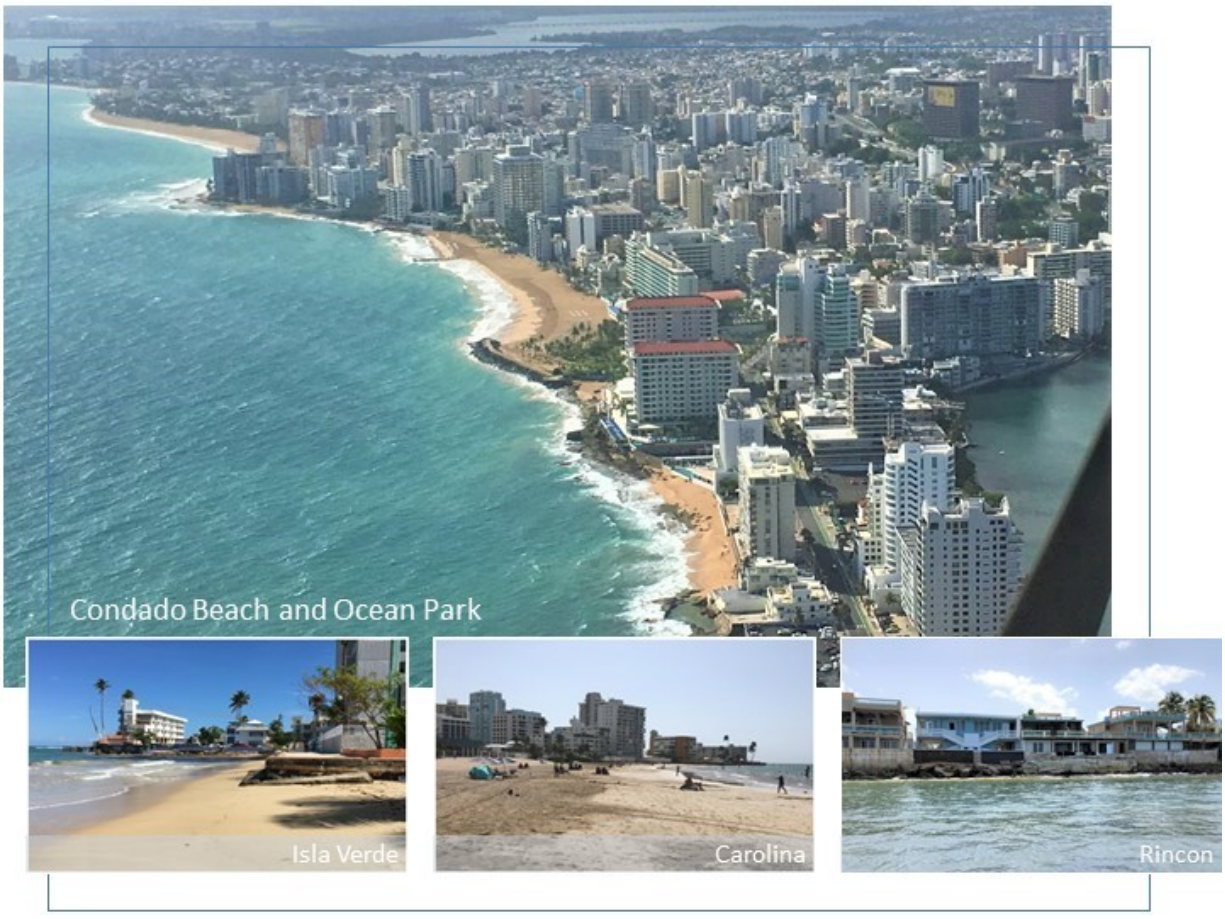
PUERTO RICO COASTAL STUDY

DRAFT INTEGRATED FEASIBILITY REPORT AND ENVIRONMENTAL ASSESSMENT



November 2020

US Army Corps of Engineers ®
Jacksonville District

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Report Reference Materials:

The executive summary informational fold-out map, **REF-1** is provided at the end of the report to serve as a reference with key points. An overall table of contents is provided, along with detailed table of contents.

Organization of this report follows Exhibit G-7 (Feasibility Report Content) provided in Appendix G of ER 1105-2-100 (30 June 2004), documenting the iterative U.S. Army Corps of Engineers (USACE) Plan Formulation Process. The planning process consists of six major steps:

(1) Specification of problems and opportunities

(2) Inventory, forecast, and analysis of existing conditions within the study area

(3) Formulation of alternative plans

(4) Evaluation of the effects of the alternative plans

(5) Comparison of the alternative plans

(6) Selection of the recommended plan based upon the comparison of the alternative plans.

Steps may be repeated as problems become better understood and new information becomes available.

Steps 1 and 2 are discussed in Chapters 1 and 2. They provide the foundation for developing alternative plans and selection of the Tentatively Selected Plan (TSP) outlined in Chapter 3.

The focus of this study, a partial response to the study authority, is Coastal Storm Risk Management (CSRM) for specific coastal areas in Puerto Rico. Each chapter, as well as the executive summary, describes plan development as it progresses through the four integrated environments that shape a CSRM project: the natural environment (species of concern and their habitat); the physical environment (waves, tides, sea level rise, etc.); the built environment (upland development, etc.); and the economic environment (vulnerability of built environment to damages). Concerns relative to plan formulation and National Environmental Policy Act (NEPA) review are summarized and encapsulated in the discussions of these four main environments.

The recommended format of an Environmental Assessment (EA) is provided in 40 CFR 1502.10 and has been integrated into the Feasibility Report. The basic table of contents for the report outlines how the EA format has been integrated into the planning process to develop a TSP that meets the requirements of both USACE Plan Formulation Policy and NEPA.

Note that sections pertinent to the NEPA analysis are denoted with an asterisk.

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EXECUTIVE SUMMARY

Introduction

Hurricanes and coastal storms are responsible for significant damages to infrastructure due to wave attack, flooding, and erosion for the entire island of Puerto Rico. This storm events threaten private and public property and critical infrastructure as well as recreational beach areas. The Puerto Rico Coastal Study began with the non-Federal sponsor, Department of Natural and Environmental Resources (DNER), bringing concerns about problems in the coastal areas of Puerto Rico to the U.S. Army Corps of Engineers (USACE), especially after Hurricane Maria (2017). In response to these problems, USACE decided to undertake this study as a partial response to Section 204 of the Flood Control Act of 1970, Public Law 91-611. Tittle IV, Subdivision B of the Bipartisan Budget Act of 2018, P.L. 115-123 provides funding and allows the study to be conducted at full federal expense under.

This study investigates alternatives that address these vulnerabilities, as well as incidental opportunities for maintenance of environmental habitat and recreation along specific areas the Puerto Rico coastline.

Purpose and Need

This report is an interim response to the study authority. The single purpose of this study is to determine whether there is economic justification and Federal interest in a plan to reduce damages to properties and infrastructure as a result of erosion, wave attack, and flooding from coastal storms and hurricanes along specific areas of the Puerto Rico coastline. The study team will produce both a draft and final report, which will be available for public review. The report will consider an array of engineering alternatives and their effects under the National Environmental Policy Act (NEPA) of 1969.

Study Area and Scoping

Initially, the Puerto Rico Coastal Study assessed the shoreline problems along approximately 30 miles of coastline island-wide in order to provide possible Coastal Storm Risk Management (CSRM) alternatives to reduce risk to infrastructure located in in the municipalities of San Juan, Carolina, Vega Baja, Arecibo, Aguadilla, Aguada, Rincon, Añasco, Mayagüez, Cabo Rojo, Loiza, Luquillo, and Humacao. The initial scoping resulted in the following areas showing potential for Federal Interest: the San Juan (Condado, Ocean Park, Isla Verde, and Carolina) and Rincon coastlines; and a segment of the major hurricane/tsunami evacuation routes in Mayaguez (PR-102) and Humacao (PR-3). Further screening of the study areas eliminated the segments in Mayaguez (PR-102) and Humacao (PR-3) based on lack of potential for economic justification. As a result, the study concentrated on approximately 7 miles of coastline in the San Juan and Carolina municipalities and 2.4 miles of coastline in the Rincon municipality. The San Juan area fronts the Atlantic Ocean on the north coast of Puerto Rico, from el Boqueron to Boca de Cangrejos, and it is located in the

municipalities of San Juan and Carolina, which are part of Metropolitan San Juan. For study purposes only, this study area will be referenced as the "San Juan Study Area" and it has been divided into four separable focus areas; Condado, Ocean Park, Isla Verde, and Carolina. The Rincon study area fronts the Atlantic Ocean on the west coast of Puerto Rico from Punta Ensenada to Corcega, delineated as just one focus area. Further investigations during the forecasting of existing and future without project conditions led to the screening out of the Carolina focus area due to the lack of potential for economic justification; therefore, modeling was performed only on the remaining focus areas Condado, Ocean Park, Isla Verde and Rincon.

There are approximately 8,000 people living within the Condado, Ocean Park and Isla Verde areas of interest. The average unemployment rate is 8% and average income is $69,576. On average, 17% of the residents live below poverty level. Six thousand eight hundred (6,800) people live in the Rincon study area. Though the unemployment rate of 8% is similar to San Juan, the level of poverty and median wage are considerably different. The percent of the population living below poverty in Rincon, 41%, is over twice that of the average population living in poverty in the San Juan area (17%). The average income in Rincon ($27,432) is less than one-third that of the entire United States' average income ($84,938).

There are approximately 800 structures and their contents at risk within Condado, Ocean Park, Isla Verde and Rincon. These damage elements have an overall estimated value of $2.9B, with structure and content valuations of $2.5B and $400M respectively.

During plan formulation, the San Juan focus areas have been divided into seven planning reaches to align with the headland and pocket beach features, where unique alternatives could be implemented to reduce damages (Condado West Headland, Condado Pocket Beach, Punta Piedrita Headland, Ocean Park Pocket Beach, Punta Las Marias Headland, Isla Verde Pocket Beach, and Punta El Medio Headland). The Rincon focus area is comprised of two planning reaches geographically separated by a stream, Rincon A lies north of Quebrada Los Ramos and Rincon B lies south. These planning reaches are considered separable elements.

Further investigations led to five planning reaches being carried forward into formulation of alternatives (Condado Pocket Beach, Punta Piedrita Headland, Ocean Park Pocket Beach, west side of Punta Las Marias, and Rincon B) while the West Condado Headland, Isla Verde Pocket Beach, Punta El Medio Headland and Rincon A planning reaches were screened out from further analysis due to the lack of potential for economic justification. The study now focuses on the San Juan and Rincon planning reaches most likely to experience damages from erosion, wave attack and flooding.

It is expected that storm-induced erosion, wave attack and flooding will continue damaging properties and infrastructure as well as reducing beach habitat during the 50-year period of analysis which will be further exacerbated by sea level rise. Additionally, coastal damages put communities at risk, and negatively impacts the economic development of local business, tourism and hotels, and decrease property values.

Problems, Opportunities, Objectives and Constraints

This study considers the main problem within the San Juan and Rincon focus areas to be coastal storms causing damage to structures and infrastructure due to wave attack, flooding, and erosion. There are opportunities that may result from implementation of a Federal project, including:

- Maintaining existing recreation and tourism: these focus areas depend heavily on tourism, as well as aesthetic quality for community.

- Maintaining or enhancing beach habitat and environmental resources: reefs and turtle and shore bird nesting areas.

This study developed the following objectives to address each of the identified problems and opportunities within all the focus areas:

- Primary Objective: Manage the risk of damages from wave attack, flooding, and erosion caused by coastal storms to property and infrastructure within the project area over a 50-year period of analysis (2028 – 2077).

- Secondary Objectives:

    - Maintain recreational use of beach and nearshore areas over a 50-year period of analysis (2028 – 2077).

    - Maintain environmental quality in the project area over a 50-year period of analysis (2028 – 2077).

The study will propose a plan consistent with federal law and policy and will avoid or minimize impacts to cultural resources, reef resources, submerged vegetation and critical infrastructure.

The Tentatively Selected Plan

This study considered structural management measures including revetments, seawalls, beach nourishment and breakwaters. Nonstructural management measures were also considered, including no-action, coastal construction control line, moratorium on construction, establishment of a no-growth program, relocation of structures, flood proofing of structures, improvement of evacuation plans, condemnation of structures and land acquisition. Several alternatives have resulted from combinations of management measures applied among the planning reaches in each focus area. These alternatives were evaluated and compared according to USACE planning principles.

The planning strategy is to identify the National Economic Development (NED) plan for each planning reach (Condado Pocket Beach, Punta Piedrita Headland, Ocean Park Pocket Beach, west side of Punta Las Marias, and Rincon B), and recommend an overarching Tentatively Selected Plan (TSP) comprised of each reach's TSP. The TSP reasonably maximizes net benefits to contribute to national economic development and is consistent with protecting the nation's environment, pursuant to national environmental statutes, applicable executive orders, and other Federal planning requirements. At this point of the study, the NED identification is still ongoing, so the team designated a TSP based on the potential for economic justification of the alternatives, as well as engineering feasibility and environmental acceptability.

The TSP consists of a combination of structural features in specific locations designed to reduce the risk of damages as a result of wave attack, coastal flooding, and erosion in the Condado Pocket Beach, Punta Piedrita Headland, Ocean Park Pocket Beach, west side of Punta Las Marias, and Rincon B planning reaches as shown in **Figure ES-1**. At this point in the study the TSP will include the following features. These may be adjusted as public comments are considered and final analyses are complete:

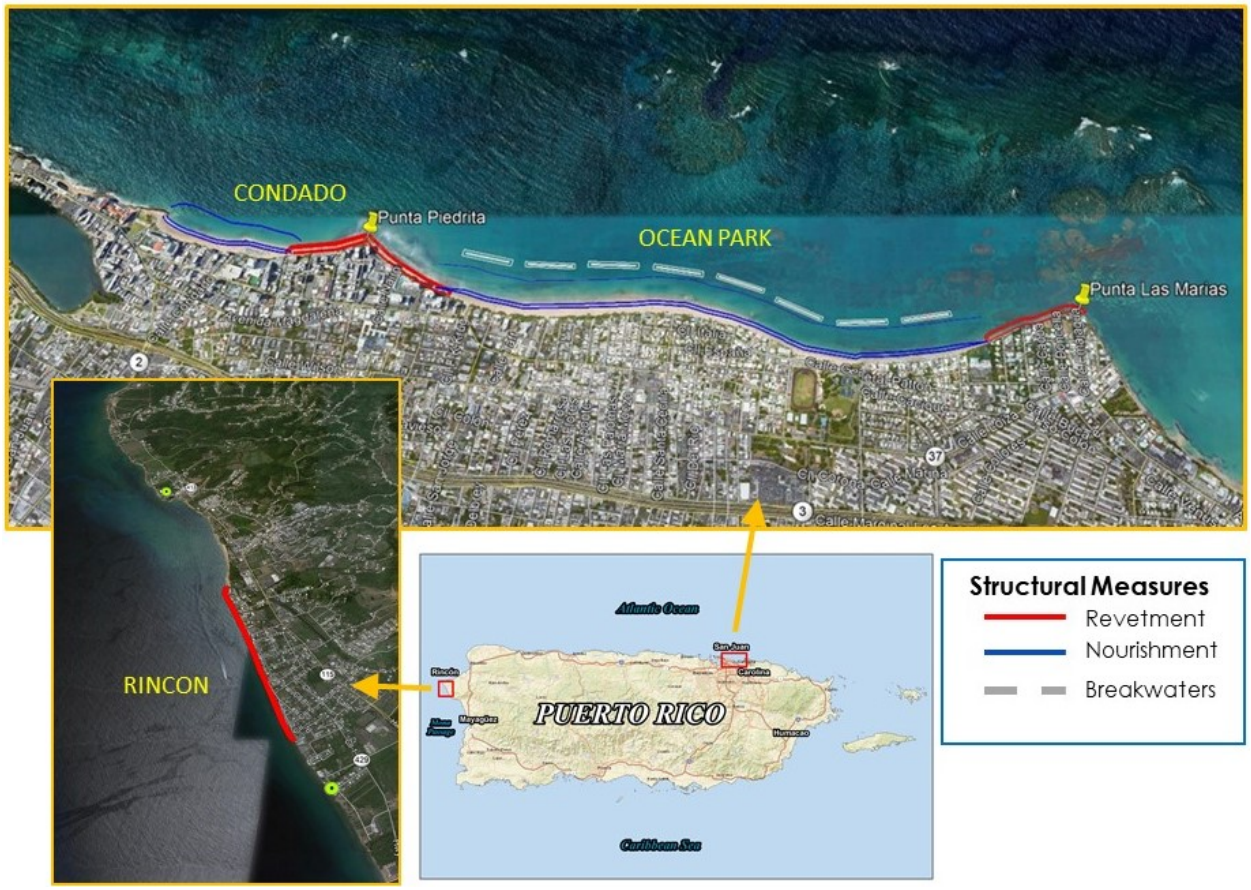
- Beach nourishment (1,910 ft) along Condado Pocket Beach shoreline;
- Stone revetment on Punta Piedrita headland (2,450 ft);
- A breakwater field in combination with beach nourishment protecting 6,810 ft along the Ocean Park Pocket Beach shoreline;
- Stone revetment on west side of Punta Las Marias headland (1,400 ft); and
- Stone revetment (5,650 ft) along the Rincon shoreline.

Although, this is not part of the Federal project recommendation, this study recognizes that Puerto Rico island wide will benefit from the non-Federal sponsor, the Commonwealth, and local communities pursuing nonstructural measures, such as implementation of a Coastal Construction Control Line, and improved evacuation plans and notification systems.

The beach nourishment alternatives that are part of the tentatively selected plan will require approximately 723,000 cy of sand over a 50-year period in Condado and Ocean park pocket beaches. For Condado Pocket Beach, three nourishment events are estimated with an average time interval of 17 years. The nourishment years would be 2028 for initial construction (110,000 cy), followed by periodic nourishment in 2040 and 2060 (51,000 cy each). For Ocean Park Pocket Beach, two nourishment events are estimated with an average time interval of 25 years. The nourishment years would be 2028 for initial construction (350,000 cy), followed by a periodic nourishment in 2053 (161,000).

There are available potential upland sand resources to support CSRM alternatives for this project. Even though offshore sources were investigated during this study, environmental risks and constructability challenges let to the conclusion of utilizing upland sand sources by truck-haul. Therefore, the assumptions and cost developed, for Condado and Ocean Park beach nourishment was based on the fact that there is beach compatible sand available from an upland sand mine located in Juncos (~ 25 miles away).

Figure ES-1. Location of Structural Features of the Tentatively Selected Plan



Benefits of The Tentatively Selected Plan

Not all future with project modeling results were completed by publication of this draft report; therefore, the TSP does not have total quantified benefits. Due to complexity of the study, and schedule constraints, this study hasn't identified the NED plan by the time of the publication of this report. With consideration given to the planning criteria evaluation, the TSP per planning reach is the alternative with most potential for economic justification that meets all planning criteria. **Table ES-1** presents the potential benefit-to-cost ratio (BCR) per planning reach.

Table ES-1 Tentatively Selected Plan Rollup

Planning Reach Alternative	Benefits (Thousands AAEQ)	Cost (Thousands AAEQ)	*Net Benefits (Thousands AAEQ)	Benefit-to-Cost Ratio (BCR)
Condado pocket beach Alt – 3 Beach nourishment	Requires 88% damage reduction to get to a 0.5 BCR	$999	Likely Negative without Recreation Benefits	Presently <1.0
Punta Piedrita Headland Alt – 2 Revetment	$950	$857	$93	1.11
Ocean Park Pocket Beach Alt – 5 Beach nourishment plus breakwaters	Requires 40% damage reduction to get to a 0.5 BCR	$3,812	A fair chance of positive net-benefits on primary benefits alone; highly probable with recreation benefits added.	Likely >1.0
Punta Las Marias Headland Alt – 2 Revetment	$507	$473	$34	1.07
Rincon Alt – 2 Revetment	$1,175	$ 1,049	$ 125	1.12

Sea Level Change (SLC)

Following procedures outlined in ER 1110-2-8162 and EP 1100-2-1, low, intermediate, and high Sea Level Change (SLC) values were estimated over the life of the project using the official USACE sea level change calculator tool. Projections for Sea Level Rise (SLR) are based on a start date of 1992, which corresponds to the midpoint of the current National Tidal Datum Epoch of 1983-2001. For the future without-project conditions in San Juan study area, SLR could be expected to increase by 0.57 ft (low), 1.21 ft (intermediate), and 3.25 ft (high) by year 2077 (50-year period of analysis) with respect to the above mentioned present local mean sea level tide datum. For Rincon study area, sea level could be expected to increase by 0.51 ft (low), 1.15 ft (intermediate), and 3.19 ft (high) by year 2077 (50-year period of analysis) with respect to the above mentioned present local mean sea level tide datum. Future SLC is expected to exacerbate the impacts of coastal flooding and wave attack as those forces would be occurring at a higher starting water level in the future as sea level rises. The intermediate SLC scenario was used for plan formulation, and the TSP will be evaluated under the three SLC scenarios. At this point of the study, BCRs and net benefits under the three SLR scenarios haven't been estimated.

Environmental Considerations

The environmental quality account considers non-monetary effects on ecological, cultural, and aesthetic resources. Under this account, the preferred plan should avoid or minimize environmental impacts and maximize environmental quality in the project area to the extent practicable considering other criteria and planning objectives. More detailed descriptions of the analysis and impacts can be found in Chapter 5 of this report and in the Environmental Appendices. For the purposes of alternatives analysis, all action

plans were compared to the future without-project condition (i.e., NEPA No Action), which factors in 50 years of sea level change (to 2077). Effects for each alternative were evaluated and were carefully considered during plan formulation and for selection of the TSP. The first step in mitigation planning involves employing efforts to avoid adverse impacts. After development of the final array of alternatives, the PDT coordinated with resource agencies who participated during the PDT meetings. These meetings focused on the primary resources that could be impacted by the proposed alternatives.

Cost Estimate and Implementation

For each of the alternatives included in the TSP, an Abbreviated Risk Analysis (ARA) was performed to assess the level of risk and to determine a reasonable contingency to be applied to each alternative. Based on the results of the ARA, an average contingency of 40% was assumed across all alternatives for the construction costs, PED and S&A. For Lands and Damages, and Real Estate administrative costs, a 30% contingency was assumed. **Table ES-2** presents the total project first cost currently estimated to be $203M including contingency (FY21 price level). The estimated Federal cost is $122 and non-Federal cost is $81M. Overall, the cost share for the project is estimated to be 62% Federal and 38% non-Federal for Initial construction, and 48% Federal and 52% non-Federal for future nourishment events (see **Table ES-3**). Project construction is assumed to begin in 2025 and takes approximately 3 years, assuming concurrent construction crews in various locations.

Table ES-2 TSP Total Project First Cost (FY 21 Price Levels).

WBS Code	Item	Total Project First Cost $K (FY21)
06	Fish & Wildlife Facilities	$17,911
10	Breakwaters & Seawalls	$28,155
16	Bank Stabilization	$28,688
17	Beach Replenishment	$41,132
	Construction Estimate Total	**$115,886**
01	Lands and Damages	$2,698
30	Planning Engineering and Design (PED)	$17,151
	Real Estate Admin Costs (Fed)	$94
	Real Estate Admin Costs (Non-Fed)	$189
31	Construction Management	$9,271
	Average Contingency (40%)	$57,818
	Project First Cost	**$203,107**

Notes:

Fish & Wildlife Facilities corresponds to compensatory mitigation costs. Land and Damages and RE administrative costs are subject to 30% contingency.

Table ES-3 Cost Share Allocations

INITIAL CONSTRUCTION					
ITEM	**Federal Cost Share**	**Federal Cost**	**Non-Federal Cost Share**	**Non-Federal Cost**	**Project First Cost**
Coastal Storm Risk Management Cost	62%	$ 109,210,000	38%	$ 66,935,000	$176,145,000
Non-Federal LERRD Contribution*	0%	$ -	100%	$ 246,000	
Non-Federal Cash Contribution				$ 66,689,000	
PERIODIC NOURISHMENT					
Periodic Nourishment	48%	$ 12,941,000	52%	$ 14,020,000	$ 26,961,000
INITIAL CONSTRUCTION + PERIODIC NOURISHMENT					
Final Project Cost Share and Cost (50 years)		$122,151,000		$ 80,955,000	$203,106,000
*Includes Non-Federal administrative costs only					
Note: Dollar values are rounded					

Coordination with Agencies and the Public

Stakeholders consist of the communities in the municipalities of San Juan, Carolina and Rincon; the non-Federal sponsor Department of Natural and Environmental Resources (DNER), as well as Federal environmental agencies, state and local agencies, and Non-Governmental Organizations (NGO). The study team has met with communities during the studies and has monthly meetings with DNER, National Marine Fisheries Service (NMFS), and U.S. Fish and Wildlife Service (USFWS).

A public scoping letter was sent in October 2018, which outlined the USACE Jacksonville District's intent to gather information to prepare an Environmental Assessment (EA) for evaluation of the feasibility of providing hurricane and storm damage reduction, and related purposes, to the Puerto Rico shoreline. The initial scoping period for the study was conducted from October 16 to November 16, 2018. Public and interagency meetings were held on November 6, 2018 in Aguadilla; November 8, 2018 in San Juan, Puerto Rico; and with participation from the DNER, USFWS, NMFS, Puerto Rico Planning Board (PRPB), Office of Permits General (OGPe), NGOs, Instituto de Cultura Puertoriquena (ICP), and the public. An additional public meeting to provide study updates was held on June 18, 2019 in Rincon. On June 22, 2020 the team met via webinar to brief representatives of the municipalities of San Juan and Carolina, DNER, and environmental agencies on the alternatives and receive feedback.

Finally, the team is in the process of coordinating a webinar meeting with these stakeholders to brief the TSP and understand their perspectives and views.

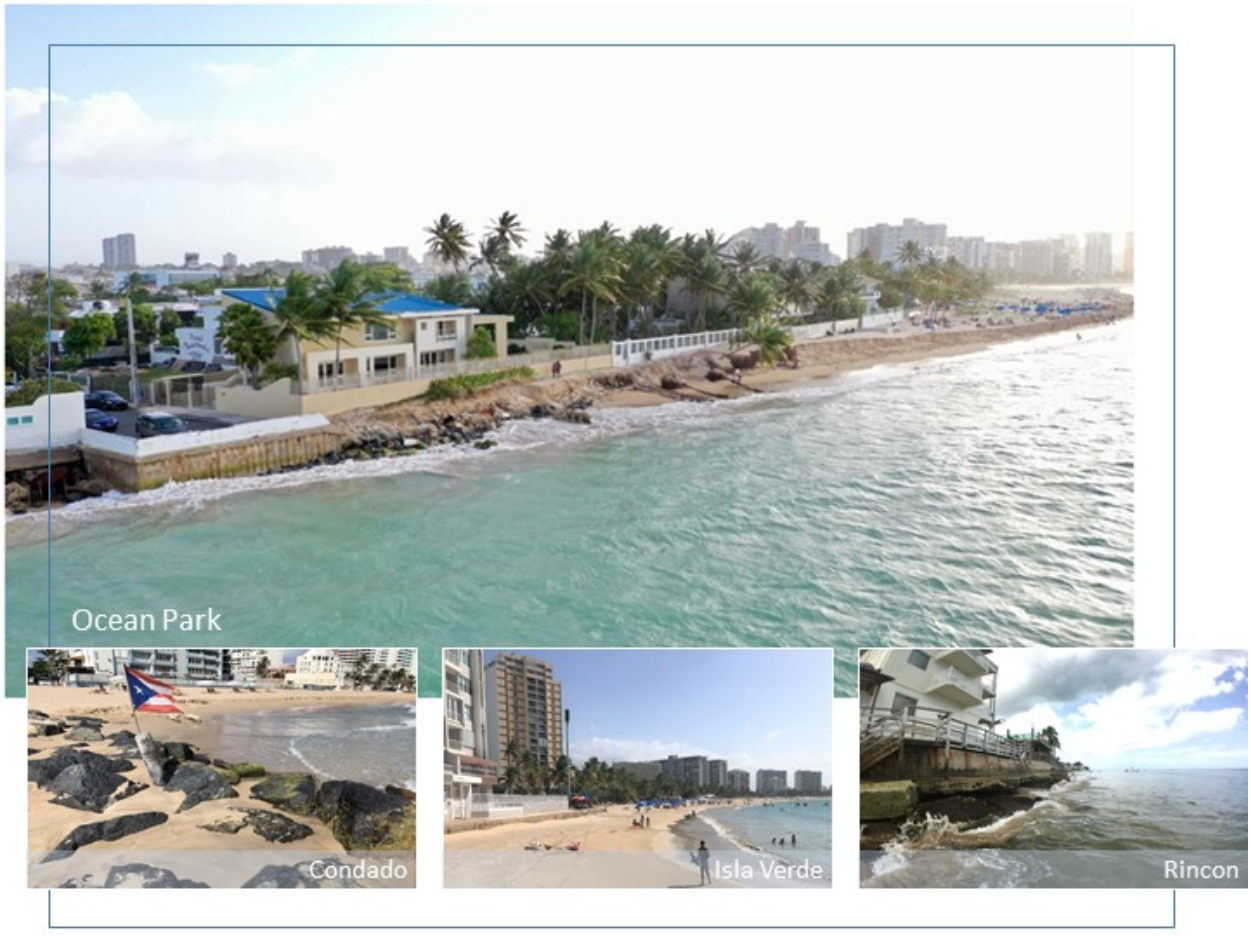
Residual Risk

The proposed project would reduce future coastal storm risk and damages which result from erosion, waves and coastal flooding within the project area. Assessment of the Coastal storm damages reduction of the Tentatively Selected Plan over the 50-year period of analysis is in progress; therefore, the overall residual damages has not been estimated yet.

The Tentatively selected Plan is designed to maximize net NED benefits in accordance with ER 1105-2-100 rather than to achieve a specific level of protection. In other words, the project is not designed to fully withstand a certain category of hurricane or a certain frequency storm event. During study scoping, it was determined that the vast majority of coastal storm risk is within 600 feet landward from the dune line or property line and therefore this boundary was selected as the landward extent of the study area. As a result, the project is not claiming any benefits beyond this designation as damages to structures past this extent were not calculated in this study. Structures within the project area would continue to be subject to damage from hurricane winds and windblown debris. Even new construction is not immune to damage, especially from these processes. The project purpose is coastal storm risk management, which is intended to reduce economic damage, and the recommended plan is not designed to prevent loss of life. Public safety risks can be reduced by actions taken at the local, state, and Federal levels.

Notably, infrastructure on the backside of Condado focus area, Ocean Park inland and backside of Carolina area, although outside of the project area, are susceptible to impacts from back bay flooding. The currently ongoing San Juan Metro Area CSRM study is recommending a plan to reduce damages to properties and infrastructure as a result of coastal flooding caused by coastal storms and hurricanes along the back bay areas in the San Juan Metro Area, comprised of the municipalities of San Juan, Cataño, Guaynabo, and Toa Baja. The risk of back bay flooding is not affected by the proposed TSP.

1.INTRODUCTION



1 INTRODUCTION*

1.1 FEDERAL STUDY PURPOSE*

Congress has authorized Federal participation in the cost of restoring and protecting the shores of the United States, its territories and possessions. Under current policy, shore protection projects are designed to reduce damages caused by wind-generated and tide-generated waves and currents along the Nation's ocean coasts, Gulf of Mexico, Great Lakes, and estuary shores. Hurricane protection was added to the erosion control mission in 1956 when Congress authorized cost-shared Federal participation in shore protection and restoration of publicly owned shore areas. The Corps participates in single purpose projects formulated exclusively for hurricane and storm damage reduction, with economic benefits equal to or exceeding the costs, based solely on damage reduction benefits, or a combination of damage reduction benefits and recreation benefits.

The purpose of this study is to determine whether there is Federal interest and economic justification in a Coastal Storm Risk Management (CSRM) project within specific coastal areas of Puerto Rico. This U.S. Army Corps of Engineers (USACE) study is an interim response to the study authority, Section 204 of the Rivers and Harbors Act of 1970, Public Law 91-611, to determine Federal interest in a plan to reduce damages to structures and infrastructure along the ocean coast of the commonwealth of Puerto Rico. More specifically, this study will assess erosion, coastal flooding, and wave attack as well as the effects of sea level change on these problems under the CSRM mission. The study develops and evaluates CSRM alternatives to reduce risk to structures and infrastructure which are critical to the nation's economy and will consider incidental opportunities for maintaining environmental resources and recreational opportunities.

1.2 STUDY SPONSOR

The non-Federal sponsor is the Puerto Rico Department of Natural and Environmental Resources (DNER), also known as (DRNA) for its Spanish name "Departamento de Recursos Naturales y Ambientales". A Feasibility Cost Sharing Agreement was executed on 9 October 2018.

1.3 STUDY AUTHORITY

Authority for this study is granted under Section 204 of the Rivers and Harbors 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.

> ***SEC. 204.*** *(a) The Secretary of the Army, acting through the Chief of Engineers, is authorized to cooperate with the Commonwealth Puerto Rico, political subdivisions thereof, and appropriate agencies and instrumentalities thereof, in the preparation of 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, and to submit to Congress reports and recommendations with respect to appropriate participation by the Department of the Army in carrying out such plans. Such plans that may be recommended to the Congress shall be*

harmonious components of overall development plans being formulated by the Commonwealth and shall be fully coordinated with all interested Federal agencies.
(b) The Secretary of the Army, acting through the Chief of Engineers, shall consider plans to meet the needs of the Commonwealth for protection against floods, wise use of flood plain lands, improvement of navigation facilities, regional water supply and waste management systems, outdoor recreational facilities, the enhancement and control of water quality, enhancement and conservation of fish and wildlife, beach erosion control, and other measures for environmental enhancement.

Study funds are appropriated under Title IV, Subdivision B of the Bipartisan Budget Act (BBA) of 2018, P.L. 115-123.

1.4 LOCATION AND NEED*

Puerto Rico is an archipelago located between the Caribbean Sea and the North Atlantic Ocean, east of the Dominican Republic and west of the U.S. Virgin Islands. The archipelago of Puerto Rico is composed of 143 islands, with three main inhabited islands, Puerto Rico, Viequez, and Culebra. The most inhabited of the three, Puerto Rico, has a land area of 3,515 square miles, almost three times the size of Rhode Island. The Puerto Rico vicinity map is shown in **Figure 1-1**. Puerto Rico has approximately 800 miles of shoreline distributed in 44 coastal municipalities. The beaches are one of the principal economic engines of the hotel/tourism industry and are a very important source of recreation for the Puerto Rican population. Over 24% of the 800 miles of coastline are occupied or developed. The analysis conducted by the Puerto Rico Coastal Zone Management Program using the 2010 Census data shows that 56% of the population (2,317,189 people) live in the coastal municipalities. Today, more than half of the population lives in the San Juan Metropolitan Area. The metropolitan municipalities, like San Juan and Carolina, are where activities and services are concentrated: Puerto Rico's main seaport and airport; the most important healthcare center in Puerto Rico and the Caribbean (Centro Médico) and the major universities. Government services are also highly concentrated in San Juan. The coastal zone of Condado, Ocean Park, Isla Verde and Carolina is where most hotels are located. Most businesses and other forms of economic activity are located in the coastal zone as well (Puerto Rico Climate Change Council (PRCCC) 2013).

Erosion, coastal flooding and wave attack damage is evident in many urban, commercial and Industrial areas. Even though the vulnerability of these public and private assets, critical infrastructure and coastal habitat have been identified by several entities in Puerto Rico, the adaptation and protection strategies have been implemented on a case by case basis, and do not comprehensively address the problems. As documented in the press release "Imprescindible el esfuerzo multisectorial para enfrentar el problema de erosión costera" (DRNA 2015), the DNER identified the existence of at least 33 beach points that are at increased risk from erosion concentrated mainly in the northern and eastern part of Puerto Rico. The coastal areas identified being at risk to coastal storm damages include the municipalities of Rincon, Aguadilla, Hatillo, Culebra, Vieques, Arecibo, Cabo Rojo, Loiza, Salinas, Carolina and San Juan, and the towns of Toa Baja, Dorado, Vega Alta, Vega Baja Luquillo, Humacao, Arroyo, Patillas and Ponce.

As is typical on the Caribbean Islands, Puerto Rico can be impacted by frequent winter storms (northeasters) as well as tropical storms and hurricanes. After Hurricane Maria in 2017, the country turned its attention to Puerto Rico due to the massive devastation that occurred island-wide. As a result

of this Hurricane and several more historical storm events, Puerto Rico coastal areas have experienced erosion and infrastructure damage prompting Federal and Local government assistance. Some of the most damaging storm events recorded include Hugo (1989), Georges (1998), Irene (2011), Matthew (2016), Irma (2017), Maria (2017), and extra-tropical storm Riley (2018).

As described in the Coastal Engineering Handbook for best practices in Puerto Rico (Department of Natural and Environmental Resources of Puerto Rico and Tetra Tech, Inc 2019), Puerto Rico faces multiple coastal management challenges, including increasing development pressures, land-based sources of pollution, wetlands and coral reef degradation, dune systems alteration, beach erosion and coastal hazards, among others.

As a result of human activities, storm events and seal level rise, the erosion of Puerto Rico coastal areas have been taking place for many years. Therefore, continued erosion of unprotected areas may be anticipated. The loss of beach in front of existing properties will cause their failure. The most practicable method of preventing failure of existing buildings and infrastructure and prevent further erosion of the shore consists of improving and stabilizing their shoreline, but a holistic solution would be impracticable to be accomplished by separate action of individual owners. This feasibility study supports a need to reduce damages to coastal properties and infrastructure during hurricane, tropical and extra tropical storm events in Puerto Rico through Federal participation on a comprehensive plan.

The purpose and scope of this study are also influenced by USACE Environmental Operating Principles and USACE Campaign Plan Fiscal Year (FY) 2015-2019, which are discussed further in Chapter 2.

Figure 1-1. Puerto Rico Vicinity Map

1.5 STUDY BACKGROUND AND SCOPING PROCESS

This island wide CSRM study began with the DNER bringing concerns about problems in the coastal areas of Puerto Rico to the USACE. Originally, the Puerto Rico Coastal study was scoped to assess shoreline erosion along the coastline of the entire island with exception of the coastline of San Juan Metropolitan Area, which was being analyzed under a separate feasibility study called "San Juan Metro Area CSRM". A NEPA scoping meeting was held in San Juan on November 8, 2018 where the study team presented the general study scope and requested feedback from communities. During that process, several communities expressed concerns of back bay flooding in the Cataño municipality, as well as the Condado Lagoon area within the San Juan municipality. As a result, the Puerto Rico Coastal study adopted the San Juan Metro Area coastline as part of the study area, to allow the San Juan Metro Area CSRM study to focus solely on back bay flooding. A brief description of the scope of the San Juan Metro Area CSRM study is provided in section 1.7.1 under related USACE and NEPA studies.

The Puerto Rico Coastal feasibility study assessed the shoreline problems along approximately 30 miles of coastline island-wide in order to provide possible CSRM alternatives to reduce risk to infrastructure located in those areas. The study considered 13 vulnerable locations identified by the DNER. These areas are located in San Juan, Carolina, Vega Baja, Arecibo, Aguadilla, Aguada, Rincón, Añasco, Mayaguez, Cabo Rojo, Loiza, Luquillo, and Humacao Municipalities[1].

The Study area was further refined to focus specifically on areas with the highest potential to support a Federal project. Potential Federal interest was based on apparent vulnerability of structures and infrastructure and evidence of damages from past storms. Several important factors were considered in the criteria selected for this initial scoping:

- Four Planning and Guidance (P&G) accounts: The four accounts were used to track benefit categories. In this case, they were used to see which reaches had the most potential for Federal Interest. These accounts are: National Economic Development (NED), Environmental Quality (EQ), Other Social Effects (OSE), and Regional Economic Development (RED). Presence of critical Infrastructure like hospitals, fire stations, shelters, schools, utilities, and major evacuation routes.
- Sea Level Change Consideration: Identifying areas at lower elevations which may have increased vulnerability to sea level rise.
- High Background Erosion Rates of Hot Spots: Identifying areas known to suffer high erosion during storms or due to natural processes occurring in the area.
- High Risk of Flooding: Identifying areas known to experience flooding along the ocean shoreline as a result of coastal storms.

Figure 1-2. shows the map with the location of the preliminary study areas, and

[1] The municipality of San Juan includes Old San Juan, Condado, and Ocean Park. The municipality of Carolina includes Isla Verde and Carolina shoreline.

Figure 1-3 summarizes the initial scoping considerations for each location. As a result of the initial scoping using the criteria previously described, the following areas showed the greatest potential for Federal Interest: the San Juan (Condado, Ocean Park, Isla Verde, and Carolina) and Rincon coastlines; and a segment of the major hurricane/tsunami evacuation routes in Mayaguez (PR-102) and Humacao (PR-3). Those areas are highlighted in green on **Figure 1-2**. During further investigation, evacuation routes in Mayaguez (PR-102) and Humacao (PR-3) were screened out from further analysis in this study. The rational for this determination is described in the following discussions.

Figure 1-2. Location of the Preliminary Study Areas

Figure 1-3 Initial Scoping for the Puerto Rico Coastal Study

	Would Provide Significant Benefits from a Federal Project				Prioritized Need for a Federal Project			
Planning Study Reaches	National Economic Development (NED)	Environmental Quality (EQ)	Other Social Effects (OSE)	Regional Economic Development (RED)	Critical Infrastructure	Sea Level rise Consideration	High background Erosion Rates, Hot spots, or erosion from storms	High risk of Flooding (in 500 year flood zone or flooding evidence)
								
Aguadilla	✓	✓	✓	✓	✓	✓	✗	✓
Aquada	✓	✓	✓	✗	✓	✓	✓	✗
Rincon	✓	✓	✓	✓	✓	✓	✓	✓
Anasco	✗	✗	✗	✗	✗	✓	✗	✓
Mayaguez	✓	✓	✓	✓	✓	✓	✗	✓
Cabo Rojo	✓	✓	✓	✓	✓	✓	✗	✓
Arecibo	✓	✓	✓	✓	✓	✓	✗	✓
Vega Baja	✓	✗	✓	✓	✗	✓	✓	✓
Loiza	✗	✗	✓	✓	✗	✓	✓	✗
Luquillo	✗	✗	✗	✗	✗	✓	✓	✗
Humacao	✓	✗	✓	✓	✓	✓	✓	✓
Old San Juan	✓	✓	✓	✓	✗	✓	✓	✗
Condado Shoreline	✓	✓	✓	✓	✓	✓	✓	✓
Ocean Park	✓	✓	✓	✓	✓	✓	✓	✓
Isla Verde	✓	✓	✓	✓	✓	✓	✓	✓
Carolina	✓	✓	✓	✓	✓	✓	✓	✓

✓ Most fully Meets ✓ Partially Meets ✗ Does not meet

Screening out of Evacuation route in Mayaguez (PR-102):

To identify the potential for the economic justification of protecting evacuation routes in Mayaguez (PR-102) and Humacao (PR-3), the NOAA Coastal Flood Exposure Mapper (Storm Surge – Category 1 to 5 Hurricane) shows that part of this area can expect flooding up to 6 feet above ground. In addition, aerial imagery from NOAA's Hurricane Maria imagery site and cost estimates for post-Maria road repairs in Mayaguez and Humacao areas were obtained from the Puerto Rico Department of Transportation to inform this decision.

The Mayaguez reach focuses on highway PR-102, approximately from Km 4.4 through 7.3, where the road is closer to the coastline. There are approximately eight structures that lie between the ocean and the highway and there are two small neighborhoods in this reach, Brisas De Mal and Guanajiro Homes, that are separated from the coastline by PR-102. Consultations with the Puerto Rico Highway and Transportation Authority reported no damage or reconstruction efforts to highway PR-102 in Mayaguez after Hurricane Maria. The **Figure 1-4** below shows the reference area (north and south) immediately following Hurricane Maria, and shows no physical damage to the road.

All of the previously described reasons supported the decision to not carry forward the Mayaguez study area.

While this study focusses in the damages coming from coastal flooding, there is residual risk in this area associated with inland flooding. The Brisas De Mal and Guanajiro Homes neighborhoods are highly vulnerable due to inland flooding coming from the Rio Guanajibo. However, a riverine flood risk management project along Rio Guanajibo will lower flood risk to these neighborhoods once it is in place. The Rio Guanajibo Project was authorized in 1996, but never constructed. The accelerated scope verification report has been approved (2020) and the team is undergoing concurrent efforts for PED and a validation report to verify the project is economically justified, environmentally acceptable and feasible from an engineering perspective. The recommended flood control project includes a channel plan with a 10-year level of protection at San German in the upper basin and a system of levees that will provide 100-year protection for the urban areas at Hormigueros and Mayaguez in the lower basin. **Figure 1-5** presents the authorized features of the Rio Guanajibo Project in the vicinity of Mayaguez.

Figure 1-4. Mayaguez (PR-102) Post Hurricane Maria

Source: https://storms.ngs.noaa.gov/storms/maria/index.html#20/18.18727/-67.16171

Source: https://storms.ngs.noaa.gov/storms/maria/index.html#20/18.18727/-67.16171

Figure 1-5 Rio Guanajibo Flood Control Project in the Mayaguez area

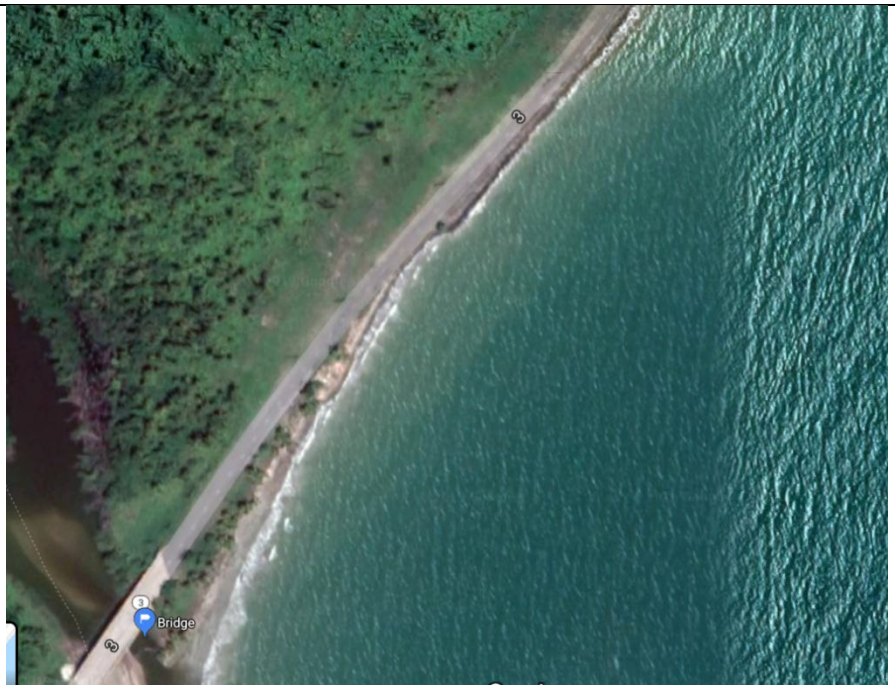
Screening out of Evacuation route in Humacao (PR-3):

The Humacao reach includes highway PR-3, from Km 69.3 through 71.8, just northeast of the confluence of Rio Antonio Ruiz with the ocean. PR-3 connects the community of Punta Santiago, located south of the river mouth, with the community of Naguabo, located about 2 miles in the northeast direction. A portion of this stretch of highway is less than 10 feet from the coastline and is protected from ocean scour by stone revetment. Based on the NOOA Coastal Flood Exposure Mapper (Storm Surge – Category 5 Hurricane), this area is highly vulnerable, and can expect flooding of up to 6 feet above ground. However, the highway lies between the coast and a nature reserve part of the Rio Antonio Ruiz floodplain and there are no structures in this reach, which indicates a lack of potential for economic justification. Consultations with the Puerto Rico Department of Transportation confirmed that the road suffered considerable damage from Hurricane Maria, but it was reconstructed by that agency in 2018. The project included repairing the pavement and portions of the stone revetment at a cost of $289,311 (See **Figure 1-6**).

These facts led the decision for Humacao study area not being carried forward.

Figure 1-6. Humacao (PR-3) Post Hurricane Maria

Source: https://storms.ngs.noaa.gov/storms/maria/index.html#16/18.1766/-65.7383



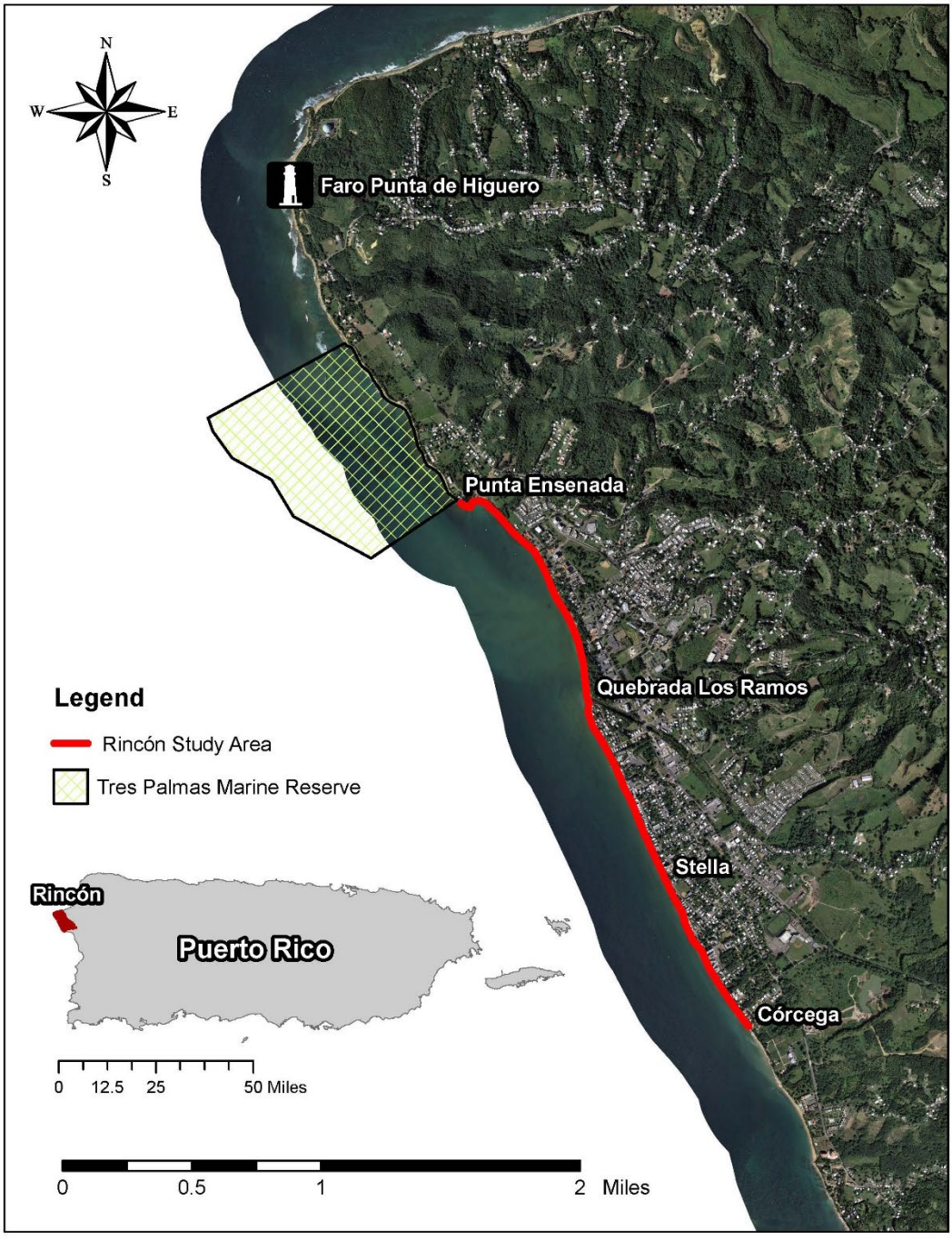
Source: Google Maps

Refined study area and determination of focus areas

As a result of the initial scoping, the refined study area encompasses approximately 7 miles of coastline in the San Juan and Carolina municipalities, and approximately 2.4 miles of coastline in Rincon municipality. The San Juan area fronts the Atlantic Ocean on the north coast of Puerto Rico, from el Boqueron to Boca de Cangrejos and it is located in the municipalities of San Juan and Carolina, which are part of Metropolitan San Juan. This stretch of ocean coastline will be referred to as the "San Juan Study Area" and it has been divided into four focus areas. The focus areas include Condado Beach, Ocean Park Beach, Isla Verde Beach and Carolina Beach. The Rincon study area fronts the Atlantic Ocean on the west coast of Puerto Rico from Punta Ensenada to Corcega Beach and is considered to be one single focus area. **Figure 1-7** and **Figure 1-8** present the focus areas for San Juan and Rincon respectively.

Figure 1-7. San Juan Focus Areas Location

Figure 1-8. Rincon Focus Area Location



1.6 RELATED DOCUMENTS*

Summaries of prior studies relevant to this project are as follows:

1.6.1 RELATED USACE STUDIES

- U.S. Army Corps of Engineers (USACE). 1948. Beach Erosion Control Study for Punta Las Marias, San Juan, Puerto Rico. Chief's Report signed December 1947. The investigation covered the north shore of Puerto Rico from a point about 4,000 feet west of Punta Las Marias to Boca de Cangrejos, a length of about 5 miles. The purpose of the study was to determine the best method of preventing further erosion of the shore and restoring or stabilizing the beach, principally with a view to protecting existing property. The report concluded that the most practicable method of completely accomplishing the purpose of the study for the critical areas at Punta Las Marias and Punta el Medio would require the adoption of a comprehensive plan comprised of (a) construction of a bulkhead, seawall, or revetment along the bluff where adequate structures of this nature do not exist; (b) placement of artificial fill on the beaches, with periodic replenishment, as required; and (c) retardation of its rate of erosion by installation of impermeable groins. However, at that time, the shore landward of the high-water line was privately owned with the exception of two detached parcels owned by the United States, which were adequately protected. Accordingly, the study area was not considered eligible for Federal aid in construction of protective works and, consequently, no analysis of the economic justification of the project was included. This project was not authorized for construction.

- U.S. Army Corps of Engineers (USACE). 1962. Beach Erosion Control Study for San Juan, Puerto Rico. Chief's Report signed August 1962. The report recommended Federal participation by the contribution of Federal funds toward the costs of measures for the restoration and protection of the shores at Condado and Ocean Park, San Juan, Puerto Rico. The plan comprised widening approximately 0.9 mile of the beach to a berm width 30 feet wider than existing by direct placement of sand fill and constructing a rubble-mound breakwater 129 feet long at the west end of the reach. Federal participation in the costs of periodic nourishment of the beach for an initial period of 10 years from the year of completion of the initial beach restoration. The Federal share was estimated at 8.2 percent of initial and periodic nourishment costs based on that time conditions of ownership and use. This project was not authorized for construction.

- U.S. Army Corps of Engineers (USACE). 1983. Reconnaissance report, Section 103 Beach Erosion Control Study for Boca de Cangrejos (Isla Verde Beach), Puerto Rico. The report recommended construction of (1) a protective and recreational beach fronting 1.1 miles of shoreline with periodic nourishment as needed. The beach fill has a 30-foot berm at +7 MLW, thence 1 vertical to 20 horizontal to existing bottom. The estimated volume of material required for initial fill for 1.1 miles of shoreline is 160,000 cubic yards. In addition, advance nourishment of 30,000 cubic yards is needed to maintain project dimensions until nourishment is needed. It is estimated that the restored beach should be nourished once every 5 years. Suitable material would be available from the entrance channel of Boca de Cangrejos (2) a groin 530 feet long to anchor the east end of the beach fill and (3) a 220-foot-long revetment from the landward edge of the groin to the

highway 187 bridge which crosses Boca de Cangrejos. The estimated benefit to cost ratio for the preliminary plan is 1.5. This project was never constructed.

- U.S. Army Corps of Engineers (USACE). 1983. Section 14 Study, Highway 187 at El Terraplen, Piñones, Puerto Rico. The study area covered between Punta Maldonado to the west and Punta Vacia Talega to the east, on the north coast of Puerto Rico. The selected plan provides for construction of a dune 2,100 feet in length, with a 20-foot berm width at elevation +10 MLW, with seaward slopes of 8 horizontal to 1 vertical, and landward slopes of 5 horizontal to 1 vertical. The estimated volume of material required for initial dune construction of 2,100 feet is 63,000 cubic yards. The estimate of annual nourishment of the dune is 5,000 cubic yards per year without vegetation, 2,000 cubic yards per year with vegetation. The borrow area is part of the Piñones State Forest. The estimated benefit to cost ratio for the selected plan is 1.7. The project was constructed in 1987.

- U.S. Army Corps of Engineers (USACE). 1997. Highway 187 at Piñones, Puerto Rico. Section 103 Shore Protection Feasibility Study and Environmental Assessment. Highway 187-Piñones project area is located on the north coast of Puerto Rico, about 11 miles east of San Juan. Highway 187 is a two-lane road that connects the city of San Juan and the municipality of Loiza and provides the only direct access and is the main hurricane evacuation route to the Piñones area. The recommended plan included Segment A: Raise 644 feet of the road along the curve at the western end of Punta Maldonado; Segment B: Construct a 244 ft breakwater on Punta Maldonado; and Segment C: Raise 4,077 feet of the road and revet the ocean side. The non-Federal sponsor, the Puerto Rico Department of Transportation and Public Works (DTOP) requested Segment A be dropped from the total project to be constructed by the DTOP without Federal participation. The other segments of the project were constructed by the USACE in 2007.

- U.S. Army Corps of Engineers (USACE). 2008. Section 103 Hurricane and Storm Damage reduction Study, Fort San Geronimo, San Juan, Puerto Rico. The study recommended construction of a concrete grout apron around Fort San Geronimo and construction of a rubble revetment around the apron. The project first cost of this plan is estimated at $2,382,000 with expected O&MRR&R costs of $5,600 on an expected average annual basis over a period of analysis of 50 years. This plan has a benefit to cost ratio of 3.3 with annual net benefits of $319,000. Project constructed in 2012.

- U.S. Army Corps of Engineers (USACE). 2018. Section 14 Integrated Feasibility Report and Environmental Assessment, Loiza, Puerto Rico. The report recommends placement of a continuous rock revetment along approximately 1,050 feet of shoreline in front of a public road, head start public school, and community center to provide emergency shoreline protection at Loiza. Elevation of the revetment crest is 8.9-ft Puerto Rico Vertical Datum of 2002 (PRVD02). Currently under construction.

- U.S. Army Corps of Engineers (USACE), FEMA, NOAA. 2018. Puerto Rico Vulnerability Study. This is part of the Hurricane Evacuation Study for Puerto Rico. The vulnerability study is the final report in a four-phase series of reports to analyze evacuation behavior, shelters, hazards and vulnerability in Puerto Rico.

- U.S. Army Corps of Engineers (USACE). 2018. San Juan Harbor Navigation Improvements Feasibility Study and Environmental Assessment, San Juan, Puerto Rico. Chief's Report signed August 2018. The recommended plan includes deepening of channels with associated channel widening and turning basins. It provides average annual benefits of $75,269,000, average annual costs of $15,172,000, and a benefit-to-cost ratio of 5.0. These improvements are currently under construction.

- U.S. Army Corps of Engineers (USACE). In Progress since 2018, expected to be complete by 2021. South Atlantic Coastal Study (SACS). The SACS is underway and provides a risk management framework designed to help local communities better understand changing flood risks associated with climate change and to provide tools to help those communities better prepare for future flood risks. In particular, it encourages planning for resilient coastal communities that incorporates wherever possible sustainable coastal landscape systems that considers future sea level and climate change scenarios.

- U.S. Army Corps of Engineers (USACE). In progress since 2018, expected to be complete by 2021. San Juan Metro Area Coastal Storm Risk Management Study, Puerto Rico, Integrated Feasibility Report and Environmental Assessment. The purpose of the San Juan Metro Area CSRM study is to determine if there is Federal interest in a plan to reduce damages to properties and infrastructure as a result of coastal flooding (combined effects of tide, storm surge, wave influence, and sea level change (SLC) rather than inland rainfall and stormwater runoff) caused by coastal storms and hurricanes along the back bay areas in the San Juan Metro Area, comprised of the municipalities of San Juan, Cataño, Guaynabo, and Toa Baja. The study team will produce a draft and final report, which will consider all engineering alternatives and their effects, under the National Environmental Policy Act (NEPA) of 1969. The draft report was open for public review from July 28 to Aug 26, 2020. The draft report and appendices can be found in the following link: www.saj.usace.army.mil/SanJuanMetro

1.6.2 RELATED NON-FEDERAL STUDIES

Many studies and reports relevant to San Juan and Rincon coastline have been completed by non-Federal interests. A list of the most relevant ones is provided in the references of this report.

- Coastal Engineering Handbook, Puerto Rico. 2019. This handbook was produced by Tetra Tech for DNER as a means to provide best practices in coastal areas of Puerto Rico.

- Arrecife Condado Artificial Reef Project San Juan, PR. 2019. This project is under permitting process and proposes to alter wave energy in critical locations along the seaward shoreline of Condado where high wave energy causes damage and life safety hazards. The proposed Project includes the installation of a shore parallel multi-segmented artificial reef, covering approximately 500 linear meters in front of the Condado Beach area. The submerged artificial reef will consist of three individual segments, approximately 170 meters (m) in average length.

1.7 FEDERAL PROJECTS NEAR THE STUDY AREA

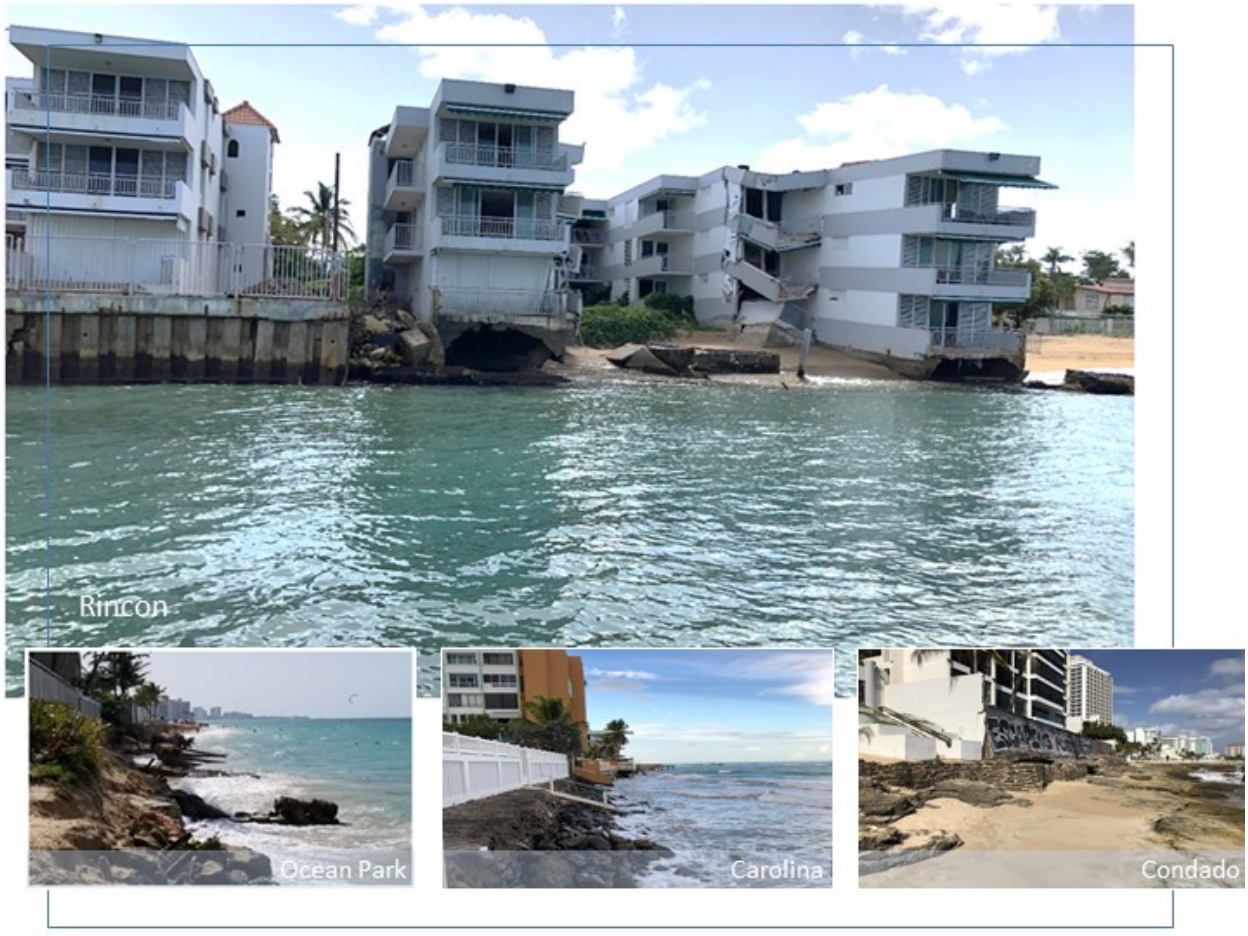
SAN JUAN HARBOR FEDERAL NAVIGATION PROJECT

San Juan Harbor is located in the north coast of the Commonwealth of Puerto Rico. It is the island's principal port, handling over 75 percent of all the Commonwealth's nonpetroleum waterborne commerce. San Juan Harbor is 3 miles long and varies in with from 0.6 to 1.6 miles, the project was completed in 1965. The Puerto Rico Port Authority is the non-Federal sponsor for authorized modifications to the existing Federal Navigation Project. The San Juan Harbor navigation improvements feasibility study report was recently approved in August 2018. The recommended plan includes deepening of channels with associated channel widening and turning basins. These improvements are currently under construction.

HIGHWAY 187 AT PIÑONES, PUERTO RICO. SECTION 103 SHORE PROTECTION PROJECT.

The project provides shore protection by elevating and armoring a 4,077-foot reach of coastal highway east of Punta Maldonado and a 477-foot reach west of Punta Maldonado. In addition, a 240-foot impervious revetment was constructed at Punta Maldonado. To mitigate for the impacts to mangroves, the project included a mitigation plan constructed in 2012. The shore protection project features were turned over to the Sponsor in Aug 1999.

2. EXISTING AND FUTURE WITHOUT-PROJECT CONDITIONS



2 EXISTING AND FUTURE WITHOUT-PROJECT CONDITIONS

2.1 GENERAL SETTING*

This chapter describes conditions as they currently exist, and as they are projected to exist if a Federal project is not implemented, within the San Juan and Rincon focus areas. Information gathered in this step helps to describe the problems and opportunities and forecast future conditions. The future without-project (FWOP) condition is the most likely condition of the study area without construction of a Federal project over 50 year period of analysis. The future without-project (FWOP) condition is also the no-action alternative for the purposes of the National Environmental Policy Act (NEPA) process, and this report uses both terms interchangeably.

The San Juan area fronts the Atlantic Ocean on the north coast of Puerto Rico, totals 6.7 miles, spanning from el Boqueron (western-most point) to Boca de Cangrejos (eastern-most point). The San Juan study area has been divided into four separable focus areas, Condado, Ocean Park, Isla Verde and Carolina. The San Juan study area shoreline has of wider beaches in the eastern portion of San Juan (Carolina and Isla Verde) with narrower beaches to the west (Condado and portions of Ocean Park). The headlands (Punta Piedrita, Punta Las Marias and Punta El Medio) segregating each pocket beach present little to no dry beach with nearshore hardbottom and coastal rock revetments or seawalls. The central portion of each pocket beach consists of a naturally sandy beach, minimal and intermittent dunes, and little to no upland vegetation. The natural beach berm width along the majority of the study area is relatively thin. **Figure 1-7** in Section 1.5 presents the geographical location of the four focus areas in San Juan with their respective headlands.

The Rincon study area fronts the Atlantic Ocean on the northwest coast of Puerto Rico, totals 2.3 miles, from Punta Ensenada (northern-most point) to Corcega (southern-most point), delineated as just one focus area. The Rincon focus area contains wider beaches and elevated berm crests to the north and narrower beaches with abandoned homes, some physically in the water, to the south. Intermittently exposed hardbottom to the north and prevalent submerged hardbottom to the south typically characterize the nearshore zone. The southern portion of Rincon, which includes Stella and Corcega, generally consisted of coastline with minimal to no dry beach. There is a prevalence of coastal structures like riprap and seawalls protecting homes and hotels. **Figure 1-8** in Section 1.5 presents the geographical location of the Rincon focus area.

Overall, the five study focus areas are highly developed with a mixture of single-family homes, condominiums, commercial structures, and hotels, which include associated structures such as pools, garages, and parking lots. The proximity of these buildings to the beach makes them potentially vulnerable to erosion, wave, and flood damage. Coastal armoring, such as seawalls or revetments in various conditions, is present in all of the focus areas. A mixture of riprap and concrete debris has been placed in front of some structures as an emergency measure to protect upland property. Although most of the seawalls have been effective in affording protection to the upland and buildings behind them from ordinary storms, loss of beach in front of some areas threatens eventual failure by undermining.

Lack of dunes and upland vegetation is common through all of the focus areas. An offshore and relatively shallow fringing reef exists in front of the San Juan focus areas, where breaking waves demonstrate the protective function of the reef to dissipate wave energy propagating toward the coastline. The Isla Verde

marine reserve is located in the nearshore waters off of Punta el Medio. The Tres Palmas marine reserve, with its coastal vegetation, sandy beaches, and shallow-water coral communities composed primarily of Elkhorn coral (*Acropora palmata*), is located north of Punta Ensenada, the northern limit of Rincon focus area. Key environmental habitats in the study area support hawksbill, leatherback, and green sea turtle species, listed hard corals, marine mammals, nearshore fish assemblages and nesting shorebirds.

In addition to the existing physical shoreline conditions and natural environment described, it is important to document the economic environment relevant to the focus areas. As June 2020, the current population of Puerto Rico is 2,860,346, with 418,140 people living in the San Juan municipality, 170,404 in the Carolina municipality and 15,000 in Rincon municipality. The San Juan and Rincon Study Areas are significant to the nation with their rich historical and cultural heritage, environmental resources, and tourism. Although not the subject of this study's formulation, tourism is a vital part of the San Juan and Rincon economy and an important consideration. Almost all the tourism industry in Rincon could be described as coastal tourism. Tourists venture to Puerto Rico's western, most remote coast to enjoy recreational uses of the coast such as surfing, fishing, snorkeling, and scuba diving. The 1968 World Surfing Championship in Rincon brought world recognition to this part of Puerto Rico's coast and forever changed surfing in Puerto Rico. In the last five decades, Puerto Rico has become a world class destination for dedicated surfers.

The following sections describe the existing and FWOP conditions of the natural, physical, built, and economic environments in additional detail.

2.2 NATURAL (GENERAL) ENVIRONMENT*

2.2.1 WATER QUALITY

As stated above the study area consists of Atlantic Ocean facing shoreline and nearshore along the north and northwest coasts of Puerto Rico. These areas are exposed predominantly to short period wind-waves with periodic exposure to longer period storm swells. In addition, water quality is affected by watershed discharges during seasonal rain and coastal storms events. The Puerto Rico Department of Natural and Environmental Resources (DNER), through the promulgation of the Puerto Rico Water Quality Standards Regulation (2019), has designated the waters of these reaches as "Class SB", where "Class SB" are coastal and estuarine waters intended for uses where the human body may come in direct or indirect contact with the water (such as swimming or fishing) and for use in propagation and preservation of desirable species. The turbidity standard for Class SB waters in Puerto Rico is not to exceed 10 nephelometric turbidity units (NTU), except by natural phenomena. The following sub-sections describe water quality for each of the focus areas.

2.2.1.1 SAN JUAN FOCUS AREAS– CONDADO, OCEAN PARK, ISLA VERDE AND CAROLINA

EXISTING CONDITION

Most of the San Juan study area is protected by linear offshore "fringing" reefs, which dissipate some of the ocean-driven waves. The San Juan bay estuary is connected to the Atlantic Ocean via Boca del Morro and el Boquerón (west of the Condado focus area) and via the Boca de Cangrejos inlet (east of the Carolina focus area). River discharges into the San Juan Bay laden storm water which contribute to degradation of water quality along the coastal waters of the San Juan study area (See **Figure 2-1**).

FUTURE WITHOUT-PROJECT CONDITION

Shoreline erosion and flooding would continue to cause chronic increases in turbidity and sedimentation and degraded water quality along the San Juan study area.

2.2.1.2 RINCON FOCUS AREA

EXISTING CONDITION

The water quality of the Rincon study area is also affected by stormwater discharges though to a lesser degree. The water quality appears to be generally good in the Rincon study area though the Rio Añasco discharges approximately five miles southeast. See

Figure 2-2.

FUTURE WITHOUT-PROJECT CONDITION

Shoreline erosion and flooding would continue to cause chronic increases in turbidity and sedimentation along and adjacent to the shorelines and degraded water quality in the Rincon study area.

Figure 2-1. October 2004 Google Earth Aerial with Hurricane Jeanne storm water discharges along the San Juan Study Area from Boca del Morro and el Boquerón to the West and Boca de Cangrejos to the east

Figure 2-2. October 2004 Google Earth Aerial after Hurricane Jeanne with nearshore turbidity along the Rincon Study Area.

2.2.2 SHORELINES AND VEGETATION

2.2.2.1 SAN JUAN FOCUS AREAS – CONDADO, OCEAN PARK, ISLA VERDE AND CAROLINA

EXISTING CONDITION

Condado
The Condado study area contains the smallest extent of dry beach out of the four San Juan areas. The sandy pocket beach in the middle is roughly 250 feet wide at its widest. The beach berm is relatively flat and there is a lack of natural features such as dunes and dune vegetation. There is some tropical coastal vegetation (coconut palm, sea grape) at the transition to the adjacent uplands.

Punta Piedrita
This headland study area contains no dry beach and waves break directly on exposed oolianite bedrock, rock revetment, nearshore hardbottom and seawalls.

Ocean Park
Ocean Park study area contains a central beach approximately 1.1 miles long and roughly 280 feet wide at the widest part of the beach. There are sparse dunes ranging from 10-15 feet above MSL with some

tropical coastal vegetation (coconut palm, sea grape, Hibiscus, tropical almond). Barbosa Park is the only undeveloped stretch of coastline amid homes and condominiums.

Punta las Marias
This headland study area contains little to no dry beach and waves break directly on exposed oolianite bedrock, rock revetment, nearshore hardbottom and seawalls.

Isla Verde
The Isla Verde study area includes a central wide beach approximately 1.3 miles long by 250 feet wide at its widest. The beach berm is relatively flat with intermittent dunes and herbaceous vegetation. The western and eastern extents of Isla Verde contain little to no dry beach. There is some tropical coastal vegetation (coconut palms, sea grapes, hibiscus, and tropical almond) at the transition to the adjacent uplands.

Carolina
The Carolina focus area contains the least amount of hard structures for any beach in San Juan from Boca de Cangrejos to El Boquerón. The easternmost half mile contains essentially no beach, where a rock revetment protects PR 187. The dry beach in the central area spans roughly 85-200 feet wide, has a very mild slope, and sparse and intermittent dunes without vegetation. There is some tropical coastal vegetation (coconut palms, sea grapes, hibiscus, tropical almond, Australian pine) at the transition to the adjacent uplands.

FUTURE WITHOUT-PROJECT CONDITION

In the future without-project condition/No Action Alternative, unabated shoreline erosion would continue to negatively impact the sandy pocket beach shorelines along the San Juan study area. The portions of the shoreline with revetment or exposed bedrock would likely remain stable while the sandy shoreline erodes. Future SLR would also impact this shoreline type in the San Juan study area inundating existing sandy beaches and increasing the rate of erosion.

2.2.2.2 RINCON FOCUS AREA

EXISTING CONDITION

The Rincon focus area contains wider beaches and elevated berm crests to the north and narrower beaches with abandoned homes, some physically in the water, to the south. The southern portion of Rincon, which includes Stella and Corcega, generally consists of coastline with minimal to no dry beach. There is high extent of coastal structures like riprap and seawalls protecting homes and hotels.

FUTURE WITHOUT-PROJECT CONDITION

In the future without-project condition/No Action Alternative, unabated shoreline erosion would continue to negatively impact the shorelines along the Rincon study area. The portions of the shoreline with riprap and seawalls would likely remain stable while the sandy shoreline erodes. Future SLR would also impact this shoreline type by inundating existing shorelines and increasing the rate of erosion.

2.2.3 SUBMERGED AQUATIC VEGETATION

2.2.3.1 SAN JUAN FOCUS AREAS – CONDADO, OCEAN PARK, ISLA VERDE AND CAROLINA

EXISTING CONDITION

Submerged aquatic vegetation (SAV) consisting of marine macroalgae and seagrass occurs at scattered locations within the study area and generally inshore of the fringing reefs. Seagrass species previously documented include shoal grass (*Halodule wrightii*), paddle grass (*Halophila decipiens*), manatee grass (*Syringodium filiforme*), and turtle grass (*Thalassia testudinum*). Scattered seagrass beds have been documented in the backreef zone inshore of the fringing reefs offshore Carolina. These include dense beds of shoal grass, paddle grass, manatee grass and turtle grass (Alcatel-Lucent 2013). In addition, turtle grass beds were documented in the backreef zone in the Condado nearshore eight months after the passing of hurricanes Irma and Maria (Tetra Tech 2018). Seasonal variation of seagrass coverage in this backreef zone is likely due to shifting sediments, currents, and changing water temperatures.

Seagrasses significantly modify the physical, chemical, and geological properties of coastal areas; they provide nutrients, primary energy, and habitats which sustain our coastal fisheries resources; and they provide foraging grounds for some endangered marine species (Vicente, 1990). Federally protected species such as green sea turtles (*Chelonia mydas*) and Antillean manatees (*Trichechus manatus manatus*) feed directly on seagrasses. Seagrass beds also serve as a substrate for epiphytes, such as filamentous algae and epiphytic diatoms, which in turn serve as food for invertebrates and fish.

A total of 13 different genera of macroalgae were observed during a 2011 benthic survey of nearby inshore Condado lagoon. The different macroalgae genus observed were: *Acetabularia, Amphiroa, Batophora, Caulerpa, Dictyopteris, Dictyota, Gracilaria, Halimeda, Jania, Laurencia, Padina, Sargassum*, and *Udotea*. *Caulerpa spp., Dictyota spp., Acetabularia spp.*, and *Laurencia spp*. were the dominant genera. The macroalgal community of the backreef zone is resilient to physical impact. High energy arriving from the Atlantic Ocean is known to scour the seafloor leaving hardbottom devoid of algae. Recolonization of those areas by green, red and brown algal species can occur in a short time frame given their high growth rates (Alcatel-Lucent 2013).

FUTURE WITHOUT-PROJECT CONDITION

In the future without-project condition/No Action Alternative, ongoing shoreline erosion would continue to negatively impact SAV along the San Juan study area from turbidity and sedimentation.

2.2.3.2 RINCON FOCUS AREA

EXISTING CONDITION

Intermittently exposed hardbottom to the north and prevalent submerged hardbottom to the south typically characterize the nearshore zone. The nearshore hardbottom appears to be somewhat ephemerally exposed oolianite bedrock. Periodic sand coverage likely limits SAV colonization to turf macro algae as mature SAV has not been found in the area. Large areas of offshore seagrass habitat occur approximately six miles south of the Rincon study reach south of the Añasco River.

FUTURE WITHOUT-PROJECT CONDITION

In the future without-project condition/No Action Alternative, ongoing shoreline erosion would continue to negatively impact SAV along the Rincon study area due to increased turbidity limiting the availability of light for growth (photosynthesis).

2.2.4 HARBOTTOM HABITAT

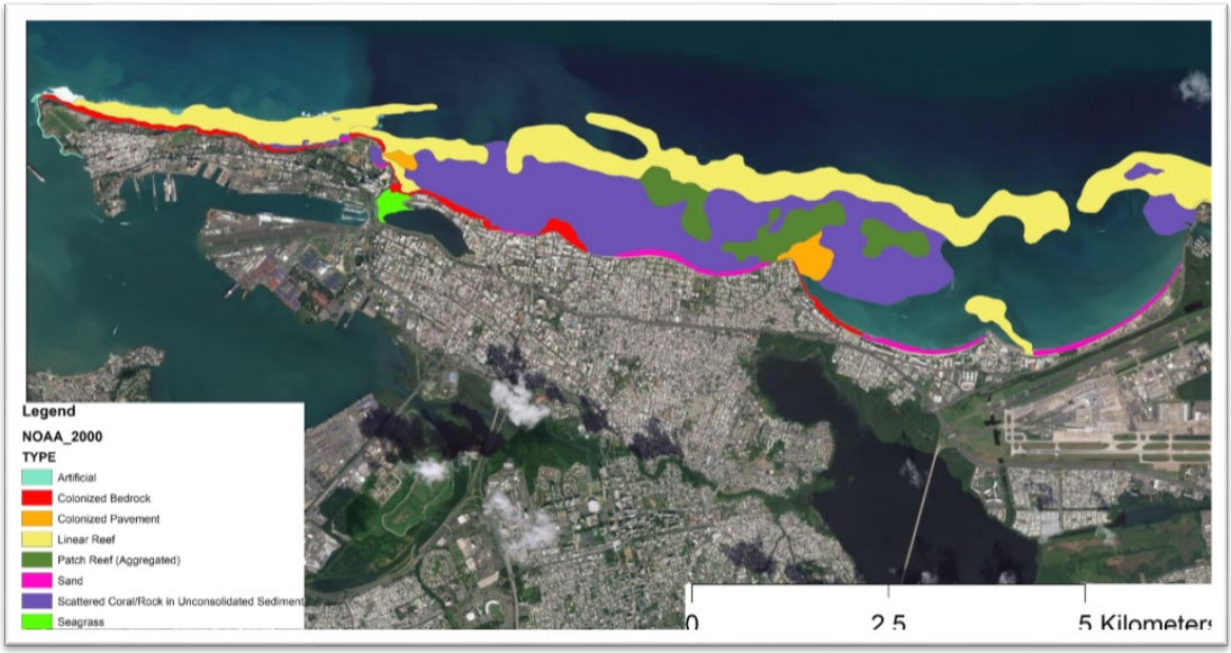
2.2.4.1 SAN JUAN FOCUS AREAS – CONDADO, OCEAN PARK, ISLA VERDE AND CAROLINA

EXISTING CONDITION

The San Juan study reach is bounded by narrow, discontinuous linear or fringing reef consisting of corals covering fossil sand dunes (i.e., oolianite). National Oceanic and Atmospheric Administration (NOAA) Benthic Habitat Mapping designated this area as Linear and Patch coral reef (NOAA 2000). These areas are characterized by reef-building Scleractinian (hard) corals which form colonies of coral polyps held together by calcium carbonate. These corals belong to the class Anthozoa in the animal phylum Cnidaria, which includes sea anemones and jellyfish. Unlike sea anemones, Scleractinian corals secrete hard carbonate exoskeletons that support and protect the coral. Hard corals (including seven (7) species listed as threatened under the ESA; See Section 2.2.6 below) occur on the fringing reefs and have been documented on the inshore patch reef and scattered rock. Scattered hardbottom habitat occurs inshore of the fringing reefs in the backreef zone (between the fringing reefs and the shoreline). This area was designated as patch reef and scattered coral/rock in unconsolidated sediment (NOAA 2000). Finally, there are areas of exposed and ephemerally exposed oolianite bedrock along the study area shorelines and are designated as colonized bedrock (NOAA 2000). See **Figure 2-3** hard corals of the genus *Montastrea*, *Diploria*, *Porides*, and *Siderastrea* have been documented in the backreef zone inshore of the fringing reefs offshore Isla Verde and Carolina (Alcatel-Lucent 2013). In addition, mostly small isolated hard corals (*Diploria*, *Siderastrea*) were documented in the backreef zone in the Condado nearshore eight months after the passing of hurricanes Irma and Maria (Tetra Tech 2018).

The fringing coral reefs, patch reef, scattered hardbottom, and colonized bedrock habitat of the study area provide valuable structure for benthic (occurring at the bottom of a body of water) fauna and flora, and fish habitat. Coral reef, patch reef, and hardbottom refer to a classification of coral communities that occur in temperate, subtropical, and tropical regions. Hardbottom lacks the diversity, density, and reef development of the higher relief fringing coral reef community and patch reefs lack connectivity. However, all provide habitat for a diverse array of invertebrate and fish species. These communities support habitat-structuring sessile (non-mobile) epifauna (organisms living on the sea floor) such as sponges, corals, bryozoans, and ascidians.

Figure 2-3. San Juan Study Reaches Benthic Habitat Map from NOAA 2000



FUTURE WITHOUT-PROJECT CONDITION

Unabated shoreline erosion and sedimentation could negatively affect nearshore hardbottom under the FWOP condition from chronic turbidity and possibly burial. In addition, ongoing erosion could also expose eolianite bedrock in other areas increasing the available consolidated hard substrate for colonization.

1.1.1.1 RINCON FOCUS AREA

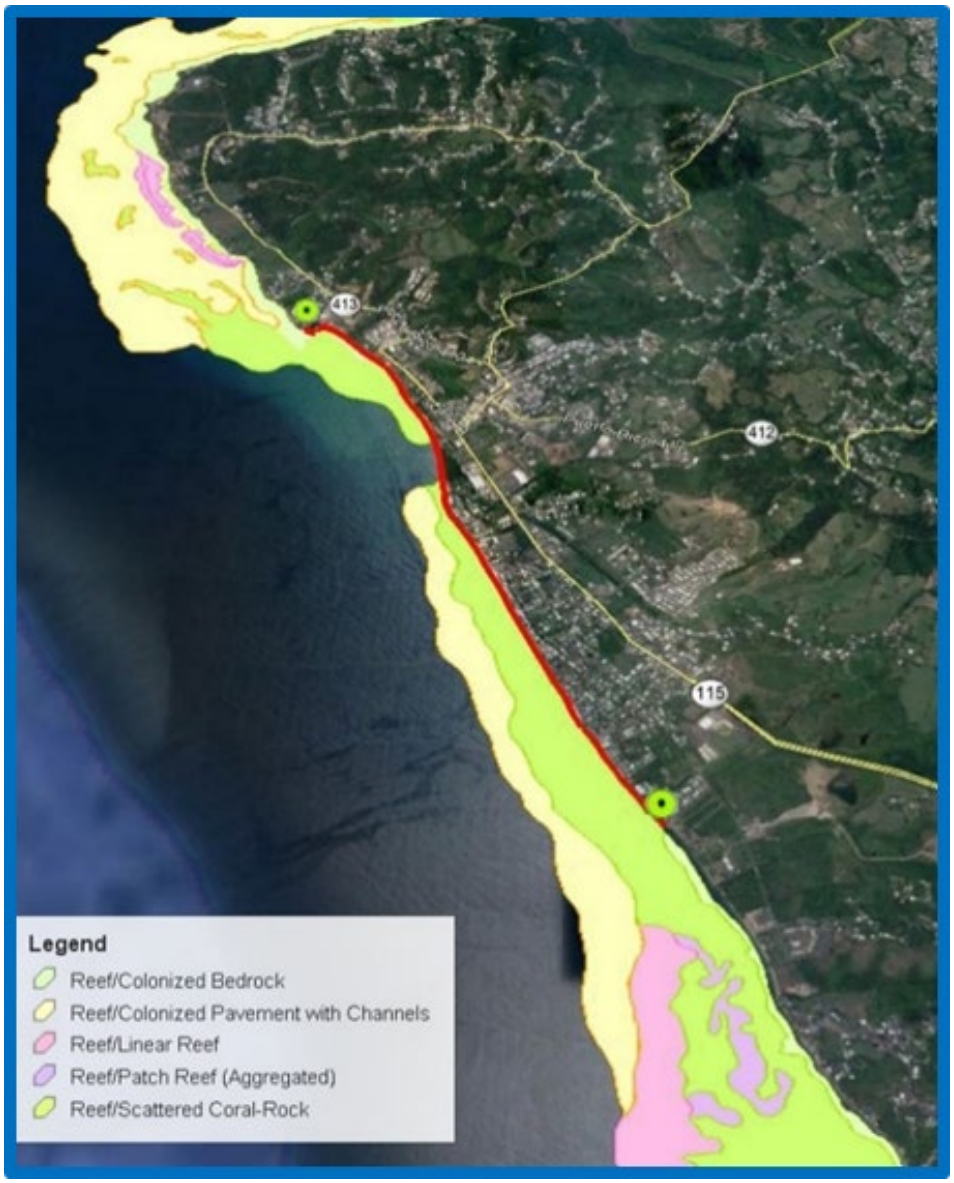
EXISTING CONDITION

Intermittently exposed hardbottom to the north and prevalent submerged hardbottom to the south typically characterize the nearshore zone of the Rincon study reach. The nearshore hardbottom appears to be partially ephemerally exposed oolianite bedrock. Periodic sand coverage likely limits colonization of the hard substrate. However, encrusting zoanthids, octocorals, turf macroalgae, seagrass and sponges could possibly occur in this habitat. The Tres Palmas marine reserve, with its coastal vegetation, sandy beaches, and shallow-water coral communities composed primarily of Elkhorn coral (*Acropora palmata*), is located north of Punta Ensenada, the northern limit of Rincon focus area. See **Figure 2-4**.

FUTURE WITHOUT-PROJECT CONDITION

Unabated shoreline erosion and sedimentation could affect nearshore hardbottom along the Rincon study area under the FWOP condition from turbidity and sedimentation. In addition, ongoing erosion could also expose more eolianite bedrock thereby increasing the available consolidated hard substrate for colonization.

Figure 2-4. Rincon Study Reach Benthic Habitat Map from NOAA 2000



2.2.5 ESSENTIAL FISH HABITAT

The Essential Fish Habitat (EFH) provisions of the Magnuson-Stevens Act are intended to protect those waters and substrates necessary to fish for spawning, breeding, feeding or growth to maturity. If a proposed action potentially affects EFH, then consultation with NMFS is required. The EFH consultation ensures the potential action considers the effects on important habitats and supports the management of sustainable marine fisheries.

In the Caribbean waters under the jurisdiction of the U.S., EFH is identified and described based on areas where the life stages of 17 managed species of fish and marine invertebrates occur. Fifteen of the 17 managed species have been documented in the study area and are listed in Error! Reference source not found. below.

EFH for this study includes all waters and substrates (coral reef, submerged aquatic vegetation, colonized bedrock, patch reef and scattered coral/rock in unconsolidated sediment) that are necessary for the reproduction, growth, and feeding of marine species.

2.2.5.1 ALL FOCUS AREAS – CONDADO, OCEAN PARK, ISLA VERDE, CAROLINA, AND RINCON

EXISTING CONDITION

Different life history stages of fishery, ornamental and other reef and reef-associated fish species inhabit the linear coral reef and backreef zones of the study area. "A rich assemblage comprised by more than 60 species of coral reef fishes and commercially important shellfish, including spiny lobster (Panulirus argus) and queen conch (Strombus gigas) have been reported to inhabit these reef systems (García-Sais et al., 2005 a, b; 2013)." These habitats see high fish abundance because they provide food and refuge. EFH within the San Juan study area includes coral reef, submerged aquatic vegetation, colonized bedrock, patch reef, scattered coral/rock in unconsolidated substrate, high salinity surf zone and marine water column with unconsolidated substrate. Many of these habitats foster growth and provide food and protection from predators and are integral to producing healthy populations of commercially and recreationally important species. Species that may occur in the project area habitats are noted in Error! Reference source not found..

Table 2-1. Managed Species Documented in the Study Area

Species	Common Name	SPAG*	FMP
Chaetodon striatus	Banded Butterflyfish		Reef Fish - aquarium trade
Epinephelus guttatus	Red Hind		Reef Fish
Cephalopholis fulva	Coney		Reef Fish
Lutjanus analis	Mutton Snapper	X	Reef Fish
Lutjanus apodus	Schoolmaster	X	Reef Fish
Lutjanus griseus	Gray Snapper		Reef Fish
Ocyurus chrysurus	Yellowtail Snapper	X	Reef Fish
Haemulon plumieri	White Grunt		Reef Fish
Balistes vetula	Queen Triggerfish		Reef Fish
Sparisoma viride	Stoplight Parrotfish	X	Reef Fish
Holocentrus ascensionis	Squirrelfish		Reef Fish
Malacanthus plumieri	Sand Tile Fish		Reef Fish
Panulirus argus	Spiny Lobster		Spiny Lobster
Strombus gigas	Queen Conch		Queen Conch
Cnidarians	All Corals		Coral

Source: Rivera, 2015; CSA Architects & Engineers, 2014; ERM, 2013; Glauco A. Rivera & Associates, 2011.
*SPAG: Potential Spawning Aggregation site in San Juan Bay (Ojeda et. al. 2007).

Per the Fishery Management Plan (FMP) for each of the four groups below, EFH is defined as (Caribbean Fisheries Management Council (CFMC) and NOAA 2004):

Spiny Lobster FMP: EFH in the U.S. Caribbean consists of all waters from MHW to the outer boundary of the EEZ- habitats used by phyllosoma larvae and seagrass, benthic algae, mangrove, coral, and live/hard bottom substrates from MHW to 100 fathoms depth used by other life stages.

Queen Conch FMP: EFH in the U.S. Caribbean consists of all waters from MHW to the outer boundary of the EEZ – habitats used by eggs and larvae and seagrass, benthic algae, coral, live/hard bottom and sand/shell substrates from MHW to 100 fathoms depth used by other life stages.

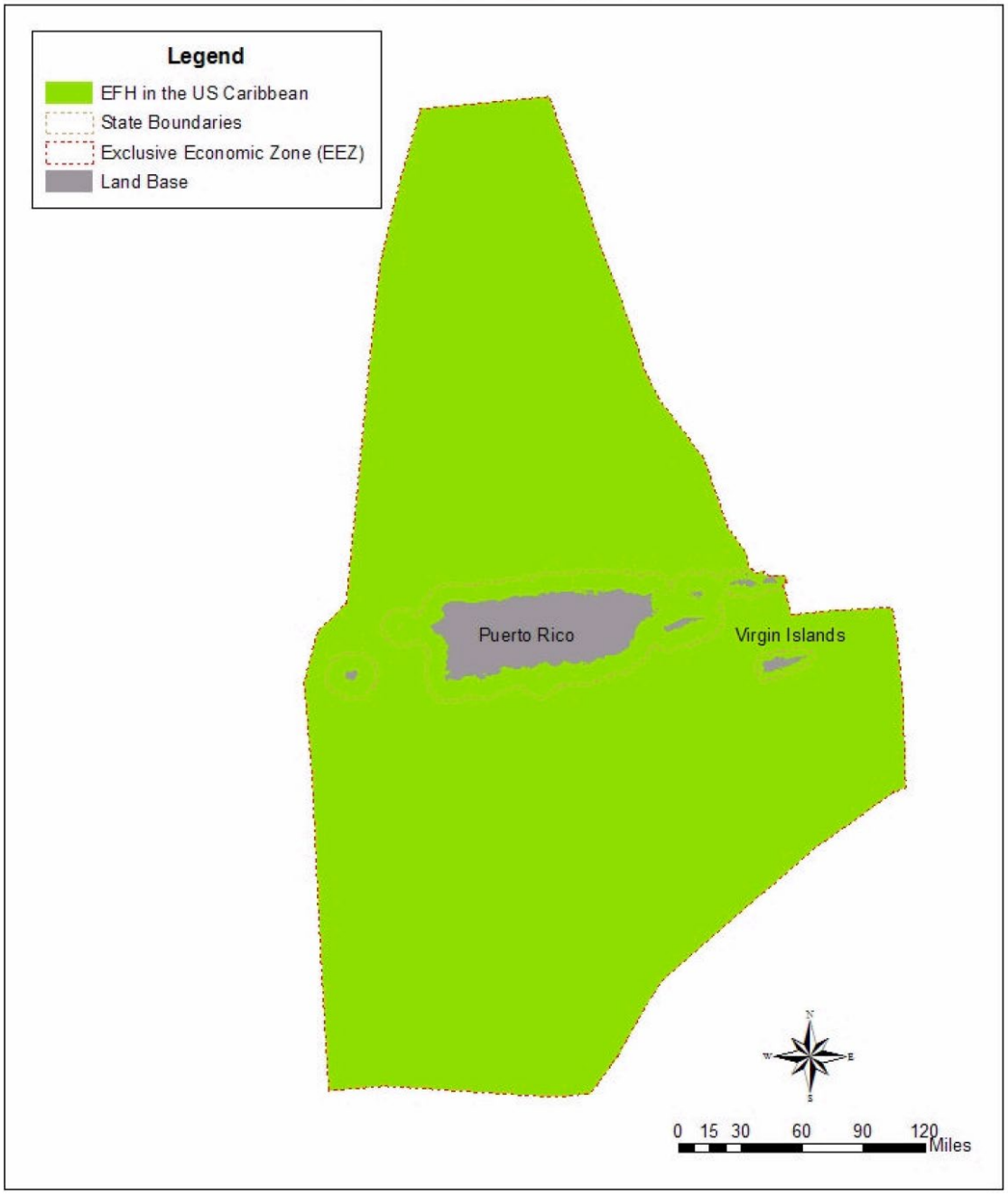
Reef Fish FMP: EFH in the U.S. Caribbean consists of all waters from MHW to the outer boundary of the EEZ – habitats used by eggs and larvae and all substrates from MHW to 100 fathoms depth used by other life stages.

Coral FMP: EFH in the U.S. Caribbean consists of all waters from mean low water (MLW) to the outer boundary of the EEZ – habitats used by larvae and coral and hard bottom substrates from MLW to 100 fathoms depth – used by other life stages.

FUTURE WITHOUT-PROJECT CONDITION

Unabated shoreline erosion could cause increased turbidity and potentially loss of backreef sea grasses in the San Juan study area. In addition, nearshore hardbottom and coral reefs could be impacted by these coastal processes as well at both San Juan and Rincon study areas. Therefore, the FWOP condition could have a negative effect to EFH due to loss of available habitat for these species.

Figure 2-5. Composite EFH for species and life stages of the Spiny Lobster, Queen Conch, Reef Fish, and Coral.



2.2.6 PROTECTED SPECIES

2.2.6.1 ALL FOCUS AREAS – CONDADO, OCEAN PARK, ISLA VERDE, CAROLINA, AND RINCON

The U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS) have responsibilities under the Endangered Species Act of 1973 (ESA) to protect certain species. There are many threatened and endangered (T&E) species known to occur near the study areas. However, not all of them would be affected by a proposed action. Accordingly, the USACE is working with USFWS Field Office in Boqueron, Puerto Rico, as well as the NMFS Southeast Regional Office in St. Petersburg, Florida to focus on the species listed in Error! Reference source not found.. This list includes the federally listed T&E species that could be present in the area based upon their geographic range. However, the actual occurrence of a species in the area would depend upon the availability of suitable habitat, the season of the year relative to a species' temperature tolerance, migratory habits, and other factors. The following sections summarize species-specific information relevant to the study area.

Table 2-2. Selected federally threatened and endangered species potentially present in the vicinity of the study areas in Rincon and San Juan, Puerto Rico

Common Name	Scientific Name	Status	Year Listed
Marine Mammals			
Antillean Manatee	*Trichechus manatus*	T	2017
Marine Turtles			
Leatherback turtle	*Dermochelys coriacea*	E	1970
Hawksbill turtle	*Eretmochelys imbricata*	E	1970
Green turtle	*Chelonia mydas*	Northwest Atlantic DPS;	2016
Fish			
Scalloped hammerhead shark	*Sphyrna lewinii*	Central and Southwest Atlantic DPS; T	2014
Nassau grouper	*Epinephelus striatus*	T	2016
Giant manta ray	*Manta birostris/ M. alfredi*	T	2017
Corals			
Elkhorn coral	*Acropora palmata*	T	2006
Staghorn coral	*Acropora cervicornis*	T	2006
Pillar coral	*Dendrogyra cylindrus*	T	2014
Rough Cactus Coral	*Mycetophyllia ferox*	T	2014
Lobed Star Coral	*Orbicella annularis*	T	2014
Mountainous Star Coral	*Orbicella faveolata*	T	2014
Boulder Star Coral	*Orbicella franksi*	T	2014

E – federally-endangered
T – federally-threatened
Endangered: A taxon "in danger of extinction throughout all or a significant portion of its range."
Threatened: A taxon "likely to become endangered within the foreseeable future throughout all or a significant portion of its range."

2.2.6.1.1 FISHES

EXISTING CONDITION

Of the three listed fish species, Nassau grouper are most likely to occur in the vicinity of the project. However, in the late 1980s Nassau grouper reached commercial extinction and a fishery moratorium was implemented in the 1990s, but commercial fishing continued in Florida and the U.S. Atlantic (including Puerto Rico) despite initial moratoriums (Frias-Torres, 2008). The scalloped hammerhead shark and giant manta ray are considered to be a migratory species that are commonly found offshore in the open ocean and on the outer continental shelf.

Scalloped Hammerhead Shark. The hammerhead sharks are recognized by their laterally expanded head that resembles a hammer. The scalloped hammerhead shark (*Sphyrna lewinii*) is distinguished by a marked central indentation on the anterior margin of the head, along with two more indentations on each side of this central indentation, giving the head a "scalloped" appearance. The body is fusiform, with a large first dorsal fin and low second dorsal and pelvic fins. Coloration is generally uniform gray, grayish brown, bronze, or olive on top of the body that shades to white on the underside with dusky or black pectoral fin tips. This shark is a high trophic level predator and opportunistic feeder with a diet that includes a wide variety of teleosts, cephalopods, crustaceans, and rays. The northwest Atlantic Ocean DPS was listed under the ESA as threatened on September 2, 2014.

Estuaries and coastal embayments have been identified as particularly important nursery areas, while offshore waters contain important spawning and feeding areas. Adult habitat consists of continental shelf areas further offshore, with adult aggregations common over seamounts and near islands. The scalloped hammerhead shark can be found in coastal warm temperate and tropical seas worldwide. In the western Atlantic Ocean, the species range extends from the northeast coast of the United States (from New Jersey to Florida) to Brazil, including the Gulf of Mexico and Caribbean Sea. The species could occur along the north and northwest coasts of Puerto Rico but likely outside of the area of influence of the proposed action.

Nassau Grouper. The Nassau grouper (*Epinephelus striatus*) is a long-lived (29 years max), moderate sized Serranid fish with large eyes and a robust body. The range of color is wide, but ground color is generally buff, with five dark brown vertical bars and a large black saddle blotch on top of caudal peduncle and a row of black spots below and behind its eye. There is also a distinctive dark tuning-fork mark beginning at the front of the upper jaw, extending dorsally (on top) along the interorbital region, and then dividing into two branches on top of the head behind the eyes; another dark band from the tip of the snout through the eye and then curving upward to meet its fellow just before the dorsal-fin origin. Juveniles exhibit a color pattern similar to adults. On 29 June 2016, NMFS issued a final rule (81 FR 42268) listing the Nassau Grouper as a threatened species under the ESA.

The Nassau grouper is primarily a shallow-water, insular fish species that has long been valued as a major fishery resource throughout the wider Caribbean, South Florida, Bermuda and the Bahamas. The Nassau grouper is considered a reef fish, but it transitions through a series of developmental shifts in habitat. The larvae are planktonic and after 35-40 days recruit from an oceanic environment into demersal habitats hiding in macroalgae, coral, and seagrass beds.

The Nassau grouper's confirmed distribution currently includes Bermuda, Florida, throughout the Bahamas and Caribbean Sea. The species does occur along the north and northwest coasts of Puerto Rico possibly within the area of influence of the proposed action.

Giant Manta Ray. On January 12, 2017, NMFS published a proposed rule in the Federal Register (82 FR 3694) to list the giant manta ray (*Manta birostris/M. alfredi*) as threatened species under the ESA. The distribution of the giant manta ray is worldwide in tropical and temperate ocean waters. On the U.S. Atlantic Coast, the giant manta ray has been documented as far north as New Jersey. The giant manta ray is commonly encountered on shallow reefs or sighted feeding offshore at the surface. The giant manta ray is occasionally observed in sandy bottom areas and seagrass beds. Regional sub-populations appear to be small and generally contain less than 1,000 adult individuals and are generally declining except for those areas where they are specifically protected (Hawaii, Maldives, Yap, Palau). The primary threats to *Manta* species are targeted fishing and fishery bycatch. This species is anticipated to occur outside the area of influence of the proposed action.

FUTURE WITHOUT-PROJECT CONDITION

No effects to these overfished and oceanic species are anticipated in the FWOP. They are not expected to occur in the San Juan study area and therefore would not be affected by unabated shoreline erosion and sedimentation in the FWOP condition.

2.2.6.1.2 SEA TURTLES

EXISTING CONDITION

Four different sea turtle species could occur in the study area, loggerhead, leatherback, hawksbill, and green. Of the four species, the leatherback and hawksbill are the most common nesting species in the San Juan and Rincon study areas. As discussed in Section 2.2.2 above, sandy beach habitat occurs within the pocket beaches of the San Juan study reach and along the shoreline of the Rincon study reach. According to DNER, sea turtle nesting on the San Juan study area beaches has increased during the past decade. At least three Non-Governmental Organizations (NGO) collaborate with DNER for sea turtle nest detection and protection, including 7-quillas, Arrecifes Pro-Ciudad and CRES. DNER and these Sea Turtle Watch groups keep detailed locations and stats of nests by species and numbers of hatchlings.

Leatherback. Leatherback sea turtles (*Dermochelys coriacea*) are widely distributed throughout the oceans of the world, and are found in waters of the Atlantic, Pacific, and Indian oceans (Ernst and Barbour, 1972). Leatherback turtles are the largest living turtles and have a larger migration range than any other sea turtle species. The leatherback is the most pelagic (open ocean) of the sea turtles and is often seen near the edge of the continental shelf; however, they are also observed just offshore of the surf line. They enter coastal waters on a seasonal basis to feed in areas where jellyfish are concentrated.

Zug and Parham (1996) pointed out that the main threat to leatherback populations in the Atlantic is the combination of fishery-related mortality (especially entanglement in gear and drowning in trawls) and the intense egg harvesting on the main nesting beaches. Boat strikes are also a threat and source of mortality for leatherbacks in Puerto Rico. There is potential for leatherbacks to be present off the north and northwest coasts and leatherback nesting has been documented on the sandy beaches of both the San Juan and Rincon study reaches. According to DNER in Ocean Park and Condado, there are from 5 to 35 leatherback sea turtle nests in a given season (generally mid-February to August/September). This includes around 8 nests in a given season in Condado with most of the nesting occurring in Ocean Park.

The Rincon study area sees similar leatherback sea turtle nesting numbers. These nest numbers are low, compared with near-by less developed areas like Piñones, Dorado. No critical habitat has been designated for leatherback turtles in the project area.

Loggerhead. The loggerhead (*Caretta caretta*) is characterized by a large head with blunt jaws. The carapace and flippers are a reddish-brown color; the plastron is yellow. Adults grow to an average weight of about 200 pounds. The USFWS and the NMFS listed the Northwest Atlantic Ocean distinct population segment (DPS) of the loggerhead sea turtle as threatened on September 22, 2011 (76 FR 58868). The species feeds on mollusks, crustaceans, fish, and other marine animals. The loggerhead sea turtle can be found throughout the temperate and tropical regions of the Atlantic, Pacific, and Indian Oceans. It may be found hundreds of miles out to sea, as well as in inshore areas such as bays, lagoons, salt marshes, creeks, ship channels, and the mouths of large rivers. Coral reefs, rocky places, and shipwrecks are often used as feeding areas. This species could occur offshore San Juan Harbor, approximately X miles from the study area. No critical habitat has been designated for loggerhead turtles in the project area. Loggerhead sea turtle nesting has not been documented in Puerto Rico (NMFS 2017; DNER 2016).

Hawksbill. The hawksbill turtle (*Eretmochelys imbricata*) is small to medium-sized compared to other sea turtle species. Hawksbill turtles are unique among sea turtles in that they have two pairs of prefrontal scales on the top of the head and each of the flippers usually has two claws. This species was listed under the ESA as endangered in 1970.

Hawksbill turtles use different habitats at different stages of their life cycle, but are most commonly associated with healthy coral reefs. The ledges and caves of coral reefs provide shelter for resting hawksbills both during the day and at night. Hawksbills are known to inhabit the same resting spot night after night. Hawksbills are also found around rocky outcrops and high energy shoals. These areas are optimum sites for sponge growth, which certain species are the preferred food of hawksbills. They are also known to inhabit mangrove-fringed bays and estuaries, particularly along the eastern shore of continents where coral reefs are absent.

Hawksbills nest year-round in Puerto Rico but nesting peaks from August - October. Hawksbills nest at night and, on average, about 4.5 times per season at intervals of approximately 14 days. They nest under the vegetation on the high beach and nests have been observed having the last eggs of the clutch as close as 3 inches from the sand's surface. Hawksbill sea turtle nesting has been documented in the San Juan study area on the sandy beach north of the Avenida Ashford (Dos Hermanos) Bridge (USFWS, 2005 – Harberer 2005). In addition, DNER 2016 reported relatively low hawksbill sea turtle nesting in Rincon with high nesting by this species occurring in southeast Puerto Rico and Vieques and Mona Islands. Designated Critical Habitat (DCH) for this species occurs approximately 50 miles east of the project area around Culebra Island.

Green. The nesting range of green sea turtles in the southeastern United States includes sandy beaches of mainland shores, barrier islands, coral islands, and volcanic islands between Texas and North Carolina, the U.S. Virgin Islands (USVI) and Puerto Rico (NMFS and USFWS, 1991). Green turtles (*Chelonia mydas*) are primarily herbivorous, feeding on algae and sea grasses, but also occasionally consume jellyfish and sponges. Green turtle foraging areas in the southeastern United States include any coastal shallow waters having macroalgae or sea grasses, including areas near mainland coastlines, islands, reefs, or shelves, and any open-ocean surface waters, especially where advection from wind and currents concentrates pelagic (open ocean) organisms (Hirth, 1997; NMFS and USFWS, 1991). Adults of both sexes are presumed to

migrate between nesting and foraging habitats along corridors adjacent to coastlines and reefs. The hardbottom and SAV habitat found in the San Juan and Rincon study areas are important grazing areas for the green sea turtle. Very few green sea turtles nest on the main island of Puerto Rico with nesting mainly occurring off the southeast coast on the island of Vieques. Though no DCH for this species occurs within the study area, there is DCH approximately 50 miles east of the project area around Culebra Island.

FUTURE WITHOUT-PROJECT CONDITION

Unabated shoreline erosion and sedimentation under the FWOP condition could negatively affect foraging sea turtles from loss of SAV habitat. Sandy beach sea turtle nesting habitat would continue to be lost to erosion and therefore, nesting opportunities would diminish within the study area.

2.2.6.1.3 ANTILLEAN MANATEES

EXISTING CONDITION

Antillean manatees (*Trichechus manatus manatus*) have large, seal-shaped bodies with paired flippers and a round, paddle-shaped tail. They are typically grey (color can range from black to light brown) and are occasionally spotted with barnacles attached to them or colored by patches of green or red algae. Average adult manatees are about nine feet long and weigh about 1,000 pounds (https://www.fws.gov/southeast/wildlife/mammals/manatee/).

The Antillean manatee inhabits the coastal waters of Puerto Rico and has been documented both feeding and traveling in San Juan Bay and along the north coast of San Juan. Manatee sightings in Rincon are fewer though both habitat and manatee population increase south of the Rincon study area (Atkins 2011). Seagrass beds in the bay and backreef zones provide suitable foraging habitat. The USFWS has jurisdiction for protection of the manatee under the ESA and the MMPA. On April 5, 2017, the USFWS published a final rule reclassifying the West Indian manatee and its two recognized subspecies (Florida and Antillean) from endangered to threatened (82 FR 16680). This species is also protected by Law Number 241 (Wildlife Law of the Commonwealth of Puerto Rico) and Regulation Number 6766, which regulates the management of threatened and endangered species in Puerto Rico. No DCH has been designated for this species in the project area.

FUTURE WITHOUT-PROJECT CONDITION

Unabated shoreline erosion and sedimentation under the FWOP condition could affect foraging manatees through loss of SAV habitat. However, this is not expected to have a significant effect on this species since SAV forage habitat would continue to be available in San Juan Bay and south of the Rincon study area.

2.2.6.1.4 CORALS

EXISTING CONDITION

All seven Caribbean hard coral species listed as threatened under the ESA have been documented on the fringing reefs along the San Juan study area and north and south of the Rincon study area. In addition, it is possible they could occur on the inshore patch reef and scattered rock in the backreef zone in San Juan. However, high wave energy, turbidity, and shifting sediment likely limit the extent of colonization of the backreef zone by these listed hard corals.

Caribbean coral reefs are being affected by the *Stony Coral Tissue Loss Disease* (SCTLD). This disease outbreak is unprecedented in terms of the large geographic range, duration of the outbreak, number of

species affected (22 species), high rates of transmission and mortality, and considerably high prevalence, e.g., within certain species. Pillar coral (*Dendrogyra cylindrus*), listed as threatened under the ESA, is highly susceptible to the disease.

Coral reef assessments and emergency triage restoration activities were conducted by NOAA for the Federal Emergency Management Agency (FEMA) in February 2018 after the passing of hurricane's Irma and Maria in September 2017. The assessment found: "Overall, an average of 11% of Puerto Rico's corals were damaged by the hurricanes; however, some sites experienced far more severe damage (up to 100%). The major reef-building and ESA listed corals were the most severely impacted species: pillar coral (*Dendrogyra cylindrus*), elkhorn coral (*Acropora palmata*), lobed star coral (*Orbicella annularis*), and staghorn coral (*A. cervicornis*)." (NOAA 2018)

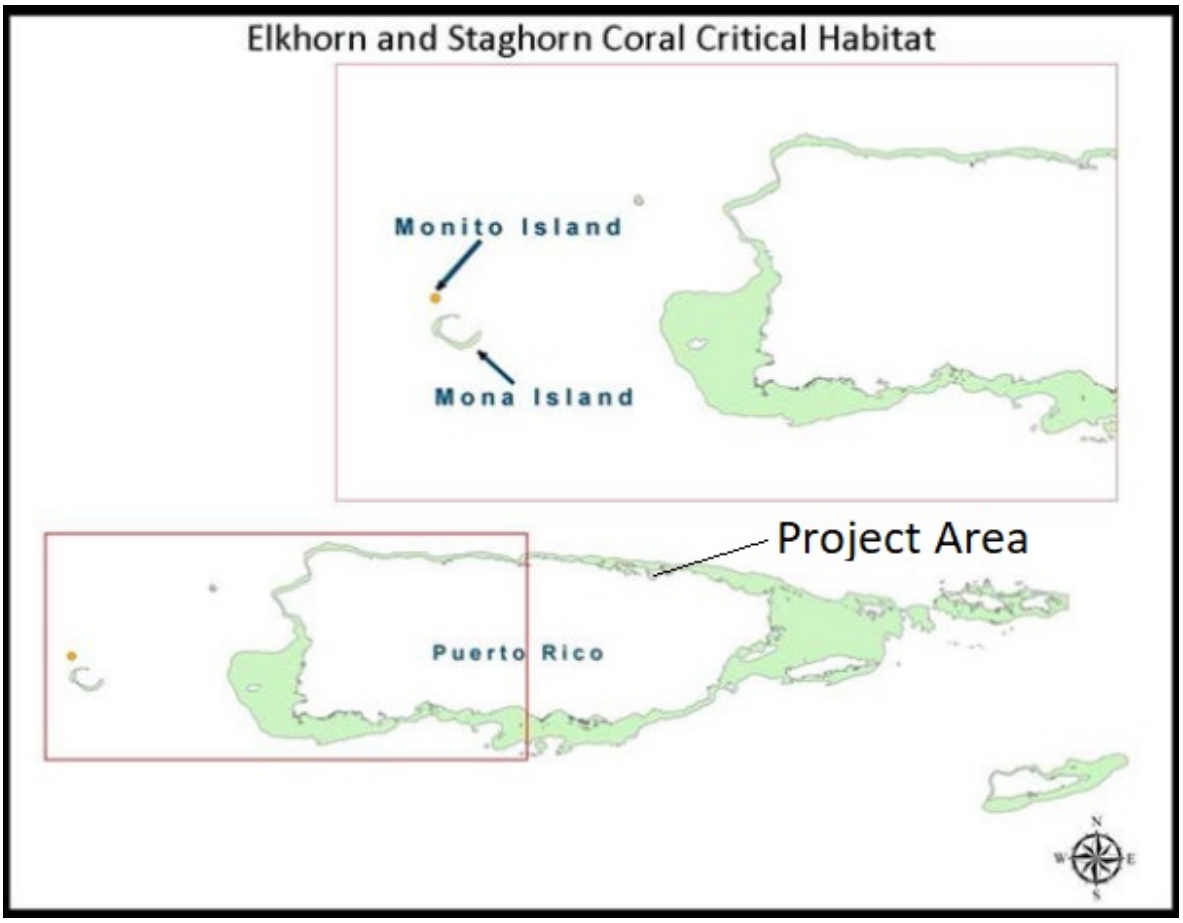
Elkhorn Coral. Elkhorn coral (*Acropora palmata*) belong to the most abundant group of corals in the world (Acropora genus) and once represented the most dominant reef building species throughout Florida and the Caribbean. Elkhorn coral is a large, branching coral with thick and sturdy antler-like branches and is found in shallow reefs, typically in water depths from 0-35 feet, as these corals prefer areas where wave action causes constant water movement. Colonies are fast growing: branches increase in length by 2-4 inches (5-10 cm) per year, with colonies reaching their maximum size in approximately 10-12 years. Over the last 10,000 years, elkhorn coral has been one of the three most important Caribbean corals contributing to reef growth and development and providing essential fish habitat. This species was listed under the ESA as threatened on May 9, 2006.

Elkhorn coral was formerly the dominant species in shallow water (3-16 ft. [1-5 m] deep) throughout the Caribbean and on the Florida Reef Tract, forming extensive, densely aggregated thickets (stands) in areas of heavy surf. Coral colonies prefer exposed reef crest and fore reef environments in depths of less than 20 feet (6 m), although isolated corals may occur to 65 feet (20 m).

NMFS has designated critical habitat for elkhorn and staghorn corals in four areas: Florida, Puerto Rico, St. John/St. Thomas, and St. Croix. **Figure 2-6** shows the DCH for Puerto Rico, which includes all areas containing consolidated hard substrate free of sand and macro-algal cover surrounding the islands of the Commonwealth of Puerto Rico, 98 ft. (30 m) in depth and shallower. In addition, a 4(d) rule (50 CFR Part 223) establishing "take" prohibitions for elkhorn and staghorn corals went into effect on November 28, 2008 for these areas. Take includes collecting, bothering, harming, harassment, damage to, death, or other actions that affect health and survival of listed species.

This species has been documented in the San Juan study area on the narrow, discontinuous linear or fringing "reef" consisting of corals covering fossil sand dunes (i.e., eolianites) trending in an east-west direction and extending, in some sites, up to 0.9 miles off shore (CFMC, 2004; CSA Architects & Engineers, 2014; ERM, 2013; Glauco A. Rivera & Associates, 2011; Coll Rivera Environmental, 2005). In addition, as discussed in Section 2.2.1.2 above the Tres Palmas marine reserve is located north of the northern limit of the Rincon study area and contains shallow-water coral communities composed primarily of Elkhorn coral (*Acropora palmata*). DCH for this species occurs in both the San Juan and Rincon study areas.

Figure 2-6. Elkhorn and Staghorn Corals Designated Critical Habitat (DCH).



Staghorn Coral. Staghorn coral (*Acropora cervicornis*) is a branching coral with cylindrical branches ranging from a few centimeters to over 6.5 feet (2 m) in length. This coral exhibits the fastest growth of all known western Atlantic corals, with branches increasing in length by 4-8 inches (10-20 cm) per year. This species was listed under the ESA as threatened on May 9, 2006.

Staghorn coral occurs in back reef and fore reef environments from 0-98 feet (0 to 30 m) deep. In addition to growing on reefs, staghorn corals often form colonies on bare sand. The upper limit is defined by wave forces, and the lower limit is controlled by suspended sediments and light availability. Fore reef zones at intermediate depths of 15-80 feet (5-25 m) were formerly dominated by extensive single species stands of staghorn coral until the mid-1980s.

Staghorn coral is found in the Atlantic Ocean, Caribbean Sea, and western Gulf of Mexico. Specifically, staghorn coral is found throughout the Florida Keys, the Bahamas, the Caribbean islands, and Venezuela. The northern limit of staghorn coral is around Boca Raton, Florida. The dominant mode of reproduction for staghorn coral is asexual fragmentation, with new colonies forming when branches break off a colony and reattach to the substrate. Sexual reproduction occurs via broadcast spawning of gametes into the water column once each year in August or September. Individual colonies are both male and female (simultaneous hermaphrodites) and will release millions of "gametes." The coral larvae (planula) live in the plankton for several days until finding a suitable area to settle, but very few larvae survive to settle

and metamorphose into new colonies. The preponderance of asexual reproduction in this species raises the possibility that genetic diversity is very low in the remnant populations. This species has been documented in the San Juan study area on the narrow, discontinuous linear or fringing "reef" consisting of corals covering fossil sand dunes (i.e., eolianites) trending in an east-west direction and extending, in some sites, up to 0.9 miles off shore (CFMC, 2004; CSA Architects & Engineers, 2014; ERM, 2013; Glauco A. Rivera & Associates, 2011; Coll Rivera Environmental, 2005). In addition, staghorn coral (*Acropora cervicornis*) occurs offshore north and south of the Rincon study area. DCH for this species occurs in both the San Juan and Rincon study areas.

Pillar Coral. Pillar coral *(Dendrogyra cylindrus)* colonies form numerous, heavy, cylindrical spires, that grow upwards from an encrusting base mass. The colonies can attain a height of 10 feet (3 m), with a pillar diameter of more than 4 inches (10 cm). Polyps are normally extended during the day, giving the colony a fuzzy appearance. This species was listed under the ESA as threatened on 10 October 2014. Colonies are typically found on flat gently sloping back reef and fore reef environment in depths of 3-82 feet (1-25 m). The species does not occur in extremely exposed locations. This species occurs in the Caribbean, the southern Gulf of Mexico, Florida, and the Bahamas. In addition, it has been documented in the San Juan study area on the narrow, discontinuous linear or fringing "reef" consisting of corals covering fossil sand dunes (i.e., eolianites) trending in an east-west direction and extending, in some sites, up to 0.9 miles off shore (CFMC, 2004; CSA Architects & Engineers, 2014; ERM, 2013; Glauco A. Rivera & Associates, 2011; Coll Rivera Environmental, 2005). In addition, it does occur offshore Rincon but is not anticipated in the study area. NMFS has not yet proposed DCH for this species.

Rough Cactus Coral. Rough cactus coral (*Mycetophyllia ferox*) colonies consist of flat plates with radiating valleys. It is a widely recognized valid species with colonies comprised of thin, weakly attached plates with interconnecting, slightly sinuous, narrow valleys. Tentacles are generally absent and corallite centers tend to form single rows. The walls of the valleys commonly join to form closed valleys, a feature not seen in other members of Mycetophyllia. The ridges are usually small and square, with a groove on top. The ridges, or walls between valleys, are commonly quite thin, and are irregular, and valleys are narrower. This species was listed under the ESA as threatened on 10 October 2014.

This species is most common in fore reef environments from 5-30 meters (but is more abundant from 10-20 meters), but also occurs at low abundance in certain deeper back reef habitats and deep lagoons. This species occurs in the Caribbean, southern Gulf of Mexico, Florida, and the Bahamas. In addition, it has been documented in the San Juan study area on the narrow, discontinuous linear or fringing "reef" consisting of corals covering fossil sand dunes (i.e., eolianites) trending in an east-west direction and extending, in some sites, up to 0.9 miles off shore (CFMC, 2004; CSA Architects & Engineers, 2014; ERM, 2013; Glauco A. Rivera & Associates, 2011; Coll Rivera Environmental, 2005). In addition, it does occur offshore Rincon but is not anticipated in the study area. NMFS has not yet proposed DCH for this species.

Lobed Star Coral. Lobed star coral (*Orbicella annularis*) colonies grow in several morphotypes that were originally described as separate species. The species occurs as long, thick columns with enlarged, dome-like tops; large, massive mounds; sheets with skirt-like edges; irregularly bumpy mounds and plates or as smooth plates. Colonies grow up to 10 feet (3 m) in diameter. The surface is covered with distinctive, often somewhat raised, corallites. This species was listed under the ESA as threatened on 10 October 2014.

Lobed star coral inhabits most reef environments and is often the predominant coral between 22-82 ft. (7-25 m). The flattened plates are most common at deeper reefs, down to 165 ft. (50 m). Common to Florida, Bahamas and Caribbean. In addition, it has been documented in the San Juan study area on the narrow, discontinuous linear or fringing "reef" consisting of corals covering fossil sand dunes (i.e., eolianites) trending in an east-west direction and extending, in some sites, up to 0.9 miles off shore (CFMC, 2004; CSA Architects & Engineers, 2014; ERM, 2013; Glauco A. Rivera & Associates, 2011; Coll Rivera Environmental, 2005). In addition, it does occur offshore Rincon but is not anticipated in the study area. NMFS has not yet proposed DCH for this species.

Mountainous Star Coral. This species has been called the "dominant reef-building coral of the Atlantic" (Brainard et al 2011). *Orbicella faveolata* buds extratentacularly to form head or sheet colonies with corallites that are uniformly distributed and closely packed, but sometimes unevenly exsert. Septa are highly exsert, with septocostae arranged in a variably conspicuous fan system, and the skeleton is generally far less dense than those of its sibling species. Active growth is typically found at the edges of colonies, forming a smooth outline with many small polyps. This species was listed under the ESA as threatened on 10 October 2014.

Orbicella faveolata is found from 3-100 feet (1-30 m) in back-reef and fore-reef habitats and is often the most abundant coral between 30-65 feet (10-20 m) in fore-reef environments. This species occurs in the Caribbean, the Gulf of Mexico, Florida, and the Bahamas. May also be present in Bermuda, but this requires confirmation. In addition, it has been documented in the San Juan study area on the narrow, discontinuous linear or fringing "reef" consisting of corals covering fossil sand dunes (i.e., eolianites) trending in an east-west direction and extending, in some sites, up to 0.9 miles off shore (CFMC, 2004; CSA Architects & Engineers, 2014; ERM, 2013; Glauco A. Rivera & Associates, 2011; Coll Rivera Environmental, 2005). In addition, it does occur offshore Rincon but is not anticipated in the study area. NMFS has not yet proposed DCH for this species.

Boulder Star Coral. This species (*Orbicella franksi*) builds massive, encrusting plate or subcolumnar colonies via extratentacular budding. The characteristically bumpy appearance of this species is caused by relatively large, unevenly exsert, and irregularly distributed corallites. Boulder Star Coral is distinguished from its sibling *Orbicella* species by this irregular or bumpy appearance; a relatively dense, heavy, and hard skeleton (corallum); thicker septo-costae with a conspicuous septocoastal midline row of lacerate teeth; and a greater degree of interspecies aggression. This species was listed under the ESA as threatened on 10 October 2014.

This species mostly grows in the open like other species of this genus, but smaller, encrusting colonies are common in shaded overhangs. It is uncommon in very shallow water, but becomes common deeper. This species occurs in the Caribbean, the Gulf of Mexico, Florida, and the Bahamas. In addition, it has been documented in the San Juan study area on the narrow, discontinuous linear or fringing "reef" consisting of corals covering fossil sand dunes (i.e., eolianites) trending in an east-west direction and extending, in some sites, up to 0.9 miles off shore (CFMC, 2004; CSA Architects & Engineers, 2014; ERM, 2013; Glauco A. Rivera & Associates, 2011; Coll Rivera Environmental, 2005). In addition, it does occur offshore Rincon but is not anticipated in the study area. NMFS has not yet proposed DCH for this species.

FUTURE WITHOUT-PROJECT CONDITION

In the future without-project condition, unabated shoreline erosion and sedimentation would continue to result in degraded water quality and negative effects to listed corals. Sedimentation could bury these

listed coral species, especially Orbicella, Mycetophyllia, and Dendrogyra, because they cannot shed the sediment like the fanlike species (Acropora; mucus sloughing). Finally, continued erosion could expose more consolidated hard substrate potentially increasing habitat for colonization by these species.

2.2.7 SEABIRDS AND SHOREBIRDS

2.2.7.1 ALL FOCUS AREAS – CONDADO, OCEAN PARK, ISLA VERDE, CAROLINA, AND RINCON

EXISTING CONDITION

The sandy and rocky shorelines and nearshore coastal waters within the San Juan and Rincon study areas are utilized by many species of seabirds and shorebirds for resting and feeding. According to the Puerto Rico Breeding Bird Atlas (Castro-Prieto, J. et al. 2020), about 58 species of birds are found within the San Juan Bay area, 44 of which are sea birds, waterfowl or wading birds. The brown pelican (*Pelecanus occidentalis*) is a permanent resident which feeds throughout the San Juan and Rincon study areas. Numerous gulls, terns, and frigate birds use the beaches for roosting and feeding.

FUTURE WITHOUT-PROJECT CONDITION

Without additional CSRM measures in place, adverse impacts to sandy beach bird habitat from unabated shoreline erosion could occur. This could affect bird assemblages in the area due to loss of habitat and foraging opportunities. However, birds would continue foraging along the rocky and reveted shorelines.

2.2.8 INVASIVE SPECIES

2.2.8.1 ALL FOCUS AREAS – CONDADO, OCEAN PARK, ISLA VERDE, CAROLINA, AND RINCON

EXISTING CONDITION

Invasive species can adversely impact native plant and animal populations by disrupting natural ecosystem functions. Islands have long been considered particularly vulnerable to biotic invasions. The 1,032 species of alien plants reported for Puerto Rico and Virgin Islands (PRVI) represent about a third of total plant diversity on these islands (DRNA 2015). Some aquatic invasive species that may occur in the project area include:

- Freshwater Plants
    - *Phragmites australis* (Common reed)
    - *Melaleuca quinquenervia* (Bottlebrush tree)
    - *Casuarina equisetifolia* (Australian pine)
- Freshwater Animals
    - *Iguana* (Green iguana)
    - *Cherax quadricarinatus* (Australian red claw crawfish)
- Marine/Estuarine Animals
    - *Pterois volitans* (Red lionfish)
    - *Oreochromis aureus* (Blue tilapia)

  - *Petrolisthes armatus* (Green porcelain crab)
  - *Perna viridis* (Asian green mussel)
  - Phyllorhiza punctata (Australian spotted jellyfish)
- Marine/Estuarine Plants
  - *Halophila stipulacea* (Mediterranean seagrass)

Species can be introduced by a variety of different mechanisms; however, most estuarine and marine species introductions are associated with shipping (Ruiz et al. 2000). Commercial shipping is the only direct mechanism related to this project. Presently, the largest single source of shipping-related introductions is ballast water (Carlton 1985, Lavoie et al. 1999). Ballast water is pumped into the hull of a vessel to stabilize the vessel and keep it upright while carrying cargo. This water can be discharged at the receiving port as the cargo is loaded or unloaded. Each vessel may take on and discharge millions of gallons of water. Ballast water taken on in foreign ports may include an abundance of aquatic plants, animals, and pathogens not native to Puerto Rico. If discharged into state waters, these foreign species may become problematic.

In addition to ballast water discharge, another important source for the introduction of nonindigenous organisms is the fouling community that grows on the hull, rudder, propellers, anchor, anchor chain, or any other submerged structure of vessels that are not properly cleaned or maintained. Historically, such fouling communities were composed of massive layers of a variety of organisms, both attached and merely entrained in or living on that growth. Although such extensive growth is not as common on seagoing vessels in recent times, it still provides an opportunity for worldwide transport of fouling organisms, particularly on towed barges and other structures like -mothballed ships and exploratory drilling platforms.

FUTURE WITHOUT-PROJECT CONDITION

In the future without-project condition, the potential will continue to exist for introduction of invasive species due to the mechanisms discussed above. Recent Federal regulations require the shipping industry to implement better controls to prevent the introduction of invasive species through the ballasts of vessels (USCG 2012). These regulations should decrease the rate at which invasive species are introduced to the study area. The USCG will continue to monitor, enforce, and revise regulations related to the discharge of ballast water while vessels are in port according to the USCG Ballast Water Management Final Rule Published 23 March 2012.

2.2.9 AIR QUALITY

2.2.9.1 ALL FOCUS AREAS – CONDADO, OCEAN PARK, ISLA VERDE, CAROLINA, AND RINCON

EXISTING CONDITION

Puerto Rico is a United States territory with commonwealth status. The USEPA, Region 2 and the Puerto Rico EQB regulate air quality in Puerto Rico. The Clean Air Act (CAA) gives USEPA the responsibility to establish the primary and secondary National Ambient Air Quality the basis of the severity of the pollution problem, nonattainment areas are categorized as marginal, moderate, serious, severe, or extreme. Each state has the authority to adopt stricter standards; however, Puerto Rico has accepted the United States Federal Standards. USEPA regulations designate Air-Quality Control Regions (AQCRs) in violation of the NAAQS as nonattainment areas. USEPA regulations designate AQCRs with levels below the NAAQS as

attainment areas. Maintenance AQCRs are areas previously designated nonattainment areas that have subsequently been designated attainment areas for a probationary period through implementation of maintenance plans. On the basis of the severity of the pollution problem, nonattainment areas are categorized as marginal, moderate, serious, severe, or extreme. Each state has the authority to adopt stricter standards; however, Puerto Rico has accepted the United States Federal Standards. USEPA regulations designate Air-Quality Control Regions (AQCRs) in violation of the NAAQS as nonattainment areas. USEPA regulations designate AQCRs with levels below the NAAQS as attainment areas. Maintenance AQCRs are areas previously designated nonattainment areas that have subsequently been designated attainment areas for a probationary period through implementation of maintenance plans. On the basis of the severity of the pollution problem, nonattainment areas are categorized as marginal, moderate, serious, severe, or extreme. Each state has the authority to adopt stricter standards; however, Puerto Rico has accepted the United States Federal Standards. USEPA regulations designate Air-Quality Control Regions (AQCRs) in violation of the NAAQS as nonattainment areas. USEPA regulations designate AQCRs with levels below the NAAQS as attainment areas. Maintenance AQCRs are areas previously designated nonattainment areas that have subsequently been designated attainment areas for a probationary period through implementation of maintenance plans. The San Juan and Rincon study areas are located within the Puerto Rico AQCR which is comprised of the entire Commonwealth of Puerto Rico, including Vieques, Culebra, and surrounding islands (40CFR§81.77). Puerto Rico has adopted the NAAQS established by the USEPA and has developed a State Implementation Plan under the CAA that incorporates permitting and regulatory requirements for stationary and mobile sources of air pollution. All areas within the AQCR are in attainment or unclassifiable (due to lack of data) for NAAQS for the following criteria pollutants: ozone, carbon monoxide, nitrogen dioxide, sulfur dioxide, PM2.5, and lead (USEPA 2008).

Due to their locations, the San Juan and Rincon study areas experience nearly constant onshore trade winds and sea breezes. These areas are surrounded by the municipalities of San Juan, Guaynabo, Cataño, Ocean Park, Carolina and Rincon. The Guaynabo non-compliance was due to pollution from power plants, industrial facilities, motor vehicles, and major San Juan emitters. In 2010 the municipality of Guaynabo became compliant air quality standards. In 2011 USEPA provided a grant to the Polytechnic University of Puerto Rico in the amount of $886,095 to install pollution-reduction technology on 72 heavy-duty trucks and replace 10 old heavy-duty trucks with 2010 or newer lower emissions diesel trucks in the Port of San Juan. These upgrades reduced the air emissions of fine particles (particulate matter, (PM)), nitrogen oxides (NOx), and carbon monoxide from diesel engines operating in the port. The municipality of Guaynabo is identified as being in moderate non-attainment of the NAAQS for particulate matter with a diameter of 10 micrometers or less (USEPA 2008).

The Puerto Rico Electric Power Authority (PREPA) owns and operates two power plants in the vicinity. The San Juan Power Plant located in the area of the bay and the Palo Seco Power Plant located in Cataño just outside the entrance of the Bay. In order to comply with upcoming Mercury and Air Toxics Standards (MATS) administered by the USEPA and to reduce cost of electricity production in Puerto Rico, PREPA is preparing to convert a number of the power generation units at its San Juan and Palo Seco Power Plants to burn natural gas as the primary fuel instead of Bunker C and Diesel (No. 6 and No. 2 type) fuel oil.

FUTURE WITHOUT-PROJECT CONDITION

If no-action were taken, no change to the existing air quality would be expected. Ambient air quality conditions in the San Juan and Rincon study areas would more than likely remain the same.

2.2.10 HAZARDOUS, TOXIC, AND RADIOACTIVE WASTE

2.2.10.1 ALL FOCUS AREAS – CONDADO, OCEAN PARK, ISLA VERDE, CAROLINA, AND RINCON

EXISTING CONDITION

The San Juan and Rincon study areas are highly developed. No hazardous or toxic materials or waste have been identified within the project footprint. No known hazardous, toxic, or radioactive waste has been encountered or released in the project area. Sediments from the San Juan Harbor navigation channel typically have traces of heavy metals, Polychlorinated biphenyls (PCBs), pesticides, Polycyclic Aromatic Hydrocarbons (PAHs), and petroleum products, at low levels that do not affect the sediment quality or the water quality in the project area.

FUTURE WITHOUT-PROJECT CONDITION

No significant effects to or from hazardous and toxic materials are anticipated from the FWOP condition.

2.2.11 NOISE

2.2.11.1 ALL FOCUS AREAS – CONDADO, OCEAN PARK, ISLA VERDE, CAROLINA, AND RINCON

EXISTING CONDITION

Noise is often defined as any sound that is undesirable because it interferes with communication, is intense enough to damage hearing, diminishes the quality of the environment, or is otherwise annoying. Response to noise varies by the type and characteristics of the noise source; distance from the source; receptor sensitivity, and time of day. Noise can be intermittent or continuous, steady or impulsive, and it may be generated by stationary or mobile sources. Noise is described by a weighted sound intensity (or level), which represents sound heard by the human ear and is measured in units called decibels (dB). The potential impacts of underwater sounds associated with dredging operations have come under increasing scrutiny by regulatory agencies.

San Juan bay has functioned as an international harbor since pre-colonial times. Over the last 300 years, San Juan Harbor has evolved to accommodate the growing shipping industry as larger vessels continued to arrive. At the same time, recreational and other commercial boat traffic and industrial noise has continued to increase. Several sources of ambient noise are present in San Juan bay. The ambient noise level of an area includes sounds from both natural (wind waves, fish, tidal currents, mammals) and artificial (commercial and recreational vessels, dredging, pile driving, etc.) sources. Tidal currents produce hydrodynamic sounds, which are most significant at very low frequencies (< 100 Hz). Vessel traffic, including vessels passing the immediate study area, generate sounds that can travel considerable distances, in frequencies ranging from 10 to 1000Hz. Sea state (surface condition of the water characterized by wave height, period, and power) also produces ambient sounds above 500 Hz. As a commercial and industrial area, San Juan bay experiences a wide range of noise from a variety of industrial activities. Biological sounds associated with mammals, fishes, and invertebrates can also generate broadband noise in the frequency of 1 to 10 kHz with intensities as high as 60 to 90 dB.

San Juan Harbor has the typical noise characteristics of a busy harbor including recreational and commercial vessel traffic, dredging vessels and dock side facilities. Noise sources for vessels include cranes, whistles and various motors for propulsion. Dockside noise sources include cranes, trucks, cars, and loading and unloading equipment. In addition to the noise in the water/marine environment, noise can impact the human environment. Background noise exposures change during the course of the day in a gradual manner, which reflects the addition and subtraction of distant noise sources. Ambient noise represents the combination of all sound within a given environment at a specified time. Humans hear sound from 0-140 dB. Sound above this level is associated with pain.

High intensity sounds can permanently damage fish hearing (Nightingale and Simenstad 2001). These sounds have been documented to be continuous and low frequencies (< 1000 Hz) and are within the audible range of listed species of both whales (7Hz–22 kHz) and sea turtles (100-1000Hz) (Clarke et al. 2002).

Noise has been documented to influence fish behavior. Fish detect and respond to sound by utilizing cues to hunt for prey, avoid predators, and for social interaction. Fish produce sound when swimming, mating, or fighting and also noise associated with swimming. Fish use a wide range of mechanisms for sound production, including scraping structures against one another, vibrating muscles, and a variety of other methods. Sounds produced by spawning fishes, such as sciaenids, are sufficiently loud and characteristic for them to be used by humans to locate spawning locations.

Relative to exposure to anthropogenic noise, NOAA guidelines define two levels of harassment for marine mammals: Level A based on a temporary threshold shift (190 dB for pinnipeds and 180 dB for cetaceans), and Level B harassment with the potential to disturb a marine mammal in the wild by causing disruption to behavioral patterns such as migration, breeding, feeding, and sheltering (160 dB for impulse noise such as pile driving and 120 dB for continuous noise such as vessel thrusters) (http://www.nwr.noaa.gov/Marine-Mammals/MM-sound-thrshld.cfm). According to Richardson et al. (1995) the following noise levels could be detrimental to marine mammals:

Prolonged exposure of 140 dB re 1 µPa/m (continuous man-made noise), at 1 km can cause permanent hearing loss. Prolonged exposure of 195 to 225 dB re 1 µPa/m (intermittent noise), at a few meters or tens of meters, can cause immediate hearing damage.

At the time this document was prepared, NOAA had released a draft report that provides guidance for assessing the effects of anthropogenic sound on marine mammal species under the jurisdiction of NMFS (NOAA 2013). The guidance will replace the current thresholds used by NOAA and described above. NOAA compiled, interpreted, and synthesized best available science to update the threshold levels for temporary and permanent hearing threshold shifts. Different target species for protection have widely divergent tolerance levels for sounds (owing to different hearing sensitivities, hearing integration times, etc.). Due to the complexity and variability of marine mammal behavioral responses, NOAA will continue to work over the next years on developing additional guidance regarding the effects of anthropogenic sound on marine mammal behavior (http://www.nmfs.noaa.gov/pr/acoustics/guidelines.htm).

FUTURE WITHOUT-PROJECT CONDITION

The San Juan study area is within an urban setting and noises related to beach recreation, recreational and commercial vessel traffic, dredging vessels, and dock side facilities would continue similar to the existing conditions. The Rincon study area is within a smaller urban setting though noises related to beach

recreation, water sports, and recreational and commercial vessel traffic, would also continue similar to the existing conditions.

2.2.12 COASTAL BARRIER RESOURCES

2.2.12.1 ALL FOCUS AREAS – CONDADO, OCEAN PARK, ISLA VERDE, CAROLINA, AND RINCON

EXISTING CONDITION

The Coastal Barrier Resources Act (CBRA) was enacted by Congress in 1982. The CBRA was implemented to prevent development of coastal barriers that provide quality habitat for migratory birds and other wildlife and spawning, nursery, nesting, and feeding grounds for a variety of commercially and recreationally important species of finfish and shellfish. As a deterrent to development, Federal insurance is not available for property within designated high-hazard areas. These high-hazard areas are called Coastal Barrier Resources System (CBRS) units.

CBRS units are areas of fragile, high-risk, and ecologically sensitive coastal barriers. Development conducted in these areas is ineligible for both direct and indirect Federal expenditures and financial assistance. Along with CBRS units are otherwise protected areas (OPAs). OPAs are national, state, or local areas that include coastal barriers that are held for conservation or recreation. The only Federal funding prohibition within OPAs is Federal flood insurance.

There are three CBRS units located near San Juan, PR-87 Punta Vacia Talega and PR-87P Punta Vacia Talega OPA approximately 13-19 km east and PR-86P Punta Salinas OPA approximately 6 km west (**Figure 2-7**). In addition, unit PR-72 Rio Guanajibo occurs approximately 11 miles south and unit PR-75 Espinar occurs approximately 11 miles north of the Rincon study area.

FUTURE WITHOUT-PROJECT CONDITION

The CBRS units and OPAs do not fall within the study area. The CBRS units and OPAs would continue to be protected from development under the CBRA in the FWOP condition pending no changes in the current regulations.

Figure 2-7. West San Juan Bay and Condado Lagoon Vicinity Coastal Barrier Resource System Units.

2.2.13 CULTURAL RESOURCES AND HISTORIC PROPERTIES

EXISTING CONDITIONS

Cultural resources include prehistoric and historic sites, structures, districts, or any other physical evidence of human activity considered important to a culture, a subculture, or a community for scientific, traditional, religious, or any other reason. Several Federal laws and regulations protect these resources, including the National Historic Preservation Act of 1966 (NHPA), the Archaeological and Historic Preservation Act of 1974 (54 U.S.C. §300101 *et. seq*.), and the Archaeological Resources Protection Act of 1979 (16 U.S.C. §§470aa-470mm). Additionally, NEPA requires that Federal agencies consider the "unique characteristics of the geographic area such as proximity to historic or cultural resources" and "the degree to which the action may adversely affect districts, sites, highways, structures, or objects listed in or eligible for listing in the National Register of Historic Places or may cause loss or destruction of significant scientific, cultural, or historical resources" (40 CFR 1508.27[b]). Documentation of historic properties and cultural resources is important for this project, as the cultural resources in the Rincon and San Juan area are significant to the history of Puerto Rico, the broader Caribbean, the United States, and world events. The area is rich in precolonial and historic human activity, with the potential for significant resources from the last several thousand years.

The analysis of impacts to cultural resources relies on existing information primarily from documents prepared by the Puerto Rico State Historic Preservation Officer (SHPO), GIS data of resources from SHPO, and properties listed in the National Register of Historic Places (NRHP). The area of potential effects (APE) for cultural resources is defined as the areas where structural measures are implemented, and non-structural measures are applied to historic properties as defined in 36 C.F.R. §800.16(l). An effect is an alteration to the characteristics of a historic property qualifying it for inclusion in or eligibility for the NRHP (36 CFR 800.16(i)). Effects may be direct or indirect. Examples of effects include visual intrusions, alterations of setting, noise, vibrations, viewsheds, and physical impacts. Indirect effects may occur where the actions enable other effects, which may be later in time or removed by distance. These may include increased development or changes in land use that may reasonably be associated with an action.

The proposed project includes measures in the Rincon area and along the shoreline from Condado to Ocean Park in the San Juan Metropolitan area. The background of these geographically and historically distinct areas will be reviewed in turn. Due to history, location, and the complexity of the archaeology in Puerto Rico, the island has been one of the central locations of archaeological research in the Caribbean. Though competing schema exist of how the islands was settled and occupied, there is broad agreement people have occupied Puerto Rico for several thousand years. The material traces of these groups include a variety of types of archaeological sites, including dense middens, panels of petroglyphs in stone, stone-lined plazas, and artifact scatters. During the subsequent colonial period, notable types of sites range from archaeological evidence of small households to large haciendas, the material traces of the development of various industries, distinctive Puerto Rican architecture, and historic districts from the Spanish colonial period through the twentieth century.

San Juan

Condado, Ocean Park, Isla Verde, and Carolina reaches are located immediately east of the San Juan islet. San Juan has been a significant port dating back to the end of the fifteenth century and the European exploration and settlement of the New World. Christopher Columbus landed on the west coast of Puerto Rico at Boquerón Bay in 1943, naming the area San Juan Bautista. At this time, the indigenous population measured approximately 60,000 people, according to a group of archaeologists gloss as Taíno. Spanish colonization of the island did not occur until 1508 when Juan Ponce de León established a permanent settlement south of San Juan Bay with the permission of the Taíno chiefdom of Guainía (Jiméz de Wagenheim 1998).

The Spanish subjection and maltreatment of the indigenous population led to a Taíno revolt in 1511. However, due to military subjugation, disease, and abuse from the Spanish, the native population was reduced by 75 percent in 1515. In order to replace the native workforce of the island's gold mines, the Spanish began importing enslaved Africans and indigenous people from nearby islands (Jiméz de Wagenheim 1998).

By 1521, the islet adjacent to *Puerto Rico* became the central Spanish settlement of San Juan and the island itself had come to be called Puerto Rico. Through the second half of the sixteenth century, San Juan became increasingly strategic for the export of sugarcane and ginger, and as a military outpost for Spain's colonial empire. In order to reinforce the military defenses of Puerto Rico, the Santa Catalina fortress (present-day *La Fortaleza*) was built and construction began on *El Morro* Castle. The city was fortified well enough to rebuke the attack of Sir Francis Drake in 1595. George Clifford, 3rd Earl of Cumberland, attacked and took the city in 1598; however, Spanish forces arrived shortly to rescue the island from the British. In 1625 Dutch forces attacked the city of San Juan, but the Spanish repelled the forces from *El Morro*. After this attack, the Spanish began improving their waterside fortifications, including the initial construction of the City Wall in 1634 (Krivor 2017).

During the beginning of the nineteenth century, Spain loosened its grip on Puerto Rico resulting in increased trade with foreign nations. Native Puerto Ricans (*Criollos*) sought political autonomy and gradually transformed the island to a sugarcane and coffee plantation-based economy (Jiméz de Wagenheim 1998). As Puerto Rico engaged in the global economy, San Juan was the center of economic development. The areas east of the San Juan islet remained relatively undeveloped, as these were outside of the protective walls and administrative hub.

The Spanish American War led to changes in the area of the proposed project. The region from Condado to Carolina was generally undeveloped during the Spanish colonial period. The San Juan region experienced rapid development after the Spanish American War ended in July 1898 with the cession of Puerto Rico to the United States. Within a decade of American control, streets were laid out in Condado and the land was sold for development (López Martínez 2008). In 1919 the first major tourist hotel, the Condado Vanderbilt Hotel, was constructed in Condado. Additional hotels followed, and the stretch of coastline from Condado to Carolina became a prominent area for both housing and tourism.

The resources recorded in the Condado, Ocean Park, Isla Verde, and Carolina reaches include those related to the precolonial inhabitants of Puerto Rico and the rich twentieth architectural heritage. Previous efforts to identify these resources have documented prehistoric archaeological sites along the coast in neighboring Carolina, both submerged and in the dune environment. There are archaeological sites located near the project reaches, and the potential exists for additional sites within the APE. As noted

in previous sections, extensive sand mining has occurred across these reaches, potentially removing unknown archaeological sites. Though the development and storm damage likely have disturbed archaeological sites across these reaches, the potential remains for additional unrecorded resources. This includes submerged prehistoric archaeological sites and shipwrecks.

Located west of the proposed project, the Condado Vanderbilt Hotel is listed on the NRHP (NRHP Reference Number 08001110). This historic property is linked to the development of the Puerto Rican tourism industry in the twentieth century. The hotel remains operational, having been renovated.

The areas south the proposed project includes neighborhoods developed in the twentieth century, many with shared unique architecture and atmosphere.

The offshore sand sources identified in Section 2.3.2 may contain cultural resources such as submerged archaeological sites and shipwrecks. The Corps is conducting a cultural resources assessment survey of the Luquillo 1&2 potential borrow areas to determine if any resources are present. The use of the existing, permitted upland sand source is a previously disturbed area and could not be permitted under Puerto Rican law if significant cultural resources were present.

Rincon

In an examination of Puerto Rican archaeology, Irving Rouse (1952) posited the Rincon area was sparsely populated prior to European conquest due to the lack of a clear embayment and the force of the prevailing winds. Based on the early chronicles at the time of European colonization, Rouse places Rincon as part of the Aymamón region at contact and ruled by a cacique of the same name. Subsequent researchers place this as part of Puerto Rico as the Yagüeca region ruled by Urayoan (Alegría 1999).

The western coast of Puerto Rico was an important stopping point for early European exploration of the Caribbean, as it provided a crucial location for topping off fresh water supplies. However, there is no evidence for development of Rincon for some time. Eighteenth century maps of Spanish settlements and infrastructure in this region do not map the town of Rincon in 1737 or 1791. A single structure is mapped inland in the 1737 map. Abbad y Lasiera (1866) reported on the conditions in Puerto Rico from 1773-1783. He provides little information on the Rincon. It is listed as one of the ports on the western side of Puerto Rico, associated with the river. He notes the settlement of Santa Rosa de Rincon was founded in 1772 (other sources provide 1770) along the river, with 11 houses and a church. He notes the area is poor and has no defense against *corsarios* (pirates).

During the nineteenth century, Rincon remained a remote settlement of Puerto Rico due to a lack of a deep-water port and limited transportation options. The SHPO site file notes two haciendas and a central (sugar processing factory) in the municipality, providing evidence of the agricultural past in Rincon. Rincon was better connected to the rest of Puerto Rico during the boom in railroad building during the late nineteenth century.

In his review of the region up to the time, Rouse (1952) reports a major shell midden site named Rincon 1, measuring 2 acres in size on Punta Ensenada, north of the study area. This site was visited by archaeologists in the early twentieth century, with the Ostiones, Santa Elena, Cuevas, and Capá styles of pottery documented in museum collections (Rouse 1952: 398). The location of this site, as recorded in the Puerto Rico SHPO site file with the added name of Fussá I, is located within a developed residential portion of the town of Rincon. After Rouse's observations, the SHPO file on Rincon suggests archaeologist forgot

about the region ("la región pasó prácticamente al olvido") for some time, until work was completed in the 1970s and 1980s. At this point, additional efforts were conducted at Fussá I and a portion of the site with petroglyphs (Fussá II) was recorded. The archive of papers presented at the International Association of Caribbean Archaeology from 1931 to 2011 has two papers including reference to Rincon, both only mentioning the existence of the petroglyphs without additional details. In addition to the archaeological sites, other cultural resources have been identified and recorded in the site files. Inland, near the study area, there are remnants of the historic coastal railroad infrastructure and a hacienda.

The NRHP includes two historic properties in the Rincon municipality. Faro de Punta Higuero (NRHP Reference Number 81000560) was listed on the NRHP in 1981 as part of the nomination of multiple lighthouses across Puerto Rico. The lighthouse was originally built in 1892, subsequently repaired in 1921 after a 1918 earthquake, and then replaced in 1922. The later construction incorporated elements from the original facility. The area is currently a park.

The second historic property is the Boiling Nuclear Superheater (BONUS) Reactor Facility (NRHP Reference Number 7001194), listed in the NRHP in 2007 as a district comprised on 6 buildings. This decommissioned nuclear reactor complex was constructed in 1960-1963 as an experimental facility and prototype. It is one of two boiling-water superheater reactors constructed in the United States and was the first nuclear plant built in Latin America. The reactor was used to produce electricity until 1968 and was decommissioned between 1969 and 1970. It was later turned into a museum, but shuttered due to potential exposure to radiation.

Though neither historic property is located near the measures proposed in this report, other unrecorded resources may exist. Though the proposed project is located on a highly eroded beach, which limits potential impacts to archaeological sites, cultural resources may be present in the area.

FUTURE WITHOUT-PROJECT CONDITION

Without the project, the current laws and regulations governing cultural resources in Puerto Rico would still apply and protect cultural resources. Without additional shoreline protection, storms may damage the resources along the coast, particularly the historic buildings located near the shore. Erosion could potentially impact archaeological sites located inland.

2.2.14 AESTHETICS AND RECREATION

2.2.14.1 ALL FOCUS AREAS – CONDADO, OCEAN PARK, ISLA VERDE, CAROLINA, AND RINCON

EXISTING CONDITION

Aesthetic resources are perhaps more difficult to define than aesthetics itself. USEPA (1973) stated the following:

"A. G. Alexander Baumgarten (1714-62) is credited with coining the word AESTHETIC, in his work Aesthetica (dated 1750), to denote "that branch of science which deals with beauty" (Klien, 1966). Like beauty, then, the word has no clear and agreed-on definition that is operative--it remains a term that designates a vague concept…"

In the context of large infrastructure projects, aesthetics generally involves personal and subjective evaluations of the acceptability of visual scenes. The subject is often approached in terms of a "viewshed", which is the scene of the proposed project and consequences as viewed from various locations. Since the study involves a large landscape, this section will be addressed from a regional San Juan metropolitan area and Rincon area aspect.

San Juan is the capital and most populous municipality in the Commonwealth of Puerto Rico. San Juan Harbor is a historic seaport and has been associated with vessels of increasing size for hundreds of years. A scenic setting is provided by the historic sites, harbor, estuary, and the numerous vessels common to these waters, including commercial and recreational boats as well as vessels calling on the Port. The coastal environment provides opportunities for swimming, boating and fishing, as well as an escape from the faster pace of land-based activities. Several boat ramps and marinas are located in the area. The project is situated in an urban/commercial setting.

The Rincon municipality is significant to the nation with its rich historical and cultural heritage, environmental resources, and tourism. In 2018, the Rincon population was estimated to be 15,000. Tourism is a vital part of the Rincon economy and an important consideration. Almost all of the tourism industry in Rincon could be described as coastal tourism. Tourists venture to Puerto Rico's western, most remote coast to enjoy passive uses of the coast such as surfing, fishing, snorkeling, and scuba diving.

In both San Juan and Rincon study areas, shoreline erosion has caused significant loss of the sandy beach leading to permitted and unpermitted shoreline hardening. Therefore, the viewshed of both study areas is negatively affected under existing conditions.

FUTURE WITHOUT-PROJECT CONDITION

In the FWOP condition/No Action Alternative, one potential effect could be storm erosion and sedimentation around the San Juan and Rincon study areas which could continue to affect local aesthetics, including appearance of water color and loss of sandy beaches. These include roadways and infrastructure, vehicular traffic, residential structures and hotels/tourist districts.

2.2.15 PUBLIC SAFETY

EXISTING CONDITIONS

Drownings in Puerto Rico's beaches constitute a social problem that took 152 lives from 2005 to 2010. Social, environmental, physical factors and economic impacts make this phenomenon a very complex one. Reasons such as a lack of knowledge of climatic conditions, rip and marine currents, lack of lifeguards, geomorphologic features in beaches and wave height influence in beach drownings. The beach in front of the Marriot Hotel in Condado, present dangerous geomorphological features to beach goers (Muñoz 2013).

FUTURE WITHOUT-PROJECT CONDITION

Rip currents would continue to occur in the future, putting population at risk.

2.3 PHYSICAL ENVIRONMENT

The San Juan focus areas consist of sandy pocket beaches between eroded headlands. The northern part of the Rincon focus area consists of sandy recreational beaches, while the southern portion has narrower to no dry beach areas. Overall, both study areas, San Juan and Rincon, are subject to frequent storm events. Adjacent properties to the shoreline can be categorized as urban and include residential, commercial, and recreational properties. Potential sources of sand that could be used to construct potential CSRM alternatives are also considered part of the physical environment. Many factors influence the coastal processes characteristic to the San Juan and Rincon shorelines. Factors include winds, tides, currents, waves, storm effects, and sea level rise. There are no other Federal projects influencing the coastal processes in these study areas. The role of each of these factors and their contribution to coastal damages are briefly described in this section.

2.3.1 SHORELINE CONDITIONS

EXISTING CONDITIONS

The following paragraphs are excerpted from Section 1.2 of the **Engineering Appendix (A)**.

The Condado focus area extends from El Boqueron, at the entrance of Laguna Condado, east about 1.1 miles to Punta Piedrita. Condado Beach contains the smallest area of dry beach out of the four focus areas within the San Juan study area. The western 0.5 miles from El Boqueron to La Ventana al Mar Park contain virtually no dry beach. Waves break directly on exposed nearshore reef and rock revetments. The sandy pocket beach is approximately 0.4 miles where the widest part of the beach is roughly 250 ft wide. The beach berm is relatively flat, and natural inundation protection features such as dunes and upland vegetation don't exist in this area. Exposed nearshore hardbottom and seawalls are present at the eastern end of Condado, approximately 0.2 miles. The entire focus area is highly developed with hotels, condominiums, residential, and commercial buildings.

The Ocean Park focus area extends from Punta Piedrita east about 1.8 miles to Punta Las Marias. The western and eastern extents of Ocean Park, approximately 0.3 and 0.4 miles respectively, contain little to no dry beach with prevalent nearshore hardbottom. The central beach spans approximately 1.1 miles where the widest part of the beach is roughly 280 ft wide. Sparse dunes with upland vegetation along 0.2 miles of the central beach ranged from 10-15 ft above MSL. The middle section of this focus area includes a public park (Barbosa Park, colloquially known as the Ultimo Trolley), which is historically known to experience extensive coastal inundation driven by large waves and storm surge. The entire focus area includes a mixture of single-family homes, condominiums, commercial structures, and hotels.

The Isla Verde focus area extends from Punta Las Marias east about 1.8 miles to Punta El Medio. Generally, there is a wider beach in the center portion of this reach. The central beach spans approximately 1.3 miles with the widest berm being 250 ft. The beach berm is relatively flat with intermittent dunes and vegetation. The western and eastern extents of Isla Verde, approximately 0.4 and 0.1 miles respectively, contain little to no dry beach. The Isla Verde focus area primarily consists of hotels, condominiums, and single-family homes, as well as commercial businesses and a public skate park.

The Carolina focus area extends from Punta El Medio east about 2 miles to Boca de Cangrejos. The dry beach in the central area spans approximately 1.5 miles with berm width ranging from 85 to 200 feet (ft), a very mild slope, and sparse and intermittent dunes without upland vegetation. The easternmost 0.5 miles contain essentially no beach, where a rock revetment protects PR-187. Carolina Beach contains the least amount of structures out of the four focus areas within the San Juan study area. Some of the structures in the center portion of this focus area include public parking lots, a beach club villa, and a public park. The westernmost area is a mixture of single-family homes, condominiums, hotels and some commercial structures.

The Rincon focus area extends from Punta Ensenada south about 2 miles to Corcega. The Rincon focus area generally contains wider beaches and elevated berm crests to the north and narrower beaches with damaged/abandoned homes, some physically in the water, to the south (Corcega). This area is a mixture of single-family homes, condominiums, commercial structures, and hotels. Seawalls, revetments, and non-engineered armoring front a majority of the homes and hotels in this focus area.

FUTURE WITHOUT-PROJECT CONDITION

The natural shoreline should continue experiencing erosion due to coastal processes. In the future without-project condition damages will continue to occur due to more frequent storms, and Seal Level Rise.

2.3.2 BEACH SEDIMENT CHARACTERISTICS

EXISTING CONDITIONS

Historical records prove that the size and height of dunes along the north coast of Puerto Rico is inadequate in many places to protect human life and coastal property; in part, as a result of decades of massive sand extraction. In 1947, the Beach Erosion Control Study for Punta Las Marias, San Juan, Puerto Rico (U.S. Army Corps of Engineers 1947) documented the removal of sand for commercial purposes. Per almost 35 years, large quantities of sand were removed for construction purposes from two locations along the shore of Ocean Park and Isla Verde. The largest borrow pit, about 500 feet in length, was located about one-half mile east of Punta del Medio. At that time, residents of this vicinity attributed erosion of their beach to the removal of sand from this pit. A smaller pit was located about 0.7 mile west of Punta del Medio. It was reported that the volume of sand removed from the beach sometimes amounted to 2,000 cubic meters (about 2,600 cubic yards) a day. The Carolina beach is also of special interest because of massive sand extraction in the 1950's for airport construction and the intense erosion reported during 1960-1980 (Island Resources Foundation, Virgin Islands 1983). This practice has been officially discontinued, but the negative impacts to the dune system hasn't been mitigated or repaired.

No beach nourishments have been conducted at any of the beaches in the study areas and as previously described, the beach has been altered from its natural state through sand mining in the past. The existing beaches on San Juan and Rincon were sampled by the USACE team in 2019 to characterize the beach sediments and assess compatibility with the potential sand source material.

The beach composite sample for San Juan Beaches (Condado, Ocean Park, Isla Verde and Carolina) was classified as clean, poorly graded, fine-grained quartz sand (SP) with a mean grain size of or 0.21 mm, and a standard deviation of 0.86 phi. The average percentage of fines passing the #230 sieve is 2.29. The

average visual shell percentage is 20%, with a range from 8.7% through 43.8%. The typical moist Munsell Color value is 6 and color is described as light brownish gray.

The beach composite sample for Rincon Beach study area was classified as clean, poorly-graded, fine-grained quartz sand (SP) with a mean grain size of or 0.34 mm, and a standard deviation of 0.97 phi. The average percentage of fines passing the #230 sieve is 0.85%. The average visual shell percentage is 27%, with a range from 8.7% through 38%. The typical moist Munsell Color value is 5 and color is described as grayish brown.

More details can be found in the **Geotechnical Appendix (D)**.

FUTURE WITHOUT-PROJECT CONDITION

Without implementing a Federal project, it is expected that the future without-project conditions of the sand composition of the existing beach will be similar to the existing conditions described above. With respect to the habitat provided by the beach in the future without project condition, increased erosion could decrease the habitat available to nesting sea turtles and bird nesting.

2.3.3 AVAILABLE SAND SOURCES

EXISTING CONDITIONS

For San Juan and Rincon study areas, several offshore sand sources and upland sand mines were investigated during the preparation of this feasibility study and their respective analysis is documented in the **Geotechnical Appendix (D)**. Puerto Rico has no specific requirements for the beach fill quality. However, from an environmental and sustainability point of view the sand placed on the beach should be similar to the sand of the existing beach and free of foreign matter, like rock, debris, and toxic material. Following is a summary of the proposed sand sources compatibility and volumes.

SAN JUAN SAND SOURCE COMPATIBILITY

Beach compatible sand for San Juan Beaches is available from one proposed nearshore sand source, La Esperanza, two proposed off-shore sand sources, Luquillo 1&2, and one upland sand mine, see **Figure 2-8**.

Figure 2-8. San Juan Project Area and Upland and Off-shore Sand Sources Location

Arithmetic composite samples were created for the beach, nearshore, offshore, and upland sand deposits. The arithmetic composite sample granularmetric parameters are summarized in **Table 2-3.**

Table 2-3. San Juan Grain Size Summary Beaches and Sand Sources

SOURCE	USCS[1]	Gravel[2] %	Silt[3] %	Mean (mm)	Standard Deviation (phi)
BEACH					
San Juan Beaches	SP	0.16	2.29	0.21	0.86
NEARSHORE SAND SOURCES					
La Esperanza	SP	5.13	3.73	0.36	1.62
POTENTIAL OFFSHORE SAND SOURCE					
Luquillo 1	SP	4.27	1.58	0.58	1.17
Luquillo 2	SP	3.80	0.08	0.59	0.85
UPLAND SAND SOURCE					
Concretos Sand Mine	SP	0.79	5.41	0.40	1.07

[1] *United Soil Classification System*
[2] *Gravel % = Percent Retained #4 Sieve*
[3] *Silt % = Percent Passing #200/230 Sieve*

The beach deposits consist of poorly graded fine-grained sand with a mean grain size of 0.21mm. The material from the nearshore, offshore, and upland sand sources is coarser than the existing beach sediments and consists of poorly graded fine to medium grained sand with a mean grain size of 0.36, 0.58, 0.59, 0.40 mm, respectively. The coarser grain-size of the offshore sediments is due to the gravel sized shell content.

In summary, La Esperanza nearshore sand source, the Luquillo offshore sand sources and the Concretos upland mine sediments are beach compatible and are similar to the sediments of the existing San Juan beaches.

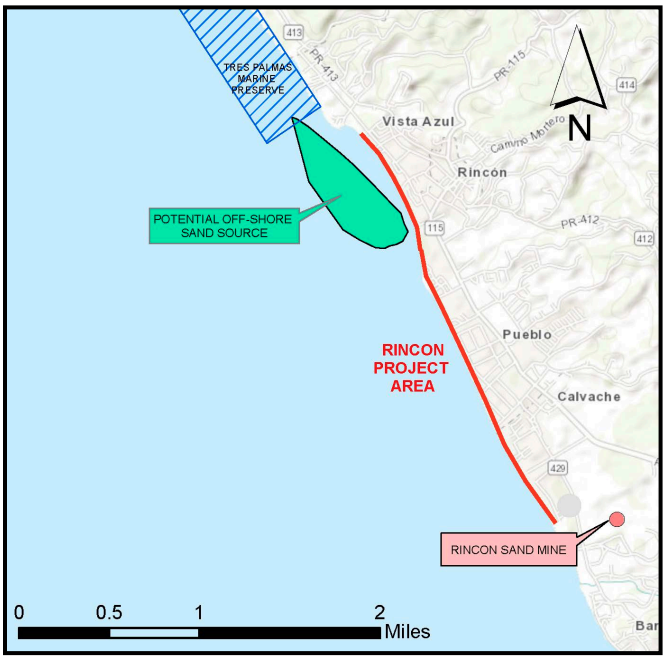
Sand volumes are estimated as follows:

- La Esperanza is a Regional Sediment Management sand source with an estimated sand volume of 200,000 cubic yards of sand.
- Luquillo 1 is approximately 170 acres in size. The sand thickness is conservatively estimated to be 5 feet, resulting in approximately 1.2 Million cubic yards of sand.
- Luquillo 2 is approximately 480 acres in size. The sand thickness is conservatively estimated to be 5 feet, resulting in approximately 3.5 Million cubic yards of sand.
- The Concretos sand mine has several million cubic yards of sand available to be mined.

RINCON SAND SOURCE COMPATIBILITY

Beach compatible sand for Rincon Beaches is available from an upland sand mine and potentially from an offshore sand source, Bajo Blanco **Figure 2-9**.

Figure 2-9. Rincon Project Area with Upland and Offshore Sand Source Locations



Arithmetic composite samples were created for the beach, the offshore, and the upland sand sources. The arithmetic composite sample's granularmetric parameters are summarized in

Table 2-4.

Table 2-4. Rincon Grain Size Summary for Beaches and Sand Sources

SOURCE	USGS[1]	Gravel[2] %	Silt[3] %	Mean (mm)	Standard Deviation (phi)
BEACH					
Rincon Beaches	SP	0.41	0.87	0.34	0.97
POTENTIAL OFF-SHORE SAND SOURCE					
Bajo Blanco	SP	n/a	n/a	0.24	0.59
UPLAND SAND SOURCE					
Rincon Sand Mines	SP	0.15	2.47	0.45	0.75

[1] *United Soil Classification System*

[2] *Gravel % = Percent Retained #4 Sieve*

[3] *Silt % = Percent Passing #200/230 Sieve*

The material from the beach and the offshore sand source are similar and consist of poorly graded fine-grained sand with a mean grain size of 0.34 and 0.24mm respectively. The material of the upland sand mine is coarser than the beach sediments and consists of poorly graded fine to medium grained sand with a mean grain size of 0.45mm.

In summary, the offshore and upland sand source sediments are beach compatible and are similar to the sediments of the existing Rincon beaches.

Sand volumes are estimated as follows:

- Only very limited volumes of sand should be considered to be dredged from the Bajo Blanco to maintain the integrity of the shoal so as not to cause erosion at the nearby beaches. The Bajo Blanco is approximately 120 acres in size and, as a rough estimate, no more than 300,000 cubic yards should be dredged from the shoal.

- The volumes available from the Rincon sand mine are unknown but estimated to be at a minimum 300,000 cubic yards.

More details can be found in the **Geotechnical Appendix (D).**

FUTURE WITHOUT-PROJECT CONDITION

In the future, it is possible that these sand sources could be mined by another agency or for another Federal project. However, at this time, there are no construction plans by any agency to use them.

2.3.4 SHORELINE CHANGE AND EROSION RATES

EXISTING CONDITIONS

Long-term shoreline changes (erosion or accretion) for a particular area is best defined by continuously repeated (i.e. yearly, every five years, every decade, etc.) topographic and bathymetric surveys collected in the same location. However, such data were not available for the PR Coastal Study areas. Due to the lack of repeated physical survey data, a combination of referenced work, USACE LiDAR, and Google Earth Imagery were used to define the long-term erosion in Rincon and San Juan.

Long-term shoreline response (erosion or accretion) in San Juan is generally minor compared to Rincon. San Juan results indicate no change at headlands over the past 90 years and minimal shoreline retreat in much of the pocket beach centers. **Table 2-5.** presents the long-term erosion rates by modeling reach[2] for Condado, Ocean Park and Isla Verde (positive values denote accretion and negative values denote erosion). For Rincon focus area, the overall long-term erosion rates used in the modeling effort is shown as the average in **Figure 2-10.**, where positive values denote accretion and negative values denote erosion.

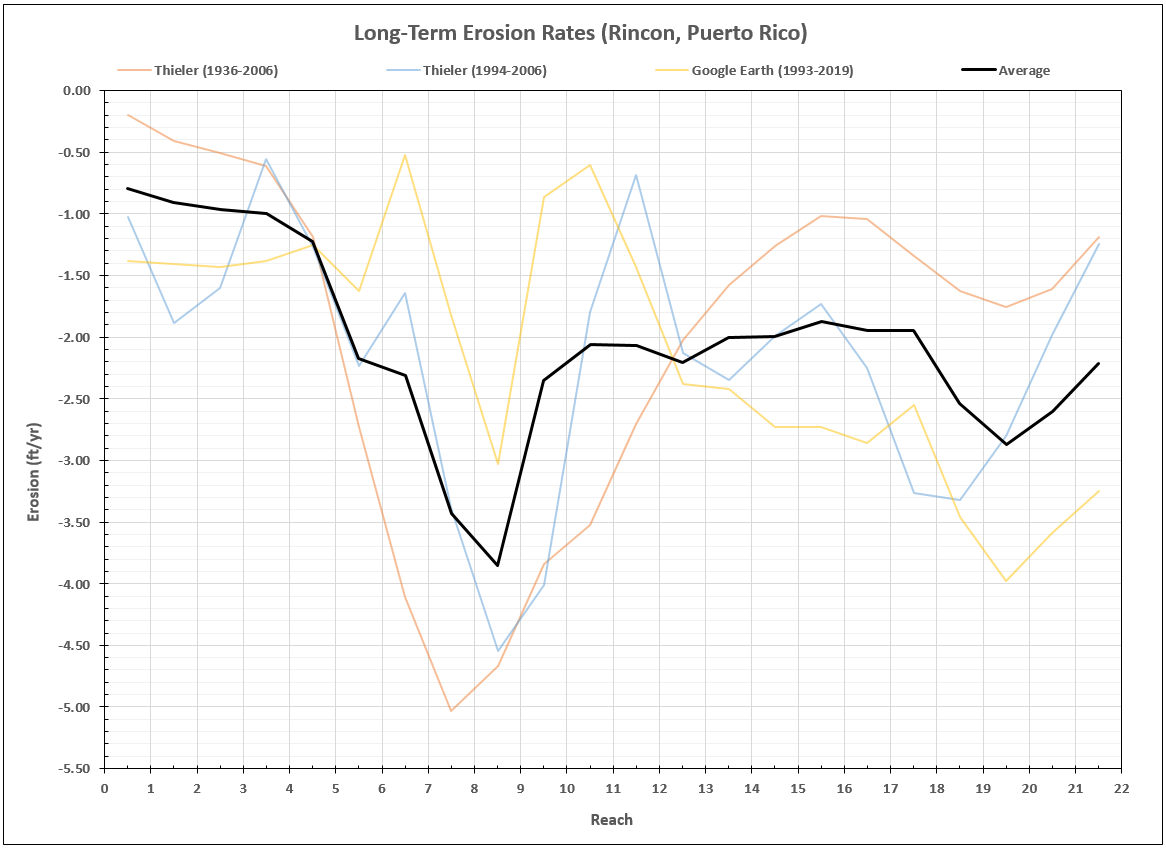
The **Engineering Appendix (A)** provides additional detail on Shoreline changes.

Table 2-5. Long-Term Erosion Rates by Modeling Reach in San Juan focus areas

Half Reach (Profile)	Condado (ft/yr)	Ocean Park (ft/yr)	Isla Verde (ft/yr)
1	-0.30	0.00	-0.43
2	-0.43	-1.15	-0.31
3	-0.41	-2.53	-0.09
4	-0.60	-1.89	-0.39
5	-0.40	-1.30	-0.69
6	0.00	-1.43	-0.37
7	0.00	-0.73	-0.04
8	0.00	-0.73	0.00
9	0.00	-0.85	0.00
10	-	-1.38	0.00
11	-	-1.40	-0.18
12	-	-1.34	-0.09
13	-	-0.05	0.00
14	-	-2.25	0.00
15	-	-2.44	0.00
16	-	-0.24	-

[2] Within Beach-*fx*, the study area is represented by divisions of the shoreline referred to as "Model Reaches". The full description of the Beach-*fx* model set-up is presented in Section 2.5.3

Figure 2-10. Long-Term Erosion Rates by Modeling Reach in Rincon Focus Area



FUTURE WITHOUT-PROJECT CONDITION

The natural shoreline should experience similar rates of erosion and accretion in the future without-project condition as described in the existing conditions section above. Existing armor (seawall, revetment, etc.) in some of the reaches is preventing erosion from proceeding landward from the armored point extending landward. However, in 2018, the DNER issued a directive prohibiting permits to build new seawalls, and revetments of any kind that may affect sandy beaches and beach dynamics, particularly on highly visited touristic-recreational and/or sea turtle nesting beaches. Therefore, in the future without-project condition, erosion would be expected to increase if revetments fail and cannot be replaced.

2.3.5 WINDS

EXISTING CONDITIONS

The study area lies within the tropical trade wind zone, resulting in moderate winds from a prevailing easterly direction all year long. Increased north-northeast winds during fall, winter, and spring seasons primarily occur from Extra Tropical (ET) cyclones in the mid- to northern-Atlantic Basin. Extreme conditions from tropical systems generally impact the island in the summer and fall months.

For the San Juan study area two stations were used to assess the general wind climate. The National Data Buoy Center (NDBC) Station #41053 located just off the San Juan coastline (18° 28.4' N, 66° 5.9' W) which contains wind data from 2010-2020, and the USACE Wave Information Study (WIS) Station #61019 (approximately 37 mi north of San Juan at 19° 0.0' N, 66° 0.0' W) which is the closest station to the San Juan study area with record from 1980-2014.

Records from WIS station #61019 show that the prevailing wind direction is from the east (about 66.6% of occurrence at an average speed of 15.9 mph). Approximately 94% of the WIS wind records from 1980-2014 were from the northeast (NE) to southeast (SE) quadrants. Average wind speeds during this time top out around 16 miles per hour (mph) from the east-NE quadrant.

For the Rincon study area, records from NDBC station PTRP4 (2012-2019) located 1.7 mi NE of the Rincon study area at 18° 22.0' N, 67° 15.1' W show that the prevailing winds (like San Juan) are from the eastern quadrant, where 79.2% of the wind records come from the NE to SE directions.

The **Engineering Appendix (A)** provides the full wind analysis.

FUTURE WITHOUT-PROJECT CONDITION

The future without-project conditions of winds are similar to the existing conditions described above.

2.3.6 WAVES

EXISTING CONDITIONS

The wave energy dissipation that occurs as waves directly impact coastal structures is often a principal cause of infrastructure damage. Wave height, period, and direction, in combination with tides and storm surge, are the most important factors influencing the behavior of the shoreline.

The San Juan study area is exposed predominantly to short period wind-waves with periodic exposure to longer period storm swells. Most of the San Juan study area is protected offshore reefs, which dissipate some of the ocean-driven waves. Periodic damage to upland development is partially attributable to large storm waves produced primarily by extra tropical storms during the late fall, winter, and early spring months and tropical disturbances during the summer and early fall months.

General wave information for the San Juan study area was obtained from the USACE WIS hindcast database for the Atlantic Ocean, WIS station 61019 (1980 – 2014). Records show that average wave heights range from 5.9 ft to 9.6 ft. Wave directions are generally from the east (63.74% of occurrence) and northeast quadrants (30.12% of occurrence). A seasonal breakdown of wave heights show that higher wave heights are more frequent in the late fall, winter, and early spring months (November through March) and tend to originate from the northeast and east quadrant equally. These larger wave heights (average range from 6.8 ft to 7.8 ft) can be attributed to the ET storms that drive large waves towards the study area. Late spring, summer, and early fall waves (April through October), are smaller and originate predominantly from the east (average range from 5.3 ft to 6.1 ft).

A seasonal breakdown of percent occurrence by wave period demonstrates that long period, storm-generated swells are common throughout the year. The late fall, winter, and spring months (November

to April) have slightly larger periods indicating the influence of ET storms throughout the months of November through April. None of the dominant wave periods are less than 8.0 seconds.

General wave information for the Rincon study area were obtained from the NDBC Gauge 41115 (2011-2019). Records show that average wave heights range from 1.9 ft to 4.1 ft. Wave directions are predominantly from the NNE (90.94% of the records). A seasonal breakdown of wave heights show that higher wave heights are more frequent in winter to spring months (November through March), which can be attributed to the ET storms that drive large waves towards the study area.

The **Engineering Appendix (A)** provides additional detail on waves.

FUTURE WITHOUT-PROJECT CONDITION

Future SLC is expected to exacerbate the impacts of coastal flooding and wave attack as those forces would be occurring at a higher starting water level in the future as sea level rises.

2.3.7 ASTRONOMICAL TIDES

EXISTING CONDITIONS

The Puerto Rico Vertical Datum of 2002 (PRVD02) is the official vertical datum of Puerto Rico and will be used as the referenced datum for water level criteria in this study.

San Juan Tides

Tides in San Juan, Puerto Rico are affected by mixed, semidiurnal tidal fluctuations of the Atlantic Ocean with two high and two low tides that occur at different elevations per tidal day. For the San Juan study area, tidal datums were acquired from the NOAA tide station 9755371 (San Juan, La Puntilla) located in the San Juan Bay. The NOAA gauge contains astronomical tide data from November 1977 to present. The mean tide range, the difference between Mean High Water (MHW) and Mean Low Water (MLW), equals 1.11 ft and the spring tide range, the difference between Mean Higher High Water (MHHW) and Mean Lower Low Water (MLLW) is 1.58 ft.

Rincon Tides

Water levels in the Rincon study area are mainly affected by wind and semi-diurnal tidal fluctuations of the Mona Passage connecting the Atlantic Ocean and Caribbean Sea basins. Tidal datums in the Rincon study area vicinity were gathered using NOAA's Mayagüez, Puerto Rico Station 9759394. Elevations from that gauge, which are referred to PRVD02 from the tidal epoch period of 1983 – 2001, are based on a 10-month analysis period ranging from May 2015 – February 2016. The mean tide range equals 1.05 ft and the spring tide range is 1.39 ft.

The **Engineering Appendix (A)** provides additional detail on Tides.

FUTURE WITHOUT-PROJECT CONDITION

Future SLC is expected to exacerbate the impacts of coastal flooding, tides will produce higher water levels in the future as sea level rises.

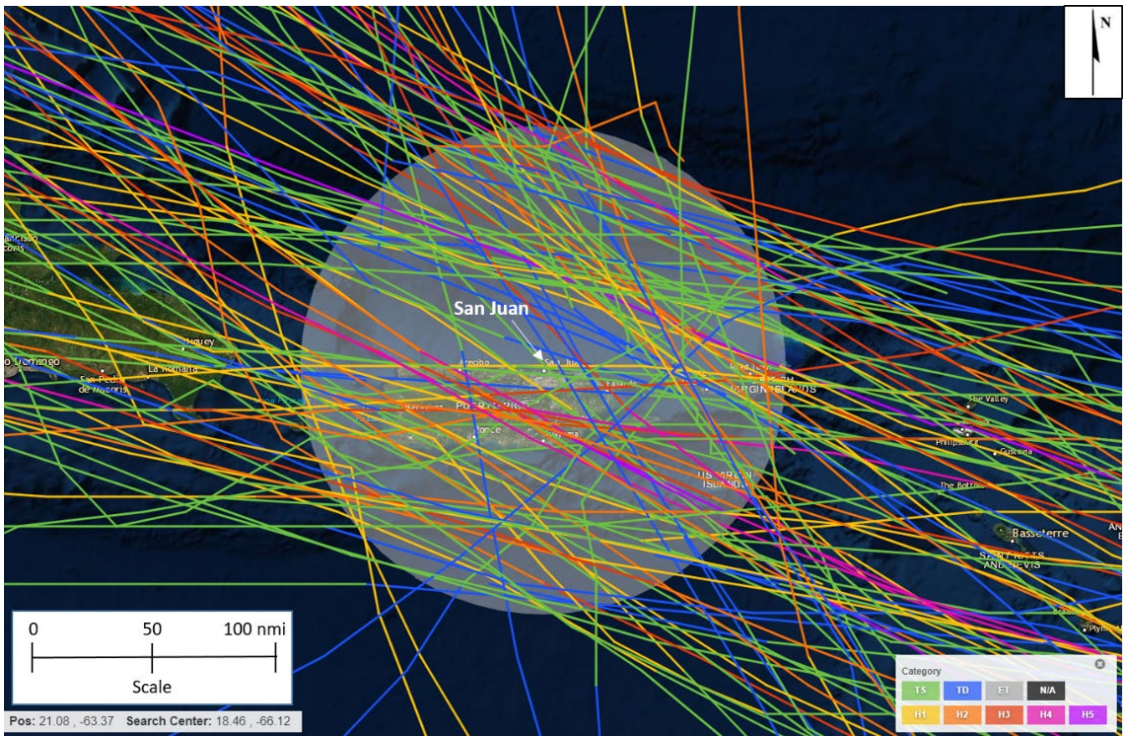
2.3.8 STORM EFFECTS

EXISTING CONDITIONS

The San Juan and Rincon study areas are located in a region of considerable hurricane activity, resulting in relatively frequent hurricane impacts. Puerto Rico coastline is generally influenced by tropical systems during the summer and fall months (hurricane season) and by northeasters during the late fall, winter, and spring months. Although hurricanes typically generate larger waves and storm surge, northeasters can have a greater cumulative effect on the area due to longer storm duration and greater frequency of event occurrence.

Figure 2-11 shows historical trajectories of hurricanes and tropical storms from 1851 to 2019 as recorded by the National Hurricane Center (NHC). These hurricane data are available from NOAA (*https://oceanservice.noaa.gov/news/historical-hurricanes/*). The shaded circle in the center of this figure indicates a 100-nautical mile radius drawn from the center of San Juan. Based on NHC records, 119 tropical storms have passed within this 100-mile radius over the 169-year period of record. The 100-mile radius was chosen because a tropical disturbance passing within this radial area would likely produce damages along the shoreline. Stronger storms are capable of producing significant damage to the coastline from far greater distances.

Figure 2-11 Historical Tropical Storm Tracks (1851-2019, 100-nautical mile radius)



At least 16 major hurricanes have severely damaged properties and infrastructure in Puerto Rico since late 1893. Following is a summary of the most damaging storm events recorded:

- Earlier historic records for Puerto Rico indicate that six hurricanes and storms with significant effects occurred in Puerto Rico between 1893 and 1956. The San Roque Hurricane of August 1893 caused significant damages to agriculture and port business. The San Ciriaco Hurricane of August 8, 1899 is considered the worst natural disaster in Puerto Rico's history. This great hurricane killed more than 3,300 people, left 25 percent of the island's population homeless, destroyed more than $7 million worth of the coffee, sugarcane and plantain crops (over $225 million in 2012 dollars) (Bush 1995). Since then, several other hurricane events have affected the island, with the San Felipe Hurricane in 1928 leaving no area of the island untouched (Bush 1995). Two hurricanes, San Nicolas, in 1931 and San Ciprian, in 1932, passed directly over the San Juan metropolitan area. The San Ciprian Hurricane crossed Puerto Rico with winds estimated at 120 miles per hour and caused 225 deaths and losses of $30 million. In September 1956, Hurricane Santa Clara, also known as Betsy, caused 9 deaths, and losses estimated at $25 million.

- Hurricane Hugo (1989) passed over the island of Puerto Rico with estimated winds of 140 mph. Hurricane Marilyn (1995), and Hurricane Hortensia (1996) caused severe floods and landslides.

- Hurricane Georges (1998) has been one of the most severe events in terms of wind effects letting long lasting impacts to agriculture and infrastructure. After hurricane Georges (1998) the National Weather Service reported enormous damage to Puerto Rico's utility infrastructure. Electricity was lost to 96% of the island's 1.3 million customers, while water and sewer service was lost to 75% of the islands 1.83 million customers. An estimated $1.6 Billion in damages was caused to municipalities and $233 million in damages to commonwealth agencies. Thus, the total damage in Puerto Rico was estimated at $1.9 Billion (National Weather Servive 2012) (FEMA 2012).

- The center of the Tropical Storm Irene (2011) passed through the northeast of Puerto Rico and became a hurricane while moving through the North of Puerto Rico. The winds of hurricane intensity remained on the waters, but the effect of the tropical storm winds and the rains affected a large part of the island. It took more than seven months to the island to recover from the heavy rains, flooding, landslides and mudslides left by the hurricane. The Government of Puerto Rico and the Federal Emergency Management Agency cited the approval of more than $83.9 million in federal grants for disaster aid (FEMA 2012).

- In September 2016, Hurricane Matthew generated several cyclonic storm surges that severely impacted the infrastructure of the west coast of Rincon, exposing the municipality's vulnerability (Aponte-Bermúdez, et al. 2017). **Figure 2-12** presents evidence of damages to the Rincon Ocean Club 2, located at Corcega beach in Rincon[3].

- The 2017 Atlantic hurricane season has been the most active in modern history. During 2017, Puerto Rico's coastal communities, critical infrastructure as well as coastal and marine habitats were severely impacted by the devastating power of hurricanes Irma (September 6, 2017) and hurricane Maria (September 20, 2017). **Figure 2-13** presents some damages to infrastructure caused by Hurricane Maria in San Juan Metropolitan area. Hurricane Maria was the second

[3] Figure 1-3 was downloaded from article: Impacto de la erosion costera a la infraestructura de Rincon, Puerto Rico, page 27, Aponte-Bermúdez, et al. 2017

hurricane classified by the National Oceanic and Atmospheric Administration's National Weather Service (NOAA-NWS) as a category five in September 2017, approximately two weeks after Hurricane Irma had affected the northern coast of the Island. Hurricane Maria devastated Puerto Rico's infrastructure, resulted in dozens of deaths, loss of homes, industries, business, and affected the livelihoods of thousands of Puerto Ricans. Response and recovery efforts were initiated and continue after the Presidential disaster declaration was issued on September 20th, 2017. During Hurricane Maria, damages along the coast of Rincon were attributable to the coastal erosion, storm surge, and wave energy. The storm surge overwash and waves were high enough to cause structural damage to upland development and inland flooding. Although most of these structures had sheet piling and/or rock revetments protection, the strong waves pounded the section of coast, causing severe damage to the slab foundation and structure body of the coastal infrastructure. Most of Rincon's coast lost a significant amount of sediment, leaving most of it without a dry sand beach, thus affecting the coast's capacity to withstand another major storm. Extensive debris still remains along the upper reach of the beach affecting beach aesthetics and tourism (U.S. Fish and Wildlife Service, Caribbean Landscape Conservation Cooperative 2019).

- **Figure** 2-14 a) shows an aerial view of four condominium complexes at Corcega beach[4] in Rincon from 18 JAN 2017, and b) to f) present images of the same structures damaged by Hurricane Maria.

- Coastal erosion on the north coast of Puerto Rico was exacerbated not only by cumulative wave action associated with hurricanes Irma and Maria but also to the 5-day high energy wave action from Winter Storm Riley in March 2018.

- **Figure 2-15** shows flooding caused by winter storm Riley at the Ocean Park area in San Juan. shows flooding caused by winter storm Riley at the Ocean Park area in San Juan.

- During the month of August 2019, the Ocean Park coastline in the San Juan Municipality experienced one of the most severe erosion events on the past four decades. Between July and August 2019, researchers in the area documented approximately 91-foot-wide loss of beach and significant vertical loss of sand in some areas of Ocean Park. **Figure 2-16** shows beach erosion and exposed seawalls foundations. Analysis of historical data and the effects of the energy deficit of the North and Northwest during the winter 2018-2019, suggest that the transport of the bottom sediment (Offshore-Onshore) or the sediment from the west to the east on the beaches of Ocean Park did not occur and that this sediment was therefore not available in the nearby coastal area to be deposited by the low-energy swell associated with the summer. shows beach erosion and exposed seawalls foundations. Analysis of historical data and the effects of the energy deficit of the North and Northwest during the winter 2018-2019, suggest that the transport of the bottom sediment (Offshore-Onshore) or the sediment from the west to the east on the beaches of Ocean Park did not occur and that this sediment was therefore not available in the nearby coastal area to be deposited by the low-energy swell associated with the summer.

[4] Figure 1-5 a) was downloaded from article: Impacto de la erosion costera a la infraestructura de Rincon, Puerto Rico, page 27, Aponte-Bermúdez, et al. 2017

Figure 2-12. a) Damages to the Rincon Ocean Club 2 condominium caused by Hurricane Matthew, September 2016. b) Close view of failed seawall and exposed foundation

Figure 2-13. Damages due to Hurricane Maria in San Juan Metropolitan Area

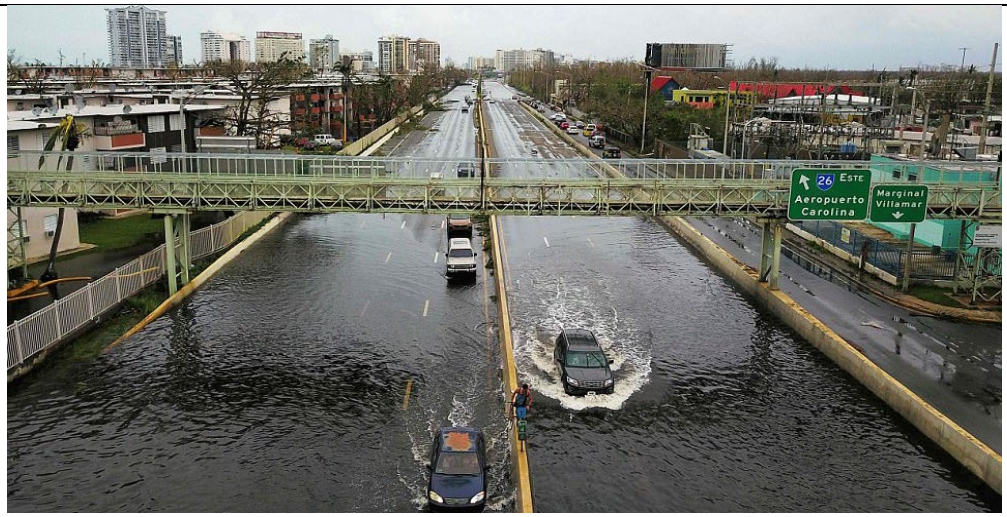


Figure 2-14. Severe damage to properties generated by Hurricane Maria in Rincon

Figure 2-15: Flooding caused by winter storm Riley at the Ocean Park area in San Juan

Figure 2-16. Severe erosional event in Ocean Park, San Juan, August 2019

FUTURE WITHOUT-PROJECT CONDITION

Future SLC is expected to exacerbate the impacts of coastal flooding and wave attack as those forces would be occurring at a higher starting water level in the future as sea level rises. This will result in storm effects reaching further inland.

2.3.9 SEA LEVEL CHANGE

The full analysis of the sea level change existing and future conditions is documented in Section 2.2.1 of the **Engineering Appendix (A)**.

Relative Sea Level (RSL) refers to local elevation of the sea with respect to land, including the lowering or rising of land through geologic processes such as subsidence and glacial rebound. It is anticipated that the global mean sea level will rise within the next 100 years. To incorporate the direct and indirect physical effects of projected future Sea Level Change (SLC) on design, construction, operation, and maintenance of USACE coastal projects, the climate assessment for Relative Sea Level Change (RSLC) follows the USACE guidance of Engineering Regulation, (ER) 1100-2-8162 (USACE 2013) and Engineering Pamphlet (EP) 1100-2-1 (USACE 2019). Three scenarios are required by ER 1100-2-8162 guidance: A Baseline (or "Low") scenario, representing the minimum expected SLC; an Intermediate scenario; and a High scenario representing the maximum expected SLC.

EXISTING CONDITIONS

Historical Sea Level Change Trends

Based on historical sea level measurements taken from NOAA gauge 9755371 San Juan Bay, PR, and NOAA gauge 9759110 Magueyes Island, PR, the historic sea level change rates for San Juan and Rincon areas were determined using the published SLC from *http://www.corpsclimate.us/ccaceslcurves.cfm*.

At gauge 9755371, the Mean Sea Level (MSL) trend from 1962 to 2018 is 2.04 mm/yr. (0.0067 ft/yr.) +/- 0.39 mm/yr. (0.0013 ft/yr.) at 95% confidence. This is equivalent to a change of 0.67 ft in 100 years for San Juan area. At gauge 9759110, the MSL trend from 1955 to 2018 is 1.82 mm/yr. (0.0060 ft/yr.) +/- 0.31 mm/yr. (0.0010 ft/yr.) at 95% confidence. This is equivalent to a change of 0.60 ft in 100 years for Rincon study area.

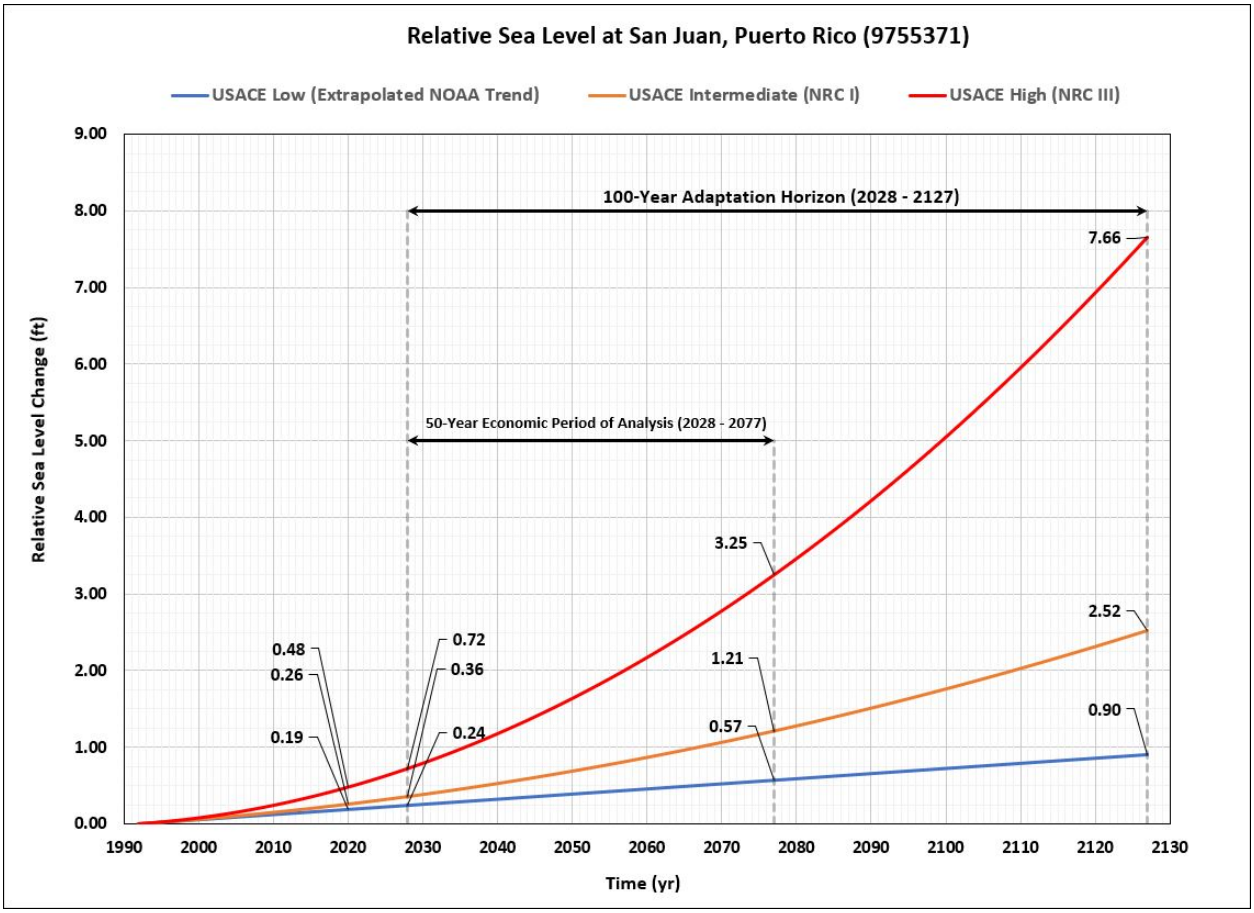
FUTURE WITHOUT-PROJECT CONDITION

Three dates are important when projecting SLC for a given study area under current guidance: (1) the project "base" year, which is the year that the project's construction is assumed to be completed; (2) the end of the economic period of analysis, which is 50 years following construction completion; and (3) the project's adaptation horizon, which is 100 years following construction completion to adapt to climatological changes. The base year for this study is 2028, the 50-yr economic period of analysis for this study is 2077, and the 100-yr adaptation horizon for this study is 2127. Following procedures outlined in ER 1110-2-8162 and EP 1100-2-1, low, intermediate, and high Sea Level Change (SLC) values were estimated over the life of the project using the official USACE sea level change calculator tool. Projections for sea level rise are based on a start date of 1992, which corresponds to the midpoint of the current National Tidal Datum Epoch of 1983-2001.

Sea Level Change Projections for San Juan, Puerto Rico

Based on USACE guidance and the historic local MSL trends in San Juan, SAJ developed three curves for the San Juan area projected to the 2127 (100-yr) adaptation horizon. The USACE low SLR curve simply extrapolates the USACE linear trend, like extrapolating an historic SLC rate. The regional USACE linear trend for San Juan (SLC Calculator) projected to 0.57 ft by 2077 and 0.90 ft by 2127 using NOAA's MSL trend stated previously. The USACE intermediate curve (NRC I) projects 1.21 ft by 2077 and 2.52 ft by 2127 increase. The USACE high curve (NRC III) estimates 3.25 ft by 2077 and 7.66 ft by 2127 increase. These data are displayed in **Figure 2-17**.

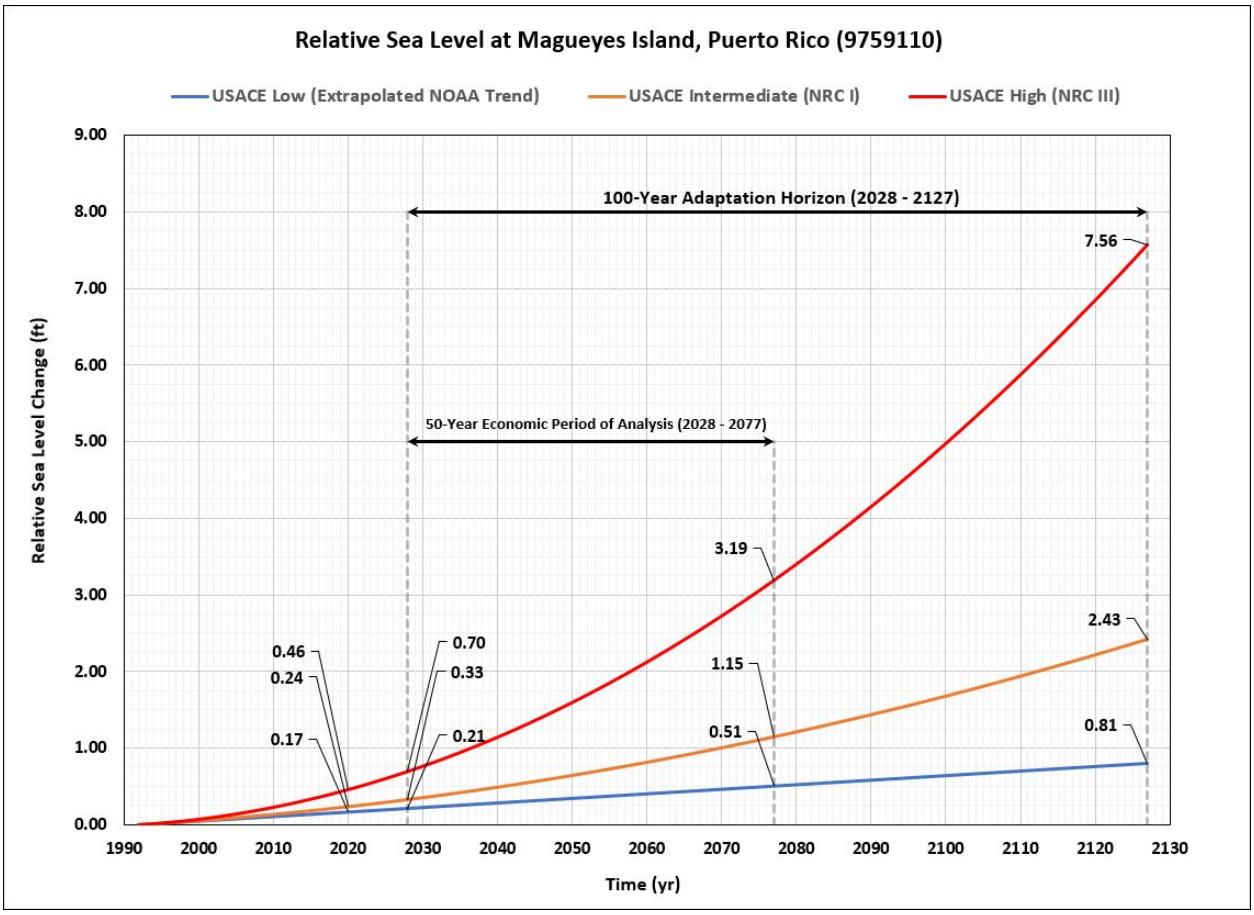
Figure 2-17. SLC Projections for San Juan, Puerto Rico



Sea Level Change Projections for Rincon, Puerto Rico

Again, like the San Juan study area, SAJ developed three curves projected to the 2127 (100-yr) adaptation horizon for the Rincon study area. Table A - 12 shows that the regional USACE linear trend for the Rincon area projects to 0.51 ft by 2077 and 0.81 ft by 2127, the USACE intermediate projects to 1.15 ft by 2077 and 2.43 ft by 2127, and the USACE high curve projects to 3.19 ft by 2077 and 7.56 ft by 2127. **Figure 2-18** displays this information graphically.

Figure 2-18. SLC Projections for Rincon, Puerto Rico



2.3.9.1 VULNERABILITY TO SEA LEVEL CHANGE

In order to evaluate the vulnerability to resources from potential SLC in the focus areas, average first-floor elevations were compared to SLC projections. Error! Reference source not found. and Error! Reference source not found. display the relative SLC projections from 2020 to 2127 for three levels of projected future SLC over the life of the project, as well as the NOAA 1% AEP above the intermediate curve and average first-floor elevations for Ocean Park (6.7 ft), Condado (18.7 ft), and Rincon (9.4 ft). The average first-floor elevations within both San Juan and Rincon have a low probability of coastal flooding caused solely by the effects of relative sea level change.

Error! Reference source not found. and Error! Reference source not found. display the tidal datums and extreme water levels for NOAA gauges 9755371 and 9759110 against the average first-floor elevations at Ocean Park, Condado, and Rincon.

The total regional sea level rise predicted by the three scenarios (low, intermediate, and high) will have an insignificant impact to the study areas, although when combined with various storm events potential impacts include overtopping of waterside structures, increased shoreline erosion, and flooding of low-

lying areas. SLC will further exacerbate the problem of inundation due to storm surge and tidal impacts to the study area for the Future Without Project condition.

Figure 2-19. Relative SLC (2020-2127) with Average First-Floor Elevations for Ocean Park (6.7 ft) and Condado (18.7 ft)

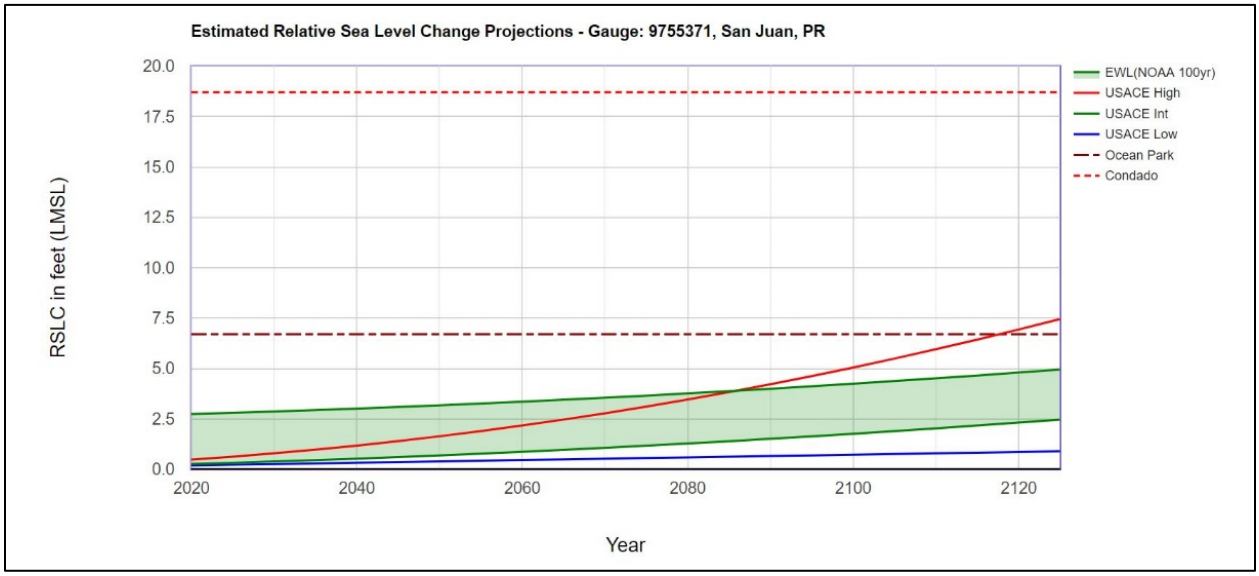


Figure 2-20. Relative SLC (2020-2127) with Average First-Floor Elevations for Rincon (9.4 ft)

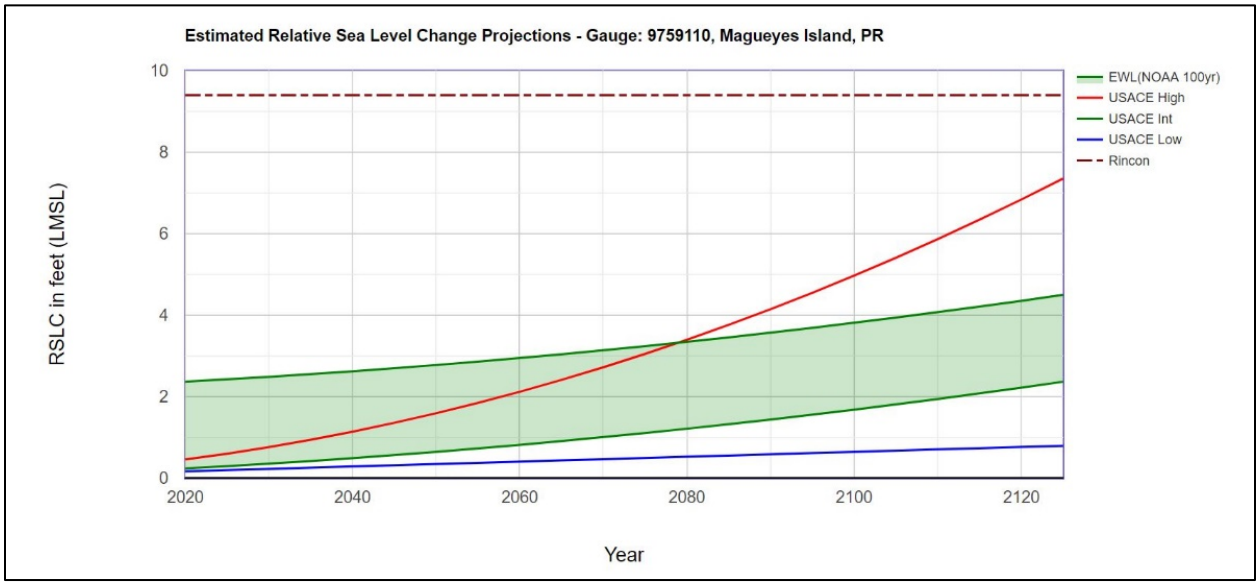


Figure 2-21. 2018 Tidal Datums and Extreme Water Levels for Gauge 9755371, San Juan, PR

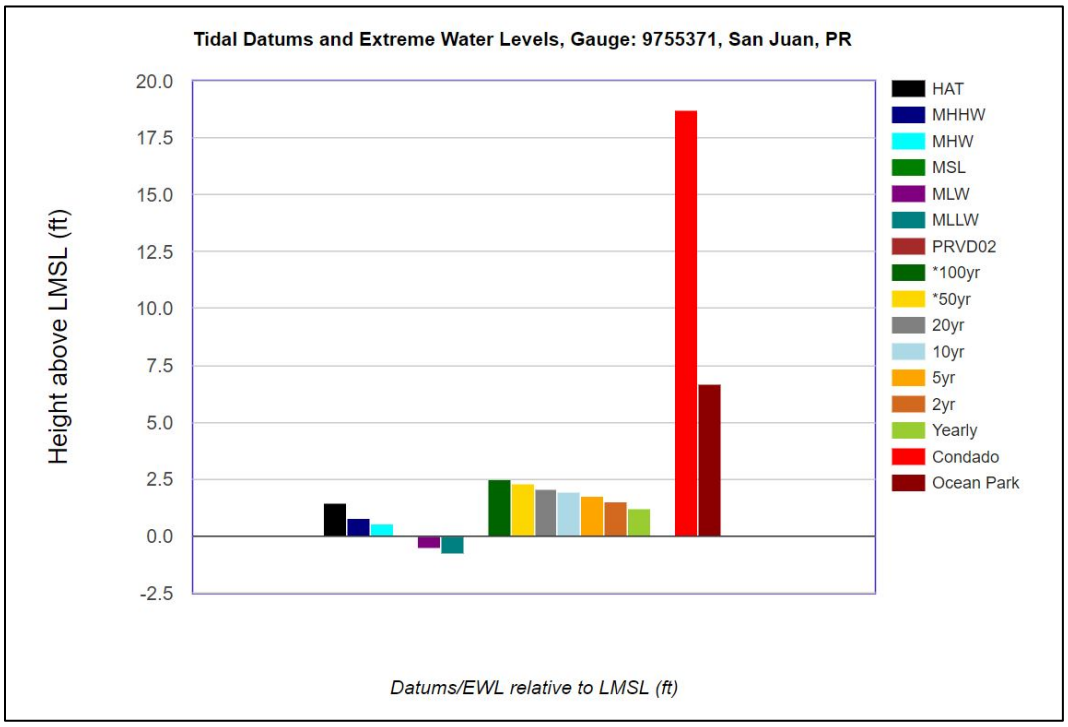
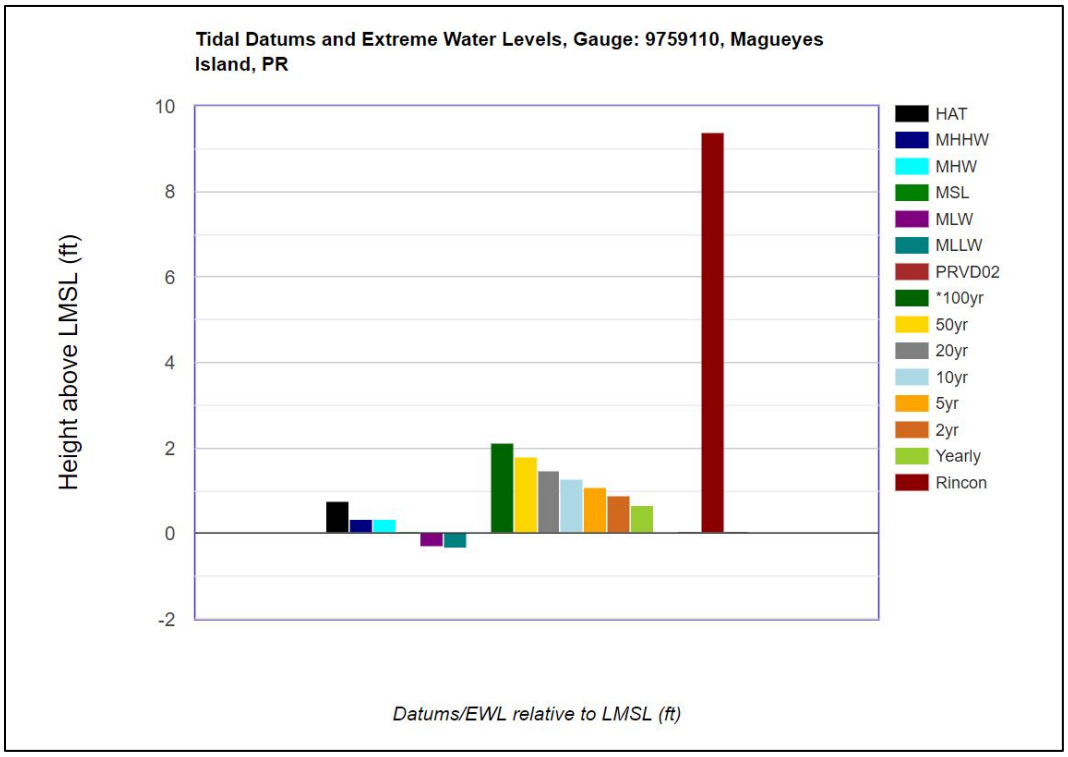


Figure 2-22. 2018 Tidal Datums and Extreme Water Levels for Gauge 9759110 Magueyes Island, PR



2.4 BUILT ENVIRONMENT

2.4.1 EFFECTS OF OTHER COASTAL STORM RISK MANAGEMENT (CSRM) AND NAVIGATIONPROJECTS

EXISTING CONDITIONS

OTHER CSRM PROJECTS

To date, no other Coastal Storm Risk Management projects have been constructed along the San Juan and Rincon study areas.

OTHER NAVIGATION PROJECTS

San Juan Harbor is a Federal navigation project located about 3 miles west of the San Juan study area, there is no evidence that San Juan Bay inlet or the navigation project affect sediment transport processes inducing erosion on the adjacent pocket beaches.

FUTURE WITHOUT-PROJECT CONDITION

The future without-project conditions of other CSRM and navigation projects are similar to the existing conditions described above.

2.4.2 HURRICANE EVACUATION ROUTES AND CRITICAL INFRASTRUCTURE

EXISTING CONDITIONS

The San Juan and Rincon structure inventory includes all structures that are within approximately 600 feet of the Mean High Water (MHW) line. In San Juan, there are 11 structures identified as critical infrastructure, which include shelters, the Presbyterian Community Hospital, police stations and a fire department (See **Figure 2-23**). PR Highway 187, PR Highway 37 and the expreso Loiza PR 26 are the main evacuation routes for the San Juan Metro area. However, these highways are set back from the shoreline making them less susceptible to storm damages. The Puerto Rico Highway and Transportation Authority (PRHTA) maintains these roads and has not expressed interest or need for a Federal project to protect these roads from coastal storm damages. The Rincon structure inventory does not contain any critical infrastructure on which the area depends, such as hospitals or emergency services. The existing medical centers, fire departments and shelters are located further inland at higher elevations (**Figure 2-24**).

FUTURE WITHOUT-PROJECT CONDITION

In the future without-project condition coastal flooding and wave attack would continue to occur, and future increase in sea levels will result in storm effects reaching further inland. The PRHTA would continue to operate and maintain the mentioned evacuation routes.

Figure 2-23. San Juan Study Area Critical Infrastructure

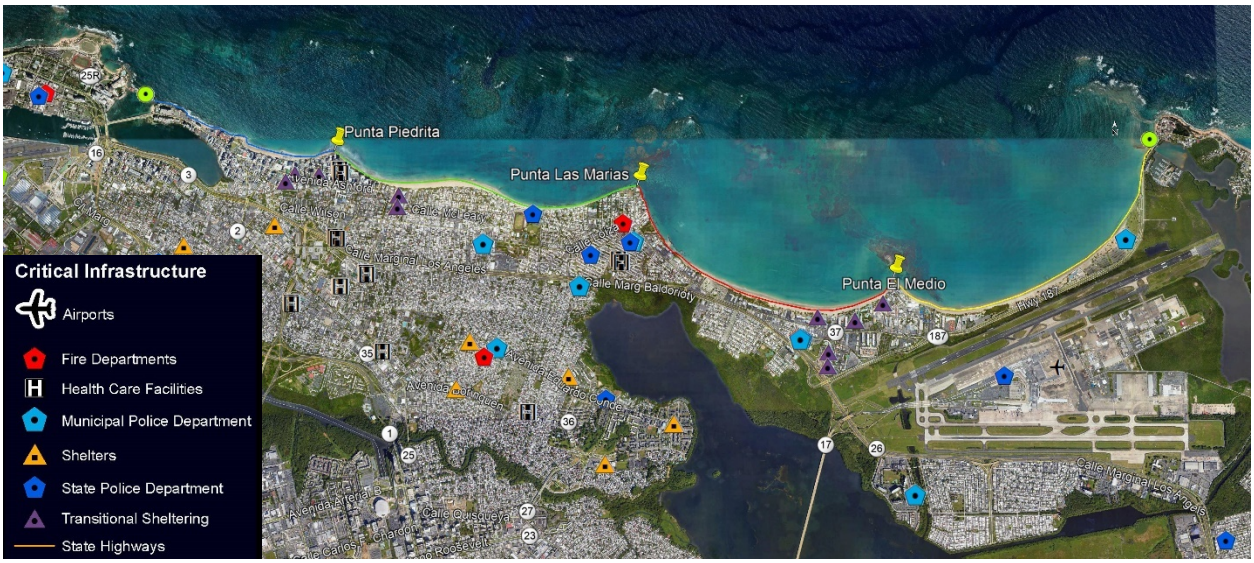
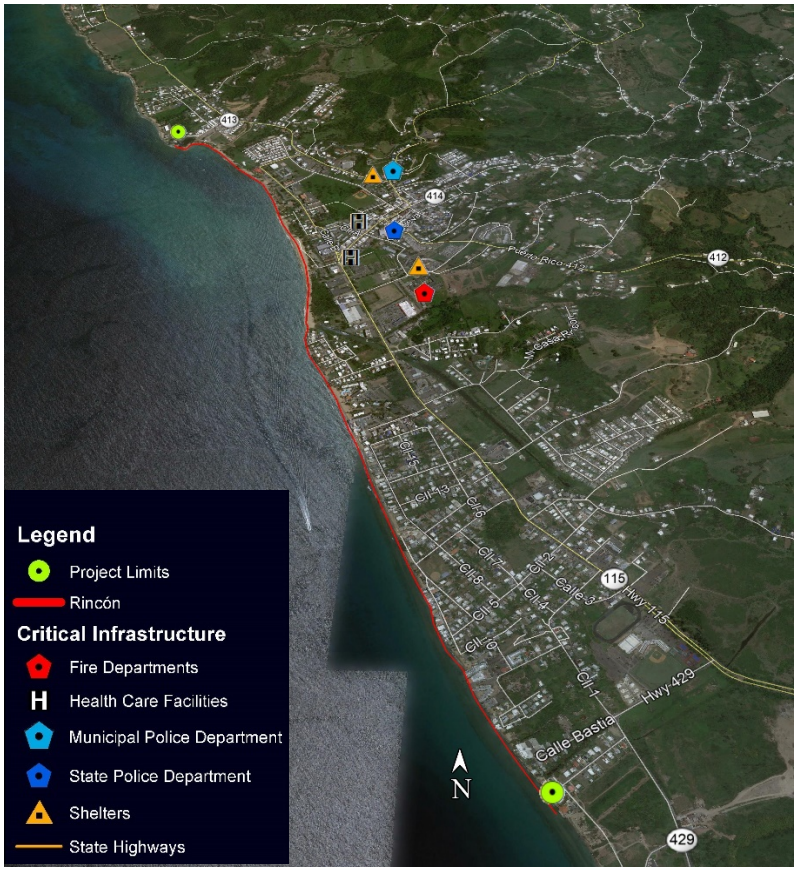


Figure 2-24. Rincon Study Area Critical Infrastructure



2.4.3 COASTAL ARMORING

The traditional response to coastal hazards in Puerto Rico, has been to design and implement vertical coastal structures to protect individual properties. Large amount of vertical structures has resulted in negative effects on both the project site as well as on adjacent coastal areas. The lack of a programmatic approach to shoreline management and protection in Puerto Rico, as well as poorly designed or maintained coastal features, have resulted in constant repairing and replacement of failed structures. The most common coastal structures in the focus areas are seawalls, and stone revetments. Section 1.2 of The **Engineering Appendix (A)** presents a detailed description of the existing coastal features in San Juan and Rincon. Overall, structure inventory located at the headlands in San Juan (West Condado, Punta Piedrita, Punta Las Marias and Punta El Medio) is broadly protected by seawalls and rock revetments. The San Juan pocket beaches contain a mixture of coastal protection, but the predominant type is seawall. Specific to Rincon, property owners have implemented unplanned or unproperly designed coastal armoring, commonly referred as manmade protection structures, which don't provide adequate level of protection. The southern part of Rincon focus area is characterized for high extent of coastal structures like stone revetments and seawalls protecting private property. Explanation about the modeling assumptions relevant to coastal armoring is provided in the **Economics Appendix (C)** Section 3.2.4.

Figure 2-25 and **Figure 2-26** present an overview of the existing coastal protection in San Juan and Rincon focus areas.

Figure 2-25 San Juan Focus Areas Existing Coastal Protection

Figure 2-26 Rincon Focus Areas Existing Coastal Protection

2.4.4 PUBLIC ACCESS AND PARKING

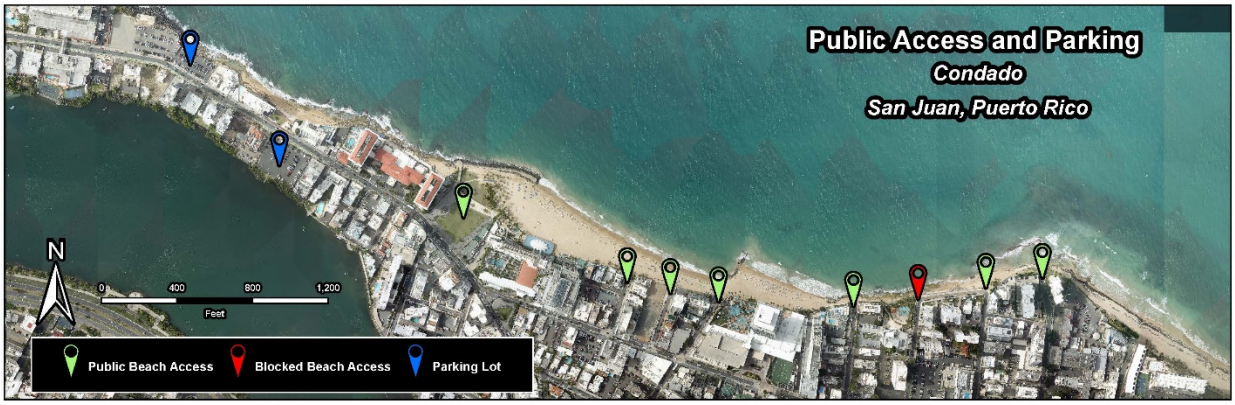
EXISTING CONDITIONS

Federal participation in CSRM projects involving placement of sand is limited to shorelines open to public use. Guidance is provided in Engineering Regulation (ER) 1105-2-100 and ER 1165-2-130. Cost sharing for any recommended plan is based on shoreline ownership, use, and the availability of public access.

CONDADO FOCUS AREA

There are currently 8 access points with 330 parking spaces and 1 blocked access point (street end) within the Condado focus area, See **Figure 2-27**.

Figure 2-27. Condado Beach Public Access Inventory



OCEAN PARK FOCUS AREA

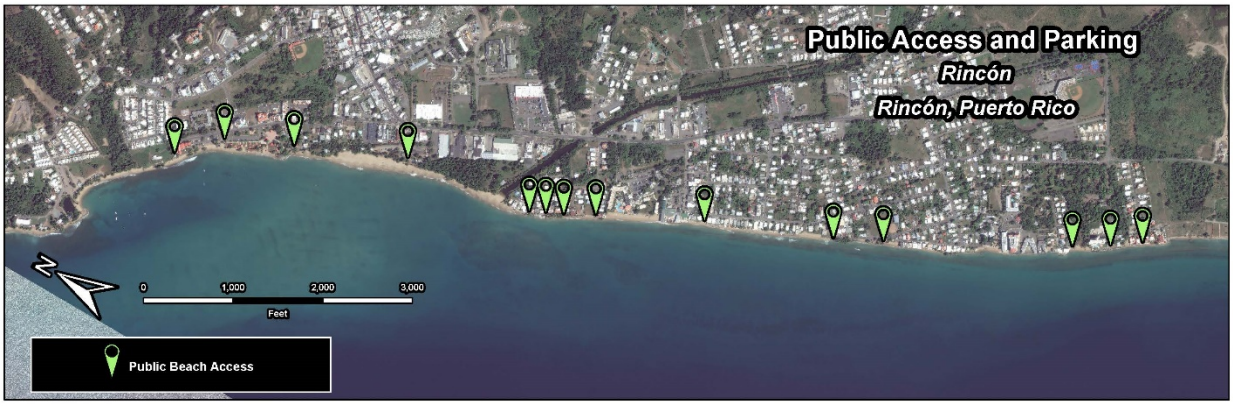
There are currently 16 access points with 500 parking spaces, and 6 blocked beach access points (street end) within Ocean Park focus area, See **Figure 2-28**.

Figure 2-28. Ocean Park Beach Public Access Inventory

RINCON FOCUS AREA

There are currently 14 access points with 91 parking spaces within the focus area of Rincon, See **Figure 2-29.**

Figure 2-29. Rincon Beach Public Access Inventory



FUTURE WITHOUT-PROJECT CONDITION

In the future without-project condition, access and parking for recreational use is not expected to change. In absence of a Federal project, there is sufficient access and parking for recreational use in San Juan and Rincon focus areas.

2.5 ECONOMIC ENVIRONMENT

The **Economic Appendix (C)** fully covers the economic investigations, the modeling efforts, and the benefits evaluation in order to get a recommended plan. This section summarizes the existing conditions and the future without project conditions (FWOP) analyses. The benefits breakdown using the Future With Project condition (FWP) will be presented in Chapter 3.

- **Existing Conditions:** Includes an assessment of socio-economic conditions, spatial organization of the study area, and an inventory of the coastal infrastructure within the study area.

- **Future Without Project Condition (FWOP):** The FWOP is a forecast of the economic conditions and structure values located within the project area that are subject to the risks associated with coastal processes and coastal storms. The FWOP is the basis for alternative comparison in order to obtain the benefits from any potential federal project.

- **Coastal Storm Risk Management (CSRM) Benefits:** The benefits are estimated through the future without-project and future with-project condition analysis using Beach-fx, while also accounting for

risk and uncertainty. Discussion of the ongoing FWP condition will address the management measures and alternative plans evaluated (see Chapter 3).

EXISTING CONDITIONS

Information on the existing economic conditions along the San Juan and Rincon focus areas was collected for economic modeling purposes (Beach-fx). The Carolina focus area appeared to not have the potential for economic justification needed to be moved forward into modeling in Beach-fx; therefore, the modeled areas in San Juan only include Condado, Ocean Park and Isla Verde. The Rincon focus area is modeled separately.

2.5.1 SOCIO ECONOMIC CONDITIONS

Data from the 5-year 2018 American Community Survey was collected at the census tract level within San Juan and Rincon focus areas. There are approximately 8,000 people living within the Condado, Ocean Park and Isla Verde (census tracts 10, 11, and 12) directly impacted by the proposed alternatives. The average unemployment rate is 8% and average income is $69,576. On average, 17% of the residents live below poverty level.

The socioeconomic characteristics of the Rincon Municipality are significantly different from those found in San Juan. The focus area of Rincon impacts primarily census tract 9596. There are about 6,800 people living within the Rincon (census tract 9596) directly impacted by the proposed alternatives. Though the unemployment of 8% is similar to the census tracts in San Juan, the level of poverty and median wage is considerably different. The percent of population living below poverty in Rincon, 41%, is over twice that of the average population living in poverty in the San Juan census tracts (17%). The average income in Rincon ($27,432) is less than one-third that of the entire United States' average income ($84,938).

2.5.2 DATA COLLECTION

Economists and real estate specialists have collected and compiled detailed structure information for the four focus areas (Rincon, Condado, Ocean Park, and Isla Verde). In total, 838 damageable structures were collected for economic modeling using Beach-fx. The structure inventory includes all structures that are within approximately 600 feet of the mean-high-water line[5].

Real estate professionals from the USACE Savannah District (SAV), using geo-spatial parcel data from Puerto Rico's Centro de Recaudación de Ingresos Municipales (Municipal Revenues Collection Center or CRIM), provided detailed data on each structure including: geographic location, structure type, foundation type, construction type, number of floors, depreciated replacement value, and approximate foundation height[6].

[5] In some areas the landward extent of the model was increased based on topography (i.e. extended to accommodate further risk estimation).

[6] Estimated foundation height was used to establish a structure's first-floor elevation.

The PR CSRM study area consists of 25 profiles, and 51 model reaches, and over 100 lots for economic modeling and reporting purposes. This hierarchical structure is depicted as follows:

- **Profiles:** Coastal surveys of the shoreline modified by USACE SAJ Coastal Engineering personnel to apply coastal morphology changes to the model reach level. Specific details can be found in the Engineering Appendix (A).

- **Beach-fx Model Reaches:** Quadrilaterals parallel with the shoreline used to incorporate coastal morphology changes for transfer to the lot level. Each model reach is separately subjected to environmental forcing irrespective of neighboring reaches.

- **Lots:** Quadrilaterals encapsulated within reaches used to transfer the effect of coastal morphology changes to the damage element.

- **Damage Elements:** Represent a unit of coastal inventory in the existing condition and a store of economic value subject to losses from wave-attack, inundation, and erosion damages.

2.5.3 STRUCTURE INVENTORY

The economic value of the existing structure inventory represents the depreciated replacement costs of damageable structures (i.e. damage elements or assets) and their associated contents along the coastline. Real Estate professionals from the USACE SAV district worked together with economists and planners to provide economic valuations for all of the 800+ damageable structures and their contents. These damage elements have an overall estimated value of $2.9B, with structure and content valuations of $2.5B and $400M respectively. Content values were established as a ratio to overall structure value. When applicable, content-to-structure ratios were based off the USACE IWR 2012 "*Nonresidential Flood Depth-Damage Functions Derived from Expert Elicitation*" report. Many items in the structure inventory had a CSVR of 0% (e.g. roads, dune walks, parking lots). It is also important to note that content valuation considers only those contents anticipated to be at risk from flood, wave, and erosion and, specifically in cases of high-rise structures, may not include total contents. As a result, the average CSVR across the entire study area is roughly 20%. The overall distribution of value by focus area is summarized in **Table 2-6**.

Table 2-6. Distribution of Structures & Structure Value by Modeled Focus Area

Focus Area	Structure	Contents
Condado	$ 854,793,000	$ 72,814,000
Ocean Park	$ 473,928,000	$ 75,973,000
Isla Verde	$ 965,683,000	$ 178,106,000
Rincon	$ 264,409,000	$ 67,248,000
Total	**$ 2,558,813,000**	**$ 394,141,000**

FUTURE WITHOUT-PROJECT CONDITIONS

2.5.4 BEACH-FX MODEL SET-UP

The **Engineering Appendix (A)** and the **Economic Appendix (C**) provide a complete description of the Beach-fx model set-up and use. Data on historic storms, beach survey profiles, and private, commercial and public structures within the project area is used as input to the Beach-fx model. The model is then used to estimate future damages resulting from hurricanes and coastal storms. The future structure inventory and values are the same as the existing condition. This approach neglects any increase in value accrued from future development. Using the existing inventory is considered preferable due to the uncertainty involved in projections of future development.

The future without-project damages are used as the base condition against which potential alternatives will be compared. The difference between FWOP and FWP damages are used to determine primary CSRM benefits.

2.5.4.1 BEACH-FX MODEL ASSUMPTIONS

Each focus area (Rincon, Condado, Ocean Park, and Isla Verde) was modeled separately, resulting in four separate modeling databases. This was required due to the complexity of the shoreline shape as well as the differences in the coastal processes subjected to each individual focus area. This section describes some key assumptions relevant to the timeframe and discount rate. The rest of the modeling assumptions, such as rebuilding, damage functions, and coastal armoring, are fully explained in section 3.2 of the Economics Appendix (C).

TIMEFRAME AND DISCOUNT RATE

- **Start Year:** The year in which the simulation begins is 2019. This year determines the starting shoreline position which will be impacted by standard erosion and storm forces throughout the period of analysis. It is also the starting point for the sea-level rise projections.

- **Base Year:** The year in which the benefits of a constructed federal project would be expected to begin accruing is 2028.

- **Period of Analysis:** 50 years, from 2028 to 2077.

- **Discount Rate:** 2.75% FY2020 Federal Water Resources Discount Rate

- **Iterations:** The number of iterations run within Beach-fx was decided based on model run time and model stabilization. The model was run with the fewest number of iterations possible to allow for stabilization using 25 iteration increments. For Rincon, 100 iterations were run. For the remaining planning reaches 50 iterations were run. The moving average of FWOP damages stabilized by this point and was thus determined an adequate number of iterations. The tentatively selected plan (TSP) will be updated with at least 100 iteration run for economic justification considerations and will be included in the final report.

2.5.5 PLANNING REACHES AND MODELING REACHES DISTRIBUTION

Section 3.71 presents the rationale used for the delineation of the planning reaches on this study. **Figure 3-2** and **Figure 3-3** show the extent of the San Juan and Rincon planning reaches. There are seven planning reaches in the San Juan study area (three pocket beaches and four headlands), and two planning reaches in Rincon where Beach-fx modeling of the FWOP condition was performed to estimate damages. Following is the list of planning reaches with their respective modeling reaches:

San Juan Planning Reaches

- Condado West Headland – Composed of Beach-fx modeling reaches Condado R-09 to R-06
- Condado Pocket Beach – Composed of Beach-fx modeling reaches Condado R-05 to R-02
- Punta Piedrita – The eastern headland of Condado, western headland of Ocean Park, comprised of modeling reach Condado R-01 and Ocean Park R-16 to R-15
- Ocean Park Pocket Beach – Composed of Beach-fx modeling reaches Ocean Park R-14 to R-03
- Punta Las Marias – Composed of Beach-fx modeling reaches Ocean Park R-02 to R-01 and Isla Verde modeling reach R-15.
- Isla Verde Pocket Beach: Composed of Beach-fx modeling reaches Isla Verde R-04 to R-14
- Punta El Medio – Composed of Isla Verde Beach-fx modeling reaches R-03 to R-01 and the unmodeled Carolina segment[7].

Rincon Planning Reaches

- Rincon A – Composed of Beach-fx modeling reaches R-01 to R-10
- Rincon B – Composed of Beach-fx modeling reaches R-11 to R-22

2.5.6 FUTURE WITHOUT PROJECT CONDITION (FWOP) – BEACH-FX

This section contains a brief summary of the FWOP damages results per every focus area (Rincon, Condado, Ocean Park and Isla Verde). The **Economic Appendix (C**) contains the full analysis of the FWOP damages, which include the descriptive statistics, damage distribution by structure category and type, spatial distribution of damages, damage distribution by damage driving parameter, temporal distribution of damages, emergency clean-up and evacuation costs, sea level Rise scenarios, and conclusions.

[7] See Section 3.7.1 for the qualitative screening of the Carolina reach.

2.5.6.1 RINCON FUTURE WITHOUT PROJECT CONDITION (FWOP) OVERALL SUMMARY

- Average Annual Equivalent damages (AAEQ) per the FWOP model results:
  - Mean Structure, Content, Armor Damage: $1,377,237 (AAEQ)
  - Average ERC&E Costs: $6,000 (AAEQ)
- Damage Distribution by Structure Category and Type: The majority of the damage is structural in nature. Structure damages account for 75% and Content damages are 25% of the damages for the FWOP.
- **Spatial Distribution of Damages**: The Rincon modeling area is made up of twenty-two Modeling Reaches and two Planning Reaches. FWOP damages are mainly concentrated in the southern portion of the focus area, which is represented by planning reach "Rincon B". Reaches 11-19 make up 86.1% of the damages. The remainder are mainly distributed in reaches 7, 8, and 22, which account for 10.7% of total damage. The concentration of damages in reaches 11-19 set the length of the reach where alternatives were formulated.
- **Damages by Damage Driving Parameter**: Damages are largely driven by flood and erosion damage. Erosion: 45.0%, Inundation: 53.3%, Wave Attack: 1.7%.
- **Temporal Distribution of Damages**: Damage in reaches that are susceptible to inundation have high damage in the initial years due to structures in these reaches being condemned and dropping out of the inventory throughout the lifecycle. In reaches where erosion is the leading damage driver, damages increase over time.
- **Emergency Clean-up and Evacuation Cost (ERC&E)**: The ERC&E is estimated to be around $6,000 (AAEQ) for Planning Reach Rincon-B.
- **Damages in Sea-Level-Rise Scenarios**: From the low to intermediate SLR scenario damages have an increase of roughly 18.0%, or $210,000 in AAEQ damages. From the intermediate to high scenario damages spike showing an increase of 320%, or roughly $4,420,000 in AAEQ damage. From the low to high scenario damages increase by 397%. There is very little shift in what drives the damages from the low to the intermediate scenario. In the high sea level rise scenario, flood damages rise steeply.
- **Rincon FWOP Conclusion**: Based on the above results, the planning reach Rincon A will make any type of alternative cost prohibitive. Therefore, plan formulation will be performed only in planning reach B, where the damages are almost entirely concentrated. The alternatives formulation is documented in Section 3.7. Damages in the FWOP increase significantly in the high sea level rise scenario; but the intermediate sea-level curve is being used for plan formulation purposes. The tentatively selected plan will be evaluated under the three SLC scenarios, and adaptation measures will be incorporated.

2.5.6.2 CONDADO FUTURE WITHOUT PROJECT CONDITION (FWOP) OVERALL SUMMARY

- Average Annual Equivalent damages (AAEQ) per the FWOP model results:
  - Mean Structure, Content, Armor Damage: $758,000 (AAEQ)
  - Average ERC&E Costs: $10,000 (AAEQ)
- **Damage Distribution by Structure Category and Type**: Structure damages account for 87% and Content damages are 13% of the damages for the FWOP. Armor damages are responsible for 1% of FWOP damages. Monetary costs resulting from emergency clean-up efforts and emergency evacuation are responsible for 1% of FWOP damages.
- **Spatial Distribution of Damages**: The Condado modeling area is made up of nine Modeling Reaches and three Planning Reaches. The Planning Reaches (West Headland, Pocket Beach, Punta Piedrita Headland) are areas with distinct engineering characteristics and areas that are separable in their potential for project implementation. The western headland is characterized by a rocky outcropping and heavy existing armor. Early engineering assessments concluded technical feasibility of measures in this area would be difficult due to the need to tie into existing structures on private property as well as the challenges presented by the offshore environment. Additionally, early modeling results indicated an extremely low chance of implementing a cost-effective measure (Damages about $185,000 AAEQ). Therefore, more detailed modeling excluded the Western Headland. Condado Pocket Beach represents the sandy pocket beach where there are many high-rise hotels very near MHW and the presence of armoring is very minimal in the existing condition. Damages in Condado Pocket Beach ($575,000 AAEQ) are the highest total as well as the highest per linear foot ($286 AAEQ). Punta Piedrita Headland is the eastern headland and is also characterized by a rocky outcropping, damages are about $194,000 AAEQ. However, unlike the West Headland, Punta Piedrita Headland is a relatively smaller reach and damages are high in this area per linear foot ($192).
- **Damages by Damage Driving Parameter**: The damages in Condado are majority erosion, driven primarily by damages in the Pocket Beach area. Erosion counts for more than 75% in the Pocket Beach. For the Punta Piedrita Headland, damages are primarily flooding (~66%) and wave (~33%) with no damages coming from erosion due to existing armoring in this area.
- **Temporal Distribution of Damages**: The distribution of FWOP damages over time in Condado shows that storm impacts play a large role in damages. In study areas where long-term gradual erosion is a severe problem, damages gradually increase over time with spikes when storms hit. In Condado, damages are sporadic and spike up and down from the start indicating vulnerability to the random nature of storm occurrences versus gradual long-term erosion.
- **Emergency Clean-up and Evacuation Cost (ERC&E)**: Condado has relatively fewer residential structures in the near-shore and as a result evacuation costs are virtually non-existent. However, emergency clean-up costs are a much larger factor and are estimated at $10,000 (AAEQ).
- **Damages in Sea-Level-Rise Scenarios**: From the low to intermediate SLR scenario damages have an increase of only 8%. However, under the high scenario damages increase 53% from the

intermediate curve and 65% from the low curve. Again, this demonstrates the increased susceptibility and vulnerability of these Puerto Rico coastal structures in the face of more severe increases in the sea level over time.

- **Condado FWOP Conclusion**: Total damages in the FWOP condition, including ERC&E, are $768,000. Based on the above results, the planning reach Condado West Headland is screened out, and plan formulation will be performed only in Condado Pocket Beach and Punta Piedrita Headland planning reaches. Damages are largely driven by storm events instead of gradual erosion. Damages in the FWOP increase significantly in the high sea level rise scenario.

2.5.6.3 OCEAN PARK FUTURE WITHOUT PROJECT CONDITION (FWOP) OVERALL SUMMARY

- Average Annual Equivalent damages (AAEQ) per the FWOP model results:
  - Mean Structure, Content, Armor Damage: $6,728,000 (AAEQ)
  - Average ERC&E Costs: $350,000 (AAEQ)

- **Spatial Distribution of Damages**: The Ocean Park modeling area is made up of sixteen Modeling Reaches and three Planning Reaches Like each of the San Juan focus areas, the planning reaches are characterized by headland points in the east and west (Punta las Marias and Punta Piedrita) and a sandy pocket beach formation between the rocky headlands (Ocean Park Pocket Beach). FWOP damages are the highest of all the focus areas, and the damages per linear foot in each of the three planning reaches are also relatively high. Punta Piedrita reach contains the Presbyterian Community Hospital which is at-risk in the FWOP as well as many high-rise condominium complexes and as a result has a high density of damages ($1,595,000 AAEQ), the most in all planning reaches per linear foot throughout the entire study ($1,152 AAEQ). Ocean Park Pocket Beach is the sandy pocket beach where there is a high density of single-family residents, the damages in this reach are $4,568,000 AAEQ, and the damages per linear foot are quite large there as well ($761 AAEQ). Punta Las Marias falls in between the other two reaches in terms of damages per linear foot ($318).

- **Damages by Damage Driving Parameter**: Overall, FWOP damages in Ocean Park are largely driven by flooding (71%) with wave damages next (20%) and lastly erosion (9%). For the Punta Piedrita Headland, damages are primarily flooding (84%) with smaller damages coming from waves (13%) and erosion (3%). Flooding counts for more than 71% in the Pocket Beach with wave damages about 20% and lastly erosion (11%). For the Punta Las Marias Headland, wave damage is greater than the other reaches (50%) followed by flooding (45%) with no damages coming from erosion due to existing armoring in this area.

- **Temporal Distribution of Damages**: Damages are almost evenly distributed throughout the period of analysis. The damages are somewhat higher in the first several years of the analysis since structures and lots have not yet been condemned.

- **Emergency Clean-up and Evacuation Cost (ERC&E)**: Ocean Park has some of the highest estimated ERC&E damages in the FWOP condition. This is again a result from the structures being mostly residential in nature which increases evacuation risk, which was estimated at $71,000

(AAEQ) in the FWOP. It is also a function of the density of structures in this focus area and each commercial and residential structure is at risk of incurring emergency clean-up costs, which is estimated at $279,000 (AAEQ) for a total combined ERC&E cost of $350,000.

- **Damages in Sea-Level-Rise Scenarios**: Damages in the SLR scenarios show similar patterns as the other focus areas. Damages only increase 13% from the baseline to the intermediate scenario, which emphasizes the high vulnerability of Ocean Park even if the baseline SLR scenario continues into the future. Again, though, damages escalate very quickly in the high SLR scenario and shows an 120% and 94% increase from the baseline and intermediate respectively. All the San Juan focus areas demonstrate an increased vulnerability in the future if sea-level rise begins to track the USACE high curve

- **Ocean Park FWOP Conclusion**: Total FWOP damages including ERC&E costs are estimated at $7,078,000. Ocean Park is relatively more vulnerable due to the many structures with low First Floor Elevation (FFE's) and a lower ground-surface elevation across the entire focus area. Based on the FWOP results, all the planning reaches in Ocean Park will move forward for formulation and evaluation of alternatives. Damages in the FWOP increase dramatically in the high SLR scenario but are also very high in the baseline condition indicating a high level of vulnerability for Ocean Park.

2.5.6.4 ISLA VERDE FUTURE WITHOUT PROJECT CONDITION (FWOP) OVERALL SUMMARY

- Average Annual Equivalent damages (AAEQ) per the FWOP model results:
    - Mean Structure, Content, Armor Damage: $221,000 (AAEQ)
    - Average ERC&E Costs: No modeling of the ERC&E was performed for Isla Verde

- **Spatial Distribution of Damages**: The Isla Verde modeling area is made up of fifteen Modeling Reaches and three Planning Reaches. The planning reaches are characterized by headland points in the east and west (Punta El Medio and Punta Las Marias) and a wide sandy pocket beach between the headlands (Isla Verde Pocket Beach). FWOP damages are the lowest of all the focus areas, and as a result, the PDT concluded early on that no-action was the most likely outcome. Based on that decision, the Isla Verde economic analysis will not have as detailed a description of damages as the previous focus areas have. Punta Las Marias reach (East side) damages are around $37,000 AAEQ, Isla Verde Pocket Beach damages are $154,000 AAEQ, and the Punta El Medio (West side) damages are $30,000 AAEQ.

- **Damages by Damage Driving Parameter**: The damages in Isla Verde are primarily flooding (48%) and wave (48%) with very low damages coming from erosion (4%).

- **Isla Verde FWOP Conclusion**: Based on the above FWOP results, the entire Isla Verde focus area (covered by three planning reaches) will make any type of alternative cost prohibited. Therefore, the no-Action alternative is being recommended.

2.5.7 LAND LOSS DAMAGES IN THE FUTURE WITHOUT PROJECT BY PLANNING REACH

Section **Error! Reference source not found.** of the **Economic Appendix (C)** describes the methodology used for estimating land loss. The FWOP land loss will be estimated for each applicable pocket beach since these are the only areas not currently armored or armored in the future subject to land loss. For this study, the only reach where land loss is a significant factor across the period of analysis is the Ocean Park Pocket Beach. Over the 50-years approximately 250,000 square feet of land is estimated to be lost in this planning reach which, in FY20 dollars is valued at approximately $17M. The average annual equivalent losses are approximately $308,000 (FY20 discount rate).

2.5.8 SUMMARY OF FUTURE WITHOUT PROJECT DAMAGES BY PLANNING REACH

The above sections of the report detailed the FWOP damages as recorded and modeled by Beach-fx per focus area. This section will summarize the FWOP damage estimates by planning reach since some planning reaches (Punta Piedrita, Punta Maria, and Punta El Medio) overlap model domains and need to be reported out separately for planning purposes. It is important to note, damage estimates were not double counted for structure inventory where overlap exists. **Table 2-7** presents the overall damages in these planning reaches and summarizes total for the entire study area, if modeled.

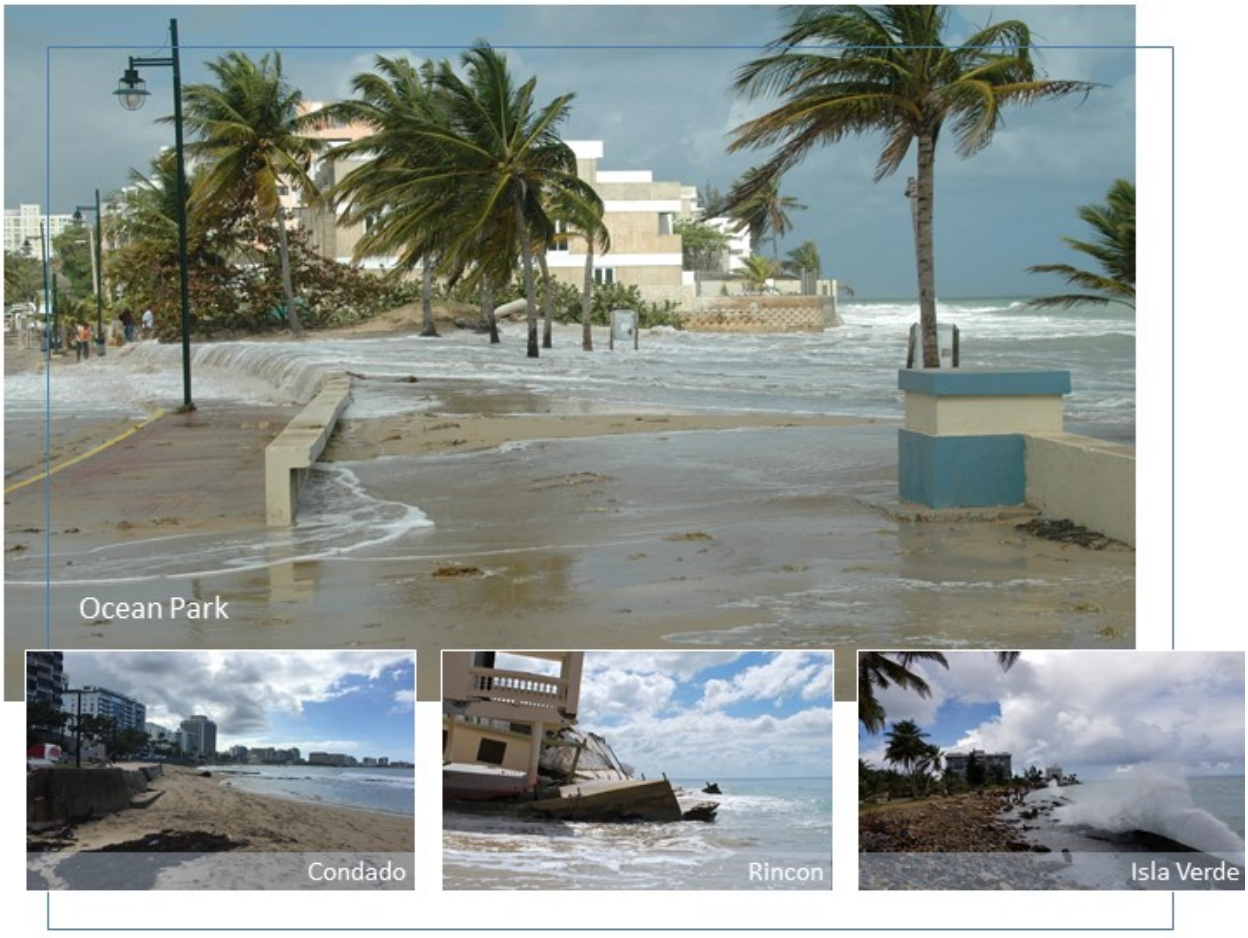
Table 2-7. Summary of FWOP damages by Planning Reach

Planning Reach	Present Value Damages $	AAEQ Damages $
Rincon A	$ 3,594,600	$133,000
Rincon B	$ 33,621,000	$1,245,000
Condado West Headland	Only preliminary Modeling	Only preliminary Modeling
Condado Pocket Beach	$ 15,512,077	$ 575,000
Punta Piedrita	$ 48,305,756	$ 1,789,000
Ocean Park Pocket Beach[8]	$ 131,655,125	$ 4,876,000
Punta Las Marias	$ 16,225,155	$ 601,000
Isla Verde Pocket Beach	$ 4,157,420	$ 154,000
Punta El Medio (West Only)[9]	$ 823,091	$ 30,000
Total	**$ 208,356,132**	**$ 7,717,000**

[8] Includes Land Loss

[9] The east end of Punta El Medio is part of Carolina Focus area, which was not modeled.

3. PLAN FORMULATION



3 PLAN FORMULATION

3.1 PLAN FORMULATION OVERVIEW

Risk-informed planning embodies all the principles and tasks of the USACE risk management framework and the six-step planning process. This paradigm shift to explicitly assessing and managing risk is more important than ever in meeting the USACE Civil Works mission. The Risk Inform Decision framework and PR Coastal study timeline are described in Section 1 of **Appendix (F) Planning Matrices and Tables**.

The Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies, established by the U.S. Water Resources Council on March 10, 1983, have been developed to guide the formulation and evaluation studies of the major Federal water resources development agencies. These principles and guidelines are commonly referred to as the "P&G," and will be cited throughout the plan formulation sections of this report.

Plan formulation is the process of developing alternative plans to address a given problem. The first step in plan formulation involves identifying all potential management measures for the given problems. A management measure is a structural or nonstructural action that can be implemented at a specific geographic site to address one or more planning objectives. An alternative plan includes one or more management measures to address the problem. Alternative plans can differ by types of measures, or how measures are combined or defined, including dimensions, quantities, materials, locations or implementation time frames.

Four accounts (P&G 1983) facilitate the evaluation of management measures and display the effects of alternative plans.

- National Economic Development (NED) account: Includes consideration of a measure's potential to meet the planning objective to reduce storm damages, as well as decrease costs of emergency services, lower flood insurance premiums, and consider project costs. Costs and benefits used to fully evaluate the NED objective are not calculated at this stage; however, estimates can be made to gage the overall cost-effectiveness of a measure for this initial screening. Effects of sea-level change and a measure's adaptability to such change were considered under the National Economic Development (NED) account.

- Environmental Quality (EQ) account: Considers ecosystem restoration, water circulation, noise level changes, public facilities and services, aesthetic values, natural resources, air and water quality, cultural and historic preservation, and other factors covered by the National Environmental Policy Act (NEPA).

- Other Social Effects (OSE) account: Includes considerations for the preservation of life, health, and public safety; community cohesion and growth; tax and property values; and, the displacement of businesses and public facilities. For evaluation purposes, the OSE account is inclusive of the planning objectives to maintain recreation and maintain a safe evacuation route, and the planning constraint to avoid conflict with legal requirements.

- Regional Economic Development (RED) account: Considers the potential impacts on the local economy including employment, income, and sales volume.

The P&G require the NED plan to be selected as the recommended plan, unless an exception is granted. Each plan was formulated in consideration of the following four criteria described in the Principles and Guidelines (P&G):

1. **Completeness:** Extent to which the plan provides and accounts for all necessary investments or actions to ensure realization of the planning objectives

2. **Effectiveness:** Extent to which the plan contributes to achieving the planning objectives

3. **Efficiency:** Extent to which the plan is the most cost-effective means of addressing the specified problems and realizing the specified opportunities, consistent with protecting the nation's environment

4. **Acceptability:** Workability and viability of the alternative plan with respect to acceptance by Federal and non-Federal entities and the public, and compatibility with existing laws, regulations, and public policies

The Sea-Level Change (SLC) Engineering Pamphlet (EP) 1100-2-1 supporting ER 1100-2-8162, suggests a tiered analysis to determine the risk of potential SLC and resulting incorporation into the plan formulation process. Incorporation of potential SLC into the USACE Planning process will require active focus on risk-based scoping to define pertinent needs, opportunities, and the appropriate level of detail for conducting investigations. In particular, close attention is needed at the beginning of each study in order to screen planning/scoping decisions. The tiered analysis for SLC is incorporated into the 6-step planning process used in this report. Based on the information in 2.3.11 and 2.5.6 the decision was made to formulate CSRM measures and alternatives around the intermediate USACE SLC curve; however, economic and physical evaluation of the tentatively selected plan will be conducted under the low and high USACE SLC curves as well. Adaptation strategies may be developed to mitigate the risk and increased vulnerability based on the TSP's sensitivity to SLC.

3.2 SCOPING*

3.2.1 FEDERAL NATIONAL ENVIRONMENTAL POLICY ACT (NEPA) SCOPING PROCESS

A public scoping letter was sent in October 2018 which outlined the USACE, Jacksonville District's intent to gather information to prepare an Environmental Assessment (EA) for evaluation of the feasibility of providing hurricane and storm damage reduction, and related purposes, to the Puerto Rico shoreline. The initial scoping period for the study was conducted from October 16 to November 16, 2018. Public and interagency meetings were held on November 6, 2018 in Aguadilla and November 8, 2018 in San Juan, with participation from the DNER, United States Fish and Wildlife Service (USFWS), National Marine Fisheries Service (NMFS), Puerto Rico Planning Board (PRPB), Office of Permits General (OGPe), Non-Governmental Organizations (NGO), Instituto de Cultura Puertoriquena (ICP), and the public. An additional public meeting to provide study updates was held on June 18, 2019 in Rincon. All correspondence associated with this NEPA scoping process is included in **Appendix I**.

3.2.2 AGENCY AND PUBLIC FEEDBACK

National Oceanic Atmospheric Administration (NOAA) and NMFS accepted cooperating agency status under NEPA on December 21, 2018. Significant support for the study was received from the public and agencies during the initial scoping period. Comments were primarily centered on a submerged breakwater/artificial reef alternative that would augment the existing natural fringing barrier reef. This could provide a relatively low-maintenance and more permanent solution. Additional comments concerning sea turtles, manatees, coral reefs/benthic resources, fish habitat, public safety, recreation and tourism were also received. Other public stakeholders expressed support for beach nourishment alternatives.

3.3 PROBLEMS AND OPPORTUNITIES*

A problem is an existing undesirable condition to be changed. An opportunity is a chance to create a future condition that is desirable.

The purpose of this feasibility study is to develop an implementable and acceptable plan to change the future condition and address specific problems and opportunities in the study area. Problems and opportunities have been identified by the Project Delivery Team (PDT) based on numerous sources, including previous USACE studies, reports completed by the non-Federal sponsor DNER, as well as scoping letter comments received from local residents and stakeholders.

3.3.1 PROBLEMS

This study considers the main problem within the San Juan and Rincon focus areas to be coastal storms causing damage to structures and infrastructure due to wave attack, flooding, and erosion.

Hurricanes and coastal storms are responsible for significant damages structures and infrastructure due to wave attack, flooding, and erosion for the entire island of Puerto Rico. These storm events threaten public and private properties, critical infrastructure as well as recreational beach areas. Many structures are located along the majority of the study area, including commercial businesses, hotels, condominiums, single family homes, in addition to roads, public parkland, and public beach access points. Loss of protective beaches and dunes, due to shoreline recession, threatens properties and infrastructure. Sea level rise and coastal storms will continue to exacerbate erosion in the study area, damaging structures and infrastructure and threatening recreational resources. Homeowners and businesses seeking to protect their property have constructed some shore protection measures, such as seawalls, large stone revetments, and gabions. Some of these structures and materials used are inadequate to provide significant storm damage protection and are often constructed in an uncoordinated fashion without regard to system-wide coastal processes, thus exacerbating erosion on adjacent shorelines.

3.3.2 OPPORTUNITIES

Opportunities are positive conditions in the study area that may result from implementation of a Federal project. Opportunities in the San Juan and Rincon focus areas include:

- Maintaining existing recreation and tourism: these focus areas depend heavily on tourism, as well as aesthetic quality for community.

- Maintaining or enhancing beach habitat and environmental resources: reefs and turtle and shore bird nesting areas.

These opportunities may be realized by implementing a single management measure or a combination of management measures which may be structural and/or non-structural. These management measures will be discussed in detail later in this chapter. Some management measures, such as beach/dune nourishment provide additional opportunities to protect natural habitat for sea turtles, shore birds, etc. While some natural functions, such as sea turtle nesting, may be disrupted during construction activities of a beach nourishment, there is an opportunity for long-term benefits in preserving the beach habitat.

3.4 OBJECTIVES

3.4.1 FEDERAL OBJECTIVES

The Federal Objective as stated in the P&G, is to contribute to national economic development (NED) consistent with protecting the nation's environment, pursuant to national environmental statutes, applicable executive orders, and other Federal planning requirements. Contributions to NED are increases in the net value of the national output of goods and services, expressed in monetary units. Contributions to NED are the direct net economic benefits that accrue in the study area and the rest of the nation.

The Federal objective is to maximize net benefits to the nation, and as such, it does not seek to identify specific targets within objectives. For example, targeting a pre-defined storm frequency (100-year storm) relative to the storm damage reduction objective would be inappropriate. Rather, the planning process includes formulation of alternative plans to maximize benefits relative to costs. The Federal objective to maximize net benefits would supersede any project-specific target output.

3.4.2 PLANNING OBJECTIVES

The planning objectives are statements of the study purpose. Planning objectives are more specific than the Federal and non-Federal objectives and reflect the problems and opportunities in the study area. An objective is developed to address each of the identified problems and opportunities while being consistent with the study authority and the USACE mission of coastal storm risk management. The overarching goal of this study is to formulate a plan for coastal storm risk management to determine if Federal participation in risk management of the damages caused by coastal storms is feasible. Specific study objectives have been developed to provide a means of determining whether individual management measures are capable of solving the study area's problems while taking advantage of the opportunities identified and avoiding the constraints. The planning objectives for the study area would be attained within the 50-year period of analysis for the study, from 2028 through 2077. These objectives apply to all the focus areas (San Juan and Rincon). The planning objectives are:

- Primary Objective: Manage the risk of damages from wave attack, flooding, and erosion caused by coastal storms to property and infrastructure within the project area over a 50-year period of analysis (2028 – 2077).

- Secondary Objectives:

    - Maintain recreational use of beach and nearshore areas over a 50-year period of analysis (2028 – 2077).

- Maintain environmental quality in the project area over a 50-year period of analysis (2028 – 2077).

3.4.2.1 FEDERAL ENVIRONMENTAL OBJECTIVES

USACE strives to balance the environmental and development needs of the Nation in full compliance with the National Environmental Policy Act (NEPA) and other authorities provided by Congress and the executive Branch. Therefore, significant environmental resources and values that would likely be impacted, favorably as well as adversely, by an alternative under consideration are identified early in the planning process. All plans are formulated to avoid to the fullest extent practicable any adverse impact on significant resources. Significant adverse impacts that cannot be avoided are mitigated as required by Section 906(d) of WRDA 1986.

This report is an integrated feasibility study and environmental document. As with a separate NEPA document, it discusses and documents the environmental effects of the recommended plan and summarizes compliance with Federal statutes and regulations.

3.4.2.2 ENVIRONMENTAL OPERATING PRINCIPLES

Consistent with the NEPA, USACE has formalized its commitment to the environment by creating a set of "Environmental Operating Principles" applicable to all its decision making and programs. These principles foster unity of purpose regarding environmental issues and ensure that environmental conservation and preservation, and restoration are considered in all USACE activities. Section 6.6.25 includes a discussion of the USACE Environmental Operating Principles and how the study addresses them.

3.4.2.3 CAMPAIGN PLAN OF THE U.S. ARMY CORPS OF ENGINEERS (USACE)

USACE Campaign Plan goals and objectives are derived, in part, from the Commander's intent, the Army Campaign Plan, and the Office of Management and Budget. The four campaign plan goals and their associated objectives also build on prior strategic planning efforts. Each campaign plan goal and objective is led by a USACE senior leader who manages and oversees actions to reach the goal and objectives.

The successful achievement of the campaign plan goals and objectives are dependent on actions implemented by the entire USACE team. The implementing actions supporting each goal and objective are contained in the headquarters staff and Major Subordinate Command (MSC) implementation guidance for the Campaign Plan. The four goals of the Campaign Plan are:

Goal 1: Deliver innovative, resilient, and sustainable solutions to the Department of Defense (DoD) and the nation.

Goal 2: Deliver enduring and essential water resource solutions, utilizing effective transformation strategies.

Goal 3: Deliver support that responds to, recovers from, and mitigates disaster impacts to the nation.

Goal 4: Build resilient People, Teams, Systems and Processes to sustain a diverse culture of collaboration, innovation and participation to shape and deliver strategic solutions.

These Campaign Plan goals and associated objectives will be addressed through the course of this feasibility study.

3.4.3 COMMONWEALTH AND LOCAL OBJECTIVES

The Puerto Rico Department of Natural and Environmental Resources (DNER) is responsible for the administration of Puerto Rico's coastal trust lands, the maritime terrestrial zone (MTZ), territorial waters and submerged lands thereunder through PR Law 23, Art.5(h). DNER also serves as the lead agency for the implementation of the Puerto Rico Coastal Management Program (PRCMP). The PRCMP was adopted in 1978 as the coastal element of the Island-wide Land Use Plan. This plan is a partnership between the United States Federal Government through NOAA and the Government of Puerto Rico (DNER and PR Planning Board). Authorized by the Coastal Zone Management Act (CZMA) of 1972 to address national coastal issues, this act provides the basis for protecting, restoring, and responsibly developing the United States' diverse coastal communities and resources. The principles of the PRCMP include developing guidance for public and private development within the coastal zone, active management of coastal and marine resources, promoting scientific research, education and public participation, as well as coordinating state and federal actions.

The DNER, through regulation 4860, as amended in 1992, has jurisdiction over the coastal maritime zone out to its jurisdictional limit. This regulation also establishes that privately developed projects within the coastal maritime zone pay an annual concession proportional to the extent and use of the area affected by the project. Not many projects in Puerto Rico, other than privately owned marinas, pay the appropriate annual fees for these concessions. All projects within the MTZ must apply for a concession for the use of the MTZ, or submerged lands and territorial waters of PR. In certain cases where the integrity or stability of an existing structure is under imminent risk of an ongoing or forecasted threat, the property owner may solicit an emergency permit under the Regulation 4860, Article 16. (Coastal Engineering Handbook, Tetra Tech 2019)

Puerto Rico faces multiple coastal management challenges that have worsened over the last decade due to intense and frequent storm events. Engineering projects that occur within certain segments of Puerto Rico shoreline must consider specific context, trends, before-and-after conditions, and project segment position (among others), these projects will need a permit or concession issued by DNER under Regulation 4860, mentioned above.

3.4.3.1 LOCAL COMPREHENSIVE PLANNING

The comprehensive planning approach provided in the US Navy's Climate Change Planning Handbook (2017) was adapted in the Coastal Engineering Handbook written for Puerto Rico by Tetra Tech, Inc. (pending publication). It follows a four-stage process to establish scope, identify and screen alternatives, calculate benefits and cost of action alternatives, and assembling a portfolio of action items.

3.5 CONSTRAINTS

3.5.1 PLANNING CONSTRAINTS

A constraint is a restriction that limits the extent of the planning process; it is a statement of effects that alternative plans should avoid. Constraints are designed to avoid undesirable changes between without

and with-project future conditions. In addition to avoiding conflict with Federal regulations, as stated in Federal law, USACE regulations, and executive orders, the following are constraints specific to the study area:

- Avoid or minimize impacts to listed species, cultural resources, reef resources, submerged aquatic vegetation and critical infrastructure.

3.5.2 LOCAL CONSIDERATIONS

Local laws do not constrain NED formulation. However, they may be considered in the selection of a Locally Preferred Plan (LPP). The non-Federal sponsor may request a Locally Preferred Plan (LPP). Approval of an LPP is contingent on approval by the ASA(CW). The team will look further into these options if needed and will coordinate with the Vertical Team and the non-Federal sponsor.

3.6 SUMMARY OF MANAGEMENT MEASURES

Appendix (F) contains some of the tables and matrices developed during the plan formulation process from management measures to alternatives formulation in order to identify the Tentatively Selected Plan.

Management measures are specific structural or nonstructural actions that would take place at geographical locations within the project areas to address one or more planning objectives. All possible measures were considered, including those beyond the authority of USACE to implement. The San Juan and Rincon focus areas were grouped together for the formulation and evaluation of preliminary management measures. The following is a description of the management measures considered.

- **Nonstructural** coastal storm risk management measures are permanent measures applied to a structure and/or its contents that prevent or provide resistance to damage from flooding. Nonstructural measures differ from structural measures in that they focus on reducing the consequences of erosion, wave attack and flooding instead of focusing on reducing the probability of the damage driver. Relocation, floodproofing (wet and dry), and evacuation plans are examples of nonstructural measures.

- **Structural** coastal storm risk management measures are man-made, constructed measures that counteract a storm event in order to reduce the hazard or to influence the course or probability of occurrence of the event. Beach nourishment, revetments and seawalls are examples of structural measures implemented to reduce risk to properties and infrastructure.

NONSTRUCTURAL

NS-1: No-Action. The no-action plan is the continuation of existing conditions. Although this measure does not address any specific problems, it will provide a comparison to other measures. Information to describe this measure was collected during the inventory of existing conditions. The rate of shoreline change, flooding, waves and storm damages will be assumed to continue over the 50-year period of

analysis. Present structures and replacement costs will be used into the future. The No Action alternative would see no additional federal involvement in storm damage reduction as outlined within this study.

NS-2: Coastal Construction Control Line. A Coastal Construction Control Line (CCCL) that does not prohibit construction, but does provide stringent structural restrictions, hasn't been established by the Common wealth of Puerto Rico. This management measure provides for improving building regulations that could be implemented by the Commonwealth of Puerto Rico. Implementing a CCCL measure would allow increasing the setback for future construction or increasing the standards for future construction to reduce storm damages. The erosion of the shoreline would continue at the present rate, unabated by this measure. Combinability: This measure would need to be combined with other measures to achieve project purposes.

NS-3: Moratorium on Construction. This management measure would not permit new construction in the area vulnerable to storm damages within the study area. As properties are damaged, reconstruction would not be permitted. The erosion of the shoreline would continue at the present rate, unabated by this measure. Although, this kind of regulation could not be implemented by the USACE, this measure could be implemented by the Commonwealth or local governments. Combinability: This measure would need to be combined with other measures to achieve project purposes.

NS-4: Establish a No-Growth Program. This management measure would allow for existing structures and limited reconstruction following storm damage but would not allow for an increased number of structures within the area vulnerable to storm damages adjacent to the study area. The erosion of the shoreline would continue at the present rate, unabated by this measure. Although this kind of regulation could not be implemented by the USACE, this measure could be implemented by the Commonwealth or local governments. Combinability: This measure would need to be combined with other measures to achieve project purposes.

NS-5: Relocation of Structures. The relocation of the structures measure would allow the area to continue to erode and the land in this area would be lost. Structures vulnerable to storm damage in the study area would be identified, and where feasible, such structures would be moved further landward on their parcels to escape the vulnerable area. Combinability: This measure would need to be combined with other measures to achieve project purposes.

NS-6: Floodproofing of Structures (Dry). Floodproofing of existing structures and regulation of flood plain and shorefront development are management measures that state and local governments could implement. Dry floodproofing involves making building and site modifications to prevent water from entering during a flooding event. Dry floodproofing methods would be to seal flood prone structures from water with door and window barriers, small scale rapid deployable floodwalls, or sealants. Dry floodproofing is generally feasible up to 3 feet and is prohibited in Federal Emergency Management Agency (FEMA) VE zones (Coastal areas with a 1% or greater chance of flooding and an additional hazard associated with storm waves). Combinability: This measure would need to be combined with other measures to achieve project purposes.

NS-7: Floodproofing of Structures (Wet): Wet floodproofing involves making a series of modifications to a structure to allow an enclosed area below the base flood elevation to flood. Generally, this includes properly anchoring the structure, using flood resistant materials below the Base Flood Elevation (BFE), protection of mechanical and utility equipment, and use of openings or breakaway walls. The method of

floodproofing reduces risk to the building but not to the contents of the building. Combinability: This measure would need to be combined with other measures to achieve project purposes.

NS-8: Condemnation of Structures and Land Acquisition: This measure would allow the shoreline to erode in the study area with a loss of land. Structures within the study area vulnerable to storm damage would be identified for acquisition. These structures would be demolished, and natural areas would be restored. Such parcels would become public property and would reduce the number of structures vulnerable to storm damages. Combinability: This measure would need to be combined with other measures to cost effectively achieve project purposes.

NS-9: Improved Hurricane Evacuation Plan: The Puerto Rico Hurricane Evacuation Study was released by FEMA, NOAA and USACE in October 2018, and references evacuation zones. Conclusions from surveys conducted in the Puerto Rico Hurricane Evacuation Study, Behavioral Study Final Report, March 2014, generally indicated that residents would be more likely to evacuate out of the evacuation zone to higher ground if directed to do so. Improvements could be implemented to shelter planning factors and to the estimate of the evacuation clearance times (amount of time it takes to safely evacuate). This would be a measure implemented by the Commonwealth, local governments or the non-Federal sponsor. Combinability: This measure would need to be combined with other measures because it doesn't accomplish project purposes of reducing damages.

STRUCTURAL

S-1: Seawalls. The construction of additional concrete seawalls, or improvements to, and maintenance of the existing bulkheads/seawalls would provide a significant degree of protection. The seawalls would be constructed at the seaward edge of the existing dune line. Existing seawalls may be demolished in favor of a new seawall to provide a seamless wall over the entire study area or select areas. This measure would stabilize the shoreline at the location of the bluff, allowing erosion to continue until the seawall becomes the water line. A concrete sheet pile wall would be appropriate due to its stability in the salt environment and its ability to withstand wave action. The seawall must be of sufficient depth underground to withstand projected scour by wave action and will require rock protection at the bottom (toe) of the structure. Combinability: This could be a stand- alone alternative or combined with beach nourishment.

S-2: Revetments. This measure would involve placement of large rock designed to withstand the wave environment along the existing dune line. The engineered structure would start at the elevation of the bluff, to tie into existing elevations, and have a sloped profile. The structure would be imbedded under the beach elevation to a depth below expected scour and future erosion. In-place materials from the excavation would be used for backfilling behind the structure. Along the shoreline, the revetment should be continuous to avoid erosional features at gaps and should include tie back features at the ends. Existing armor can either be incorporated into the structure or demolished to provide a seamless structure. Combinability: This could be a stand- alone alternative or combined with beach nourishment.

S-3: Beach Nourishment. This management measure includes initial construction of a beach fill and future renourishments at regular intervals. Renourishment of the beach would be undertaken periodically to maintain the erosion control features within design dimensions. Dimensions of the beach fill would be based on economic optimization of benefits provided with consideration to cost, as well as the potential environmental impacts. Beach nourishment material is anticipated to be available in adequate quantities from offshore and/or upland borrow areas. Combinability: This could be a stand- alone alternative or combined with seawalls, revetments, breakwaters and groins.

S-4: Groins/T-Head Groins. A series of groins in the problem area would help hold a beach in front of existing development and prevent further losses of land. The construction of groins would have to be supplemented with nourishment so that adjacent beaches would not be starved of sand. For this reason, groins are considered a method to help hold the fill in place and to reduce periodic nourishment requirements. The groins would be constructed of large size rock, designed to interlock together and with a foundation such to avoid subsidence. The groins would be placed perpendicular to the shoreline and would extend from above the mean high-water line out into shallow water. The length, orientation, and head of the structure (T-head or not) would be designed based on wave conditions, storms and sediment transport. The beach fill material would come from offshore and/or upland borrow areas. Combinability: This measure would need to be combined with beach nourishment or dunes only.

S-5: Perched beach. This management measure would use the "perched beach concept" to limit the amount of underwater beach fill and retain the dry beach for a longer period. Such construction would limit cross-shore losses of fill material. This would be accomplished by placement of a submerged continues breakwater in shallow water with beach fill material placed "perched" behind the structure. This measure may reduce initial nourishment (fill) quantities and reduce renourishment requirements. The submerged structure would be constructed out of large size rock with a foundation material to avoid subsidence. The beach fill material would come from offshore and/or upland borrow areas. Combinability: This could be a stand- alone alternative.

S-6: Nearshore Placement. Dredged material would be placed periodically in the nearshore to dissipate wave energy, nourish the active profile, or placed as a combination of both. This method allows placement in water depths 15 feet and deeper. This management measure assumes that a portion of the sand placed in shallow water will move towards the beach under normal wave conditions. Over time, following construction, the sand bar will migrate towards the beach, attach to the beach and shape into the normal equilibrium profile of the beach (thus adding material and enlarging the beach). The dredged material would come from offshore borrow area. Combinability: This measure would need to be combined with other measures because it doesn't accomplish project purposes of reducing damages.

S-7: Breakwaters. The construction of breakwaters offshore along the study focus areas is considered as a management measure to stabilize the existing beach and reduce damages to shorefront properties. Such structures reduce the amount of wave energy reaching the shoreline behind them. As a result, the rate of annual erosion could decrease. The breakwaters would be constructed of large size rock with foundation materials to prevent subsidence. The breakwaters would be trapezoidal in profile and would be placed parallel to the shoreline in shallow water. The breakwaters would be constructed in segments separated from each other to prevent infilling between the existing beach and the breakwaters. The elevation and length of each breakwater segment and the distance between segments would be designed using the wave and sediment transport characteristics of the reach. This measure could benefit the environmental resources in the area, with the rock mimicking natural reefs adjacent to the study area, and potentially creating foraging habitat for benthic species. Combinability: This could be a stand- alone alternative, but better storm damage reduction is achieved when combined with beach nourishment or dunes only.

S-8: Dunes and vegetation. The presence of dunes is essential if a beach is to remain stable and able to accommodate the stress from unpredictable storms and extreme conditions of wind, wave, and elevated sea surfaces. Dunes maintain a sand repository that, during storms, provides sacrificial sand before structures would be damaged. The dune system provides a measure of public safety and property protection. Proper vegetation on dunes increases sand erosion resistance by binding the sand together

via extensive root masses penetrating deep into the sand. Further, such vegetation promotes dune growth through its sand trapping action when significant wind action transports substantial quantities of sand. This measure would include placement of beach compatible material, from either upland or offshore sources, in a dune feature where a berm is not feasible. If in the existing conditions there is a dune, the top elevation of the constructed dune would tie into the existing dune. The front slope of the dune would be a function of the material grain size and construction equipment. Vegetation would be planted after placement of the dune material. Combinability: This could be a stand- alone alternative, but better storm damage reduction is achieved when combined with groins and breakwaters.

3.6.1 SCREENING OF MANAGEMENT MEASURES

Screening is the ongoing process of eliminating measures which will no longer be considered, based on evaluation criteria. Management measures were evaluated by how they will individually meet planning objectives given planning constraints during a 50-year planning horizon within the focus areas. In addition to planning objectives and constraints, measures were also rated on their potential to meet the Federal Objectives (Four Accounts). The management measures were evaluated and rated in a matrix as follows: Each planning criteria is worth up to 2 points under evaluation; 0 = does not meet criteria, 1 = partially meets criteria, and 2 = fully meets criteria. Highest possible score = 16. If the total rating equals a number greater than 8, the measure partially meets, at least, over half of the objectives, constraints and P&G accounts and is carried forward for further analysis. If the total rating is equal to or less than 8, the measure is not considered further.

Planning Criteria for Screening of Measures (all Focus Areas)

- Meet Planning Objectives (Total 6 points)
  - Manage the risk of damages from wave attack, flooding and erosion
  - Maintain recreational use of beach and nearshore areas
  - Maintain environmental quality in the project area
- Avoid Planning Constraints (Total 2 points)
  - Cannot violate Federal regulations or laws
- Evaluate Planning & Guidance 4 Accounts (Total 8 Points)
  - National Economic Development (NED) For the NED account only qualitative analysis was provided during the initial screening of management measures because costs and benefits were not yet developed at this stage of plan formulation;
  - Environmental Quality (EQ) includes ecosystem value, public facilities and services, aesthetic values, natural resources, air and water quality, cultural and historical preservation and other factors covered by the National Environmental Policy Act (NEPA);
  - Other Social Effects (OSE) includes security and preservation of life, health, and safety, community cohesion and growth, tax and property values, displacement of businesses, and public facilities, and Issues affecting access to, or availability of, recreational activities;

- Regional Economic Development (RED) includes impact on local economy including local employment, income, and sales volume.

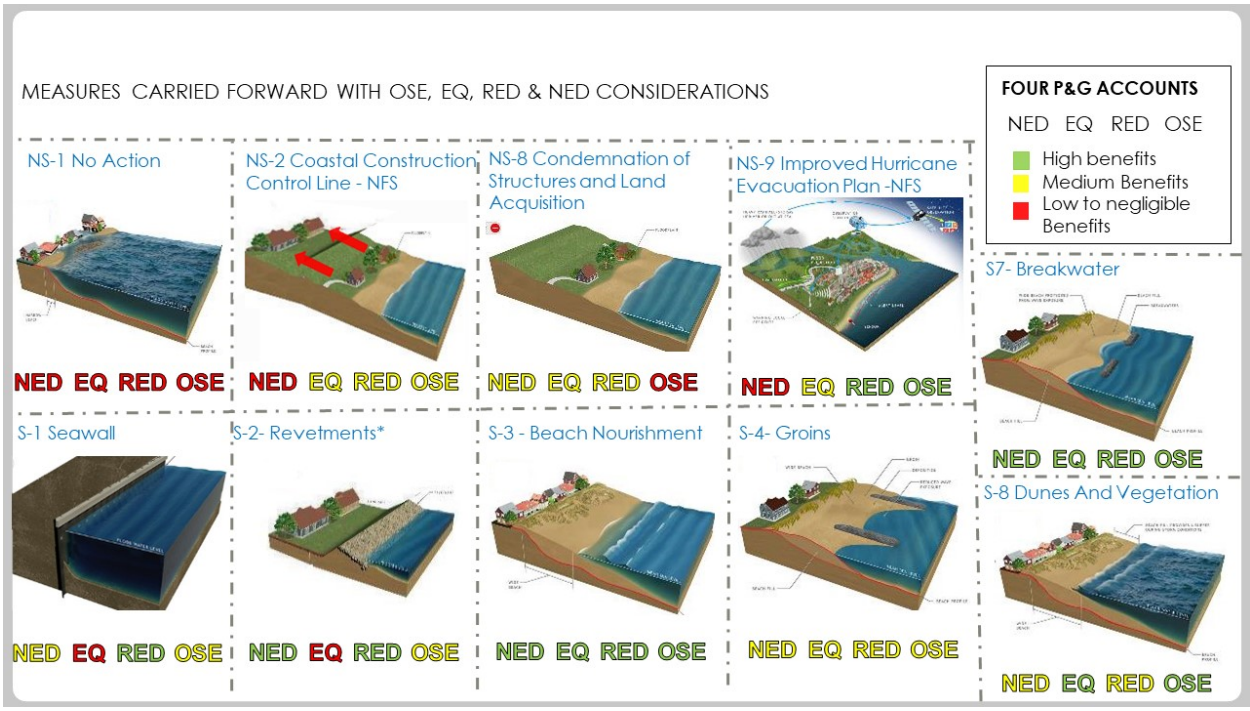
In the **Appendix (F)**, **Table 2-1** and **Table 2-2** present the nonstructural measures evaluation using the nonstructural flood risk management matrix user guide from the USACE National Nonstructural Committee and **Table 2-3** presents the Matrix with complete structural and nonstructural measures evaluation and scores.

The results of the screening are summarized in **Table 3-1** below. **Table 3-1** presents the measures carried forward with OSE, EQ, RED and NED considerations, where the results of the evaluation performed in the screening matrixes for measures under the four P&G accounts are graphically expressed. Measures that scored highest rank of 2 are designated with green; measures that scored a mid-range of 1 are shown in yellow; and measures that scored zero are shown in red.

Table 3-1 Management Measures Screening Results

MEASURES SCREENED OUT	
NONSTRUCTURAL	STRUCTURAL
NS-3: Moratorium on Construction	S-5: Submerged Artificial Reef/perched beach
NS-4: Establish a No-Growth Program	S-6: Nearshore Placement
NS-5: Relocation of Structures	
NS-6: Floodproofing of Structures (Dry)	
NS-7: Floodproofing of Structures (Wet)	
MEASURES CARRIED FORWARD	
NONSTRUCTURAL	STRUCTURAL
NS-1: No Action	S-1: Seawalls
NS-2: Coastal Construction Control Line	S-2: Revetments
NS-8: Condemnation of Structures and Land Acquisition	S-3: Beach nourishment
	S-4: Groins/T-Head Groins
NS-9: Improved Hurricane Evacuation Plan	S-7: Breakwaters
	S-8: Dunes and vegetation

Figure 3-1. Measures Carried Forward with OSE, EQ, RED, & NED Considerations



MEASURES SCREENED OUT

NONSTRUCTURAL

NS-3: Moratorium on Construction. This measure was screened out since it scored less than 8 points on the criteria evaluation. This measure would impact future construction but not reduce damages to existing inventory which NED calculation is based on for this study. It could be implemented by the Commonwealth of Puerto Rico.

NS-4: Establish a No-Growth Program. This measure was screened out since it scored less than 8 points on the criteria evaluation. This measure would impact future construction but not reduce damages to existing inventory which NED calculation is based on for this study. It could be implemented by the Commonwealth of Puerto Rico.

NS-5: Relocation of Structures. This measure was screened out since it scored less than 8 points on the criteria evaluation. This measure would eliminate the risk only to a few structures. Removing those damageable elements won't reduce the risk to adjacent infrastructure; therefore, there is some risk transfer to the second row. Likely to be high cost, and more property would need to be acquired as sea level rises.

NS-6: Floodproofing of Structures (Dry). This measure was screened out since it scored less than 8 points on the criteria evaluation. Since dry floodproofing is only sufficient to protect against 3 feet (expected

flooding is between 3 to 6 feet), sea level rise alone in the next 50 years could quickly exceed this threshold. Flow velocity during storm events are expected to be moderate 3 to 6 feet per second, coupled with presence of debris during hurricane events and most of the structures are located on coastal beach front areas, which are valid reasons to conclude that Dry Floodproofing won't be effective at reducing damages to the focus areas structure inventory.

NS-7: Floodproofing of Structures (Wet): This measure was screened out since it scored less than 8 points on the criteria evaluation. In the focus areas most of the structures are concrete, one-story, slab on grade construction in low lying elevations; others are high rise buildings with very robust foundations and parking lots on the first floor. To create a wet floodproofing opportunity, at least a two-story building would be needed, or the concrete structures would need to be raised. This would be extremely cost prohibitive.

STRUCTURAL

S-5: Perched beach. Even though this measure scored more than 8 points on the criteria evaluation, it is being screened out due to the excessive cost to implement this measure on large areas. For Rincon area construction cost would likely exceed those for other structural measures (such as beach nourishment with groins or breakwaters) that could provide similar benefits. For the San Juan reaches, this measure also could carry significant difficulties in construction and maintenance since the structure would be located in the surf zone, where high amount of hardbottoms exist. Due to these points, perched beach is eliminated from further analysis.

S-6: Nearshore Placement. This measure was screened out since it scored 8 points on the criteria evaluation. Typically, nearshore placement is conducted when a sand source's characteristics do not match the native beach and direct placement on the beach (beach nourishment) is not possible for permitting reasons. For Rincon and San Juan, the presence of hard bottoms and coral reefs nearby represent environmental constrains to place sand in the nearshore. Additionally, beach profiles show deep water (25 to 40 ft) in the proximity of the nearshore, increasing the risk of sand loss. Preliminary investigations indicate that beach quality material is available from upland and offshore sand sources. Material of this quality would likely be more effective for storm damage reduction if placed as a typical beach nourishment and not in the nearshore. Due to these considerations nearshore placement is eliminated from further analysis.

NONSTRUCTURAL MEASURES CARRIED FORWARD:

From the summary presented in **Table 3-1** the No-Action (NS-1) measure will be carried forward as the Future Without Project Condition. The nonstructural measures (NS-2 & NS-9), Coastal construction control line, and improved evacuation plans and notification systems are carried forward, but would not be considered part of the Federal Plan recommendation because these cannot be implemented by USACE. This study identifies that Puerto Rico island wide will benefit from the non-Federal sponsor and local communities pursuing these two nonstructural measures in the future. The other nonstructural measure (NS-8), Condemnation of Structures and Land Acquisition will be carried forward to be analyzed once remaining damages have been quantified:

NS-1: No-Action. The no-action plan is the continuation of existing conditions. Although this measure does not address any specific problems, it will provide a comparison to other measures.

NS-2: Coastal Construction Control Line (CCCL). This measure is carried forward to be considered and implemented in the future by the non-Federal sponsor and local communities. Even though this measure would impact future construction, there is plenty of evidence that some structures within Rincon and San Juan are damage beyond repair due to the fact that were constructed encroaching the shoreline, so having a CCCL would support better coastal planning. Implementing a CCCL measure would allow increasing the setback for construction or increasing the standards for construction to reduce storm damages. Combinability: This measure would need to be combined with other measures to achieve project purposes.

NS-8: Condemnation of Structures and Land Acquisition: After the evaluation of nonstructural measures using the Matrix from the USACE National Nonstructural Committee, this measure score higher due to the expected flooding (moderate 3 to 6 feet), flow velocity during storm events (moderate 3 to 6 feet per second), presence of debris during hurricane events, and most of the structures being located on coastal beach front areas. Specific to Rincon focus area, there are many structures with fair to poor overall structure condition. Therefore, this measure is carried forward to be analyzed once the FWOP/FWP is complete, repetitive losses and remaining damages are estimated. Combinability: This measure would need to be combined with other measures to achieve project purposes.

NS-9: Improved Hurricane Evacuation Plan: This measure is carried forward to be considered and implemented by the Commonwealth, local governments or the non-Federal sponsor in the future. This measure would reduce the risk of life loss to the population but won't reduce the damages to existing inventory which NED calculation is based on for this study. In Puerto Rico, there is an evacuation program in place, which allow the majority of the population to evacuate damage prone areas following the hurricane preparedness. However, improving hurricane evacuation plan, estimating clearance times, will allow the community to evacuate in a timely manner to effectively reduce life risk, as well as prepare shelters on time. Combinability: This measure would need to be combined with other measures to achieve project purposes.

STRUCTURAL MEASURES CARRIED FORWARD:

From the summary presented in **Table 3-1** there are six structural measures to be carried forward to formulate alternatives for San Juan and Rincon focus areas.

S-1: Seawalls. This measure would stabilize the shoreline at the location or at the seaward edge of the existing dune line. A concrete sheet pile wall is proposed due to its stability in the salt environment and its ability to withstand wave action. The seawall must be of sufficient depth underground to withstand projected scour by wave action and will require rock protection at the bottom (toe) of the structure. Combinability: This could be a stand- alone alternative or combined with beach nourishment.

S-2: Revetments. Revetments have been placed on similar beaches to protect critically damaged or eroding areas. This measure would involve placement of large rock designed to withstand the wave environment along the existing dune line or existing coastal protection structures. The engineered structure would start at the elevation of the bluff, to tie into existing elevations, and have a sloped profile. The structure would be imbedded under the beach elevation to a depth below expected scour and future erosion. Existing armor can either be incorporated into the structure or demolished to provide a seamless structure. Combinability: This could be a stand- alone alternative or combined with beach nourishment.

S-3: Beach Nourishment. This management measure includes initial construction of a beach fill and future renourishments at regular intervals. Renourishment of the beach would be undertaken periodically to

maintain the erosion control features within design dimensions. Dimensions of the beach fill would be based on economic optimization of benefits provided with consideration to cost, as well as the potential environmental impacts. Beach nourishment material is anticipated to be available in adequate quantities from offshore and/or upland borrow areas. Combinability: This could be a stand- alone alternative, or combined with breakwaters, groins, seawalls and revetments.

S-4: Groins/T-Head Groins. A series of groins in the problem area would help hold a beach in front of existing development and prevent further losses of land. The construction of groins would have to be supplemented with nourishment so that adjacent beaches would not be starved of sand. For this reason, groins are considered a method to help hold the fill in place and to reduce periodic nourishment requirements. The beach fill material would come from offshore and/or upland borrow areas. Combinability: This measure would need to be combined with beach nourishment (S-3 or S-8).

S-7: Breakwaters. The construction of breakwaters offshore along the project areas is considered as a management measure to stabilize the existing beach and reduce damages to shorefront properties. Such structures reduce the amount of wave energy reaching the shoreline behind them. As a result, the rate of annual erosion could decrease. The breakwaters would be constructed of large size rock with foundation materials to prevent subsidence. The breakwaters would be trapezoidal in profile and would be placed parallel to the shoreline in shallow water. The breakwaters would be constructed in segments separated from each other to prevent infilling between the existing beach and the breakwaters. The elevation of each breakwater segment and the distance between segments would be designed using the wave and sediment transport characteristics of the reach. This measure could benefit the environmental resources in the area, with the rock mimicking natural reefs adjacent to the study area, and potentially creating foraging habitat for benthic species. Combinability: This measure could be a stand-alone alternative, but better storm damage reduction is achieved when combined with beach nourishment (S-3 or S-8).

S-8: Dunes and vegetation. Dunes are an integral component of the beach/dune system; unfortunately, dune starvation through sand mining and hardening of shorelines has increased the erosion problems throughout Puerto Rico. The presence of dunes is essential if a beach is to remain stable and able to accommodate the stress from unpredictable storms and extreme conditions of wind, wave, and elevated sea surfaces. This measure would include placement of beach compatible material, from either upland or offshore sources, in a dune feature where a full berm/dune renourishment is not feasible. If in the existing conditions there is a dune, the top elevation of the constructed dune would tie into the existing dune. The front slope of the dune would be a function of the material grain size and construction equipment. Vegetation would be planted after placement of the dune material. Combinability: This could be a stand-alone alternative, but better storm damage reduction is achieved when combined with T groins or breakwaters.

3.7 FORMULATION OF ALTERNATIVES

The purpose of this study is to formulate and evaluate an array of alternatives and recommend the one that most effectively addresses the problems, meet the objectives, and complies with applicable Commonwealth, and Federal laws and regulations. Alternatives are formulated to maximize storm damage reduction and minimize cost. The Four accounts, National Economic Development (NED), Environmental Quality (EQ), Regional Economic Development (RED), and Other Social Effects (OSE), are used to evaluate the plans.

3.7.1 DETERMINATION OF PLANNING REACHES

As a result of the initial scoping process described in Section 1.5, five focus areas: Condado, Ocean Park, Isla Verde, Carolina, and Rincon were considered of interest. Further investigations during the forecasting of existing and future without project conditions led to the screening out of the Carolina focus area.

The Carolina focus area was screened from further analysis upon evaluation of the damage potential and susceptibility. The Coastal Hazards Systems (CHS) storm water levels were plotted against the LiDAR data at 5 shore-parallel profiles along the Carolina Segment. The CHS output from the 100-year storm event demonstrates that predominantly the western portion of Carolina would be susceptible to potential impacts. There are 32 structures that comprise the structure inventory in the Carolina focus area. These structures have an average first floor elevation estimated to be at or around 10.2 feet (PRVD02). The FEMA water levels suggests that limited flooding, likely only during the low frequency events (i.e. less than 0.01 annual chance exceedance), could potentially cause damage to the structures due to the existing ground and finished first floor elevation of these structures. The flooding susceptibility appeared to be limited to a smaller portion within western Carolina focus area, however it should be noted that the CHS grid is relatively coarse. Additionally, the central pocket beach in Carolina contains a limited structure inventory, consisting of mainly a large parking area and elevated roadway. Therefore, the Carolina focus area did not have the potential for economic justification to be carried forward for further analysis with Beach-fx modeling.

Plan formulation focuses on the remaining focus areas, Condado, Ocean Park, Isla Verde and Rincon. Section 2.3.1 described the differences in physical shoreline conditions between the headlands and the sandy pocket beaches within each focus area. In summary, the headlands are designated as critically eroded areas with no dry beach where waves break directly on coastal structures, and pocket beaches are comprised of sandy beach areas with wider berms and intermittent dunes. As a result, different structural measures are effective for the pocket beaches and the headlands due to the unique characteristics associated with the two types of shoreline. This delineation of the planning reaches reduced the suitable measures at the headlands to seawalls and revetments. Beach nourishment won't be feasible at the headlands from an engineering standpoint because these areas are mostly armored, and the sediment transport will remove the sand placed to adjacent beaches.

The San Juan study area has been divided into seven planning reaches to align with the headland and pocket beach features, where unique alternatives could be implemented to reduce damages (Condado West Headland, Condado Pocket Beach, Punta Piedrita Headland, Ocean Park Pocket Beach, Punta Las Marias Headland, Isla Verde Pocket Beach, and Punta El Medio Headland). The Rincon focus area is comprised of two planning reaches geographically separated by a stream, Rincon A lies north of Quebrada Los Ramos and Rincon B lies south. These planning reaches are considered separable elements. **Figure 3-2** and **Figure 3-3** show the extent of the San Juan and Rincon planning reaches. As previously documented in Section 2.5.5, Beach-fx modeling of the future without project (FWOP) condition was performed on the seven planning reaches (three pocket beaches and four headlands) in the San Juan study area, and two planning reaches in Rincon in order to estimate damages.

The planning strategy is to identify the alternative for each planning reach that reasonably maximizes net CSRM benefits, while protecting the environment, and recommend an overarching TSP for the study.

As described in Section 2.5.6, Beach-fx was run for the FWOP condition using three Sea Level Change (SLC) scenarios, as prescribed by ER 1100-2-8162. The results of the FWOP Beach-fx simulations provide an

understanding of the damages drivers (erosion, wave attack and flooding), which is key to developing effective alternatives to reduce those damages. **Figure 3-4** shows a depiction of the relative risk of coastal storm damages (represented by the size of the green dots) within each planning reach. The highest relative risk is displayed in Ocean Park pocket Beach, followed by Rincon B. In Ocean Park, the average first floor elevations are relatively low (6.7 ft PRVD02) in comparison to the rest of the focus areas. In addition, there is higher vulnerability of the structure inventory (single family residences), which directly correlates to the damages obtained in Ocean Park.

Figure 3-2. San Juan Planning Reaches

Figure 3-3 Rincon Planning Reaches

Figure 3-4. Relative Risk of Coastal Storm Damages

3.7.1.1 PLANNING REACHES SELECTION FOR FORMULATION OF ALTERNATIVES

The comparison of FWOP damages to Rough Order of Magnitude (ROM) cost of the structural measures carried forward was used to make decisions on the initial screening of the planning reaches. These ROM costs were brought to present value (PV), and broken down to a cost per linear foot (LF) of shoreline. Additional graphics and support information are presented in the Economic Appendix. As a result, five planning reaches would be moving forward into plan formulation: Condado Pocket Beach, Punta Piedrita Headland, Ocean Park Pocket Beach, Punta Las Marias (west side only), and Rincon B. The Following is a summary of the rationale behind this selection:

PLANNING REACHES SCREENED OUT

Condado West Headland: The Condado west headland consist mainly of hotels and condominiums which already have very robust coastal protection in place. Early FWOP modeling results estimated damages to be $185,000 AAEQ or $5M Present Value, which indicated an extremely low possibility of identifying a cost-effective measure. This led to the conclusion that constructing additional complementary seawalls or revetments will require very complex construction methodologies and would be cost prohibitive. Therefore, the recommendation for the western headland of Condado is No-Action.

Isla Verde Pocket Beach: The FWOP damages for the Isla Verde pocket beach are estimated to be $154,000 AAEQ or $4.1M Present Value under the Intermediate SLC scenario. The very low FWOP damages relative to the length of the reach, make any of the measures cost prohibitive; therefore, the recommendation is No-Action in this planning reach.

Punta El Medio Headland: The western side of this reach has very low FWOP damages ($30,000 AAEQ or $0.8M). The eastern side of the headland falls within the Carolina focus area; as previously described, the entire Carolina Focus area has been screened out based on a qualitative assessment (no Beach-fx modeling). As a result, the recommendation is No-Action in this planning reach.

Rincon A: FWOP modeling resulted in very limited damages in the northern part of the Rincon focus area (Rincon A). These damages are estimated to be $133,200 AAEQ or $3.6M Present Value under the Intermediate SLC scenario. This indicates that it is highly unlikely any alternatives would provide a benefit justifying their cost to implement; therefore, the recommendation is No-Action in this planning reach.

PLANNING REACHES CARRIED FORWARD

Condado Pocket Beach: The FWOP damages are estimated to be $555,000 AAEQ or $15.5M Present Value under the Intermediate SLC scenario. Since this is a sandy beach area, beach nourishment with different configurations (only dune, only berm or combination), breakwaters, and revetments are feasible measures to provide damage reduction in this reach from an engineering standpoint. Preliminary ROM costs show potential for these measures. Therefore, this reach will be carried forward into plan formulation and an array of alternatives is being developed and assessed for potential of economic justification.

Punta Piedrita Headland: The FWOP damages are estimated to be $1,787,000 AAEQ or $48.3M Present Value under the Intermediate SLC scenario. As previously described, seawalls and revetment are the only measures that could be feasible for this rocky headland. Based on ROM costs, revetments were a less costly option and estimated to provide similar protection to a seawall. Also, the vertical structures (seawalls) increase wave reflection resulting in erosional effects, which make this measure less favorable

by the non-Federal sponsor, environmental agencies and the public. Therefore, revetment is the measure most applicable in this planning reach. This reach will be carried forward into plan formulation and the revetment alternative will be evaluated for potential of economic justification.

Ocean Park Pocket Beach: The FWOP damages are estimated to be $4,869,000 AAEQ or $131.6M Present Value under the Intermediate SLC scenario. From an engineering standpoint, beach nourishment alternatives with different configurations of berm and dune, breakwaters, and revetment are feasible measures to provide damage reduction in this reach. Preliminary ROM costs show potential for these measures. This reach will be carried forward into plan formulation and an array of alternatives is being developed and assessed for potential of economic justification.

Punta Las Marias Headland: The exact same selection and screening as described for Punta Piedrita is applicable for this planning reach as well. Revetments is the measure selected for further analysis. The FWOP damages on the eastern side of Punta Las Marias Headland is estimated at $37,000 AAEQ or $1.04M Present Value, which are far less than the ROM cost of a revetment in this segment ($505,000 AAEQ or $13.6M Present Value). Therefore, only the western portion of this planning reach is being considered for action.

Rincon B: The FWOP damages are estimated to be $1,243,000 AAEQ or $33.6M Present Value under the Intermediate SLC scenario. From an engineering standpoint, revetments, beach nourishment with different configurations, as well as combined with breakwaters are feasible measures to provide damage reduction in this reach. Preliminary ROM costs show potential for these measures. This reach will be carried forward into plan formulation and an array of alternatives is being developed and assessed for potential of economic justification.

3.7.2 PRELIMINARY ARRAY OF ALTERNATIVES

As concluded in previous section, the planning reaches selected for plan formulation are Condado Pocket Beach, Punta Piedrita Headland, Ocean Park Pocket Beach, Punta Las Marias Headland (west side only), and Rincon B.

Measures, used singularly or in combination with others, create alternatives. Only structural measures carried forward (Section 3.6.1) were used to formulate the below alternatives. The nonstructural measures Coastal Construction Control Line and improved evacuation plans would not be considered part of the Federal Plan recommendation; it is acknowledged that the non-Federal sponsor, the Commonwealth, and local communities could pursue these two nonstructural measures in the future. The nonstructural measure NS-8, Condemnation of Structures and Land Acquisition, was carried forward from the screening of measures presented in Section 3.6.1, and its analysis is presented in Section 3.7.4.1.

In this study, different alternatives were formulated for the pocket beaches and the headlands due to the unique characteristics associated with the two types of shoreline. Overall, the pocket beaches contain sandy areas, which are most suitable for beach nourishment alternatives. **Table 3-2** presents the alternatives considered for the San Juan pocket beaches, as well as Rincon and for the headlands planning reaches.

Costs were developed for each of the alternatives on these planning reaches. The design considerations, mitigation and real estate requirements are presented in the following section.

Table 3-2. General Suite of alternatives for pocket beaches and headlands

SUITE OF ALTERNATIVES FOR SAN JUAN POCKET BEACHES AND RINCON
• **Alt-1** No Action • **Alt-2** Revetment • **Alt-3** Beach nourishment • **Alt-4** Breakwaters • **Alt-5** Beach nourishment + Breakwaters
SUITE OF ALTERNATIVES FOR SAN JUAN HEADLANDS
• **Alt-1** No Action • **Alt-2** Revetment

3.7.2.1 CLASS 4 COST OF THE PRELIMINARY ARRAY OF ALTERNATIVES

In order to evaluate the potential for economic justification for alternatives in the study reaches being carried forward, class 4 cost estimates were developed. The class 4 costs (more refined than rough order of magnitude costs but less refined than certified costs) include both construction and non-construction costs. The construction costs are based upon historical pricing data from previously studied and/or constructed projects in Florida and Puerto Rico, escalated to FY20 dollars, and then entered into MCACES/MII. Non-construction costs include Lands and Damages (Real Estate), Pre-Construction, Engineering and Design (PED), and Construction Management (S&A). An average contingency of 40% was assumed across all alternatives for the construction costs, PED and S&A. For Lands and Damages, and Real Estate administrative costs, a 30% contingency was assumed.

Sand sources investigations let to the conclusion that beach nourishment by dredging won't be cost effective due to the large distance of the potential offshore sand sources (around 30 miles from the project area). If using a hopper dredge, the pipeline corridor would need to cross the existing coral reef fringe in San Juan, which represent a high environmental risk of impacting the coral reefs. Therefore, in order to minimize environmental impacts, the cost of beach nourishment alternatives is being developed using an upland sand source (truck -haul).

During the process of developing the cost of the alternatives for Condado Pocket Beach, Ocean Park Pocket Beach and Rincon, the beach nourishment alternative (Alt-3), or alternatives which include it (Alt-5), were expanded to minimum and maximum templates including different number of nourishment events. The final dimensions of the template for a beach nourishment alternative will be developed through modeling optimizations between the draft and final report. **Table 3-3** to **Table 3-7** encompass the Class 4 (First Cost) in FY21 for all the alternatives considered in the five planning reaches.

Table 3-3. Condado Pocket Beach Alternatives Class 4 Cost

CONDADO POCKET BEACH ALTERNATIVES		DESIGN CONSIDERATIONS	REQUIRED MITIGATION (Acres)	REAL ESTATE Lands and Damages (Acres)	TOTAL COST $FY21
Alt1	No Action	N/A	N/A	N/A	
Alt-2	Revetment	Revetment length: 1,910 feet. Crest Elevation: 14 ft-PRVD02 3 to 5 Ton Stone	1.73 acres potential hardbottom impact (1.34 acres colonized bedrock, 0.39 acres unconsolidated sediment with scattered coral/rock)	0.74 Acres staging area + 0.07 Acres access portion	$18,324,127
Alt 3a	Beach Nourishment - Dune only	Dune length: 1,910 ft Dune Crest Elevation: 18 ft-PRVD02 Dune Crest Width: 20 ft Side slopes: 5H:1V Two nourishment events during 50-year: Restauration volume: 100,000 cy (2028) Nourishment volume: 100,000 cy (2054) Truck Haul - Compatible material from an upland sand source in Los Juncos	2.36 acres potential hardbottom impact (1.93 acres colonized bedrock and 0.43 acres unconsolidated sediment with scattered coral/rock)	0.74 Acres staging area + 0.07 Acres access portion	$26,652,966
Alt 3b	Beach Nourishment - Berm - 100'	Berm length: 1,910 ft Berm Width: 100 ft Berm Crest Elevation: 3 ft-PRVD02 Berm Side slopes: 15H:1V Three nourishment events during 50-year: Initial volume: 190,000 cy (2028) Renourishment volume: 87,000 cy (2040) Renourishment volume: 87,000 cy (2060) Truck Haul - Compatible material from an upland sand source in Los Juncos	4.08 acres potential hardbottom impact (1.74 acres colonized bedrock, 2.3 acres unconsolidated sediment with scattered coral/rock)	0.74 Acres staging area + 0.07 Acres access portion	$46,143,010
Alt 3c	Beach Nourishment - Berm - 50'	Berm length: 1,910 ft Berm Width: 50 ft Berm Crest Elevation: 3 ft-PRVD02 Berm Side slopes: 15H:1V Three nourishment events during 50-year: Initial volume: 110,000 cy (2028) Renourishment volume: 51,000 cy (2040) Renourishment volume: 51,000 cy (2060) Truck Haul - Compatible material from an upland sand source in Los Juncos	3.75 acres potential hardbottom impact (1.83 acres colonized bedrock, 1.92 acres unconsolidated sediment with scattered coral/rock)	0.74 Acres staging area + 0.07 Acres access portion	$31,690,398
Alt-4	Breakwater	Number of Breakwaters: 2 Each one length: 500 feet. Crest Elevation: -0.8 ft PRVD02 (MLLW) Crest Width: 15 ft Side slopes: 2H:1V Armor Stone: 775 SF Core Stone: 435 SF	2.82 acres potential hardbottom impact (2.82 acres unconsolidated sediment with scattered coral/rock)	0.74 Acres staging area + 0.07 Acres access portion	$22,905,703
Alt-5a	Beach Nourishment - Berm 50' + Breakwater	Same breakwater design proposed on Alternative 4. Berm length: 1,910 ft Berm Width: 100 ft Berm Crest Elevation: 3 ft-PRVD02 Berm Side slopes: 15H:1V One nourishment event during 50-year: Initial construction volume: 110,000 cy (2028) Truck Haul - Compatible material from an upland sand source in Los Juncos	4.07 acres potential hardbottom impact (1.83 acres colonized bedrock, 2.24 acres unconsolidated sediment with scattered coral/rock)	0.74 Acres staging area + 0.07 Acres access portion	$36,524,837
Alt-5b	Beach Nourishment- Berm 100' + Breakwater	Same breakwater design proposed on Alternative 4. Berm length: 1,910 ft Berm Width: 100 ft Berm Crest Elevation: 3 ft-PRVD02 Berm Side slopes: 15H:1V One nourishment event during 50-year: Initial volume: 190,000 cy (2028) Truck Haul - Compatible material from an upland sand source in Los Juncos	4.07 acres potential hardbottom impact (1.83 acres colonized bedrock, 2.24 acres unconsolidated sediment with scattered coral/rock)	0.74 Acres staging area + 0.07 Acres access portion	$43,768,892

Table 3-4. Ocean Park Pocket Beach Alternatives Class 4 Cost

OCEAN PARK POCKET BEACH ALTERNATIVES		DESIGN CONSIDERATIONS	REQUIRED MITIGATION (Acres)	REAL ESTATE Lands and Damages (Acres)	TOTAL COST $FY21
Alt1	No Action	N/A	N/A	N/A	
Alt-2	Revetment	Revetment length: 6,810 feet. Crest Elevation: 11 ft-PRVD02 3 to 5 Ton Stone	0.95 acres potential hardbottom impact (0.15 acres colonized bedrock, 0.80 acres unconsolidated sediment with scattered coral/rock)	0.38 Acres Staging area	$39,207,080
Alt 3a	Beach Nourishment - Dune & 100' Berm	Beach length: 6,810 ft Berm Crest Width: 100 ft; Berm Crest Elevation: 3 ft-PRVD02 Berm Side slopes: 15H:1V Dune Crest Elevation: 15 ft-PRVD02; Dune Crest Width: 20 ft Dune Side slopes: 5H:1V Nourishment interval =17 years Three nourishment events during 50-year: Initial Volume: 800,000 cy (2028) Renourishment Volume: 368,000 cy (2040) Nourishment Volume: 368,000 cy (2060) Truck Haul - Compatible material from an upland sand source in Los Juncos	4.00 acres potential hardbottom impact (0.94 acres colonized bedrock, 3.06 acres unconsolidated sediment with scattered coral/rock)	0.38 Acres Staging area	$151,367,451
Alt 3b	Beach Nourishment - Dune & 50' Berm	Beach length: 6,810 ft Berm Crest Width: 50 ft; Berm Crest Elevation: 3 ft-PRVD02 Berm Side slopes: 15H:1V Dune Crest Elevation: 10 ft-PRVD02; Dune Crest Width: 10 ft Dune Side slopes: 5H:1V Nourishment interval =17 years Three nourishment events during 50-year: Initial Volume: 350,000 cy (2028) Nourishment Volume: 161,000 cy (2040) Nourishment Volume: 161,000 cy (2060) Truck Haul - Compatible material from an upland sand source in Los Juncos	2.23 acres potential hardbottom impact (0.68 acres colonized bedrock, 1.55 acres unconsolidated sediment with scattered coral/rock)	0.38 Acres Staging area	$69,436,601
Alt-4	Breakwaters	Number of Breakwaters: 8 Each one length: 600 feet Gap distance: 7 @ 250 ft long Crest Elevation: -0.8 ft PRVD02 (MLLW) Crest Width: 15 ft Side slopes: 2H:1V Armor Stone: 665 SF Core Stone: 295 SF	3.29 acres potential hardbottom impact (1.83 acres colonized bedrock, 1.46 acres unconsolidated sediment with scattered coral/rock)	0.38 Acres Staging area	$56,056,736
Alt-5a	Bech Nourishment - Dune & 50' Berm + Breakwaters	Same breakwater design proposed on Alternative 4. Beach length: 6,810 ft Berm Crest Elevation: 3 ft-PRVD02; Berm Crest Width: 50 ft Berm Side slopes: 15H:1V Dune Crest Elevation: 10 ft-PRVD02; Dune Crest Width: 10 ft Berm Side slopes: 5H:1V Nourishment interval =25 years Two nourishment events during 50-year: Initial Volume: 350,000 cy (2028) Renourishment Volume: 161,000 cy (2053) Truck Haul - Compatible material from an upland sand source in Los Juncos	5.52 acres potential hardbottom impact (0.68 acres colonized bedrock, 3.01 acres unconsolidated sediment with scattered coral/rock, 1.83 acres patch reef)	0.38 Acres Staging area	$109,081,603
Alt-5b	Bech Nourishment - Dune & 100' Berm + Breakwaters	Same breakwater design proposed on Alternative 4. Beach length: 6,810 ft Berm Crest Elevation: 3 ft-PRVD02; Berm Crest Width: 100 ft Berm Side slopes: 15H:1V Dune Crest Elevation: 10 ft-PRVD02; Dune Crest Width: 10 ft Berm Side slopes: 5H:1V Nourishment interval =25 years Two nourishment events during 50-year: Initial Volume: 800,000 cy (2028) Renourishment Volume: 368,000 cy (2053) Truck Haul - Compatible material from an upland sand source in Los Juncos	5.52 acres potential hardbottom impact (0.68 acres colonized bedrock, 3.01 acres unconsolidated sediment with scattered coral/rock, 1.83 acres patch reef)	0.38 Acres Staging area	$168,573,407

Table 3-5. Punta Piedrita Headland Alternatives Class 4 Cost

PUNTA PIEDRITA HEADLAND ALTERNATIVES		DESIGN CONSIDERATIONS	REQUIRED MITIGATION (Acres)	REAL ESTATE Lands and Damages (Acres)	TOTAL COST $FY21
Alt1	No Action	N/A	N/A	N/A	
Alt-2	Revetment	Total Revetment length: 2,450 feet Western side on Condado Revetment length: 1,100 feet Crest Elevation: 14 ft-PRVD02 3 to 5 Ton Stone Eastern side on Ocean Park Revetment length: 1,350 feet Crest Elevation: 11 ft-PRVD02 3 to 5 Ton Stone	2.53 acres potential hardbottom impact (2.31 acres colonized bedrock and 0.22 acres unconsolidated sediment with scattered coral/rock)	0.24 Acres Stagging area	$21,333,927

Table 3-6. Punta Las Marias Headland Alternatives Class 4 Cost

PUNTA LAS MARIAS HEADLAND (West Side) ALTERNATIVES		DESIGN CONSIDERATIONS	REQUIRED MITIGATION (Acres)	REAL ESTATE Lands and Damages (Acres)	TOTAL COST $FY21
Alt1	No Action	N/A	N/A	N/A	
Alt-2	Revetment	Western side on Ocean Park Revetment length: 1,400 feet Crest Elevation: 11 ft-PRVD02 3 to 5 Ton Stone	2.13 acres potential hardbottom impact (0.724 acres patch reef, 1.265 acres patch reef, unconsolidated sediment with scattered coral/rock, 0.14 acres patch reef)	0.40 Acres Staging area	$13,100,612

Table 3-7. Rincon B Alternatives Class 4 Cost

RINCON ALTERNATIVES (R11-R19)		DESIGN CONSIDERATIONS	REQUIRED MITIGATION (Acres)	REAL ESTATE Lands and Damages (Acres)	TOTAL COST $FY21
Alt-1	No Action	N/A	N/A	N/A	
Alt-2	Revetment	Revetment length: 5,650 feet. Crest Elevation: 11 ft-PRVD02 2 to 4 Ton Stone	0.82 acres potential hardbottom impact (0.75 acres unconsolidated sediment with scattered coral/rock and 0.07 acres colonized pavement)	0.88 Acres Staging Area	$27,900,109
Alt-3	Beach Nourishment - Dune & 75' Berm	Beach length: 5650 ft Berm Crest Width: 75 ft; Berm Crest Elevation: 3 ft-PRVD02 Berm Side slopes: 15H:1V Dune Crest Elevation: 12 ft-PRVD02; Dune Crest Width: 20 ft Dune Side slopes: 5H:1V Nourishment interval =10 years Five nourishment events during 50-year: Initial Volume: 390,000 cy (2028) Renourishment Volume: 265,000 cy (2035) Renourishment Volume: 265,000 cy (2044) Renourishment Volume: 265,000 cy (2055) Renourishment Volume: 265,000 cy (2066) Truck Haul - Compatible material from an upland sand source in Rincon	5.33 acres potential hardbottom impact (0.75 acres unconsolidated sediment with scattered coral/rock and 4.58 acres colonized pavement)	0.88 Acres Staging Area	$122,265,342
Alt-4	Breakwater	Number of Breakwaters: 20 Each one length: 200 feet Gap distance: 19 @ 100 ft long Crest Elevation: 6 ft PRVD02 (MLLW) Crest Width: 15 ft Side slopes: 2H:1V Armor Stone: 750 SF Core Stone: 200 SF	2.01 acres potential hardbottom impact (1.27 acres colonized pavement and 0.74 acres unconsolidated sediment with scattered coral/rock)	0.88 Acres Staging Area	$49,557,339
Alt-5	Beach Nourishment - 25' Berm+ Breakwater	Same breakwater design proposed on Alternative 4. Beach length: 5650 ft Berm Crest Width: 25 ft or equivalent volume; Berm Crest Elevation: 3 ft-PRVD02 Berm Side slopes: 15H:1V Nourishment interval =10 years Five nourishment events during 50-year: Initial Volume: 120,000 cy (2028) Renourishment Volume: 82,000 cy (2035) Renourishment Volume: 82,000 cy (2044) Renourishment Volume: 82,000 cy (2055) Renourishment Volume: 82,000 cy (2066) Truck Haul - Compatible material from an upland sand source in Rincon	2.87 acres potential hardbottom impact (2.13 acres colonized pavement and 0.74 acres unconsolidated sediment with scattered coral/rock)	0.88 Acres Staging Area	$89,255,022

Note: Alternative 4 – Breakwaters. Engineering investigations for Rincon shoreline and the hydrodynamics of this area led to the screening out of breakwaters for Rincon B planning reach. As a result, the breakwaters alternative could not be considered a stand-alone alternative in Rincon because this measure should be implemented in combination with beach nourishment to provide storm damage reduction and avoid impacts to adjacent shorelines. Following is the rationale behind this decision:

- How offshore breakwaters work: An offshore breakwater provides protection by reducing the amount of wave energy reaching the shore in its lee. This reduction of wave energy reduces the transport of sediment by alongshore current or circulation in the breakwater's shadow resulting in deposition of sand in the lee of the structure. This deposition causes the growth of a salient (spit) from the shoreline. Thus, offshore breakwaters provide protection to the upland not only by reducing incident wave energy, but also by building a wider protective beach which acts as a buffer during storm events.

- Concerns with offshore breakwaters: Offshore Breakwaters can result in shoreline erosion of adjacent beaches by trapping sand that would have been transported downdrift. The shoreline response to the construction of offshore breakwaters is predominantly governed by the resulting alterations in the alongshore transport of material and, to a lesser extent, the offshore losses induced by rip currents created by the structure.

- Avoiding impacts to adjacent shorelines: Pre-filling the area with sand (imported from outside the littoral system) during initial construction of offshore breakwaters is to mitigate the structures' tendency to impound sand by "saturating" the field to (or beyond) its designed shoreline response. This advanced nourishment provides a source of material for salient formation, thus theoretically making the shoreline "transparent" to the ambient littoral drift.

The San Juan pocket beaches have different sediment transport dynamic than Rincon; therefore, the breakwaters would be a feasible stand-alone alternative there.

3.7.3 FWOP BEACH-FX DAMAGES VS ALTERNATIVES CLASS 4 COST

This section presents the preliminary array of alternatives comparison using FWOP damages and cost, which provides insight into where alternatives have potential for economic justification or merit more in-depth analysis. This is part of the evaluation to screen the alternatives and select the final array.

The class 4 costs presented in the previous section were converted to Present Value (PV) to be used in the following economic evaluation. A project's benefit-to-cost ratio (BCR) must be greater than 1.0 in order for an alternative to be justified and implementable (i.e., the benefits must be greater than the costs). Benefits equal damages prevented, or the difference between the FWOP damages and damages resulting after implementation of an alternative (FWP damages). In this section, damages are used as a proxy for benefits. Using FWOP damages as a substitute for the benefits will overestimate the benefit provided by any alternative since this assumes that 100% of damages have been prevented. Therefore, if the cost of an alternative is equal to, or less than, the FWOP damages, the BCR can be assumed to approximate 1, and the alternative has potential for economic justification.

Table 3-8 presents the cost (PV) of the alternatives and the FWOP damages under the intermedia SLC scenario for all the planning reaches. Wherever FWOP damages were far below an alternative's cost, it was assumed that the alternative would not have potential for economic justification.

Table 3-8. Planning Reaches Beach-fx FWOP Damages vs. Alternatives Cost

ALTERNATIVE	FWOP $PV (Thousands)	COST $PV (Thousands)
CONDADO POCKET BEACH		
Alt 2 Revetment	$15,500	$18,324
Alt 3-a Beach Nourishment – Dune only		$22,379
Alt 3-b Beach Nourishment – Berm 100’		$38,622
Alt 3-c Beach Nourishment – Berm 50’		$26,967
Alt 4 Breakwaters		$23,399
Alt 5a Beach Nourishment – Berm 50’ + Breakwater		$34,549
Alt 5b Beach Nourishment – Berm 100’ + Breakwater		$41,793
PUNTA PIEDRITA HEADLAND		
Alt 2- Revetment	$48,000	$21,334
OCEAN PARK POCKET BEACH		
Alt 2 Revetment	$132,000	$39,207
Alt 3-a Beach Nourishment – Dune&Berm 100’		$122,142
Alt 3-c Beach Nourishment –Dune& Berm 50’		$56,296
Alt 4 Breakwaters		$57,312
Alt 5a Beach Nourishment – Dune&Berm 50’ + Breakwater		$102,921
Alt 5b Beach Nourishment – Dune&Berm 100’ + Breakwater		$153,182
PUNTA LAS MARIAS (WEST SIDE)		
Alt 2- Revetment	$14,200	$13,100
RINCON B		
Alt 2 Revetment	$37,100	$27,900
Alt 3 Beach Nourishment – Dune&Berm 75’		$87,454
Alt 5 Beach Nourishment – Berm 25’ + Breakwater		$78,512

3.7.4 FUTURE WITH PROJECT (FWP) DAMAGES AND BENEFITS ESTIMATION USING BEACH-FX

The FWOP damages are used as the base condition and potential project alternatives are measured against this base. The difference between FWOP and FWP damages is used to determine primary CSRM benefits. Once benefits for each of the planning reaches' alternatives are calculated, they will be compared to the costs of implementing the alternative. Dividing the total benefits by the total costs of the alternative yields a benefit-to-cost ratio. This ratio must be greater than 1.0 (i.e. the benefits must be greater than the costs) in order for the alternative to be justified and implementable.

The federally preferred plan, or NED, is the plan that maximizes net benefits. Net benefits are determined by simply subtracting the cost of any given alternative from the benefits of that alternative ($Benefits - Costs = Net\ Benefits$).

Not all FWP modeling results were completed by publication of this draft report so some alternatives carried forward for consideration do not have quantified benefits. At this point during the plan formulation process, Alternative 2 (revetments) has been modeled in Rincon B, Punta Piedrita, Punta Las Marias (west side only), and both the Pocket Beaches of Ocean Park and Condado. Also, a specific dune-only nourishment configuration has been modeled in Condado. The remaining alternatives considered on the focus array are currently being configured for Beach-fx modeling. In this section, only the CSRM benefits will be analyzed (i.e. storm-damage reduction to structures and infrastructure). Potential recreation benefits will be modeled for the tentatively selected plan and will be discussed in section 4.9.

Table 3-9 and **Table 3-10** show the results from the only two alternatives modeled in the applicable Planning Reaches. Based on this data, revetment is potentially economically viable in Punta Piedrita and Punta Las Marias. The dune-only nourishment option is unlikely justified in Condado Pocket Beach; therefore, new beach nourishment templates are being developed for modeling and evaluation.

Table 3-9. Net Benefits Analysis for Alternative 2 – Revetment

Alternative 2: Revetment						
Planning Reach	**FWOP Damages**	**FWP Damages**	**Benefits**	**Cost**	**Net-Benefits**	**BCR**
Rincon B[10]	$1,373,000	$182,000	$1,175,000	$1,049,000	$125,000	1.12
Condado Pocket Beach	$ 568,000	$ 97,000	$ 471,000	$ 814,000	$ (343,000)	0.58
Punta Piedrita	$ 1,785,000	$ 835,000	$ 950,000	$ 857,000	$ 93,000	1.11
Ocean Park Pocket Beach[10]	$ 4,876,000	$ 2,566,000	$ 2,310,000	$ 2,309,000	$ 1,000	1.0
Punta Las Marias Reduced[11] (West)	$ 524,000	$ 17,000	$ 507,000	$ 473,000	$ 34,000	1.07

[10] Includes Land Loss

[11] The revetment length was reduced from modeling reach R01-R03 to just R01-R02. Reach R03 will be analyzed alongside the Ocean Park Pocket Beach alternatives

Table 3-10. Net benefits Analysis for Alternative 3a – Condado Pocket Beach

Alternative 3a: Nourishment - Dune Only						
Planning Reach	**FWOP**	**FWP**	**Benefits**	**Cost**	**Net-Benefits**	**BCR**
Condado Pocket Beach	$ 568,000	$ 254,000	$ 314,000	$ 828,000	$ (514,000)	0.38

3.7.4.1 PRELIMINARY ANALYSIS OF NONSTRUCTURAL MEASURE NS-8: CONDEMNATION OF STRUCTURES AND LAND ACQUISITION

The nonstructural measure NS-8, Condemnation of Structures and Land Acquisition, was carried forward from the screening of measures presented in Section 3.6.1. This measure would allow the shoreline to erode in the study area with a loss of land. Parcels, both developed and undeveloped, vulnerable to storm damage would be bought, and structures would be demolished. Parcels would be managed by the non-federal sponsor, remaining undeveloped into the future and reducing future storm damages.

This nonstructural measure is being considered for Rincon planning reach. Cost of the alternatives presented in Section 3.7.2.1 concluded that the structural measure with the lowest cost is revetment; as a result, the team conducted preliminary investigations for buyouts in Rincon based on two options: buyouts in addition to revetments; and buyouts in place of revetments. For buyouts in addition to the revetment, the residual damage to buyout properties would have to exceed their market value. Given the high damage reduction capabilities of the revetment from the FWP modeling, this was not considered further. For buyouts in place of the revetment, only properties with FWOP damage greater than market value would be eligible. Without market values, the team used depreciated replacement values (which are significantly lower). They found that only a few properties would be eligible. Given the limited number of eligible properties, the NED net benefits would not match those of the revetment. This analysis is not included in the draft report; thus, the final report will document the detail showing that buyouts can be screened out based on their cost effectiveness.

3.7.5 COMPARISON AND EVALUATION OF THE ARRAY OF ALTERNATIVES

This section presents the alternatives comparison in order to screen the alternatives and further identify the Tentatively Selected Plan.

Criteria to evaluate the array of alternatives consisted of evaluations under the four P&G accounts, the required evaluation criteria of completeness, efficiency, effectiveness and acceptability, and the risk based on resilience and residual damages. Following, there is an explanation of the rational used for the matrix evaluation presented in **Table 3-11**.

- Evaluation of the effects of the four P&G accounts on the array of alternatives:
  - National Economic Development (NED) account: Includes consideration of an alternative's potential to meet the planning objective to reduce storm damages, as well as decrease costs of emergency services, lower flood insurance premiums. Any potential project that is in the Federal interest must display feasibility by satisfying benefit-cost criteria. Generally, this ratio must be

greater than one to allow Federal participation in continued study and any project proposal. Sections 3.7.3 and 3.7.4 presents the benefits analysis to identify which alternatives have potential for economic justification. At this point of the study, the FWP modeling in Beach-fx hasn't been fully completed. Therefore, the TSP will include alternatives where benefits have not been quantified yet. The modeling results will be documented in the final report.

- Environmental Quality (EQ) account: Environmental acceptability must be ascertained with regard to ecological, cultural and aesthetics impacts; and adverse impacts should be avoided if possible or minimized if avoided is not possible. Only a qualitative analysis has been conducted at this stage to evaluate the alternatives and estimate the long-term positive or negative effects that they would have on the beach/dune and nearshore habitat. The evaluation of alternatives based on environmental acceptability is accomplished with respect to Federal environmental statutes. For example, the USACE considers the Coastal Zone Management Act (CZMA), Endangered Species Act of 1973, Magnuson-Stevens Fishery Management and Conservation Act, and the Fish and Wildlife Coordination Act (FWCA). The USACE also considers local input as well as aesthetics. Under Puerto Rico law, the non-Federal sponsor (DNER) is also the entity responsible for the protection and management of the coastal zone, coral reefs, essential fish habitats, and coastal biodiversity wildlife. Pursuant to the CZMA, the USACE will determine whether the proposed project is consistent with the enforceable policies of the National Oceanic and Atmospheric Administration-approved Puerto Rico coastal zone management program and will seek concurrence with that determination. The DNER has proposed a change to its approved coastal zone management program that would prohibit rock revetments and/or seawalls in sandy beach areas where there is public beach use and recreation. The proposed change has not yet been approved by NOAA. However, the USACE acknowledges the ecological and aesthetic impacts that structures could have on sandy beaches in Puerto Rico and that structural intervention is contrary to Puerto Rico's environmental protection policies.

  The final array of alternatives includes a variety of hard and soft structures in every planning reach. This study acknowledge that there are potential negative impacts of implementation of rock revetments in sandy beaches, including 1) accelerated loss of the sandy beach seaward of the revetment; 2) accelerated loss of the sandy beach downdrift of the revetment; 3) loss of environmental habitat for sea turtles, shorebirds, and Essential Fish Habitat; 4) loss of riparian public access to the water; 5) loss of alongshore public access; 6) safety concerns for swimmers and surfers due to waves and water interacting with the revetment; 7) unpleasing aesthetics; 8) loss of public recreation area; 9) loss of beach culture; and 10) loss of tourism economy.

- Other Social Effects (OSE) account: Includes considerations for the preservation of life, health, and public safety; community cohesion and growth; tax and property values; and, the displacement of businesses and public facilities. This evaluation was conducted taking into consideration the OSE factors listed in ER 1105-2-100. The planning metrics developed by the Institute of Water Resources (Applying Other Social Effects in Alternative Analysis, 2013) were used as a guidance. OSE matrixes with the criteria and evaluations are shown in Error! Reference source not found. to Error! Reference source not found. on the **Appendix (F).**

- Regional Economic Development (RED) account: Considers the potential impacts on the local economy and sales volume. These benefits will be quantified for the TSP and only qualitative analysis has been used for the array of alternatives at this stage.

- For the evaluation criteria of completeness, efficiency, effectiveness and acceptability, it was imperative that the plans presented should be complete and sound, and in sufficient detail to allow development of engineering plans and specifications. For alternatives where FWP modeling hasn't been completed, assumptions on potential damage reduction were used at this time to assess the efficiency and effectiveness criteria. The acceptability criteria from the public perspective was coordinated with the non-Federal sponsor and input received during NEPA scoping coordination. The alternative options and plans should be acceptable to the local residents, agencies, organization, and the non-Federal sponsor (DNER), as well as the interested Commonwealth and Federal agencies. The non-Federal sponsor has indicated that they will not support any recommendation that meets with strong public opposition. Unacceptable plans to the DNER and the public include any structure that significantly impedes beach access, such as rock revetments on sandy beaches. Revetments are considered acceptable on headlands or shorelines characterized for natural or manmade coastal protection where no sand exist in front of them.

- Resilience evaluation: The USACE climate preparedness and resilience goal is to develop practical, nationally consistent and regionally tailored, legally justifiable and cost-effective adaptation measures, both structural and nonstructural, that will reduce vulnerabilities and improve resilience to these challenges (USACE Climate Change Adaptation Plan and Report 2011). The EP 1100-1-2 2016 USACE Resilience Initiative Roadmap states the Principles of Resilience (Prepare, Absorb, Recover, and Adapt), and the Engineering and Construction Bulleting No 2018-2 provide the policy and guidance for applying the USACE principles of resilience. These sources were used to evaluate the alternatives.

Table 3-11. Comparison and Evaluation of the Final Array of Alternatives

CONDADO POCKET BEACH	Design	Benefits							Planning and Guidance Criteria				Resilience	Residual Damages
Alternative	Functionality	FWO Damages ($PV)		Primary Damages Reduced (NED)		Recreation	Other Social Effects (OSE)	Regional Economic Development (RED)	Environmental (EQ)	Acceptability	Completeness	Efficiency	Effectiveness		
		Description	$	Methodology	$	Description									
Alt 1 No Action	This would function like the FWOP condition. No changes to the project area would occur under the scope of this project.	The damages in Condado pocket beach are majority from erosion. Erosion counts for more than 75% of the damages.	15,500,000												100%
Alt 2 Revetment	The revetment will likely reduce damages to upland properties and infrastructure. However, revetment along the sandy portion of coastline would likely adversely impact the sandy beach width; thus, reducing the functionality of a revetment design.			The revetment alternative reduce damage associated with erosion, but the cost far exceed the benefits. Therefore this alternative produce negative Net benefits.		No recreation benefits.	The effects of revetment on health and safety, economic vitality, social connectedness, identity, social vulnerability, participation, and recreation have been measured (see OSE matrix) and didn't meet score.	Disruptions to the economic network is the largest driver of negative impacts to a regional economy. Revetment would mitigate risks of disruption and allow for resumption of economic activity quicker than FWOP condition	Could negatively effect sea turtle nesting habitat and shorebird habitat where a sandy beach exists. Protects structures but could exacerbate beach erosion and loss of habitat.	Even tough this is consistent with Federal regulations, recent local policy (2018) prohibits hard structures on sandy beaches, particulary on highly visited touristic-recreational and/or sea turtle nesting beaches. Construction of revetments on the sandy pocket beach will alter the beach aesthethics and would lack of support from the public.	The plan provides and accounts for all necessary investments or actions to ensure realization of the planning objectives.	Very likely that it is not cost effective	Revetent is likely the least effective alternative in the pocket beach of Condado due to the current presence of large upland seawalls and the small sandy berm along this stretch.	Revetment would be built to sufficient height to reduce risk over 50 years. It could be adaptable to account for SLR. Operation and maintenance are standard, Periodic inspections would be necessary to avoid costly repairs.	High risk of high residual damage. Moderate cost risk.
Alt 3a Beach Nourishment - Dune Only	A dune-only nourishment alternative would function as inundation, erosion, and wave attack protection for the pocket beach in Condado. Sand added to the landward portion of the beach width would slump as water encroaches the dune toe in large storm surge/wave conditions, acting as an indirect sand source to the berm over time. However, the active beach width in the eastern portion of the pocket beach is not wide enough to accomadate an effective berm design, and would require significant advanced fill to act as a platform for dune sediment. Preliminary modeling has shown the fucntionality of a dune-only nourishment here is hindered by the amount of sediment needed over 50 years because of this (and thus reducing the ultimate BCR to below 1).			The dune alternative only reduce about 50% of the damage associated with erosion. In addition the cost far exceed the benefits. Therefore this alternative produce negative Net benefits.		No recreation benefits.	Reduction of flooding and wave attack during storm events could allow communities to resume normal life sooner and in a safe manner compared to losses in FWOP. Dune construction could reduce the beach width for recreation, and dunes that are too high can block the view on first floor properties; however, possitive effects of this nature based measure (dunes) outcome the negative. Provide protection of property value and tax value. Hotels and commercial business provide the main source of income in the area. See OSE matrix where received a satisfactory score.	Reduction storm damages could allow businesses to contribute to the economy more compared to losses in FWOP. Dune enhancement could improve beach for tourism and recreation purposes posibly stimulating local economy.	Dune creation improves dune habitat and potentially beach habitat for sea turtle nesting. Limits sand migration onto nearshore benthic habitat.	This is consistent with Federal and local regulations. Construction of dunes on the sandy pocket beach will likely be supported by general public; however, dune construction could reduce the beach width for recreation, and dunes that are too high can block the view on first floor properties.	The plan provides and accounts for all necessary investments or actions to ensure realization of the planning objectives.	Very likely that it is not cost effective	A dune-only nourishment would act as the first line of defense during high waves and surge and high rates of erosion during large storm events. However, the current presence of large seawalls linining the upland portion of the Condado pocket beach reduces the effectiveness of this alternative.	The current presence of large seawalls linining the upland portion of the Condado pocket beach reduces the effectiveness of this alternative.	High risk of high residual damage. Moderate cost risk.
Alt 3b Beach Nourishment - Berm 100'	A berm-only nourishment alternative would function primarily as ersion protection, but would also offer some wave-attack and inundation damage reduction (larger berm would include more beach width for wave run-up to attenuate before ocean waters hit coastal structures). The majority of damages in this pocket beach are erosion damages, so this alternative is thought to function best prior to FWP modeling. A 100' berm may not require less sediment over 50 years than smaller berms because of the helical pocket-beach pheonomenon and very low to no net longshore transport. This is contrary to other beach designs in environments with high net longshore transport.			Expected to significantly limit damage from all drivers, but the cost far exceed the FWOP damages. Likely Negative even after including the Recreation Benefits.		This alterative is expected to have significant recreation benefits. However, it is not expected to provided enough primary benefits to reach the .51 BCR threshold for the consideration of recreation.	Reduction of flooding and wave attack during storm events could allow communities to resume normal life sooner and in a safe manner compared to losses in FWOP. Beach nourishment will enhance berm width for recreation. Provide protection of property value and tax value. Hotels and commercial business provide the main source of income in the area. See OSE matrix where received a satisfactory score.	Reduction storm damages could allow businesses to contribute to the economy more compared to losses in FWOP. Berm nourishment could improve beach for tourism and recreation purposes posibly stimulating local economy.	Improves beach habitat for sea turtle nesting.	This is consistent with Federal and local regulations. Berm nourishment will likely be supported by public.	The plan provides and accounts for all necessary investments or actions to ensure realization of the planning objectives.	Very likely it is not cost effective	A berm-only nourishment design is likely the most effective soft measure due to the current without-project damage distribution (high erosion damages). Volume needed for a 100 ft berm may not be more effective than a 50 ft berm simply due to the lack of longshore transport within Condado's pocket beach.	Berm-only nourishments would primarily reduce the risk of erosion damages over the 50-yr lifecycle, and berm templates can be "refilled" if major events reduce sediment volume past the design specs.	Low risk of high residual damage. However,there is significant high cost risk.
Alt 3c Beach Nourishment - Berm 50'	A berm-only nourishment alternative would function primarily as ersion protection, but would also offer some wave-attack and inundation damage reduction (larger berm would include more beach width for wave run-up to attenuate before ocean waters hit coastal structures). The majority of damages in this pocket beach are erosion damages, so this alternative is thought to function best prior to FWP modeling. A 50' berm may be more cost effective over 50 years than a larger template (i.e. Alt 3b) due to the statements made in Alt 3b.			Expected to significantly limit damage from all drivers. Likely Negative without Recreation Benefits.		This alterative is expected to have significant recreation benefits. However, further analysis is needed to assess if it would pass the .51 BCR threshold for the consideration of recreation.	Reduction of flooding and wave attack during storm events could allow communities to resume normal life sooner and in a safe manner compared to losses in FWOP. Beach nourishment will enhance berm width for recreation. Provide protection of property value and tax value. Hotels and commercial business provide the main source of income in the area. See OSE matrix where received a satisfactory score.	Reduction storm damages could allow businesses to contribute to the economy more compared to losses in FWOP. Berm nourishment could improve beach for tourism and recreation purposes posibly stimulating local economy.	Improves beach habitat for sea turtle nesting.	This is consistent with Federal and local regulations. Berm nourishment will likely be supported by public.	The plan provides and accounts for all necessary investments or actions to ensure realization of the planning objectives.	Very likely it is cost effective	A berm-only nourishment design is likely the most effective soft measure due to the current without-project damage distribution (high erosion damages). Volume needed for a 50 ft berm may not be less effective than a 100 ft berm simply due to the lack of longshore transport within Condado's pocket beach.	Berm-only nourishments would primarily reduce the risk of erosion damages over the 50-yr lifecycle, and berm templates can be "refilled" if major events reduce sediment volume past the design specs.	Moderate risk of high residual damage. Significant cost risk.
Alt-4 Breakwater	Breakwaters would primarily funtion to absorb or attenuate wave energy propagating to the coastline. Reducing wave energy will lessen wave attack damages and erosion in lee of the breakwater structures. Avoiding impacts to adjacent shorelines would need to be assessed, as breakwaters tend to increase accretion immediately landward of the structures, which could limit sediment transport along the coast. However, adverse impacts are less likely in the Condado pocket beach since longshore sediment transport is very minimal.			Expected to reduce wave damages and reduce erosion, but minimal reduction in flooding. Likely Negative without Recreation Benefits.		This alterative is expected to have moderate recreation benefits. However, further analysis is needed to assess if it would pass the .51 BCR threshold for the consideration of recreation.	Reduction of flooding and wave attack during storm events could allow communities to resume normal life sooner and in a safe manner compared to losses in FWOP. Breakwaters could promove beach acretion, which enhance recreational activities. See OSE matrix where received a satisfactory score.	Reduction storm damages could allow businesses to contribute to the economy more compared to losses in FWOP. Breakwater could improve nearshore recreation posibly stimulating local economy.	Breakwater should help maintain sandy beach habitat. Breakwater construction on unconsolidated substrate or uncolonized pavement could enhance reef habitat.	This is consistent with Federal and local regulations. Construction of breakwaters will likely be supported by public.	The plan provides and accounts for all necessary investments or actions to ensure realization of the planning objectives.	Very likely it is cost effective	Breakwaters would provide effective protection against wave attack and wave-induced erosion and flooding.	Breakwaters would reduce the risk of wave-induced damages and erosion. Adaptation measures would include initial construction of a wide-crested breakwater system to allow for additional rock placement if global sea levels continue to rise over the 50-yr project lifecycle.	Moderate risk of high residual damage. Significant cost risk.
Alt-5a Beach Nourishment Berm 50'+ Breakwater	This would function to minimize wave attack and erosion damages and help avoid impact to adjacent shorelines from breakwater structures by saturating the sediment trap in lee if the breakwaters. Sediment saturation will be a bit less for this alternative than for Alt 5b.			This alternative is expected to provide large reduction in damages originating from erosion, waves and flood damage. The cost far exceed the FWOP damages. Likely Negative even after including the Recreation Benefits.		This alterative is expected to have significant recreation benefits. However, it is very unlikely that it would pass the .51 BCR threshold for the consideration of recreation.	Reduction of flooding and wave attack during storm events could allow communities to resume normal life sooner and in a safe manner compared to losses in FWOP. Breakwaters could promove beach acretion, which enhance recreational activities. Provide protection of property value and tax value. Hotels and commercial business provide the main source of income in the area. See OSE matrix where received a satisfactory score.	Reduction storm damages could allow businesses to contribute to the economy more compared to losses in FWOP. Berm enhansement could improve beach for tourism and Breakwater could improve nearshore recreation posibly stimulating local economy.	Berm creation/nourishment improves beach habitat for sea turtle nesting, but there is a high risk of negative impacts on nearshore coral reefs. Breakwater construction on unconsolidated substrate or uncolonized pavement could enhance reef habitat.	This is consistent with Federal and local regulations. Construction of berm and breakwaters will likely be supported by public.	The plan provides and accounts for all necessary investments or actions to ensure realization of the planning objectives.	Very likely that it is not cost effective	The combination of hard breakwater structures and a soft-sand berm would be most effective, but also most expensive.	If afforded, this alternative would effectively reduce the risk of all of the main damage drivers with minimal adverse impacts to downdrift beaches.Breakwaters are currently designed to be adaptable to rising mean sea levels with wide crests (allow for additional stone to be placed on the crest of the breakwaters).	Low risk of high residual damage. However,there is significant high cost risk.
Alt-5b Beach Nourishment Berm 100' + Breakwater	This would function to minimize wave attack and erosion damages and help avoid impact to adjacent shorelines from breakwater structures by saturating the sediment trap in lee if the breakwaters. Sediment saturation will be a bit more for this alternative than for Alt 5a.			This alternative is expected to provide large reduction in damages originating from erosion, waves and flood damage. The cost far exceed the FWOP damages. Likely Negative even after including the Recreation Benefits.		This alterative is expected to have the highest recreation benefit. However, it is very unlikely that it would pass the .51 BCR threshold for the consideration of recreation.	Reduction of flooding and wave attack during storm events could allow communities to resume normal life sooner and in a safe manner compared to losses in FWOP. Breakwaters could promove beach acretion, which enhance recreational activities. Provide protection of property value and tax value. Hotels and commercial business provide the main source of income in the area. See OSE matrix where received a satisfactory score.	Reduction storm damages could allow businesses to contribute to the economy more compared to losses in FWOP. Berm enhansement could improve beach for tourism and Breakwater could improve nearshore recreation posibly stimulating local economy.	Berm creation/nourishment improves beach habitat for sea turtle nesting, but there is a high risk of negative impacts on nearshore coral reefs. Breakwater construction on unconsolidated substrate or uncolonized pavement could enhance reef habitat.	This is consistent with Federal and local regulations. Construction of berm and breakwaters will likely be supported by public.	The plan provides and accounts for all necessary investments or actions to ensure realization of the planning objectives.	Very likely that it is not cost effective	The combination of hard breakwater structures and a soft-sand berm would be most effective, but also most expensive.	If afforded, this alternative would effectively reduce the risk of all of the main damage drivers with minimal adverse impacts to downdrift beaches.Breakwaters are currently designed to be adaptable to rising mean sea levels with wide crests (allow for additional stone to be placed on the crest of the breakwaters).	Low risk of high residual damage. However,there is significant high cost risk.

OCEAN PARK POCKET BEACH	Design	Benefits							Planning and Guidance Criteria				Resilience	Residual Damages
Alternative	Functionality	FWO Damages ($PV)		Primary Damages Reduced (NED)		Recreation	Other Social Effects (OSE)	Regional Economic Development (RED)	Environmental (EQ)	Acceptability	Completeness	Efficiency	Effectiveness		
		Description	$	Methodology	$	Description									
Alt 1 No Action	This would function like the FWOP condition. No changes to the project area would occur under the scope of this project.	Flooding counts for more than 71% in the Pocket Beach with wave damages about 20% and lastly erosion (11%).	132,000,000												100%
Alt-2 Revetment	The revetment will likely reduce damages to upland properties and infrastructure. However, revetment along the sandy portion of coastline would likely adversely impact the sandy beach width; thus, reducing the functionality of a revetment design.			The revetment alternative didn't reduce most of the damages associated with flooding, making the cost exceed the benefits. Therefore this alternative produce negative Net benefits.		No recreation benefits.	The effects of revetment on health and safety, economic vitality, social connectedness, identity, social vulnerability, participation, and recreation have been measured (see OSE matrix) and didn't meet score.	Disruptions to the economic network is the largest driver of negative impacts to a regional economy. Revetment would mitigate risks of disruption and allow for resumption of economic activity quicker than FWOP condition	Could negatively effect sea turtle nesting habitat and shorebird habitat where a sandy beach exists. Protects structures but could exacerbate beach erosion and loss of habitat.	Even tough this is consistent with Federal regulations, recent local policy (2018) prohibits hard structures on sandy beaches, particulary on highly visited touristic-recreational and/or sea turtle nesting beaches. Construction of revetments on the sandy pocket beach will alter the beach aesthetics and would lack of support from the public.	The plan provides and accounts for all necessary investments or actions to ensure realization of the planning objectives.	Very likely that it is not cost effective	This plan is effective at reducing erosion, wave attack and flooding; however, implementation in sandy pocket beaches would eliminate beach/dune interaction, incurring in potential loss of beach recreation and sea turtle habitat.	Revetment would be built to sufficient height to reduce risk over 50 years. It could be adaptable to account for SLR. Operation and maintenance are standard, Periodic inspections would be necessary to avoid costly repairs.	High risk of high residual damage. Moderate cost risk.
Alt 3a Beach Nourishment - Dune & 100' Berm	A traditional berm+dune nourishment alternative would function as erosion protection from the added berm width and would reduce wave-attack and inundation damages from the added dune material. A 100' berm may not require less sediment over 50 years than smaller berms because of the helical pocket-beach pheonomenon and very low to no net longshore transport. This is contrary to other beach designs in environments with high net longshore transport.			Expected to significantly limit damage from all drivers. It is likely to provide high net benefits after including the Recreation Benefits.		This alterative is expected to have significant recreation benefits. However, further analysis is needed to assess if it would pass the .51 BCR threshold for the consideration of recreation.	Reduction of flooding and wave attack during storm events could allow communities to resume normal life sooner and in a safe manner compared to losses in FWOP. Dunes could reduce the beach width for recreation and dunes that are too high can block the view on first floor properties; however, possitive effects of this nature based measure (berm/dune) outcome the negative. Provide protection of property value and tax value. Hotels and commercial business provide the main source of income in the area. See OSE matrix where received a satisfactory score.	Reduction storm damages could allow businesses to contribute to the economy more compared to losses in FWOP. Beach nourishment could improve beach for tourism and recreation purposes posibly stimulating local economy.	Berm/Dune nourishment improves beach habitat for sea turtle nesting, but there is a high risk of negative impacts on nearshore coral reefs. This could temporarily affect the nearshore resources during construction.	This is consistent with Federal and local regulations. Construction of dune and berm on the sandy pocket beach will likely be supported by general public; however, dunes that are too high can block the view on first floor properties.	The plan provides and accounts for all necessary investments or actions to ensure realization of the planning objectives.	Very likely it is cost effective	A typical dune/berm nourishment would effectively reduce erosion damages with the addition of more berm material and wave attack and inundation damages with the addition of more dune material (or the addition of a dune where dunes didn't already exist).	A typical dune/berm nourishment would reduce the risk of inundation, erosion, and wave damages and would be adaptable in the future if mean sea levels continue to rise in the area.	Low risk of high residual damage. However,there is significant high cost risk.
Alt 3b Beach Nourishment - Dune & 50' Berm	A traditional berm+dune nourishment alternative would function as erosion protection from the added berm width and would reduce wave-attack and inundation damages from the added dune material. A 50' berm may not require more sediment over 50 years than larger berms because of the helical pocket-beach pheonomenon and very low to no net longshore transport. This is contrary to other beach designs in environments with high net longshore transport.			Expected to significantly limit damage from all drivers. It is likely to provide high net benefits after including the Recreation Benefits.		This alterative is expected to have significant recreation benefits. However, further analysis is needed to assess if it would pass the .51 BCR threshold for the consideration of recreation.	Reduction of flooding and wave attack during storm events could allow communities to resume normal life sooner and in a safe manner compared to losses in FWOP. Dunes could reduce the beach width for recreation and dunes that are too high can block the view on first floor properties; however, possitive effects of this nature based measure (berm/dune) outcome the negative. Provide protection of property value and tax value. Hotels and commercial business provide the main source of income in the area. See OSE matrix where received a satisfactory	Reduction storm damages could allow businesses to contribute to the economy more compared to losses in FWOP. Beach nourishment could improve beach for tourism and recreation purposes posibly stimulating local economy.	Berm/Dune nourishment improves beach habitat for sea turtle nesting, but there is a high risk of negative impacts on nearshore coral reefs. This could temporarily affect the nearshore resources during construction.	This is consistent with Federal and local regulations. Construction of dune and berm on the sandy pocket beach will likely be supported by general public; however, dunes that are too high can block the view on first floor properties.	The plan provides and accounts for all necessary investments or actions to ensure realization of the planning objectives.	Very likely it is cost effective	A typical dune/berm nourishment would effectively reduce erosion damages with the addition of more berm material and wave attack and inundation damages with the addition of more dune material (or the addition of a dune where dunes didn't already exist).	A typical dune/berm nourishment would reduce the risk of inundation, erosion, and wave damages and would be adaptable in the future if mean sea levels continue to rise in the area.	Moderate risk of high residual damage. Low cost risk.
Alt-4 Breakwater	Breakwaters would primarily funtion to absorb or attenuate wave energy propagating to the coastline. Reducing wave energy will lessen wave attack damages and erosion in lee of the breakwater structures. Avoiding impacts to adjacent shorelines would need to be assessed, as breakwaters tend to increase accretion immediately landward of the structures, which could limit sediment transport along the coast. However, adverse impacts are less likely in the Ocean Park pocket beach since longshore sediment transport is very minimal.			Expected to reduce wave damages and reduce erosion, but minimal reduction in flooding. Likely Negative without Recreation Benefits.		This alterative is expected to have moderate recreation benefits. However, further analysis is needed to assess if it would pass the .51 BCR threshold for the consideration of recreation.	Reduction of flooding and wave attack during storm events could allow communities to resume normal life sooner and in a safe manner compared to losses in FWOP. Breakwaters could promove beach acretion, which enhance recreational activities. See OSE matrix where received a satisfactory score.	Reduction storm damages could allow businesses to contribute to the economy more compared to losses in FWOP. Breakwater could improve nearshore recreation posibly stimulating local economy.	Breakwater should help maintain sandy beach habitat. Breakwater construction on unconsolidated substrate or uncolonized pavement could enhance reef habitat. It could temporarely affect the nearshore resources during construction.	This is consistent with Federal and local regulations. Construction of breakwaters will likely be supported by public.	The plan provides and accounts for all necessary investments or actions to ensure realization of the planning objectives.	Very likely it is cost effective	Breakwaters would effectively reduce wave attack and erosion damages in lee of the structures and inundation damages indirectly from the reduction of wave setup and runup.	Breakwaters would reduce the risk of erosion and wave attack damages, but they would be less effective if unchanged over the life time of the project. Breakwaters are currently designed to have wide, emergent crests so they can be adabptable in the future if mean sea levels continue to rise over the 50-yr project time span.	High risk of high residual damage. Low cost risk.
Alt-5a Beach Nourishment Dune&Berm 50'+ Breakwater	This would function to minimize wave attack and erosion damages and help avoid impact to adjacent shorelines from breakwater structures by saturating the sediment trap in lee if the breakwaters. Sediment saturation will be a bit less for this alternative than for Alt 5b.			This alternative is expected to provide large reduction in damages originating from erosion, waves and flood damage. Likely to produce positive net benefits after including the Recreation Benefits.		This alterative is expected to have significant recreation benefits. However, further analysis is needed to assess if it would pass the .51 BCR threshold for the consideration of recreation.	Reduction of flooding and wave attack during storm events could allow communities to resume normal life sooner and in a safe manner compared to losses in FWOP. Dune enhancement could reduce the beach width for recreation and dunes that are too high can block the view on first floor properties; however, possitive effects of this nature based measure (berm/dune) outcome the negative. Breakwaters could promove beach acretion, which enhance recreational activities. Provide protection of property value and tax value. Hotels and commercial business provide the main source of income in the area. See OSE matrix where received a satisfactory score.	Reduction storm damages could allow businesses to contribute to the economy more compared to losses in FWOP. Berm/dune enhansement could improve beach for tourism and Breakwater could improve nearshore recreation posibly stimulating local economy.	Berm/Dune nourishment improves beach habitat for sea turtle nesting, but there is a high risk of negative impacts on nearshore coral reefs. Breakwater construction on unconsolidated substrate or uncolonized pavement could enhance reef habitat. These features could temporary affect the nearshore resources during construction.	This is consistent with Federal and local regulations. Construction of dune/berm and breakwaters will likely be supported by public.	The plan provides and accounts for all necessary investments or actions to ensure realization of the planning objectives.	Very likely that it is cost effective	If afforded, this alternative would effectively reduce all of the main damage drivers with minimal adverse impacts to adjacent beaches.	If afforded, this alternative would effectively reduce the risk of all of the main damage drivers with minimal adverse impacts to adjacent beaches.Breakwaters are currently designed to be adaptable to rising mean sea levels with wide crests (allow for additional stone to be placed on the crest of the breakwaters).	Moderate risk of high residual damage. Moderate cost risk.
Alt-5b Beach Nourishment Dune&Berm 100'+ Breakwater	This would function to minimize wave attack and erosion damages and help avoid impact to adjacent shorelines from breakwater structures by saturating the sediment trap in lee if the breakwaters. Sediment saturation will be a bit more for this alternative than for Alt 5a.			This alternative is expected to provide large reduction in damages originating from erosion, waves and flood damage. Likely to produce positive net benefits after including the Recreation Benefits.		This alterative is expected to have significant recreation benefits. However, further analysis is needed to assess if it would pass the .51 BCR threshold for the consideration of recreation.	Reduction of flooding and wave attack during storm events could allow communities to resume normal life sooner and in a safe manner compared to losses in FWOP. Dune enhancement could reduce the beach width for recreation and dunes that are too high can block the view on first floor properties; however, possitive effects of this nature based measure (berm/dune) outcome the negative. Breakwaters could promove beach acretion, which enhance recreational activities. Provide protection of property value and tax value. Hotels and commercial business provide the main source of income in the area. See OSE matrix where received a satisfactory score.	Reduction storm damages could allow businesses to contribute to the economy more compared to losses in FWOP. Berm/dune enhansement could improve beach for tourism and Breakwater could improve nearshore recreation posibly stimulating local economy.	Berm/Dune nourishment improves beach habitat for sea turtle nesting, but there is a high risk of negative impacts on nearshore coral reefs. Breakwater construction on unconsolidated substrate or uncolonized pavement could enhance reef habitat. These features could temporary affect the nearshore resources during construction.	This is consistent with Federal and local regulations. Construction of dune/berm and breakwaters will likely be supported by public.	The plan provides and accounts for all necessary investments or actions to ensure realization of the planning objectives.	Very likely that it is not cost effective	If afforded, this alternative would effectively reduce all of the main damage drivers with minimal adverse impacts to adjacent beaches.	If afforded, this alternative would effectively reduce the risk of all of the main damage drivers with minimal adverse impacts to adjacent beaches.Breakwaters are currently designed to be adaptable to rising mean sea levels with wide crests (allow for additional stone to be placed on the crest of the breakwaters).	Low risk of high residual damage. However,there is significant high cost risk.

RINCON B (R11-R19)	Design	Benefits							Planning and Guidance Criteria				Resilience	Residual Damages
Alternative	Functionality	FWO Damages		Primary Damages Reduced (NED)		Recreation	Other Social Effects (OSE)	Regional Economic Development (RED)	Environmental (EQ)	Acceptability	Completeness	Efficiency	Effectiveness		
		Description	$	Methodology	$	Description									
Alt-1 No Action	This would function like the FWOP condition. No changes to the project area would occur under the scope of this project.	FWOP damages primarly come from flooding of low-lying areas and events associated with erosion (undermining of structure, land loss, lot condemnation.) There is very little wave damage.	38,400,000												100%
Alt-2 Revetment	The majority of Rincon Planning Reach B consists of existing hard structures lining the coast. Constructing revetment within this reach would essentially fortify existing seawalls or under-designed existing revetment. A properly-designed revetment would function to reduce erosion and armor damages, and would help to attenuate some wave energy as waves could percolate through the porous structure.			The revetment completely eliminates damage associated with erosion (undermining of structure, land loss, lot condemnation), and partially eliminates damage from flooding.	31,713,000	Very limited to no recreation benefits.	The effects of revetment on health and safety, economic vitality, social connectedness, identity, social vulnerability, participation, and recreation have been measured (see OSE matrix) and partially met score.	Disruptions to the economic network is the largest driver of negative impacts to a regional economy. Revetment would mitigate risks of disruption and allow for resumption of economic activity quicker than FWOP condition	Rincon project area (R11-R19) presents high amount of armoring along the shoreline. There is very limited dry beach providing sea turtle nesting habitat and shorebird habitat.	Even tough this is consistent with Federal and local regulations, construction of revetments at large scale altering the beach aesthethics would lack of support from the public. The Rincon segment from (R11-R19) contains some hotels and parkland areas that use the beach for recreation purposes. It is anticipated that the public will express oposition towards this alternative.	The plan provides and accounts for all necessary investments or actions to ensure realization of the planning objectives.	Very likely it is cost effective	Revetment within Planning Reach B would effectively reduce erosion and armor damages, while also attenuating wave energy through the porous structure.	Revetment would reduce the risk of erosion and armor damage, but wouldn't reduce the risk of inundation damages if sea level trends continue to yield rising mean sea levels in the area.	~20% residual risk (almost exclusively from flooding.) Virtually no cost risk.
Alt-3 Beach Nourishment - Dune &75' Berm	A traditional berm+dune nourishment alternative would function as erosion protection from the added berm width and would reduce wave-attack and inundation damages from the added dune material. However, this area is currently sand starved with net longshore transport to the south, so the cost of sediment needed over a 50-yr project to retain a design fill template would likely outweigh the available FWOP damage amount (i.e. yield a BCR under 1.0).			Expected to significantly limit damage from all drivers, but cost is very high.		This alterative is expected to have the highest recreation benefit. However, it is not expected to provided enough primary benefits to reach the .51 BCR threshold for the consideration of recreation.	Reduction of flooding and wave attack during storm events could allow communities to resume normal life sooner and in a safe manner compared to losses in FWOP. Dunes could reduce the beach width for recreation and dunes that are too high can block the view on first floor properties; however, possitive effects of this nature based measure (berm/dune) outcome the negative. Provide protection of property value and tax value. Hotels and commercial business provide the main source of income in the area. See OSE matrix where received a satisfactory score.	Reduction storm damages could allow businesses to contribute to the economy more compared to losses in FWOP. Beach nourishment could improve beach for tourism and recreation purposes posibly stimulating local economy.	Berm/Dune nourishment improves beach habitat for sea turtle nesting. This could temporarily affect the nearshore resources during construction.	This is consistent with Federal and local regulations. Construction of dune and berm will improve beach habitat for turtle nesting, and recreation. It will likely be supported by general public; however, dunes that are too high can block the view on first floor properties.	The plan provides and accounts for all necessary investments or actions to ensure realization of the planning objectives.	Very likely that it is not cost effective	A typical dune/berm nourishment would effectively reduce erosion damages with the addition of more berm material and wave attack and inundation damages with the addition of more dune material (or the addition of a dune where dunes didn't already exist).	A typical dune/berm nourishment would reduce the risk of inundation, erosion, and wave damages and would be adaptable in the future if mean sea levels continue to rise in the area.	Low risk of high residual damage. Significant (~100% guaranteed) cost risk.
Alt-4 Breakwater	Breakwaters would primarily funtion to absorb or attenuate wave energy proagating to the coastline. Reducing wave energy will lessen wave attack damages and erosion in lee of the breakwater structures. Avoiding impacts to adjacent shorelines would need to be assessed by adding sediment to saturate the sand-starved system, as breakwaters tend to increase accretion immediately landward of the structures, which could limit sediment transport along the coast.			EN stated this alternative is not applicable in Rincon. No economic methodology is available.		N/A	Reduction of flooding and wave attack during storm events could allow communities to resume normal life sooner and in a safe manner compared to losses in FWOP. Breakwaters could promove beach acretion, which enhance recreational activities. See OSE matrix where received a satisfactory score.	Reduction storm damages could allow businesses to contribute to the economy more compared to losses in FWOP. Breakwater could improve nearshore recreation posibly stimulating local economy.	Breakwater should help maintain sandy beach habitat. Breakwater construction on unconsolidated substrate or uncolonized pavement could enhance reef habitat. It could temporarely affect the nearshore resources during construction.	This is consistent with Federal and local regulations. Construction of breakwaters will likely be supported by public.	This alternative can not be considered as a stand alone alternative.	Very likely that it is not cost effective	Breakwaters would effectively reduce wave attack and erosion damages in lee of the structures and inundation damages indirectly from the reduction of wave setup and runup.	Breakwaters would reduce the risk of erosion and wave attack damages, but they would be less effective if unchanged over the life time of the project. Breakwaters are currently designed to have wide, emergent crests so they can be adabptable in the future if mean sea levels continue to rise over the 50-yr project time span.	N/A
Alt-5 Beach Nourishment - 25' berm + Breakwater	This would function to minimize wave attack and erosion damages and help avoid impact to adjacent shorelines from breakwater structures by saturating the sediment trap in lee if the breakwaters.			This alternative is expected to provide large reduction in damages originating from erosion and provided a moderate reduction in flood damage.		This alterative is expected to have moderate recreation benefits. However, it is not expected to provided enough primary benefits to reach the .51 BCR threshold for the consideration of recreation.	Reduction of flooding and wave attack during storm events could allow communities to resume normal life sooner and in a safe manner compared to losses in FWOP. Dune enhancement could reduce the beach width for recreation and dunes that are too high can block the view on first floor properties; however, possitive effects of this nature based measure (berm/dune) outcome the negative. Breakwaters could promove beach acretion, which enhance recreational activities. Provide protection of property value and tax value. Hotels and commercial business provide the main source of income in the area. See OSE matrix where received a satisfactory score.	Reduction storm damages could allow businesses to contribute to the economy more compared to losses in FWOP. Berm/dune enhansement could improve beach for tourism and Breakwater could improve nearshore recreation posibly stimulating local economy.	Beach nourishment improves beach habitat for sea turtle nesting. Breakwater construction on unconsolidated substrate or uncolonized pavement could enhance reef habitat. These features could temporary affect the nearshore resources during construction.	This is consistent with Federal and local regulations. Construction of beach nourishment and breakwaters will likely be supported by public.	The plan provides and accounts for all necessary investments or actions to ensure realization of the planning objectives.	Very likely that it is not cost effective	If afforded, this alternative would effectively reduce all of the main damage drivers with minimal adverse impacts to downdrift beaches.	If afforded, this alternative would effectively reduce the risk of all of the main damage drivers with minimal adverse impacts to downdrift beaches.Breakwaters are currently designed to be adaptable to rising mean sea levels with wide crests (allow for additional stone to be placed on the crest of the breakwaters).	Moderate risk of high residual damage. Significant cost risk.

PUNTA PIEDRITA	Design	Benefits							Planning and Guidance Criteria				Resilience	Residual Damages
Alternative	Functionality	FWO Damages		Primary Damages Reduced (NED)		Recreation	Other Social Effects (OSE)	Regional Economic Development (RED)	Environmental (EQ)	Acceptability	Completeness	Efficiency	Effectiveness		
		Description	$	Methodology	$	Description									
Alt-1 No Action	This would function like the FWOP condition. No changes to the project area would occur under the scope of this project.	For the Punta Piedrita Headland, damages are primarily flooding (84%) with smaller damages coming from waves (13%) and erosion (3%).	48,000,000												100%
Alt-2 Revetment	Revetment will predominantly provide erosion protection and coastline wave attenuation. Additional benefits of rock revetment include stabilizing seawalls if tied into existing structures and providing some level of inundation protection.			The revetment completely eliminates damage associated with erosion and wave attack, and significately eliminates damage from flooding.		No recreation benefits.	The effects of revetment on health and safety, economic vitality, social connectedness, identity, social vulnerability, participation, and recreation have been measured (see OSE matrix) and partially met score.	Disruptions to the economic network is the largest driver of negative impacts to a regional economy. Revetment would mitigate risks of disruption and allow for resumption of economic activity quicker than FWOP condition	The headland area presents high amount of armoring along the shoreline. There is no dry beach providing sea turtle nesting habitat and shorebird habitat.	This is consistent with Federal and local regulations. Construction of revetments on the headlands where no other feasible alternatives could implemented will likely be supported by public.	The plan provides and accounts for all necessary investments or actions to ensure realization of the planning objectives.	Very likely it is cost effective	Revetment would effectively reduce erosion and armor damages, while also attenuating wave energy through the porous structure.	Revetment would reduce the risk of erosion and armor damage, but wouldn't reduce the risk of inundation damages if sea level trends continue to yield rising mean sea levels in the area.	Low risk of high residual damage. Moderate cost risk.

PUNTA LAS MARIAS	Design	Benefits							Planning and Guidance Criteria				Resilience	Residual Damages
Alternative	Functionality	FWO Damages		Primary Damages Reduced (NED)		Recreation	Other Social Effects (OSE)	Regional Economic Development (RED)	Environmental (EQ)	Acceptability	Completeness	Efficiency	Effectiveness		
		Description	$	Methodology	$	Description									
Alt-1 No Action	This would function like the FWOP condition. No changes to the project area would occur under the scope of this project.	Wave damage is greater than the other reaches (50%) followed by flooding (45%) with no damages coming from erosion due to existing armoring in this area.	15,200,000												100%
Alt-2 Revetment	Revetment will predominantly provide erosion protection and coastline wave attenuation. Additional benefits of rock revetment include stabilizing seawalls if tied into existing structures and providing some level of inundation protection.			The revetment significately eliminates damage associated with wave attack, and partially eliminates damage from flooding.		No recreation benefits.	The effects of revetment on health and safety, economic vitality, social connectedness, identity, social vulnerability, participation, and recreation have been measured (see OSE matrix) and partially met score.	Disruptions to the economic network is the largest driver of negative impacts to a regional economy. Revetment would mitigate risks of disruption and allow for resumption of economic activity quicker than FWOP condition	The headland area presents high amount of armoring along the shoreline. There is no dry beach providing sea turtle nesting habitat and shorebird habitat.	This is consistent with Federal and local regulations. Construction of revetments on the headlands where no other feasible alternatives could implemented will likely be supported by public.	The plan provides and accounts for all necessary investments or actions to ensure realization of the planning objectives.	Very likely it is cost effective	Revetment would effectively reduce erosion and armor damages, while also attenuating wave energy through the porous structure.	Revetment would reduce the risk of erosion and armor damage, but wouldn't reduce the risk of inundation damages if sea level trends continue to yield rising mean sea levels in the area.	Low risk of high residual damage. Moderate cost risk.

3.7.6 CONCLUSIONS OF THE COMPARISON AND EVALUATION OF THE ALTERNATIVES

- **Condado Pocket Beach**: results presented in **Table 3-8** reveal that no alternative is showing definitive economic justification; however, some of the alternatives could be further refined and may be economically justified once FWP modeling is complete. The revetment alternative (Alt-2) has the lowest cost, but preliminary FWP modeling results indicated that this alternative is not cost effective (BCR<1). In addition, this alternative is most likely the least effective alternative in the pocket beach of Condado due to the current presence of large upland seawalls and the small sandy berm along this stretch. Revetments along the sandy pocket beach could negatively effect sea turtle nesting habitat and shorebird habitat; alter the beach aesthetics, potential recreation and would lack of support from the public. The breakwater alternative (Alt-4) mainly works reducing wave energy then lessen wave attack damages and erosion in lee of the breakwater structures. This alternative appears to have a lower cost than beach nourishment alternatives but considering that the main damage driver in Condado pocket beach is erosion, it is probable that its effectiveness would be lower than Alt 3c. Nevertheless, breakwaters (Alt 4) would be further analyzed as part of the final array. The beach nourishment for a large template (Alt-3b) and Alt-5, breakwaters combined with beach nourishment, far exceed the FWOP damages and won't be carried forward. The beach nourishment alternative (berm-only) for a small template (Alt-3c) would function primarily as erosion protection but would also offer some wave-attack and inundation damage reduction. Due to the fact that the majority of damages in this pocket beach are erosion damages, it is expected that this alternative will be cost effective. Alt-3c satisfactorily meets the four planning criteria of acceptability, completeness, efficiency and effectiveness in Condado pocket beach planning reach. Therefore, the Alt-3c will be carried forward into the final array to quantify the full benefits.

- **Punta Piedrita and Punta Las Marias Headlands**: The revetment alternative (Alt-2) will provide significant erosion protection and coastline wave attenuation. Since most of the shoreline within these headlands have already been armored by the locals in the past, there is no existing dry beach providing sea turtle nesting habitat and shorebird habitat. Therefore, no significant impacts are expected with the construction of new revetments. Preliminary FWP modeling results indicate that this alternative is cost effective for both headlands. This alternative satisfactorily meets the four planning criteria of acceptability, completeness, efficiency and effectiveness for the Punta Piedrita and Punta Las Marias planning reaches. Therefore, the revetment alternative (Alt-2) will be carried forward into the final array to quantify the full benefits.

- **Ocean Park Pocket Beach**: for this reach, the results presented in **Table 3-8** suggest that most of the alternatives have potential for economic justification. The revetment alternative (Alt-2) has the lowest cost, but preliminary FWP modeling results indicated that this alternative is not cost effective (BCR<1). In addition, revetments along the sandy pocket beach could negatively effect sea turtle nesting habitat and shorebird habitat; alter the beach aesthetics, potential recreation and would lack of support from the public. The beach nourishment alternatives (Alt 3a and Alt 3b) would effectively reduce erosion damages, wave attack and inundation damages with the combination of a berm and dune system (or the addition of a dune where dunes didn't already exist). Positive and negative effects of beach nourishment alternatives have been documented in **Table 3-11**, and overall these alternatives will improve beach habitat for sea turtle nesting, and support recreation, which makes it very acceptable to the public. The breakwater alternative (Alt-

4) and Alt- 5a which combines beach nourishment with a set of breakwaters have cost below the FWOP damages; and will be further analyzed to quantify benefits. Therefore, Alt 3a, Alt 3b, Alt 4 and Alt 5a show potential for economic justification, and satisfactorily meet environmental and public acceptability in order to be carried forward.

- **Rincon B**: results suggest that the only alternative showing potential for economic justification is revetments (Alt-2). The Rincon Planning Reach B comprises large amount of hard structures along the coast that have been implemented by property owners, and there is very limited dry beach providing sea turtle nesting habitat and shorebird habitat. The revetment alternative would likely be effective reducing waves, erosion and armor damages. However, implementation of this alternative at a large scale, would probably lack of support from the public. The revetment alternative would be carried forward into the final array to quantify the full benefits. The beach nourishment alternative (Alt-3) far exceed the FWOP damages and won't be carried forward. As previously documented, the breakwaters could not function as a stand-alone alternative. Alt-5 which combines beach nourishment with a set of breakwaters is expected to minimize wave attack and flooding and also provide large reduction in damages originating from erosion. Positive and negative effects of beach nourishment combined with breakwaters have been documented in **Table 3-11**, and overall this alternative will improve beach habitat for sea turtle nesting, and support recreation, which makes it very acceptable to the public. Therefore, the Alt 5 is being carried forward for further analysis.

3.7.7 FINAL ARRAY OF ALTERNATIVES

After the above evaluation, the array of alternatives was significantly reduced. This development and screening process led to identifying a final array of alternative plans which will be further refined. This final array will be further evaluated during the future with-project (FWP) quantification. **Table 3-12** presents the final array of alternatives.

Table 3-12. Final Array of Alternatives

Planning Reach	Alternative	Description
Condado Pocket Beach	Alt-3c Beach nourishment	This alternative includes initial construction of a beach fill (110,000 cy) and two future renourishments of 51,000 cy each. Periodic nourishment of the beach would be undertaken to maintain the erosion control features within design dimensions. There were several combinations of project dimensions initially considered for beach nourishment, but the proposed volume is based on a 50' berm or equivalent volume. The template optimizations and refined volumes will be finalized during FWP phase.
	Alt-4 Breakwaters	An initial configuration is based on 2 detached breakwaters. Further analysis of this alternative will determine the optimized dimensions and configuration of the structures.
Punta Piedrita Headland	Alt-2 Revetment	A stone revetment of 14 ft-PRVD02 crest elevation on the western side, contiguous to a revetment of 11 ft-PRVD02 crest elevation on the eastern side. This will protect the entire headland, reducing erosion, flood and wave risk.
Ocean Park Pocket Beach	Alt-3 Beach nourishment	Based on FWOP vs Cost, both Alt 3a and 3b show potential for economic justification. Further modeling will determine the optimized dimensions of berm and dune.
	Alt-4 Breakwaters	An initial configuration is based on 8 detached breakwaters. Further analysis of this alternative will determine the optimized dimensions and configuration of the structures.
	Alt-5 Beach nourishment + Breakwaters	A set of 8 breakwaters is initially proposed to reduce wave energy; combined with beach nourishment to address flooding and erosion. The beach nourishment includes initial construction of a beach fill (350,000 cy) and one future renourishment of 161,000 cy. There were several combinations of project dimensions initially considered for beach nourishment, but the proposed volume is based on a 50' berm with 10ft elevation dune or equivalent volume. The template optimizations and refined volumes will be finalized during FWP phase.

Punta Las Marias Headland	Alt-2 Revetment	A stone revetment of 11 ft-PRVD02 crest elevation on the western side of this headland will be considered to reduce erosion, flood and wave risk.
Rincon B	Alt-2 Revetment	A stone revetment of 11 ft-PRVD02 crest elevation on the entire reach (R11 to R19) will be considered to reduce erosion, flood and wave risk.
	Alt-5 Beach nourishment + Breakwaters	A set of 20 breakwaters is initially proposed to reduce wave energy; combined with beach nourishment to address flooding and erosion. The beach nourishment includes initial construction of a beach fill (120,000 cy) and four future renourishment of 82,000 cy each. This volume was based on a 25' berm or equivalent volume, but the template optimizations will be finalized during FWP phase.

3.8 SUMMARY OF ENVIRONMENTAL EFFECTS OF THE FINAL ARRAY OF ALTERNATIVES

The environmental effects of the final array of alternatives formulated per planning reach are evaluated in **Table 3-13** (**Table 3-13** presents a summary of the Environmental effects of the alternatives compared to the future without-project condition "the No Action alternative"), and the effects of the TSP only will be described in Chapter 5. The environmental operating principles have been used throughout the planning process and identified and addressed specifically in Chapter 6 of this report.

Table 3-13. Summary of Environmental Effects of the Final Array of Alternatives and the No Action Alternative

ALTERNATIVE ENVIRONMENTAL FACTOR	CONDADO	PUNTA PIEDRITAS	OCEAN PARK	PUNTA LAS MARIAS	RINCON	No-Acton Plan
GENERAL ENVIRONMENTAL SETTING (refer to Sections 2.1 and 5.1.1)	TSP: Beach Nourishment Additional Measures Included in Final Array: Breakwaters	TSP: Revetment	TSP: Beach Nourishment Plus Breakwaters	TSP: Revetment	TSP: Revetment Additional Measures Included in Final Array: Breakwaters and/or Nourishment	
Water Quality	TSP: Beach nourishment using truck hauled sand from an upland quarry could result in direct but temporary increases in turbidity affecting local water quality during construction. Sedimentation may increase in the local area due to the construction, although BMPs (best management practices) would be used to avoid and minimize these impacts. Turbidity monitoring would be conducted during construction to maintain 10 NTU above background standard or temporarily shut down; No long-term impacts anticipated. Additional Measures: breakwater construction could result in similar direct but temporary effects to water quality. BMPs and monitoring required during construction.	TSP: Headland revetment construction in the water may result in direct but minor impact to local water quality. Turbidity monitoring would be conducted during construction to maintain 10 NTU above background standard or temporarily shut down; No long-term impacts anticipated.	TSP: Beach nourishment using truck hauled sand from an upland quarry and breakwater construction could result in direct but temporary increases in turbidity affecting local water quality during construction. Sedimentation may increase in the local area due to the construction, although BMPs (best management practices) would be used to avoid and minimize these impacts. Turbidity monitoring would be conducted during construction to maintain 10 NTU above background standard or temporarily shut down; No long-term impacts anticipated. Additional Measures: constructing either breakwaters or nourishment alone would have similar, though lesser effects to water quality than constructing the TSP combined measures.	TSP: Headland revetment construction in the water may result in direct but minor impact to local water quality. Turbidity monitoring would be conducted during construction to maintain 10 NTU above background standard or temporarily shut down; No long-term impacts anticipated.	TSP: Revetment construction in the water may result in direct but minor impact to local water quality. Sedimentation may increase in the local area due to the construction, although BMPs (best management practices) would be used to avoid and minimize these impacts. Turbidity monitoring would be conducted during construction to maintain 10 NTU above background standard or temporarily shut down; No long-term impacts anticipated. Additional Measures: truck haul beach nourishment or breakwater construction could result in similar direct but temporary effects to water quality. BMPs and monitoring required during construction.	In the FWOP/no-action alternative there could be degradation of water quality from erosion and sedimentation due to SLR and storm events. This could result in effects to listed corals adjacent to the San Juan and Rincon study reaches.
SAV	TSP and Additional Measures: Construction is not anticipated to directly affect SAV (See 5.1.3, 5.1.5, and Appendix G-3).	TSP: Construction is not anticipated to directly affect SAV (See 5.1.3, 5.1.5, and Appendix G-3).	TSP and Additional Measures: Construction is not anticipated to directly affect SAV (See 5.1.3, 5.1.5, and Appendix G-3).	TSP: Construction is not anticipated to directly affect SAV (See 5.1.3, 5.1.5, and Appendix G-3).	TSP and Additional Measures: Construction is not anticipated to directly affect SAV (See 5.1.3, 5.1.5, and Appendix G-3).	In the FWOP/no-action alternative there could be degradation of water quality from erosion and sedimentation due to SLR and storm events. This could result to impacts to SAV.
Hardbottom Habitat	TSP: Construction of nourishment could affect approximately 3.75 acres of hardbottom including colonized bedrock and scattered coral/rock in unconsolidated substrate (See 5.1.3, 5.1.5, and Appendix G). BMPs and monitoring required during construction. Additional Measures: Breakwater construction could affect approximately 2.82 acres of hardbottom including colonized	TSP: Construction could affect 2.53 acres of hardbottom including colonized bedrock and scattered coral/rock in unconsolidated substrate (See 5.1.3, 5.1.5, and Appendix G).	TSP: Construction of breakwaters and nourishment could affect approximately 3.29 and 2.23 acres (respectively) for a TSP combined total of 5.52 acres of hardbottom including colonized bedrock, scattered coral/rock in unconsolidated substrate and patch reef. Properly designed breakwater construction would create habitat. See 5.1.3, 5.1.5, and Appendix G.	TSP: Construction could affect approximately 2.13 acres of hardbottom including colonized bedrock and scattered coral/rock in unconsolidated substrate (See 5.1.3, 5.1.5, and Appendix G).	TSP: Construction could affect 0.82 acres of hardbottom including colonized bedrock and scattered coral/rock in unconsolidated substrate (See 5.1.3, 5.1.5, and Appendix G). Additional Measures: truck haul beach nourishment or breakwater construction could affect approximately 5.33 and 2.01 acres (respectively) of nearshore hardbottom. Properly designed breakwater	In the FWOP/no-action alternative there could be degradation of water quality from erosion and sedimentation due to SLR and storm events. This could result to impacts to hardbottom habitat.

ALTERNATIVE ENVIRONMENTAL FACTOR	CONDADO	PUNTA PIEDRITAS	OCEAN PARK	PUNTA LAS MARIAS	RINCON	No-Acton Plan
	bedrock and scattered coral/rock in unconsolidated substrate (See 5.1.3, 5.1.5, and Appendix G). Properly designed breakwater construction would create habitat. See 5.1.3, 5.1.5, and Appendix G. BMPs and monitoring required during construction.		Additional Measures: Only constructing one or the other. Breakwater construction could affect 3.29 acres and nourishment 2.23 acres of hardbottom habitat. See 5.1.3, 5.1.5, and Appendix G. BMPs and monitoring required during construction.		construction would create habitat. See 5.1.3, 5.1.5, and Appendix G. BMPs and monitoring required during construction.	
Threatened and Endangered Species	KEY for acronyms: NE=No Effect, MANLAA=May Affect, but is Not Likely to Adversely Affect, MALAA=May Affect, but it Likely to Adversely Affect					
Fish -Nassau Grouper -Scalloped Hammerhead Shark -Giant Manta Ray	TSP and Additional Measures: Truck haul beach nourishment and breakwater construction is expected to have no effect on these overfished and oceanic species. They are not anticipated to occur in the construction area.	TSP: Headland revetment construction in the water is expected to have no effect on these overfished and oceanic species. They are not anticipated to occur in the construction area.	TSP and Additional Measures: Truck haul nourishment and breakwater construction is expected to have no effect on these overfished and oceanic species. They are not anticipated to occur in the construction area.	TSP: Headland revetment construction in the water is expected to have no effect on these overfished and oceanic species. They are not anticipated to occur in the construction area.	TSP and Additional Measures: Revetment or breakwater construction in the water and nourishment are expected to have no effect on these overfished and oceanic species. They are not anticipated to occur in the construction area.	The FWOP/no-action alternative would likely have no effect to Nassau grouper, scalloped hammerhead shark, or giant manta ray.
Sea Turtles -Loggerhead -Leatherback -Green -Hawksbill	TSP: Truck haul beach nourishment May Affect nesting sea turtles. Therefore, nest monitoring and avoidance during construction would be required. See 5.1.6.3 Additional Measures: Breakwater construction would result in a MANLAA determination for these species. Monitoring during and post construction and adaptive management would be conducted to ensure the emergent structures do not entrain nesting or hatchling sea turtles.	TSP: Headland revetment construction in the water MANLAA these species. Monitoring and shutdown during construction required. In addition, headland revetment construction above MHW should also result in MANLAA to nesting sea turtles as nesting in the rocky headlands should be rare. However, nest monitoring and avoidance during construction would also be required. See 5.1.6.3	TSP and Additional Measures: Truck haul beach nourishment May Affect nesting sea turtles. Therefore, nest monitoring and avoidance during construction would be required. See 5.1.6.3. Breakwater construction would result in a MANLAA determination for these species. Monitoring during and post construction and adaptive management would be conducted to ensure the emergent structures do not entrain nesting or hatchling sea turtles.	TSP: Headland revetment construction in the water MANLAA these species. Monitoring and shutdown during construction required. In addition, headland revetment construction above MHW should also result in MANLAA to nesting sea turtles as nesting in the rocky headlands should be rare. However, nest monitoring and avoidance during construction would also be required. See 5.1.6.3	TSP: Revetment construction in the water May Affect nesting sea turtles. Therefore, nest monitoring and avoidance during construction would be required. See 5.1.6.3 Additional Measures: Truck haul beach nourishment also May Affect nesting sea turtles and breakwater construction MANLAA these species. Monitoring and shutdown during construction required. In addition, sea turtle nest monitoring and avoidance during construction would also be required. See 5.1.6.3	The FWOP/no-action alternative, sea turtle nesting beach would continue to be lost to erosion and SLR.
Antillean Manatee	TSP and Additional Measures: Construction MANLAA this species. Standard construction conditions to be employed including monitoring and shutdown during construction (See 5.1.6.4).	TSP: Construction MANLAA this species. Standard construction conditions to be employed including monitoring and shutdown during construction required (See 5.1.6.4).	TSP and Additional Measures: Construction MANLAA this species. Standard construction conditions to be employed including monitoring and shutdown during construction required (See 5.1.6.4).	TSP: Construction MANLAA this species. Standard construction conditions to be employed including monitoring and shutdown during construction required (See 5.1.6.4).	TSP and Additional Measures: Construction MANLAA this species. Standard construction conditions to be employed including monitoring and shutdown during construction (See 5.1.6.4).	In the FWOP/no-action alternative there could be degradation of water quality from erosion and sedimentation due to SLR and storm events. This could result to impacts to SAV which would Antillean manatee foraging habitat.
Listed Corals -Elkhorn -Staghorn -Pillar	TSP: Truck haul beach nourishment MANLAA these species and May Affect but is not likely to adversely modify Acroporid coral DCH. Turbidity monitoring and shutdown during construction required (See 5.1.4 and 5.1.6.5).	TSP: Headland revetment construction in the water MANLAA these species and May Affect but is not likely to adversely modify Acroporid coral DCH. Turbidity monitoring and shutdown during construction required (See 5.1.4 and 5.1.6.5).	TSP and Additional Measures: Truck haul beach nourishment and breakwater construction MANLAA these species and May Affect but is not likely to adversely modify Acroporid coral DCH. The final siting of the breakwaters would be determined after updated	TSP: Headland revetment construction in the water MANLAA these species and May Affect but is not likely to adversely modify Acroporid coral DCH. Turbidity monitoring and shutdown during construction required (See 5.1.4 and 5.1.6.5).	TSP: Revetment construction in the water MANLAA these species and May Affect but is not likely to adversely modify Acroporid coral DCH. Turbidity monitoring and shutdown during construction required (See 5.1.4 and 5.1.6.5).	In the FWOP/no-action alternative there could be degradation of water quality from erosion and sedimentation due to SLR and storm events. This could result to effects to listed corals and Acroporid coral DCH adjacent the San Juan and Rincon study areas.

ALTERNATIVE ENVIRONMENTAL FACTOR	CONDADO	PUNTA PIEDRITAS	OCEAN PARK	PUNTA LAS MARIAS	RINCON	No-Acton Plan
-Lobed Star -Mountainous Star -Boulder Star -Rough Cactus	Additional Measures: Breakwater construction MANLAA these species and May Affect but is not likely to adversely modify Acroporid coral DCH. The final siting of the breakwaters would be determined after updated benthic surveys can be conducted in order to minimize impacts to these species (See 5.1.6.3). Turbidity monitoring and shutdown during construction required (See 5.1.4 and 5.1.6.5).		benthic surveys can be conducted in order to minimize impacts to these species (See 5.1.6.3). Turbidity monitoring and shutdown during construction required (See 5.1.4 and 5.1.6.5).		Additional Measures: Truck haul beach nourishment and breakwater construction MANLAA these species. The final siting of the breakwaters would be determined after updated benthic surveys can be conducted in order to minimize impacts to these species (See 5.1.6.3). Turbidity monitoring and shutdown during construction required (See 5.1.4 and 5.1.6.5).	
Essential Fish Habitat	TSP: Construction could affect EFH including colonized bedrock and scattered coral/rock in unconsolidated substrate (See 5.1.3, 5.1.5, and Appendix G). Additional Measures: Properly designed, breakwaters could provide habitat (See Appendix G).	TSP: Construction could affect EFH including colonized bedrock and scattered coral/rock in unconsolidated substrate (See 5.1.3, 5.1.5, and Appendix G).	TSP: Construction could affect EFH including colonized bedrock, scattered coral/rock in unconsolidated substrate, and patch reef (See 5.1.3, 5.1.5, and Appendix G). Properly designed, breakwaters could provide habitat (See Appendix G). Additional Measures: Constructing either of these measures separately, but not combined, would have a lesser effect to EFH.	TSP: Construction could affect EFH including colonized bedrock and scattered coral/rock in unconsolidated substrate (See 5.1.3, 5.1.5, and Appendix G).	TSP: Construction could affect EFH including colonized bedrock and scattered coral/rock in unconsolidated substrate (See 5.1.3 and 5.1.5). Additional Measures: Nourishment and breakwater construction could affect EFH including colonized bedrock and scattered coral/rock in unconsolidated substrate (See 5.1.3 and 5.1.5). Properly designed, breakwaters could provide habitat (See Appendix G).	In the FWOP/no-action alternative there could be degradation of water quality from erosion and sedimentation due to SLR and storm events. This could result to impacts to EFH.
Seabirds and Shorebirds	TSP and Additional Measures: Temporary disturbance during construction. Nourishment would provide habitat (See 5.1.7 and Appendix G).	TSP: Temporary disturbance during construction. Revetment would provide habitat (See 5.1.7 and Appendix G).	TSP and Additional Measures: Construction could affect birds and bird habitat. CSRM measures would provide habitat (See 5.1.7 and Appendix G).	TSP: Temporary disturbance during construction. Revetment would provide habitat (See 5.1.7 and Appendix G).	TSP and Additional Measures: Temporary disturbance during construction. CSRM measures would provide habitat (See 5.1.7 and Appendix G).	In the FWOP/no-action alternative there could be erosion and loss of bird habitat due to SLR and storm events.
Air Quality	TSP and Additional Measures: Anticipated air quality impacts resulting from construction equipment emissions and other construction activities are expected to be minor and temporary.	TSP: Anticipated air quality impacts resulting from construction equipment emissions and other construction activities are expected to be minor and temporary.	TSP and Additional Measures: Anticipated air quality impacts resulting from construction equipment emissions and other construction activities are expected to be minor and temporary.	TSP: Anticipated air quality impacts resulting from construction equipment emissions and other construction activities are expected to be minor and temporary.	TSP and Additional Measures: The adverse impacts to air quality due to emissions from construction activities are anticipated to be minor and temporary.	The FWOP/no-action alternative would likely have no effect to air quality.
Invasive Species	TSP and Additional Measures: Construction would not cause additional threats from invasive species; BMPs required during construction to avoid the spread and help control invasive species.	TSP: Construction would not cause additional threats from invasive species; BMPs required during construction to avoid the spread and help control invasive species.	TSP and Additional Measures: Construction would not cause additional threats from invasive species; BMPs required during construction to avoid the spread and help control invasive species.	TSP: Construction would not cause additional threats from invasive species; BMPs required during construction to avoid the spread and help control invasive species.	TSP and Additional Measures: Construction would not cause additional threats from invasive species; BMPs required during construction to avoid the spread and help control invasive species.	In the FWOP/no-action alternative control of invasive species would continue to be governed by regulation.
Environmental Justice	TSP and Additional Measures: Construction is not anticipated to have a disproportionately high and adverse impact on low income or minority communities or cause negative secondary effects. Beneficial effect to the overall area anticipated from sustainable storm risk management measures. Would	TSP: Construction is not anticipated to have a disproportionately high and adverse impact on low income or minority communities or cause negative secondary effects. Beneficial effect to the overall area anticipated from sustainable storm risk management measures. Would benefit all	TSP and Additional Measures: Construction is not anticipated to have a disproportionately high and adverse impact on low income or minority communities or cause negative secondary effects. Beneficial effect to the overall area anticipated from sustainable storm risk management measures. Would	TSP: Construction is not anticipated to have a disproportionately high and adverse impact on low income or minority communities or cause negative secondary effects. Beneficial effect to the overall area anticipated from sustainable storm risk management measures. Would benefit all	TSP and Additional Measures: Construction is not anticipated to have a disproportionately high and adverse impact on low income or minority communities or cause negative secondary effects. Beneficial effect to the overall area anticipated from sustainable storm risk management measures. Would	In the FWOP/no-action alternative flooding from SLR and storm damage would continue to effect low income and minority communities around San Juan bay.

ALTERNATIVE ENVIRONMENTAL FACTOR	CONDADO	PUNTA PIEDRITAS	OCEAN PARK	PUNTA LAS MARIAS	RINCON	No-Acton Plan
	benefit all populations in the area via reduction in damages as a result of storm surge and sea level rise.	populations in the area via reduction in damages as a result of storm surge and sea level rise.	benefit all populations in the area via reduction in damages as a result of storm surge and sea level rise.	populations in the area via reduction in damages as a result of storm surge and sea level rise.	benefit all populations in the area via reduction in damages as a result of storm surge and sea level rise.	
Noise	TSP and Additional Measures: Minor adverse impacts to wildlife due to displacement from construction noise; Temporary and minor impact to human populations due to the construction activities.	TSP: Minor adverse impacts to wildlife due to displacement from construction noise; Temporary and minor impact to human populations due to the construction activities.	TSP and Additional Measures: Minor adverse impacts to wildlife due to displacement from construction noise; Temporary and minor impact to human populations due to the construction activities.	TSP: Minor adverse impacts to wildlife due to displacement from construction noise; Temporary and minor impact to human populations due to the construction activities.	TSP and Additional Measures: Minor adverse impacts to wildlife due to displacement from construction noise; Temporary and minor impact to human populations due to the construction activities.	In the FWOP/no-action alternative noise levels would continue to reflect that of active metropolitan areas and coastal environments.
HTRW	TSP and Additional Measures: Construction would not cause additional threats from HTRW; Additional investigations could be required in PED. BMPs required during construction to avoid the spread and help control hazardous substances.	TSP: Construction would not cause additional threats from HTRW; Additional investigations could be required in PED. BMPs required during construction to avoid the spread and help control hazardous substances.	TSP and Additional Measures: Construction would not cause additional threats from HTRW; Additional investigations could be required in PED. BMPs required during construction to avoid the spread and help control hazardous substances.	TSP: Construction would not cause additional threats from HTRW; Additional investigations could be required in PED. BMPs required during construction to avoid the spread and help control hazardous substances.	TSP and Additional Measures: Construction would not cause additional threats from HTRW; Additional investigations could be required in PED. BMPs required during construction to avoid the spread and help control hazardous substances.	In the FWOP/no-action alternative control of HTRW would continue to be governed by regulation.
Aesthetics	TSP and Additional Measures: Truck haul dune fill and breakwater construction could temporarily impact local aesthetics during construction but benefic local aesthetics in the long term; Not out of character for the San Juan area.	TSP: Headland Revetments could temporarily impact local aesthetics during construction but benefic local aesthetics in the long term; Not out of character for the San Juan area.	TSP and Additional Measures: Truck haul dune fill and breakwaters could temporarily impact local aesthetics during construction but benefic local aesthetics in the long term; Not out of character for the San Juan area.	TSP: Headland Revetments could temporarily impact local aesthetics during construction but benefic local aesthetics in the long term; Not out of character for the San Juan area.	TSP and Additional Measures: Revetments, nourishment or breakwaters could temporarily impact local aesthetics during construction and could alter the long-term aesthetics of the area. Considering structures are actively eroding into the ocean along the Rincon shoreline, these measures could benefit local aesthetics in the long term. Not out of character for the Rincon area.	In the FWOP/no-action alternative local aesthetics would continue to reflect those of an active harbor and San Juan metropolitan area around San Juan bay.
Coastal Barrier Resources	TSP and Additional Measures: No effect to CBRS units as they are too far away to be affected.	TSP: No effect to CBRS units as they are too far away to be affected.	TSP and Additional Measures: No effect to CBRS units as they are too far away to be affected.	TSP: No effect to CBRS units as they are too far away to be affected.	TSP and Additional Measures: No effect to CBRS units as they are too far away to be affected.	In the FWOP/no-action alternative CBRS units would continue to be governed by regulation.
Cultural and Historic Resources	TSP and Additional Measures: The construction may impact historic properties. The source of any sand may directly impact cultural resources. The construction of new features may have potential cumulative or indirect effects to historic properties. Additional investigations will be required in PED.	TSP: The construction may impact historic properties. The source of any sand may directly impact cultural resources. The construction of new features may have potential cumulative or indirect effects to historic properties. Additional investigations will be required in PED.	TSP and Additional Measures: The construction may impact historic properties. The construction of new features may have potential cumulative or indirect effects to historic properties. Additional investigations will be required in PED.	TSP: The construction may impact historic properties. The source of any sand may directly impact cultural resources. The construction of new features may have potential cumulative or indirect effects to historic properties. Additional investigations will be required in PED.	TSP and Additional Measures: The construction may impact historic properties. The construction of new features may have potential cumulative or indirect effects to historic properties. Additional investigations will be required in PED.	In the FWOP/no-action alternative impacts to historic properties are not anticipated.

3.9 THE TENTATIVELY SELECTED PLAN

The NED/TSP is the plan that reasonably maximizes net economic benefits consistent with protecting the Nation's environment. Due to complexity of the study, and schedule constraints, this study has not identified the NED plan by the time of the publication of this report. With consideration given to the planning criteria evaluation, the TSP per planning reach is the alternative with most potential for economic justification that meets all planning criteria, but the TSP may be adjusted based on data being developed.

It is important to note, that no alternatives were screened out due to their inability to maintain existing recreation (beach and nearshore) since those benefits were not included during the screening of alternatives. USACE is planning this single purpose project formulated exclusively for coastal storm risk management, with economic benefits equal to or exceeding the costs, based solely on damage reduction benefits, or a combination of damage reduction benefits and recreation benefits. Under current policy, recreation must be incidental in the formulation process and may not be more than 50% of the total benefits required for justification (ER 1105-2-100, 3-4.b.(4)(a)).

The economic analysis presented in section 3.7.4 resulted in several alternatives having negative net benefits and a benefit to cost ratio less than 1. Those alternatives did not meet the criteria of economic justification, therefore are not part of the TSP. The Alt-2 revetment in planning reaches Punta Piedrita and Punta Las Marias have a positive BCR and are considered environmentally acceptable and feasible from an engineering standpoint.

Since the final array of alternatives presented in **Table 3-12** is still under evaluation, Net benefits have not been finally quantified, there is a possibility that some planning reaches will not be economically justified. If not economically justified, then the recommendation for that planning reach will be No Action. Final results of the analysis will be provided in future communications.

Using the available results, the tentatively selected plan will include the following alternatives per planning reach, see **Table 3-14**.

Table 3-14. Tentatively Selected Plan Rollup

Planning Reach Alternative	Benefits (Thousands AAEQ)	Cost (Thousands AAEQ)	*Net Benefits (Thousands AAEQ)	BCR
Condado pocket beach Alt – 3 Beach nourishment	Requires 88% damage reduction to get to a 0.5 BCR	$999	Likely Negative without Recreation Benefits	Presently <1.0
Punta Piedrita Headland Alt – 2 Revetment	$950	$857	$93	1.11
Ocean Park Pocket Beach Alt – 5 Beach nourishment plus breakwaters	Requires 40% damage reduction to get to a 0.5 BCR	$3,812	A fair chance of positive net-benefits on primary benefits alone; highly probable with recreation benefits added.	Likely >1.0
Punta Las Marias Headland Alt – 2 Revetment	$507	$473	$34	1.07
Rincon Alt – 2 Revetment	$1,175	$ 1,049	$ 125	1.12

This study concludes that there is potential for Federal Interest in a comprehensive plan to reduce the risk of storm damages due to wave attack, flooding and erosion to the Condado and Ocean Park pocket beaches, Punta Piedrita and Punta Las Marias headlands, and Rincon B planning reaches, summarized in **Table 3-14**. At this point in the study the TSP will include the following features, but this recommendation may be adjusted as public comments are considered and final analyses are completed. A detailed description of the TSP is included in the next chapter. Overall, the TSP is most likely to include:

- Beach nourishment (1,910 ft) along Condado Pocket Beach shoreline;
- Stone revetment on Punta Piedrita headland (2,450 ft);
- A breakwater field in combination with beach nourishment protecting 6,810 ft along the Ocean Park Pocket Beach shoreline;
- Stone revetment on west side of Punta Las Marias headland (1,400 ft); and
- Stone revetment (5,650 ft) along the Rincon shoreline.

Although this is not part of the Federal project recommendation, this study recognizes that Puerto Rico island wide will benefit from the non-Federal sponsor and local communities pursuing non-structural measures, such as implementation of a Coastal Construction Control Line, and improved evacuation plans and notification systems.

Typically, the NED plan becomes the Recommended Plan unless the non-Federal sponsor opts to pursue a Locally Preferred Plan (LPP) which differs from the NED plan. An LPP is subject to the requirements described in ER 1105-2-100. At this point of the study the non-Federal sponsor has not requested an LPP.

3.9.1 UNCERTAINTY OF THE TSP

For those TSP components which have been modeled, a probabilistic analysis of a BCR greater than 1.0 will be described, consistent with section 8-d of ER 1105-2-101 ("Risk Assessment for Flood Risk Management Studies") in the Economics appendix. However, at the time of the release of this report there are some potential alternatives in consideration that have not been fully analyzed with FWP modeling and are part of the recommended action. Though the results are not fully quantified, uncertainty associated with choosing those actions, or not choosing those actions have been fully documented in Section 8.2 of the Economic Appendix. Following there is a brief description of the uncertainty associated with the TSP:

- Condado Pocket beach: The beach nourishment alternative has not been modeled in Beach-fx yet, and there is a likelihood that this alternative will not have economic justification. This alternative would need to reduce around 90% of the FWOP damages to get to a 0.5 BCR based on storm damage reduction in order to claim additional recreation benefits. The expected recreation benefits for this alternative are high as beach visitation averages ~362,000 visitors annually and it will help to get the BCR above 1. The cost uncertainty is high due to the variability of the volumes that might be needed in order to achieve the damage reduction required; nevertheless, the FWP modeling will allow for optimization of the beach nourishment configuration to achieve maximum net-benefits. In the case of FWP modeling results indicate that no alternative could be economically justified, the recommended alternative will be no-Action.

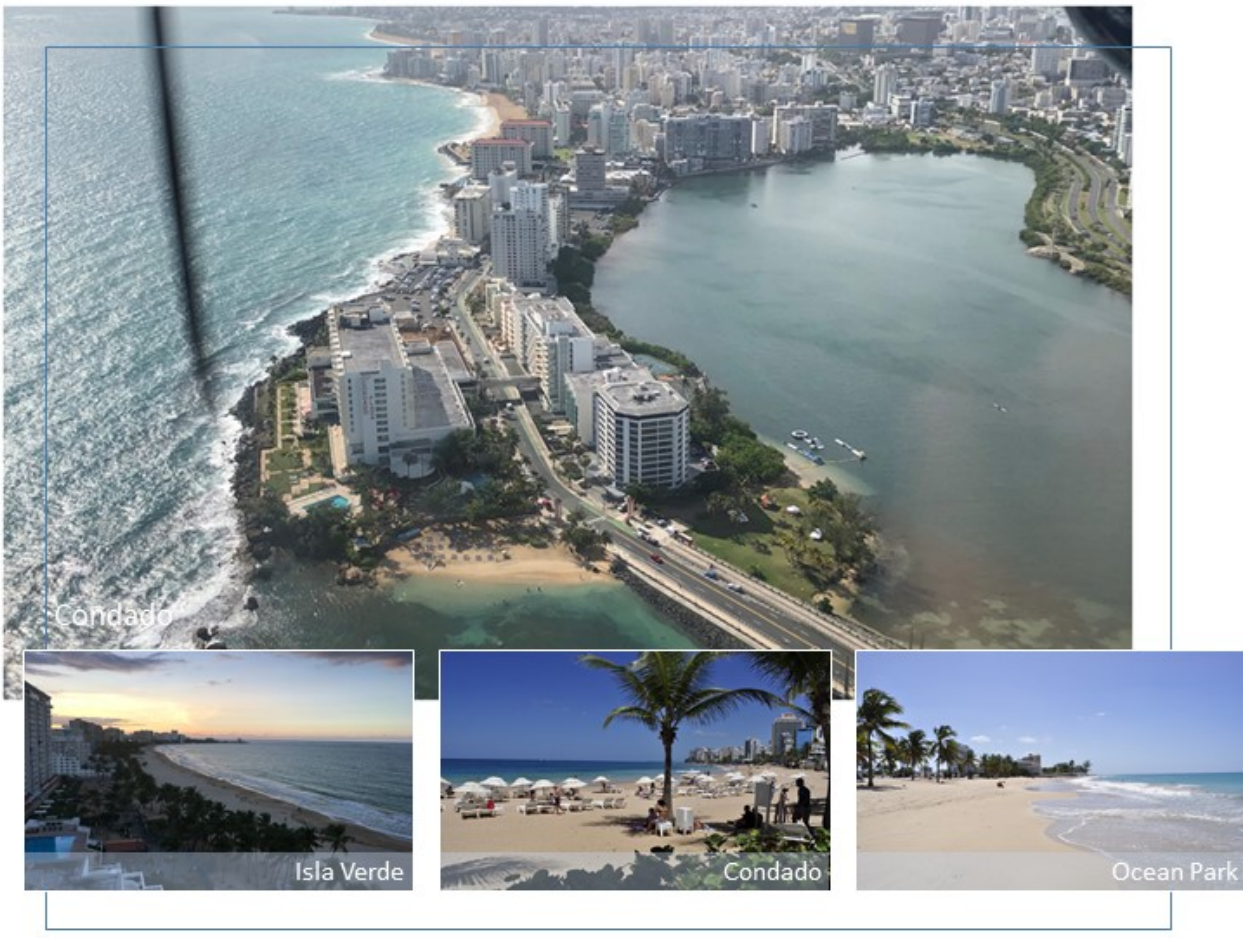
- Punta Piedrita Headland: The revetment alternative has been modeled in Beach-fx, and results in an average BCR of 1.1, and average net benefits of $93,000 AAEQ based on 50 iterations. Section 8.2.4 of the Economics Appendix describes the probabilistic results of positive net-benefits for this alternative. Over 50 modeled lifecycles, this alternative results in positive net benefits in about 78% of the lifecycles with net benefits ranging from minimum $(31,000) AAEQ to maximum $34,000. Around one-third of all iterations have net-benefits greater than $10,000. There is low uncertainty in choosing this alternative.

- Ocean Park Pocket Beach: The breakwater field in combination with beach nourishment alternative has not been modeled in Beach-fx yet, but the risk of this alternative not having economic justification is low. This alternative would need to reduce only 40% of the FWOP damages to get to a 0.5 BCR based on storm damage reduction in order to claim additional recreation benefits. The expected recreation benefits for this alternative are significant, which will increase overall net benefits. The combination of breakwaters and nourishment would increase the level of risk reduction, but there is high uncertainty if adding either measure to the other will provide a commensurate increase in net benefits (i.e. high risk to incremental justification). The cost uncertainty is high due to the variability of the volumes and the number of breakwaters that might be needed in order to achieve the damage reduction required. There is high uncertainty associated with the modeling of breakwaters, which still needs to be completed, and the assessment of how they perform in providing damage reduction. At this point, this alternative is considered very low risk with respect to economic justification.

- Punta Las Marias Headland (West): The revetment alternative has been modeled in Beach-fx, and results in an average BCR of 1.07, and average net benefits of $34,000 AAEQ based on 50 iterations. Section 8.2.5 of the Economics Appendix describes the probabilistic results of positive net-benefits for this alternative. Over 50 modeled lifecycles, this alternative results in positive net benefits in about 73% of the lifecycles with net benefits ranging from minimum $(241,000) AAEQ to maximum $337,000. There is low uncertainty at choosing this alternative.

- Rincon B: The revetment alternative has been modeled in Beach-fx, and results in an average BCR of 1.12, and average net benefits of $125,000 AAEQ based on 50 iterations. There are no recreation benefits anticipated for this alternative. The probabilistic results will be documented in the final report. The cost uncertainty is low, conceptual designs are not expected to significantly change, and modeling confirmed that the revetment alternative reduces about 80% of the FWOP damages. There is low uncertainty at choosing this alternative.

4. RECOMMENDED PLAN

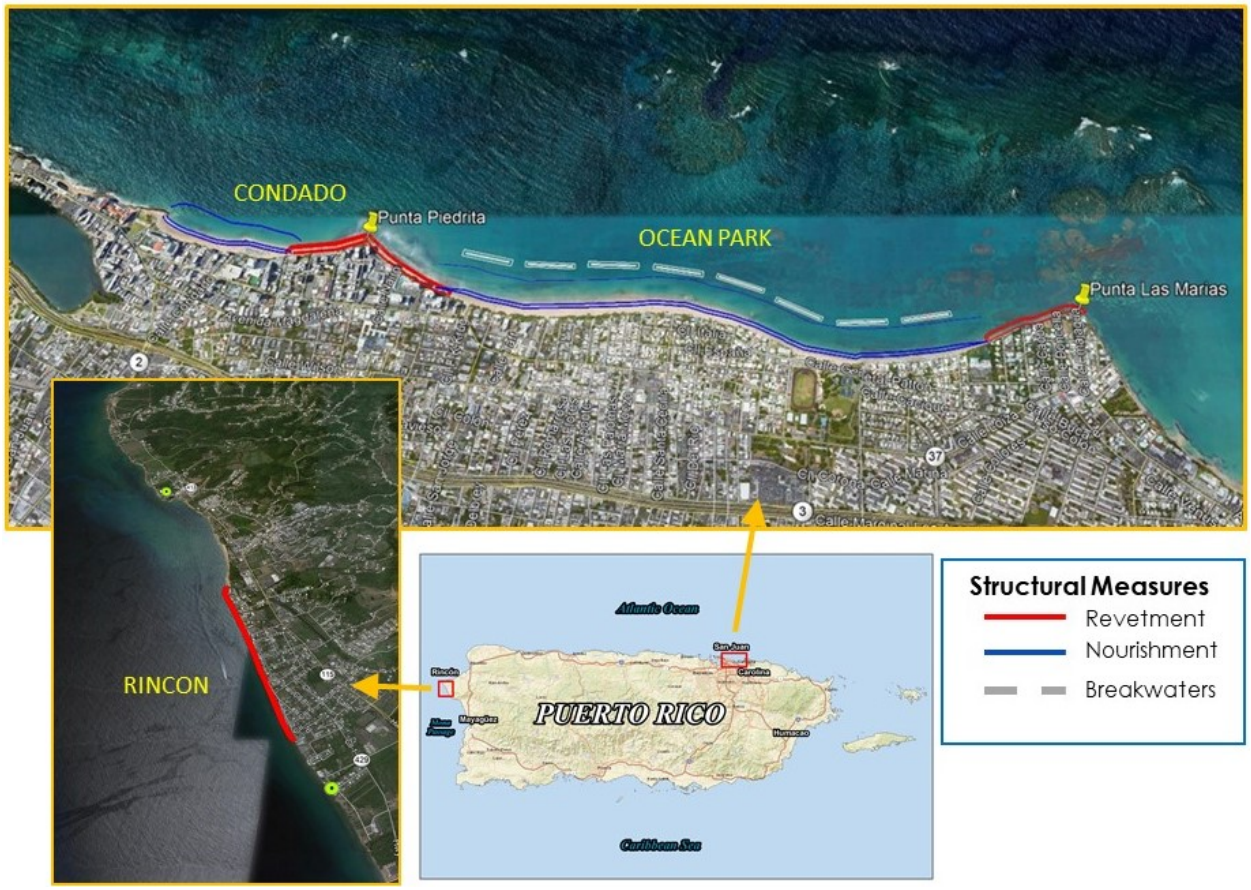


4 THE TENTATIVELY SELECTED PLAN

4.1 DESCRIPTION OF THE TENTATIVELY SELECTED PLAN

The Tentatively Selected Plan (TSP) for the Puerto Rico Coastal Study consists of a combination of structural features designed to reduce the risk of damages as a result of wave attack, coastal flooding, and erosion in Condado, Ocean Park and Rincon focus areas. At this point in the study, the TSP will include, beach nourishment along the Condado pocket beach shoreline, stone revetment along Punta Piedrita headland, a breakwater field combined with beach nourishment along the Ocean Park pocket beach shoreline, stone revetment along Punta Las Marias headland (west side), and stone revetment along the Rincon B coastline (See **Figure 4-1**). Although the TSP was formulated to avoid and minimize impacts to every extent possible, impacts are expected to occur and as such the TSP includes mitigation. These features and aspects of the TSP are discussed in this Chapter.

Figure 4-1. Location of Structural Features of the Tentatively Selected Plan



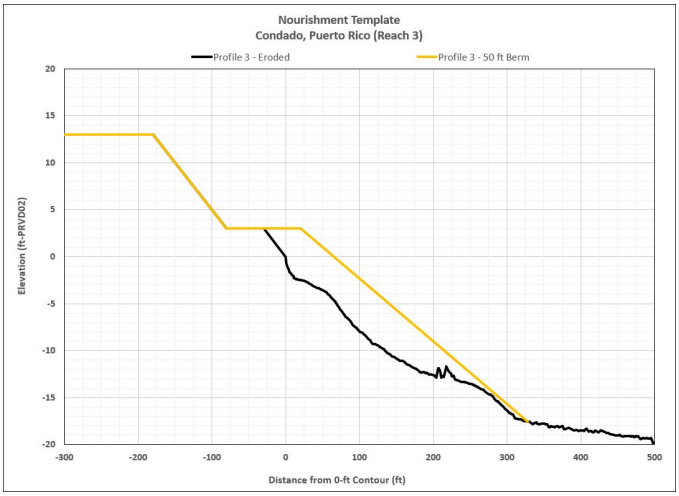
4.2 PROJECT DESIGN- CONCEPTUAL DETAILS OF THE TSP BY PLANNING REACH

Full FWP analyses and modeling has not yet been completed. Designs and assumptions described below are at a 10% level of design and are at a conceptual level only. The PED phase (which occurs after the feasibility phase is complete) would refine design to get to 100% level for construction. Construction of the beach nourishment in Condado and Ocean Park pocket beaches, which are part of the tentatively selected plan will likely require about 723,000 cy of sand over a 50-year period. The beach nourishment design template can be described by three factors, the dimensions of the dune, dimensions of the berm, and shoreline slopes. The below conceptual designs are subject to change, based on results of the FWP modeling.

4.2.1 CONDADO POCKET BEACH

The selected plan for Condado Pocket Beach starts at the inclined groin located at the Ventana al Mar Park moving east with the implementation of a beach nourishment system of 1,910 ft. The preliminary conceptual design specifications are presented in **Table 4-1**.

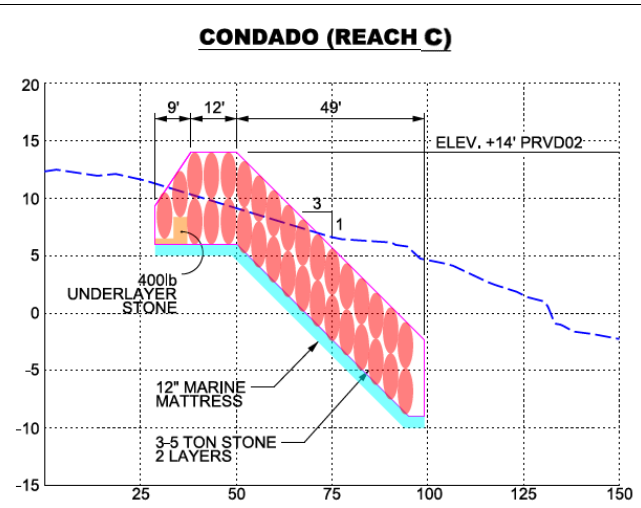
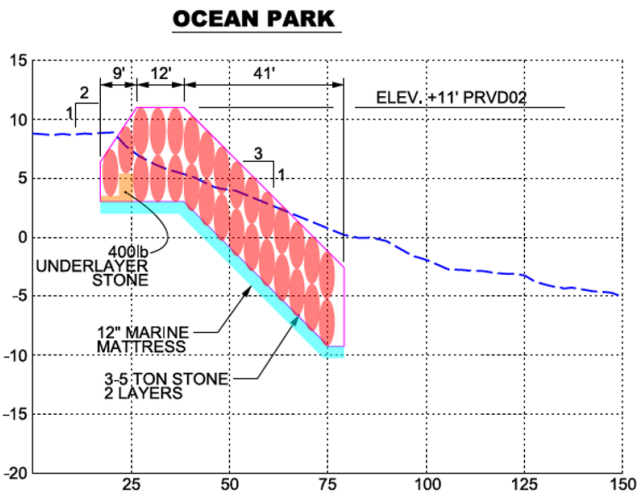
Table 4-1. Condado Pocket Beach Project Description

Condado Pocket Beach	
Beach Nourishment Location: R2-R5 Length: Approximately 1,910 ft Crest Width: 50ft berm or equivalent volume for berm & dune Side slopes: 15H:1V Mean grain size: 0.28 mm Average volume of initial construction 110,000 cy (year 2028) Two renourishment events of 51,000 cy during 50-years (years 2040 & 2060) Compatible material from an upland sand source in Los Juncos.	**Representative template** 

4.2.2 PUNTA PIEDRITA HEADLAND

The selected plan for the Punta Piedrita headland consists of 1,100 ft of stone revetment on the west side of the headland followed by 1,350 ft of stone revetment on the east side. The preliminary conceptual design specifications are presented in **Table 4-2**.

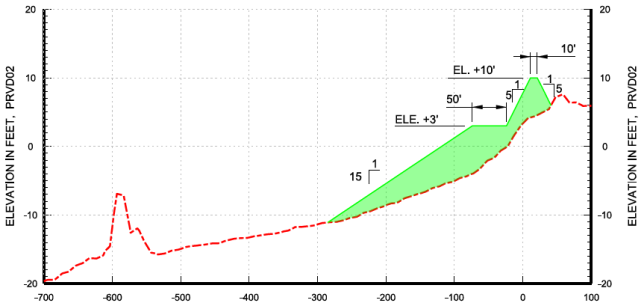
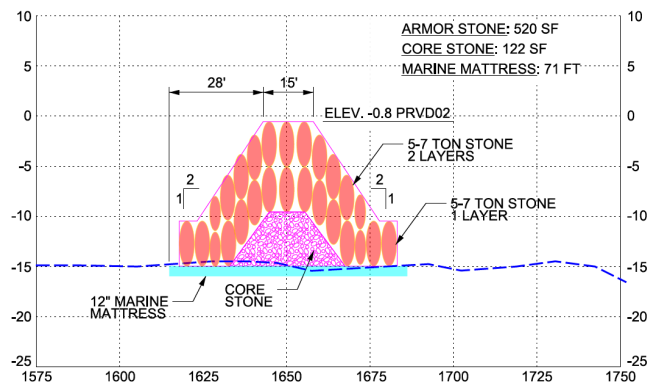
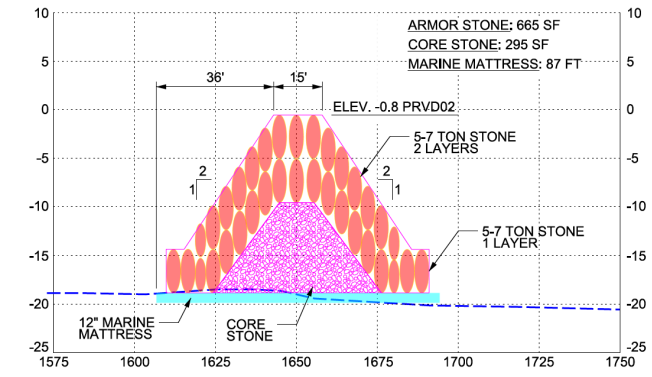
Table 4-2. Punta Piedrita Project Description

Punta Piedrita Headland	
Revetment on the west side Location: R1 Length: Approximately 1100 ft Crest Elevation: 14 ft PRVD02 Crest Width: 12 ft Side slopes: 3H:1V Stone size: 3-5 Ton, approx. 4 ft diameter stone Exposed Stone Type: Granite	
Revetment on the east side Location: R15-R16 Length: Approximately 1,350 ft Crest Elevation: 11 ft PRVD02 Crest Width: 12 ft Side slopes: 3H:1V Stone size: 3-5 Ton, approx. 4 ft diameter stone Exposed Stone Type: Granite	

4.2.3 OCEAN PARK POCKET BEACH

The selected plan for Ocean Park pocket beach starts at the end of the proposed revetment in Punta Piedrita headland with the implementation of 6,810 ft of beach nourishment in combination with a breakwater field in front of the sandy portion of the beach. The preliminary conceptual design specifications are presented in **Table 4-3**.

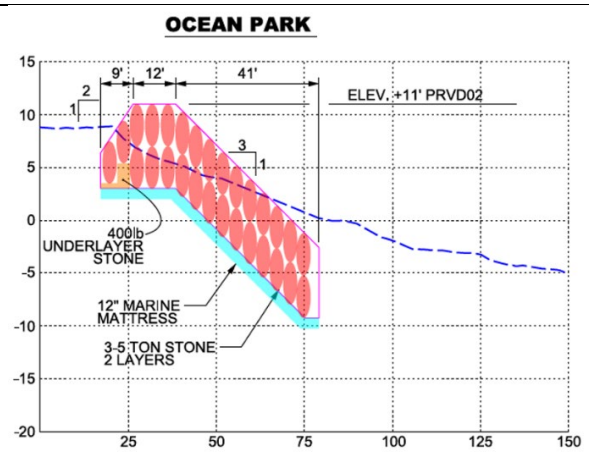
Table 4-3. Ocean Park Pocket Beach Project Description

Ocean Park Pocket Beach	
Beach Nourishment Location: R3-R14 Length: Approximately 6,810 ft Crest Width: 50ft berm and 10 ft dune or equivalent volume for berm & dune Side slopes: 15H:1V Mean grain size: 0.28 mm Average volume of initial construction 350,000 cy (year 2028) One renourishment event of 161,000 cy during 50-years (year 2053) Compatible material from an upland sand source in Los Juncos.	**Representative template** 
Breakwaters conceptual design Location: R3-R14 Number of breakwaters: 8 Crest Length (each breakwater): 600 ft Cross-shore Distance: 500 ft from approx. 0 ft contour Gap Distance: 7 @ 250 ft long Crest Elevation: -0.77 ft PRVD02 (MLLW) Crest Width: 15 ft Side slopes: 2H:1V Stone size: 5-7 Ton, approx. 4.5 ft diameter stone Exposed stone type: Granite Breakwater height: From East to West, BWs are numbered 1-8. BWs 1-5 (eastern location of OP) are located at depths in the 15 ft-PRVD02 range (see cross section at profile 8). BW 6-8 are located at depths between 18 to 22 ft-PRVD02 depths which is sampled at the profile 12 cross section.	**OCEAN PARK (PROFILE 8)**  **OCEAN PARK (PROFILE 12)** 

4.2.4 PUNTA LAS MARIAS HEADLAND (WEST SIDE)

The selected plan for the Punta Las Marias headland consists of 1,400 ft of stone revetment on the west side of the headland. The preliminary conceptual design specifications are presented in **Table 4-4**.

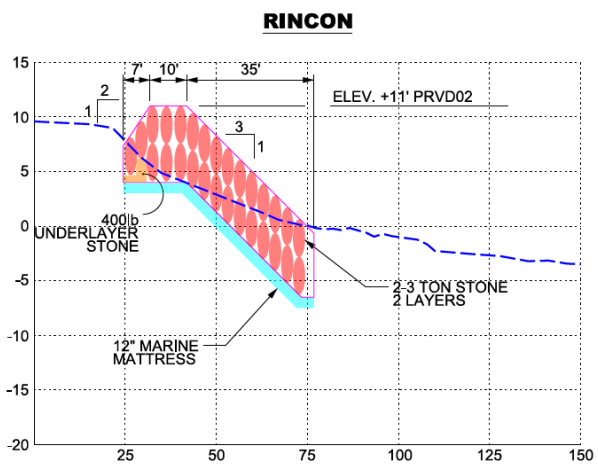
Table 4-4. Punta Las Marias Project Description

Punta Las Marias Headland (West side)	
Revetment Location: R1-R2 Length: Approximately 1400 ft Crest Elevation: 11 ft PRVD02 Crest Width: 12 ft Side slopes: 3H:1V Stone size: 3-5 Ton, approx. 4 ft diameter stone Exposed Stone Type: Granite	

4.2.5 RINCON

The selected plan for Rincon focus area includes 5,650 ft of stone revetment starting south of Quebrada Los Ramos and ending at Stella. The conceptual design specifications are presented in **Table 4-5**.

Table 4-5. Rincon Project Description

Rincon B	
Revetment Location: R11-R19 Length: Approximately 5650 ft Crest Elevation: 11 ft PRVD02 Crest Width: 10 ft Side slopes: 3H:1V Stone size: 2-3 Ton, approx. 3 ft diameter stone Exposed stone type: Granite	

4.2.6 PERIODIC NOURISHMENT EVENTS

As stated, the Tentatively Selected Plan will include a beach nourishment in Condado and Ocean Park Pocket Beaches. At this point of the study, the FWP Beach-fx modeling hasn't been completed; therefore, professional judgment has been applied to determine the number of periodic nourishment events.

- For Condado Pocket Beach, three nourishment events are estimated with an average time interval of 17 years. The nourishment years would be 2028 for initial construction, followed by periodic nourishment in 2040 and 2060.

- For Ocean Park Pocket Beach, two nourishment events are estimated with an average time interval of 25 years. The nourishment years would be 2028 for initial construction, followed by a periodic nourishment in 2053.

4.2.7 RECOMMENDED SAND SOURCE

The tentatively selected plan will require approximately 723,000 cy of sand over a 50-year period in Condado and Ocean park pocket beaches.

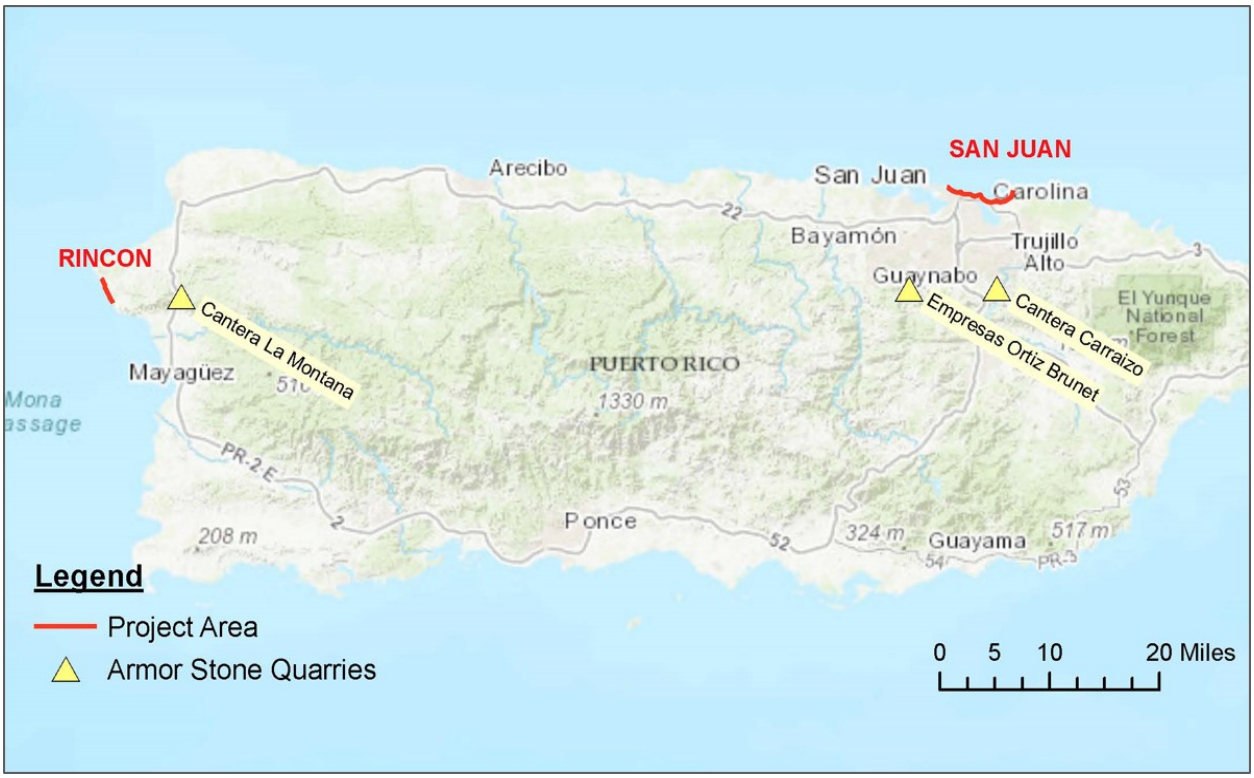
As detailed in the **Geotechnical Appendix (D)**, there is adequate beach quality sand to meet the estimated sand needs of the tentatively selected plan. The Concretos sand mine (Juncos) was used to develop the Total Project Cost estimate. This upland sand source has several million cubic yards of sand available to be mined. This volume is more than adequate to meet the average total forecasted project volume.

4.2.8 ARMOR STONE AVAILABILITY

Armor stone for revetments and breakwaters is available for the San Juan and Rincon project areas from the armor stone quarries listed below and depicted in **Figure 4-2**. The quarries listed were either used or are being considered for use in other USACE projects in Puerto Rico. The distance to project sites is 25-35 miles.

- Cantera La Montana, Cadena
- Cantera Carraizo, Trujillo Alto
- Empresas Ortiz Brunet, Guaynabo

Figure 4-2. Armor Stone Quarry Locations



4.2.9 PROJECT MITIGATION

Although the alternatives were formulated to avoid and minimize impacts to every extent possible, impacts are expected to occur and would be addressed with mitigation, which is evaluated further in Section 5.1 and in the preliminary mitigation plan in the **Environmental Appendix (G)**, Attachment 4.

4.3 PROJECT CONSTRUCTION

The TSP includes several structural features. For cost development purposes, the initial construction of the project features would be conducted under 4 separated contracts (1 to 4), and Contracts 5 & 6 will be considered periodic renourishments. Project construction is assumed to begin in 2025 and takes approximately 3 years, assuming concurrent construction crews in various locations. See **Table 4-6** for contracts distribution of the TSP.

Table 4-6. Contracts distribution for the TSP

Description	Reaches	Measure
Cnt.1 – Rincon Revetment	Rincon B	Demolition and Stone Revetment
Cnt.2 – San Juan Revetment	Punta Piedrita and Punta Las Marias Headlands	Demolition and Stone Revetment
Cnt.3 – San Juan Breakwaters	Ocean Park Pocket Beach	Breakwaters
Cnt.4 – San Juan Beach Nourishment (2028)	Condado Pocket Beach and Ocean Park Pocket Beach	Beach Nourishment by Truck-Haul (460,000 CY)
Cnt.5 – San Juan Beach Nourishment (2040)	Condado Pocket Beach	Beach Nourishment by Truck-Haul (51,000 CY)
Cnt.6 – San Juan Beach Nourishment (2053)	Ocean Park Pocket Beach	Beach Nourishment by Truck-Haul (161,000 CY)
Cnt.7 – San Juan Beach Nourishment (2060)	Condado Pocket Beach	Beach Nourishment by Truck-Haul (51,000 CY)

4.4 PROJECT MONITORING

Physical monitoring of the recommended project is necessary to assess project performance and to ensure that project functionality is maintained throughout the 50-year period of Federal participation in the project. The monitoring plan will be directed primarily toward accomplishing systematic measurements of the beach profile shape. Profile surveys should provide accurate assessments of dune and beach fill volumes and a basis for assessing post-construction dune and beach fill adjustments, as well as variation in the profile shape due to seasonal changes and storms. Monitoring will play a vital role in determining if project periodic nourishment is necessary. Post construction monitoring activities include topographic and bathymetric surveys of the placement area and adjacent areas on an annual basis for 3 years following construction and then biannually until the next construction event. Measured wind, wave, and water level information will be obtained from the best available existing data sources. This data will be applied in support of previously discussed monitoring efforts. It will also be used to periodically assess the state of sea level rise and to determine if reassessment of the project volumes and/or periodic nourishment intervals is required. Other monitoring efforts include periodic physical inspections of the breakwaters and revetments.

4.5 OPERATIONS AND MAINTENANCE CONSIDERATIONS

The 33 U.S. Code § 426e (Federal aid in protection of shores) states, "When in the opinion of the Chief of Engineers the most suitable and economical remedial measures would be provided by periodic beach nourishment, the term "construction" may be construed for the purposes of sections 426e to 426h–1 of this title to include the deposit of sand fill at suitable intervals of time to furnish sand supply to project shores for a length of time specified by the Chief of Engineers." By this provision, periodic nourishment is

considered construction and not maintenance, and therefore is cost shared. The TSP involves initial construction and periodic nourishment, and it is technically "beach nourishment." Physical (topographic and bathymetric) and environmental surveys supporting beach nourishment are cost-shared activities included in the total project cost. The operations, maintenance, repair, rehabilitation, and replacement (OMRR&R) anticipated for this project includes any necessary long-term topographic and bathymetric surveys (different from those supporting beach nourishment activities) of the placement area and adjacent areas, and biannual monitoring until the next construction event. Other OMRR&R items may include revegetating the dune as needed between nourishment activities (per Policy Guidance Letter No. 27 (11/17/92)), scarp repair, and beach tilling. The operations and maintenance will also include publicizing floodplain information, ensuring continued conditions of public ownership and use of the shore, performing surveillance of the beach, and any specific directions prescribed by the government. Based on the size and scope of the Recommended Plan and the cost of similar activities for similar projects, the annual average costs for OMRR&R are estimated to be $91,828 per year.

Operations and maintenance is borne 100% by the non-Federal sponsor and is detailed in a Project Partnership Agreement (PPA). An Operations and Maintenance Manual will be completed by USACE and provided to the sponsor following completion of initial construction.

4.6 LANDS, EASEMENTS, RIGHTS-OF-WAY, RELOCATIONS AND DISPOSAL (LERRD) SUMMARY

The following discussion summarizes the Real Estate Appendix (E), which can be referenced for more details.

4.6.1 REAL ESTATE REQUIREMENTS

The Real Estate Plan (REP) describes the lands, easements, rights of way, relocation, and disposal areas (LERRD) anticipated, identified or estimated at this time, that appear to be required for construction, operation and maintenance of the proposed project; including estimated acreage, estates, ownerships, and preliminarily and roughly estimated values and identified assumptions. The non-Federal sponsor shall provide lands, easements, and rights-of-way.

The following project features have related real estate requirements that are necessary to provide adequate construction room to build proposed shore protection management features and secure lands needed for Operations and Maintenance (O&M):

- Revetments: Total area for Revetments is 17.06 acres, within the Terrestrial Maritime Zone (TMZ) which is owned or controlled by the Non-Federal Sponsor. No lands need to be acquired by the non-Federal sponsor. Lands are required and will be certified as Perpetual Beach Storm Reduction Easement.

- Beach Nourishment: Total area for Beach/Dune Nourishment is 6.43 acres, within the TMZ which is owned or controlled by the Non-Federal Sponsor. No lands will need to be acquired by the non-Federal sponsor. Lands are required and will be certified as Perpetual Beach Storm Reduction Easement.

- Breakwaters: Total area consists of 13.94 acres, located within submerged lands owned or controlled by the Non-Federal Sponsor. No lands will need to be acquired by the non-Federal sponsor. non-Federal sponsor will make lands available via Land Certification.

- Staging Areas: Staging and storage areas have been identified for every reach of the project. Out of the five staging areas identified for the project, three are owned by municipalities and two by private owners. Total area consists of 2.64 acres. Lands will need to be acquired as Temporary Work Area Easement by the non-Federal sponsor.

- Disposal: At this phase of feasibility, no disposal area for ground or marsh material will be required. If later during PED phase, it's determined that disposal of material is needed, the project will identify and use local landfill for this purpose. Lands would not need to be acquired by the non-Federal sponsor.

- Borrow Area/Sand Sources: Offshore sand sources and upland sand mines were identified for both study areas. Near shore and offshore sand sources are on submerged lands owned or controlled by the non-Federal sponsor. In case Upland sand sources (privately owned sand mines) are used, sand material will be purchased from the mine. No lands will need to be acquired by the non-Federal sponsor.

- Mitigation: Mitigation areas are anticipated to be used as remediation for projects impacts on submerged lands owned or controlled by the non-Federal sponsor. Location and area needed will be determined later during the design phase. No lands will need to be acquired by the non-Federal sponsor. non-Federal sponsor will make lands available via Land Certification in fee interest.

- Road Access: Road access would be over public roads and highways. Land will not be needed to be acquired by the non-Federal sponsor.

- Operation and Maintenance: After construction is completed, operation and maintenance of the project features will be done within lands owned or controlled by the non-Federal sponsor.

4.6.2 SUMMARY OF REAL ESTATE COSTS

The potential acquisition, temporary work area easements, due to staging areas includes approximately 2.64 acres for a total cost, including contingency (30%), of $3,875,793. That includes a combined Federal/Non-Federal administration cost to acquire these lands estimated at $368,289. This total RE cost assumes that all the project features will be constructed within the TMZ which is owned or controlled by the Non-Federal sponsor and will be certified by Perpetual Beach Storm Reduction Easements. **Table 4-7** Presents the Real Estate Cost.

Table 4-7. Summary of Real Estate Cost

		FY21	
		FEDERAL	**NON-FEDERAL**
01B	Lands and damages		$2,698,080
	Administrative Cost	$94,433	$188,866
	sub-total	**$94,433**	**$2,886,946**
	Contingencies 30%	$28,330	$866,084
	Total Estimated Real Estate Cost	**$122,763**	**$3,753,030**

4.7 TOTAL PROJECT COST

The Micro-Computer Aided Cost Estimating System (MCACES) Second Generation (MII) Cost Estimate for the TSP was based on the scope outlined in the **Engineering Appendix (A)** and was formatted based upon the Civil Works Work Breakdown Structure (CWWBS) in accordance with Cost Engineering Regulations. For project justification purposes, the estimated costs are categorized under the appropriate CWWBS code and include both construction and non-construction costs. Full analysis is provided in the **Cost Appendix (D)**.

4.7.1 CONSTRUCTION COST

As the Project Delivery Team quickly transition from an array of alternatives to a TSP, the construction costs are still based upon historical pricing data from previously studied and/or constructed projects in Florida and Puerto Rico, escalated to FY20 dollars, and then entered into MCACES/MII. These costs include all major project components categorized under the appropriate CWWBS to the sub-feature level. Further refinements of these costs, to transition from a Class 4 to a Class 3 Level of Estimate (certified cost) will be completed as the study progress through the various stages of review. As part of that process more refined costs, in the format of labor, equipment and materials will be developed in accordance with Cost Engineering Regulations.

4.7.2 NON-CONSTRUCTION COST

Non-construction costs typically include Lands and Damages (Real Estate), Planning, Engineering and Design (PED), and Construction Management (S&A). These costs are provided by the PDT either as a lump sum cost or as a percentage of the total construction contract cost. Section 4.6.2 summarizes the Lands and Damages cost provided by Real Estate. PED costs are for the preparation of contract plans and specifications (P&S) and include itemized costs that were provided by the PDT, as well as costs for Post-Construction Monitoring costs and percentages for Engineering During Construction (EDC) that were

provided by the project manager. Construction Management costs are for the supervision and administration of a contract and include Project Management and Contract Admin costs. These costs were provided by the project manager and are included as a percentage of the total construction contract cost.

4.7.3 TOTAL PROJECT COST SUMMARY

The cost estimate for the Tentative Selected Plan (TSP) is prepared with an identified price level date and inflation factors are used to adjust the pricing to the construction schedule. This estimate is known as the Fully Funded Cost Estimate or Total Project Cost Summary (TPCS). The TPCS on the TSP contains contingencies as noted in the estimate presented below and were determined based on ER 1110-2-1302 from 30 June 2016. For each of the alternatives included in the TSP, an Abbreviated Risk Analysis (ARA) was performed to assess the level of risk and to determine a reasonable contingency to be applied to each alternative. Based on the results of the ARAs, an average contingency of 40% was assumed across all alternatives for the construction costs, PED and S&A. The same contingency percentage was assumed during the initial screening of construction measures and seems reasonable at this point in time. For Lands and Damages, and Real Estate administrative costs, a 30% contingency was assumed. The contingencies will be reviewed further during ATR of the draft report as alternatives are refined and risks are further assessed. At that moment, a full Cost and Schedule Risk Analysis (CSRA) will be performed to establish the project contingency. **Table 4-8** presents the Total Project First Cost.

Table 4-8. TSP Total Project First Cost, FY21 Price Levels

WBS Code	Item	Total Project First Cost $K (FY21)
06	Fish & Wildlife Facilities	$17,911
10	Breakwaters & Seawalls	$28,155
16	Bank Stabilization	$28,688
17	Beach Replenishment	$41,132
	Construction Estimate Total	**$115,886**
01	Lands and Damages	$2,698
30	Planning Engineering and Design (PED)	$17,151
	Real Estate Admin Costs (Fed)	$94
	Real Estate Admin Costs (Non-Fed)	$189
31	Construction Management	$9,271
	Average Contingency (40%)	$57,818
	Project First Cost	**$203,107**

Notes:

Fish & Wildlife Facilities corresponds to compensatory mitigation costs. Lands and Damages and RE administrative costs are subject to 30% contingency.

4.8 SEA LEVEL CHANGE CONSIDERATIONS

An important aspect about the recommended plan is its performance under different Sea Level Change scenarios. As discussed earlier in this report, the study area is experiencing Sea Level Rise (SLR). Each of the SLR scenarios described earlier are considered equally likely to occur. Therefore, if the project does not perform, then it cannot be considered a completely effective plan. At this point of the study, BCRs and net benefits under the three SLR scenarios haven't been estimated.

4.9 BENEFITS OF THE TENTATIVELY SELECTED PLAN

4.9.1 STORM DAMAGE REDUCTION BENEFITS

Not all FWP modeling results were completed by publication of this draft report so some alternatives carried forward for consideration do not have quantified benefits. The total benefits of the TSP will be updated once the FWP modeling is complete.

4.9.2 RECREATION BENEFITS

The **Economics Appendix (C)** contains the methodology used for the recreation benefits estimate. For this study, the full recreation analysis based on the contingent valuation method will be performed on the TSP. At this point, a Unit Day Value (UDV) and an estimate of recreation benefits in the FWOP condition will be used instead.

4.9.2.1 UNIT DAY VALUE METHODOLOGY

According to ER-1105-2-200, incidental recreation benefits that result from the construction of a project can be calculated and added to overall project benefits in CSRM studies. Recreation benefits are not to be used in plan formulation, but they can be included in total project benefits so long as primary benefits (i.e. CSRM and land loss benefits) constitute 51% of the benefits required for economic justification. Recreation benefits represent a vital component of a CSRM project and access for the public to use and recreate on the beach is the foundation for federal interest in the project. Though recreation cannot be used for plan formulation these benefits play a significant role in increasing net-benefits and contributing to NED.

Recreation benefits were calculated using the Unit Day Value method, as described in EGM 09-03 and in Appendix E of ER 1105-2-100. The Unit Day Value (UDV) method estimates a user's willingness to pay for a given recreational opportunity (i.e. a dollar amount the recreational experience would be worth to them were they required to pay). This value is estimated via a series of criteria applied to the various recreation facilities and opportunities provided by the project; criteria gauging the overall quality of the experience, availability, carrying capacity, accessibility, and environmental factors. Each criterion can be assigned a score selected from one-of-five possible ranges which represents rating from low to high. These point values are summed together and applied a dollar value based on the current UDV guidance. The current unit-day values applicable to PRCS, provided by USACE Economic Guidance Memo #20-03, *Unit Day Values for Recreation*, FY 2020, are presented in **Table 4-9.** Linear interpolation was used to estimate the dollar value of point scores between ranges.

Table 4-9. FY20 Unit Day Value Point to Dollar Conversion

Point Values	General Recreation Values	General Fishing and Hunting Values
0	$4.21	$6.06
10	$5.00	$6.85
20	$5.53	$7.37
30	$6.32	$8.16
40	$7.90	$8.95
50	$8.95	$9.74
60	$9.74	$10.80
70	$10.27	$11.32
80	$11.32	$12.11
90	$12.11	$12.38
100	$12.64	$12.64

4.9.2.2 FUTURE WITHOUT PROJECT RECREATION ESTIMATE

The first step in estimating the benefit from recreation is to estimate visitation to the specific planning reaches.

For Rincon, the complete loss of sandy beach in Rincon B means there are no visitor estimates and the recreation benefit in the FWOP condition is $0.

For Condado Pocket Beach, hotel occupancy data[12] was combined with a 2017 visitor profile report "Perfil de los Visitantes" developed by the Junta de Planificacion which estimated that 39% of visitors to Puerto Rico engaged in beach activities. Hotel occupancy data was then multiplied by 39% to estimate number of annual visitors to Condado Pocket Beach. For Ocean Park Pocket Beach, a similar approach was used but since there are relatively few hotels and many more residential structures, visitation was increased by the population of the planning reach using the census tract data described in Section 2.1.1 of the Economics Appendix.

Following visitation estimation, it is required to assign a UDV point score to the planning reaches in the FWOP. For the majority of model reaches within the sandy pocket beaches the berm width maintains sufficient carrying capacity throughout the period of analysis to support recreation and overall, the beach in the planning reach has excess carrying capacity based on the estimated visitation. However, the quality of the recreation is diminished over time by repeated exposure to coastal storms. The point assignments

[12] Hotel occupancy data was used since the majority of occupancy types in the Condado Pocket Beach planning reach are hotels.

are based on qualitative criteria; they depend on best professional judgment (i.e. "judgment criteria"). The differences in the assigned point scores vary for each category depending on the relevant recreation facilities and a comparison to the criteria outlined in USACE Economic Guidance Memo #20-03 (Table 1, Guidelines for Assigning Points for General Recreation) and then are converted to willingness-to-pay (WTP) dollar values as described in **Table 4-9**. WTP scores for Ocean Park Pocket Beach and Condado Pocket Beach are described in **Table 4-10.**

Multiplying the annual visitation by the WTP values estimated by the UDV methodology the Condado Pocket Beach and Ocean Park Pocket Beach have an estimated recreation value of $109.4M and $32.6M (FY20 price level) respectively from 2028-2077. Amortized over the period of analysis using the FY20 discount rate of 2.75% you get an average annual recreation benefit in the FWOP of $746,000 and $269,000. Upon plan recommendation, this recreation benefit will be compared to the recreation benefit provided the plan and will constitute recreation benefits.

Table 4-10. Ocean Park and Condado Pocket Beach Willingness-to-Pay Estimate (FWOP)

Year	Ocean Park Pocket Beach WTP (FY20)	Condado Pocket Beach WTP (FY20)
2028	$ 6.24	$6.64
2038	$ 6.16	$6.24
2048	$ 6.08	$6.00
2058	$ 6.00	$5.85
2068	$ 5.93	$5.69

4.9.3 REGIONAL ECONOMIC DEVELOPMENT

When the economic activity lost in the study area can be transferred to another area or region in the national economy, these losses cannot be included in the NED account. However, the impacts on the employment, income, and output of the regional economy are considered part of the Regional Economic Development (RED) account. The input-output macroeconomic model RECONS will be used to address the impacts of the construction spending only associated with the TSP. RECONS is the USACE certified model which measures the direct public investment (i.e. project-specific federal and non-Federal construction expenditures) to estimate new levels of sales, value added, employment, and income for each industry impacted by the public investment. These results will be provided in the final report.

4.9.4 ECONOMIC SUMMARY

The economic summary will be updated once the modeling is complete. The economic results that will be presented in this section will reflect incorporation of storm damage reduction, land loss and recreation benefits, interest during construction (IDC) and operations, maintenance, repair, rehabilitation, and replacement (OMRR&R), as well as the refined costs in the Total Project Cost Summary (TPCS) found in **Appendix B – Cost Engineering and Risk Analysis**.

4.9.5 QUALITATIVE BENEFITS WITH REGARD TO THE FOUR P&G ACCOUNTS

As mentioned earlier in the Plan Formulation Rationale, the four accounts NED, RED, EQ and OSE are always used as criteria in formulation and selection of a plan. This study has identified viable alternatives to manage the risk to life and infrastructure in the Condado pocket beach, Punta Piedrita headland, Ocean Park pocket beach, Punta Las Marias headland (west side), and Rincon B planning reaches. Though quantification of all the NED and RED benefits is still ongoing, the TSP is considered to be a robust and effective proposal for risk reduction. The TSP is effective, efficient, acceptable and complete. It provides enhanced life safety and positive economic benefits to the nation. The study team will continue to optimize the proposed solutions in order to provide the public with the best available alternative. There are a number of worthy considerations in all the four accounts briefly summarized below:

NATIONAL ECONOMIC DEVELOPMENT (NED)

- AAEQ Net Benefits = TBD
- BCR at 2.75% = TBD
- It is expected that the TSP will provide risk reduction from storms vs emergency funding for temporary repairs in project area.
- TOTAL =863 assets that are vulnerable to damage with estimated value of $2.9B
- TSP Area Population: ~14,600 people

ENVIRONMENTAL QUALITY

- Potential for habitat creation through the Breakwaters construction in Ocean Park pocket beach
- Potential to restore the beach/dune iteration through the beach nourishment implementation

OTHER SOCIAL EFFECTS

- Reduces flooding frequency, erosion along shoreline and impacts to infrastructure due to wave attack
- Reduces risk of damages while keeping the economic vitality of the region
- Provides community resilience and adaptability associated with climate change, especially, sea level rise
- Most features contribute to both cultural and community identity by maintaining or improving beach and nearshore recreational areas

REGIONAL ECONOMIC DEVELOPMENT

- Some features advance tourism
- Risk reduction from coastal storms also avoids long-lasting disruptions and shutdowns to the local economy

4.10 FEDERAL IMPLEMENTATION RESPONSIBILITIES

USACE is responsible for budgeting for the Federal share of future Federal construction projects. Federal funding is subject to budgetary constraints inherent in the formation of the national civil works budget in a given fiscal year. USACE would perform the necessary preconstruction engineering and design (PED) needed prior to construction. USACE would obtain water quality certification pursuant to Section 401 of the Clean Water Act, coordinate with the state as required by the Coastal Zone Management Act and construct the project. Cost sharing of PED, initial construction, and periodic nourishment will be in accordance with WRDA 1986, as amended, subject to the availability of appropriations.

4.11 NON-FEDERAL IMPLEMENTATION RESPONSIBILITIES

The non-federal sponsor for the CSRM project would be the DNER. The non-federal project sponsor would provide an up-front cash contribution for initial construction costs of the proposed project. The amount of the non-federal up-front cash contribution would be based on cost sharing principles reflecting shoreline use, ownership, and public access in existence at the time of construction. The non-federal sponsor would provide the entire cost of all material placed on or seaward of private undeveloped lands and developed private lands (which are inaccessible to the public). The non-federal sponsor would provide lands, easements, and rights-of-way and bear a portion of the administrative costs associated with land requirements. Other general non-federal responsibilities, such as continuing public use of the project beach, for which benefits are claimed in the economic justification of the project, and controlling water pollution to safeguard the health of bathers, must also be assumed by the non-federal sponsor before the project can be constructed. The non-federal project sponsor will be responsible for all costs of operation, maintenance, repair, rehabilitation, and replacement of project features. Section 402 of the 1986 Water Resources Development Act (33 USC 701b-12) as amended by Section 14 of the 1988 Water Resources Development Act, states that "Before construction of any project for local flood protection or any project for hurricane or storm damage reduction, that involves Federal assistance from the Secretary, the non-Federal interests shall agree to participate in and comply with applicable Federal floodplain management and flood insurance programs." The non-federal sponsor and communities must be enrolled in, and in compliance with, the National Flood Insurance Program (NFIP) to receive Federal funding for a recommended storm damage reduction project.

4.12 RECOMMENDED PLAN COST SHARING

Federal participation in CSRM projects involving placement of sand is limited to shorelines open to public use. Guidance is provided in Engineering Regulation (ER) 1105-2-100 and ER 1165-2-130. Cost sharing for any recommended plan is based on shoreline ownership, use, and the availability of public access. For full Federal cost sharing, public access with adequate parking (or another way for the public to reach access, such as a public bus or beach shuttle) must be provided every ½ mile.

Data from the Municipal Revenues Collection Center or CRIM, Google Earth and Google Maps were used to determine parcels information, shorefront length, access type and access description. **Figure 4-3** and **Figure 4-4** show the location of public access with parking for San Juan planning reaches and Rincon (R11-R19) respectively, where the TSP is being proposed. **Table 4-11** contains the total shoreline length and number of public access and parking by planning reach.

Figure 4-3. Public Beach Access Points for the San Juan Planning Reaches

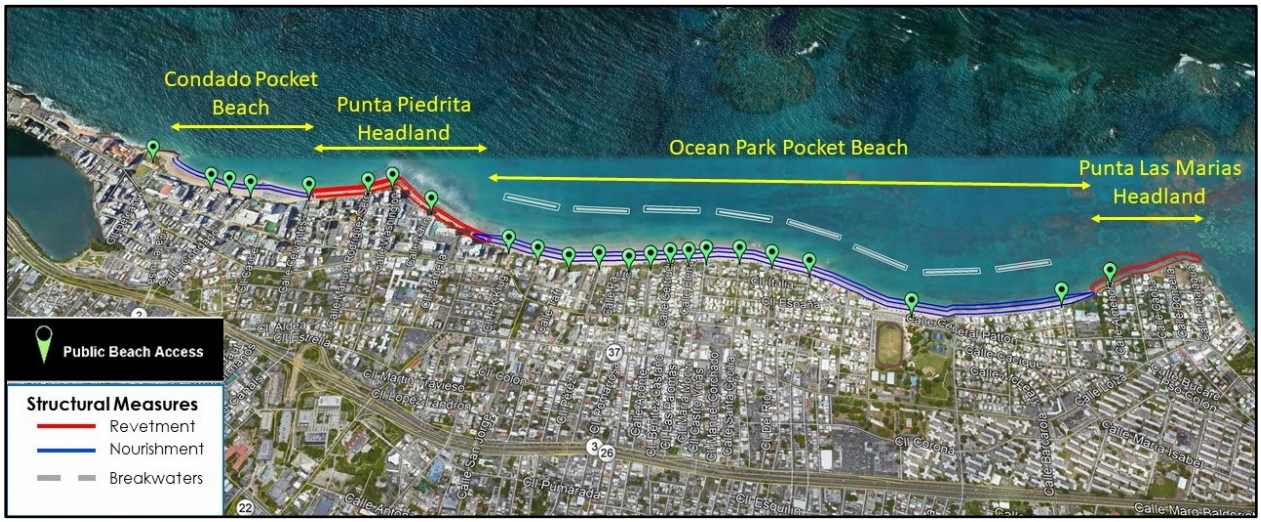


Figure 4-4. Public Beach Access Points for the Rincon B Planning Reach (R11-R19)

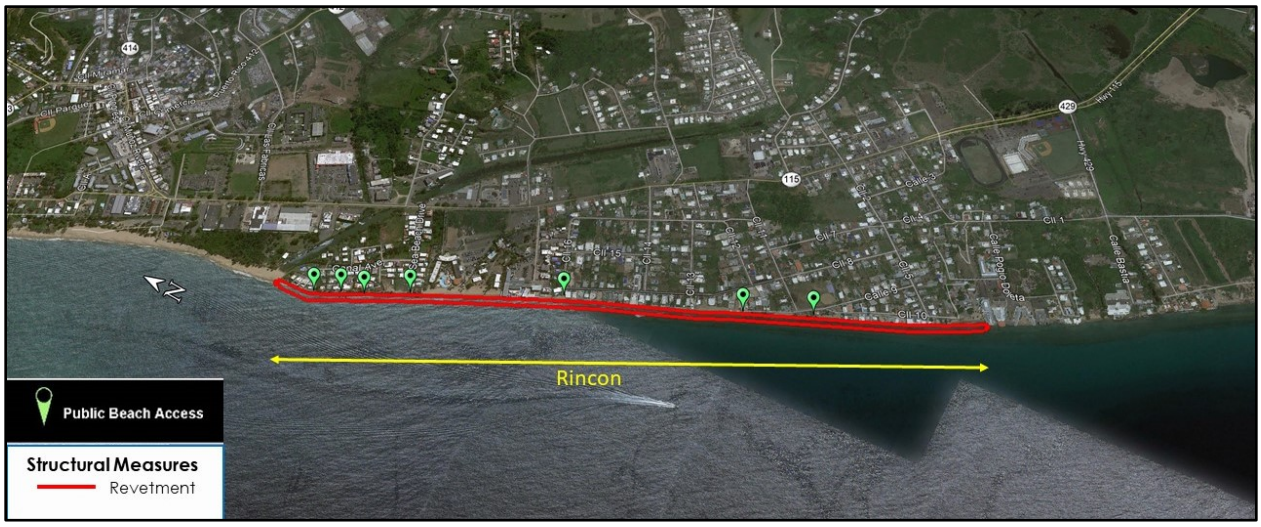


Table 4-11. Shorefront Length and Existing Parking

Planning Reach	Total Shorefront Length (Feet)	Number of Public access with Parking	Total parking spaces
Condado Pocket Beach	2,325	5	260
Punta Piedrita Headland	2,432	3	77
Ocean Park Pocket Beach	7,433	14	460
Punta Las Marias Headland	1,498	1	12
Rincon	5,645	7	61

There are currently 5 access points with 260 parking spaces, within the Condado Pocket Beach project area; 3 access points with 77 parking spaces, within the Punta Piedrita project area; 14 access points with 460 parking spaces, within the Ocean Park Pocket Beach project area; 1 access point with 12 parking spaces, within the Punta Las Marias project area; and 7 access points with 61 parking spaces, within the Rincon project area.

The current cost share estimates are based on policy guidance provided by ER 1105-2-100, Appendix E and ER 1165-2-130. Cost sharing for this project is determined by section 103(c)(5) of WRDA 1986, which establishes a maximum cost share of 65% (Federal)/35% (non-Federal) for CSRM. To provide for other than the cost sharing established in section 103, statutory language directing a different cost sharing percentage would have been required. The WRDA of 1999 changed the cost sharing policy previously provided by WRDA 1986 by setting the non-federal share of periodic nourishment carried out after January 1, 2003 to 50% for projects authorized for construction after December 31, 1999. **Table 4-12** shows the Federal and non-Federal cost sharing percentages for the TSP. Additional detail on how percentages were calculated is given in the **Public Access and Cost Sharing Assessment Appendix (H)**. Changes to shoreline ownership and use prior to construction could change the stated cost sharing percentages. Overall, the cost share for the project area is estimated to be 62% Federal and 38% non-Federal for Initial construction, and 48% Federal and 52% non-Federal future nourishment events.

Table 4-12. Recommended Plan Cost Sharing

TENTATIVELY SELECTED PLAN PROJECT AREA							
Shore Ownership and Project Purpose (as defined in ER 1105-2-100)	INITIAL CONSTRUCTION				PERIODIC NOURISHMENT*		
	Maximum Level of Federal Participation in Construction Costs	Shoreline Length (Feet)	Shoreline Length X Federal Participation %	Shoreline Length X non-Federal Participation %	% Of Federal Participation for Periodic Nourishment	Shoreline Length X Federal Participation %	Shoreline Length X non-Federal Participation %
I. Federally Owned	100%	0	0	0	100%	0	0
II. Publicly and Privately Owned, Protection results in Public Benefits							
A. Coastal Storm Risk Management (CSRM) on Developed Lands (Public/Private)	65%	17,718	11,517	6,201	50%	8,859	8,859
B. CSRM on Undeveloped Public Lands**	65%	805	523	282	50%	403	403
C. CSRM on Undeveloped Private Lands	0%	810	-	810	0%	-	810
III. Privately Owned, Use limited to private interest (No public access within 1/4 mile)	0%	0	0	0	0%	0	0
IV. CBRA Zone	0%	0	0	0	0%	0	0
	Total Distance:	**19,333**	**12,040**	**7,293**	**Total Distance:**	**9,262**	**10,072**
	Cost Shares:		**62%**	**38%**	**Cost Shares:**	**48%**	**52%**

* Periodic nourishment is considered "construction"

** Non-Federal public shores dedicated to recreation or fish and wildlife purposes

4.12.1TENTATIVELY SELECTED PLAN COST ALLOCATION

The estimated total project cost for the TSP, including contingency is $203,106,000 (FY21 price levels). **Table 4-13** shows the breakdown between initial project cost and periodic nourishments for the TSP. For project identification purposes, the estimated costs are categorized under the appropriate CWWBS code and include both construction and non-construction costs. **Table 4-14** presents cost allocation for the TSP.

Table 4-13. TSP Cost Summary Breakdown (Project First Cost, FY21 Price Levels)

		INITIAL CONSTRUCTION (Thousands)			PERIODIC NOURISHMENT (Thousands)
WBS Code	**Item**	**REVETMENTS**	**BREAKWATERS**	**BEACH NOURISHMENT**	
6	Fish & Wildlife Facilities	$ 6,654	$ 6,703	$ 4,554	$ -
10	Breakwaters & Seawalls	$ -	$ 28,155	$ -	$ -
16	Bank Stabilization	$ 28,687	$ -	$ 19,045	$ -
17	Beach Replenishment	$ -	$ -	$ 6,404	$ 15,682
	Construction Estimate Total	**$ 35,341**	**$ 34,858**	**$ 30,003**	**$ 15,682**
1	Lands and Damages	$ 1,096	$ -	$ 1,603	$ -
30	Planning Engineering and Design (PED)	$ 5,230	$ 5,159	$ 4,440	$ 2,321
	Real Estate Admin Costs (Fed)	$ 38	$ -	$ 56	$ -
	Real Estate Admin Costs (Non-Fed)	$ 77	$ -	$ 112	$ -
31	Construction Management	$ 2,828	$ 2,789	$ 2,400	$ 1,255
	Average Contingency (40%)	$ 17,723	$ 17,122	$ 15,269	$ 7,703
	SUBTOTAL	**$ 62,334**	**$ 59,928**	**$ 53,884**	**$ 26,961**
	TOTAL	**$ 176,145**			**$ 26,961**
Total Project Cost for 50-year period of Federal Participation =				**$ 203,106**	

Notes:

Fish & Wildlife Facilities corresponds to compensatory mitigation costs. Lands and Damages and RE administrative costs are subject to 30% contingency.

Table 4-14. Tentatively Selected Plan Cost Allocation

INITIAL CONSTRUCTION					
ITEM	**Federal Cost Share**	**Federal Cost**	**Non-Federal Cost Share**	**Non-Federal Cost**	**Project First Cost**
Coastal Storm Risk Management Cost	62%	$ 109,210,000	38%	$ 66,935,000	$176,145,000
Non-Federal LERRD Contribution*	0%	$ -	100%	$ 246,000	
Non-Federal Cash Contribution				$ 66,689,000	
PERIODIC NOURISHMENT					
Periodic Nourishment	48%	$ 12,941,000	52%	$ 14,020,000	$ 26,961,000
INITIAL CONSTRUCTION + PERIODIC NOURISHMENT					
Final Project Cost Share and Cost (50 years)		$122,151,000		$ 80,955,000	$203,106,000
*Includes Non-Federal administrative costs only					
Note: Dollar values are rounded					

4.13 FINANCIAL ANALYSIS OF NON-FEDERAL SPONSOR'S CAPABILITIES

By memorandum dated April 24, 2007, the Assistant Secretary of the Army (Civil Works), granted approval of the self-certification of non-federal sponsors for their ability to pay the non-federal share of projects. The self-certification is required prior to submission of the Project Partnership Agreement, typically during the PED phase of the project.

4.14 VIEWS OF THE NON-FEDERAL SPONSOR

DNER is the non-federal sponsor for the Tentatively Selected Plan. They have been an integral part of the project team from the conception of the project. At each step of the process, the DNER has contributed to the available information, participated in the formulation, and reviewed the products. The DNER supports the CSRM study efforts and will continue to work with the team through completion of the final report.

4.15 RISK AND UNCERTAINTY

First, as an event-based Monte Carlo life-cycle simulation, Beach-fx fully incorporates risk and uncertainty to determine an optimized plan under many future scenarios. Second, an Abbreviated Risk Analysis (ARA) was performed to assess the level of risk and to determine a reasonable contingency to be applied to each alternative. A full Cost Schedule Risk Analysis (CSRA) will be completed during ATR, which addresses risks to project implementation and construction. Based on the results of the ARA analysis, the Jacksonville District recommends a contingency value of 40% for the construction costs, PED and S&A. This contingency includes risks related to costs for the effect of schedule delay on overall project cost.

4.15.1 RESIDUAL RISK

The proposed project would greatly reduce, but not completely eliminate future coastal storm risk and damages which result from erosion, waves and coastal flooding within the project area. At this point of the study, the residual damages for the TSP over the 50-year period of analysis have not been estimated; therefore, those will be documented in the final report.

The Tentatively selected Plan is designed to maximize net NED benefits in accordance with ER 1105-2-100 rather than to achieve a specific level of protection. In other words, the project is not designed to fully withstand a certain category of hurricane or a certain frequency storm event. During study scoping, it was determined that the vast majority of coastal storm risk is within 600 feet landward from the dune line or property line and therefore this boundary was selected as the landward extent of the study area. As a result, the project is not claiming any benefits beyond this designation as damages to structures past this extent were not calculated in this study. Structures within the project area would continue to be subject to damage from hurricane winds and windblown debris. Even new construction is not immune to damage, especially from these processes. The project purpose is coastal storm risk management, and the recommended plan is not designed to prevent loss of life. Public safety risks can be reduced by actions taken at the local, state, and Federal levels.

Notably, infrastructure on the backside of Condado focus area, Ocean Park inland and backside of Carolina area, although outside of the PR Coastal project area, are susceptible to impacts from sea level rise in the future through back bay flooding. The currently ongoing San Juan Metro Area CSRM study is recommending a plan to reduce damages to properties and infrastructure as a result of coastal flooding caused by coastal storms and hurricanes along the back bay areas in the San Juan Metro Area, comprised of the municipalities of San Juan, Cataño, Guaynabo, and Toa Baja. The San Juan Metro Area CSRMS found that the FWOP damages modeled by G2CRM show that the vast majority of damages occur at or below the 1% annual exceedance coastal flood elevation, which is a storm that has a 1% chance of occurring in any given year. After further analysis of reaches 4 through 6 (communicating San Juan Bay, Los Corozos Lagoon, San Jose Lagoon and La Torrecilla Lagoon), the San Juan Metro Area study team determined that those reaches have multiple sources of coastal flooding influences and the uncertainty in the exchanges of flow between them is too high without performing more extensive hydrologic modeling. The San Juan Metro Area CSRM study recommended those areas to be evaluated under a separate study in order to adequately address both storm surge and precipitation holistically, using the same study authority that is used for that study.

Section 2.4 of the **Engineering Appendix (A)** presents additional information relevant to the potential risk of back-bay flooding in the PR Coastal study area.

4.16 SEA LEVEL CHANGE CONSIDERATIONS

An important aspect about the recommended plan is its performance under different Sea Level Change scenarios. As discussed earlier in this report, the study area is experiencing Sea Level Rise (SLR). Each of the SLR scenarios described earlier are considered equally likely to occur. Therefore, if the project does not perform, then it cannot be considered a completely effective plan. At this point of the study, BCRs and net benefits under the three SLR scenarios hasn't been estimated

4.16.1 PROJECT ADAPTABILITY

The intermediate SLC scenario has been selected as a basis for the feasibility level of design. Therefore, all proposed project features will be designed to account for 50 years of potential sea level rise (approximately 1.13 ft). This increase in water elevation due to sea level rise is reflected as an increase in the design elevation of hard structures such as revetments, dunes, and breakwaters.

The optimization of the design elevation for the project features will be performed later in the study, including incorporation of recent guidance (ECB 2020-6). As this optimization occurs, the crest elevation and other critical threshold elevations will be defined and compared against the sea level rise curves. This comparison will allow the appropriate design refinements to be recommended as well as proposition of potential methodologies that may trigger sea level change adaptations for project features. Additional analysis is forthcoming to determine the additional project modifications that would be needed for the Federal project up to and beyond the 50-yr planning horizon necessary to provide the same level of protection.

GENERAL

Sea level change is a growing concern in coastal regions of the United States. It is therefore necessary to ensure that coastal projects are adaptable to changing conditions. Constructing or elevating shoreline structures (revetments, breakwaters, groins, etc.), raising dunes, floodproofing infrastructure, and implementing storm warning and evacuation plans are some types of coastal adaptation methods. Assessing adaptation requirements of the project most often requires considering SLC impacts to the project for an extended 100-year Horizon. The following is a brief description of possible adaptation measures to the project.

DUNE RAISING

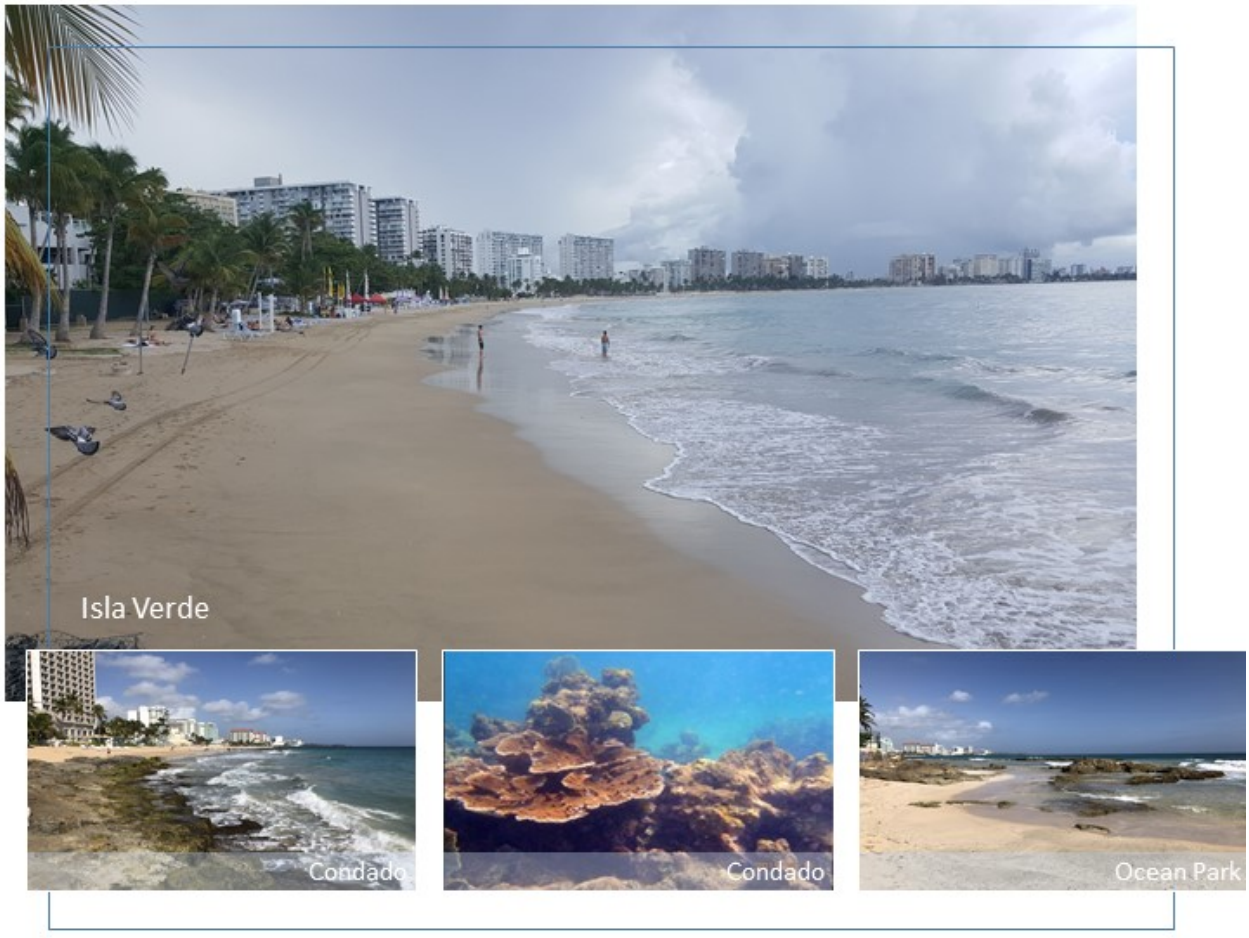
For the tentatively selected plan, an efficient and environmentally acceptable way of adapting the project is to raise the crest elevation of the proposed dune. The active portion of the shoreline profile, the berm and foreshore, will adjust naturally with rising tide levels. The dune, however, will require additional material to raise its elevation.

Dune raising extends the dune's footprint seaward, rather than landward, ensuring that there is sufficient land/real estate to make the adaptation without interfering with upland infrastructure.

HARD STRUCTURES

The tentatively selected plan considers hard structures such as breakwaters and revetments. These structures can be adapted by raising their crest elevation.

5. EFFECTS OF THE RECOMMENDED PLAN



5 EFFECTS OF THE TENTATIVELY SELECTED PLAN*

This section is the scientific and analytic evaluation of effects that would result from implementing the Recommended Plan. Chapter 2 of this report provides information on existing conditions as well as effects resulting from the "no-action alternative," or the "Future Without-Project Conditions." **Table 3-13** provides a summary of direct and indirect effects of the final array of alternatives. The following section focuses on anticipated changes to the existing environment including direct, indirect, and cumulative effects as a result of the Tentatively Selected Plan, or the "Future With-Project Conditions."

5.1 NATURAL (GENERAL) ENVIRONMENT

5.1.1 WATER QUALITY

Water quality can be affected by the proposed project directly or indirectly and temporarily. Direct, temporary effects on water quality may occur during project construction; increased turbidity is primary among these effects. Long term effects are not anticipated. A Water Quality Certification (WQC) in Accordance with Section 401 of the Clean Water Act, as amended, will be obtained and the conditions of this certification will be adhered to as a commitment of the construction of this project.

Construction could require up to two years. The direct impacts to local waters during construction would be minor but adverse. Revetment and breakwater construction in the water may result in direct but minor impacts to local water quality due to construction related turbidity. Sedimentation may increase in the local area due to the construction, although BMPs (best management practices) would be used to minimize these impacts.

5.1.2 SHORELINES

The TSP is expected to stabilize shorelines in both the San Juan and Rincon study areas. This would be through direct beach quality sand placement via truck haul (Condado and Ocean Park pocket beaches) or wave attenuation from revetment and breakwaters.

5.1.3 SAV

The USACE has determined that construction of the proposed CSRM measures would not directly affect existing seagrass. However, temporary indirect effects from elevated turbidity levels during construction could occur. Best available information was used to generate preliminary impact estimates (See **Appendix G Preliminary Mitigation Plan**). These included NOAA National Ocean Service benthic atlas dataset for Puerto Rico and the USVI from 2000, and recent geophysical and in-water surveys conducted for the Pacific Caribbean Cable System landing in 2013 and the Condado Reefs permit in 2018. Existing seagrass in the backreef zone of the San Juan study area and in the Rincon study area are expected to be highly variable in coverage and location. It is anticipated that final siting of any structures would avoid seagrasses based on in-water surveys conducted prior to construction.

Long term benefits for seagrass are anticipated from shoreline stabilization. It is possible sand could accumulate on the leeward (landward) side of the breakwaters, and added to the wave attenuation effects, it is possible seagrass could colonize these areas as a result.

5.1.4 HARDBOTTOM HABITAT

As discussed in Section 2.2.4, hardbottom habitat is present in both the San Juan and Rincon study areas. The USACE anticipates that construction could directly affect existing hardbottom habitat. Please see **Appendix G-3** for more information. Preliminarily estimated acreages of direct impacts are:

- Approximately 6.04 acres of scattered coral/rock in unconsolidated substrate
- Approximately 6.09 acres of colonized bedrock
- Approximately 0.10 acres of colonized pavement
- Approximately 2.55 acres of patch reef

These are preliminary estimates of direct impact using available information and the actual acreages are expected to change once updated field surveys can be conducted. In addition, breakwaters and revetment would increase the amount of consolidated hard substrate available for colonization. In the Condado and Ocean Park pocket beaches and Rincon the final designs may use a different combination of measures than currently planned. The preliminary hardbottom impact acreages above are anticipated to be conservative estimates covering the largest potential project footprint. Therefore, the impact estimates will be revised as necessary once modeling, updated benthic surveys, and design refinements are completed in PED.

Indirect impacts to hardbottom habitats would be due, in large part, to any turbidity resulting from the construction activities. Best Management Practices (BMPs) would be employed to minimize turbidity during in-water construction activities. Turbidity could result in sub-lethal effects (injury, decreased fecundity, etc.) on the macro invertebrate community. The USACE will conduct turbidity monitoring in accordance with a monitoring plan that will be developed prior to construction to insure avoidance and minimization of effects to hardbottom habitat. Therefore, significant indirect impacts to hardbottoms and coral reefs from turbidity and sedimentation as a result of construction are not anticipated. The equilibrium toe of fill would be estimated, and sediment transport modeling would be conducted in PED to estimate the effects and dispersion of placed sand.

5.1.5 ESSENTIAL FISH HABITAT

Based on preliminary impact estimates the proposed project could affect Essential Fish Habitat (EFH) including colonized bedrock, colonized pavement, patch reef and scattered coral/rock in unconsolidated sediment (See Section 2.2.5). However, the final designs would be refined to further avoid and minimize impacts and may end up as a different combination of CSRM measures than currently planned. For example, the final location of the breakwaters could be moved and/or the final beach nourishment footprint/quantity could be revised, to avoid significant resources identified during updated field surveys. Considering this, the relatively small TSP footprint, and expected habitat enhancement benefits from construction of the breakwaters, the USACE has determined at this time and based on the preliminarily estimated impacts, the project is not anticipated to significantly affect EFH or federally managed fisheries in Puerto Rico.

Effects of the proposed action could include death and injury of fishes and forage habitat during construction. Direct removal of hardbottom habitats could occur as well as temporary changes in water quality. The below list summarizes potential effects of the proposed project on EFH and managed species.

1. Injury or mortality of individual fishes (adults, sub-adults, juveniles, larvae, and/or eggs, depending on species, time of year, location, etc.) due to construction. No one area would experience an extended duration of temporary effects during construction. It is expected fish could swim from construction area as a result of noise/disturbance.

2. Indirectly affecting foraging behavior of individuals through production of turbidity at construction site (an effect temporary in duration).

3. Indirectly affecting movements of individuals around/away from construction equipment/area and related disturbed benthic habitats (an effect temporary in duration).

4. Directly affecting foraging and refuge habitats by removal of hardbottom habitats.

5. Directly benefitting foraging and refuge habitat through construction of enhanced breakwaters and additional habitat creation as needed.

These impacts would occur on a temporary and localized scale. As noted, the effects would only be felt in the area of construction activity which would not be taking place at all locations at all times. Individually or in sum, the above are not anticipated to significantly adversely affect managed species or EFH. An EFH Assessment is incorporated into this integrated document in sections 2.2 and 5.1 and will be coordinated with NMFS concurrent with the public review of the Draft IFR/EA.

5.1.6 PROTECTED SPECIES

5.1.6.1 OVERVIEW

A summary of effect determinations for Threatened and Endangered Species as a result of the proposed project is in **Table 5-1**. The USACE determined that the proposed project, will have “no effect” (NE) on scalloped hammerhead shark, Nassau grouper, and giant manta ray; “may affect, but is not likely to adversely affect” (MANLAA), loggerhead, hawksbill, leatherback and green sea turtles, Antillean manatee, and elkhorn, staghorn, pillar, rough cactus, lobed star, mountainous star and boulder star corals; and will not adversely modify DCH for Acroporid corals. Project designs will be refined to minimize potential effects to the extent feasible. A biological assessment evaluating these determinations will be sent to the NMFS and USFWS initiating consultation under Section 7 of the ESA.

Table 5-1. Summary of Effect Determination for Threatened and Endangered Species. (Details can be found in Appendix G.)

2020 PUERTO RICO COASTAL CSRM STUDY ESA TABLE			
Common Name	**Scientific Name**	**Status**	**Determination**
Marine Mammals			
Antillean manatee	*Trichechus manatus*	T	MANLAA
Sea Turtles			
Loggerhead sea turtle NW Atlantic DPS	*Caretta caretta*	T	MANLAA
Hawksbill sea turtle	*Eretmochelys imbricata*	E	MANLAA
Leatherback sea turtle	*Dermochelys coriacea*	E	MANLAA
Green sea turtle South Atlantic DPS	*Chelonia mydas*	T	MANLAA
Fish			
Nassau grouper	*Epinephelus striatus*	T	NE
Scalloped hammerhead shark	*Sphyrna lewinii*	E	NE
Giant manta ray	*Manta birostris*	T	NE
Invertebrates			
Elkhorn coral	*Acropora palmata*	T	MANLAA
Staghorn coral	*Acropora cervicornis*	T	MANLAA
Acroporid Coral Designated Critical Habitat			NLAM
Pillar coral	*Dendrogyra cylindrus*	T	MANLAA
Lobed star coral	*Orbicella annularis*	T	MANLAA
Mountainous star coral	*Orbicella faveolata*	T	MANLAA
Boulder star coral	*Orbicella franksi*	T	MANLAA
Rough cactus coral	*Mycetophyllia ferox*	T	MANLAA

5.1.6.2 FISH (NASSAU GROUPER, SCALLOPED HAMMERHEAD SHARK, AND GIANT MANTA RAY)

Considering the overlaps of various life stages in distribution within the proposed project area and subsequent risk of take relative to construction operations, this section considers the impacts of the proposed project to scalloped hammerhead shark (SHS), Nassau grouper (NG), and giant manta ray (GMR) together. Potential direct and indirect impacts associated with in-water construction that may adversely impact these species could include entrainment and/or capture of adults, juveniles, larvae, and eggs, short-term impacts to foraging and refuge habitat, water quality, and disruption of migratory pathways. However, given the mobility of these species, the anticipated small area of active construction and anticipated lack of occurrence of these species in the action area, the likelihood of proposed construction activities to incidentally take SHS, NG and GMR is discountable. Therefore, the no effect determination for these species is based on the anticipated low abundance within the project area and the mandatory buffer distances between construction activities and coral reef habitat.

5.1.6.3 SEA TURTLES

Current conservation measures implemented by the USACE to reduce impacts to sea turtles during in-water construction are discussed in Section 6 of this report (Environmental Compliance). The USACE will use the following measures outlined below during the construction of the proposed project (described in detail in Appendix G):

a. Protected species observers during in-water work.
b. Shut-down of construction activities and monitoring should a turtle come within 50-feet until the animal leaves the area of its own volition.

In addition, truck haul beach nourishment at Condado and Ocean Park pocket beaches, breakwater and revetment construction could affect nesting sea turtles. Truck hauled sand consistent with existing native beach sediments could enhance sea turtle nesting habitat. Breakwaters may adversely affect nesting and hatchling sea turtles by serving as a barrier or obstruction during ingress or egress at nesting sites. Therefore, the USACE will consult with USFWS to develop sea turtle avoidance and minimization measures including, in part, nest monitoring protocols similar to those used in Florida and included in the Statewide Programmatic Biological Opinion (SPBO) for shoreline activities along the coast of Florida (USFWS 2015). The SPBO includes sea turtle nest relocation from the active construction area before 9 am the morning following deposition. The USACE anticipates sea turtle nest monitoring would be required during construction and if possible, any sea turtle nests within the action area would be left in place, buffered and avoided. As discussed in Section 2.2.6.1.2, San Juan and Rincon primarily see leatherback sea turtle nesting so perhaps limiting construction to avoid the peak leatherback nesting season could further minimize impacts.

5.1.6.4 ANTILLEAN MANATEE

The proposed project may affect but is not likely to adversely affect the manatee. The contractor would adhere to the USFWS standard manatee conditions during in-water construction in order to avoid impacts. The Contractor may be held responsible for any manatee harmed, harassed, or killed as a result of vessel collisions or construction activities. Failure of the Contractor to follow these specifications is a violation of the Endangered Species Act and could result in prosecution of the Contractor under the Endangered Species Act or the Marine Mammals Protection Act. The standard manatee conditions apply year-round in Puerto Rico. The Contractor will be instructed to take the necessary precautions to avoid contact with manatees. If manatees are sighted within 100 yards of the construction activity, all appropriate precautions would be implemented to insure protection of the manatee. The Contractor would stop, alter course, or maneuver as necessary to avoid operating moving equipment (including watercraft) any closer than 100 yards of the manatee. Operation of equipment closer than 50-feet to a manatee shall necessitate immediate shutdown of that equipment.

5.1.6.5 CORALS

As stated in Section 2.2.6.1.4, all seven (7) Caribbean hard coral species listed as threatened under the ESA have been documented on the fringing reefs along the San Juan study area and north and south of the Rincon study area. In addition, it is possible they could occur on the inshore patch reef and scattered rock habitat in the backreef zone in San Juan. However, high wave energy, turbidity, and shifting sediment likely limit the extent of colonization of the backreef zone by these reef building listed hard corals.

Nearshore turbidity and sedimentation affect hard corals differently based on the morphology of each species (flat vs. branching). *Dendrogyra* is considered a highly sensitive species and is also considered a highly susceptible species for SCTLD. Thin, stick forms such as *Acropora cervicornis* are ideally suited passive shedders. These species have little surface available for sediment accumulation and staghorn corals have polyps that are widely separated, further reducing the chance of sediment clogging (Meyer, 1989). The equilibrium toe of fill will be calculated, and sediment transport modeling conducted in PED to avoid and minimize impacts to these listed hard corals from truck haul nourishment.

The USACE will conduct turbidity monitoring in accordance with a monitoring plan that will be developed prior to construction to insure avoidance and minimization of effects to hardbottom habitat. Therefore, indirect impacts to listed corals from turbidity and sedimentation as a result of construction are not anticipated.

5.1.7 SEABIRDS AND SHOREBIRDS

The USACE does not anticipate that avian species, including shorebirds, seabirds, and migratory birds, would be adversely affected by the proposed project. Only temporary impacts to the bird community are anticipated as individuals avoid active construction areas due to noise and general activity.

USACE is committed to monitoring the assumptions of the project to ensure that additional impacts to natural resources in the project area are not incurred including monitoring for nesting birds during construction. In addition, long term benefits to birds and bird habitat are anticipated from shoreline stabilization due to construction of the TSP.

5.1.8 INVASIVE SPECIES

The proposed project would include measures to clean construction equipment before and between use which should reduce the potential for the introduction and spread of invasive species.

5.1.9 AIR QUALITY

Construction equipment is typically powered by diesel engines. Depending on the size, type, age, and condition of the equipment, various emissions can be expected for the duration of the operation. The project area is compliant with Puerto Rico air quality standards. The proposed construction would occur in areas that experience nearly constant trade winds and sea breezes. In the long term, post construction, air quality is expected to remain as described in the FWOP condition.

The proposed project has been analyzed for conformity applicability pursuant to regulations implementing Section 176(c) of the Clean Air Act. It has been determined that the activities proposed under this proposed project would not exceed de minimis (a level of risk too small to be concerned with) levels of direct or indirect emissions of a criteria pollutant or its precursors and are exempted by 40 CFR Part 93.153. For these reasons a conformity determination is not required for this proposed project.

5.1.10 HAZARDOUS, TOXIC, AND RADIOACTIVE WASTE

Using an EPA web mapper (https://www.epa.gov/superfund/search-superfund-sites-where-you-live), the proposed project is not expected to encounter HTRW. No HTRW would be released in the project area during or after construction. The project should not impact existing sediment conditions. None of the construction areas would be affected by HTRW. The proposed project would not change or affect the ability for Federal regulations, U.S. Customs, and Port Security to continue to address the transportation of any HTRW. It is anticipated additional investigations would be conducted in PED prior to construction to ensure no HTRW exists within the project area.

5.1.11 NOISE

5.1.11.1 IMPACTS OF CONSTRUCTION NOISE ON MARINE LIFE

NMFS is currently developing guidelines for determining sound pressure level thresholds for fish and marine mammals, based on existing studies, the NMFS current thresholds for determining impacts to marine mammals is between 180 and 190 dB re 1 uPa for potential injury to cetaceans and pinnipeds respectively, and 160 dB re 1 uPa for behavioral disturbance/harassment from an impulsive noise source, and 120 dB re 1 uPa from a continuous source. Reine et al (2012) found that the 120 dB re 1uPa proposed threshold was exceeded by ambient noises in their study area. It is unlikely that underwater sound from conventional construction operations can cause physical injury to marine mammals and fish species. Some temporary loss of hearing could occur if the animal remains in the immediate vicinity of construction for lengthy durations, although the risk of this outcome is low. Fish and marine mammals would likely respond to construction by using avoidance techniques. Avoidance is defined as an effect that causes the animal to not occupy an area that is periodically or infrequently occupied. Construction is likely to cause avoidance due to noise (and increased turbidity and other temporary water quality changes). Therefore, construction activities would likely cause the temporary displacement of fish and marine mammals as a response to the noise.

In the long term, construction of the TSP is not anticipated to significantly affect ambient noise levels in the project areas. Breakwaters and revetment would generate noise from breaking waves, but levels are anticipated to be similar to existing conditions.

5.1.11.2 IMPACT OF CONSTRUCTION NOISE ON THE HUMAN ENVIRONMENT

There would be a temporary increase in the ambient noise level during the construction phase of the project. The construction would be within 150m of sensitive receptors. However, since construction should not occur in one position for any extended period of time, there will be no disproportionate adverse impact on any communities. Noise generated by this project would not be substantially different from other ambient noise levels of an active harbor and metropolitan area.

5.1.12 COASTAL BARRIER RESOURCES

The proposed project would not affect the CBRS Units or the OPAs located in the vicinity of San Juan bay, PR-87 Punta Vacia Talega and PR-87P Punta Vacia Talega OPA approximately 13-19 km east and PR-86P Punta Salinas OPA approximately 6 km west (Figure 2-30). In addition, unit PR-72 Rio Guanajibo occurs approximately 11 miles south and unit PR-75 Espinar occurs approximately 11 miles north of the Rincon

study area. These resources are geographically distant from the project area and no features are to be constructed within the CBRS Units.

5.1.13 CULTURAL RESOURCES AND HISTORIC PROPERTIES

Analysis of potential impacts to historic and cultural resources considered both direct and indirect effects (see Section 2.1.14). Direct effects may result from physically altering, damaging, or destroying all or part of a historic or cultural property, or changing the character of physical features within the property's setting that contribute to its historic significance. An effects analysis focuses on the characteristics of a historic property that qualify it for inclusion in the NRHP and assesses the potential to alter historically significant characteristics and diminish the integrity of a historic property. There may also be cultural resources of value which are not eligible for inclusion in the NRHP. The APE for direct affects was defined as being within and adjacent to the proposed alternatives, as well as staging and work areas.

Indirect effects are reasonably foreseeable effects caused by an undertaking that may occur later in time, be farther removed in distance or be cumulative. In the case of the alternatives, these may include increased development associated with the protection afforded by the alternatives and increased pedestrian traffic along the seawalls. As discussed in the Section 2: Existing Conditions and Future Without-Project Conditions portion of this document, there are cultural resources and historic properties recorded near the proposed project and additional resources may be present.

FUTURE WITH-PROJECT

Though background research documented no cultural resources and historic properties within the areas for direct effects, a full inventory has not yet been conducted. Each of the alternatives has the potential to affect cultural resources. The direct footprint of construction may disturb archaeological sites, be a visual intrusion in historic districts, or alter the appreciation of historic structures. The potential exists for archaeological sites in submerged areas, shipwrecks, and additional visual intrusion altering the character of historic districts or structures. The conceptual nature of the plans, lack of clear staging and access areas, and planning timeline prevent a full accounting of effects to cultural resources. The improvement of resiliency of these areas may serve to protect cultural resources, such as historic structures, as well as the continued use of areas.

As project designs are refined and optimized, impacts to cultural resources be minimized and avoided where possible. Consultation with SHPO and coordination with the Instituto de Cultura Puertorriqueña and interested parties is ongoing, including review of the APE prior to TSP and SHPO concurrence on the use of a programmatic agreement (PA). The Corps has initiated a survey of the offshore sand areas to assess if it is feasible to use the areas identified in Section 2.3.2. These efforts are ongoing. Due to the lack of detailed project designs during the current feasibility stage, it will not be possible to conduct fieldwork to identify and evaluate cultural resources or to determine the effects of the TSP on historic properties. In consultation with SHPO, pursuant to 54 USC 306108, 36CFR§ 800.4(b)(2), and 36 CFR 800.14(b)(1)(ii), USACE is deferring final identification and evaluation of historic properties until after project approval, when additional funding and design details are available. Because the USACE cannot fully determine how the project may affect historic properties prior to finalization of this feasibility study, a PA will be used to ensure compliance with Section 106 of the NHPA. Specifically, the scope and diversity of potential effects of the project and constraints of the USACE planning policy make a PA for compliance with Section 106 essential. The PA will allow the USACE to complete the necessary archaeological surveys during the follow on PED phase of the

project, and it will also allow for the identification of historic properties, assessment of effects, and inclusion of measures to avoid, minimize, and mitigate effects to historic properties to be completed after project features have been clearly defined and sited. A draft PA and relevant correspondence are included as **Appendix G** to this report and was previously sent to the SHPO and the Instituto de Cultura Puertorriqueña for review. The PA will be completed prior to the issuance of a FONSI.

5.1.14 AESTHETIC RESOURCES

The proposed project, during construction, could alter the aesthetic resources of Condado, Ocean Park, and Rincon, and increase recreational opportunities. Although the definition of aesthetics is fluid (see Section 2.2.18), for the purposes of the present evaluation, the principal aesthetic "targets" include the visual perception of Puerto Rico's land- and seascapes, historic features, and certain architecture. The degree to which any adverse feature affects aesthetics is frequently based on scale, position, and proximity relative to the viewer. Temporary impacts to recreational activities during construction and a temporary reduction in the aesthetic appeal during construction are anticipated. However, the CSRM measures could also enhance local aesthetic in the long-term.

As a public safety measure, boating would be prohibited near the operating construction equipment. Recreational access to these areas would return to pre-construction conditions following completion of the project. Although short-term impacts could occur, no long-term adverse effects are anticipated. Information would be provided to the USCG so they could issue a "Notice to Mariners" prior to initiation of construction and for each major change in the construction activities. This would alert public boaters of areas to avoid and the possibility of limited and restricted access. No significant adverse impacts to recreational boating are expected from the proposed project.

5.1.15 ENVIRONMENTAL JUSTICE

The USACE collected and analyzed information to consider the potential impacts of the proposed action on minority and low-income populations. The information and analyses presented below demonstrates that the proposed action complies with Executive Order 12898 and would not cause disproportionately high and adverse impacts to minority or low-income populations. **Appendix G** provides a full Environmental Justice Analysis report.

The CSRM areas of interest is bordered by numerous EJ communities. Possible factors that could impact EJ communities include those resulting directly from the construction of the project and the secondary effects that could occur as a result of the shoreline improvements. These factors include, but are not limited to the following:

- Construction equipment through neighborhoods
- Noise from construction
- Air emissions from construction
- Affects to subsistence fishermen
- Increasing exposure to contaminants
- Decreasing water quality

5.1.15.1 CONSTRUCTION RELATED IMPACTS

The proposed action consists of a collection of key structural, non-structural and natural features in strategic locations in order to increase storm resiliency and flooding within the Condado, Ocean Park, and Rincon areas. As such, the construction and operational activities are within the shallow waters of coastal Puerto Rico. The construction and operational work areas are located near residential communities, schools, and hospitals which are situated near the coastal areas of the bay. Impacts from noise, air, and other inconveniences are not likely to significantly impact identified communities. Compared to most large, entirely land-based projects, there is little potential for direct adverse impacts to minority populations, low-income populations, the elderly, or children. The result of the project would provide a benefit to the identified communities, as it will reduce flooding and provide benefits to the coastal communities, such as recreational opportunities. Recreational opportunities include improved access to the coastline, increased natural recreational areas, and improved wildlife and natural communities. As indicated in previous sections of this document, during construction there would be temporary and minor impacts resulting from increase turbidity (decreased water quality) from in-water work. These impacts will be temporary and minor and will not disproportionately impact low-income, minority, juvenile, or elderly populations. Additionally, the potential exists for subsistence fishing along the coast; however, these practices will not be significantly impacted by the proposed project due to the impacts being temporary. The project is likely to increase availability of locations for the local population to fish. No significant impacts to fish populations are expected to result from the construction of the project. In summary, there will be no disproportionately high or adverse impact on low-income or minority populations resulting from the construction of the project.

5.1.15.2 PUBLIC ENGAGEMENT DURING CONSTRUCTION

An important component of any project is informing the public at all stages of the project (i.e., planning, design, construction, and maintenance). USACE engaged in public outreach efforts through the media and public information meetings during the feasibility phase (planning phase). USACE will provide a contact information link on the public website for anyone with concerns about, or related to, the project.

5.2 CUMULATIVE EFFECTS

5.2.1 CUMULATIVE EFFECTS ANALYSIS

NEPA, as implemented by Council on Environmental Quality (CEQ) regulations (40 CFR §§ 1500 -1508), requires Federal agencies, including the USACE, to consider cumulative impacts in rendering a decision on a Federal action under its jurisdiction. According to 40 CFR § 1508.7, a *cumulative impact* is the impact on the environment that results from the incremental impact of the proposed project when added to other past, present, and reasonably foreseeable future actions regardless of the agency (Federal or non-Federal) or person that undertakes such other actions; cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time. Due to the small spatial extent and short duration of project impacts, no significant cumulative impacts are anticipated (refer to **Table 5-2** below).

Table 5-2. Summary of Cumulative Effects.

Resource	Past and Present (Baseline/Existing Condition)	Future Without-Project including reasonably foreseeable actions	Future With-Project
Threatened and Endangered Species: Sea Turtles	Four sea turtle species occur in the area (loggerhead, green, hawksbill, and leatherback). Leatherback, hawksbill, and occasionally green turtles nest on beaches within the project area. Juvenile green and hawksbill turtles use SAV and nearshore hardbottom areas for feeding, resting, and shelter from predators. Past and current threats to sea turtle populations include artificial lighting, beach armoring, anthropogenic disturbance, trawling, dredging, vessel strikes, fishing gear entanglement, and ingestion of discarded anthropogenic marine debris.	Sea turtle nesting and nearshore habitat use would continue within the project area. Ongoing threats to sea turtle populations would continue. In the absence of the project, coastal erosion would continue, and property owners may use armor to protect their property, both of which would result in loss of sandy nesting beach habitat.	Construction is not anticipated to result in loss of habitat. Sea turtles may be disturbed by turbidity and noise during construction. Standard protective measures for in-water work would be followed during construction to avoid effects to swimming sea turtles. Nest monitoring and avoidance and work windows would be employed to minimize adverse impacts to nesting sea turtles. Due to the small spatial extent and short duration of project impacts, no significant cumulative impacts are anticipated.
Threatened and Endangered Species: Antillean Manatee	The Antillean manatee is common in San Jun bay area but less so in Rincon. Past and current threats to manatee populations include vessel strikes, fishing gear entanglement, loss of foraging habitat (SAV), ingestion of marine debris, pollution, and underwater noise.	Manatees would continue to occur in the area. Ongoing threats to manatee populations would continue.	In addition to ongoing threats, manatees may be disturbed by turbidity and noise during construction. Standard protection measures for in-water work would be followed during construction. These include in part monitoring and shut-down of construction activities should a manatee come within 50-feet.
Threatened and Endangered Species: Fish	As discussed in Sections 2.2.5.1.1 and 5.1.6.2 above the species are expected to not be present in the project area. Nassau grouper have been badly overfished but were known to occur on the fringing reefs along the north and northwest coasts in the past. Scalloped hammerhead shark and giant manta ray are oceanic species but did occur in the past along the project areas. Populations of these three species have declined, mainly due to fisheries overexploitation and incidental by-catch. Other past and current threats are habitat loss and degradation, entanglement in marine debris, pollution, and anthropogenic disturbance.	These species would continue to be rare in the area. Ongoing threats to populations would continue and may result in further decreases in population size and range.	In addition to ongoing threats, these ESA listed species could be disturbed by turbidity and noise during construction. Due to the small spatial extent and short duration of project impacts, and the expected low abundance in the project area, it is not likely these species would be effected by construction.
Threatened and Endangered Species: Corals	As discussed in Sections 2.2.6.1.4 and 5.1.6.5 above, all seven (7) listed species are known to occur on the fringing reefs along the north coast and north and south of the Rincon study area. Past and current threats are habitat loss and degradation from entanglement in marine pollution/debris, degraded water quality, SLR and anthropogenic disturbance.	These species would continue to occur within and near the project area. Ongoing threats to populations would continue and may result in further decreases in population size and range.	These listed species are not expected to be affected by construction. Turbidity would be monitored during construction and activities would cease if the 10 NTU above background standard were exceeded and until levels return to background. Due to the small spatial extent and short duration of project effects, and the expected distances from construction activities, it is not likely these species would be affected. Habitat benefits provided by the project could improve water quality in the region possibly indirectly benefitting these species.

Resource	Past and Present (Baseline/Existing Condition)	Future Without-Project including reasonably foreseeable actions	Future With-Project
Nearshore Hardbottom	As discussed in Sections 2.2.4 and 5.1.4 above, hardbottom habitat occurs in the project areas. Past and current threats are habitat loss and degradation from unabated shoreline erosion and sedimentation, entanglement with marine pollution/debris, degraded water quality, SLR and anthropogenic disturbance.	Hardbottom habitat would continue to occur in the project areas. Ongoing threats would continue and may result in further decreases in colonization.	Hardbottom habitat could be affected by construction. Turbidity would be monitored during construction and activities would cease if the 10 NTU above background standard were exceeded and until levels return to background. Due to the small spatial extent and short duration of project effects, it is not likely hardbottom habitat would be significantly cumulatively affected by construction. Construction of the TSP would provide consolidated hard substrate (rock) from the revetment and breakwaters as well as through compensatory mitigation (as required) which would enhance hardbottom habitat in the study areas.
Birds	As discussed in Sections 2.2.7 and 5.1.7 above, bird habitat for shorebirds, seabirds, and migratory birds occurs in the project areas. Past and current threats include habitat loss and degradation from unabated shoreline erosion and sedimentation, shoreline development, and other anthropogenic disturbance.	Migratory and resident birds would continue to inhabit the project areas. Ongoing threats would continue and may result in further decreases in habitat and bird occurrence in these areas.	The USACE does not anticipate that avian species, including shorebirds, seabirds, and migratory birds, would be adversely affected by the proposed construction. Individual birds could avoid the active construction areas due to noise and general activity.
Essential Fish Habitat	EFH in the area includes hardbottom habitat (colonized bedrock, patch reef and scattered coral/rock in unconsolidated sediment) (See Section 5.1.5). Past and current threats include habitat loss and degradation from unabated shoreline erosion and sedimentation, shoreline development, and other anthropogenic disturbance.	Local extents of these EFH areas would fluctuate with natural variability. In the absence of the project, property owners may construct armoring to protect their property, which may result in impacts to nearshore EFH.	The preliminary impact estimates will be revised as necessary once updated field surveys can be conducted. In addition, the preliminary TSP is draft and could be modified to further avoid and minimize impacts. Considering the relatively small TSP footprint, and expected habitat enhancement benefits from construction of the revetment and breakwaters, the project is not anticipated to significantly affect EFH or federally managed fisheries in Puerto Rico. No long-term or secondary impacts are anticipated.
Water Quality	The project area consists of Class III waters, which are designated as suitable for recreation, propagation, and maintenance of a healthy, well balanced population of fish and wildlife. The predominant issue that affects water quality in the area is turbidity, which varies significantly under natural conditions (e.g., during storms), sometimes exceeding 29 NTU. Historically, coastal water quality has been affected by unrelated anthropogenic sources such as storm water and effluent runoff resulting in increased nutrients and freshwater inputs. Urbanization and population growth in the region contributes to coastal water quality degradation.	Turbidity would continue to occur intermittently due to storm activity, rainfall, currents, and other natural phenomena. Water quality may deteriorate due to unrelated anthropogenic sources such as storm water and effluent runoff.	In addition to the ongoing natural and anthropogenic fluctuations in water quality, local, short-term turbidity could occur adjacent to the construction sites. BMPs would be implemented during construction to reduce the magnitude and extent of turbidity, and adverse effects on water quality are expected to be minor. Turbidity would be monitored during construction to ensure that Commonwealth water quality standards are met. Due to the small spatial extent and short duration of project impacts, no long-term effects are expected.

Resource	Past and Present (Baseline/Existing Condition)	Future Without-Project including reasonably foreseeable actions	Future With-Project
Cultural Resources	The project area is in a historically significant area, with archaeological sites, historic structures, and historic districts.	Project-specific impacts would be avoided, but risk of storm damages to cultural resources may not be reduced.	The reduced risk may lead to development, but resources would continue to be protected by local laws and regulations.

5.2.1.1 SEA-LEVEL CHANGE

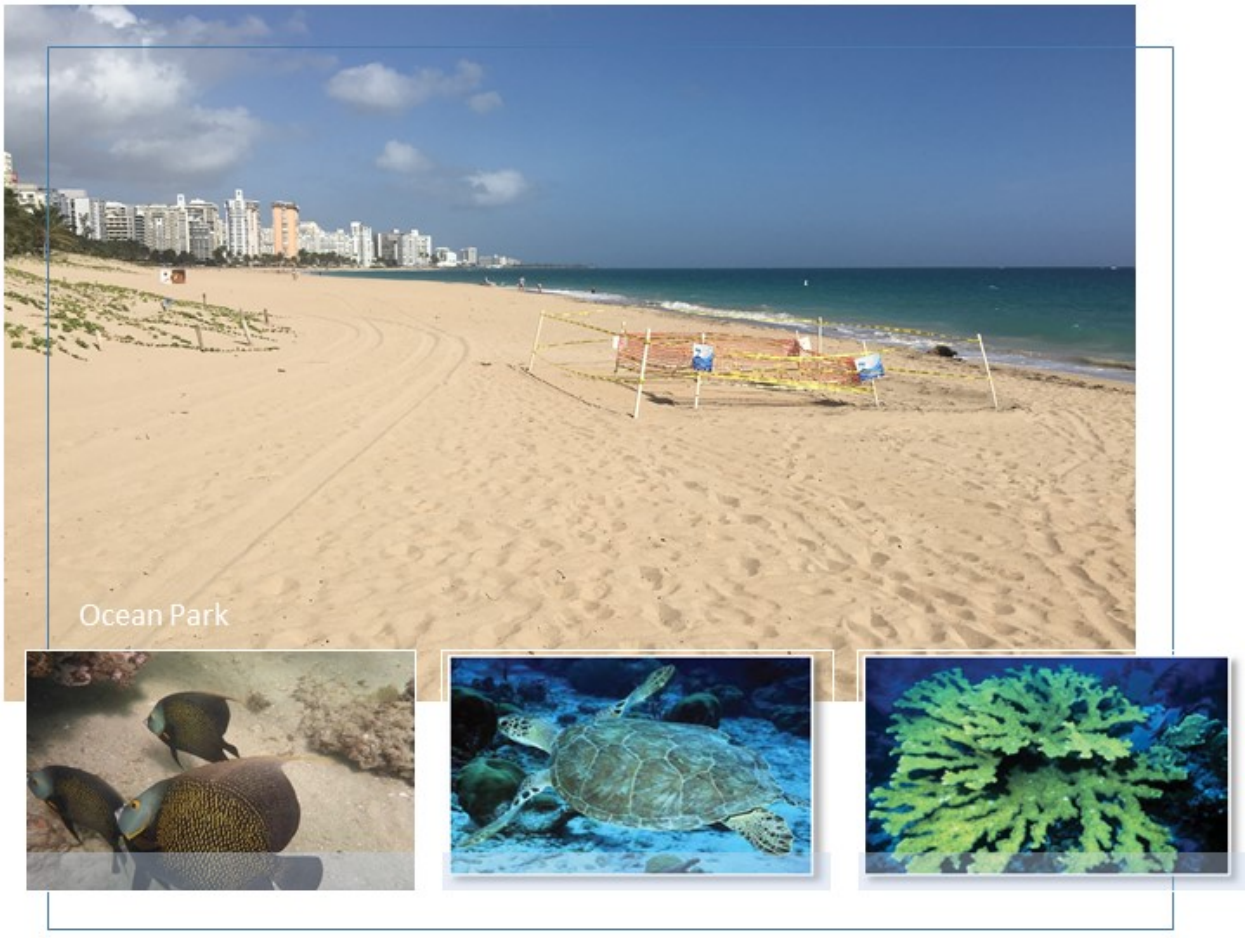
Potential relative sea-level change must be considered in every USACE coastal activity as far inland as the extent of estimated tidal influence. Future sea-level change is likely to result in both direct and indirect impacts on nearshore marine resources in the project area. Direct impacts could include changes in the areal extent of exposed hardbottom habitat due to sand movement. Indirect impacts could result from increased beach erosion, which may prompt more frequent (and possibly more extensive) beach nourishment projects in the area. The largest uncertainty is predicting the level and types of human activities that may be conducted to protect the shoreline in response to advancing sea level.

USACE Circular No. 1165-2-211 provides estimates of sea level rise ranging from 0.39 ft. (0.12 m) to 2.1 ft. (0.63 m) over the next 50 years. The U.S. Climate Mid-Atlantic Region details both how sea-level change affects coastal environments and what planners should address to protect the environment and economy. Those structures and policies would not necessarily accommodate a significant acceleration in the rate of sea-level rise.

5.2.1.2 CONCLUSIONS

Potential cumulative impacts on many resources were considered as part of this study and the majority of these resources were determined to have little risk of being cumulatively negatively impacted as a result of the proposed project. These included land use, terrestrial natural resources, threatened or endangered species, other fish and wildlife, managed fishes, hardbottom and coral reef, the estuarine water column, certain water quality parameters (turbidity and hazardous and toxic constituents), sediments (hazardous and toxic constituents), coastal barrier resources, bay shorelines and adjacent properties), air quality, noise, aesthetics, cultural and historic resources, environmental justice, and recreation.

6. ENVIRONMENTAL COMPLIANCE



6 ENVIRONMENTAL COMPLIANCE*

This chapter discusses the status of coordination and compliance of the tentatively selected plan (TSP) with environmental requirements. Additionally, it shows how the TSP meets USACE Environmental Operating Principles.

6.1 SCOPING

The NEPA scoping period for the study was initiated by letter dated October 16, 2018. Public and interagency meetings were held November 6 and 8, 2018 in Aguadilla and San Juan (respectively). Comments and feedback received were primarily concerning protection of sea turtles, manatees, coral reefs/benthic resources, and fish habitat; ensuring public safety; and preservation and enhancement of recreation and tourism. Pertinent correspondence associated with this NEPA scoping process is included in **Appendix I**.

6.2 COOPERATING AGENCIES

This proposed project has been coordinated with the following agencies, among others: USFWS, NMFS, U.S. Environmental Protection Agency (EPA), State Historic Preservation Officer (SHPO), Department of Natural and Environmental Resources, Puerto Rico Environmental Quality Board and OGPe. The EPA by electronic correspondence dated November 13, 2018 indicated they will be a Participating Agency under NEPA and E.O. 13807 ("One Federal Decision"). USFWS by letter dated November 15, 2018 indicated they will not be able to be a cooperating agency for the NEPA process; however, the USFWS will provide technical assistance regarding possible impacts to fish and wildlife resources. The NMFS by letter dated December 21, 2018 accepted USACE's invitation to participate as a cooperating agency. As a cooperating agency, NMFS will provide comments on the draft IFR/EA and participate in teleconferences during study development. Correspondence from all Federal and State agencies in included in **Appendix I.**

6.3 LIST OF RECIPIENTS

The NOA of the draft IFR/EA and Draft FONSI will be mailed to those listed in **Appendix I**. In addition, due to current circumstances with COVID-19, electronic distribution (email and webpage) of these documents will also occur.

6.4 COMMENTS RECEIVED AND RESPONSE

Comments received during scoping and public meetings are discussed in Section 6.1 above and included in **Appendix I**. Comments received in response to release of this draft IFR/EA will be discussed here and included in **Appendix I** as well.

6.5 ENVIRONMENTAL COMMITMENTS

USACE shall comply with the terms and conditions resulting from ESA consultations with the USFWS and NMFS, and the Water Quality Certification issued by DNER.

SEA TURTLES IN THE WATER

- The contractor shall instruct all personnel associated with the project of the potential presence of these species and the need to avoid collisions with them. All construction personnel are responsible for observing water-related activities for the presence of sea turtles.

- The contractor shall be responsible for insuring sea turtle nesting monitoring and avoidance activities are conducted. Prior to the start of any work on the beach each morning the contractor shall coordinate with the sea turtle nest monitor to ensure all nests are marked for avoidance.

- The contractor shall advise all construction personnel that there are civil and criminal penalties for harming, harassing, or killing sea turtles, which are protected under the Endangered Species Act of 1973.

- Siltation barriers shall be made of material in which a sea turtle cannot become entangled, be properly secured, and be regularly monitored to avoid protected species entrapment. Barriers may not block sea turtle entry to or exit from the area.

- All vessels associated with the construction project shall operate at " no wake/idle" speeds at all times while in the construction area and while in water depths where the draft of the vessel provides less than a four-foot clearance from the bottom. All vessels will preferentially follow deep-water routes (e.g., marked channels) whenever possible.

- If a sea turtle is seen within 100 yards of the active construction or vessel movement, all appropriate precautions shall be implemented to ensure its protection. These precautions shall include cessation of operation of any moving equipment closer than 50 feet of a sea turtle. Operation of any mechanical construction equipment shall cease immediately if a sea turtle is seen within a 50-ft radius of the equipment. Activities shall not resume until the sea turtle has departed the project area of its own volition.

- Any collision with and/or injury to a sea turtle shall be reported immediately to the National Marine Fisheries Service's Protected Resources Division (727-824-5312) and the local authorized sea turtle stranding/rescue organization.

MANATEES

- All vessels associated with the construction project shall operate at "Idle Speed/No Wake" at all times while in the immediate area and while in water where the draft of the vessel provides less than a 4-foot clearance from the bottom. All vessels will follow routes of deep water whenever possible.

- Siltation or turbidity barriers shall be made of material in which manatees cannot become entangled, shall be properly secured, and shall be regularly monitored to avoid manatee entanglement or entrapment. Barriers must not impede manatee movement.

- All on-site project personnel are responsible for observing water-related activities for the presence of manatee(s). All in-water operations, including vessels, must be shut down if a manatee(s) comes within 50 feet of the operation. Activities will not resume until the manatee(s) has moved beyond the 50-foot radius of the project operation, or until 30 minutes elapses if the manatee(s) has not reappeared within 50 feet of the operation. Animals must not be herded away or harassed into leaving.

- Any collision with or injury to a manatee shall be reported to Department of Natural and Environmental Resources Law Enforcement (787-724-5700) and the USFWS Caribbean Ecological Services Field Office (787-851-7297).

- Temporary signs concerning manatees shall be posted prior to and during all in-water project activities. All signs are to be removed by the contractor upon completion of the project. Example awareness signs are located here: https://www.fws.gov/caribbean/es/documents/ManateeSignsLetreros.pdf.

WATER QUALITY

- The Contractor shall monitor water quality (turbidity) at the construction sites, as required by the 401 Water Quality Certification.

- If turbidity values at the construction site exceed permitted values, the Contractor shall suspend all construction activities. Construction shall not continue until water quality meets state standards.

OTHER

- Migratory birds (adult birds, eggs and chicks) shall be protected during construction activities.

- The USACE has conducted a review of cultural recorded resources located near the proposed project features. The USACE will conduct surveys to refine the locations of resources as the features are designed to ensure avoidance and minimization of effects to cultural resources from the construction and implementation of the alternatives. If avoidance is not possible, USACE will develop mitigation measures with the SHPO with input from Instituto de Cultura Puertorriqueña (ICP) and other interested parties. The terms detailing how USACE will ensure additional measures to protect cultural resources are in a PA being developed by USACE and SHPO. As project designs are refined and optimized, impacts to cultural resources will continue to be minimized and avoided in some cases. Because the USACE cannot fully determine how the project may affect historic properties prior to finalization of this feasibility study, a PA will be used to ensure compliance with Section 106 of the National Historic Preservation Act of 1966 (NHPA). Specifically, the scope and diversity of potential effects of the project and constraints of the USACE planning policy make a PA for compliance with Section 106 essential. The PA will allow the USACE to

complete the necessary archaeological surveys during the follow-on PED phase of the project, and it will also allow any additional inventories and mitigation to be completed after measures have been clearly defined and sited. Consultation and coordination with all interested parties is ongoing and will be finalized prior to project implementation.

The environmental resources within the project boundaries and those affected outside the limits of permanent work would be protected during the entire period of work.

- An oil spill prevention plan shall be required.

6.6 COMPLIANCE WITH ENVIRONMENTAL REQUIREMENTS

6.6.1 NATIONAL ENVIRONMENTAL POLICY ACT (NEPA) OF 1969

Environmental information on the project has been compiled in this draft IFR/EA. This draft IFR/EA will be coordinated with interested stakeholders for review and comment. The project is in compliance with the National Environmental Policy Act.

6.6.2 ENDANGERED SPECIES ACT OF 1973

The USACE determined that the proposed project, will have "no effect" (NE) on scalloped hammerhead shark, Nassau grouper, and giant manta ray; "may affect, but is not likely to adversely affect" (MANLAA), loggerhead, hawksbill, leatherback and green sea turtles, Antillean manatee, and elkhorn, staghorn, pillar, rough cactus, lobed star, mountainous star and boulder star corals; and will not adversely modify DCH for Acroporid corals. The USACE will initiate consultation with both the USFWS and NMFS after noticing of this draft IFR/EA. All correspondence can be found within Appendix I: Pertinent Correspondence. This project will be in full compliance with the Endangered Species Act.

6.6.3 FISH & WILDLIFE COORDINATION ACT OF 1958

In accordance with an interagency agreement between the USFWS and USACE, coordination with the USFWS shall be conducted through the NEPA process and the Endangered Species Act. The project will be in full compliance with the Act.

6.6.4 NATIONAL HISTORIC PRESERVATION ACT OF 1966 (*INTER ALIA*)

The Proposed Action will be in compliance with Section 106 of the National Historic Preservation Act when the programmatic agreement is executed. USACE has initiated consultation, consulted on a tentative APE prior to determination of a TSP, and received concurrence on the development of a programmatic agreement with SHPO. Pursuant to 54 U.S.C. 306108, 36 CFR 800.4(b)(2), and 36 CFR 800.14(b)(1)(ii), USACE will defer final identification and evaluation of historic properties until after project approval, additional funding becomes available, and prior to construction by executing the programmatic agreement. A draft programmatic agreement has been provided to SHPO and the ICP and is included as an **Appendix G** to this report.

6.6.5 CLEAN WATER ACT OF 1972

A Section 401 water quality certification application will be submitted to DNER, and USACE will obtain this certification prior to construction. All Commonwealth water quality requirements would be met. A Section 404(b) evaluation is included in this report as **Appendix G, Attachment 1**. The project shall be in full compliance with this Act.

6.6.6 CLEAN AIR ACT OF 1972

The short-term impacts from construction equipment associated with the project would not significantly impact air quality. No air quality permits would be required for this project. The study areas are designated as an attainment area for Federal air quality standards under the Clean Air Act. Because the project is located within an attainment area, USEPA's General Conformity Rule to implement Section 176(c) of the Clean Air Act does not apply and a conformity determination is not required.

6.6.7 COASTAL ZONE MANAGEMENT ACT OF 1972

A Federal consistency determination (CD) in accordance with 15 CFR 930 Subpart C is included in this report as Appendix G. The USACE CD determined the proposed activity is consistent to the maximum extent practicable with the enforceable policies of the Puerto Rico Coastal Management Program. The CD will be submitted to the PRPB and Commonwealth concurrence is anticipated after public review of the draft IFR/EA. The project is in compliance with this Act.

6.6.8 FARMLAND PROTECTION POLICY ACT OF 1981

No prime or unique farmland would be impacted by implementation of this project. This Act is not applicable to the project.

6.6.9 WILD AND SCENIC RIVER ACT OF 1968

No designated Wild and Scenic river reaches would be affected by project related activities. This project is in compliance with this Act.

6.6.10 MARINE MAMMAL PROTECTION ACT OF 1972

USACE does not anticipate the take of any marine mammal during any activities associated with the project. Trained observers will monitor construction activities to ensure appropriate actions are taken to avoid adverse effects to listed and protected marine mammal species during project construction. Therefore, this project is in compliance with this Act.

6.6.11 ESTUARY PROTECTION ACT OF 1968

In the Estuary Protection Act Congress declared that many estuaries in the United States are rich in a variety of natural, commercial, and other resources, including environmental natural beauty, and are of immediate and potential value to the present and future generations of Americans. This Act is intended

to protect, conserve, and restore estuaries in balance with developing them to further the growth and development of the Nation. The nearby, inshore San Juan Bay Estuary is of national significance but would not be affected by the proposed action, therefore, this project is consistent with the purposes of this Act.

6.6.12 FEDERAL WATER PROJECT RECREATION ACT

The project is consistent with the principles of the Federal Water Project Recreation Act, (Public Law 89-72) as amended.

6.6.13 MAGNUSON-STEVENS FISHERY CONSERVATION AND MANAGEMENT ACT OF 1976

Pursuant to the 2019 EFH Finding between USACE and NMFS, USACE's Notice of Availability of the draft IFR/EA will initiate consultation under the Magnuson-Stevens Fishery Conservation and Management Act. The EFH assessment can be found in sections 2.2.1-2.2.5 and 5.1.1-5.1.5. The USACE has determined, based on the preliminarily estimated impacts, the project is not anticipated to significantly affect EFH or federally managed fisheries in Puerto Rico. The project will be in compliance with the Act.

6.6.14 COASTAL BARRIER RESOURCES ACT AND COASTAL BARRIER IMPROVEMENT ACT OF 1990

The Coastal Barrier Resources Act (CBRA) and the Coastal Barrier Improvement Act of 1990 (CBIA) limit federally subsidized development within the CBRA Units to limit the loss of human life by discouraging development in high risk areas, to reduce wasteful expenditures of Federal resources, and to protect the natural resources associated with coastal barriers. CBIA provides development goals for undeveloped coastal property held in public ownership, including wildlife refuges, parks, and other lands set aside for conservation ("otherwise protected areas," or OPAs). These public lands are excluded from most of the CBRA restrictions, although they are prohibited from receiving Federal Flood Insurance for new structures.

There are limits to Federal expenditures related to actions that could affect a unit. The proposed project would not affect the three CBRS Units located near San Juan, PR-87 Punta Vacia Talega and PR-87P Punta Vacia Talega OPA approximately 13-19 km east and PR-86P Punta Salinas OPA approximately 6 km west (Figure X). In addition, the project would not affect the two units located near Rincon, PR-72 Rio Guanajibo 11 miles south and PR-75 Espinar 11 miles north. This project is in compliance with the Act.

6.6.15 RIVERS AND HARBORS ACT OF 1899

The proposed work in not anticipated to obstruct navigable waters of the United States. The proposed action will be subject to public notice and other evaluations normally conducted for activities subject to the Act. The project will be in compliance with this Act.

6.6.16 ANADROMOUS FISH CONSERVATION ACT

This Act authorizes the Secretaries of the Interior and Commerce to enter into cooperative agreements

with the States and other non-Federal interests for conservation, development, and enhancement of anadromous fish and to contribute up to 50 percent as the Federal share of the cost of carrying out such agreements. As this project is not receiving funding for these purposes, this Act does not apply.

6.6.17 MIGRATORY BIRD TREATY ACT AND MIGRATORY BIRD CONSERVATION ACT

Migratory birds would be minimally affected by construction. USACE will include our standard migratory bird protection requirements in the project plans and specifications and will require the Contractor to abide by those requirements. Construction activities will be monitored at dawn or dusk daily during the nesting season to protect nesting migratory birds. If nesting activities occur within the construction area, appropriate buffers will be placed around nests to ensure their protection. The project is in compliance with these Acts.

6.6.18 UNIFORM RELOCATION ASSISTANCE AND REAL PROPERTY ACQUISITION POLICIES ACT OF 1970.

The purpose of PL 91-646 is to ensure that owners of real property to be acquired for Federal and federally assisted projects are treated fairly and consistently and that persons displaced as a direct result of such acquisition will not suffer disproportionate injuries as a result of projects designed for the benefit of the public as a whole.

While one of the alternatives considered during plan formulation included the acquisition of real property, this is not part of the Recommended Plan. Therefore, this project does not involve any real property acquisition or displacement of property owners or tenants. Therefore, this Act is not relevant to this project.

6.6.19 EXECUTIVE ORDER (EO) 11990, PROTECTION OF WETLANDS

No wetlands would be affected by the proposed plan. The project is in compliance with the goals of this Executive Order.

6.6.20 E.O 11988, FLOOD PLAIN MANAGEMENT

To comply with EO 11988, the policy of USACE is to formulate projects that, to the extent possible, avoid or minimize adverse effects associated with the use of the floodplain and avoid inducing development in the floodplain unless there is no practicable alternative. No activities associated with this project are located within a floodplain, which is defined by EO 11988 as an “area which has a one percent or greater chance of flooding in any given year.” The project is located within the Coastal High Hazard Area (CHHA), as defined by EO 11988 as an “area subject to inundation by one-percent-annual chance of flood, extending from offshore to the inland limit of a primary frontal dune along an open coast and any other area subject to high velocity wave action from storms.” The project shoreline is significantly developed, and further development is anticipated to be minimal.

CSRM projects are inherently located in coastal areas and are often located in CHHAs based on the problems the project is seeking to alleviate. The primary objective of the St. Lucie County Coastal Storm

Damage Reduction Project is to reduce infrastructure damage. There is no practicable alternative that could be located outside of the CHHA that would achieve this objective.

For the reasons stated above, the project shall be in compliance with EO 11988, Floodplain Management.

Executive Order 11988 requires Federal agencies avoid, to the extent possible, the long- and short-term adverse impacts associated with the occupancy and modification of flood plains and to avoid direct and indirect support of floodplain development wherever there is a practicable alternative. In accomplishing this objective, "each agency shall provide leadership and shall take action to reduce the risk of flood loss, to minimize the impact of floods on human safety, health, and welfare, and to restore and preserve the natural and beneficial values served by flood plains in carrying out its responsibilities."

The Water Resources Council Floodplain Management Guidelines for implementation of EO 11988, as referenced in USACE ER 1165-2-26, requires an eight-step process that agencies should carry out as part of their decision making on projects that have potential impacts to, or are within the floodplain. The eight steps and project-specific responses to them are summarized below.

1. **Determine if a proposed action is in the base floodplain (that area which has a one percent or greater chance of flooding in any given year).** The proposed action is within the base floodplain. However, the project is designed to reduce damages to existing infrastructure located landward of the proposed project.

2. **If the action is in the base flood plain, identify and evaluate practicable alternatives to the action or to location of the action in the base flood plain.** Chapters 3 discusses the process of screening and analyzing both measures and alternatives. Nonstructural, structural, and NNBF measures were all considered in the process.

3. **If the action must be in the floodplain, advise the general public in the affected area and obtain their views and comments.** An Environmental Assessment (EA) is being developed concurrently with the study. During this process the local stakeholders and the general public have been afforded the opportunity to review and comment on the study recommendations.

4. **Identify beneficial and adverse impacts due to the action and any expected losses of natural and beneficial flood plain values. Where actions proposed to be located outside the base flood plain will affect the base flood plain, impacts resulting from these actions should also be identified.** The anticipated impacts and environmental compliance associated with the Tentatively Selected Plan are summarized in Chapters 5 and 6. The project is not expected to alter or impact the natural or beneficial flood plain values.

5. **If the action is likely to induce development in the base flood plain, determine if a practicable non-flood plain alternative for the development exists.** The project provides benefits primarily for existing and previously approved development and is not likely to induce significant development. Nonstructural components of the project, and real estate requirements required for construction of the project will reduce the level of development that is at risk.

6. **As part of the planning process under the Principles and Guidelines, determine viable methods**

to minimize any adverse impacts of the action including any likely induced development for which there is no practicable alternative and methods to restore and preserve the natural and beneficial flood plain values. This should include reevaluation of the "no action" alternative. The project is not expected to induce development in the flood plain. In areas where the project will impact the natural or beneficial flood plain values, environmental mitigation is planned. Due to the built-out level of the city the impact to natural floodplains is considered minimal. Chapter 3 of this report summarizes the alternative identification, screening and selection process. The "no action" alternative was included in the plan formulation phase.

7. **If the final determination is made that no practicable alternative exists to locating the action in the flood plain, advise the general public in the affected area of the findings.** The Draft Integrated Feasibility Report and EA will be provided for public review. Public meetings will be scheduled during the public review period. Comments received will be addressed and, if appropriate, incorporated into the Final Report.

8. **Recommend the plan most responsive to the planning objectives established by the study and consistent with the requirements of the Executive Order.** The tentatively selected plan is the most responsive to all of the study objectives and the most consistent with the executive order.

6.6.21 E.O. 12898, ENVIRONMENTAL JUSTICE

On February 11, 1994, the President of the United States issued Executive Order 12898, *Federal Actions to Address Environmental Justice Populations and Low-Income Populations*. The Executive Order mandates that each Federal agency make environmental justice part of the agency mission and to address, as appropriate, disproportionately high and adverse human health or environmental effects of the programs and policies on minority and low-income populations.

Any potential adverse effects of the proposed action would be more likely to affect those of higher socioeconomic status, such as large watercraft owners or those living in the coastal area surrounding the project. The beneficial effect of a wider, more sustainable beach would benefit all members of the public who are able to obtain transportation to access the beach. The storm damage reduction benefits are primarily benefitting the landowners in this area. There are no disproportionate adverse impacts to minority or low income implementation of the project. **See Appendix G** for the Environmental Justice analysis.

6.6.22 E.O. 13045, DISPARATE RISKS INVOLVING CHILDREN

On April 21, 1997, the President of the United States issued Executive Order 13045, *Protection of Children from Environmental Health Risks and Safety Risks*. The Executive Order mandates that each Federal agency make it a high priority to identify and assess environmental health risks and safety risks that may disproportionately affect children and ensure that its policies, programs, activities, and standards address disproportionate risks to children that result from environmental health risks or safety risks.

As the proposed action does not affect children disproportionately from other members of the population, the proposed action would not increase any environmental health or safety risks to children.

6.6.23 E.O. 13089, CORAL REEF PROTECTION

The EO refers to "those species, habitats, and other natural resources associated with coral reefs." Coral reefs are not anticipated to be affect by construction activities due to distances from the project area. The project is in compliance with this EO.

6.6.24 E.O. 13112, INVASIVE SPECIES

The proposed action will require the mobilization of construction equipment from other geographical regions. Construction equipment has the potential to transport species from one region to another, introducing them to new habitats where they are able to out-compete native species. The proposed project would include measures to clean construction equipment before and between use which should reduce the potential for the introduction and spread of invasive species.

6.6.25 ENVIRONMENTAL OPERATING PRINCIPLES

1. **Foster sustainability as a way of life throughout the organization.**

The proposed project formulated measures and alternatives by considering sustainable measures that would mimic the existing site conditions to every extent possible, both when considering structural, non-structural and natural and nature-based features. Measures were formulated and combined into alternatives with long term adaptability and resilience in mind, to reduce the risk of damages from storm surge combined with sea level change.

2. **Proactively consider environmental consequences of all USACE activities and act accordingly.**

Each measure and subsequently each alternative considered both positive and negative effects in the environmental quality account. Effects were avoided and minimized by considering width footprints of measures, and choosing measures that would have minimal impacts to resources. Additionally, living shorelines consider the native vegetation within the area, and were chosen to create habitat in those environments while serving the function to reduce damages from storm surge.

3. **Create mutually supporting economic and environmentally sustainable solutions.**

The above description in number 2 demonstrates how environmental effects were considered during the formulation process and in some areas will create additional habitat. The entire TSP will support the San Juan Metro Area by providing a comprehensive plan to allow communities experience less damages from storms and hurricanes and recover faster after storms. Additionally, several of the features (living shorelines, breakwaters) bring in recreational elements which can bring communities together, as well as potentially support tourism, therefore strengthening the economy, community and environment together.

4. **Continue to meet our corporate responsibility and accountability under the law for activities undertaken by USACE, which may impact human and natural environments.**

This report includes all information necessary to document how the project meets USACE's corporate responsibility and accountability requirements for actions that may impact human and natural environments.

5. **Consider the environment in employing a risk management and systems approach throughout the life cycles of projects and programs.**

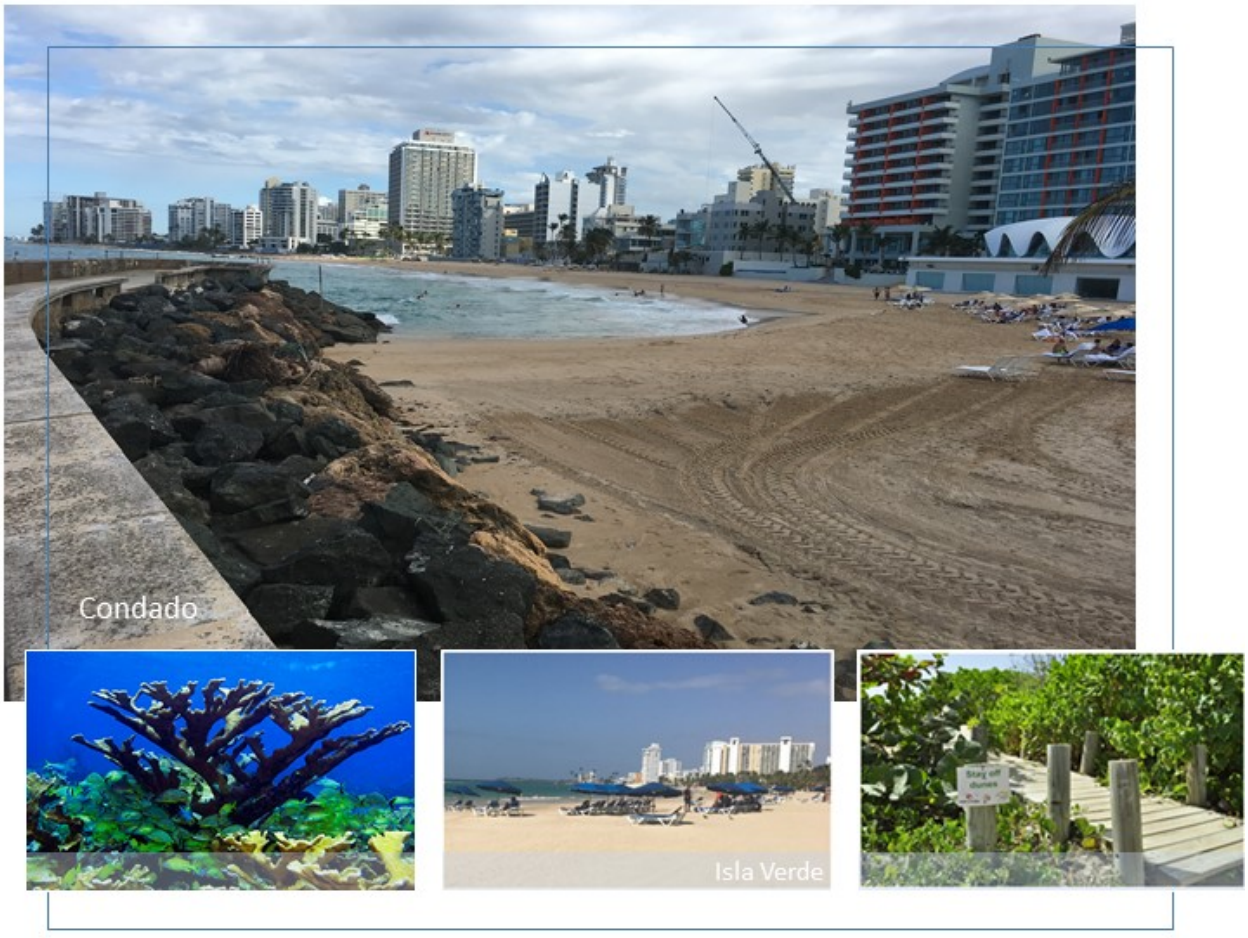
The team is involved throughout the study process to ensure that environmental considerations are considered for the life of the project.

6. **Leverage scientific, economic and social knowledge to understand the environmental context and effects of USACE actions in a collaborative manner.**

The entire Project Delivery Team understands the need to consider the environment during its decision-making process and worked collaboratively with agencies to foster education and sharing of policies and best management practices.

7. **Employ an open, transparent process that respects views of individuals and groups interested in USACE activites.** The actions taken to involve the public, resource agencies, and NGOs who may be interested in the project are outlined in Section 6.1 through 6.4 of this report.

7. RECOMMENDATIONS



7 RECOMMENDATIONS

I have given consideration to all significant aspects in the overall public interest including engineering feasibility, economic, social, cost and risk analysis, and environmental effects. The Tentatively Selected Plan described in this draft report provides the most likely optimum solution for coastal storm risk management benefits within the study area that can be developed with the framework of the formulation concepts.

The Tentatively Selected Plan, shown in REF-1 is under current evaluation and the confirmation on the National Economic Development (NED) Plan will be provided with the Final Report. The Tentatively Selected Plan will include beach nourishment on 1,910 ft along Condado Pocket Beach; 2,450 ft of stone revetment on Punta Piedrita headland; a breakwater field in combination with beach nourishment (6,810 ft) along the Ocean Park Pocket Beach shoreline; 1,400 ft of stone revetment on the west side of Punta Las Marias headland; and 5,650 ft of stone revetment along the Rincon shoreline.

7.1 ITEMS OF LOCAL COOPERATION

Recommendations for provision of Federal participation in the Recommended Plan described in this report would require the project sponsor to enter into a written Project Partnership Agreement (PPA), as required by Section 221 of Public Law 91-611, as amended, to provide local cooperation satisfactory to the Secretary of the Army. Such local cooperation shall include:

a. Provide a minimum of 35 percent of initial project costs assigned to coastal and storm damage reduction, plus 100 percent of initial project costs assigned to protecting undeveloped private lands and other private shores which do not provide public benefits, and 50 percent of periodic nourishment costs assigned to coastal and storm damage reduction, plus 100 percent of periodic nourishment costs assigned to protecting undeveloped private lands and other private shores which do provide public benefits, and as further defined below:

   1) Provide, during design, 35 percent of design costs allocated to coastal and storm damage reduction in accordance with the terms of a design agreement entered into prior to commencement of design work for the project;

   2) Provide all lands, easements, rights-of-way, including suitable borrow areas, and perform or assure performance of all relocations, including utility relocations, as determined by the Federal government to be necessary for the initial construction, periodic nourishment or operation and maintenance of the project;

   3) Provide, during construction, any additional amounts necessary to make its total contribution equal to 35 percent of initial project costs assigned to coastal and storm damage reduction plus 100 percent of initial project costs assigned to protecting undeveloped private lands and other private shores which do not provide public benefits;

b. 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 which might reduce

the outputs produced by the project, hinder operation and maintenance of the project, or interfere with the project's proper function;

c. Inform affected interests, at least yearly, of the extent of protection afforded by the flood risk management features; 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 US.C. 701 b-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 flood risk management features;

d. Operate, maintain, repair, replace, and rehabilitate the completed project, or functional portion 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;

e. For so long as the project remains authorized, ensure continued conditions of public ownership and use of the shore upon which the amount of Federal participation is based;

f. Provide and maintain necessary access roads, parking areas, and other public uses facilities, open and available to all on equal terms;

g. At least twice annually and after storm events, perform surveillance of the beach to determine losses of nourishment material from the project design section and provide the results of such surveillance to the Federal government;

h. 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;

i. Hold and save the United States free from all damages arising from the initial construction, periodic nourishment, operation, maintenance, repair, replacement, and rehabilitation of the project, except for damages due to the fault or negligence of the United States or its contractors;

j. Keep, and maintain books, records, documents, and other evidence pertaining to costs and expenses incurred pursuant to the project, for a minimum of 3 years after completion of the accounting for which such books, records, documents, and other evidence are required, to the extent and in such detail as will properly reflect total cost of the project, and in accordance with the standards for financial management systems set forth in the Uniform Administrative Requirements for Grants and Cooperative Agreements to State and local governments at 32 CFR, Section 33.20;

k. 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), 42 USC 9601-9675, that may exist in, on, or under lands, easements, or rights-of-way that the Federal government determines to be necessary for the initial construction, periodic nourishment, operation and maintenance of the project;

l. 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 required for the initial construction, periodic nourishment, or operation and maintenance of the project;

m. 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, replace, and rehabilitate the project in a manner that will not cause liability to arise under CERCLA;

n. Comply with Section 221 of Public Law 91-611, Flood Control Act of 1970, as amended, (42 US C. 1962d-5b) and Section 101 (e) of the WRDA 86, Public Law 99-662, as amended, (33 US.C. 221 l(e)) which provide that the Secretary of the Army shall not commence the construction of any water resources project or separable element thereof, until the non-Federal sponsor has entered into a written agreement to furnish its required cooperation for the project or separable element;

o. Comply with the applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, as amended, (42 US.C. 46014655) and the Uniform Regulations contained in 49 CFR Part 24, in acquiring lands, easements, and rights-of-way necessary for construction, operation, and maintenance of the project including those necessary for relocations, the borrowing of material, or the disposal of dredged or excavated material; and inform all affected persons of applicable benefits, policies, and procedures in connection with said act;

p. Comply with all applicable Federal and state laws and regulations, including, but not limited to: Section 601 of the Civil Rights Act of 1964, Public Law 88-352 (42 USC. 2000d), and Department of Defense Directive 5500.11 issued pursuant thereto; 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 USC. 3141-3148 and 40 USC. 3701-3708 (revising, codifying and enacting without substantive change the provisions of the Davis-Bacon Act (formerly 40 USC. 276a et seq.), the Contract Work Hours and Safety Standards Act (formerly 40 US.C. 327 et seq.), and the Copeland Anti-Kickback Act (formerly 40 US.C. 276c)); and

q. Not use funds from other Federal programs, including any non-Federal contribution required as a matching share therefore, to meet any of the non-Federal sponsor's obligations for the project unless the Federal agency providing the funds verifies in writing that such funds are authorized to be used to carry out the project.

7.2 DISCLAIMER

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 higher authority as proposals for project modification and/or implementation funding.

7.3 CERTIFICATION OF PUBLIC ACCESSIBILITY

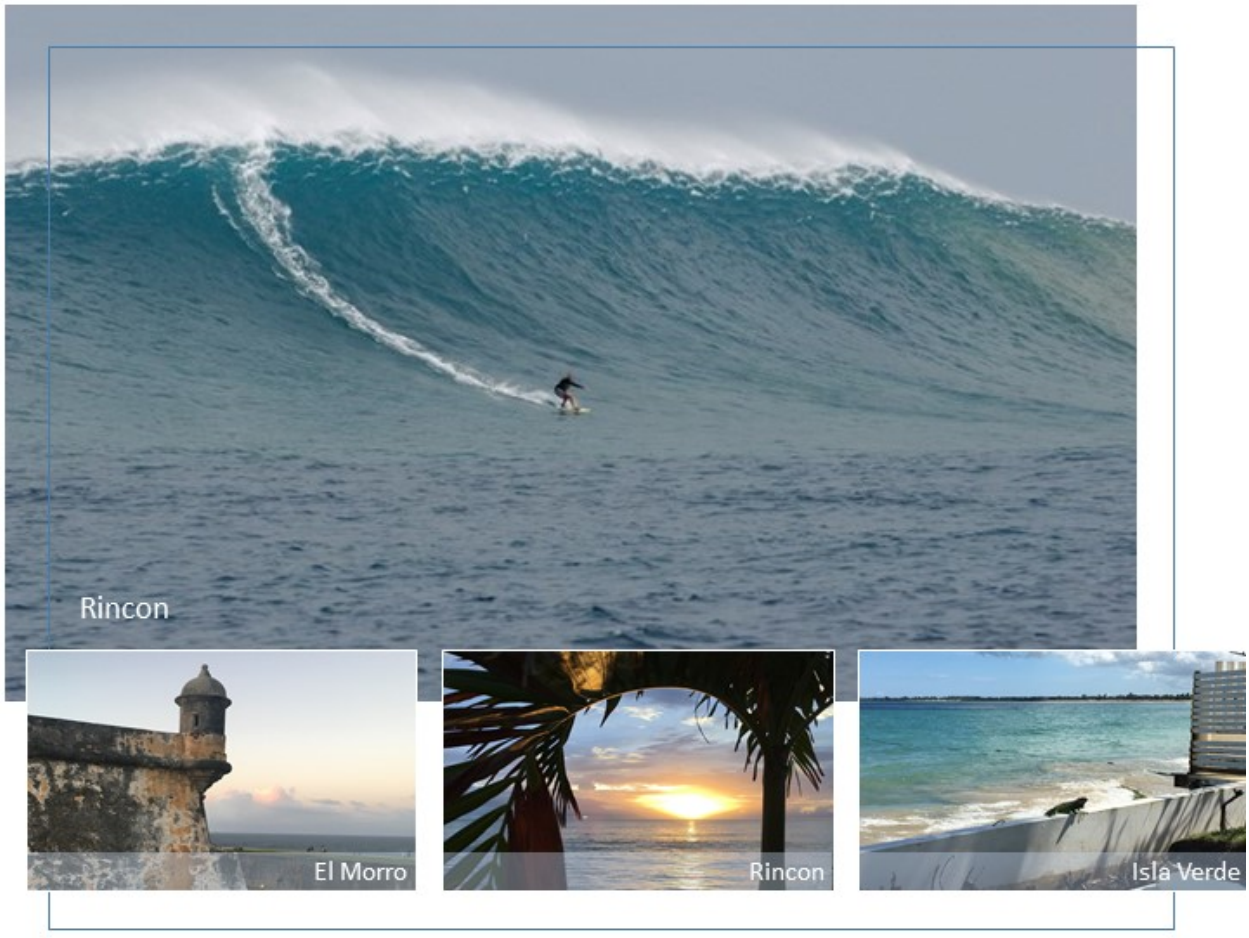
As part of the obligations established in the project partnership agreement (PPA) for the Puerto Rico, Coastal Storm Risk Management (CSRM) Project, the non-Federal sponsor shall assure continued conditions of public ownership and public use of the shore upon which Federal participation is based during the economic life of the project. The non-Federal sponsor shall also provide and maintain necessary access roads, parking areas, and other public use facilities, open and available to all on equal terms. ln the determination of the Federal interest in cost sharing, Federal participation was limited to areas where public beach access and adequate parking are available. For shoreline reaches farther than 1/4 mile from public access with adequate parking, Federal participation was not provided. The maximum Federal participation allowable for each land use category is applied for cost sharing. I therefore conclude that there is reasonable public availability of the project beaches in all areas where Federal participation is provided.

Andrew D. Kelly, Jr.

Colonel, U.S. Army

District Commander

8. LIST OF PREPARERS



8 LIST OF PREPARERS

8.1 PREPARERS

This feasibility study with integrated Environmental Assessment was prepared and reviewed by the following U.S. Army Corps of Engineers personnel:

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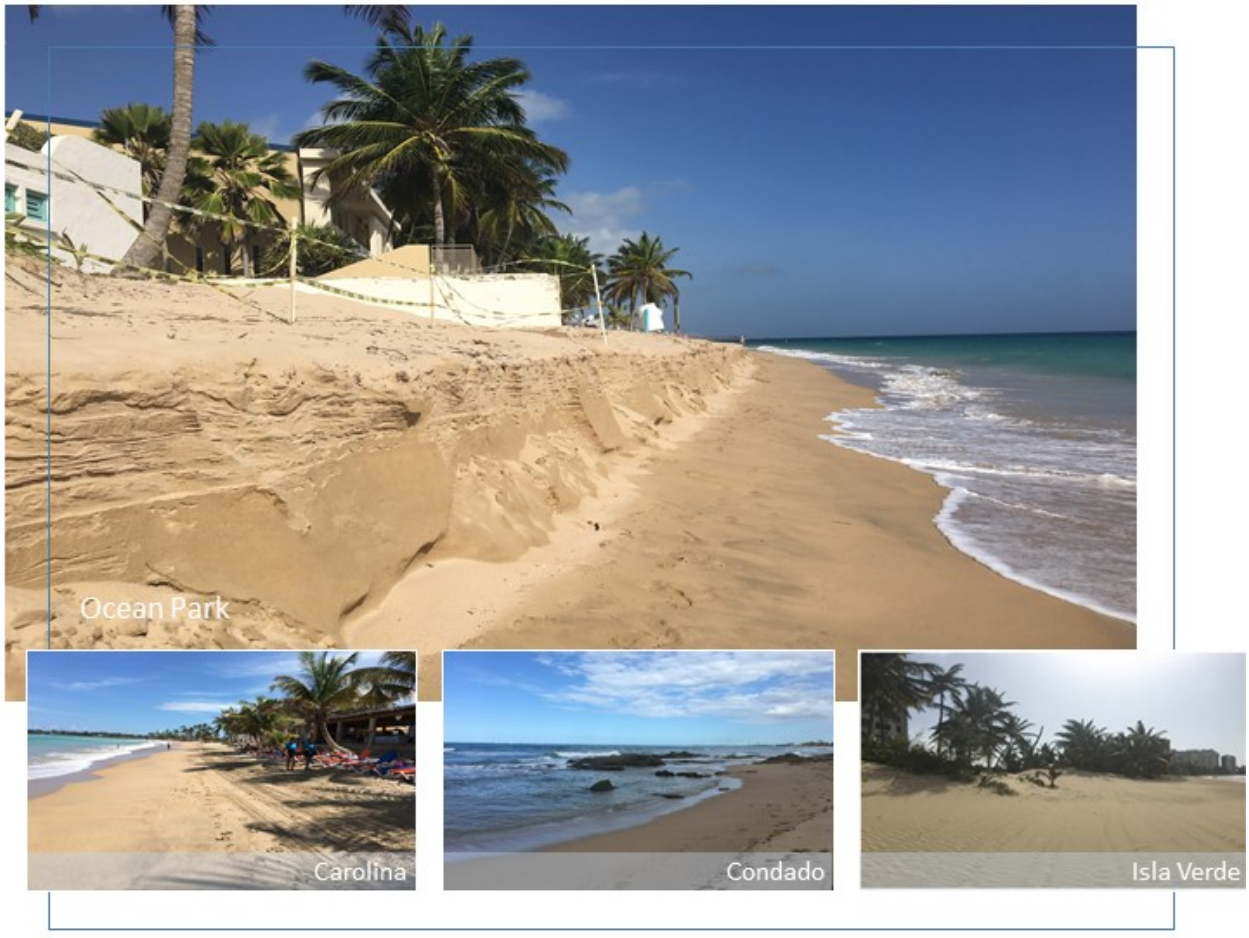
9. REFERENCES AND INDEX



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9.2 LIST OF ACRONYMS

AAEQ: Average Annual Equivalent

ASA(CW): Assistant Secretary of the Army for Civil Works

BCR: Benefit-cost ratio

BMP: Best Management Practices

CBIA: Coastal Barrier Improvement Act

CBRA: Coastal Barrier Resources Act

CBRS: Coastal Barrier Resources System

CCCL Coastal Construction Control Line

CFR: Code of Federal Regulations

CG: Construction General

CSRA: Cost and Schedule Risk Analysis

CSRM: Coastal Storm Risk Management

cy: cubic yards

CZMA: Coastal Zone Management Act

DEIS: Draft Environmental Impact Statement

DNER: Department of Natural and Environmental Resources

DoD: Department of Defense

EA: Environmental Assessment

ECL: Erosion Control Line

EFH: Essential Fish Habitat

EIS: Environmental Impact Statement

EQ: Environmental Quality

FCCE: Flood Control and Coastal Emergencies

FDEM: Florida Division of Emergency Management

FDEP: Florida Department of Environmental Protection

FMP: Fishery Management Plan

FONSI: Finding of No Significant Impact

FWC: Florida Fish and Wildlife Conservation Commission

FWOP: Future Without-Project

FWP: Future With-Project

FY: Fiscal Year

GHG: Green House Gas

HTRW: Hazardous, Toxic or Radioactive Waste

ICP: Instituto de Cultura Puertoriquena

IDC: Interest During Construction

IPR: In Progress review

LERRD: Lands, Easements, Rights-of-Way, Relocations and Disposal

m: meters

MCACES - Micro-Computer Aided Cost Estimating System

MHW: Mean High Water

MLW: Mean Low Water

MLLW: Mean Lower Low Water

MOU: Memorandum of Understanding

MSC: Major Subordinate Command

MSFCMA: Magnuson-Stevens Fishery Conservation and Management Act

MSL: Mean Sea Level

MTZ: Maritime Terrestrial Zone

NAGPRA: Native American Graves Protection and Repatriation Act

NAVD88: North American Vertical Datum of 1988

NED: National Economic Development

NEPA: National Environmental Policy Act

NGO: Non-governmental Organizations

NHC: National Hurricane Center

NHPA: National Historic Preservation Act

NGVD29: National Geodetic Vertical Datum of 1929

NMFS: National Marine Fisheries Service

NOA: Notice of Availability

NOAA: National Oceanic Atmospheric Administration

NOI: Notice of Intent

NOS: National Ocean Service

NRHP: National Register of Historic Places

OCS: Outer Continental Shelf

OMRR&R: Operation, Maintenance, Rehabilitation, Repair and Replacement

OPA: Other Protected Areas

OSE: Other Social Effects

PBO: Programmatic Biological Opinion

P3BO: Programmatic Piping Plover Biological Opinion

PCA: Project Cooperation Agreement

PDT: Project Delivery Team

PED: Preconstruction Engineering and Design

PGL: Policy Guidance Letter

PIR: Project Information Report

PPA: Project Partnership Agreement

PRHTA: Puerto Rico Highway and Transportation Authority

PRVD02: Puerto Rico Vertical Datum of 2002

PV: Present Value

RED: Regional Economic Development

ROM: Rough Order of Magnitude

RSL: Relative sea level

SHPO: State Historic Preservation Office

S&A: Supervision and Administration (Construction Management)

SLC: Sea Level Change

SPBO: Statewide Programmatic Biological Opinion

TCM: Travel Cost Method

T.S.: Tropical Storm

TSP: Tentatively Selected Plan

UDV: Unit Day Value

USACE: United States Army Corps of Engineers

USC: United State Code

USFWS: United States Fish and Wildlife Service

VT: Vertical Team

WIS: Wave Information Study

WRDA: Water Resources Development Act

WRRDA: Water Resources Reform and Development Act

Reference 1 Map

Puerto Rico Coastal Study

INTRODUCTION

BACKGROUND

The initial areas of interest include the municipalities of San Juan, Carolina, Vega Baja, Arecibo, Aguadilla, Aguada, Rincon, Añasco, Mayagüez, Cabo Rojo, Loiza, Luquillo, and Humacao. After scoping process and plan formulation phase, the project area for Federal recommendation is within the municipalities of San Juan and Rincon. This area has approximately 800 structures, including critical infrastructure, with a combined estimated value of approximately $2.9 billion. It is expected that storm-induced erosion, wave attack and flooding will continue damaging properties and infrastructure as well as reducing beach habitat during the 50-year period of analysis which will be further exacerbated by sea level rise.

STUDY AUTHORIZATION AND PROCESS

Authority for the Puerto Rico Coastal Storm Risk Management (CSRM) study is granted under Section 204 of the Flood Control Act of 1970, Public Law 91-611. Study funds were appropriated under Bipartisan Budget Act of 2018 Public Law 115-123. The study will examine alternatives and will recommend one plan that meets Corps criteria to be the Tentatively Selected Plan. If the plan is supported by Corps decision makers, it will receive an approved Chief's Report recommending it for authorization. The plan will then need to received appropriations for construction, which would be cost shared as appropriate between USACE and DNER.

PLAN FORMULATION

PROBLEMS IN THE STUDY AREA

Coastal storm damages to property and infrastructure due to wave attack, inundation, and erosion. These problems from storms and hurricanes have been increasingly evident in Puerto Rico over the recent past, with special attention on the storm season in 2017 which left severe destruction from Hurricane Irma and Maria, followed by winter storm Riley in 2018.

STUDY OPPORTUNITIES

- Maintain recreation: Area depends heavily on tourism, as well as aesthetic quality for community
- Maintain or enhance beach habitat/environmental resources

STUDY OBJECTIVES

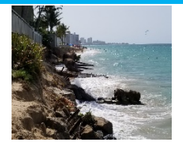
Main Objective:
- Manage the risk of damages from wave attack, flooding, and erosion caused by coastal storms

Secondary Objectives:
- Maintain environmental quality
- Maintain recreation

STUDY CONSTRAINTS

- Avoid or minimize impacts to cultural resources, reef resources, submerged vegetation and critical infrastructure






Plan formulation is the process of developing alternative plans to address a given problem. The Corps uses a 6-step planning process:

1. Problem Identification
2. Inventory Existing Conditions and Forecast Future Conditions
3. Formulate Alternatives
4. Evaluate Alternatives
5. Compare Alternatives
6. Select a Plan

In order to formulate alternative plans the team identified preliminary management measures. A management measure is a structural or nonstructural action that can be implemented at a specific geographic site to address one or more planning objectives. Measures are then screened against planning criteria, including objectives and constraints, and are combined into alternative plans.

GENERAL SUITE OF ALTERNATIVES

- **Alt-1** No Action
- **Alt-2** Revetment
- **Alt-3** Beach nourishment
- **Alt-4** Breakwaters
- **Alt-5** Beach nourishment + Breakwaters

ECONOMICS – The National Economic Development Plan (NED)

The NED should represent the alternative that achieves the greatest net benefits consistent with protecting the environment.

PRIMARY BENEFITS
Storm damage reduction

INCIDENTAL BENEFITS
Recreation

COSTS
Cost of alternative plan over a 50-year period of Federal participation

PRIMARY (CSRM) BENEFITS = **ESTIMATED $ DAMAGES WITHOUT PROJECT** - **ESTIMATED $ DAMAGES WITH PROJECT**

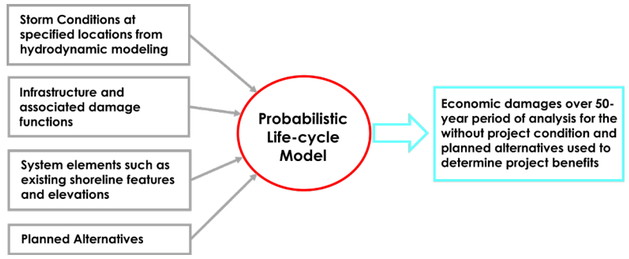
$$\text{Benefit to Cost Ratio} = \frac{\text{TOTAL BENEFITS}}{\text{COSTS}}$$

In addition, plans must have a benefit to cost ratio > 1

ENVIRONMENTAL & CULTURAL RESOURCES

The National Environmental Policy Act (NEPA) is a federal law enacted in 1969. As required by NEPA, the Corps will assess potential environmental effects of alternatives, to include cultural resources and the human environment. The findings will be explained in a NEPA document, which will be integrated into the Draft and Final feasibility Report. The NEPA document will be available for public review and comment before any decisions are made or actions are taken. Your input helps the Corps in identifying key environmental issues that may need to be evaluated.

ENGINEERING & ECONOMICS MODELING



The engineering analysis for this study considers the existing shoreline conditions and natural coastal processes in the study area, as well as sea level rise scenarios. Beach-fx model is then used to estimate the future damages to property and infrastructure resulting from hurricanes and coastal storms. The future without-project damages (FWOP) are used as the base condition against which potential alternatives will be compared. The difference between FWOP and Future with-Project (FWP) damages are used to determine primary CSRM benefits.

TENTATIVELY SELECTED PLAN

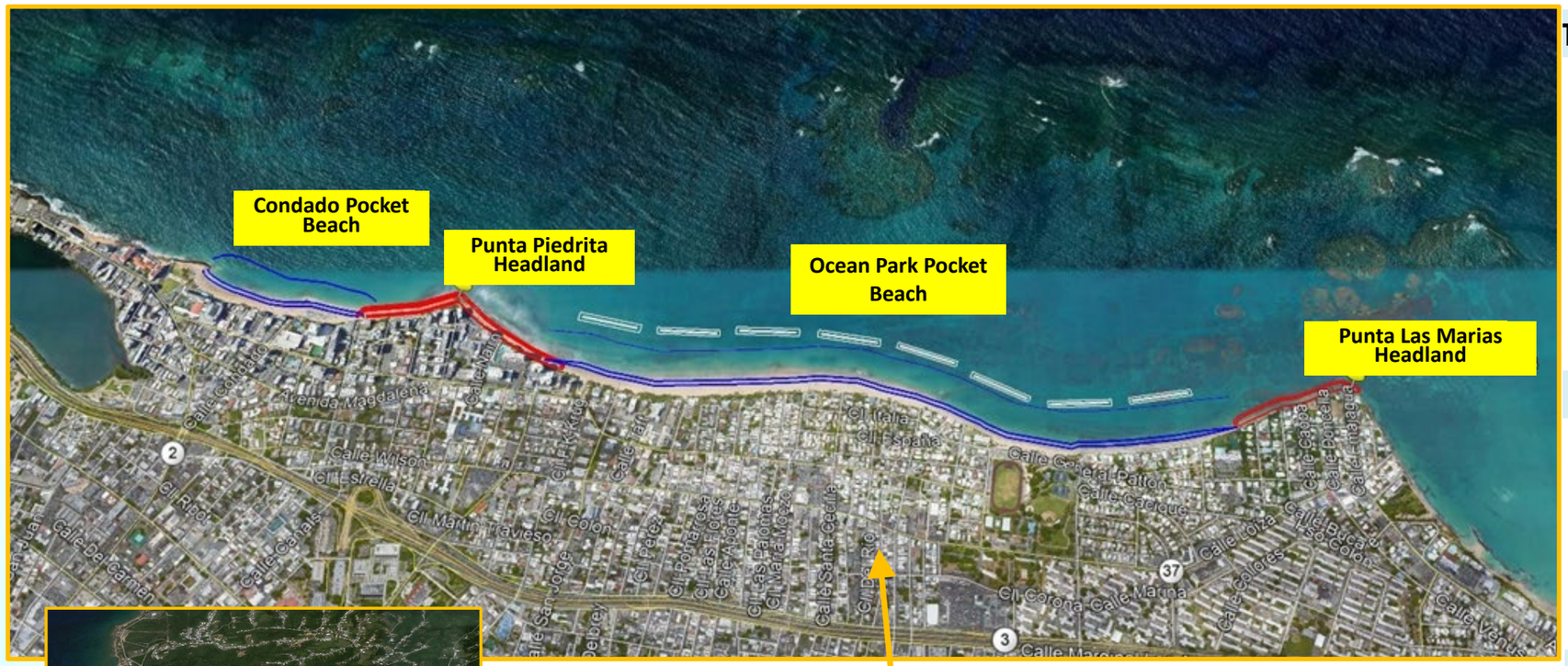
The four Planning and Guidance accounts NED, Regional Economic Development (RED), Environmental Quality (EQ) and Other Social Effects (OSE) are used as criteria in formulation and selection of the TSP. This study has identified viable alternatives to manage the risk of damages to property and infrastructure in the Condado pocket beach, Punta Piedrita headland, Ocean Park pocket beach, Punta Las Marias headland (west side), and Rincon B planning reaches. Though quantification of all the NED and RED benefits is still ongoing, the TSP is considered to be a robust and effective proposal for risk reduction. The TSP is effective, efficient, acceptable and complete. It provides enhanced life safety and positive economic benefits to the nation. The study team will continue to optimize the proposed solutions in order to provide the public with the best available alternative.

ESTIMATED STUDY SCHEDULE

ALTERNATIVES MILESTONE	PLAN FORMULATION/ ENGINEERING & ECONOMIC MODELING	TENTATIVELY SELECTED PLAN MILESTONE	DRAFT REPORT & NEPA - PUBLIC, TECHNICAL & POLICY REVIEW	AGENCY DECISION MILESTONE	FINAL REPORT - State and Agency Review	CHIEF OF ENGINEERS REPORT	PROJECT ENGINEERING & DESIGN/ CONSTRUCTION
December 2018	December 2018 to June 2020	July 2020	November 2020	March 2021	November 2021	February 2022	*2022 through 2024

*Contingent on authorization and appropriations

THE TENTATIVELY SELECTED PLAN



Structural Measures

- Revetment
- Nourishment
- Breakwaters

TSP KEY FEATURES

* Beach nourishment (1,910 ft) along Condado Pocket Beach shoreline;
* Stone revetment on Punta Piedrita headland (2,450 ft);
* A breakwater field in combination with beach nourishment protecting 6,810 ft along the Ocean Park Pocket Beach shoreline;
* Stone revetment on west side of Punta Las Marias headland (1,400 ft); and
* Stone revetment (5,650 ft) along the Rincon shoreline.

TOTAL PROJECT FIRST COST** (FY21): $203 M

Federal Cost: $122 M
(62% Initial construction and 48% periodic nourishment)
Non-Federal Cost: $81M
(38% Initial construction and 52% periodic nourishment)

**Includes 40% Contingency. Based on Class 4 cost and Abbreviated Risk Assessment

ESTIMATED MITIGATION

Total Mitigation by Habitat (acres):
Colonized Bedrock: 6.09
Scattered Coral-Rock: 6.04
Patch Reef/Aggregated: 2.55
Colonized pavement: 0.10

Total Mitigation by Planning Reach (acres):
Condado pocket beach: 3.75
Punta Piedrita headland: 2.53
Ocean Park pocket beach: 5.52
Punta Las Marias headland: 2.13
Rincon : 0.82
TOTAL: 14.8

COMPENSATORY MITIGATION

- A **functional assessment** will be included in the final report using worst case scenario/ largest potential CSRM measure footprints.
- Updated **resource surveys** will be completed in PED and the functional assessment updated at that time to reflect the final mitigation numbers.

PUBLIC ENGAGEMENT

Release of Integrated IFR/EA: 11/20/2020
Public Meetings (2): 12/10/2020
Participating Agencies: DNER, NMFS and USFWS