPB adopts and implements an aggressive densification policy to provide for future population requirements of land.

C. Detailed Study Area Characteristics

The detailed study area includes Plazuela Ward, a residential area consisting of 45 housing units, 32 concrete and 13 wood. Structure values deviate from $14,000 to $27,000. Average content was estimated at $4,235. The urban core includes the northern sector which has residential developments and schools; the southern part which has 63 commercial retail and miscellaneous sales stores, financial institutions, public and nonprofit facilities. Municipal government and commercial areas are also located in this zone.

The Cataluña zone is mostly of residential development, whereas the Catalana ward has a mix of housing, commercial, and financial uses. The Palmas Altas ward, west of the central business zone, is dedicated to the industrial park.

There are 914 residential units which are flooded by the Río Manatí with the 100-year and SPF flood frequencies. Average structure value is estimated at $31,000 and $9,700 for contents.

Commercial, public, industrial and other uses amount to 168 additional buildings, which complete the inventory of property subject to flooding of 1,082 structures.

II. FLOOD DAMAGE ANALYSIS

A. General

This section provides a description of damage reaches and zones of the property subject to flooding, values of property, and depth-damage relationships used to calculate flood damage estimates. Potential flood damages and damage estimates for the alternative flood control plans under consideration are also included.

The inventory of property subject to flooding was conducted through field visits using flood maps for existing conditions developed as part of this study.

B. Damage Reaches and Zones

Since the topographical differences of the study area, as you shift outwards from the main stream are minimal, only one damage reach was defined in the study area as described below.

Reach 1. Includes the detailed study area that lies in the western margin of the Río Grande de Manatí. The reach was further subdivided into eight (8) zones to facilitate incremental analysis for economic evaluation. This reach extends from the mouth of Río Grande de Manati to the south of the urban core of the town of Barceloneta.

The zones from 1 to 8 are shown on Table D-5.

The damage zones are also shown on Plate D-1 and facilitate to account for differences in topography, property, and flooding levels.

C. Inventory of Property Subject to Flooding

For purposes of this analysis, property subject to flooding was grouped in seven land use categories. These are: residential, commercial, public, nonprofit organization facilities, industrial, utilities, and highways and streets. The following paragraphs describe the property subject to flooding and land use categories.

1. Residential. A total of 914 residential structures in the study area are subject to flooding by the 100-year flood frequency. They include 45 units in Plazuela Ward, 244 in the urban core (north and south), and 169 in Cataluña. In the Catalana sector there are 131 and 88 single family units in the Villa Barcelona I residential development. The second phase of Villa Barcelona II, is a residential development to be constructed during 1994. It was considered in the inventory included for Table D-6 that shows their distribution by flood frequency.

Most of the residential structures affected consist of reinforced concrete, one-family housing units. There are some scattered units built of mixed concrete and some wood-frame materials, mostly in Plazuela ward. Average size of structure varies from 600 square feet to 1,500 square feet.

TABLE D-5

RIO GRANDE DE MANATI DETAILED PROJECT REPORT

REACHES AND ZONES FOR ECONOMIC ANALYSIS

REACH	ZONE	DESCRIPTION
1		Total Urban Study Area
	1	Plazuela Ward
	2	Urban Core North
	3	Industrial Zone West of Urban Zone
	4	Urban Core South
	5	Cataluña Residential Development
	6	Catalana Residential Development and Catalana Ward
	7	Villa Barcelona I
	8	Villa Barcelona II

TABLE D-6

RIO GRANDE DE MANATI DETAILED PROJECT REPORT
INVENTORY OF RESIDENTIAL PROPERTY SUBJECT TO FLOODING

REACH	ZONE	SECTOR	TYPE OF CONSTRUCTION	NUMBER OF STRUCTURES					
				5-YEAR	10-YEAR	25-YEAR	50-YEAR	100-YEAR	SPF
1	1	Plazuela Ward	70% Concrete - One Family 30% Wood Frame - One Family	0	45	45	45	45	45
	2	Urban Core - North	100% Concrete - One Family	0	184	184	184	184	184
	4	Urban Core - South	100% Concrete - One Family	0	60	60	60	60	60
	5	Catalina Res. Dev.	100% Concrete - One Family	0	0	0	169	169	169
	6	Catalana Ward and Catalana Res. Dev.	100% Concrete - One Family	131	131	131	131	131	131
	7	Villa Barcelona I	100% Concrete - One Family	0	0	89	89	89	89
	8	Villa Barcelona II	100% Concrete - One Family	0	0	236	236	236	236
		TOTAL BASIN	AVERAGE:	131	420	745	914	914	914

2. Commercial. A total of 91 commercial establishments within the study area are affected by the 100-year flood. The historical depth-damage relationships developed at the Antilles Office considers eight different categories as commercial activity. Businesses were grouped on the basis of the type of transaction performed, the merchandise or services offered, and the similarities in the display of contents. Only four of these categories are present in the Río Grande de Manatí study area. These are described as follows:

Commercial category 1. Professional services offices, general merchandise outlets, miscellaneous retail stores, auto parts stores, sporting goods stores, drug stores, electrical equipment stores, food stores, auto, services outlets, and apparel and accessories stores.

Commercial category 3. Eating and drinking places, repair services outlets, and small building materials outlets.

Commercial category 6. Finance institutions and real estate offices.

Commercial category 7. Warehouses.

Table D-7 shows the number of commercial establishments affected by flooding by reach and commercial category and a brief description of the establishments.

3. Public. The public category comprises all facilities operated by the Commonwealth and municipal governments within the study area. Those affected by ten years and lower recurrence frequency floods are shown on Table D-8 by reach and zone.

4. Industrial. An industrial site consisting of 14 structures subject to flooding are established in the study area. The major ones are described below:

a. General Instruments P. R. Corp. Manufacturers of TV signal descramblers or video cipher renewable security modules produced to prevent illegal alteration of video transmissions between earth stations and satellites.

b. Playtex Corp. Apparel manufacturing with vertically integrated and technologically advanced facilities that produces women undergarments and ship these to the mainland.

TABLE D-7

RIO GRANDE DE MANATI DETAILED PROJECT REPORT
INVENTORY OF COMMERCIAL PROPERTY SUBJECT TO FLOODING

COMMERCIAL CATEGORY	TYPE OF ESTABLISHMENT	ZONES 1	2	3	4	5	6	TOTAL BASIN
1	Apparell Stores		1		5			6
	Medical Doctors Offices		2		2			4
	Food Stores		3		4	3	1	11
	Bakeries		2			1		3
	Professional Offices				3			3
	Miscellaneous Retail Stores		3		4	3	1	11
	Cold Storage (frigorifico)		1			1		2
	Horse Racing Agency		1					1
	Jewelry Stores		2					2
	Auto Tires Stores						1	1
	Gas Stations				2			2
	Photography Laboratories				1			1
	Auto Parts Stores				1			1
	Sports Goods Shops				1			1
	Liquor Stores				1			1
	Clinical Laboratories				1			1
	Drug Stores				4			4
	Gift Shop				1			1
	TOTAL COMMERCIAL CATEGORY 1		15		30	8	3	56
2	Beauty Parlors				1			1
	Travel Agencies				3			3
	Funeral Homes				1			1
	Laundries						1	1
	Barber Shops				1			1
	TOTAL COMMERCIAL CATEGORY 2				6		1	7
3	Restaurants		6		6	2	1	15
	Taverns(Bars)		4		1		1	6
	T.V. Repair Shops				1			1
	Auto Mechanics Shops				1			1
	Hardware Stores						2	2
	TOTAL COMMERCIAL CATEGORY 3		10		9	2	4	25
6	Commercial Banks				1			1
	Financial Institutions				2			2
	TOTAL COMMERCIAL CATEGORY 6				3			3
	TOTAL BASIN		25		48	10	8	91
TOTAL COMMERCIAL ESTABLISHMENTS		91						

TABLE D-8

RIO GRANDE DE MANATI DETAILED PROJECT REPORT
PUBLIC FACILITIES AFFECTED BY FLOODS

REACH	ZONE	FACILITY DESCRIPTION
1	1	DEPARTMENT OF PUBLIC WORKS (MUNICIPAL)
		ADMINISTRATIVE OFFICES
		WAREHOUSE
		AUTOMOTIVE SHOP
	2	COMMUNITY CENTER (DAVILA FREYTES HOUSING PROJECT)
		ADMINISTRATIVE OFFICES (DAVILA FREYTES HOUSING PROJECT)
	2	COMMUNITY CENTER (LAZUELA HOUSING PROJECT)
		PUERTO RICO TELEPHONE CO. FACILITY
		JUSTICE DEPARTMENT (COURT)
		HEAD START FACILITIES
		LABOR DEPARTMENT FACILITIES
	3	STATE POLICE FACILITIES
		EDUCATION DEPARTMENT OFFICES
		PRASA PUMPING STATION
		MUNICIPAL GOVERNMENT FIELD OFFICES
		ATHLETIC PARK FACILITIES
	4	ELEMENTARY SCHOOL (4 BUILDINGS)
		FIRE DEPARTMENT FACILITIES
		MUNICIPAL BAND AUDITORIUM
		PUBLIC PARKING BUILDING
		INTERMEDIATE PUBLIC SCHOOL (7 BUILDINGS)
		SPORTS COURT BUILDING
		ELECTRIC POWER AUTHORITY LOCAL OFFICE
		PUBLIC HIGH SCHOOL (7 BUILDINGS)
		CITY HALL
		PUBLIC HEALTH DEPARTMENT FACILITIES
	5	U.S. POST OFFICE FACILITIES
		TOTAL PUBLIC FACILITIES AFFECTED BY FLOODING: 54

The occupancy and total structures area follows:

Industry	Total Area (Sq. Ft.)
General Instruments PR, Inc.	39,901
General Instruments PR, Inc.	5,460
Playtex Barceloneta Corp.	11,263
Playtex Barceloneta	11,311
Playtex Barceloneta	10,740
General Instruments PR, Inc.	12,604
General Instruments PR, Inc.	11,141
General Instruments PR, Inc.	12,642
TOTAL	122,724

Above described industries are labor intensive category industries. The municipality of Barceloneta actually leases one of the buildings and another was sold to Playtex Corp., while the remaining 4 are projected to be leased within the next two years.

5. Utilities. Included in this category are a substation of the Puerto Rico. Electric Power Authority, and a major pumping station of the Puerto Rico Aqueduct and Sewage Authority. This category also includes the water, telephone, sewage, and electric lines and meters within the flood plain. No detailed data are available on the number of such facilities.

6. Nonprofit organizations. This category comprises five churches, one fraternity house, three religious facilities, a nonprofit credit union, and a political party structure.

7. Highways and streets. This category includes all sidewalks, roads, highways, and streets in the flood plain area. Kilometers of affected streets and highways by flooding were measured from flooded area maps developed for this study. Table D-9 shows kilometers of streets and highways by reach and flood frequency. Approximately 18 kilometers are affected by the SPF.

D. Assessment of Property Values

1. Structural values. Structure sizes and content values for all facilities within the flood plain were assessed through field visits and by comparison with previous study areas. Structure values for all land uses were determined on information gathered from the Rio Puerto Nuevo Economic Update (Jacksonville District, 1990) and were based on an appraisal of the structures and comparable data available from various sources. Value of land was not

TABLE JD-9-

RIO GRANDE DE MANATI DETAILED PROJECT REPORT
KILOMETERS OF HIGHWAYS AND STREETS AFFECTED BY FLOODS

EXCEEDANCE FREQUENCY (YEARS)	HIGHWAYS	STREETS	TOTAL
2			
5	2.2	10.1	12.2
10	2.6	10.1	12.6
25	3.5	14.6	18.1
50	3.5	14.6	18.1
100	3.5	14.6	18.1
200(SPF)	3.5	14.6	18.1

included in the economic analysis. All prices are at 1993 price levels and reflect the assessment of property values, replacement costs of structures after allowing for depreciation, and contents subject to flooding.

2. Residential. Residential content values were determined through a field survey of the study area completed in 1992 and updated in first quarter of 1993. A sample consisting of 100 households was selected to investigate the average value of residential contents for the area. Homogeneity of structures in each development allowed for the use of average figures to estimate total content values. Experience in other studies performed has shown that content values do not vary significantly for similar type of developments throughout Puerto Rico. Table D-10 shows average structure and content values for residential developments.

3. Other land uses. Structure values for commercial, public, utilities, and industrial land uses were based on field visits and assessments and on the data obtained from the property owners. These data were checked with comparable data in the Río Grande de Loíza, Río Grande de Arecibo, and Río Puerto Nuevo to establish its validity. A professional appraiser was contracted by the Real Estate Division to estimate the value of real property along the Río Puerto Nuevo study area. Content values indicate actual estimates obtained through a field investigation conducted on a 100 percent of the commercial establishments within the study area. A similar approach was followed for other land use categories within the flood plain. Table D-11 shows structures and content values for land uses other than residential affected by the SPF.

Values for utilities only include the value of structure and contents for major utilities in the flood plain. They do not include the value of meters and distribution lines in the flood plain which could not be estimated due to the complexity, diversity, and number of such facilities. Repair and maintenance costs for highways and streets were obtained from the Puerto Rico Department of Public Works, Highways Maintenance Division. Only a percentage of those costs was used in estimating damages to streets and highways based on the depth of flood.

4. Other property (external to main structure). This property refers to lawns, yards, parking areas, fences, automobiles, and other facilities outside the main structures. Values for this property were obtained through field visits and were integrated with the various land uses.

E. Depth-Damage Relationships

Depth-damage relationships for the residential, commercial, and public land uses developed for the Río Puerto Nuevo Survey Report (Jacksonville District, 1984) and the Río Cibuco Detailed Project Report (Jacksonville, 1982), were utilized to estimate flood damages for existing development. Damage curves were developed using historical data on flood damages throughout the island.

Depth-damage curves on a percentage basis were developed for the residential and commercial land uses and for public schools. Available historical damage data for comparable areas throughout the island allowed the establishment of relationships between depth of water and percentage damage

TABLE DS10

RIO GRANDE DE MANATI DETAILED PROJECT REPORT
AVERAGE STRUCTURE AND CONTENTS VALUES
RESIDENTIAL LAND USE

ZONE	SECTOR	TYPE OF CONSTRUCTION	NO. OF STRUCTURES	AVERAGE STRUCTURE VALUE	AVERAGE CONTENT VALUE
1	Plazuela Ward	45% Concrete - One Family	20	$21,000	$6,300
		55% Wood/Zinc-Concrete/Zinc	25	$8,600	$2,580
2	Urban Core North	100% Concrete - One Family	184	$43,900	$13,170
4	Urban Core South	100% Concrete - One Family	60	$28,200	$8,460
5	Cataluna Residential Development	100% Concrete - One Family	169	$41,200	$12,360
6	Catalana Residential Development and Catalana Ward	100% Concrete - One Family	131	$32,700	$9,810
7	Villa Barcelona I Res. Development	100% Concrete - One Family	89	$30,000	$9,000
8	Villa Barcelona II Res. Development	100% Concrete - One Family	236	$30,000	$9,000

TOTAL VALUE OF RESIDENTIAL PROPERTY SUBJECT TO FLOODING: (THOUSANDS)

STRUCTURES	$31,401,100
CONTENTS	$9,420,330
TOTAL	$40,821,430

TABLE D-11

RIO GRANDE DE MANATI DETAILED PROJECT REPORT

STRUCTURE AND CONTENTS VALUES FOR USES OTHER THAN RESIDENTIAL

($1000 OF 1993)

LAND USE	NO. OF STRUCTURES	STRUCTURES VALUE	CONTENTS VALUE
COMMERCIAL	91	3,553	2,772
PUBLIC	54	3,925	1,499
NON-PROFIT	11	437	141
INDUSTRIAL	14	3,001	12,437
TOTAL	170	10,916	16,849

potential to structure and contents for residential, commercial, and school facilities. Such data were not available for some land uses and the depth-damage relationships were established on an absolute basis from information provided by representatives of those land uses.

1. Residential. To determine the damage susceptibility of residential structures, the actual damages to 250 comparable structures throughout Puerto Rico during the floods of Eloise (1975) were analyzed. The data was obtained from the Damage Survey Reports (DSR) of the Federal Disaster Assistance Administration known today as the Federal Emergency Management Agency (FEMA). Restoration of damages was executed under the Minimum Repair Program of that agency. For each residential structure the cost of replacing or repairing the structural damages was divided by the total estimated value of the structure. A minimum-least-squares curve of the percentages of structural damages related to the depth of water was fitted to the data. The curve was used to determine structural damages to all residential structures within the flood plain. Most of the structural damages are to the following categories: electric system, plumbing system, windows, doors, air conditioning units, water heaters, kitchen cabinets, built-in stoves and ovens, bathroom fixtures, wall-to-wall carpeting, paint, and other furnishings. The foundations and the structures do not suffer significant damages because they are primarily built of reinforced concrete. These are affected mostly in areas near the river banks where velocities are significant. Due to lack of data, relationships between velocities and damage potential could not be developed and were not considered. To determine residential content damage susceptibility, actual damages to content in 30 residential structures in the Puerto Nuevo area during the 1977 flood were analyzed. These data were obtained from the Small Business Administration records on disaster loans to residents in the area and from records of flood insurance policy claims from the National Flood Insurance Program (NFIP). The value of contents damaged was divided by estimates of the total value of contents, and a minimum-least-square regression of percentage of contents damages to depths of water was fitted to the data. This curve was then used to determine damages from different flood stages to the contents of residences throughout the flood plain. Figure D-3 shows the curves. The historical depth of water was obtained from the U. S. Geological Survey records and residents of the area. These curves were updated in 1987 using actual flood damages to 98 housing structures from the 1985 floods along the Río Cibuco.

2. Commercial establishments. Curves derived for the various categories of commercial establishments for the Río Puerto Nuevo area were developed by a professional appraiser with considerable experience on investigating claims under the National Flood Insurance Program (NFIP).

Average damages in terms of a percentage were determined by the analysis of claims under the NFIP. Empirical data were used to develop damages for floodwaters of less than 1.2 meters depth. Percentage figures for damages occurring at depths over 1.2 meters were estimated by the appraiser on the basis of professional judgment. Although similar in nature, different types of businesses show different contents damage percentages since the merchandise is displayed differently. For commercial facilities, major structural damages consist of the electrical system plumbing facilities, door, windows, air conditioning units, and other furnishings.

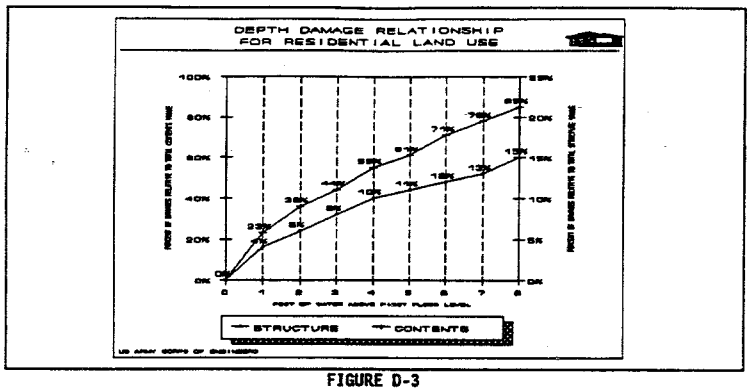

FIGURE D-3

In some instances a total loss at 1.2, 2.1, or 2.4 meters depth has been considered. In other cases total loss does not occur at this depth. The average floor-to-ceiling height in an average commercial building is between 2.4 and 3.1 meters, while other types of businesses have higher ceilings and some property is stored or placed above 2.4 meters.

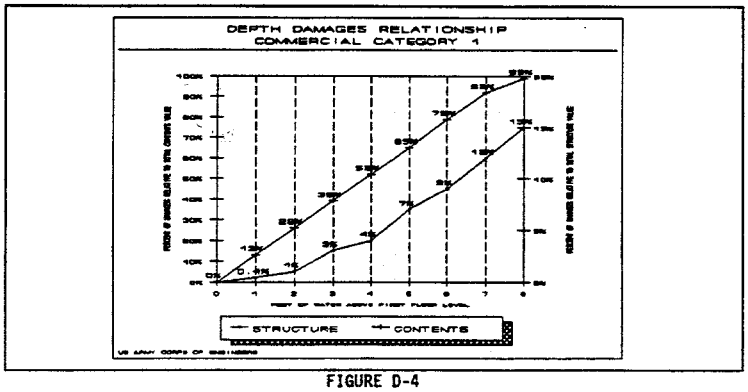

FIGURE D-4

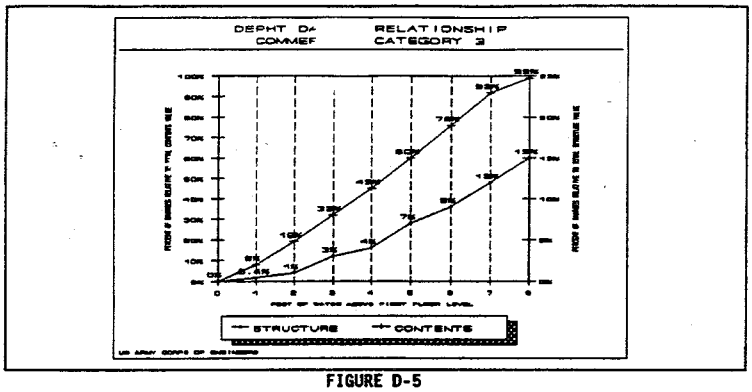

FIGURE D-5

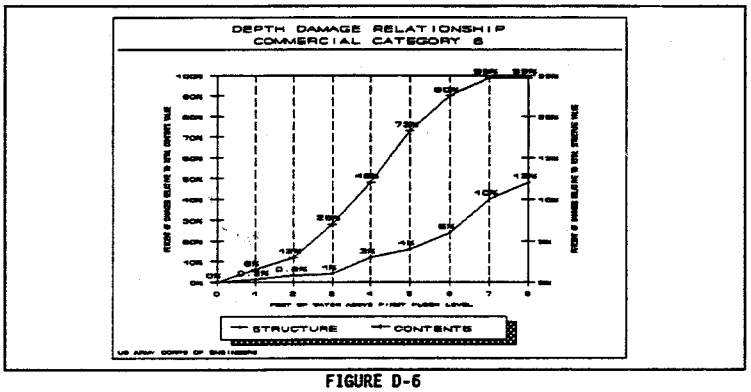

FIGURE D-6

Figures 4 to 7 present the depth-damage percentage relationships for the various commercial categories found in the study area. These are category 1, 3, 6 and 7.

3. Industrial. For this category of damage interviews were conducted directly with plant managers in the Río Grande de Manatí study area. Interviews were the only way to estimate the total content value and also the potential depth-damage relationship. This was confirmed by the manager and/or plant

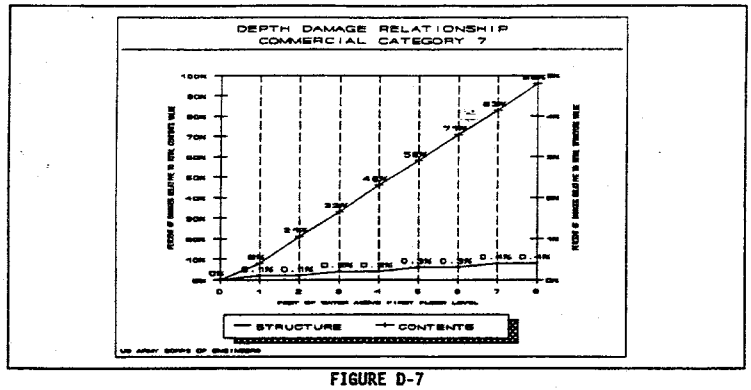

FIGURE D-7

manager. First flood elevations were obtained from a topographic plate supplied by the Puerto Rico Industrial Development Company and verified in the field survey. A 100 percent of industries were covered. Damage figures were provided by each plant on an absolute basis rather than on a percentage basis. The information obtained was compared with those of the Upper Río Grande de Loíza Feasibility Report.

4. Utilities. Cleanup and repair costs for water, sewage, electric, gas and telephone lines, meters, and power stations were estimated at $2,000 per 4,000 square meters of developed land in the flood plain. These figures are based on field observations and discussions with representatives from the various utilities companies.

5. Highways and streets. Damage to highways and streets were estimated applying a percentage of the cost of repair per kilometer to the number of kilometers flooded for each flood frequency analyzed. Damage per kilometer was developed through discussions with officials of the San Juan Regional Office of the Department of Transportation and Public Works (DTPW). Analysis of current highway construction and repair costs was obtained from a variety of sources. In accordance with DTPW, the total cost of repairing a badly damaged two-lane highway is $79,600 per kilometer. Damages to highways and streets during the flood events analyzed were estimated as a function of the water elevation above the surface of the pavement. A ceiling of 80 percent of the estimated maximum potential restoration cost was established in the evaluation of damages for the worst condition in this category of land use. Damages to streets were estimated at 75 percent of the highway damage per kilometer following the same procedure as indicated above.

6. Public buildings and offices. Damage estimates to structure and contents of public buildings and offices were ascertained using the depth-damage

relationship developed for elementary schools. For school buildings, data provided by the Superintendent of Schools, the school directors, the Public Buildings Authority, and the General Services Administration were used to develop basic depth-damage relationships.

7. Nonprofit organizations. Damage potential to the structures and contents of these facilities were developed using the depth-damage relationship for elementary schools.

F. Flood Damages

1. Historical damages. Historical damages for the town of Barceloneta were obtained through the Municipal Civil Defense office. During 1985 the town was severely flooded twice, May 17-18 and October 5-7. Both events flooded the same areas and had similar stages, as informed by the Municipal Government and Geological Survey office. These events produced damages that were recorded, to public buildings and facilities; commercial establishments, residential property contents, and street roads and sidewalks. Flood damages reported for October 1985 exceeded $7.4 million in losses. The 1985 flood event affected 90 percent of the towns and cities in Puerto Rico, resulting in the evacuation of over 3,500 persons in the Barceloneta, Manati, and Arecibo area. Raging waters of the Río Grande de Manatí swept thousands of vehicles and cut off the towns along the northern part of Puerto Rico.

On May 12-13, 1986, heavy rains caused floods with damages reported at $2.9 million. Over 57 percent of the damages reported relate to structure contents. A summary of the damages for October 1985, May 1986, and newspaper clippings are shown in Enclosures 1 to 3.

2. Potential damages. Potential damages for existing and future conditions associated with selected frequencies and land uses are also presented for the area flooded by the Río Grande de Manatí. The damage estimates reflect 1993 price levels.Flood damages according to flood frequency for residential, commercial, public, and nonprofit land uses were estimated utilizing a computer program developed at the San Juan Area Office. The program applies the depth-damage relationships previously considered to the value of structure and contents of different land uses considering the depth of water above the level of the first floor in each particular case. Since it is desired to compute the damage that can be expected in any year, the damage corresponding to each magnitude of flooding is weighted by the percent chance of each being exceeded. The sum of the weighted damages represent the expected annual flood damage.

To compare alternative plans and to correlate damages with costs, an equivalent annual damage is computed. This equivalent value represents a uniform distribution of annual values and is computed by discounting and amortizing each year's expected annual damage figure over the period of analysis, taking into account the time value of money associated with damage estimates. Expected annual damages and equivalent annual damages were computed utilizing the Expected Annual Flood Damages Computation Model developed by the Hydrologic Engineering Center, U. S. Army Corps of Engineers. Potential damages were estimated using April 1993 price levels for structure and content values and were discounted at 8 1/4 percent interest rate for the first 50 years of the project life.

a. Existing conditions (1993). Table D-12 shows flood damage estimates for single events and land use categories under existing conditions. Total damages for the study area range from $3,969,000 for the 5-year flood to $28,602,000 for the SPF. The residential and industrial land uses are the most affected. It is also observed that considerable damages occur to public schools and other public buildings at the lower frequency events. Damage to utilities and commerce is also significant.

b. Future conditions. Increased flood damage for future conditions only reflect the application of the affluency factor to existing household's content values as specified in the Principles and Guidelines for Water and Related Land Resources. This document requires that affluence considerations be limited to 50 percent of a structure's current value. The projected annual growth rate of real per capita disposable income was utilized to measure future changes in residential contents.

3. Expected annual flood damages. Expected annual damages for existing (1993), base year (1998), and future conditions (2048) are shown on Table D-13. For existing conditions (1993) expected average annual damages for the study area are estimated at $3.0 million, while for the planning period 1998 and 2048 expected annual damages are estimated at $3.1 million and $3.3 million, respectively. Table D-14 shows the equivalent flood damages by land use category. Equivalent average damages for industry is almost twice that for residential uses reflecting the high content value of scientific instruments and specialized communications products being manufactured in several of the industrial plants in the study area.

III. NATIONAL ECONOMIC DEVELOPMENT BENEFITS

A. General

This section describes the procedures utilized to estimate the various categories of national economic benefits analyzed for assessing flood control plans for the detailed study area. It also presents aggregate cost data of the plans considered. Costs are discussed in detail in Appendix C, Design and Cost Estimates, while the flood control plans are described in detail in the Main Report.

B. Categories of Benefits Considered

1. Inundation reduction and residual flooding damage. Reduction of physical damages to property, experienced by occupants of the flood plain, are considered a contribution to income at the national level. The difference between expected physical annual damages expressed in monetary terms under the with and without projects conditions for each plan was taken as the contribution (the benefits) of that plan. Appropriate multiple frequency computations of hydrologic and hydraulic conditions and stage-damage relationships were used to estimate physical flood damages in the area. Inundation reduction benefits for each of the candidate flood control plans are presented on Table D-15. Residual damages are also presented on this table.

TABLE D-12

RIO GRANDE DE MANATI DETAILED PROJECT REPORT
FLOOD DAMAGES FOR SINGLE FLOOD EVENTS
WITHOUT PROJECT CONDITIONS
($1000 OF 1993)

	FLOOD FREQUENCY					
RESIDENTIAL LAND USE:	5 YRS.	10 YRS.	25 YRS.	50 YRS.	100 YRS.	SPF
STUDY YEAR 1993:	$632	$1,772	$5,160	$6,332	$8,860	$11,243
BASE YEAR 1998:	695	1,939	6,227	7,965	11,179	14,994
FUTURE YEAR 2048:	870	2,416	7,364	9,714	13,555	18,024
S OTHER THAN RESIDENTIAL:	5 YRS.	10 YRS.	25 YRS.	50 YRS.	100 YRS.	SPF
COMMERCIAL	$39	$400	$1,491	$1,600	$2,468	$3,074
PUBLIC	79	400	1,024	1,088	1,247	1,366
NON-PROFIT	2	12	59	68	141	185
INDUSTRY	2,549	7,009	11,477	11,477	11,478	11,478
UTILITIES	593	593	623	661	661	661
STREETS & HIGHWAYS	75	158	370	436	559	595
TOTAL OTHER THAN RESIDENTIAL:	$3,337	$8,572	$15,044	$15,330	$16,554	$17,359
TOTAL DAMAGES:						
STUDY YEAR 1993:	$3,969	$10,344	$20,204	$21,662	$25,414	$28,602
BASE YEAR 1998:	4,032	10,511	21,271	23,295	27,733	32,353
FUTURE YEAR 2048:	4,207	10,988	22,408	25,044	30,109	35,383

TABLE D-13

RIO GRANDE DE MANATI DETAILED PROJECT REPORT
EXPECTED ANNUAL FLOOD DAMAGES
WITHOUT PROJECT CONDITIONS
($1000 OF 1993)

RESIDENTIAL LAND USE

EXISTING CONDITIONS	BASE YEAR 1998	FUTURE YEAR 2048
$681	$815	$989

USES OTHER THAN RESIDENTIAL:	
COMMERCIAL	$158
PUBLIC	118
NON-PROFIT	7
INDUSTRY	1,794
UTILITIES	230
HIGHWAYS	55
TOTAL USES OTHER THAN RESIDENTIAL:	$2,362
TOTAL EXPECTED ANNUAL DAMAGES:	
STUDY YEAR 1993:	$3,043
BASE YEAR 1998:	$3,177
FUTURE YEAR 2048:	$3,351

TABLE D-14

RIO GRANDE DE MANATI DETAILED PROJECT REPORT
EQUIVALENT FLOOD DAMAGES
WITHOUT PROJECT CONDITIONS
($1000 OF 1993)

DAMAGE CATEGORY:	
RESIDENTIAL	$908
COMMERCIAL	158
PUBLIC	119
NON-PROFIT	7
INDUSTRY	1,794
UTILITIES	230
HIGHWAYS	55
TOTAL **	$3,271

** Discount Rate = 8 1/4%
** Period of Analysis = 50 years.

TABLE B&15

RIO GRANDE DE MANATI DETAILED PROJECT REPORT
CONTRIBUTION OF ALTERNATIVES TO REDUCTION OF DAMAGES
($1000 OF 1993)

LAND USE	WITHOUT PROJECT	DAMAGE REDUCTION					
		PLAN 1 50 YEAR LEVEE		PLAN 2 100 YEAR LEVEE		PLAN 3 SPF LEVEE	
		DAMAGE REDUCED	RESIDUALS	DAMAGE REDUCED	RESIDUALS	DAMAGE REDUCED	RESIDUALS
RESIDENTIAL	908	688	220	764	144	823	85
COMMERCIAL	158	117	41	133	25	144	14
PUBLIC	119	99	20	107	12	112	7
NON-PROFIT	7	5	2	5	2	6	1
INDUSTRIAL	1,794	1,622	172	1,699	95	1,743	51
UTILITIES	230	220	10	224	6	227	3
HIGHWAYS	55	45	10	49	6	52	3
TOTAL	$3,271	$2,796	$475	$2,981	$290	$3,107	$164

Utilizing the depth/damage relationships previously discussed and flood stage data developed as discussed in Appendix A, Hydrology and Hydraulics, residual damage estimates were developed for each reach, land use category, and level of protection. The plans are discussed in detail in the Main Report.

2. Employment benefits. The use of unemployed labor resources that would have remained unemployed in the absence of a plan is considered a project benefit. The NED benefit is limited to payments to unemployed and underemployed labor resources directly utilized in the construction and installation of the project and also includes labor used for operations and maintenance.

Traditionally, the unemployment rate in Puerto Rico has been very high. Between 1985 and 1991 it averaged about 17 percent. In the early 1990's, it came down to about 15 percent. At present (1993), this rate has increased to 18.5 percent for the January-February-March reporting period. High unemployment still remains one of the major socioeconomic problems in Puerto Rico.

In 1992 the construction industry, which constitutes one of the dynamic sectors of the economy, accounted for about 54,000 jobs of a total work force of 1,090,000. There is a considerable pool of unemployed persons, some of whom could be employed in the event of the construction of a flood control project.

For determining the portion of construction labor cost allocated to the unemployed, it was assumed that 20 percent of the total construction cost of a project would be used for the wages and salaries of the construction workers. This figure was arrived at on the basis of information provided by representatives of the local private construction industry contacted through telephone calls, data obtained from the Unemployment Insurance Bureau of the Puerto Rico Department of Labor and Human Resources, and general familiarity with the ongoing Portugués and Bucaná Flood Control Project, currently being built by the Corps of Engineers in the Ponce Metropolitan Area, which shows comparable labor characteristics to the study area labor market.

To determine the relative amount and classification of labor, an analysis of the construction schedule at each river stream was made. The percentage distribution for the various categories is as follows:

Skilled	-	60%
Unskilled	-	10%
Others	-	30%

These percentages were determined from actual data for the Portugués and Bucaná channel improvements project. They were assumed to remain constant during the construction phase due to the nature of the project.

Wages and salaries used to employ workers drawn from the unemployed pool for each category of workers were determined on the basis of an analysis of empirical data from the Portugués and Bucaná channel improvements project. Percentages determined are as follows:

Skilled	-	20%
Unskilled	-	80%
Others	-	50%

Annual benefits were amortized at 8 1/4 percent rate over the 50-year life span of the project.

Table D-16 shows typical computation of employment benefits for Río Grande de Manatí Detailed Project Report.

C. Benefits and Costs Analysis

1. Costs. Total first costs, interest during construction, total investment costs, and annual costs estimates for the plans under consideration for Río Grande de Manatí are indicated on Table D-17. Detailed discussion of items are shown in Appendix C (Design and Costs Estimates).

2. Benefits. A summary of all benefit categories previously discussed is shown on Table D-18. On the basis of the criterion of maximum contribution to National Economic Benefits, the recommended plan is Plan 2. 100-year levee.

3. Benefit to cost ratios. Benefit to cost ratios for the plans under consideration are also shown on Table D-19.

4. Regional impacts. The economic benefits derived from the structural flood control measures depicted in the alternatives under consideration are shown on Table D-19. Additional economic benefits for the region are expected to accrue from other factors which are not specifically considered in the present study.

D. Recommended Plan.

1. Description of plan. The recommended plan of improvements consists of providing a ring levee, two pilot channels and interior drainage facilities for flood protection for the town of Barceloneta to provide 100-year protection.

2. The economic impacts of the recommended plan. These are presented on Table D-20. The economic analysis of the recommended plan was determined by comparing the inundation damages and benefits figures for 1993 and comparing these with the cost figures (refer to Appendix C, Design and Cost Estimates) for establishing the economics of the recommended plan. The discount rate of 8 1/4 percent for fiscal year 1993 and the current fiscal year (1994) discount rate of 8 percent are used to discount cost and benefits over a project life of 50 years. Benefits analysis associated with employment are also included. Net National Economic Development benefits are approximately $2.0 million annually. This would produce direct and indirect net regional income of $5.8 million and some 168 temporary jobs and 128 permanent jobs.

TABLE D-16

RIO GRANDE DE NANATI DETAILED PROJECT REPORT
SAMPLE EMPLOYMENT BENEFITS COMPUTATION
($1000 1993)

EMPLOYMENT BENEFITS COMPUTATION FOR PLAN NO. 2
CONSTRUCTION PERIOD - 19 MONTHS

1. CONTRACT CONSTRUCTION AND MANAGEMENT COST	6,772					
2. WAGES AND SALARIES(20%)	1,354					
		MONTH 6	MONTH 9	MONTH 12	MONTH 15	MONTH 19
3. CONSTRUCTION SCHEDULE - (%)		20	20	20	30	10
4. WAGES AND SALARIES PER PERIOD		271	271	271	406	135
5. DISTRIBUTION BY CATEGORY OF WORKERS						
SKILLED (60%)		163	163	163	244	81
UNSKILLED (10%)		27	27	27	41	14
OTHERS(30%)		81	81	81	122	41
6. WAGES TO THE UNEMPLOYED						
SKILLED (20%)		33	33	33	49	16
UNSKILLED (80%)		22	22	22	33	11
OTHERS (50%)		41	41	41	61	20
SUBTOTAL(BENEFIT CLAIMED)		95	95	95	142	47
7. WORTH OF BENEFIT AT END OF CONSTRUCTION *		103	101	99	146	47
8. TOTAL BENEFIT FOR 19 MONTHS:	497					
9. EQUIVALENT ANNUAL BENEFIT: #	42					

Notes: * Annual Interest rate = 8.25 %
Amortized at i= 8.25% for 50 years.

TABLE D-17

RIO GRANDE DE MANATI DETAILED PROJECT REPORT
SUMMARY OF ECONOMIC COSTS
($1000 OF APRIL 1993)

	----------ALTERNATIVES CONSIDERED--------		
	PLAN 1 50 YR LEVEE	PLAN 2 100 YR LEVEE	PLAN 3 SPF LEVEE
TOTAL CONSTRUCTION COST	$6,813	$7,651	$9,387
PLANNING ENGINEERING & DESIGN	474	525	639
CONSTRUCTION MANAGEMENT	710	788	957
REAL ESTATE	1,547	1,613	1,739
TOTAL FIRST COST	9,544	10,577	12,722
INTEREST DURING CONSTRUCTION	640	718	879
TOTAL INVESTMENT COST	10,184	11,295	13,601
ANNUAL INVESTMENT COST	856	950	1,144
ANNUAL OPERATION AND MAINT. COST	37	37	37
TOTAL ANNUAL COST	$893	$987	$1,181

TABLE D-18

RIO GRANDE DE MANATI DETAILED PROJECT REPORT
ANALYSIS OF CANDITATE FINAL PLANS
SUMMARY OF ANNUALIZED BENEFITS AND COSTS
($1000 OF 1993)

PROJECT BENEFITS AND COSTS	ALTERNATIVES CONSIDERED		
	PLAN 1 50 YEAR LEVEE	PLAN 2 100 YEAR LEVEE	PLAN 3 SPF LEVEE
BENEFITS:			
Inundation Reduction	$2,796	$2,981	$3,107
Employment	$47	$53	$65
TOTAL PROJECT BENEFITS	$2,843	$3,034	$3,172
PROJECT COSTS	$893	$987	$1,181
NET NED BENEFITS *	$1,903	$1,994	$1,926
BENEFITS/COST RATIO	3.1	3.0	2.6

Note: (1) Benefits and Costs amortized at 8.25%.

* Optimization process does not include employment benefits.

TABLE D-19

RIO GRANDE DE MANATI DETAILED PROJECT REPORT
REGIONAL IMPACTS OF RECOMMENDED PLAN
($1000 OF 1993)

REGIONAL ANNUAL INCOME	$5,821
REGIONAL ANNUAL COST	$598
NET REGIONAL BENEFIT	$5,223
REGIONAL EMPLOYMENT	
Permanent Jobs:	128
Temporary Jobs:	168

TABLE D-20

RIO GRANDE DE MANATI DETAILED PROJECT REPORT
ECONOMICS OF THE RECOMMENDED PLAN
($1000 OF 1993)

	8.0% interest	8.25% interest
TOTAL FIRST COST	$10,374	$10,577
INTEREST DURING CONSTRUCTION	$696	$718
TOTAL INVESTMENT COSTS	$11,070	$11,295
AVERAGE ANNUAL ECONOMIC COSTS	$905	$950
OPERATION AND MAINTENANCE COSTS	$37	$37
TOTAL ANNUAL COSTS	$942	$987
AVERAGE EQUIVALENT ANNUAL BENEFITS:		
Inundation	$2,982	$2,981
Employment	$43	$53
TOTAL ANNUAL BENEFITS	$3,025	$3,034
NET NED BENEFITS	$2,083	$2,047
BENEFIT COST RATIO	3.21	3.10

RIO GRANDE DE MANATI @ BARCELONETA, P.R.
DETAILED PROJECT REPORT
SECTION 205 FLOOD CONTROL

APPENDIX E
REAL ESTATE PLAN

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REAL ESTATE PLAN
DETAILED PROJECT REPORT
SECTION 205 FLOOD CONTROL
RIO GRANDE DE MANATI AT BARCELONETA
PUERTO RICO

CHART OF ACCOUNTS

01	LANDS AND DAMAGES		
01A	PROJECT PLANNING		$ 25,000
01AX	CONTINGENCIES	$ 6,250	
01B	ACQUISITIONS		
01B2	BY LOCAL SPONSOR		60,000
01B4	REVIEW OF LOCAL SPONSOR		12,000
01BX	CONTINGENCIES	18,000	
01C	CONDEMNATIONS		
01C2	BY LOCAL SPONSOR		40,000
01C4	REVIEW OF LOCAL SPONSOR		4,000
01CX	CONTINGENCIES	11,000	
01E	APPRAISALS		
01E2	BY LOCAL SPONSOR		30,000
01E4	REVIEW OF LOCAL SPONSOR		9,000
01EX	CONTINGENCIES	9,750	
01F	PL 91-646 ASSISTANCE		
01F2	BY LOCAL SPONSOR		7,000
01F4	REVIEW OF LOCAL SPONSOR		2,800
01FX	CONTINGENCIES	2,450	
01G	TEMPORARY PERMITS		
01G2	BY LOCAL SPONSOR		3,000
01G4	REVIEW OF LOCAL SPONSOR		800
01G6	DAMAGE CLAIMS		2,000
01GX	CONTINGENCIES	1,450	
01R	REAL ESTATE PAYMENTS		
01R1	LAND PAYMENTS		
01R1B	BY LOCAL SPONSOR		933,000
01R2	PL 91-646 ASSISTANCE PAYMENTS		
01R2B	BY LOCAL SPONSOR		162,000
01RX	CONTINGENCIES	273,750	
29	PROJECT COOPERATION AGREEMENTS (PCA)		
29A	DRAFT PCA		
29A1	REAL ESTATE ACTIVITIES		2,000
29X	CONTINGENCIES	500	
TOTAL REAL ESTATE COSTS EXCLUDING CONTINGENCIES (RD)			$1,293,000
TOTAL REAL ESTATE CONTINGENCIES COST (RD)		$ 323,000	
TOTAL PROJECT REAL ESTATE COST			$1,616,000

REAL ESTATE PLAN
DETAILED PROJECT REPORT
SECTION 205 FLOOD CONTROL
RIO GRANDE DE MANATI AT BARCELONETA
PUERTO RICO

STATEMENT OF PURPOSE

This Real Estate Plan is tentative in nature for planning purposes only and both the final real property acquisition lines and the estimate of value are subject to change even after approval of the Detailed Project Report (DPR).

AUTHORIZATION

This study is undertaken by virtue of the authority of *Section 205* of the *Flood Control Act of 1948, as amended*. This study was requested by the Puerto Rico Department of Natural Resources. The date of Reconnaissance Report Certification is April 11, 1989.

PROJECT LOCATION AND DESCRIPTION

The Rio Grande de Manati is located in the north central coastal region of Puerto Rico. The river originates in the Cordillera Central Mountain Range of Puerto Rico approximately 2,625 feet above mean sea level. The river flows in a slightly northwesterly direction through a belt of limestone hills into a deep and narrow canyon-like valley, then across an alluvial plain before finally emptying into the Atlantic Ocean. The total area covered by the Rio Manati watershed is approximately 202 square miles. The coastal alluvial plain (project location) extends for approximately 15 miles and averages roughly 1.5 miles in width. Nearly all of the land in this plain is in the designated floodway.

The Municipality of Barceloneta covers an area of 24.2 square miles. Terrain is characterized by the extensive coastal flood plain in the north and a series of limestone hills in the south. The towns of Barceloneta and Manati are the main urban centers of the area. Barceloneta is a relatively small, densely populated area, located on the west side of the Rio Grande de Manati approximately 2.75 miles south of the Atlantic Ocean. Puerto Rico Highways #2 and #140 are the main arteries serving Barceloneta. Flooding, and the surrounding limestone hills, have considerably limited the expansion of Barceloneta.

The land in the project and vicinity of the project is predominately agricultural/grazing land within the floodway, further defined as Flood Zone 1. The floodway is defined as:

The watercourse of the channel, river, creek, brook, or natural drainage channel and that portion of adjacent lands to permit the discharge of the base flood without cumulatively increasing the water surface elevation by more than one foot in undeveloped areas, or six inches in developed areas.

Flood Zone 2 is defined as: *the area situated between the floodway limits and the limits of the 100-year floodplain.* Flood Zone 2 regulations permit new buildings in this zone when these are designed and constructed in such a way that will cause the least possible obstruction to the flow of water, will provide safety conditions, will resist the effects of hydrodynamic and hydrostatic pressures of floodwater or coastal surges, and comply with any other applicable provision of law or regulation.

These definitions are per the Commonwealth of Puerto Rico Planning Board's *Regulation for Floodable Zones, Regulation 13, Second Revision dated March 6, 1987.*

The agricultural/grazing land located in the floodway (Flood Zone 1) would still be subject to flooding after the project is implemented, though at considerably less stages than pre-project flooding. Flood Zone 1 restricts land uses to exclude new construction, structures, landfills, substantial improvements or other developments. The Puerto Rico Planning Board (PRPB) will maintain these lands under flood plain regulations to prohibit development as will be specified in the proposed Project Cooperation Agreement (PCA).

The proposed project is designed to protect the populated area in and around Barceloneta from periodic flooding. This would be accomplished by *ringing* the town with a combination of pilot channels, levees, internal drainage channels and culverts. Throughout the project, minimal interior drainage channels would basically parallel the levees along the inside to reroute drainage flows to the culvert outlets. Four road rampings would be required to accommodate levee and channel improvements. Each would require a one year temporary road easement during construction. One residence would be acquired at the east levee tie-in on the southeast corner of the project and two residences would be acquired at the west levee tie-in on the southwest corner. Four residences would need to be acquired on Puerto Rico Highway #684, just north of the east levee, due to severed access. Approximately 11 acres will be severed from its parent tract by the east levee on the east side and the Manati River bed and interior drainage channel on the west (creating an inaccessible island). This severed land will be used as a temporary staging area for a period of three years. A permanent disposal area consisting of 6.8 acres would be required adjacent to the west side of the west levee in the southwest corner of the project.

A more detailed description of the project features and affected lands from the southeast corner, counter-clockwise to the southwest corner is as follows:

Proposed project improvements would begin at a point where Puerto Rico Highway #140 enters the town of Barceloneta just south of the river's large oxbow. From this point an approximately 2,234 feet upstream pilot channel would *straighten* the existing riverbed cutting off an area where the east levee and interior drainage channel improvements would begin. The east levee would begin at its tie-in point into the hillside across Puerto Rico Highway #140, requiring the acquisition of one residence. The levee would then extend across the road and northeast within the existing riverbed, which would then be cut off by the proposed upstream pilot channel. Affected lands within this portion of the project are both agricultural tracts within the designated floodway, and residential property at the tie-in point across Puerto Rico Highway #140, located in Flood Zone 2.

From the point approximately where the upstream pilot channel would terminate to the northeast, the east levee would skirt Barceloneta to the east, cut across the existing river oxbow in two places (severing an ownership tract as discussed above) before crossing Puerto Rico Highway #684. The proposed interior drainage channel along this stretch would parallel the levee north to its intersection with the existing riverbed, then run northwest and north around the proposed recreation area before rejoining the levee just before its intersection with Puerto Rico Highway #684. Affected lands throughout this part of the project are large agricultural tracts within the designated floodway. No residential/commercial improvements are affected by this portion of the project, though a public boat ramp located where the east levee will cut across the existing river oxbow to the south would require relocation. Relocation of this boat ramp requires the acquisition of approximately .57 of an acre.

Just east of proposed culvert 2 would be the downstream pilot channel. This channel will convey the water in a fashion so as to bypass the existing river oxbow. The downstream pilot channel would require a construction bypass road easement from levee right-of-way to the pilot channel area for a period of two years for construction purposes. The aforementioned boat ramp would be relocated to extend from Puerto Rico Highway #684 to the river, just north of culvert 2, and requires a permanent access road. Affected tracts are large agricultural ownerships within the designated floodway. No improvements are affected by this portion of the project.

Near the proposed levee and Puerto Rico Highway #684 intersection, Puerto Rico Highway #684 would require ramping over the levee and drainage channel. From the east levee's intersection

with Puerto Rico Highway #684 and Calle Plazuela Road, to culvert 1, the east levee and interior drainage channel would run northwest and west across large agricultural tracts within the designated floodway. The four residences on Puerto Rico Highway #684, just north of its intersection with the east levee, will need to be acquired due to severed access by the raised road embankment.

Culvert 1 would separate the east levee from the west levee. From culvert 1, the west levee and interior drainage channel would run southwest and south to a tie-in point across Puerto Rico Highway #682. Road rampings over the levee and channel would be required at the west levee's intersections with Puerto Rico Highways #681 and #682. The west levee tie-in point across Puerto Rico Highway #682 would require the acquisition of two residences. The west levee would affect agricultural floodway land, a raised area under development within Flood Zone 2, and residential homesites in Flood Zone 2 at the tie-in point.

The proposed 6.8 acre permanent disposal area is located contiguous to, and along the west side of the west levee in the project's extreme southwest corner. The proposed staging area will be the severed area of the oxbow consisting of 11 acres.

No borrow areas have been delineated for acquisition. It is proposed that most of the borrow material will be purchased from a commercial borrow site located west of Barceloneta. The quality of material from on-site excavations of the pilot and drainage channels is reportedly relatively poor.

GOVERNMENT-OWNED LAND

No U.S. Government land exists in the project. Approximately 100 acres of project lands are owned by the Puerto Rico Land Authority. The Municipality of Barceloneta owns approximately 10 acres of land within the project area and the riverbed of the Rio Grande de Manati is owned by the Department of Natural Resources. No costs are included in this report for lands within the riverbed.

ATTITUDE OF OWNERS

The landowners willingly granted rights-of-entry for survey and exploration to the Corps of Engineers through the local sponsor, which indicates there is general support for the project.

APPRAISAL INFORMATION

Fifteen ownership tracts are affected by the project. There are three land classifications of various sizes included in the project area for real estate valuation purposes. They consist of

large agricultural lands within the floodway, residential property outside of the floodway and developable acreage outside the floodway.

The fee area required for the project totals approximately 127.97 acres at a cost of $676,251. Eleven acres of the fee area required consist of the severed oxbow area which will be used as a temporary staging area for a period of three years. The severance damage estimate ($34,650) and the estimated value of the three year temporary staging area easement ($11,550) exceeds fee value of the 11 acres ($38,500) therefore fee title will be acquired. Three residential improvements, valued at a total of $123,000 are also affected by the project and would be acquired. Approximately 10.70 acres of temporary easement valued at $5,556 would be needed for project purposes. Severance damages assessed at $11,435 include portions of two tracts (.15 of an acre total) which after project will become unusable for conforming land uses due to their sizes and irregular shapes. Also included under severance damages are approximately .28 of an acre ($21,000) and four residential structures ($96,000) located just north of the east levee and Puerto Rico Highway #684 intersection. This land and four homes are assessed severance damages due to severed access by the proposed raised road embankment. The total estimated severance damages incurred by the project is $128,435.

RELOCATIONS ASSISTANCE (PUBLIC LAW 91-646)

a. Displacement of Families:

Under this project, a total of seven residences will need to be relocated in accordance with *Public Law 91-646, as amended*.

b. Cost of Relocation Assistance:

Estimates of all costs to comply with PL 91-646 total $161,700. A payment of $22,500 is allowed for each of the seven residential acquisitions ($157,500 total) which includes the costs associated with providing displaced persons with decent, safe and sanitary housing. Also included in this payment are expenses incurred for recording fees, transfer taxes and costs for prepayment of pre-existing mortgages incident to conveying real property to the local sponsor. Approximately $4,200 (or $600 each) is estimated for moving expenses associated with the seven residential relocations required for this project.

c. Replacement Housing:

The relocation of the seven families affected by the project should not cause an impact on the area housing market, due to the small number of replacement houses required. In addition, a very

thorough Replacement Housing Study was completed in May of 1992, for the Rio De La Plata Flood Control Project. Rio De La Plata is also located on the north coast of Puerto Rico, approximately 15 miles east of Rio Grande de Manati. This housing study concluded that there is sufficient decent, safe and sanitary housing available in the area.

ACQUISITION/ADMINISTRATIVE COSTS

The ownership data used in calculating the project acquisition/administrative costs includes a total of 15 affected ownership tracts of which 7 are improved with residential structures requiring acquisition. Based on this information the estimated costs are as follows:

Federal Acquisition/Administrative Estimate:

Project Planning	$ 25,000
Review of Acquisitions ($800 ea)	12,000
Review of Appraisals ($600 ea)	9,000
Review of Condemnations (est. of 4 at $1,000 ea)	4,000
Review of PL 91-646 Assistance ($400 ea)	2,800
Review of Temporary Permits	800
Draft PCA	2,000
Total Federal Acquisition/Administrative Cost (Rounded):	$ 56,000

Non-Federal Acquisition/Administrative Estimate:

Acquisitions ($4,000 ea)	$ 60,000
Appraisals ($2,000 ea)	30,000
Condemnations (est. of 4 at $10,000 ea)	40,000
PL 91-646 Assistance ($1,000 ea)	7,000
Temporary Permits	3,000
Damage Claims	2,000
Total Non-Federal Acquisition/Administrative Cost (Rounded):	$ 142,000

RELOCATIONS

The following information under relocations is provided:

a. Relocations of Public Highways, Utilities, Railroads and Pipelines:

As previously described, there will be four road rampings required to accommodate levee and channel improvements. Each will require a one year temporary road access easement during

construction. A public boat ramp will require relocation and as such, a permanent access road and new boat ramp will extend from Puerto Rico Highway #684 to the river. (Real estate for the relocated boat ramp is valued at $1,995; however, an Attorney's Opinion of Compensability is being prepared to determine eligibility for crediting purposes.) The downstream pilot channel will require a construction bypass road easement from the levee right-of-way to the pilot channel for a period of two years for construction purposes.

Coordination with the Antilles Office and Engineering Division indicates that no other public utilities, railroads or pipelines will be relocated for this project.

b. Relocations of Cemeteries:

There are no identified cemeteries located on project lands to be acquired, though it has been reported that an unmarked burial ground is located near the extreme southeast corner of the project area. It is presumed at this time that the burial ground will not be disturbed by the project. Refer to *Cultural Resources*.

c. Reestablishment of Towns:

There are no towns affected by the project.

d. Relocations of Structures and Facilities:

There are no known structures or facilities, such as public schools, fire houses, hospitals, libraries, etc. utilized in the performance of a governmental function which will be affected by the project.

NON-FEDERAL OPERATION/MAINTENANCE RESPONSIBILITIES

In accordance with the proposed Project Cooperation Agreement (PCA), the non-Federal sponsor shall maintain and operate the project after completion pursuant to direction of the U.S. Government.

LOCAL SPONSOR'S AUTHORITY TO PARTICIPATE IN THE PROJECT

The Department of Natural Resources of the Commonwealth of Puerto Rico is the local sponsor for the majority of the flood control projects in Puerto Rico. They have provided all lands required to date for the on-going Portugues and Bucana Flood Control Project since 1974. They provided all necessary lands for the Sabana Grande Project completed in 1990, and are currently acquiring lands for the Rio Cibuco Project at Vega Baja, Puerto Rico.

Certain substances are under the surveillance of the Department of Natural Resources. These items include *siliceous and calcareous mineral substances, sand, argillaceous, magnesian and ferruginous earth, clay and other substances of this kind which may be used for construction, agriculture, or the arts.*

TIMBER

The predominate use of land in the project area is for cattle grazing, though there are some sugar cane fields in the east portion of the project area. There is no standing timber or other vegetative cover that has significant recreation or scenic value.

CULTURAL RESOURCES

A cultural resources reconnaissance survey was conducted along portions of the project area in 1990. A total of 11 sites were identified, and additional assessment work to determine National Register eligibility was recommended for 6 of the 11 sites. Due to subsequent design changes, two sites will now be avoided leaving four sites requiring eligibility assessment.

The first site to be eliminated has had human burials recovered from it which date to the period between A.D. 600-1200. The second site eliminated by design changes dates to the late 19th or early 20th Century.

Two sites of the four requiring eligibility assessments are located at the north end of the project area. One is a small historic period artifact scatter, and the other is a small scatter of pre-Columbian ceramic and lithic artifacts. Another site, affected by the proposed ramp over Puerto Rico Highway #684 is a pre-Columbian residential site. The last site is located along the east levee alignment between the proposed downstream pilot channel and the downtown waterfront.

MITIGATION

According to Engineering Division, Jacksonville District, the project's net effects to wetlands will require no land acquisition for mitigation.

ESTIMATED COSTS OF LANDS, EASEMENTS, RIGHTS-OF-WAY AND RELOCATIONS

The following is a summary of real estate costs for subject project.

Lands and Damages		
Lands (138.67 acres total)		
Fee Simple: 127.97 acres	$676,251	
Easement: 10.70 acres	5,556	
Total		$681,807
Improvements		
Residences: 3		123,000
Severance Damages		
Land: .43 acres	$ 32,435	
Residences: 4	96,000	
Total		128,435
Minerals		0
Total Lands and Damages (Rounded)		**$ 933,000**
Acquisition/Administrative Costs (Rounded)		
Federal		56,000
Non-Federal		142,000
Public Law 91-646 (Rounded)		162,000
Contingencies (25%) (Rounded)		323,000
Total Estimated Real Estate Costs		**$1,616,000**

REAL ESTATE ACQUISITION SCHEDULE

Land acquisition required for project construction is scheduled to begin after the execution of Project Cooperation Agreement. It is estimated that acquisition time will be 24 months with acquisition beginning in July 1994.

ESTATES TO BE ACQUIRED

Fee Simple Excluding Minerals (With Restriction on Use of the Surface): The fee simple title to (the land described in Schedule A), (Tracts Nos. _____, _____ and _____), subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines; excepting and excluding from the taking all (coal) (oil and gas), in and under said land and all appurtenant rights for the exploration, development, production and removal of said (coal) (oil and gas), but without the right to enter upon or over the surface of said land for the purpose of drilling and extracting therefrom said (coal) (oil and gas).

Temporary Road Access Easement: A temporary and assignable easement and right-of-way in, on, over, and across (the land described in Schedule A) (Tracts Nos. _____, _____and _____), for a period not to exceed_____, beginning with date possession of the land is granted to the United States, for use by the United States, its representatives, agents, and contractors, for the location, construction, operation, maintenance, alteration, replacement and use of an access road and appurtenances thereto; together with the right to plant thereon trees, grass, shrubs and protect and control vegetation, to trim, cut, fell, remove, and dispose of any and all timber, trees, underbrush, obstructions, and other vegetation, structures, or obstacles within the limits of the right-of-way; reserving, however, to the owners, their heirs and assigns, the right to use the surface of the land as access to their adjoining land; subject, however, to existing easements for public roads and highways, public utilities, railroads, and pipelines.[1]

---

[1] Where an outstanding interest in the subsurface mineral estate is part of a block ownership which is to be excluded from the taking in accordance with paragraph 5-28g(2), the following clause will be added: *excepting and excluding from the taking all interests in the (coal) (oil and gas) which are outstanding in parties other than the surface owners and all appurtenant rights for the exploration, development and removal of said (coal) (oil and gas) so excluded.*

RIO GRANDE DE MANATI DETAILED PROJECT REPORT

APPENDIX F
COORDINATION

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APPENDIX F
COORDINATION

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DEPARTMENT OF NATURAL RESOURCES

SEP 11 1986

Lt. Col. Stanley G. Phernambucq
Deputy District Engineer for
Puerto Rico and Virgin Islands
U. S. Army Corps of Engineers
400 Fernández Juncos Avenue
San Juan, Puerto Rico 00901

Dear Liutenant Colonel Phernambucq:

During the recent months we have coordinated very closely with your Planning Section the Corps of Engineers ongoing and planned flood control study program in Puerto Rico with particular emphasis on the scheduling and cost sharing of studies.

A particular issue identified during this coordination is the one relating to the complementarity of efforts between our agencies in those basins where both of us are conducting investigations. Specifically, I want to point out at ongoing efforts at Río Grande de Loíza and Río Grande de Arecibo.

In the case of Río Grande de Loíza, Corps of Engineers emphasis should be placed on flood control alternatives for the upper part of the basin, south of Highway 3. Regarding the coastal flood plain, our Department is in the process of designing and constructing flood mitigation measures. We request, however, that the Corps finalize the existing hydraulics for the coastal flood plain with a bidimensional model in order to assist us at checking the final elevations for the improvements we are proposing for the area.

In the case of Río Grande de Arecibo, we have commissioned a consulting firm a flood control study for the upper part of the basin at the town of Utuado. The Department expects the construction of a flood control project in the area by the state government. We therefore request that the Corps survey study for the basin emphasize the flooding problem and plan formulation for the coastal flood plain, particularly the city of Arecibo.

We also request that an appraisal report under Section 205 of the 1948 Flood Control Act be initiated for the Río Grande de Manatí at Barceloneta as soon as possible. This is in accordance to the flood control program coordinated with your Planning Section.

We look forward for a continuous and productive relationship between the Corps and the Department in solving the water resources problems and needs of Puerto Rico.

Cordially,

Justo A. Méndez
Secretary

DEPARTMENT OF NATURAL RESOURCES

DEC 06 1988

Col. Robert L. Herndon
District Engineer
U. S. Army Corps of Engineers
P. O. Box 4970
Jacksonville, Florida 32232-0019

Dear Colonel Herndon:

Re: Reconnaissance Report Río Grande de Manatí at Barceloneta, Puerto Rico

The Department of Natural Resources has reviewed the Draft Reconnaissance Report for the reference project and generally concurs with the findings contained therein.

This letter of intent, while not considered a binding contract, is furnished to document our support of this project and our intent to act as local sponsor for the feasibility phase of the study. An amount of $100,000 has been budgeted for fiscal year 1988-89 and additional monies are being budgeted for the following year to continue and complete our cost sharing responsibility for the project.

Following execution of the feasibility cost sharing agreement the corresponding funds will be made available to the Corps of Engineers. The Department of Natural Resources agrees to serve on the Executive Committee and study Management Team, as indicated on the draft report, throughout the feasibility phase of the study.

Cordially,

Justo A. Méndez
Secretary

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
P. O. BOX 4970
JACKSONVILLE, FLORIDA 32232-0019

REPLY TO
ATTENTION OF

FEB 06 1990

Planning Division
Environmental Resource Branch

Honorable Luis Fontanez Olivo
Mayor Municipality of Barceloneta
Box 277
Barceloneta, Puerto Rico 00617

Dear Mayor Fontanez Olivo:

The Jacksonville District of the U.S. Army corps of Engineers is conducting a feasibility study for flood control for the Rio Grande de Manati in the vicinity of the town of Barceloneta. The study was authorized under Section 205 of the Flood Control Act of 1948 as amended. The local sponsor for the study is the Department of Natural Resources.

The proposed plan to provide flood protection to the above mentioned study area is under consideration (refer to enclosure).

The Corps of Engineers is soliciting views and comments that would aid in conducting the study. Where applicable, comments and information are requested in conformance with the following: Clean Water Act, Fish and Wildlife Coordination Act, National Environmental Policy Act, and National Historic Preservation Act.

We look forward to coordinating the future development of this study with your office as well as with other state and Federal agencies.

Please provide any comments on inquiries to the above address within thirty days of the date of this letter.

Sincerely,

A. J. Salem
Chief, Planning Division

Enclosure

RIO GRANDE DE MANATI AT BARCELONETA
MAILING LIST

Honorable Pedro Roselló
Governor of Puerto Rico
La Fortaleza
Box 82
San Juan Puerto Rico 00901

Mr. Eduardo Laureano
Federal Affairs Advisor
La Fortaleza
Box 82
San Juan Puerto Rico 00901-1793

Mr. Hector Russe, President
PR Environmental Quality Board
PO Box 11488
Santurce PR 00919
(send to DS-PD for 10 cys with Spanish Abstract)

Eng. Norma E. Burgos
Chairwoman, Puerto Rico Planning Board
PO Box 41119 Minillas Sta
San Juan PR 00940-9985 (7 cys)

Eng. César Barreto, Administrator
PR Permits and Regulations Admin
PO Box 41179 Minillas Sta
Santurce PR 00940

Mr. Pedro A. Gelabert, Secretary
PR Department of Natural Resources
PO Box 5887 Pta de Tierra
San Juan PR 00906

Mr. Julio Dumois, Asst
Secretary for Flood Control
PR Dept of Natural Resources
PO Box 5887 Pta de Tierra
San Juan PR 00906

Mr. Neftalí Soto, Secretary
PR Department of Agriculture
PO Box 10163
Santurce PR 00908

Honorable Jose A. Torres, Secretary
PR Department of Education
PO Box 759
Hato Rey PR 00919

Dr. Arleen Pabón de Rocafort
State Historic Preservation Officer
Office of the Governor
La Fortaleza
PO Box 82
San Juan PR 00901

Eng. Miguel Cordero, Executive Director
PR Electric Power Auth
GPO Box 4267
San Juan PR 00936-4267

Eng. Agustin Garcia Acevado
President
Puerto Rico Telephone Co
GPO Box 998
San Juan PR 00936

Honorable Zaida Hernández
President, Puerto Rico House of Representatives
PO Box 2228
San Juan PR 00901

Mr. Pedro Toledo
Superintendent
PR Police Department
GPO Box 70166
San Juan PR 00936

Mr. Juan F. Woodroffe
President
PR Industrial Development Co.
GPO Box 2350
San Juan PR 00936

Honorable Carlos I. Pesquera Morales
Secretary of Transportation and Public Works
PO Box 41269 Minillas Sta
Santurce PR 00940

President
PR Engineers and Surveyors Assn
GPO Box 3845
San Juan PR 00936

Mr. Allen Zack
District Chief, Caribbean District
US Geological Survey WRD
GPO Box 4424
San Juan PR 00936

Mr. James P. Oland
Field Supervisor
Caribbean Field Office
US Fish and Wildlife Service
PO Box 491
Boqueron PR 00622

Director
Caribbean Area Office
USDA Soil Conservation Service
PO Box 4868
San Juan PR 00936-4868

Area Supervisor
National Marine Fisheries Service
Environmental Assessment Branch
3500 Delwood Beach Road
Panama City FL 32407-7499

National Marine Fisheries Service
Habitat Conservation Div F-SER 1
9450 Koger Blvd
St Petersburg FL 33702

Commander (OAN)
Seventh Coast Guard District
909 SE 1st Avenue
Brickell Plaza Federal Bldg
Miami FL 33131-3050

Regional Director
US Fish and Wildlife Service
75 Spring Street SW
Atlanta GA 30303-3376

Honorable Carlos Romero Barceló
PR Resident Commissioner
US House of Representatives
427 Cannon Bldg
Washington DC 20515

Chief, Environmental Impacts Branch
Environmental Protection Agency
26 Federal Plaza Rm 1104
New York NY 10278-0001 (3 cys)

Director
Office of Environmental Proj Review
Department of the Interior
Rm 4241 19th and C St NW
Washington DC 20240

Mr. José Martínez
Chief, Planning Group
CESAJ-DS-PG
400 Fernandez Juncos
San Juan PR 00901-3299

Sol Luis Fontanes Olivo
Alcalde
Box 2049
Barceloneta, Puerto Rico 00617

Natural Resources Defense Council
1350 New York Avenue NW
Washington DC

Dr. Emilio M. Colón
Executive Director
PR Aqueducts and Sewers Authority
PO Box 7066, Sc. Obrero Station
Santurce PR 00916

Honorable Roberto Reach Benítez
President, PR Senate
Box 3431
San Juan PR 00904

Dr. Sergio L. González Quevedo
Executive Director
PR Highway Authority
GPO Box 42007
San Juan PR 00940-2007

Dr. Antonio Vélez Ramos, Interino
Executive Director
PR Land Authority
PO Box 9745
Santurce PR 00908

Mr. Juan O. Cruz
Director, Caribbean Office
Federal Highway Administration
Rm 150, Federal Office Bldg
Chardón Street
Hato Rey PR 00919

Director, Office Federal Activities
Environmental Protection Agency A-104
401 M Street SW
Washington DC 20024-2610 (5 cys)

Mr. John Freyffert
Administrator
Federal Emergency Mgmt Adm.
Rm 713, 500 C Street SW
Washington DC 20024-2514

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Southeast Regional Office
9450 Koger Boulevard
St. Petersburg, FL 33702

February 13, 1990

Mr. A. J. Salem
Chief, Planning Division
Department of the Army, Corps of Engineers
P.O. Box 4970
Jacksonville, FL 32232-0019

Dear Mr. Salem:

The National Marine Fisheries Service has reviewed the proposed plans for flood control for the Rio Grande de Manati in the vicinity of the town of Barceloneta, Puerto Rico in accordance with your letter of February 8, 1990.

Based on the information provided, we have no comment at this time. If you have any questions, please contact Dr. Edwin Keppner of our Panama City Area Office at 904/234-5061.

Sincerely yours,

Edwin J. Keppner

for Andreas Mager, Jr.
Assistant Regional Director
Habitat Conservation Division

cc:
F/SER1

February 15, 1990

Mr. A. J. Salem
Chief, Planning Division
Jacksonville District
Corps of Engineers
P.O. Box 4970
Jacksonville, Florida 32232-0019

Attention: Planning Division-Environmental
Resource Branch

Dear Mr. Salem:

Reference is made to your letter dated February 8, 1990 including information on the feasibility study for flood control for the Rio Grande de Manati in Barceloneta, being conducted by the Jacksonville District of the U.S. Army Corps of Engineers.

We endorse the efforts you are devoting to this project which we understand will be of great benefit for the area. Specifically, our facilities, projects, and plans are not directly affected by this action.

Sincerely,

José A. Buitrago
Executive Director

JAB/lat

ESTADO LIBRE ASOCIADO DE PUERTO RICO
DEPARTAMENTO DE SALUD
ADMINISTRACION DE FACILIDADES
Y SERVICIOS DE SALUD
HOSPITAL REGIONAL DE ARECIBO
ARECIBO, PUERTO RICO 00612

March 3, 1990

Department of the Army
Jacksonville District
Corps of Engineers
P.O. Box 4970
Jacksonville, Florida 32232-0019

Attn. Planning Division
Re: Study for flood control
for the Río Grande de Manatí
in the vicinity of the town
of Barceloneta, as of letter
February 8, 1990

I have studied the preliminary plans and alternatives for flood control of Río Manatí in the vicinity of the town of Barceloenta.

At this level our main concern in activities of this kind is the quality of the very productive and rich acquifers running along the subsoil of this area.

This office does not foresee any problem and encourages the prompt realization of this proyect.

Sincerely,

ENVIRONMENTAL HEALTH PROGRAM
PUERTO RICO DEPARTMENT OF HEALTH

Hiram Gómez Hernández, M.S.S.
Regional Director

HGH/dm

cc Lcdo. Ricardo J. Mayoral

U.S. Department of Transportation
United States Coast Guard

Commander
Seventh Coast Guard District

MAILING ADDRESS:
Brickell Plaza Bldg.
909 S.E. First Ave.
Miami, FL 32131-305
Staff Symbo_: (m)
Phone:(305) 536-5651

16450
5 March 1990

Planning Division
Department Of The Army
Jacksonville District, Corps of Engineers
P. O. Box 4970
Jacksonville, Florida 32232-0019

Sirs:

The projects at Buenna Vista, Puerto Rico and on the Rio Grande de Manati near Barceloneta have been reviewed by the Coast Guard Marine Safety Office, San Juan, Puerto Rico. We have no specific comments on either project.

Please keep us advised as the projects develop.

H. R. PRZEDOMSKI
By direction

Copy: CGD7(oan)

Gobierno Municipal

BARCELONETA, PUERTO RICO

Oficina del Alcalde

March 5, 1990

Mr. A.J. Salem
Chief, Planning Division
Jacksonville District Corps of Engineers
P.O. Box 4970
Jacksonville, Florida 32232-009019

Att: Planning Division

Dear Mr. Salem:

We are in receipt of your February 23, 1990 letter, and look forward to meeting you personally at the public hearing scheduled to take place in our Municipal Assembly Hall on March 7, 1990.

We understand the limitations outlined of your February 23, letter and desire that the Corps continue with its funded studies. You may count on our full cooperation on the projected flood control measures for Barceloneta. As a private matter and funded entirely by us, we will perform separate studies on the possibility of developing navegation improvements and a Port in the river which would assure year-round maintenance to keep the river's mouth open and thus aid in the flood control problem that presently exists. Our objective would be supplemental to yours and would be of great benefit to our community.

Please keep us informed on the progress of your work.

Sincerely,

Sol Luis Fontanes Olivo
Mayor

SLF/dvl

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
CARIBBEAN FIELD OFFICE
1413 FERNANDEZ JUNCOS AVENUE
SANTURCE, PUERTO RICO 00909

March 6, 1990

Department of the Army
Jacksonville District, Corps of Engineers
ATTN: A. J. Salem, Chief
Planning Division
Environmental Studies Section
P. O. Box 4970
Jacksonville, FL 32232-0019

Re: Río Grande de Manatí Flood Control Project
(Barceloneta, Puerto Rico)

Dear Mr. Salem:

The Caribbean Field Office has received and reviewed the preliminary alternatives for the above referenced project. Our comments are issued in accordance to the Clean Water Act and the National Environmental Policy Act.

Although such a project is urgently needed to protect life and property at Barceloneta, we are concerned about its possible effects on Caño Tiburones marsh land. Although this area is actively pumped to lower the water table and reclaim the land for agricultural purposes and flood control, swampy patches still remain. These areas support a wide variety of waterfowl and rare species, such as the West Indian Whistling Duck and the White-crowned Pigeon.

Any flood control project in the Barceloneta area should take into account the importance of the marsh as both water resource and habitat to try to preserve its integrity. If the project results in a net loss of wetlands at the marsh or around Manatí River, suitable plans for on-site mitigation should be developed as part of the project.

The water regime of the wetland areas should be maintained. Adverse impacts on the water quality of the river or the channels traversing the marsh should be reduced to a minimum.

On the other hand, the project could be used to impose developmental constraints in the area, minimizing further degradation of the marsh land.

Presently, a draft Environmental Impact Statement for the project is needed to thoroughly evaluate the proposed alternatives and their possible impacts on the region. For this reason, we would appreciate receiving a copy of this document as soon as it becomes available.

If you have any questions, do not hesitate to contact Luis F. Campos, Chief of the Water Management Staff, at (809) 729-6951.

Sincerely,

Pedro A. Gelabert
Director

ESTADO LIBRE ASOCIADO DE PUERTO RICO
POLICIA DE PUERTO RICO

SAOC-1-10-285

DIRIJA TODA
LA CORRESPONDENCIA OFICIAL
AL SUPERINTENDENTE
G.P.O. BOX 70166
SAN JUAN, PUERTO RICO 00936
Tel. 793-1234

March 6, 1990

Mr. A.J. Salem
Chief, Planning
Department of the Army
Jacksonville District, Corps of Engineers
P.O. Box 4970
Jacksonville, Florida 32232-0019

Dear Mr. Salem:

Reference is made to your letters dated February 7, 1990, February 8, 1990, concerning study for flood control for the Rio Anton Ruiz in the vecinity of Punta Santiago, Humacao and the Rio Grande de Manatí in the vecinity of the town of Barceloneta, that the U.S. Army Corps of Engineers are conducting.

Copy of these communications have been referred to both police Area Commander for their comments.

Views or comments if any you will be advised.

Be assured of our assistance and cooperation in this and all matters of mutual interest.

Sincerely,

Benito Cruz López, Col.
Assistant Superintendent in
Field Operations

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION II
26 FEDERAL PLAZA
NEW YORK, NEW YORK 10278

MAR 06 1990

Mr. R.J. Salem, Chief
Planning Division
U.S. Army Corps of Engineers
Jacksonville District
P.O. Box 4970
Jacksonville, Florida 32232-0019

Dear Mr. Salem:

The Environmental Protection Agency has reviewed the preliminary alternatives for the flood control project for the Rio Grande de Manati in the vicinity of the town of Barceloneta, Puerto Rico. Based on our review, we offer the following comments.

The planned study should provide detailed information on the project's impacts. Specifically, the study should address the impact of channel straightening on both surface water quality and ground water resources. This should include a discussion about the potential for discovery of hazardous contamination in dredged sediments; their potential impacts on surface water quality should they be resuspended; and appropriate measures for the proper disposal of such sediment. Additionally, we recommend that the study include information concerning the amount of sediment to be removed; the disposal sites for the excess dredge material; and the quantity of fill needed for the levees. Lastly, we recommend that they study provide the location of any wetlands in the study area and the impacts to these wetlands due to project construction.

Thank you for the opportunity to comment on this project. If you have any questions concerning our comments, please call Ms. Vicki Snitzler Neeck of my staff at (212) 264-6677.

Sincerely yours,

John Filippelli, Chief
Federal Activities Section
Environmental Impacts Branch

Commonwealth of Puerto Rico
Department of Transportation and Public Works
HIGHWAY AUTHORITY

HIGHWAY AUTHORITY

Box 3909 G. P. O. – San Juan, Puerto Rico 00936 – Cable Address: AUTOCARR

No. 0502-OF-gpq
Please mention this number when referring to this subject.
Address official communication to the EXECUTIVE DIRECTOR

093-4
90021311106

March 7, 1990

Planning Division
Environmental Resource Branch
Department of the Army
Jacksonville District,
Corps of Engineers
P.O. BOX 4970
Jacksonville, Florida 32232-0019

Att: A. J. Salem
Chief Planning Division

Re: Feasibility Studies for Flood Control for Río Grande de Manatí, Barceloneta and Río Antón Ruíz at Humacao.

Dear Sirs:

The following are our comments relating to the reference studies as requested in your letters dated February 7 and 8 of 1990.

1. Feasibility Study for Flood Control for the Río Grande de Manatí in the vicinity of the town of Barceloneta.

   The area to be protected by the flood control alternative encompass portions of the town of Barceloneta and areas in its vicinity. This includes Highways PR-140, PR-684 and PR-681. The topographic conditions of the surroundings of Barceloneta restrain its development and hinder the better provision of services in the sector. The proposed measures, particularly alternatives 2, 3 and 4, can improve the existing conditions because they will open up new areas to development. The area adjacent to the town can absorve part of the area's need for dwelling units and services. The developments in this sector will have direct access to the future De Diego Toll Road (PR-22) and to the existing highway PR-2.

2. Feasibility Study for Flood Control for the Río Antón Ruíz, Punta Santiago, Humacao.

The flood control measures proposed in the study's alternatives plans are going to promote future development in the vicinity of Punta Santiago near the existing development. We estimate the new development will produce a moderate future growth.

This area is now served by Highway PR-3 but there are plans for a relocation (PR-53) that by its very nature will atract a significant portion of PR-3's traffic volumes.

As a result the alternative plans for the flood control will not adversely affect the area in terms of highway needs.

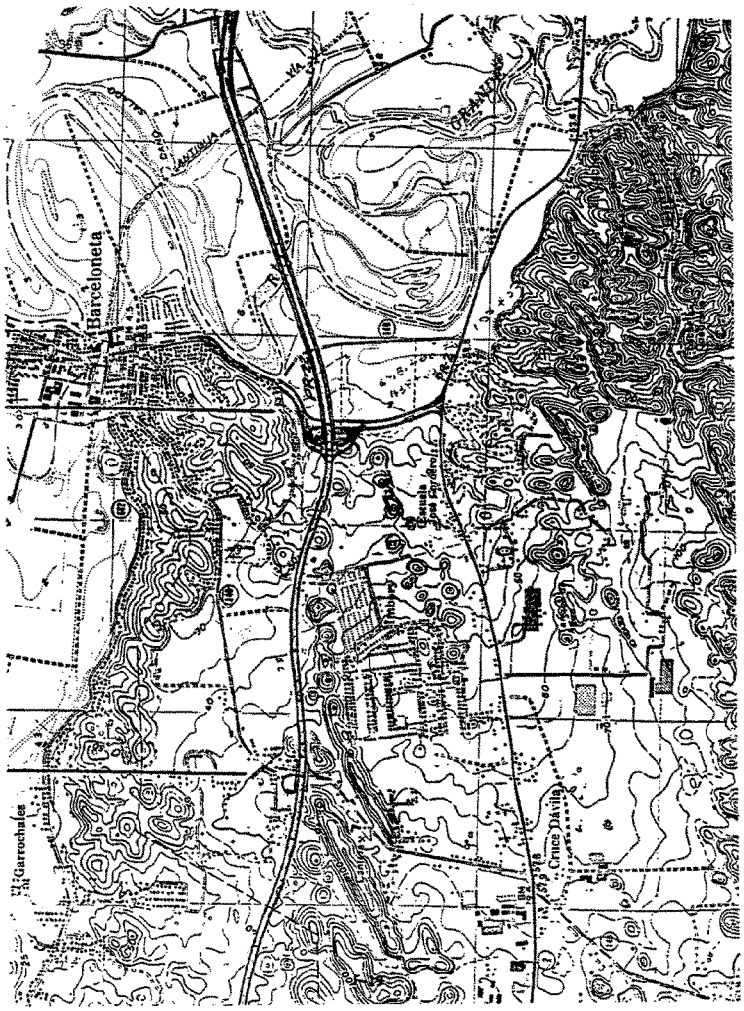
We also include a map illustrating the proposed PR-22 highway project in the vicinity of the town of Barceloneta.

If you have a question, please, do not hesitate to contact us.

Cordially Yours,

José S. Rodríguez
Planning Area Director

Enclosure:-


Barreloneta
Garrochales
Cruce Dávila

Commonwealth of Puerto Rico
Senate
Capitol
San Juan, Puerto Rico 00901

Miguel A. Hernández Agosto
President

March 14, 1990

Mr. A. J. Salem
Chief, Planning Division
Department of Army
Corps of Engineers
Jacksonville, Florida 32232-0019

REF: Preliminary Alternatives for Flood Control
Río Grande de Manatí, Barceloneta

Dear Mr. Salem:

Regarding your inquiry on the project of reference, we have no specific comments in view of the information supplied. Further consideration could be given to the different alternatives once the possible environmental impact of the proposed channel straightening is clarified. At this time we do not have an assessment of the direct effects the remedial construction would have on existing structures and land use.

Sincerely,

Miguel A. Hernández Agosto

ato

COMMONWEALTH OF PUERTO RICO
OFFICE OF THE GOVERNOR
PUERTO RICO PLANNING BOARD

Minillas Governmental Center, North Bldg.
De Diego Ave, Stop 22
P.O. Box 41119, San Juan, P.R. 00940-9985

March 15, 1990

A. G. Salem, Chief
Department of the Army
Jacksonville District
Corps of Engineers
P.O. Box 4970
Jacksonville, Florida 32232-0019

Dear Mr. Salem:

I make reference to your request for comments for the proposed flood control plans from Rio Grande Manati in the vicinity of the town of Barceloneta. The proposed plans includes four (4) alternatives which will provide protection against the 100-year flood and the SPF.

According with our flood zone map number 6B and FEMA's Panels 720000-0035C, 0035 , the area to be protected is classified within the floodway and the floodway fringe. Also, our preliminary report, Communities Living in High Risk Flood Areas,(Dec. 1985), recommends the relocation of sixty six (66) residential units located in the east of the town and in the Central Plazuela Sector. Said report also recommends, the construction of a floodwall and a levee to the northern and the western parts of the town.

Plan 1 presents the best flood control alternative for the study area. The alternative provides protection against the 500-year flood and will make possible the development of approximately 150 cuerdas which could be included as part of the urban limit. This alternative would make it unnecessary to relocate the above mentioned residential units.

The plan preserves the "Reserva Natural Hacienda La Esperanza", which would be affected by the others plans in the southwestern part of the natural reserve. The area considered for development could be developed in a compact manner, such as to maximize the use of the existing infrastructure.

Finally, we call your attention to the fact that all of the plans will entail a floodway revision to FEMA Panels 0035 and our Flood Zone Map Number 6B. Therefore, we recommend coordinating with FEMA the necessary authorization before comencing the works. Once any of the flood control plans has been constructed, the appropriate FEMA panels should be revised according with the Corps hydrologic-hydraulic study.

Cordially,

Patria G. Custodio
Chairperson

United States Department of the Interior

GEOLOGICAL SURVEY

GPO Box 4424
San Juan, Puerto Rico 00936

March 30, 1990

Mr. A.J. Salem
Department of the Army
ATTN: Planning Division
Jacksonville District, COE
P.O. Box 4970
Jacksonville, Florida 32232-0019

Dear Mr. Salem:

SUBJECT: Feasibility study for flood control for the Rio Grande de Manati in the vicinity of the town of Barceloneta.

After studying the several alternative plans to provide flood protection to the town of Barceloneta, we consider that the use of Plan 2 seems to be the best one to mitigate the flood problem in the area, due to its higher degree of protection to the urban area against the SPF.

If you have any questions regarding this matter, please do not hesitate to contact my supervisor, Eng. Heriberto Torres-Sierra, or myself at (809) 749-4346.

Cordially,

Francisco Pérez-Blair

Francisco Pérez-Blair
Civil Engineer

FPB/jer

Puerto Rico Telephone Company

G.P.O. Box 998
San Juan, Puerto Rico 009[illegible]

April 3, 1990

Mr. A. J. Salem
Chief, Planning Division
Department of the Army
Jacksonville District
Corps of Engineers
P.O. Box 4970
Jacksonville, Florida 32232-0019

Dear Mr. Salem:

We refer to your letter dated February 8, 1990 in which you inform us of the study being undertaken by the Corps of Engineers, for flood control for the Rio Grande of Manati.

Please be informed that engineer Iván Miranda, Director of our Outside Plant Engineering Department Metro and Island North Districts, will evaluate and coordinate all phases concerning our facilities.

We will appreciate your submitting to us the construction drawings and other details related to this project. As soon as we receive these documents, we will proceed to perform a study of the area to determine if our outside plant will be affected.

For additional information, please contact engineer Miranda at telephone number (809) 792-8120.

Cordially,

Nestali Bernard
Group Director
Engineering, Staff &
Technical Services

emd

Commonwealth of Puerto Rico
PUERTO RICO AQUEDUCT & SEWER AUTHORITY

April 18, 1990

Mr. A. J. Salem
Chief, Planning Division
Department of the Army
Jacksonville District
Corps of Engineers
P.O. Box 4970
Jacksonville, Florida 32232-0019

Re: **Flood Control Feasibility Studies Río Grande de Manati and Río Antón Ruiz de Humacao**

Dear Mr. Salem:

Your correspondence of February 7, and 8, 1990 relative to subject matter requests our views and comments pertinent to the proposed feasibility studies for flood control at these two sites.

The generic information provided in the above stated correspondence does not allow us to offer specific information relative to the potential impact to existing utilities in our aqueduct and sewer systems in those area.

We are confident that any impact to our existing utilities caused by the proposed studies will be considered and included in the overall budget for said projects as PRASA expects that the cost of necessary revisions and/or modification to our utilities will be borne by the projects.

If and when these projects materialize PRASA will interface with your organization on as needed basis.

Very Truly Yours,

9/27/90

Eduardo [illegible]nchez Claudio
Acting [illegible]v Executive
Director [illegible]perations
and Engin[illegible]

United States Department of the Interior
FISH AND WILDLIFE SERVICE
CARIBBEAN FIELD OFFICE
P.O. BOX 491
BOQUERON, PUERTO RICO 00622

June 18, 1990

Mr. A.J. Salem
Chief Planning Division
US Army Corps of Engineers
PO Box 4970
Jacksonville, Florida 32232

Re: Rio Grande de Manati,
Barceloneta, Puerto Rico

Dear Mr. Salem:

This is in reply to your February 8, 1990, letter requesting our views and comments on the proposed flood control measures for the Rio Grande de Manati at the town of Barceloneta. Several structural methods are being contemplated, these include levees, river channelization, and drainage ditches. The Municipality of Barceloneta has applied for Corps permits for several flood control projects. These include gabion bank protection of the Rio Grande de Manati as it runs through the town, a proposed channel diversion as in COE Plan 2, and a proposed marina facility at the mouth of the river.

National Wetland Inventory maps indicate the wetlands in the area to be primarily Estuarine Scrub Shrub, Estuarine Forested, Estuarine Emergent, Palustrine Emergent, and Palustrine Forested (see enclosure) areas with "+" have been field checked. The Service prefers either Plan #1 or Plan #2. These plans would not have serious impacts to the fish and wildlife resources of the area since they are limited to the area around the town of Barceloneta.

Thank you for the opportunity to comment on this action, if you have any questions please do not hesitate to call.

Sincerely,

Hilda Diaz-Soltero
Field Supervisor

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT CORPS OF ENGINEERS, ANTILLES OFFICE
400 FERNANDEZ JUNCOS AVENUE
SAN JUAN, PUERTO RICO 00901-3299

REPLY TO
ATTENTION OF

February 14, 1990

Planning Section

Honorable Rafael Hernández Colón
Governor of Puerto Rico
La Fortaleza
Box 82
San Juan, Puerto Rico 00901

Dear Governor Hernández Colón:

The U. S. Army Corps of Engineers and the Department of Natural Resources have initiated a feasibility study to analyze flood control alternatives to solve the flooding caused by Río Grande de Manatí at the town of Barceloneta. The study was authorized under the Section 205 of the Flood Control Act of 1948 as amended. The study was requested by the P. R. Department of Natural Resources in a letter dated September 11, 1986. Study costs are shared by the Commonwealth and the Federal Government.

The area of Barceloneta has experienced frequent serious flooding throughout its history. The main objective of this study is to evaluate in detail the magnitude of the flooding problem and to examine the engineering, economic, and environmental feasibility of the alternative flood control plans for the area.

A public meeting will be held at 7:30 p.m. on Wednesday, March 7, 1990, at the Salón Asamblea Municipal. The purposes of the meeting are to inform and discuss the scope and programing of the study as well as to collect information on the magnitude of the flooding problem.

It would be a pleasure to have you or your representative participate in this meeting.

Sincerely,

Charles S. Cox
Lt Col, Corps of Engineers
Deputy District Engineer for
Puerto Rico & Virgin Islands

Enclosure

Invitees to Public Meeting: letters from DDE

① Honorable Rafael Hernández Colón
Governor of Puerto Rico
La Fortaleza
Box 82
San Juan, Puerto Rico 00901*R
Governor Hernández Colón*R
*E

② Honorable José E. Laborde
Secretary of Natural Resources
P. O. Box 5887, Puerta de Tierra
San Juan, Puerto Rico 00906*R
Mr. Secretary*R
*E

③ Eng. Patria Custodio
Chairwoman
Puerto Rico Planning Board
P. O. Box 41119, Minillas Station
San Juan, Puerto Rico 00940*R
Engineer Custodio*R
*E

④ Honorable Jaime Fuster
Resident Commissioner of Puerto Rico
427 Cannon Building, HOB
Washington, D. C. 20515*R
Mr. Fuster*R
*E

⑤ Honorable Sol Luis Fontánez Olivo
Mayor of Barceloneta
Box 277
Barceloneta, Puerto Rico 00661*R
Mayor Fontánez Olivo*R
*E

⑥ Honorable Joaquín Rosa Ocasio
Representative
House of Representatives
Box 2228
San Juan, Puerto Rico 00901*R
Mr. Rosa Ocasio*R
*E

⑦ Honorable Edgardo Rosario Burgos
Puerto Rico Senate
Box 3431
San Juan, Puerto Rico 00904*R
Senator Rosario Burgos*R
*E

⑧ Honorable Américo Martínez Cruz
Senator
Puerto Rico Senate
Box 3431
San Juan, Puerto Rico 00904*R
Senator Martínez Cruz*R
*E

LISTA DE ASISTENTES A LA
REUNION PUBLICA DEL
RIO MANATI EN BARCELONETA

7 de marzo de 1990

1) Angel G.-Montés Soto
2) Julio César Vázquez Negrón
3) Margarita Silva Maldonado
4) José M. Soto Muñoz
5) Migdalia Bonet Acevedo
6) Luis Moya
7) Carmen Y. Suárez Serrano
8) María E. Molina Archilla
9) Sonia N. Caballero
10) Héctor J. Sánchez Hernández
11) Charlie N. García
12) José Colón Rosa
13) Luis Roberto Soler
14) Francisco A. Pumarejo
15) Carlos A. Pérez
16) Néstor Vargas Feliciano
[illegible] José A. Acevedo Ballester
Herman Rivera Vargas
[illegible] Carlos Gutiérrez Serrano
40) Noel A. Gutiérrez Cruz
21) Hiram Gómez Hernández
22) José A. Avalo Collazo
23) Daniel A. Fiedler
24) Jorge Nieves Quiñones
25) Ildefonso Vilar
26) Aida Cordero Arroyo
27) Ing. Herminio A. Saldaña Tuero
28) Ing. Mario Medero Rosado
29) Jaime A. Riera
30) Jorge L. Valentín Sierra
31) Ernesto González Cruz
32) Luis López
33) Rodolfo Martínez
34) Roberto Batista Escobar
35) Wilalberto Rodríguez Irizarry
36) Danilo Rodríguez Ferrer
37) Rafael Reverón Mercado
38) Iván Gómez Pomales
39) Benjamín Pérez Sánchez
40) Raúl Calderón Pérez
41) María M. Súarez Serrano
Santiago Vélez Aguila
[illegible] José A. Rodríguez
[illegible]4) Héctor R. López Collazo
[illegible]5) Antonia Kortright Llenzo
46) Félix Cortés Rivera
47) Ana Celia Cortés de Mislán
48) Carmen R. Montañez Díaz
49) Esther M. Ruiz Rosado
50) Ralph Schinella
51) Hon. Sol Luis Fontánez, Mayor
52) Juan Felicier, Deputy Mayor
53) Víctor Rodríguez Mena, Civil Defense
54) Pedro A. Carmona Colón, Department of Education
55) Néstor Rico Ramos, Industrial Development Compar
56) Francisco A. Pumarejo, Deptartment of housing
57) Alexis Molinares,
58) Lisandro Reyes Hernández
59) Ing. Pedro R. Cruz, Regulations and Permits Admin.
60) Edgar Fuentes Ortega, Deptartment of Agriculture
61) Arturo González Pérez, Historic Preservation
62) María M. Cassé, Dept. Natural Resources
63) Hilton Miró, Dept. Natural Resources
64) Rey Morales, Dept. Natural Resources
65) LTC Charles S. Cox, Corps of Engineers
66) Roberto Cortés Colón, Corps of Engineers
67) Elsa Jiménez, Corps of Engineers
68) Jorge M. Tous, Corps of Engineers
69) Emilio Colón, Corps of Engineers
70) Isabel Suazo, Corps of Engineers

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT CORPS OF ENGINEERS, ANTILLES OFFICE
400 FERNANDEZ JUNCOS AVENUE
SAN JUAN, PUERTO RICO 00901-3299

REPLY TO
ATTENTION OF

February 4, 1991

Planning Section

Mr. José S. Rodríguez
Director of Land Use Plans Bureau
Puerto Rico Planning Board
P. O. Box 41119, Minillas Station
San Juan, Puerto Rico 00940

Dear Mr. Rodríguez:

This letter is to invite you or a representative from your office to the initial Río Grande de Manatí at Barceloneta Flood Control Study Management Team (SMT) meeting to be held at our offices on February 21, 1991, at 9:30 a. m.

The SMT is the focal point for monitoring the progress and direction of the study. Subject to approval by the Executive Committee (EC), the SMT will determine the nature of the tasks to be conducted and the extent of planning, evaluation, and coordination activities. In addition, the SMT will be responsible for evaluating any problems, issues or conflicts that may arise during the course of the study and presenting them along with potential solutions to the EC for resolution. The EC would have the final responsibility for study direction, planning, and evaluation activities, budgets, and schedules. The EC would be co-chaired by the District Engineer and the Secretary of the Department of Natural Resources.

The preliminary alternatives for solving the flooding problem where presented to the participating government agencies and to the public during the public meeting held on March 7, 1990, at the town of Barceloneta. After studying four alternate levee alignments, we are ready for the selection of a plan which would be developed into the recommended plan. During the meeting members of the SMT will be presented with the preliminary findings of the study and will be given an opportunity to express their views and concerns of the proposed flood control alternatives and at the same time participate in the evaluation of any problems or issues that may arise during the meeting. The draft report is scheduled to be coordinated with all participating government agencies and the public by the end of January 1992.

If you have any further questions about the Study Management Team meeting please contact Mr. Jorge M. Tous, Study Team Manager, at 729-6893.

Sincerely,

William T. Coffey
Lt Col, U. S. Army
Deputy District Engineer for
Puerto Rico & Virgin Islands

Copy furnished:

District Engineer
Secretary, DNR

A G E N D A

STUDY MANAGEMENT TEAM MEETING
RIO GRANDE DE MANATI AT BARCELONETA FEASIBILITY STUDY

February 21, 1991

9:30 - 9:35 a.m.	Welcome (Lt. Col. William T. Coffey)
9:35 - 9:45 a.m.	Introduction and Opening Remarks (Eng. Roberto Cortés)
9:45 - 10:00 a.m.	Review of Authorization and Funding for Planning Studies (Eng. Roberto Cortés)
10:00 - 11:00 a.m.	Presentation of the Study (Eng. Jorge Tous)

- Description of Preliminary Plans
- Impacts of Preliminary Plans
  - Flooding
  - Relocations
  - Urban Expansion
  - Areas for Borrow and Disposal of Materials
  - Environmental Resources
  - Cultural Resources
- Economic Analysis of Preliminary Plans
- Selection of Final Plan
- Selection of Recommended Plan
- Present Study Schedule

11:00 - 11:45 a.m. Open Discussion by Team Members

STUDY MANAGEMENT TEAM MEETING
RIO GRANDE DE MANATI AT BARCELONETA FEASIBILITY STUDY
February 21, 1991

LIST OF ATTENDEES

NAME (Please print.)	AGENCY	PHONE NO.
Herminio A. Saldaña Tuero	P.R. LAND AUTH	723-9090
Rolando Mosquera	Junta de Planificación	722-2780
Rafael Morales	" "	723-6200 x-2012
Grissetto Felix-Fernández	Autoridad Carreteras (P.R.H.A.)	728-6290
Francisco Marrero	Cuerpo Ingenieros	729-6892
William Penn	De Diego Management Assoc. (DDMA)	721-5535
Edil Rosas	Corps of Engineers	729-689[illegible]
Isabel Suarez	Corps of Engineers	729-689[illegible]
Miguel A. Rodríguez	Corps of Engineers	729-6895
Jose A. Arroyo	DNR	724-3422
Luis A. Ruiz	Municipio Bta	846-5092
Edwin Arroyo Carmona	Municipio Bta	846-0089

DEPARTMENT OF THE ARMY
JACKSONVILLE DISTRICT, CORPS OF ENGINEERS
P. O. BOX 4970
JACKSONVILLE, FLORIDA 32232-0019

REPLY TO
ATTENTION OF

October 21, 1991

Planning Division
Environmental Resources Branch

Mr. James P. Oland
Field Supervisor
U.S. Fish & Wildlife Service
Caribbean Field Office
P.O. Box 491
Boqueron, Puerto Rico 00622-0491

Dear Mr. Oland:

Pursuant to the Endangered Species Act as amended the Corps of Engineers, Jacksonville District is requesting a list of any listed or proposed species or critical or proposed habitat that may be present in the study area (see enclosed map) for the Section 205 flood control study being conducted for the Rio Grande de Manati at Barceloneta.

Sincerely,

A. J. Salem
Chief, Planning Division

Enclosure

United States Department of the Interior

FISH AND WILDLIFE SERVICE
CARIBBEAN FIELD OFFICE
P.O. BOX 491
BOQUERON, PUERTO RICO

November 5, 1991

A. J. Salem
Chief, Planning Division
Department of the Army
Jacksonville District Corps of Engineers
P.O. Box 4970
Jacksonville, Florida 32232-0019

Re: Flood Control Study,
Río Grande de
Manatí, Barceloneta

Dear Mr. Salem:

This is in response to your letter of October 21, 1991, concerning the Section 205 flood control study for the Río Grande de Manatí at Barceloneta, Puerto Rico. Your letter requested a list of proposed or listed threatened/endangered species or critical habitat which may be present in the study area. Based on the map provided with your letter the following species may be found within or in waters adjacent to the study area: Cassia mirabilis, Trichechus manatus (Antillean manatee), and Epicrates inornatus (Puerto Rican boa). Please feel free to call this office if you have any questions.

RECEIVED
NOV 1[illegible] 1991
SJAO
Regulatory/Section

Sincerely,

Vance P. Vicente
Acting Field Supervisor

ss
cc:
COE, San Juan

DEPARTMENT OF THE ARMY
SAN JUAN AREA OFFICE, JACKSONVILLE DISTRICT CORPS OF ENGINEERS
400 FERNANDEZ JUNCOS AVENUE
SAN JUAN, PUERTO RICO 00901-3299

REPLY TO ATTENTION OF

February 3, 1992

Planning Section

Dear:

This letter is to invite you or a representative from your office to the second Río Grande de Manatí at Barceloneta Flood Control Study, Study Management Team (SMT) meeting to be held at our offices on February 21, 1992, at 9:00 a. m.

General information on the flood control study, to include discussion of preliminary structural and non-structural alternatives to minimize flood damages, was presented to government agencies and residents during a public meeting held on March 7, 1990, at the town of Barceloneta. During the first SMT meeting held on February 21, 1991, a detailed discussion of the preliminary alternatives provided participants with the opportunity to present views and concerns on proposed flood control project.

After more detailed studies, a final levee alignment has been selected. The plan that includes an earthen levee around the developed area of the town of Barceloneta will provide protection for the 100-year flood event and will include recreation facilities within lands of the project. Enclosed is a conceptual drawing of the recommended plan. The plan would be discussed during the meeting together with its performance, costs, benefits, and all potential issues or problems that could be expected during the final stages of the feasibility study. The meeting will be chaired by Eng. Hilton Miró, Assistant Secretary, Flood Control Area, Department of Natural Resources and Eng. Roberto Cortés, Chief, Planning Section, Corps of Engineers.

The draft report is scheduled to be completed by June 1992; and after the required in-house review, it would be coordinated with all participating government agencies and the public by the end of September 1992.

Should you have any further questions about the Study Management Team meeting, please contact Eng. Jorge M. Tous, Study Team Manager, at 729-6893.

Sincerely,

William T. Coffey
Lt Col, U. S. Army
Deputy District Engineer for
Puerto Rico & Virgin Islands

Enclosures

RIO GRANDE DE MANATI AT BARCELONETA
MAILING LIST FOR
STUDY MANAGEMENT TEAM MEETING
21 February 1992

Mr. Fernando Guzmán
Director of the Area for Environmental
Evaluation and Scientific Analysis
Environmental Quality Board
P. O. Box 11488
Santurce, Puerto Rico 00936

Mr. Jorge Rivera
Chief, Environmental Study Office
P.R. Highway Authority
Box 3909 G. P. O.
San Juan, Puerto Rico 00936

Mrs. Silvia Abadía
Director of Land Use Plans Bureau
Puerto Rico Planning Board
P. O. Box 41119, Minillas Station
San Juan, Puerto Rico 00940

Mr. Rafael Pérez Vega
P. R. Land Authority
P. O. Box 9745
Santurce, Puerto Rico 00908

Honorable Sol Luis Fontanes Olivo
Mayor of Barceloneta
P. O. Box 277
Barceloneta, Puerto Rico 00617

Mr. Juan Hernández
Acting Director of Civil Defese
Municipality of Barceloneta
P. O. Box 277
Barceloneta, Puerto Rico 00617

Mr. Javier Blanco
Director
Fideicomiso de Conservación de P. R.
P. O. Box 4747
San Juan, Puerto Rico 00902

STUDY MANAGEMENT TEAM MEETING
RIO GRANDE DE MANATI AT BARCELONETA FEASIBILITY STUDY
February 21, 1992

LIST OF ATTENDEES

NAME (Please print.)	AGENCY	PHONE NO.
HERMINIO A. SALDAÑA	AUTORIDAD DE TIERRAS de P.R	723-4090
Reinaldo MESQUIDA	JUNTA de PLANIFICACION	723-6200 x4492
NOSE R. GONZALEZ	" " "	"
Luis A. Ruiz	Municipio Barceloneta	846-5096
Lisandro Reyes	Municipio Barceloneta	846-3400 ext 20
Lisbeth Hyman	RECURSOS NATURALES	724-3422
Jose A. Arroyo	DRN	724-3727
Jorge M. Tous	USCE	
HILTON MIRO DEFRES	DRN	725-3852
Roberto Cortés	USCE	
Jorge Rivera Jiménez	Autoridad de Carreteras	728-6290
Sol Luis Fontanez Olivo	Municipio de Barceloneta	846-6096

A G E N D A

STUDY MANAGEMENT TEAM MEETING
RIO GRANDE DE MANATI AT BARCELONETA FEASIBILITY STUDY

February 21, 1992

9:00 - 9:10 a.m.	Introduction and opening remarks (Eng. Roberto Cortés, Chief, Planning Section and Eng. Hilton Miró, Assistant Secretary, Flood Control Area
9:10 - 10:00 a.m.	Presentation of recommended plan (Eng. Jorge Tous)

Description
- Levee alignment
- Interior drainage
- Recreation

Impacts of recommended plan
- Flooding
- Relocations and Roads
- Urban expansion
- Borrow and disposal areas
- Environmental resources
- Cultural resources
- Economic analysis
- Study schedule

10:00 - 11:00	Open discussion by team members
11:00 - 11:30	Closing remarks (Eng. Roberto Cortés)

DEPARTMENT OF NATURAL RESOURCES

DEC 29 1993

Col. Terrance C. Salt
District Engineer
Jacksonville District
U.S. Army Corps of Engineers
PO Box 4970
Jacksonville, Florida 32232-0019

Dear Colonel Salt:

The Puerto Rico Department of Natural Resources has reviewed the Rio Grande de Manatí at Barceloneta, Puerto Rico, draft Detailed Project Report and Environmental Assessment and generally concurs with the findings contained therein. The Department of Natural Resources is legally capable of fulfilling the requirements of local cooperation.

This Letter of Intent, while not considered a binding contract, is furnished to document our support of the recommended plan of improvements and our intent to act as local sponsor for its implementation.

Project funding will be obtained by annual appropriations from the Commonwealth Legislature capital investment program for flood control works managed by the Puerto Rico Department of Natural Resources.

Sincerely,

Pedro A. Gelabert
Secretary

JAA/nilda

DEPARTMENT OF NATURAL RESOURCES

February 17, 1994

Mr. José A. Martínez
Chief, Planning Section
Antilles Office
U.S. Army Corps of Engineers
400 Fernández Juncos Avenue
San Juan, Puerto Rico 00901

Dear Mr. Martínez:

Subject: Río Grande de Manatí Flood Control Study

The purpose of this letter is to express the way the Department of Natural and Environmental Resources intends to secure the use 207.7 acres of land located in the north and eastern part of the town of Barceloneta necessary for residual interior flooding management as part of the Río de Manatí flood control project.

At the time of signature of the Project Cooperation Agreement the Department intends to secure the use of the acreage in question either through a special zoning from the Puerto Rico Planning Board or through an agreement with the land owner, the Puerto Rico Land Authority, to the effect that the land in question will remain in agricultural use. Authorization from both the U.S. Army Corps of Engineers and our Department will be required in case any change in land use is requested.

Sincerely,

Julio F. Dumois
Assistant Secretary
Water Resources and
Flood Control Area

JAA/nilda

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION II
JACOB K. JAVITS FEDERAL BUILDING
NEW YORK, NEW YORK 10278-0012

NOV 1 1993

Mr. A. J. Salem, Chief
Planning Division
Department of the Army
Jacksonville District Corps of Engineers
P. O. Box 4970
Jacksonville, Florida 32232-0019

Dear Mr. Salem:

The Environmental Protection Agency has reviewed the draft detailed project report and environmental assessment (EA) for the Rio Grande de Manati, Barceloneta, Puerto Rico. The EA evaluates structural and nonstructural measures to provide protection against the 100-year flood in the vicinity of Barceloneta. In this regard, the document proposes the construction of 5,200 meters of levees around the town of Barceloneta and two pilot channels approximately 1,545 meters long in the Rio Grande de Manati. Based on our review, we offer the following comments.

The document states that the proposed flood protection project may enhance economic and quality-of-life improvements in Barceloneta. Moreover, the draft EA indicates that the proposed project and the new construction of Highway 22 may stimulate regional growth. However, the document does not evaluate the secondary impacts of the proposed flood control project. Given that new demands for housing and services could result in adverse environmental impacts, the final EA should assess the project's potential secondary impacts and provide mitigation measures.

Thank you for the opportunity to comment. We look forward to receiving the final EA for our review. Should you have any questions, please have Mr. Joseph Bergstein of my staff contacted at (212) 264-6677.

Sincerely yours,

Laura J. Livingston, Assistant Chief
Environmental Impacts Branch

Commonwealth of Puerto Rico
PUERTO RICO AQUEDUCT & SEWER AUTHORITY

19 de octubre de 1993

Mr. A. J. Salem
Chief, Planning Division
Department of the Army
Jacksonville District Corps of Engineers
P.O. Box 4970
Jacksonville, Florida 32232-0019

Dear Mr. Salem:

Re: **BARCELONETA, PUERTO RICO**
Study to Determine the Feasibility
of Providing a Small Flood Control
Project for the Río Grande de Manatí
in the Vicinity of Barceloneta

Reference is made to your letter dated September 28, 1993 regarding the above reference project.

After our analysis we are concerned about the possible effects during the construction stage on the quality of the productive aquifier running along the subsoil of this area.

We also want to inform you that PRASA has some filtered water and sewer pipelines in the premises that could be affected.

In general terms this Authority endorses the proposed project but protection measures should be taken to avoid any adverse effect in our water sources or in out infraestructures. The contractor in charge should contact our Operation Area for specific details.

If you have any doubts do not hesitate to contact us.

Cordially yours,

José A. Calderón
Director for Engineering

Gobierno Municipal

BARCELONETA, PUERTO RICO

Oficina del Alcalde

October 20, 1993

Mr. A.J. Salem
Chief, Planning Division
Department of the Army
Jacksonville District Corps of Engineers
P.O. Box 4970
Jacksonville, Florida 32232-0019

Dear Mr. Salem:

I acknowledge received a copy of the Draft Detailed Project Report and Environmental Assessment you sent me on the first week of this month. After very conciously revision of the draft, I endorsed the recommended actions that the USCOE is proposing for the flood control in the town of Barceloneta.

On behave of the people who have lived so many years risking their lives due to continious flooding of the river, I will emphasize the importance for the development of this project. At the same time the habitants of the city of Barceloneta will be pleased to surpass the scars left from the so named Río Manatí fury.

Cordially,

Sol Luis Fontanes Olivo
Mayor

COMMONWEALTH OF PUERTO RICO
OFFICE OF THE GOVERNOR
PUERTO RICO PLANNING BOARD

Minillas Governmental Center, North Bldg.
De Diego Ave, Stop 22
P. O. Box 41119, San Juan, P. R. 00940 - 1119

February 1, 1994

Mr. A. J. Salem, Chief
Planning Division
Department of the Army
Jacksonville District
Corps of Engineers
P.O. Box 4970
Jacksonville, Florida 32232-0019

RE: Río Grande de Manatí
Barceloneta, Puerto Rico

Dear Mr. Salem:

Reference is made to your request for comments for the Draft Detailed Project Report and Environmental Assessment on Río Grande de Manatí flood control project in the municipality of Barceloneta.

The recommended plan, shown in Plate 5, will protect the urban core of the municipality from the 100 year flood of Río Grande de Manatí. The proposed levee alignment was in agreement with the Land Use Plan for the Municipality due to the fact that the urban expansion was located to the south of the town. Also, the recommended plan consider the future development to the west within those lands located in the floodway fringe.

We would like to point out an important issue about the land to be used for local run-off under the 100 year flood. That land actually classified within the floodway, will be reclassified as non floodable from the 100 year flood of the river after completion of the project. This matter should be attended in order to restrict any future development that can affect the project operation.

Regarding the floodplain management, we had to take into account that FEMA's base flood elevations are lower (one meter) than the 100 year flood stages computed by the Corps study for this project.

Therefore, we will contact FEMA in order to request a flood insurance study revision for Río Grande de Manatí Basin.

Cordially,

Norma E. Burgos-Andujar
Chairwoman

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Southeast Regional Office
9450 Koger Boulevard
St. Petersburg, Florida 33702

October 26, 1993

Colonel Terrence C. Salt
District Engineer, Jacksonville District
Department of the Army, Corps of Engineers
P.O. Box 4970
Jacksonville, Florida 32232-0019

Dear Colonel Salt:

The National Marine Fisheries Service (NMFS) has revieved the Section 205 Draft Detailed Project Report and Environmental Assessment for the Rio Grande de Manati at Barceloneta, Puerto Rico. The report was submitted to us by cover letter dated September 28, 1993.

Based on the information provided in the report, we do not expect the project to have significant adverse impacts to marine or estuarine fishery resources for which the NMFS has stewardship responsibility. Thank you for the opportunity to review this project. If we may provide further assistance, please contact Ms. Shelley Du Puy of our Miami Field Office at 305-595-8352.

Sincerely,

Andreas Mager, Jr.
Assistant Regional Director
Habitat Conservation Division

COMMONWEALTH OF PUERTO RICO
PUERTO RICO INDUSTRIAL DEVELOPMENT COMPANY
G.P.O. BOX 2350 SAN JUAN, PUERTO RICO 00936

TELEX: 3252678
3654319
3855245

October 26, 1993

Mr. A. J. Salem
Chief, Planning Division
Environmental Branch
Departament of the Army
Jacksonville District Corps
of Engineers
P.O. Box 4970
Jacksonville, Florida 32232-0019

Attention: CESAJ-PD-PB

Dear Mr. Salem:

Re: Flood Control Project for
Río Grande de Manatí at
Barceloneta, Draft Detailed
Project Report and Environmental
Assessment

Reference is made to your letter dated September 28, 1993, related to the draft of the document mentioned above.

The Puerto Rico Industrial Development Company (PRIDCO) has evaluated the Draft Detailed Project Report and Environmental Assessment and, in our opinion, the document addresses the most significant and relevant aspects of the proposed action. In addition, the proposed project is in harmony with PRIDCO's industrial and economic development plans for the area. Based upon that evaluation, PRIDCO endorses the proposed flood control project provided that all aspects of its design, construction, and operation comply with applicable state and federal regulations and provided that it guarantees protection of the environment.

We hope these comments be useful to your purpose.

Cordially,

Ramón Sanabria Berríos
Vice President for Development

TELEFONICA
DE PUERTO RICO

P.O. Box 360998, San Juan, P.R. 00936-0998

October 28, 1993

Department of the Army
Jacksonville District Corps
of Engineers
PO Box 4970
Jacksonville, FL 32232-0019

Attention Mr. AJ Salem, Chief
Planning Division

Dear Mr. Salem:

CESAJ-PD-PB

We received the Draft Detailed Project Report and Environmental Assessment regarding the Río Grande de Manatí project at Barceloneta. Our company endorses favorably the flood control improvements for this river.

However, a set of drawings is required to make our field survey and telephone plant relocations prior to constructions at estate roads 684, 681, 682 and 140.

We will appreciate if you contact Mr. José Meléndez, North Area Outside Plant Engineering Division Manager, after the approval of the project so we can coordinate with the Puerto Rico Natural Resources Department the relocation of our utilities.

Cordially yours,

Pedro N. Cruz, Engineer
Director
Island Outside Plant,
Engineering and Technical
Services Department

United States Department of Agriculture
Soil Conservation Service
Caribbean Area
PO Box 364868
San Juan, PR 00936-4868

October 14, 1993

Mr. A.J. Salem
Chief, Planning Division
Department of the Army
Jacksonville District Corps of Engineers
PO Box 4970
Jacksonville, Florida 32232-0019

Dear Mr. Salem:

Re: Proposed flood control project for the Rio Grande de Manati in the vicinity of Barceloneta, Puerto Rico.

According to place C-1, the proposed project plan is in an area including two soils: Coloso silty clay loam and Toa silty clay loam. Coloso series consists of deep, somewhat poorly drained soils on flood plains. They formed in stratified alluvial sediments. Typically these soils have a brown silty clay loam surface layer 7 inches thick. The underlying material from 7 to 13 inches is brown silty clay loam, from 13 to 33 inches is dark gray and light gray silty clay loam, and from 33 to 60 inches is dark gray and light gray silty clay loam, and from 33 to 60 inches is dark gray silty clay. Slopes range from 0 to 2 percent. Toa series consists of deep, well drained soils on flood plains. They formed in alluvial sediments of mixed origin. Typically these soils have a dark brown clay loam surface layer 8 inches thick. A subsurface layer from 8 to 17 inches is dark brown silty clay loam. The subsoil from 17 to 29 inches is dark yellowish brown silty clay loam. The substratum from 29 to 43 inches is dark brown silty clay loam and from 43 to 64 inches is dark yellowish brown clay loam. Slopes range from 0 to 2 percent.

These two soils are included in the prime farmland list. As required by the Farmland Protection Policy Act, a Farmland Conversion Impact Rating (AD-1006) was submitted for evaluation and returned by us on June 1, 1992. Furthermore, the Coloso and Toa map units are currently listed as

non-hydric map units that may contain hydric inclusions, and warrants further investigation to determine if hydric soils are within these delineations.

We have no more comments other than recommending during the construction phase to maintain the soil movement to a minimum and to plant vegetation after construction on any disturbed area to reduce soil erosion.

Sincerely,

ROY L. VICK
Staff Soil Scientist