

FINAL CONTINUING AUTHORITIES PROGRAM (CAP) CONVERSION FEASIBILITY REPORT FOR RÍO CULEBRINAS at Aguadilla and Aguada, PUERTO RICO



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U.S. Army Corps of Engineers
South Atlantic Division
Jacksonville District

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Final CAP Conversion Feasibility Report for Río Culebrinas at Aguadilla and Aguada, Puerto Rico

Executive Summary

Background

The purpose of this report is (1) to reaffirm the economic justification, environmental acceptability and engineering feasibility of the plan previously identified in the Río Culebrinas Detailed Project Report (DPR) and Environmental Assessment (EA) that was approved by the South Atlantic Division Commander in June 2004; and (2) to serve as documentation to support preparation of a Chief's Report to convert the full project from a Continuing Authorities Program (CAP) project to a specifically authorized project. The Project was further reviewed and updated in 2015 with a Draft Addendum to the DPR and EA. However, it was never approved due to the cost exceeding the CAP funding limit of \$10M. The recommended plan is the National Economic Development (NED) plan and includes the major features:

- Two levees (Aguadilla and Espinar) with a total length of approximately 3.03 km (2.05 miles);
- Interior drainage features consisting of a 1 meter (3.28 feet) deep and 7 meter (22.97 feet) wide drainage channel along the protected side of each levee;
- A two-way drainage structure near the north end of the Espinar Levee; three one-way drainage structures along the Aguadilla Levee;
- A 60-meter (196.85 feet) long cutoff channel for the Caño Madre Vieja to connect two meanders of the stream where the Aguadilla Levee will interrupt it (4 meters [13.12 feet] deep by 43.2 meters [141.73 feet] wide);
- Three paved roadway ramps across the levees;
- A borrow area located in Aguada;
- Net creation of approximately 11 to 12 acres of wetlands for mitigation based on unavoidable impacts to approximately 10 acres of wetlands in the levee right of way (further described in EA, Appendix D and in section 2.3 of this report).

Construction has not been initiated on this project. The Municipality of Aguadilla is the non-Federal sponsor.

Study Location

The study area is located on the northwest end of the main island of Puerto Rico. The project is located along the Caño Madre Vieja tributary of the Río Culebrinas. The Río Culebrinas flows from the higher elevations to the east of the project to the ocean just west of the project location. The Caño Madre Vieja is a small streamlet within the floodplain of the Río Culebrinas. The Caño Madre Vieja splits off of the Río Culebrinas and meanders through the large floodplain in the coastal area and flows into the ocean. The Caño Madre Vieja, associated floodplain, and wetlands lie between the municipalities of Aguadilla and Aguada.

Authorization

The Río Culebrinas Section 205 Project was initially authorized under the CAP, Section 205 of the Flood Control Act of 1948 (Public Law 80-858), as amended (33 U.S.C. § 701s). Because costs exceeded CAP limits, the project is now being planned under the authority of Section 204 of the Flood Control Act of 1970 (Public Law 91-611) authorizing studies for flood control in the United States and its territories. Title IV, Division B of the Bipartisan Budget Act (BBA) of 2018 (Public Law 115-123) authorizes the Government to conduct the study at full federal expense to the extent that investigations appropriations provided under the 2018 BBA are available and used for such purpose.

Project Changes

Due to updated Corps' models and levee safety standards, the 2004 Recommended Plan required several design modifications. Design changes include the use of concrete (instead of metal) culverts, armoring for the cutoff channel, and revisions to the levee side slopes to meet current Corps levee design guidance criteria. The dimensions of the levees increased when the side slopes went from 2.5:1 in the 2004 plan to 3:1 in the 2015 plan. The 2004 project was self-mitigating; however, due to the increases in the width of the levee cross sections and the need for additional lands, the current project was reviewed for its potential environmental impacts with respect to adjacent wetlands. The Corps determined that the revised levee design would affect additional wetlands more than anticipated in 2004 and thus a mitigation plan would be implemented.

Project Costs and Benefits

The updated Certified Project First Cost for the Río Culebrinas project is \$25.034M. When the cost is compared to the benefits determined in the 2004 study, the BCR is 1.50. Due to the projected project cost being above the authorized funding limit of \$10M, the project could not proceed under the Continuing Authorities Program. The impacts to municipalities from the flooding from the Caño Madre Vieja caused by Hurricane Maria in 2017 led to the Río Culebrinas project receiving BBA funding.

Compliance with USACE Quality Control Standards

The Rio Culebrinas project is fully compliant with current USACE Quality Control Standards. District Quality Control (DQC) was implemented throughout the report development process and at each delivery level. Engineer Circular (EC) 1165-2-217 requirements and guidelines were implemented for the reviews for this report. A project Review Plan was developed, endorsed by the Ecosystem Planning Center of Expertise (ECO-PCX), and approved by South Atlantic Division. The procedures outlined in the EC were utilized to complete DQC and Agency Technical Review (ATR) for the report.

Project Economics

A Level 1 Reaffirmation Report as defined by Director of Civil Works Policy Memorandum CWPM 12-001, also known as a Level 1 economic analysis, was conducted for this report. The objective of the Level 1 economic analysis is to confirm the continued existence of the structures that the Federal project was designed to protect, and to confirm that the assumptions made in the original study continue to be realistic. The project scope, area, and purpose remain the same as stated in the 2004 approved report. The inventory of property has not changed significantly since 2004. Because no major changes have occurred in the study area, it is

reasonable to assume that the inventory of property subject to flooding is comparable to the inventory in the 2004 assessment. The 2015 Bureau of Labor Statistics data show that Puerto Rico unemployment rate was at 13.6% or more than 100% above the national rate.

Since the original report in 2004, the estimated cost of the project has increased significantly (from \$4.7 million to \$25.034 million). Even accounting for inflation, the real costs of the project have increased over time. Because a level 1 economic analysis takes the current cost and deflates it to the price level of the estimated benefits, the benefit cost ratio (BCR) has therefore decreased over time. A summary of the changing costs, BCR, and net benefits is provided in Table ES- 1: Río Culebrinas Cost and BCR comparison over time.

Table ES- 1: Río Culebrinas Cost and BCR Comparison Over Time

	2004 (Initial CAP Analysis)	2015	2020 (Current CAP Conversion)
Project First Cost	\$4,741,400	\$16,971,000	\$25,034,000
IDC	\$111,100	\$405,510	\$956,081,
Investment Cost	\$4,862,500	\$17,376,510	\$25,991,081
Average Annual Investment Cost	\$303,100	\$531,960	\$1,018,191,
Annual OMRR&R	\$15,000	\$21,700	\$24,000
Total AAEQ Cost	\$318,100	\$594,583	\$1,042,191
Total AAEQ Cost *	\$318,100	\$553,707	\$704,655
AAEQ Benefits (04 Price Level)	\$1,058,500	\$1,058,500	\$1,058,500
BCR	3.33	1.91	1.50
Net Benefits	\$740,400	\$504,793	\$353,845

* adjusted to price level of benefits, FY04

Environmental

Few changes have occurred to the environmental conditions of the project area since the project was approved in 2004. The Corps' 2015 Detailed Project Report (DPR) Draft Addendum concluded that the Recommended Plan would result in unavoidable impacts to approximately 10 acres of wetlands within the levee right-of-way. The Draft DPR proposed a mitigation plan that would create approximately 13 acres of wetlands. A portion of the plan included excavation in existing wetlands to ensure hydrologic connection; therefore, the total net creation would be approximately 11 – 12 acres of wetlands. The Corps will conduct a functional analysis during the project's PED phase to verify that the functional equivalent is still valid and ensure the appropriate performance measures are in place. Detailed calculations and exact acreages are

not expected to change by more than 50% from the project's initial mitigation plan. The mitigation plan will be finalized during the design phase when the project is reviewed on the Biddability, Constructability, Operability, Environmental and Sustainability (BCOES) characteristics. The current EA concludes that construction may affect, but is not likely to adversely affect, the Puerto Rican Boa. Standard protection measures for the boa will be implemented to protect any boas that may be in the area during construction.

Recommendation

It is recommended that the project presented in the Río Culebrinas Detailed Project Report and Environmental Assessment dated June 2004, approved previously under Section 205 of the 1948 Flood Control Act, as modified in this Continuing Authorities Program (CAP) Conversion Feasibility Report, at an estimated first cost of \$25,034,000, be authorized. The updated CAP Conversion Report concludes that the project as previously planned and modified based on current conditions is economically justified, environmentally acceptable, and feasible from an engineering standpoint.

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 they are transmitted to the Congress as proposals for authorization and implementation funding. However, prior to transmittal to the Congress, the sponsor, the States, interested Federal agencies, and other parties will be advised of any modifications and will be afforded an opportunity to comment further.

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1. STUDY OVERVIEW

The purpose of this report is (1) to reaffirm the economic justification, environmental acceptability and engineering feasibility of the plan previously identified in the Río Culebrinas Detailed Project Report (DPR) and Environmental Assessment (EA) that was approved by the South Atlantic Division Commander in June 2004; and (2) to convert this project from the Continuing Authorities Program (CAP) to a specifically authorized project. This is an expedited review of the previously approved plan without additional plan formulation and is a supplement to the 2004 DPR and EA. After approval of the 2004 Río Culebrinas DPR and EA, the Municipality of Aguadilla (non-Federal sponsor) requested the project be placed on hold for a number of reasons (i.e., bid climate, delay in Federal and sponsor funding, etc.). The pause was concurred with by the U.S. Army Corps of Engineers (USACE). In 2015 a draft addendum to the 2004 DPR EA was prepared to reflect updated costs, benefits, and updates due to updated Corps' models and levee safety standards. The 2004 Recommended Plan required several design modifications. Design changes include the use of concrete (instead of metal) culverts, armoring for the cutoff channel, and revisions to the levee side slopes to meet current Corps levee design guidance criteria. The dimensions of the levees increased from 2.5:1 in the 2004 plan to 3:1 in the 2015 plan. The 2004 project was self-mitigating; however, due to the increases in the width of the levee cross sections and the need for additional lands, the current project was reviewed for its potential environmental impacts with respect to adjacent wetlands. The Corps determined that the revised levee design would affect additional wetlands more than anticipated in 2004 and thus a mitigation plan would be implemented.

In 2015 the project was suspended due to project costs exceeding the CAP funding limits for the federal share, so the 2015 draft addendum was never approved. Due to the impact of Hurricane Maria in 2017 and sponsor request, the project was included in the list of projects to receive funding in the Bipartisan Budget Act (BBA) of 2018 (Public Law 115-123), with plans for it to be converted to a specifically authorized project.

1.1. Study Location, Purpose and Need

The Río Culebrinas originates in the western part of the central mountain range of Puerto Rico, approximately 130 kilometers (km [80.8 miles]) west of the City of San Juan (Figure 1). The Río Culebrinas flows in a westerly direction through the areas of San Sebastian, Moca, Aguadilla, and Aguada where the river discharges into the Aguadilla Bay in the Mona Passage on the northwestern coast of Puerto Rico. Tributaries of the Río Culebrinas include the Caño Madre Vieja, Río Guatemala, Río Caño, Río Sonador, and Quebrada Grande.

The total length of the Río Culebrinas channel is approximately 43.94 km (27.3 miles). The Caño Madre Vieja, a 2.09 km (1.3 miles) long tributary of Río Culebrinas, is an old river outlet that flows across the study area and discharges into the Aguadilla Bay. This small intermittent stream is the political boundary dividing the municipalities of Aguadilla and Aguada.

The Río Culebrinas basin includes the municipalities listed above, as well as the communities of Lares, San Sebastian, and Moca. The basin has a total drainage area of approximately 266.8 km² (103 square miles) to the mouth of the river, and is bordered to the north and east by the Río Guajataca basin; to the south by the Río Culebra and Río Grande de Anasco basins; and to the west by the Aguadilla Bay.

Although flooding can occur at any time during the year in the Río Culebrinas basin, it is most frequent during the period of May through December. The large rainfall-driven peak discharges in the basin are generally associated with hurricanes, tropical depressions and tropical waves passing over or near Puerto Rico. Due to the steep slopes in the upper basin, flash floods from intense thunderstorms are a common event affecting this area and can occur anytime during the year.

During the flood season, floodwaters overtopping the Río Culebrinas and Caño Madre Vieja pose potential dangers to surrounding residents and are a source of frequent flood damage to properties. The area that is principally flooded within the basin includes the mostly confined, relatively flat Río Culebrinas floodplain located between the towns of Aguada, Aguadilla, and Moca. Below Highway 115, the 100-year (0.01-exceedance probability) flood event inundates over 6.07 km² (1,500 acres) of land. The entire community of Espinar in Aguada associated with the Ermita de Espinar, which was founded originally in 1516 and is located in the middle of the floodplain between Río Culebrinas and Caño Madre Vieja, is surrounded by flood water during rain events with a 0.5 exceedance probability (2-yr) and larger. Floodwaters from the Río Culebrinas and Caño Madre Vieja inundate all major highways and roads in the Río Culebrinas floodplain.

The purpose of the authorized 2004 Río Culebrinas Project DPR was to investigate in detail the frequent flooding and related problems caused by overflows from Río Culebrinas into Caño Madre Vieja, in the southwest portions of Aguadilla and the community of Espinar in Aguada. The DPR considered flood risk management alternative measures and whether they could be implemented without causing adverse impacts to the communities, the environment, or the existing infrastructure in the area. The DPR also investigated if the recommended plan was the most appropriate course of action within federal and Puerto Rico guidelines and regulations. Tangible benefits envisioned from implementing the approved plan and authorized project included inundation reduction benefits, redevelopment benefits, and flood insurance cost savings. A summary of the plan formulation conducted in the 2004 DPR can be found in Section 3.1.

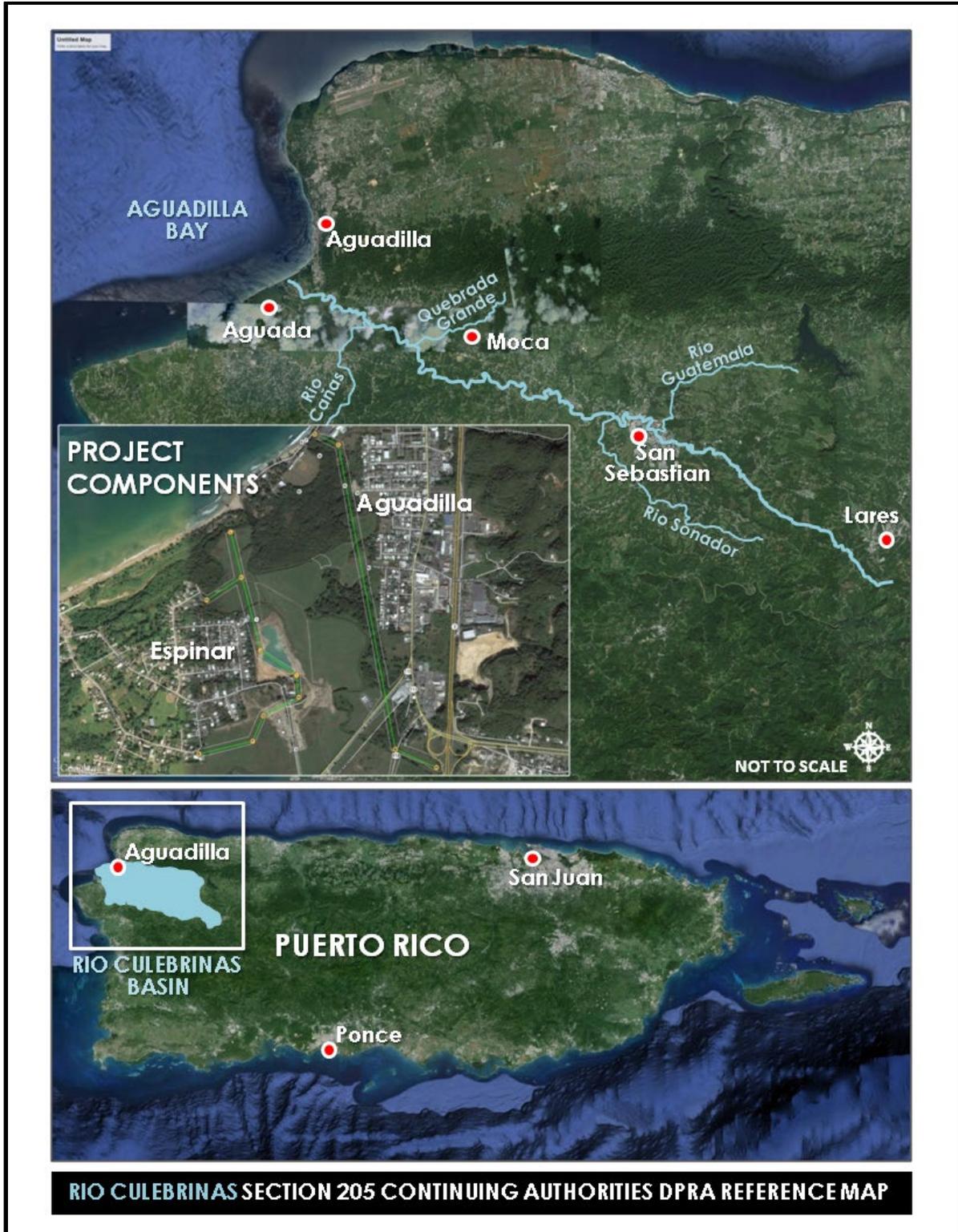


Figure 1: Project Location

1.2. Authorization

The 2004 DPR 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 \$68,750,000 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 \$10,000,000 shall be allotted for a project at any single locality. The provisions of local cooperation 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.

The current study is conducted pursuant to Section 204 of the Flood Control Act of 1970 (Public Law 91-611) which authorizes the Secretary of the Army, acting through the Chief of Engineers, to prepare plans for the development, utilization and conservation of water and related land resources of drainage basins and coastal areas in the Commonwealth of Puerto Rico.

Title IV, Division B of the Bipartisan Budget Act of 2018 (Public Law 115-123) enacted February 9, 2018 (hereinafter "BBA 2018"), authorizes the Government to conduct the study at full Federal expense to the extent that investigations appropriations provided under the BBA 2018 are available and used for such purpose.

The Bipartisan Budget Act of 2018 (Public Law 115-123), Title IV, Division B provides funding authority for this CAP Conversion Feasibility Report Study; Title IV of the Bipartisan Budget Act of 2018 states:

For an additional amount for " Investigations" for necessary expenses related to the completion, or initiation and completion, of flood and storm damage reduction, including shore protection, studies which are currently authorized or which are authorized after the date of enactment of this subdivision, to reduce risk from future floods and hurricanes, at full Federal expense, \$135,000,000, to remain available until expended: Provided, That of such amount, not less than \$75,000,000 is available for such studies in States and insular areas that were impacted by Hurricanes Harvey, Irma, and Maria: Provided further, That funds made available under this heading shall be for high-priority studies of projects in States and insular areas with more than one flood-related major disaster declared pursuant to the Robert T. Stafford Disaster Relief and Emergency Assistance Act (42 U.S.C. 5121 et seq.) in calendar years 2014, 2015, 2016, or 2017: Provided further, That such amount is designated by the Congress as being for an emergency requirement pursuant to section 251 (b)(2)(A)(i) of the Balanced Budget and Emergency Deficit Control Act of 1985: Provided further, That the Assistant Secretary of the Army for Civil Works shall provide a monthly report to the Committees on Appropriations of the House of Representatives and the Senate detailing the allocation and obligation of these

funds, including new studies selected to be initiated using funds provided under this heading, beginning not later than 60 days after the enactment of this subdivision.

The previously approved CAP project is detailed in the 2004 Río Culebrinas Aguadilla-Aguada, Puerto Rico Final Detailed Project Report and Environmental Assessment (2004 DPR/EA). After approval of the 2004 DPR/EA, the Municipality of Aguadilla requested that plans and specifications be placed on hold until local development plans within the project's vicinity were considered by the Municipality. In 2013 the Municipality confirmed that future land uses within the project area would not affect this project and confirmed their commitment to completing the project.

The 2015 Detailed Project Report (DPR) Draft Addendum was developed to update the 2004 DPR/EA and confirm the previous analysis of alternatives and impacts, including:

- An updated cost and benefit analysis;
- Refinements to the 2004 DPR/EA levee design to meet current USACE design/construction standards; and
- An updated Finding of No Significant Impact based on the levee design refinements (refer to the 2015 DPR Draft Addendum Appendices).

On March 16, 2016, Jacksonville District sent a memo to the Commander requesting termination of the project because, based on the analysis of the 2015 DPR Draft Addendum, the project costs would exceed the CAP limit for the federal share.

The sponsor supports the plan to convert the project as previously scoped to be specifically authorized, and this report updates the Corps' prior analysis under the CAP.

1.3. Project Design

The 2004 DPR/EA selected plan was the National Economic Development (NED) Plan and provides flood risk management for the southwestern section of the Municipality of Aguadilla and for the community of Espinar in Aguada against the 100-year (0.01 exceedence probability) flood event. This plan was also the recommended plan within the 2015 DPR Draft Addendum. The economically justified project provides flood risk management for over 3,300 families. Completion of all components of the plan are necessary to achieve full project benefits. These components are described below and major features are depicted in Figure 2.

- Two levees (Aguadilla and Espinar) with a total length of approximately 3.03 km (2.05 miles);
- Interior drainage features consisting of a 1 meter (3.28 feet) deep and 7 meter (22.97 feet) wide drainage channel along the protected side of each levee;
- A two-way drainage structure near the north end of the Espinar Levee; three one-way drainage structures along the Aguadilla Levee;
- A 60-meter (196.85 feet) long cutoff channel for the Caño Madre Vieja to connect two meanders of the stream where the Aguadilla Levee will interrupt it (4 meters [13.12 feet] deep by 43.2 meters [141.73 feet] wide);
- Three paved roadway ramps across the levees;
- A borrow area located in Aguada;
- Net creation of approximately 11 to 12 acres of wetlands for mitigation based on unavoidable impacts to approximately 10 acres of wetlands in the levee right of way (further described in EA, Appendix D and in section 2.3 of this report).

The non-Federal Sponsor will be responsible for OMRR&R.

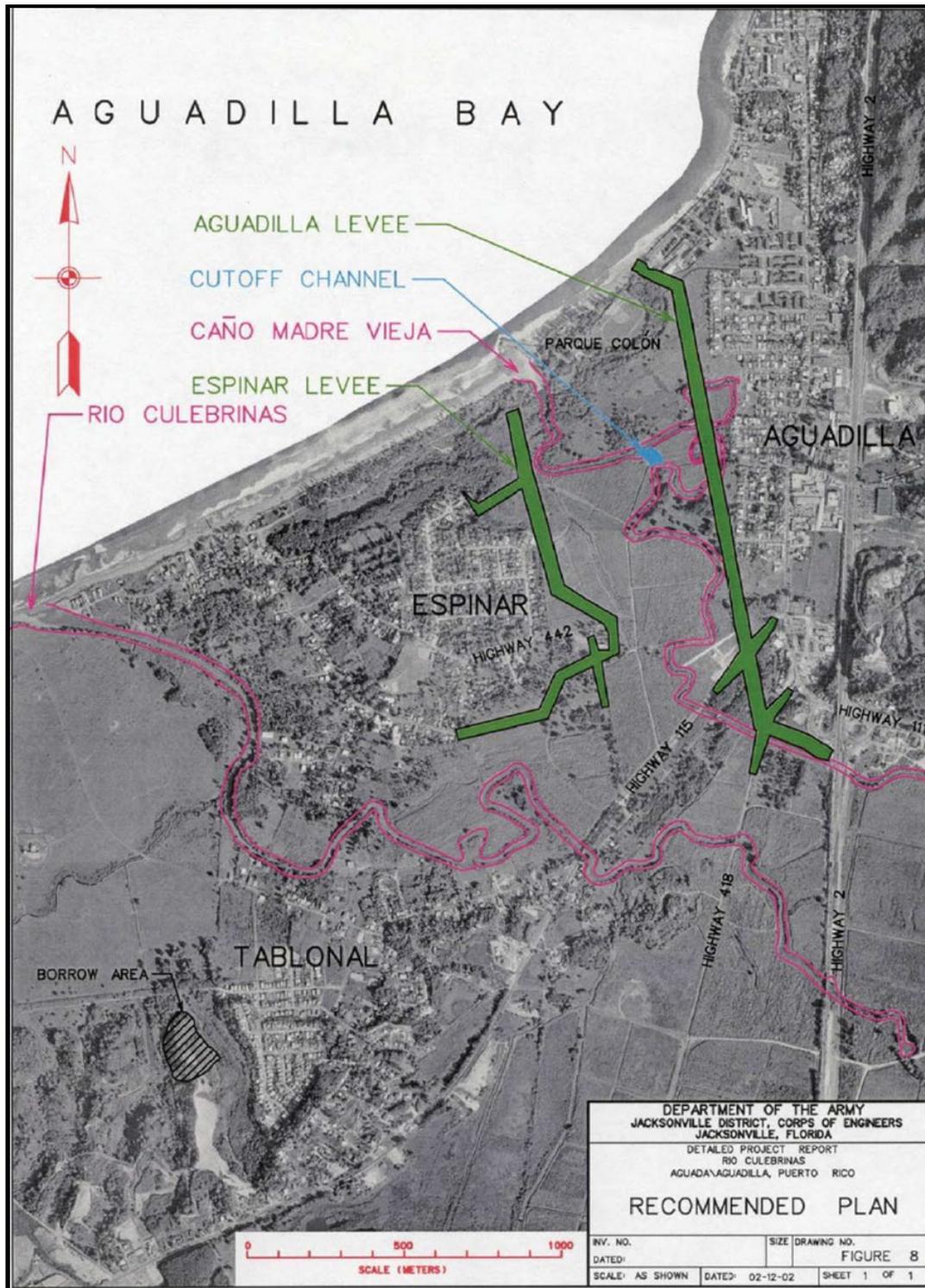


Figure 2: 2004 DPR/EA Approved Features

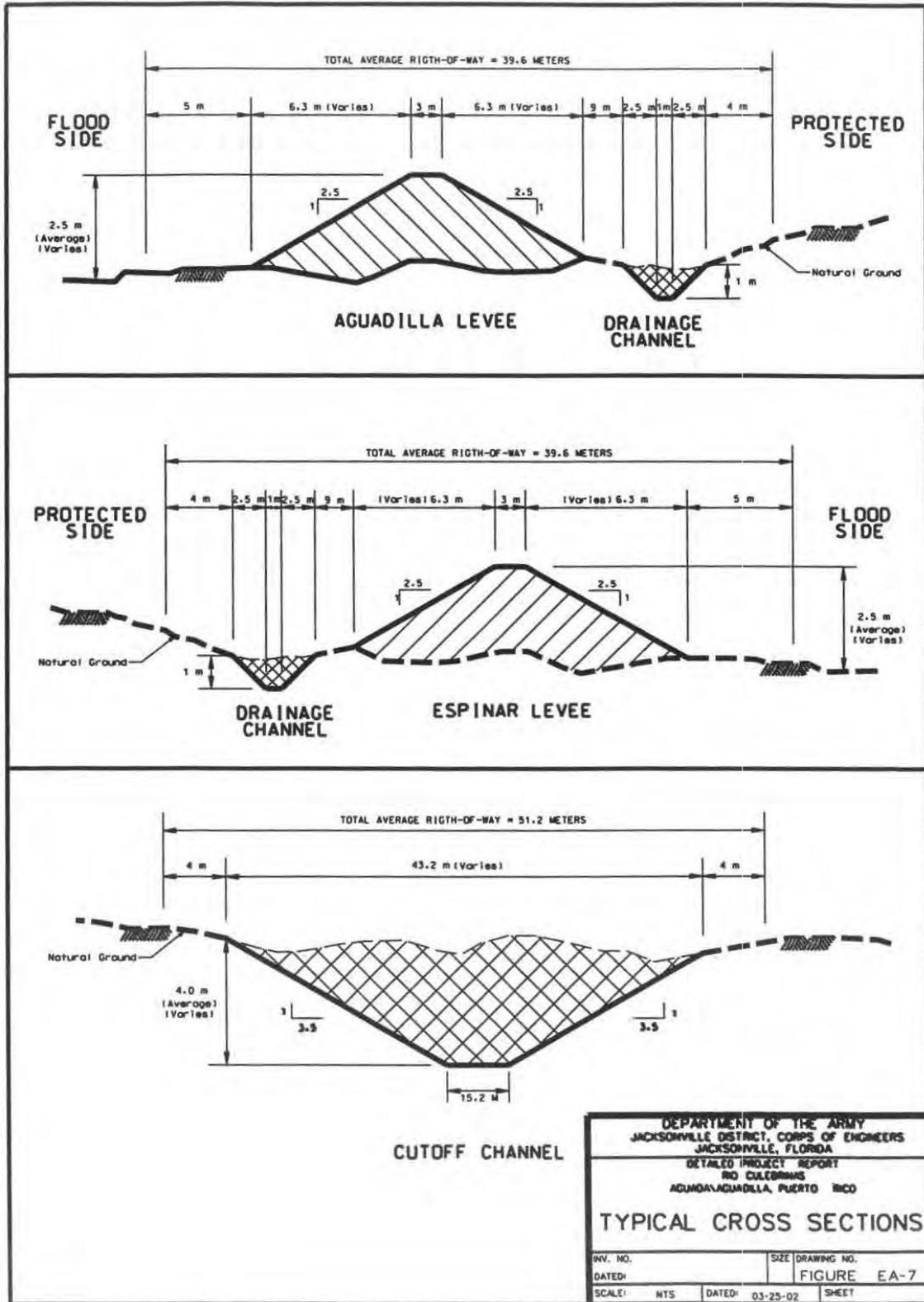


Figure 3: 2004 DPR/EA Approved Features Preliminary Design

The Aguadilla Levee would begin at high ground near Highway 2 and extend towards the north for approximately 1.8 km (1.12 miles) to end at high ground near Yumet Avenue. The Espinar levee would begin at high ground on the southern end of the Espinar Community, extend to the east and then to the north for approximately 1.5 km (0.93 miles), and end at the boundary of CBRS Unit PR-75 (south of the existing mouth of Caño Madre Vieja). Both levees would have an average height of 2.5 meters (8.20 feet), 2.5 to 1 side slopes, and a levee crest of 3 meters (9.84 feet). See Figure 3 for the existing design features.

The interior drainage facilities consist of a 1 meter (3.28 feet) deep and 7 meter (22.97 feet) wide drainage channel along the protected side of each levee. These drainage facilities include the construction of a two-way drainage structure near the north end of the Espinar Levee; three one-way drainage structures along the Aguadilla Levee; and drainage channels to reconnect isolated sections of Caño Madre Vieja, providing 0.04 Km² (8.6 acres) of additional open water.

The construction of the 100-year levees, interior drainage facilities, and cutoff channel would require approximately 84,101 cubic meters (110,000 cubic yards) of fill. Approximately 24,466 cubic meters (32,000 cubic yards) would come from the excavation of the cut-off and interior drainage channels, while the rest of the fill would come from a commercial borrow site at the Tablonal Quarry.

1.4. Construction Status

Construction has not been initiated on this project.

2. OVERVIEW OF CHANGED CONDITIONS FROM CONTINUING AUTHORITIES PROGRAM AUTHORIZATION

Since the completion of the 2004 DPR/EA, there have not been any changes in overall project scope or purpose. There have been, however, changes to the project with respect to costs, benefits, and current engineering practices. The objectives and scope of the project remain the same as when the project was originally proposed as documented in the 2004 DPR/EA.

Public Law 115-123 provides that all repair, rehabilitation, study, design, and construction of USACE projects in Puerto Rico and the United States Virgin Islands (USVI), using the Bipartisan Budget Act of 2018 Investigation funds, shall be conducted at full federal expense. A new Federal Cost Sharing Agreement (FCSA) between the Department of the Army and the Municipality of Aguadilla was executed on September 17, 2018, to address this new funding arrangement.

The authorized project's overall objective is to provide flood risk management components for Aguadilla and the community of Espinar in Aguada. The main flood risk management components resulting from the study include two levee segments designed for a 100-year flood event. There have been no changes to the project location or general configuration due to encroachment or environmental concerns. However, minor engineering design refinements due to changes in design regulations will need to be made during final project engineering design. Design changes will include the use of concrete (instead of metal) culverts, revisions to the levee side slopes to meet current USACE levee design guidance criteria (side slopes of 3 horizontal to 1 vertical), and armoring for the cutoff channel. All other design criteria as described in the 2004 DPR/EA remain the same. OMRR&R will remain the responsibility of the Non-Federal Sponsor.

2.1. Socioeconomic conditions (population, structure inventory, real estate)

The population centers within the study area are Aguadilla, Aguada, and Espinar (which is unincorporated and part of the Aguada municipality). According to 2017 Census estimates, the populations of Aguadilla and Aguada are 53,164 and 38,118*, respectively (*including approximately 1,400 people in Espinar). The 2017 calendar year is the most recent year for which the U.S. Census Bureau has population estimates in Puerto Rico. Development within the study area is primary residential in nature, with nearly 800 residential properties subject to flooding (both single family homes and multi-family residences). There are also approximately 100 commercial properties (including retail stores, restaurants, pharmacies, business/service offices, and gas stations) as well as 24 public properties. Notable properties in the study area include a police department, a U.S. Army reserve station, a senior center, and a historic church (the Ermita de Espinar).

The primary economic activity in Aguadilla is manufacturing, including rubber, textiles, plastics, and other products. Most manufacturing facilities in Aguadilla are located in one of two major industrial parks, the San Antonio Technological Park or the Camaseyes Industrial Park. Other important economic activities in Aguadilla include tourism and service industries, healthcare, retail, and commercial fishing. One of Puerto Rico's most important airports, the Rafael Hernandez Airport, is located near the city. The primary economic activities in Aguada are tourism, agriculture and agricultural processing, light manufacturing, commercial fishing, services, and retail. Both cities have a mixed income socioeconomic profile, with some affluent households but also relatively high unemployment (greater than 10% in both cities).

The socioeconomic conditions have not changed significantly since 2004. Economic growth and population growth have been relatively static over the past 15 years. In fact, as with the overall economy of Puerto Rico itself, the total population and economic output of each city actually decreased slightly between 2000 and 2017 (the last year of available data). This was due in part to the major economic recession experienced by the island that began in 2008.

2.1.1. Population

Aguadilla and Aguada experienced steady population growth from 1980 to 2000. The total combined population of the two municipalities increased from 86,173 in 1980 to 106,811 in 2000, approximately a 19% increase. However the population actually decreased slightly from 2000 to 2010 (see Figure 4), due primarily to emigration to the mainland United States. The combined population declined from 106,811 in 2000 to 102,810 in 2010 (approximately a 4% decrease).

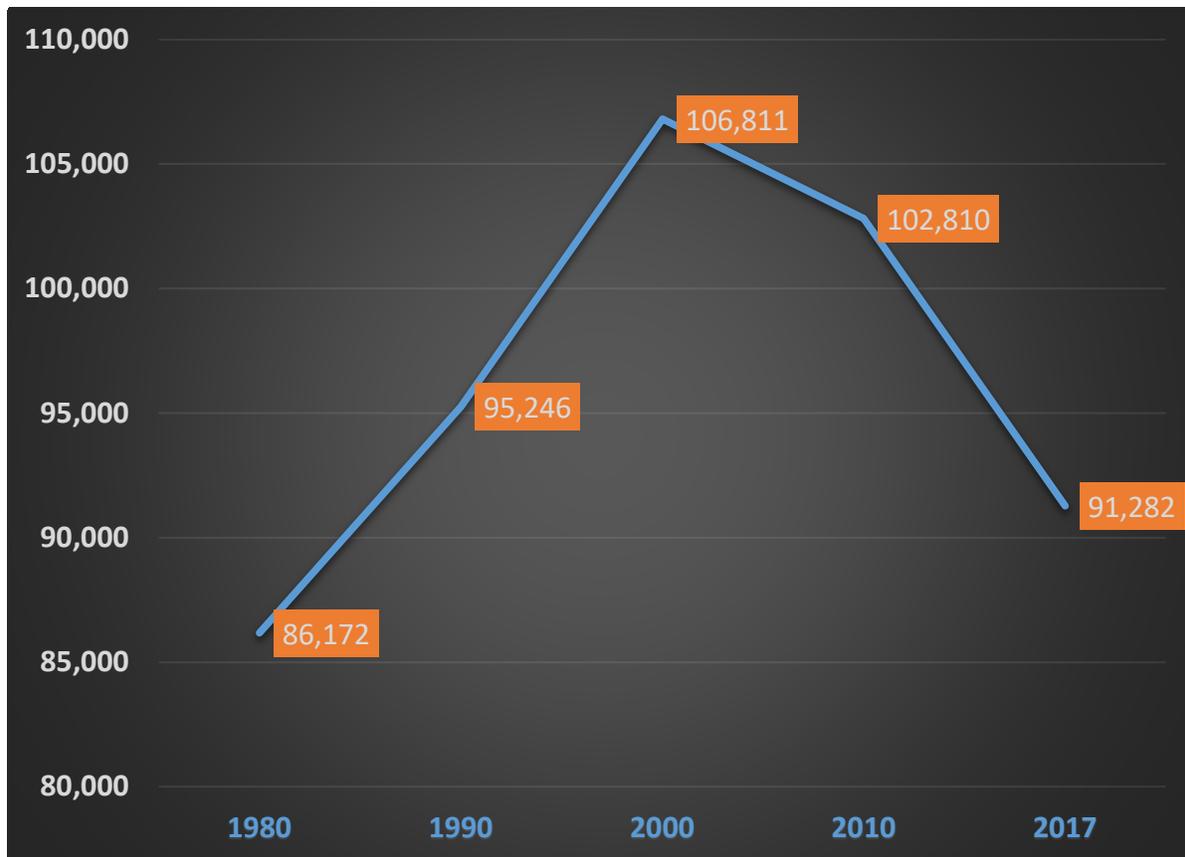


Figure 4: Total Combined population for Aquadilla and Aquada over Time

Since the 2004 Río Culebrinas DPR/EA, the population of the study area has continued to decrease. This is partially due to lingering effects of the economic recession. In the short term, this trend is expected to accelerate due to the damage caused by Hurricane Maria (2018 data are not yet available). During the site investigations for this review, it was estimated that approximately 90% of the residences within the area impacted by the flooding post Hurricane Maria were still occupied or being reoccupied.

2.1.2. Employment

In the 2004 DPR/EA, the total combined unemployment rate for Aguadilla and Aguada was estimated to be 14.7%. The most recent available employment data for this area are provided by the United States Bureau of Labor Statistics (BLS). According to the BLS, the unemployment rate for the Aguadilla-Isabel-San Sebastian metropolitan statistical area (which includes Aguadilla and Aguada) was 15.1% in October 2017, up slightly from 15.0% in May of 2013. Therefore, the overall employment situation has not changed significantly since 2004. This area still has a much higher unemployment rate than the national average (3.5%) and the Puerto Rico average (11.4%).

Also, the employment profile of the study area has not changed significantly since 2004. In the 2004 DPR/EA, the largest sectors of employment were manufacturing, services (including financial services and retail), government activities (including schools and law enforcement),

and trade/transportation related industries (including utilities). These sectors continue to be by far the largest sectors, as defined by number of employed persons.

2.1.3. Infrastructure

The 2004 DPR/EA noted key infrastructure in the study area, including:

- The Aguadilla Wastewater Treatment Facility,
- An Electric Power Transmission facility and eight substations,
- Several major roads and highways, including highway PR-2, 110, and 115, and
- The second largest airport in Puerto Rico, the Rafael Hernandez Airport

All of the noted infrastructure is still located in the study area. No major infrastructure improvements have occurred since 2004.

2.1.4. Tourism

The 2004 DPR/EA noted key tourism and recreational opportunities that are vital to the region's economy. Most importantly, numerous high quality beaches are located in Puerto Rico's northwestern coastal region. These include the Crashboat, Gas Chambers, and Wilderness beaches which all areas are well known for world class surfing opportunities. Also, Desecho Island National Wildlife Refuge is less than 25 miles from Puerto Rico's northwestern coast. This Island is world famous for scuba diving, though only with permission from the U.S. Fish and Wildlife Service.

All of the tourism opportunities noted in the 2004 DPR/EA are still available. Tourism is still a vital contributor to the region's economy.

2.2. Engineering conditions (weather conditions)

The climate in this area is characteristically tropical. The annual temperature in this region varies from a mean low of approximately 21 °C to a mean high of approximately 26°C. The annual precipitation for the region varies from a mean low of 115 to a mean high of 205 centimeters (45 to 81 inches). The annual pattern of rainfall in the basin is such that the wettest period of the year is the hurricane season, which occurs in the latter part of the summer and the early part of fall.

Since the year 1900, there have been at least 38 damaging floods in the Río Culebrinas Basin. The largest flood of record occurred on September 16, 1975. This flood had an estimated recurrence interval of approximately 50-100 years. The discharge associated with this flood was estimated at 1,954 cubic meters per second (cms), or 69,004.9 cubic feet per second (cfs). The stages just downstream of PR Hwy 2 were 7.2 meters (23.6 feet) mean sea level (msl), for about 3.2 meters (10.5 feet) of water depth.

The National Weather Service (NWS) operates a number of rain gauges in Puerto Rico. The NWS Technical Paper No. 42 (TP-42) shows generalized estimates of the Probable Maximum Precipitation (PMP) and rainfall depth-frequency data for Puerto Rico and the US Virgin Islands. Contained in the report are iso-pluvial maps of precipitation contours for selected frequencies. The maps indicate rainfall increases toward the central mountain region of Puerto Rico. Point rainfalls for the Río Culebrinas basin were obtained from TP-42 and are listed in Table A-2 of the 2015 DPR Draft Addendum Appendix B.

The Standard Project Storm (SPS) is defined as the most severe flood-producing rainfall depth-area-duration relationship and the iso-hyetal pattern of any storm that is considered reasonably characteristic of the region. The Standard Project Flood is the runoff and flooding caused by the SPS.

The PMP 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. The SPS was assumed to be 50 percent of the PMP, as per EM 1110-2-1411, Standard Project Flood Determination.

Climate change review requirements for USACE projects changed in 2018. New data has revealed that the average rainfall for the 100 year 24-hour storm has increased from 9.8 inches (Detailed Project Report) to 11.70 inches (Atlas14). These changes along with the new rainfall data table will require reanalysis which will be conducted during Preconstruction Engineering and Design (PED).

2.3. Environmental Conditions and Cultural Resources

2.3.1. Environmental Conditions

Pursuant to the National Environmental Policy Act of 1969, as amended, USACE assessed the effects of the proposed action in the June 2004 Environmental Assessment (EA) for the Río Culebrinas Section 205 Flood Risk Reduction CAP Study at Aguada and Aguadilla in Puerto Rico. The 2019 EA (see Appendix E) updates the 2004 EA analysis and adopts the 2004 EA, by reference, where the information is valid and applicable.

Few changes in the environmental conditions of the project area have occurred since the project authorization in 2004. The Corps' 2015 Detailed Project Report (DPR) Draft Addendum concluded that the Recommended Plan would result in unavoidable impacts to approximately 10 acres of wetlands within the levee right of way. The DPR proposed a conceptual mitigation plan which would create approximately 13 acres of wetlands, which is further discussed in "Mitigation" in Section 3.2. A public and agency review of the draft EA and FONSI were completed on April 20, 2019. All comments submitted during the review period were considered in the final EA and FONSI. Details on the consultations and coordination for potential effects to listed threatened and endangered species as well as the project's compliance with other federal laws and regulations are provided in the 2019 EA.

2.3.2. Cultural Resources

A cultural resources survey of the proposed levee alignment was conducted in 1999. As a result of this survey, two archaeological sites eligible for the National Register of Historic Places (NRHP) (Culebrinas Site 1 and the Iglesia de Espinar archaeological site) were identified within the proposed Espinar Levee footprint. Since the 1999 archaeological investigation, the study area has been heavily disturbed. Aerial photography of the study area shows that the Culebrinas Site 1 and the Iglesia de Espinar archaeological site have been severely impacted by ground disturbing activities. Additional Phase I cultural resources surveys are necessary at these locations to verify the presence of intact deposits at Culebrinas Site 1 and the Iglesia de Espinar archaeological site. USACE has consulted on the Recommended Plan with the Puerto Rico Historic Preservation Officer (SHPO) and the Advisory Council on Historic Preservation pursuant to Section 106 of the National Historic Preservation Act of 1966, as amended. USACE executed a Programmatic Agreement with the Puerto Rico SHPO on May 24, 2019. The

Programmatic Agreement outlines the process in which USACE will consult with the Puerto Rico SHPO to avoid, minimize, and mitigate adverse effects to historic properties.

2.4. Impacts of Hurricane Maria

Hurricane Maria, the worst storm to hit Puerto Rico in 80 years, first made landfall near the southeastern town of Yabucoa and traveled northwest across the island. The powerful Category 4 storm arrived only two weeks after Hurricane Irma passed just north of the island. The storm crossed the island with sustained winds of 155 miles per hour, which resulted in uprooted trees, downed weather stations and cell towers, and ripped wooden and tin roofs off homes. Electricity was cut off to 100 percent of the island leaving approximately 1 million people without power. Access to clean water and food became limited for most of the population.

Heavy rains and flash floods brought on by the storm exacerbated widespread devastation, turning streets into rivers full of debris. In some areas, floodwaters were waist-high, more than 30 inches deep, and often sewage-ridden. The main damages sustained in the project area are from flooding. Large portions of Aguadilla and Aguada were inundated by the overburdened Río Culebrinas and Caño Madre Vieja floodplains. See Figure 5 and Figure 6. However, the areas impacted by post Hurricane Maria flooding appear to be at 90% re-occupancy. The project area's vegetation, mainly grasses and shrubs, appears to have rapidly recovered and is not substantially different than the pre-storm conditions.



Figure 5: Flooding Post Hurricane Maria 2017 in Aguadilla



Figure 6: Caño Madre Vieja Flooding Post Hurricane Maria 2017 (20 September 2017)

3. VALIDATION OF AUTHORIZED/MODIFIED PROJECT

After approval of the 2004 DPR/EA, the Municipality of Aguadilla (the non-Federal sponsor) requested that plans and specifications be placed on hold until additional development plans within the project's vicinity were considered. In 2013 the Municipality confirmed that future land uses within the project area would not affect this project and confirmed their commitment to completing the project.

The 2015 DPR Draft Addendum was to update project information and confirm the previous analysis of alternatives and impacts in the 2004 DPR/EA, including:

- An updated cost and benefit analysis;
- Refinements to the 2004 levee design to meet current USACE design/construction standards;
- Implementation of a mitigation plan to offset wetland impacts; and
- An updated Draft Finding of No Significant Impact (FONSI) for design refinements. (FONSI was not signed).

3.1. Validation of the Initial 2004 DPR Plan Formulation

This section discusses the plan formulation that was conducted in 2004 used to determine the recommended plan. In the 2004 DPR, an analysis of alternatives was performed to address problems with the flooding of Caño Madre Vieja and Rio Culebrinas affecting communities in Aguadilla and Aguada as illustrated in Figure 2. Planning objectives were centered on life

safety, reduction of property losses, protection of the natural flood plain and environmental resources, and opportunities for future economic growth.

The following assumptions and criteria were established for the evaluation of alternatives.

- Each alternative must be complete in itself
- Designs must reduce catastrophic damages should they fail
- Be based on most probable future hydrologic conditions
- Should minimize residual flooding and damages
- A possible pilot channel in Caño Madre Vieja to address cutoff of existing channel by proposed levee
- Earthen levees to address encroachment concerns
- Minimize real estate, while providing sufficient drainage and runoff storage without a pumping station
- Financially, each alternative and its elements must be justified and incrementally justified, respectively
- Different alternatives and similar ones with varying degrees of protection were examined to optimize National Economic Development (NED) benefits
- The study year is 2003, base year 2008, and end of planning period 2058

The future without project (FWOP) was presented as the no action alternative and served as the benchmark for proposed flood-control alternatives. Paramount concerns are impacts to life safety and property. The no action alternative continues to allow periodic disruption of economic growth through the manufacturing and tourism industries in the area where relocation is not possible.

All measures and preliminary screening are summarized in Table 3-1.

Table 3-1: Summary of Nonstructural and Structural Measures considered in 2004 DPR

Measure	Description	Benefit	Limitations	Screening
Nonstructural				
Floodplain management, Puerto Rico Board Regulation 13	Regulatory management of new development in flood plain, FEMA compliant since 1987	Requires new development to be flood compliant	No protection to existing structures	Considered in all alternatives
National Flood Insurance Program (NFIP)	National flood and emergency flood programs.	Does not reduce or prevent flooding, only reimburses after damages incurred	Financial limitations prevent most residents from acquiring flood insurance	Considered in all alternatives
Temporary and permanent flood plain evacuation	Temporary warning system and alternate evacuation locations or permanent relocation of hundreds of concrete structures.	Warning system can save lives	High cost for a temporary warning system and relocation, high costs an lack of acceptability for permanent evacuation	Not considered, impractical, excluded
Channel Maintenance	Stream cleanup of trash, debris, and sediment	Can restore natural capacity of river	Does not solve problems with intermediate and large floods	Considered in all alternatives
Structural				
Flood Proofing	Structural change allowing flooding around individual structures without affecting their interior	Little or no damage to structure	Loss of access and economic activity. Potential danger to public health and safety	Not considered, difficult to implement, excluded
Multipurpose Reservoirs	Reservoir to retain water levels during peak flows for gradual release	Potential water supply and recreational use	No flood reduction in lower flood plain	Does not meet need, excluded
Channel Improvements	Realignment of river channel	Effective flood control for entire lower plain	Added costly structural requirements at ocean outlet such as a jetty. Adverse impacts on riverine invertebrate habitat, and changes of water flows into estuary and swamps.	Too costly, irreversible environmental and cultural impacts. Not considered
Levees and/or Floodwalls	Structure sufficient to preclude flood waters from entering susceptible areas	Most practical, acceptable, and efficient due to physical and natural conditions of study area	Minimal channel realignment, structural acquisition and utility relocation required	Low cost and effective flood protection, considered

All nonstructural measures except evacuation were carried forward for every plan in the 2004 DPR. Four alternative plans were developed including the no action. A summary of the notable differences among the final array of plans for the 2004 DPR is found in Table 3-2.

Table 3-2: Summary of notable differences among 2004 plans (Figures in \$ of 1999)

	Plan 1 50 year	Plan 2 100 year	Plan 3 SPF	No Action
Flood Protection	50 year storm event	100 year storm event	Standard Project Flood	None
Design	1 meter high	2.5 meters high	3 meters high, Espinar levee 3.3 kilometers long and wraps around the community of Espinar	None
Land Use	38 acres	42 acres	80 acres	None
Reduction in Property Losses	77%	87%	100%	None
Residual Flooding (In \$1,000 annual)	\$194.0	\$105.0	\$0	\$831.0
Estimated Total Costs	\$4 Million	\$4.1 Million	\$6.3 Million	\$0
Benefit/Cost Ratio	2.2	2.4	1.8	0

Among all of the plans, including the no-action alternative, two of which provide lower or no flood protection, the selected plan that maximized the net NED benefits was Plan 2, providing 100-year flood protection to the urban areas in southwest Aguadilla and the community of Espinar in Aguada. This plan formulation and plan selection is still valid today based on the finding explained throughout this report. As noted the conditions today are very similar as they were in 2004. Site conditions were verified in 2015 and 2019 and no significant changes have occurred. Although construction costs have increased from the 2004 recommended plan, it is mainly due to the economic conditions and the bidding environment. Due to this, it is assumed that all four plans would have similarly increased in construction cost. Jacksonville District believes that the 2004 plan and recommended plan is still valid.

3.2. Updated Design

The 2015 DPR Draft Addendum, which informs this study, made changes to the proposed Espinar and Aguadilla levees, as well as the Caño Madre Vieja Cutoff Channel, to meet the new design standards. See Figure 7. The changes require an approximate increase in total project acreage from 0.176 square kilometers (43.47 acres) to 0.187 square kilometers (46.17 acres).

3.2.1. Levee Changes

- An additional 2.45 meters (8.45 feet) of right-of-way due to slope requirement changes from 2.5:1 to 3:1 resulting in an average levee right-of-way of 36.05 meters (118.27 feet) instead of 33.6 meters (110.24 feet).
- The additional right-of-way for the levees resulted in an increase in lands required from approximately 0.14 square kilometers (42 acres) to approximately 0.17 square kilometers (44 acres).
- Channel Improvement Easement Changes for the Caño Madre Vieja Cutoff Channel
- An additional 6.0 meters (19.68 feet) of new channel width from approximately 57.2 meters (187.66 feet) instead of 51.2 meters (167.98 feet) as originally designed.

- The additional right-of-way for the Caño Madre Vieja cutoff channel resulted in an increase from approximately 0.005 square kilometers (1.3 acres) to 0.008 square kilometers (2 acres) of land to be acquired.

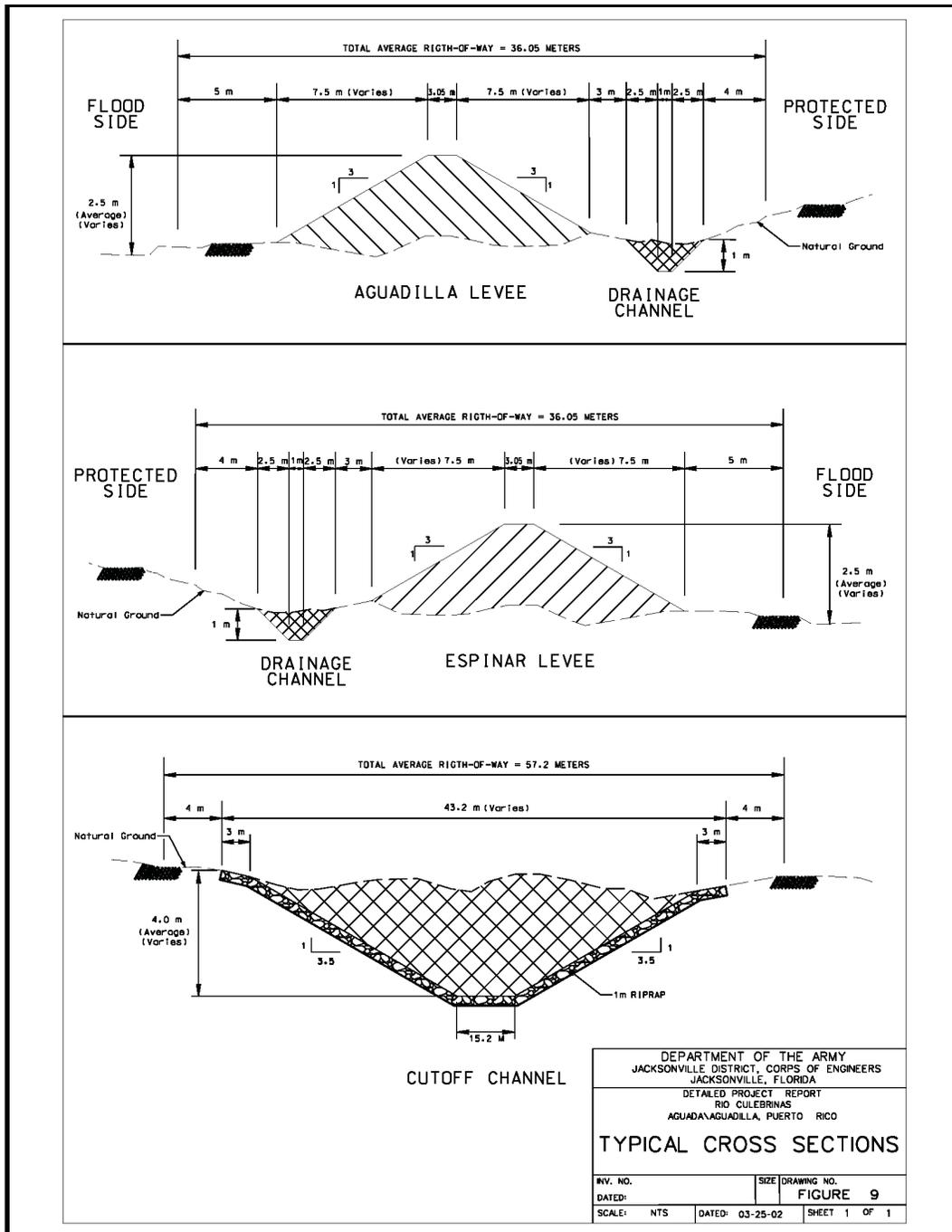


Figure 7: 2015 DPR Draft Addendum Design Changes

In addition, the following mitigation areas have been added to the updated project.

3.2.2. Mitigation

The 2004 DPR/EA did not include a detailed wetland delineation or any compensatory mitigation. The Corps' 2015 DPR Draft Addendum concluded that the Recommended Plan would result in unavoidable impacts to approximately 10 acres of wetlands within the levee right-of-way. See Figure 8. The 2019 EA (Appendix D) includes a proposed mitigation plan. See Figure 9. The 2015 DPR Draft Addendum proposed a conceptual mitigation plan that would create additional wetlands. A portion of the plan included excavation in existing wetlands to ensure hydrologic connection; therefore, the total net creation would be approximately 11 – 12 acres of wetlands. Proposed wetland impact mitigation includes excavation to create:

- Freshwater mitigation area 0.44 square kilometers (10.83 acres); and
- Tidal mitigation area 0.003 square kilometers (0.86 acres).

The Corps will conduct a functional analysis during the project's PED phase to verify that the functional equivalent is still valid and ensure the appropriate performance measures are in place. Detailed calculations and exact acreages are not expected to change by more than 50% from the project's conceptual mitigation plan proposed in the DPR. The mitigation plan will be finalized during the design phase when the project is reviewed on the BCOES characteristics.

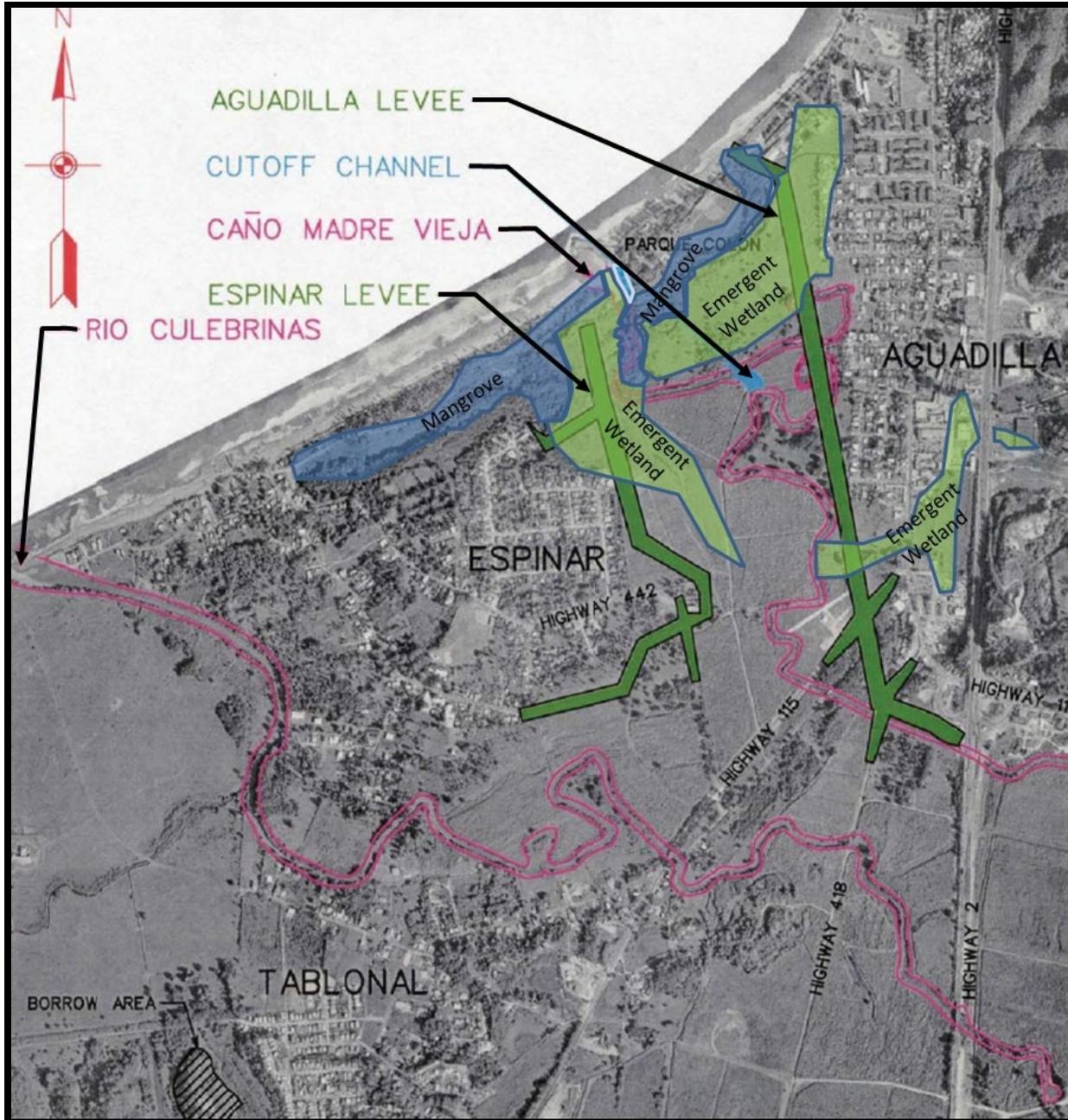


Figure 8: Approximate Location of Existing Mangroves and Emergent Wetlands in the Project Vicinity With Project Overlay from the 2015 DPR Draft Addendum

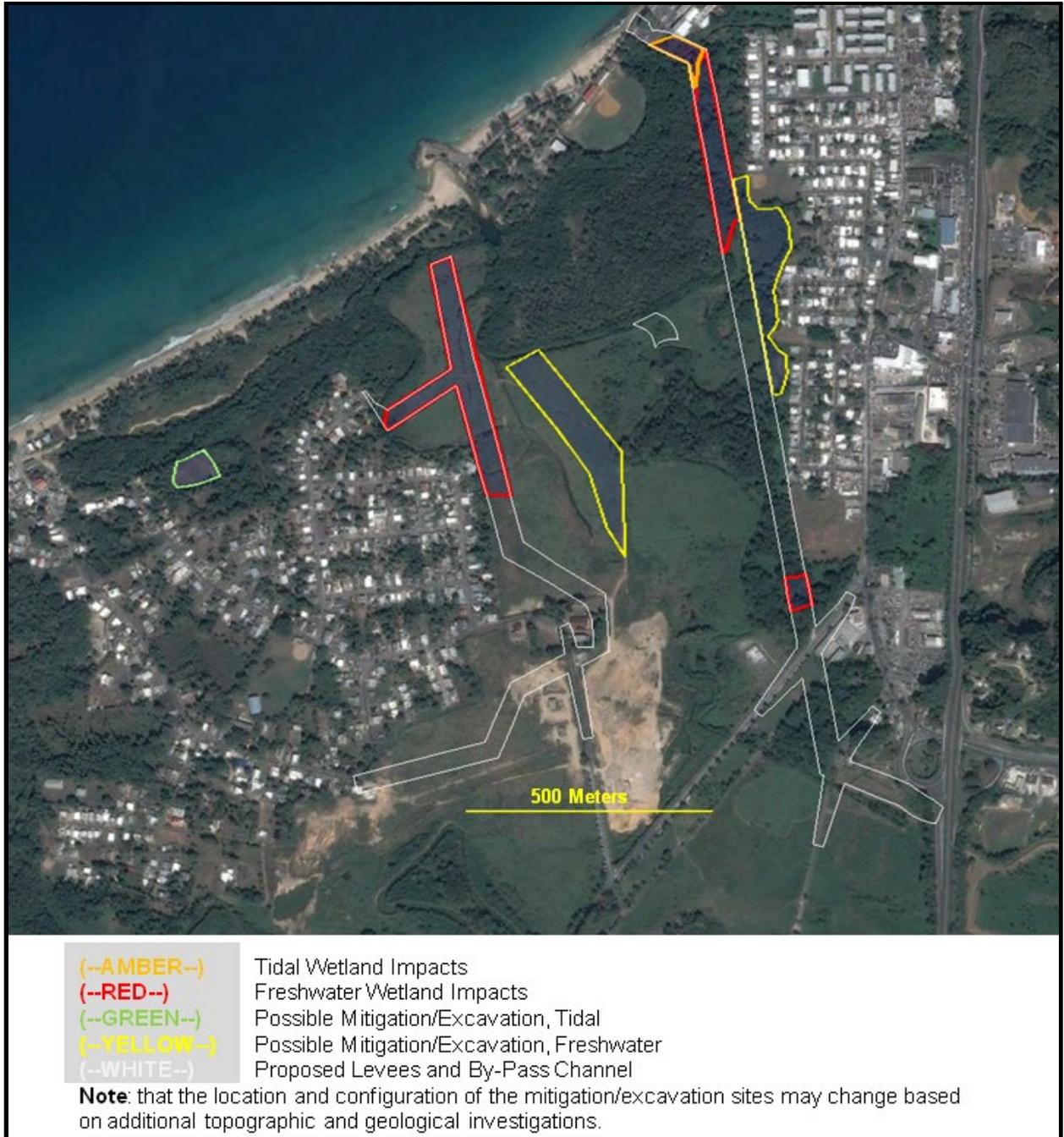


Figure 9: Location of Wetlands Impacted by Proposed 2015 DPR Draft Addendum Project Design Modifications and Proposed Mitigation Sites

All other design criteria as described in the 2004 DPR/EA remain the same in the 2015 DPR Draft Addendum and this Conversion Report.

3.2.3. Hydrology/Hydraulic Analyses

The hydrologic investigations and hydraulic designs were originally completed in the 2004 Rio Culebrinas Final DPR/EA. In 2014, the hydrology and hydraulics analyses were revisited and evaluated for completeness and verification of land use. The evaluation, presented in Appendix A of the 2015 DPR Draft Addendum, concluded that the 2004 assumptions were still valid; that residual flooding and controlled overtopping would result in the same effects to structures and land uses, as presented in the 2004 analyses. Therefore, no changes were made to the 2004 hydrology and hydraulics analyses. The revisited analyses in 2015 were verified as acceptable for task purpose and resulted in confirmation that the benefits of the project are likely similar to what was originally quantified and communicated in the 2004 Report.

The recent re-evaluation completed in 2019 as part of the validation effort, led to the engineering conclusion that the selected plan is still valid because land use and environmental conditions are comparable to what they were in 2004. However, additional requirements of hydrology and hydraulics analyses will be necessary during PED to confirm all design parameters for project features.

3.2.4 Climate Change Assessment

USACE established an overarching USACE Climate Change Adaptation Policy Statement to support climate preparedness and resilience in 2011. In 2014, the policy was updated and the Climate Preparedness and Resilience (CPR) Community of Practice (CoP) was established. CPR policy states that climate change assessments are to be considered for all phases of the project life cycle, for both existing and proposed projects. As a result, in order to determine the risk and resiliency of the project to climate change, the Rio Culebrinas project was evaluated in accordance with USACE climate guidance.

The primary purpose of the Rio Culebrinas project is to provide flood protection, caused by overflows from Rio Culebrinas into Cano Madre Vieja, in the southwest portions of the town of Aguadilla and the community of Espinar in the Municipality of Aguada.

The Rio Culebrinas project was assessed for climate impacts due to sea level change (SLC) and inland hydrology (precipitation). It is important to note that the climate change analysis included within this Validation report is limited in scope and therefore the climate assessment is scaled back based on project purpose and complexity.

Sea Level Change

The climate assessment for sea level change follows the USACE guidance of Engineer Regulation (ER) 1100-2-8162, Incorporating Sea Level Change in Civil Works Programs, and Engineer Technical Letter (ETL) 1100-2-1, Procedures to Evaluate Sea Level Change: Impacts, Responses, and Adaptation. ER 1100-2-8162 and ETL 1100-2-1 provide guidance for incorporating the direct and indirect physical effects of projected future sea level change across the project life cycle in managing, planning, engineering, designing, constructing, operating, and maintaining USACE projects and systems of projects.

All elevations within the 2004 Feasibility Report are referenced to the National Geodetic Vertical Datum (NGVD). Applicability regarding the use of the NGVD29 datum for Puerto Rico has changed since 2004, with Puerto Rico Vertical Datum of 2002 (PRVD02) being identified as the

official vertical datum in the National Spatial Reference System for Puerto Rico in 2012. The 2004 Feasibility Report was based on survey data collected in 1995, referenced to NGVD29. Based on the reported survey control marks reported in the historic Microstation/Inroads DTM files (1995), and the recent (2019) Lidar/Aerial Photo ground control work, the vertical datum difference based on these sources is 0.11 meters +/- 2cm (0.36 feet). Therefore, all report elevations were converted to PRVD02.

The Rio Culebrinas project consists of two levees, Aguadilla and Espinar, each containing an interior drainage channel along the protected side of each levee. The interior drainage is managed through four drainage structures, one drainage structure near the northern end of the Espinar Levee and three drainage structures along the Aguadilla Levee. Each drainage structure consists of multiple 1.52 meter (5 ft.) diameter culverts, each at a proposed invert elevation of -0.41 m (- 1.35 ft.) PRVD02 . Runoff from the protected side of the levees would collect in land areas designated for flood retention, and discharge to the flood plain through culverts. The culverts at the drainage structures would be fitted with flap gate controls that would prohibit flow from the flood plain into the protected area. This prevents backflow through the inlet structure when stages in the floodway are higher than stages upstream of the levee. However, discharge to the floodway is terminated and all flow entering the area behind the levee is effectively trapped until the gates open. The trapped floodwater is called residual flooding and is a direct function of that volume of the trapped water. This flooding for the with-project condition has been identified as “residual” flooding areas within the 2004 Feasibility Report. The interior drainage capability and upstream residual flooding has the potential to be impacted by multiple factors including but not limited to, changes to inland hydrology, designated land availability for flood retention, and climate change.

Changes in the residual flooded area (as shown in the 2004 Report) will have a direct effect on the predicted residual flood stages, and surface area of the residual flooded area if the originally predicted land area designated for flood retention is not applicable at the time of future Pre-Construction Engineering and Design (PED) activities. Additionally, minor modifications to the hydraulic design of these interior drainage structures may be necessary as updated hydrologic and hydraulic modeling is performed using NOAA-Atlas 14 rainfall depths with appropriate rainfall temporal distribution instructions. Finally, climate change could impact interior drainage capability if sea level rise or future increases in precipitation and streamflow were to occur. Currently, the project has been designed using a tidal boundary condition of 0.49 m (1.61 feet) PRVD02. During PED, the three aforementioned conditions will be analyzed to determine if refinements to the 2004 Feasibility level design are necessary. Design refinements include but are not limited to: design of culvert barrels at a higher invert elevation, additional barrels added to proposed layout to improve discharge capabilities, larger outlet structure capacity, construction of a pump station to augment the design outlet structures, and/or excavation within the remaining residual flooded area to contain the design volume of floodwater at the design stage for the original residual flooded area.

Since levees are the main project feature identified to resolve flooding concerns, their performance thresholds are identified as critical. The Aguadilla Levee would begin at high ground near Highway 2 and extend towards the north for approximately 1.8 km (1.12 miles) to end at high ground near Yumet Avenue. The Espinar levee would begin at high ground on the southern end of the Espinar Community, extend to the east and then to the north for approximately 1.5 km (0.93 miles), and end at the boundary of CBRS Unit PR-75 (south of the

existing mouth of Caño Madre Vieja). Both levees were designed with varying superiority above the modeled water surface elevation throughout the levee reach. The modeling for the Feasibility Study assumed a downstream tidal boundary of 0.49 m PRVD02 (1.61 feet). Since no updated hydraulic and hydrologic modeling has been completed since the feasibility report, a relationship between the tidal boundary and upstream water surface elevation has been assumed to be 1:1 for this analysis. Each levee was designed with an overtopping section, located at the downstream most levee station, where the levee contained a minimal superiority design of .33 m (1.08 ft.). Therefore, if the tidal boundary were to increase by 0.33 m (1.08 ft.), the resulting upstream water surface elevation may be close to overtopping the designed levee crest elevation. Since this portion of the levee was designed for overtopping, the non-overtopping section was also analyzed as a critical threshold elevation. Within this reach, a tidal boundary increase of 0.58 m (1.9 feet) may cause upstream water surface elevations to overtop upstream levee sections, not designed for overtopping. Therefore, the two sea level rise scenarios identified as critical for the levees are 0.82 m (2.7 ft.) PRVD02 and 1.07 m (3.51 ft.) PRVD02.

To assess the vulnerability of the Rio Culebrinas project to future SLC, the web-based USACE Sea Level Change Curve (SLC) Calculator was used at NOAA tidal gauge 9759110, Magueyes Island, PR for the following three SLC scenarios:

- Baseline (or “low”) estimate, which is based on historic sea level rise and represents the minimum expected sea level change.
- Intermediate estimate.
- High estimate, representing the maximum expected sea level change.

The NOAA tide gauge is located approximately 30 miles south-southeast of the Rio Culebrinas project area. Note that the tidal datum relationship established by NOAA is based at the center of the tidal epoch in 1992 and mean sea level (MSL) is 0.05 ft. above PRVD02 in NOAA publications, as shown in Figure 10. It is important to note that within the Sea Level Change Curve Calculator tool, the datum values relative to Local Mean Sea Level (LMSL) are the same as to MSL, as illustrated in Figure 11. Therefore the Local MSL reported along the y-axis in the RSLC graphic is being used interchangeably as MSL, which is 0.05 ft. above PRVD02. Therefore, all critical threshold elevations were converted to MSL for plotting within the Sea Level Change Calculator.

Figure 12 shows the estimated Relative Sea Level Change (RSLC) Low, Intermediate and High projection curves from the USACE Sea-Level Change Curve Calculators for the 100-year project lifecycle (est. start date of 2023). The critical elevation lines shown in Figure 12 are at 2.75 ft. and 3.55 ft. MSL, corresponding to the critical elevations for potential levee overtopping.

NOTICE: All data values are relative to the MSL.

Elevations on Mean Sea Level

Station: 9759110, Magueyes Island, PR
 Status: Accepted (Sep 8 2017)
 Units: Feet
 Control Station:
 T.M.: 0
 Epoch: 1983-2001
 Datum: MSL

Datum	Value	Description
MHHW	0.33	Mean Higher-High Water
MHW	0.33	Mean High Water
MTL	0.00	Mean Tide Level
MSL	0.00	Mean Sea Level
DTL	0.00	Mean Diurnal Tide Level
MLW	-0.32	Mean Low Water
MLLW	-0.33	Mean Lower-Low Water
PRVD02	-0.05	Puerto Rico Vertical Datum of 2002
STND	-3.91	Station Datum
GT	0.67	Great Diurnal Range
MN	0.65	Mean Range of Tide
DHQ	0.01	Mean Diurnal High Water Inequality
DLQ	0.01	Mean Diurnal Low Water Inequality

Figure 10. Gauge 9759110, Magueyes Island, PR Tidal Datum

Version of Data : 05/17/2017
 ID: 9759110
 Reference Datum: LMSL
 Name: Magueyes Island, PR
 HAT: 0.75 (ft)
 MHHW: 0.34 (ft)
 MHW: 0.33 (ft)
 MSL: 0.00 (ft)
 MLW: -0.32 (ft)
 MLLW: -0.33 (ft)
 PRVD02: NaN (ft)
 EWL Type: NOAA GEV (LMSL)
 *100 Yr: 2.13 (ft)
 50 Yr: 1.81 (ft)
 20 Yr: 1.47 (ft)
 10 Yr: 1.26 (ft)
 5 Yr: 1.09 (ft)
 2 Yr: 0.89 (ft)
 Yearly: 0.67 (ft)
 Monthly: NaN (ft)
 From: 1955
 To: 2007
 Years of Record: 52

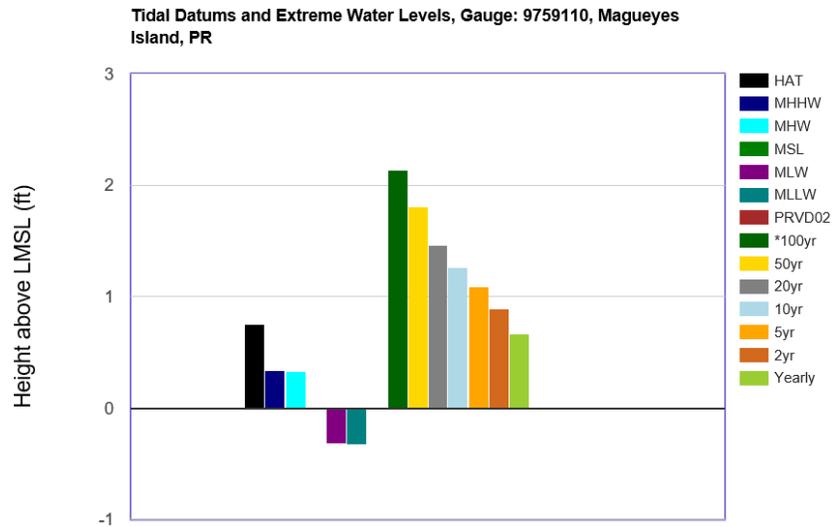


Figure 11. Gauge 9759110, Magueyes Island, PR Tidal Datum relative to LMSL

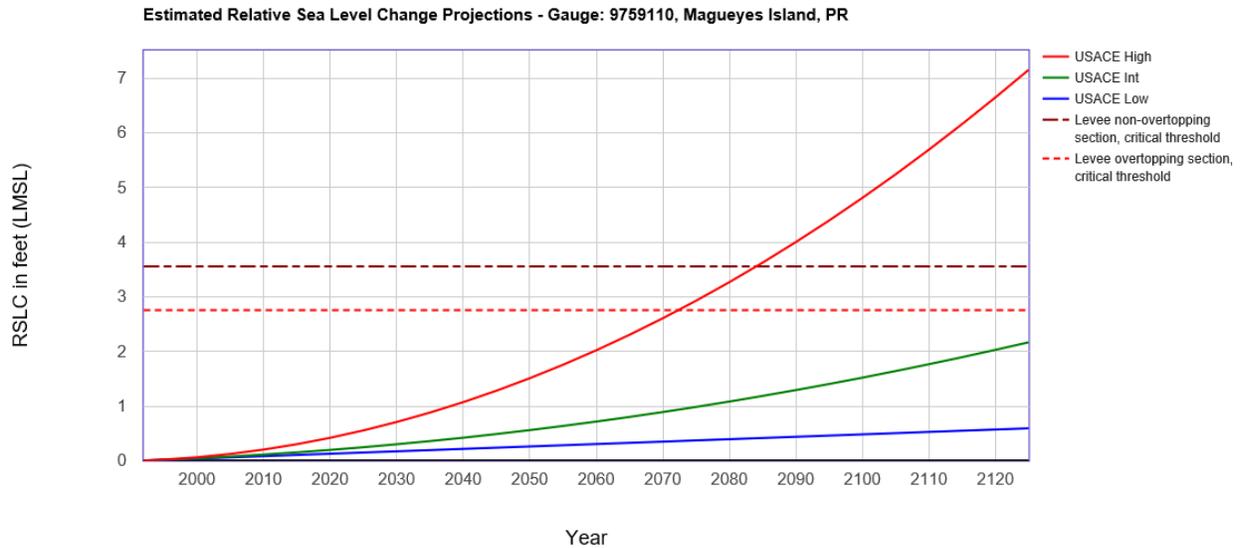


Figure 12. Sea Level Projects vs. Critical Threshold Elevations for Gauge 9759110, Magueyes Island, PR

This analysis of the projected Sea Level Change curves show that the levee may begin to experience increased tidal influence (from mean sea levels) in 2072 if the High curve was to occur and well beyond 2125 if the Intermediate curve occurs. Additionally, the Sea Level Change Curve Calculator tool was utilized to determine when the sea level change and other components of the total water level could potentially reach the critical elevation. Per the 2004 Report, historically, the study area has never been extensively flooded by hurricane or storm tides because of its location relative to the direction of winds and historical storm tracks. However, various combinations of water levels and sea level curves were plotted in Figure 13 through Figure 15 to gain a better understanding of the potential impact to the project. The 10% extreme water level (EWL) and the high sea level curve may impact the project features beginning in 2050. The intermediate + 10% EWL would potentially see impacts to the project features just prior to 2100. No impacts to the project features would be experienced due to the 10% EWL and the low curve. Similarly with the tides, MHHW and the high curve will not impact the project until 2065. No impacts to the project would be experienced due to MHHW and the intermediate and low curve.

The projected sea level elevations under the high curve scenario indicate that the project may be vulnerable to sea level change and the project may not function as intended over time, therefore during PED additional analysis by the project team will assess the resiliency and potential adaptation measures needed for the project. These measures may include potential modifications to levee heights or additional resiliency within the overtopping section previously designed.

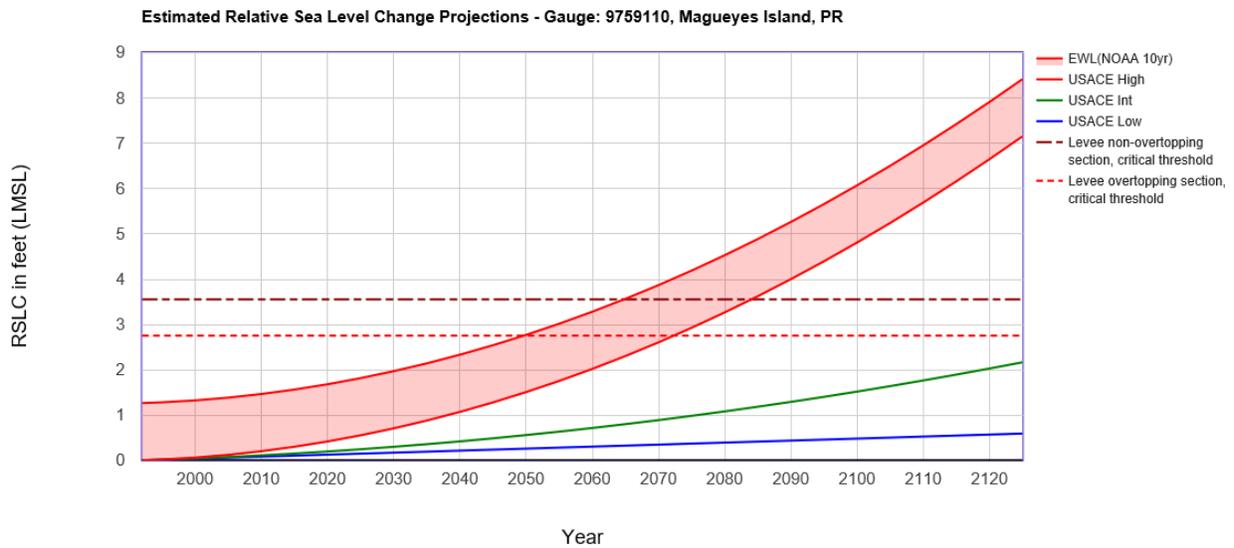


Figure 13. 10-year EWL with High Sea Level Curve Versus Critical Threshold for Gauge 9751639

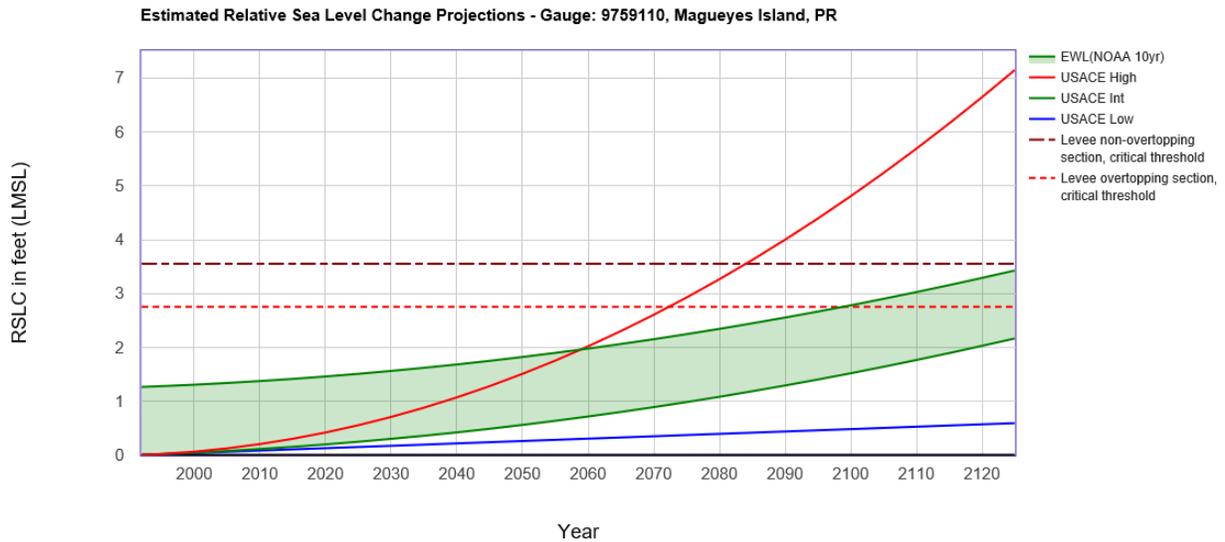


Figure 14. 10-year EWL with Intermediate Sea Level Curve Versus Critical Threshold for Gauge 9751639

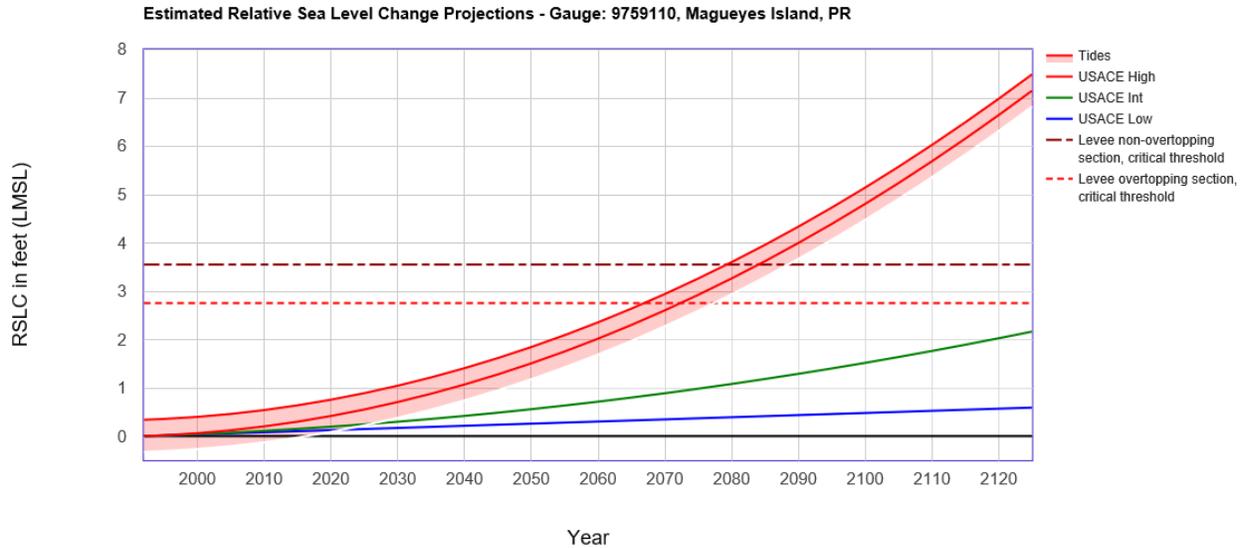


Figure 15. Tidal Signal with High Sea Level Curve Versus Critical Threshold for Gauge 9751639

Inland Hydrology

The climate assessment for inland hydrology follows the USACE guidance of Engineering and Construction Bulletin (ECB) 2018-14, Guidance for Incorporating Climate Change Impacts to Inland Hydrology in Civil Works Studies, Designs, and Projects. ECB 2018-14 provides guidance for incorporating climate change information in the hydrologic analyses in accordance with the USACE climate preparedness and resilience policy and ER 1105-2-101, Risk Assessment for Flood Risk Management Studies.

The vulnerability and risk to this project associated with inland hydrology climate change was assessed qualitatively as outlined in ECB 2018-14. The vulnerability assessment includes a literature review and an application of climate tools to evaluate observed and projected climate trends.

A synthesis of USACE peer reviewed climate literature (US Climate Change and Hydrology Literature Applicable to US Army Corps of Engineers Missions – Caribbean Region 21) is available for the Caribbean Region and is the primary source of information in this literature review. The literature review shows that observed precipitation trends are unclear in the Caribbean Region and that there is little evidence that indicates change in observed average stream flow. The literature review also shows that there is reasonable consensus that the intensity and frequency of extreme storm events will increase in the future for the Caribbean Region. There is, however, no clear consensus that projected stream flow will change in the future.

A full evaluation of observed and projected climate trends was not performed because the Climate Hydrology Assessment Tool (CHAT) is not currently available to use for projects in Puerto Rico. In lieu of using the CHAT tool, the Nonstationary Detection Tool (NSD) was used to assess the stationarity of annual peak stream flow in Puerto Rico. There were not any nonstationarities detected, as no events met the criteria for consensus, robustness, and magnitude and were not considered statistically significant. It should be noted that stream flow

gauges in Puerto are often unreliable because gauges are either located downstream of the regulated dams, located in the floodplain or are not maintained and therefore do not accurately record observed flows in the river channel. This uncertainty in stream flow data makes it challenging to assess historic trends in Puerto Rico.

Risk Assessment

Based on the inland hydrology vulnerability assessment (literature review results indicate a potential for increases in extreme precipitation) and the potential adverse impacts due to future SLC, it would be beneficial for the project to account for risk due to climate change by developing a strategy for adaptive management of the project, shown in Figure 3.

Adaptive management could be used as a means of ensuring that the project is resilient to the impact of climate change for the duration of the project life cycle. This includes that the design of the project can easily be adapted to handle extreme wet and dry conditions, including floods, droughts, and impacts from SLC. This will ensure that the plan selected is robust enough to accommodate changing climatic conditions.

If sea level rise trends increase significantly, or if an increase in the frequency of extreme storm events increases the project design event, then future resiliency and adaptation measures to the area served by the project could include:

- a) Potential modifications to levee heights or additional resiliency within the overtopping section previously designed.
- b) Potential modification to culvert design to include additional barrels being added to layout to improve discharge capabilities,
- c) Construction of a pump station to augment the design outlet structures
- d) Excavation within the remaining residual flooded area (increase interior drainage channel) to contain the any increase in the volume of floodwater at the design stage for the original residual flooded area

Table 3-3. Climate Risk Register for Rio Culebrinas Project

Feature or Measure	Trigger	Hazard	Harm	Qualitative Likelihood
Levees	Increased Sea Level	Future sea-level elevation may be larger than present.	Flood waters may remain on the levee for longer durations, and more frequently, potentially damaging or overtopping levee	Somewhat Likely
Culverts	Increased extreme precipitation	Future flood volumes may be larger than present in protected area.	Stages may increase therefore increasing the residual flooding within the interior drainage area.	Somewhat Likely
Culverts	Increased Sea Level	Future sea-level elevation may be larger than present.	Increased SLR may cause culvert discharge to terminate due to a rise in tailwater conditions, therefore causing an increase in residual flooding.	Somewhat Likely

3.3. Economic Update (Level 1 update)

In accordance with the relevant guidance document, CWPM 12-001, a Level 1 Economic Update requires a qualitative assessment of existing conditions and key benefit assumptions. The objective of this assessment is to confirm the continued existence of the structures that the Federal project was designed to protect, and to confirm that the assumptions made in the original study continue to be realistic.

3.3.1. Scope of Project

The scope of the project has not changed since the last approved report (2004 DPR/EA). No major changes have occurred. The project area remains the same. The purpose of the project remains the same. The project will be implemented as designed in the 2004 DPR/EA and the 2015 DPR Draft Addendum, with some design refinements. These refinements (described in Updated Design Section) do not affect project benefits, and are reflected in the updated project cost estimate either directly in the estimate itself or (for small scale items with significant uncertainty) in the contingency of the cost estimate. Therefore, this economic update is consistent with the refined design.

3.3.2. Economic Benefit Assumptions

The primary project benefits were derived through reduction of flood damage to structures in the study area, including residential, commercial, and public structures. Incidental additional benefits of the project include employment benefits and flood insurance overhead reduction benefits. The purpose of this section is to demonstrate that the benefit assumptions made in the 2004 DPR/EA are still valid.

3.3.2.1. Inventory of Property Subject to Flooding

In the 2004 DPR/EA, property subject to flooding was grouped into six land use categories: residential, commercial, public, non-profit organization facilities, utilities, and road (highways and streets). The residential structures primarily consisted of small single-family houses built of reinforced concrete. More than 90% of residential structures in the floodplain are subject to damage by the 100 year rainfall induced flood. This continues to be the case. The study also identified 95 commercial structures subject to flooding, including service offices, retail outlets, eating/drinking establishments, auto dealers, hardware stores, and one warehouse. The study identified 24 public structures (owned by the Commonwealth of Puerto Rico), seven non-profit structures (churches, private schools, etc.), and utilities in the form of 18 electric substations. These structures were all located in or near Aguadilla. For modeling purposes, the study area was divided into three damage reaches, summarized in Table 3-4.

Table 3-4: Río Culebrinas Economic Reaches

Reach	Description of Reach
1	Espinar Ward of Aguada; primarily low income residential community
2	Residential Public Housing development in Aguadilla
3	Southern portion of Aguadilla; mix of residential, commercial, public, and utility structures

In all three of these reaches, the inventory of property subject to flooding has not changed significantly since 2004. The reaches have experienced neither significant growth and development, nor condemnation or major changes in land use. Aerial imagery of the three Reaches demonstrates that the number and distribution of structures are generally the same.



Figure 16: Aerial imagery of Reach 1 in 2004 and 2018



Figure 17: Aerial imagery of Reach 2 in 2004 and 2018



Figure 18: Aerial imagery of Reach 3 in 2004 and 2018

Because no major changes have occurred in the study area, it is reasonable to assume that the inventory of property subject to flooding is comparable to the 2004 assessment.

3.3.2.2. *Inundation Reduction Benefits*

In addition to the inventory of property subject to flooding, the inundation reduction benefits in 2004 DPR/EA depend on a number of key assumptions. The first is the relationship between structure values and content values. Content values in the 2004 study were based on comparative analyses of similar flood risk management studies in Puerto Rico. According to page E-4 in the 2004 Economic Appendix, “Experience in other studies has shown that content values do not vary significantly in Puerto Rico for similar types of developments and socioeconomic conditions”. There is no evidence to suggest that the content values would have changed over time in this area. Therefore, the content-to-structure value ratios developed in 2004 are assumed to be reasonable.

Another critical set of assumptions concern the relationship between flood depth and damage. According to page E-12 in the 2004 Economics Appendix,

Depth-damage relationships for the residential, commercial, and public land uses developed for the Rio Puerto Nuevo Survey Report (Jacksonville District, 1984) were

utilized to estimate flood damages for existing development. These damage curves were developed using historical data on flood damages throughout the island.

Based on existing Puerto Rico data, a different depth-damage curve was developed for each type of property: residential, public, and non-profit. Seven different depth-damage curves were developed for commercial properties because commercial construction types vary considerably in the floodplain. Each category of commercial property has its own unique characteristics. Thus each category had its own estimated content-to-structure value ratio and its own depth-damage relationship. The different commercial categories are summarized in Table 3-5. More information (including graphical displays of each different curve) is provided in the Economics Appendix of the 2004 DPR/EA and the 2015 DPR Draft Addendum.

Table 3-5: Categories of Commercial Structures

Category	Description
1	General services and retail
2	Professional and Personal Services
3	Eating and Drinking establishments
4	Auto Dealers
5	Hardware stores and building materials
6	Financial institutions and real estate offices
7	Warehouses

*Note: Only commercial categories relevant to the Río Culebrinas study area are presented here.

Though the original Río Culebrinas study was completed in 2004, these curves still represent the best available information about the relationship between depth and damage in Puerto Rico. Construction methods and ground conditions are somewhat different in Puerto Rico than in mainland United States. These curves are site specific and are more appropriate than generic depth-damage curves developed by IWR (which might be used in a study in the mainland United States).

3.3.2.3. *Employment Benefits*

For some USACE construction projects, the employment of underutilized labor resources is a valid category of NED benefits. The basis for considering this benefit is contained in ER 1105-2-100, Planning Guidance Notebook, dated April 2000:

Benefits from use of otherwise unemployed or underemployed labor resources may be recognized as a project benefit if the area has substantial and persistent unemployment at the time the plan is submitted for authorization and for appropriations to begin construction. Substantial and persistent unemployment exists in an area when: The current rate of unemployment, as determined by the appropriate annual statistics for the most recent 12 consecutive months, is 6 percent or more and has averaged at least 6 percent for the qualifying time periods. The annual average rate of unemployment has been at least: (a) 50 percent above the national average for three of the preceding four calendar years, or (b) 75 percent above the national average for two of the preceding three calendar years, or (c) 100 percent above the national average for one of the preceding two calendar years.

In the 2004 DPR/EA, the 2002 national average unemployment rate was reported at 5.8%, while the 2002 average unemployment rate for Puerto Rico was reportedly 12.3%. In other words, the unemployment rate for Puerto Rico was more than 100% above the national average for at least one of the preceding two calendar years. Therefore, use of underemployed labor resources was a valid NED benefit category.

As of 2014, this criterion is still met. The most recent available unemployment data from the BLS (February 2015) shows that the national average unemployment rate is 5.5%, while the average for Puerto Rico is 13.6%. In other words, the current unemployment rate for Puerto Rico is more than 100% above the national average. The 2004 report described unemployment as “as one of the main socioeconomic problems in Puerto Rico.” This clearly continues to be the case. Therefore, use of underemployed labor resources is a valid NED benefit category.

3.3.3. Reduction in Flood Insurance Overhead

ER 1105-2-100, Planning Guidance Notebook, also defines the reduction in flood insurance overhead costs as a valid category of NED benefits. Specifically, when occupants of the previously floodable land are no longer required to purchase flood insurance for projects providing 100 year or higher level of protection, it is appropriate to claim as a benefit the expense of servicing these policies and a pro-rata share of FEMA’s administrative costs. In other words, in the with project condition, it will be much less costly to administer FEMA’s flood insurance program than it would have been in the without project condition. This is a valid source of NED benefits.

The 2004 DPR/EA calculated flood insurance benefits using annual administration costs provided in Economic Guidance Memorandum 03-03. The costs were estimated to be \$133 per policy (in 2003 dollars). Given that the BCR is being updated by deflating current costs to the price level of the approved benefits, the \$133 per policy figure is still appropriate for benefit calculations.

When completing a Level 1 Economic Analysis it is assumed that the previously computed benefits are still valid. New project cost estimates are deflated to the price level of the benefits, and a new Benefit to Cost Ratio (BCR) is calculated. For the Level 1 Economic Analysis no new modeling or plan formulation is required and the BCR of the project is updated based on the best available cost information.

3.4. Cost Update

Development of the project’s current cost estimate is in accordance with the current USACE guidance. These costs are depicted in Table 3-6. The total cost estimate in FY20 dollars (including all contingencies) is \$25,034,000. The major construction features in this cost estimate include, relocations of utilities and three road ramps, demolition of an existing road and culvert, construction of a cutoff channel in the flood plain to connect portions of the existing river system, construction of two levees in the Rio Culebrinas floodplain to provide 100-year flood protection, and construction of several drainage culverts structures to be placed through the levees and road ramps to provide interior drainage. Also included are costs associated with mitigation of approximately 11.69 acres and wetland excavation of approximately 100 cubic yards.

The estimate was developed using the information available in the feasibility report prepared in 2004. This estimate assumed no change to the current scope of work. Features in this estimate

were updated based on the new Corps guidance (See Section 4). Slopes on the levees were adjusted to 3H: 1V and the corrugated metal pipe culvert was changed to reinforced concrete. The cost estimate assumes site access from existing town streets, state highways and agricultural roads in the vicinity of the project which would provide adequate access for construction, future maintenance, and to the borrow and disposal areas. No detour road would be necessary for the construction of Highway 442 ramps. Highway 418 could be utilized as a detour road while constructing the Highway 115 ramps and vice versa. The borrow area is located approximately 2 miles away from the project. The site conditions include wet areas that reduce the overall productivity. Work will be performed in a flood area and the weather can impact the productivity and the duration of the project. Productivity was adjusted to reflect some delays due to wet conditions. The duration takes into account 5 weather days per month. The estimate assumed that labor and equipment will be available in the area.

Table 3-6: Río Culebrinas Current Costs

Relocations (telephone, electric, sewers, water lines)	\$880,000
Roads, Railroads, and Bridges (3 road ramps and demolition of an existing road and culvert)	\$2,691,000
Channels and Canals	\$941,000
Levees and Floodwalls	\$2,219,000
Floodway Diversion Structures	\$6,478,000
Fish and Wildlife Facilities (mitigation (11.69 acres))	\$2,418,000
Total Construction Cost	\$15,627,000
Lands and Damages	\$5,041,000
PED	\$2,789,000
Construction Management	\$1,578,000
Total Non-construction Cost	\$9,408,000
Project First Cost	\$25,034,000

*Estimate in FY20 price levels, provided by certified cost report dated 11-8-19

USACE Cost Engineering expects all projects in Puerto Rico, including Río Culebrinas, to see rising costs due to the effects of Hurricane Maria and the resulting Supplemental funding. The effects to the cost estimate will include but not be limited to the following: 1) rising costs in materials, 2) rising costs in labor rates, 3) availability of skilled labor on the island, 4) availability of local and/or worldwide contractors to perform all the work needed on the island, 5) rising fuel prices, and 6) future funding amounts to execute the project.

3.5. Cost Risk Analysis

The cost risk analysis is the process of identifying and measuring the cost impact of project uncertainties on the estimated total project cost. This risk analysis was accomplished as a joint analysis between the cost engineer and the appropriate project delivery team (PDT) members. This section provides a summary of significant risk analysis results that were identified in the Abbreviated Risk Analysis (ARA). Risk analysis results are intended to provide project leadership with contingency information for scheduling, budgeting, and project control purposes. Results also provide tools to support decision making and risk management as projects progress through planning and implementation.

In order to establish a contingency for the project cost estimate, the contingencies were removed from the estimate prior to running the analysis. The total estimated Construction cost

of the remaining project excluding contingency was established at approximately \$11,737,750. Land Cost remaining for the project is approximately \$3,786,000. Planning, Engineering & Design plus Supervision & Administration cost is \$3,248,000. This yields a total ARA base cost of approximately \$18,772,000. The total contingency was quantified as approximately \$5,632,000, or about 30% total contingency for the project. The cost risk elements that were evaluated through the risk analysis are project growth, acquisition strategy, construction elements, quantities for current scope, cost estimate assumptions, and external project risks. Each of these elements were given a risk level based on each feature of work for the project. The key cost risk elements identified through the risk analysis were “construction elements” and “quantities for current scope” for the “roads and ramps” feature of work and “external project risks” for the utilities feature of work.

This project is identified as a Class 3 estimate as defined in ER 1110-2-1302, Civil Works Cost Engineering, with technical information approaching 10-60% of project design. A contingency of 30% generated from the ARA is reasonable for this stage of the project development per ER 1110-2-1302. The project schedule is shown in Table 3-7.

Table 3-7: Rio Culebrinas Project Schedule

ID	Task Name	Duration	Start	Finish
1	Rio Culebrinas Contracts	1304 days	Thu 11/1/18	Tue 10/31/23
2	Culebrinas	1304 days	Thu 11/1/18	Tue 10/31/23
3	Contract #1	1304 days	Thu 11/1/18	Tue 10/31/23
4	Planning Report	304 days	Thu 11/1/18	Tue 12/31/19
5	Planning Report	304 days	Thu 11/1/18	Tue 12/31/19
6	Lands + Plans & Specs	730 days	Wed 1/13/21	Tue 10/31/23
7	Land Acquisition	730 days	Wed 1/13/21	Tue 10/31/23
8	Plans & Specs	730 days	Wed 1/13/21	Tue 10/31/23
9	Award	0 days	Wed 10/20/21	Wed 10/20/21
10	S&A Contract #1	485 days	Tue 11/16/21	Tue 9/26/23
11	Construction	485 days	Tue 11/16/21	Tue 9/26/23
12	Notice to Proceed	0 days	Tue 11/16/21	Tue 11/16/21
13	Mobilization	20 days	Wed 11/17/21	Tue 12/14/21
14	Relocations	120 days	Wed 12/15/21	Tue 5/31/22
15	Levees and Floodwalls	110 days	Wed 11/9/22	Tue 4/11/23
16	Aguadilla Levee (62K CY)	60 days	Wed 11/9/22	Tue 1/31/23
17	Espinar Levee (52K CY)	45 days	Wed 2/8/23	Tue 4/11/23
18	Diversion Structure	325 days	Wed 6/1/22	Tue 8/29/23
19	AL-S1	40 days	Wed 6/1/22	Tue 7/26/22
20	AL-S2	75 days	Wed 7/27/22	Tue 11/8/22
21	AL-S3	60 days	Wed 11/9/22	Tue 1/31/23
22	EL-S-1A	50 days	Wed 2/1/23	Tue 4/11/23
23	Extend Concrete box	100 days	Wed 4/12/23	Tue 8/29/23
24	Fish and Wildlife Facilities	120 days	Wed 4/12/23	Tue 9/26/23
25	Mitigation Areas	120 days	Wed 4/12/23	Tue 9/26/23

3.6. Updated BCR and Net Benefits

In a Level 1 Economic Update, the Benefit-Cost Ratio (BCR) is computed by comparing the current annual costs to previously estimated benefits. At the Office of Management and Budget (OMB) interest rate (7.0%), the BCR is 0.98. The BCR and net benefits are summarized in Table 3-8 and Table 3-9. As previously noted, construction has not yet begun on the project. Therefore, the remaining benefit remaining cost ratio is not applicable.

Table 3-8: Río Culebrinas Updated BCR with incidental benefits*

Project First Cost	\$25,034,000
IDC	\$956,081
Total Investment Cost	\$25,991,081
Average Annual Investment Cost	\$680,655
Annual O&M	\$24,000
Total AAEQ Cost	\$704,655
AAEQ Benefits	\$1,058,500
BCR	1.50
Net Benefits	\$353,845

*Incidental Benefits include recreation, employment benefits, and flood insurance overhead reduction benefits.

Table 3-9: Río Culebrinas Updated BCR Without Incidental Benefits

Project First Cost	\$25,034,000
IDC	\$956,081
Total Investment Cost	\$25,991,081
Average Annual Investment Cost	\$680,655
Annual O&M	\$24,000
Total AAEQ Cost	\$704,655
AAEQ Benefits	\$1,011,200
BCR	1.44
Net Benefits	\$306,545

Notes:

- 1.) Cost Estimate based on certified FY20 TPCS and construction schedule dated November 8, 2019.
- 2.) Costs deflated to price level of benefits (FY2004) using September 2019 CWCIS,
- 3.) Annual Costs amortized over a 50 year period of analysis at the FY20 discount rate (2.75%).
- 4.) Total Project BCR and RBRCR are the same because construction has not initiated on this project.

Since the original report in 2004, the estimated cost of the project has increased significantly (from \$4.7 million to \$25.0 million). Even accounting for inflation, the real cost of the project has increased over time. Because a level 1 Economic Update takes the current cost and deflates it to the price level of the estimated benefits, the BCR has therefore decreased over time. A summary of the changing costs, BCR, and net benefits is provided in Table 3-10.

Table 3-10: Río Culebrinas Cost and BCR Comparison Over Time

	2004	2015	2020
Project First Cost	\$4,741,400	\$16,971,000	\$25,034,000
IDC	\$111,100	\$405,510	\$956,081,
Investment Cost	\$4,862,500	\$17,376,510	\$25,991,081
Average Annual Investment Cost	\$303,100	\$531,960	\$1,018,191,
Annual OMRR&R	\$15,000	\$21,700	\$24,000
Total AAEQ Cost	\$318,100	\$594,583	\$1,042,191,900
Total AAEQ Cost *	\$318,100	\$553,707	\$704,655
AAEQ Benefits (04 Price Level)	\$1,058,500	\$1,058,500	\$1,058,500
BCR	3.33	1.91	1.50
Net Benefits	\$740,400	\$504,793	\$353,845

* adjusted to price level of benefits, FY04

3.7. Real Estate Update

3.7.1. Roads and Utilities

The project is expected to have road and utility relocations and the project sponsor will be responsible for performing all facility/utility relocations as part of its Lands, Easements, Rights-of-ways, Relocations, and Disposal areas (LERRDs) delivery responsibilities.

- **ROADS.** There are three sites where the proposed levee crosses highways owned and maintained by the Puerto Rico Highway and Transportation Authority. Accordingly, three road ramps will be required at Highways 418, 115, and 442.
- **BRIDGES.** One existing bridge/box culvert located in Cano Madre Vieja under Highway 418 would have to be extended approximately 10 meters at each end to accommodate the proposed road ramp levee crossing.
- **UTILITIES.** There are water lines, sewer lines, electric power lines, and telephone lines that would require relocation but are currently not all specifically identified.

The costs for relocations are addressed in Table 3-6 and are not anticipated to exceed 30 percent of the estimated total project costs.

3.7.2. Relocation Assistance

In the 2015 DPR, 23 residential structures were estimated for acquisition and relocation assistance benefits under the Uniform Relocation Act, Public Law 91-646. However, the 23 properties could not be verified for this CAP conversion report. An updated review of the project design using Google Earth identified nine (9) residential properties and two (2) commercial businesses that will be total takes and could result in relocation benefits. However, the possibility exists that multiple dwelling units were built on the tracts, which could result in a higher number of relocation assistance cases. A physical inspection of the premises is needed during PED to verify that additional properties are not required based on the PED level design.

3.7.3. Updated Real Estate Costs

This is a planning level real estate cost estimate update based on available information.

Background: The 2015 DPR real estate addendum describes that its real estate costs were derived from a review of a 2004 Gross Appraisal [performed in support of the 2004 Detailed Project Report (DPR)]; SAJ Real Estate cannot locate the 2004 Gross Appraisal or verify its findings. However, a SAJ Staff Appraiser does recall performing an informal review of the 2004 Gross Appraisal for the Draft 2015 DPR real estate addendum and agrees with its conclusion that due to the large 30% contingency factor, and macro-economic impact of the 2008 Financial Crisis on real estate markets in Puerto Rico, the 2004 market data was acceptable for continued use in 2015.

Currently, the negative financial impacts of Hurricane Maria in 2017 enable extrapolation of flat to declining real estate market conditions to further support that the 2004 real estate values are still within the limits of a Rough Order Magnitude (ROM) cost estimate.

However, USACE Real Estate Policy Guidance Letter No. 31- Real Estate Support to Civil Works Planning, dated January 11, 2019, requires a ROM Real Estate Cost Estimate to be prepared by a USACE appraiser to validate the real estate costs, where the real estate values are 15% or less than total project costs. A ROM real estate Cost Estimate was completed by the Savannah District, U.S. Army Corps of Engineers on January 10, 2020. The ROM Real Estate Cost Estimate is \$3,375,000 which is less than the real estate cost identified in the FY20 certified cost estimate.

For this report, a review of the project design was performed. In the feasibility design, the alignment of the Highway 115 road ramp over the East Levee requires the acquisition of a large industrial building. A potential significant real estate cost savings to the project can possibly be realized if the road ramp design is realigned about 50 feet south of the current road alignment, which will negate the need to acquire the industrial building. This possibility will be further explored in PED.

The Draft 2015 DPR Real Estate Addendum confirmed the real estate costs from the 2004 gross appraisal report as shown in Table 3-11.

Table 3-11: ROM Real Estate Cost

	COST
Total Land and Damages	\$1,486,200
Total Acquisition/Admin Costs.	\$1,096,000
Public Law 91-646 Payments	\$2,300,000
Total Real Estate Costs (Contingency 30% Rounded)	\$4,882,200
Contingency* (30% Rounded)	\$1,464,660
TOTAL PROJECT REAL ESTATE COST	\$6,346,860

4. RISK AND UNCERTAINTY

Site conditions and other characteristics detailed in the 2004 Río Culebrinas DPR have remained fairly consistent over the years. The 2015 DPR Draft Addendum saw little change in site conditions and included design updates for the then current design criteria. Due to the updates in the 2015 DPR Draft Addendum, the risk and uncertainty for the study has been

reduced and there is a higher level of confidence that the recommended plan remains economically justified, environmental acceptable and feasible from an engineering perspective. However, risk and uncertainty still exist and during PED the new Engineering Construction Bulletin 2018-14, Guidance for Incorporating Climate Change Impacts to Inland Hydrology, and the latest design standards and practices will be used and evaluated.

4.1. RESIDUAL AND TRANSFERRED RISK

It is important to note that there are residual risks associated with the project. The Río Culebrinas project, like all Flood Risk Management (FRM) projects, does not prevent all potential future flood damages. Even after project construction and implementation, some flood damages could occur in the study area. More information about residual damages is provided in the Economics Appendix (Appendix E) of the 2004 Report. As explained in Appendix E, the project as designed is expected to reduce damages for events up to the 100 year Annual Chance Event (ACE). A detailed breakout is provided below, in Table 4-1.

Table 4-1: Río Culebrinas Cost and BCR Comparison Over Time

Land Use	Recommended Plan	
	Damage Reduced (\$1,000s of 2003)	Residual Damages (\$1,000s of 2003)
Residential	461.6	52.0
Commercial	202.5	73.8
Public	62.3	7.1
Non-profit	0.2	0.2
Utilities	275.7	10.7
Streets & Highways	8.9	2.6
TOTALS	1,011.2	146.4

As noted in Table 11, the damages in the with-project condition are \$146,400 (less than 14.5% of total damages in the without-project condition). The vast majority of these damages are associated with residential and commercial properties, though there are some residual damages in all categories. Though there is some residual flood risk after project implementation, the best available information suggests that the return on investment is positive for this project. The purpose of the CAP conversion report is to determine whether the project is still economically justified, environmentally acceptable, and feasible from an engineering perspective. Based on the available information, the project is economically justified, environmentally acceptable and technically feasible.

4.2. TRANSFERRED RISK

Because the project will be constructed downstream first (with contracts moving gradually upstream over time), there is no expectation of transferred risk during construction or after project completion. The sequence of construction will be designed in part to avoid induced flooding or other adverse impacts. Finally, the mouth of the channel flows directly into the

Atlantic Ocean. No additional flow or velocities are being introduced into other riverine settings or populated areas.

However, according to ER 1110-2-1156, Safety of Dams – Policy and Procedures, all FRM projects must complete a detailed Potential Failure Mode Analysis and Risk Assessment (RA). Because the Culebrinas project largely consists of channelization, rather than levees, the type of project “failure” described in ER 1110-2-1156 (i.e., dam and levee breaches as well as overwash/overtopping events) do not really apply to most features. However, some levee features are a part of the project. Therefore, the risk of levee failure must be considered. In this case, the risk of levee failure is expected to be low (i.e., within tolerable risk guidelines), because the levees are being built to current engineering standards and design requirements. Unlike more traditional Risk Assessments, which are typically focused on existing infrastructure built decades ago, future construction contracts will implement essential agency guidelines (as described in ER 1110-2-1156), including minimum requirements for hydraulics, geotechnical design, and structural design. Still, during the PED phase, a Semi-Quantitative Risk Assessment and RA will need to be completed for this project in accordance with ER 1110-2-1156. In the interim period, the reasonable expectation of levee risk is low enough that it does not affect the recommendation of this report.

4.3. RISK AND UNCERTAINTIES DURING REVIEW PROCESS

This report is prepared in accordance with the Río Culebrinas Project Management Plan, ER 1105-2-100, Planning Guidance Notebook, and will undergo feasibility phase reviews in accordance with EC 1165-2-217, Review Policy for Civil Works. These reviews include District Quality Control, Agency Technical Review, and Policy and Legal reviews of this CAP Conversion Report and design. Since no changes are being proposed to the project design for this previously authorized project, an exclusion from completing a Type I Independent External Peer Review was granted by SAD on March 5, 2019.

4.4. SUPPLEMENTAL CONSIDERATIONS FOR PED AND IMPLEMENTATION

4.4.1. Engineering

The PED level hydrology and hydraulic analyses to be performed will include all of the following with the intent of verifying adequacy of original feature designs, and investigating and matching cost efficiencies to the desired level of performance using state-of-the-art computing tools. The Engineering Community of Practice (CoP) recommends an update of models after 5 to 10 years for projects moving forward. All USACE Regulations, Policies and Community of Practice standards will be adhered to with proper Quality Control reviews accordingly:

- Update the project rainfall depths with NOAA Atlas 14 (based on H&H updates to other Puerto Rico projects, NOAA Atlas 14 rainfall depths are significantly different from previous rainfall calculations) and re-model the drainage basin using CoP approved computing software (HEC-HMS) to determine design flow rates. The previous model used, HEC-1, while a good model, and has been replaced by the preferred HEC-HMS model. The period of return frequency floods to be included are the 2-year, 5-year, 10-year, 25-year, 50-year, 100-year and Standard Project Flood (SPF). The different frequencies are used to identify risk and make risk informed decisions with respect to final levee heights and other features. The SPF is used to identify residual risk as the project is to provide the 100-year flood damage reduction capability. LiDAR data collected to date will be used for the project’s basin analysis.

- Update the hydraulic routing of flood flows through the floodplain(s) using CoP approved computing software (1D/2D HEC-RAS). Previous model used, 1-dimensional UNET, has demonstrated a trend requiring higher levees than necessary. Because of the split floodplain (common inflow, two outlets to the sea) and road features crossing the same, a 2-dimensional routing model will be used to ensure flood flows through the separate outlets are properly accounted for resulting in optimal levee heights for cost efficiency. The hydrographic survey was last collected in 1995 (23 years ago). Because of the floodplain extent and aggradation of sediment over the years, a new hydrographic survey will be required. All hydraulic control and conveyance features will be verified for cost efficiency and performance adequacy or new criteria will be developed to ensure proper feature hydraulic design.
- Sea Level Rise will be investigated through model sensitivity analyses, e.g. varying downstream boundary conditions (sea) to determine potential impacts on design features effectiveness and change in levee height risks/level of flood damage reduction over time.
- Levee safety standards that impact design have been recently updated and will need to be reviewed as PED is conducted to ensure all USACE Design Standards are incorporated. See Table 4-2.

Table 4-2: USACE Levee Safety Program Guidance Update

Document Number	Title	POC/Lead	% Complete	Current Phase	Est'd Publication	Status Date
EC 1165-2-218	Levee Safety Policy & Procedures	Tammy Conforti (HQ)	85%	Publication	3QFY19	4Oct18
ECB	Procedures for Site Visits and Inspections for Levees within the USACE Portfolio	Rich Varuso (RMC)	85%	Review	3QFY19	4Oct18
ECB	Relief Wells	Pat Conroy (MVS)	75%	Publication	2QFY19	4Oct18
EM 1110-2-1913*	Levee Design Manual	Scott Shewbridge (RMC)	98%	Publication	2QFY19	4Oct18
ER 1110-1-1807	Drilling in Earth Embankment Dams and Levees	Nicole Kennedy (NAB)	5%	Preparation	4QFY19	4Oct18
EM 1110-2-2902	Conduits, Pipes, and Culverts	Christina Neutz (LRL)	45%	Execution	1QFY20	4Oct18
EM 1110-2-TBD	Seepage Control Cutoffs for Dams and Levees	Dave Paul (RMC)	85%	Review	3QFY19	4Oct18
EM 1110-2-1908	Instrumentation of Embankment Dams and Levees	Rich Varuso (RMC)	65%	Execution	2QFY19	4Oct18
EM 1110-2-2502	Retaining and Floodwalls	Kent Hokens (MVP)	45%	Execution	4QFY20	4Oct18
EM 1110-2-1914	Relief Wells	Pat Conroy (MVS)	5%	Preparation	4QFY20	4Oct18

4.4.2. Environmental

The wetland habitat functional analysis will be completed during PED to verify that the functional equivalent is still valid and ensure the appropriate performance measures are in place. However, there is risk that additional acreage for mitigation will be required. The team feels that it will be no more than 6 to 7 additional acres and is confident that the existing contingencies are adequate to capture this with little impacts to the overall project cost. This is described in previous sections of the report in more detail and in the project's proposed mitigation plan which can be found in Appendix D of the 2019 EA.

4.4.3. Real Estate

As previously stated in the report, USACE Real Estate Policy Guidance Letter No. 31- Real Estate Support to Civil Works Planning, dated January 11, 2019 requires a ROM Real Estate Cost Estimate to be prepared by a USACE appraiser to validate the real estate costs, where the real estate values are 15% or less than total project costs. Therefore, a ROM real estate Cost Estimate has been requested from Savannah District and is scheduled to be completed by January 10, 2020. Given the conceptual nature of the project at this stage of planning, the relatively vague real estate requirements of a project at 30% design completion, and the large real estate cost contingency factor, it's anticipated that the ROM real estate Cost Estimate will be within an acceptable range of cost, with regard to the project certified cost, but a moderate variance in real estate cost could be expected.

For this report, Real Estate performed a desktop review of the 30% project design. In the 30% design, the alignment of the Highway 115 road ramp over the East Levee requires the acquisition of a large industrial building. A potential significant real estate cost savings to the project can possibly be realized if the road ramp design is realigned about 50 feet south of the current road alignment, which will negate the need to acquire the industrial building. This possibility will be further evaluated in PED if the project receives PED funding.

5. COST SHARING

If funded by regular appropriations, the cost share for the Culebrinas project will be 65% Federal and 35% non-federal, with a minimum 5% cash contribution. The remaining 30% of the non-federal share can be provided in LERRDS, cash, or a combination of the two. The non-federal share may not exceed 50% of PED costs.

There is a possibility the project will be funded using BBA 2018 funds. In this case, the project will be designed and constructed using 100% Federal funds.

6. ITEMS OF LOCAL COOPERATION

Federal implementation of the recommended plan would be subject to the non-federal sponsor agreeing to comply with applicable federal laws and policies, including but not limited to:

- 1) Provide a minimum of 35 percent, but not to exceed 50 percent, of total flood control project costs as further specified below:
 - a) Provide 35 percent of design costs in accordance with the terms of a design agreement entered into prior to commencement of design work;
 - b) Provide, during construction, a cash contribution of funds equal to 5 percent of total flood control project costs;
 - c) Provide all lands, easements, and rights-of-way, perform or ensure the performance of all relocations, and provide relocation assistance, as determined by the Federal Government to be required for the initial construction or the operation and maintenance of the flood control components of the project, all in compliance with applicable provisions of the Uniform Relocation and Assistance and real Property Acquisition Policies Act of 1970, as amended (42 U.S.C. 4601-4655) and the regulations contained in 49 C.F.R. Part 24;

- d) Provide, during construction, any additional funds necessary to make its total contribution for flood control components equal to at least 25 percent of flood control costs;
- 2) For as long as the project remains authorized, operate, maintain, repair, rehabilitate, and replace the project, or functional portions of the project at no cost to the Federal Government, in a manner compatible with the project's authorized purposes and in accordance with applicable federal and state laws and regulations and any specific directions prescribed by the Federal Government;
- 3) Inform affected interests, at least annually, of the extent of protection afforded by the project; participate in and comply with applicable federal floodplain management and flood insurance programs; comply with Section 402 of the Water Resources Development Act of 1986, as amended (33 U.S.C. 701b-12); and publicize floodplain information in the area concerned and provide this information to zoning and other regulatory agencies for their use in adopting regulations, or taking other actions, to prevent unwise future development and to ensure compatibility with protection levels provided by the project;
- 4) Prevent obstructions or encroachments on the project (including prescribing and enforcing regulations to prevent such obstructions or encroachments) such as any new developments on project lands, easements, and rights-of-way or the addition of facilities that may reduce the level of protection the project affords, hinder operation and maintenance of the project, or interfere with the project's proper function;
- 5) Give the Federal Government a right to enter, at reasonable times and in a reasonable manner, upon property that the non-federal sponsor owns or controls for access to the project for the purpose of completing, inspecting, operating, maintaining, repairing, rehabilitating, or replacing the project;
- 6) Hold and save the United States free from all damages arising from the construction, operation, maintenance, repair, rehabilitation, and replacement of the project, except for damages due to the fault or negligence of the United States or its contractors;
- 7) Perform, or ensure performance of, any investigations for hazardous substances that are determined necessary to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), Public Law 96-510, as amended (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 construction, operation, or maintenance of the project. However, for lands that the Federal Government determines to be subject to the navigation 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;
- 8) Assume, as between the Federal Government and the non-federal sponsor, complete financial responsibility for all necessary cleanup and response costs of any hazardous substances regulated under CERCLA that are located in, on, or under lands, easements, or rights-of-way that the Federal Government determines to be required for construction, operation, or maintenance of the project; and
- 9) Agree, as between the Federal Government and the non-federal sponsor, that the non-federal sponsor shall be considered the operator of the project for the purpose of CERCLA liability, and to the maximum extent practicable, operate, maintain, repair, rehabilitate, and replace the project in a manner that will not cause liability to arise under CERCLA.

- 10) Participate in and comply with applicable Federal floodplain management and flood insurance programs;
- 11) 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;
- 12) If applicable, 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 initial construction, operation, and maintenance 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 the said Act;
- 13) Comply with all applicable Federal 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 all applicable Federal labor standards requirements including, but not limited to, 40 U.S.C. 3141- 3148 and 40 U.S.C. 3701 – 3708 (revising, codifying, and enacting without substantial change the provisions of the Davis-Bacon Act (formerly 40 U.S.C. 276a et seq.), the Contract Work Hours and Safety Standards Act (formerly 40 U.S.C. 327 et seq.), and the Copeland Anti-Kickback Act (formerly 40 U.S.C. 276c et seq.);
- 14) 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 Partnership Agreements to Commonwealth and Local Governments at 32 Code of Federal Regulations (CFR) Section 33.20;
- 15) 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.

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7. RECOMMENDATIONS

I recommend authorization of the project presented in the Rio Culebrinas Detailed Project Report and Environmental Assessment dated June 2004, approved previously to be implemented under Section 205 of the 1948 Flood Control Act, as modified in this Continuing Authorities Program Conversion Report, at an estimated first cost of \$25,034,000. I concur with the conclusions in this updated Conversion Report that the project as previously planned and modified based on current conditions is economically justified, environmentally acceptable, and feasible from an engineering standpoint.

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 they are transmitted to the Congress as proposals for authorization and implementation funding. However, prior to transmittal to the Congress, the sponsor, the States, interested Federal agencies, and other parties will be advised of any modifications and will be afforded an opportunity to comment further.


Date 06 MAR 2020

ANDREW D. KELLY, JR.
COL, EN
Commanding