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2026

PLAN DE MITIGACIÓN CONTRA PELIGROS NATURALES

Municipio de Barranquitas

PLANES DE MITIGACIÓN CONTRA PELIGROS NATURALES

PROFESSIONAL LICENSED PLANNER CERTIFICATION

As per Act 160-1996 as amended (20 L.P.R.A § 3501 - 20 L.P.R.A § 3515), I _____, who bears Puerto Rico professional planning license number ___, certify that this document was prepared using the best available sources and in accordance with the best practices of the planning profession as of _____, 2026. I certify this document herewith my professional seal.

FEMA APPROVAL

This Local Hazard Mitigation Plan for the Municipality of Barranquitas was approved by FEMA on

_____

Statement of Funding

This Local Hazard Mitigation Plan was prepared for the Municipality of Barranquitas and the Puerto Rico Planning Board by the consulting firm AtkinsRéalis Caribe, LLP as per the stipulations of contract number 2026-000032 and any amendment thereof, duly registered in Puerto Rico's Office of the Comptroller.

Language Requirement

In accordance with Presidential Executive Order #14224, the 2026 version of the Barranquitas Local Hazard Mitigation Plan has been prepared in English for submission to FEMA and FEMA's review.

A non-certified Spanish translation of the final draft for public discussion and of the final approved LHMP was prepared for the benefit of the population with limited English proficiency.

Should any discrepancy arise between the English and the Spanish text, the English version shall prevail.

Statement on Maps

The maps presented in this document are related to a planning exercise. These maps are not intended to establish any regulatory requirement, procedure, or benefit.

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List of Acronyms

ABFE	Advisory Base Flood Elevation
ACS	American Community Survey
AMMED	Municipal Agency for Disaster and Emergency Management, by its Spanish acronym
BFE	Base Flood Elevation
BLE	Base Flood Engineering
BRIC	Building Resilient Infrastructure and Communities
CDBG-DR	Community Development Block Grant - Disaster Recovery
CDBG-MIT	Community Development Block Grant - Mitigation
CEACC	Committee of Experts and Advisors on Climate Change
COR3	Central Office for Recovery, Reconstruction and Resiliency
CRS	Community Rating Systems
DEM	Digital Elevation Model
DHS	Department of Homeland Security
DNER	Department of Natural and Environmental Resources
DPS	Department of Public Safety
DTOP	Department of Transportation and Public Works
EAL	Expected Annual Loss
EOP	Emergency Operation Plan
EPA	Environmental Protection Agency
FEMA	Federal Emergency Management Agency
FHWA	Federal Highway Administration
FIRM	Flood Insurance Rate Map
FIS	Flood Insurance Study
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
GIS	Geographic Information System
HMGP	Hazard Mitigation Grant Program
HUD	U.S. Department of Housing and Urban Development
IFRC	International Federation of the Red Cross

IRRM	Interim Risk Reduction Measures
LHMP	Local Hazard Mitigation Plan
LUMA	Luma Energy
MHHW	Mean Higher High Water
mph	Miles per hour
MSL	Mean Sea Level
NCEI	National Centers for Environmental Information
NDRF	National Disaster Recovery Framework
NID	National Inventory Dams
NIMS	National Incident Management System
NIST	National Institute of Standards and Technology
NOAA	National Oceanic and Atmospheric Administration
NTHMP	National Tsunami Hazard Mitigation Program
OMME	Municipal Emergency Management Office
OPM	Municipal Public Works, by its Spanish acronym
PRASA	Puerto Rico Aqueduct and Sewers Authority
PREMB	Puerto Rico Emergency Management Bureau
PREPA	Puerto Rico Electric Power Authority
PRHTA	Puerto Rico Highway and Transportation Authority
PRPB	Puerto Rico Planning Board
PRSN	Puerto Rico Seismic Network
PT	Territorial Plan, by its Spanish acronym
PUT-PR	Puerto Rico Land Use Plan, by its Spanish acronym
SHMO	State Hazard Mitigation Officer
SFLA	Southern Federal Land Assessment
UHI	Urban Heat Island
USACE	United States Army Corps of Engineers
USDA	United State Department of Agriculture
USDOT	United States Department of Transportation
USGS	United States Geological Survey
VSL	Value of Statistical Life

Executive Summary

This document is the 2026 update of the Local Hazard Mitigation Plan (LHMP) for the Municipality of Barranquitas, Puerto Rico. It identifies the natural hazards that may affect the municipality, assesses risks to people, property, infrastructure, and community lifelines, and establishes mitigation strategies intended to reduce losses and strengthen long-term resilience. The plan was prepared in accordance with the Stafford Act, the Disaster Mitigation Act of 2000, and 44 CFR Part 201 through a coordinated process involving the Municipality of Barranquitas, the Puerto Rico Planning Board, stakeholders, and the public. It was funded through the Puerto Rico Planning Board and prepared by AtkinsRéalis Caribe, LLP.

Introduction and Background

The Municipality of Barranquitas and the Puerto Rico Planning Board updated the LHMP to provide a coordinated framework for reducing hazard-related risks and protecting residents, property, infrastructure, natural resources, and essential services. This document represents the fourth revision of the municipal LHMP: the original plan was approved by FEMA in 2005, followed by updates in 2012 and 2020. The 2026 update reflects current conditions, updated technical information, revised federal guidance, and mitigation priorities for the next planning cycle while maintaining the municipality's eligibility for applicable federal mitigation funding.

The primary objectives of the plan are to:

- Identify and evaluate natural hazards threatening the municipality.
- Establish strategies to reduce risks to life, property, infrastructure, and essential services.
- Promote interagency coordination and community involvement.

Public Policy

- The plan aligns with applicable federal, Puerto Rico, and municipal policies governing hazard mitigation, land use, emergency management, and resilience.
- The Stafford Act and its Hazard Mitigation Grant Program provide funding for cost-effective mitigation.

- The Disaster Mitigation Act of 2000 requires LHMP adoption for federal funding eligibility.
- The National Flood Insurance Act establishes the NFIP to provide flood insurance and encourages floodplain management.
- FEMA's regulations (44 CFR Part 201) and planning guides outline requirements and procedures for mitigation planning.
- The National Disaster Recovery Framework guides recovery coordination.
- The National Earthquake Hazards Reduction Program, National Dam Safety Program, and National Incident Management System support seismic risk reduction, dam safety, preparedness, and coordinated incident management.

Puerto Rico Policies

- Act No. 161-2009 reforms the permitting system to improve efficiency.
- Act No. 33-2019 mandates mitigation and resilience measures in response to changing weather patterns.
- Act No. 107-2020 (Municipal Code) which gives municipalities some powers for regulating land use.
- The Puerto Rico Land Use Plan (PUT-PR) classifies land and guides sustainable development.
- The Puerto Rico State Natural Hazard Mitigation Plan (2021) provides a jurisdiction-wide framework.
- The Puerto Rico Mitigation Action Plan (CDBG-DR MIT) directs federal mitigation funds post-hurricanes Irma and María.
- The Barranquitas LHMP (2020) and Barranquitas Municipal Recovery Plan provide prior mitigation frameworks, recovery priorities, and potential strategies for consideration in this update.

Planning Process

The 2026 LHMP update follows FEMA guidance and was developed through coordination among the Municipality of Barranquitas, the Puerto Rico Planning Board, the Planning Committee, stakeholders, and the public. Public participation included notifications, online and printed outreach, opportunities to submit comments, and three planned community meetings. Input received during the first public meeting identified concerns involving deteriorated bridges, clogged drainage, limited emergency access, flooding, runoff, landslides, erosion, fallen trees and utility poles, wildfire risk, and community isolation. The plan also applies to the FEMA Lifelines

framework to evaluate essential services and potential cascading impacts.

Municipal Profile

The Municipality of Barranquitas is in Puerto Rico's central mountainous region and is characterized by rugged terrain, steep slopes, narrow ridges, deep valleys, and an extensive drainage network. The municipality covers approximately 34.28 square miles and is divided into eight wards: Barrio-Pueblo, Barrancas, Cañabón, Helechal, Honduras, Palo Hincado, Quebrada Grande, and Quebradillas. Its mountainous physiography, dispersed development, river systems, and transportation corridors influence local exposure to landslides, flooding, tropical cyclones, earthquakes, and other hazards.

Demographics

According to the U.S. Census Bureau's American Community Survey (ACS) 2020–2024 Five-Year Estimates, Barranquitas has 29,054 residents, representing an increase of 661 residents, or 2.33%, from the 2019 ACS estimate. The municipality's age distribution is shifting toward older groups: 5,629 residents are 65 years of age or older, while younger cohorts generally declined. A combined 11,959 residents are younger than 18 or older than 64, indicating a substantial population that may require additional support during preparedness, evacuation, response, and recovery activities.

Socioeconomic Conditions

Barranquitas faces socioeconomic conditions that may affect household preparedness and disaster recovery, including poverty, food-assistance needs, disability-related needs, limited labor-force participation, and unequal access to transportation, healthcare, and financial resources. These factors can reduce the capacity of some residents to evacuate, protect property, absorb disaster-related costs, and recover without additional assistance. Mitigation and outreach efforts should therefore prioritize accessible communication, continuity of essential services, and support for socially vulnerable populations.

Housing

The housing profile of Barranquitas reflects a predominantly residential municipality with a substantial share of older structures. Buildings constructed under earlier codes may be more susceptible to earthquake shaking, tropical-cyclone winds, flooding, and slope-related impacts. Housing vulnerability may be compounded by limited

household income, the age of residents, and constraints on access to transportation or insurance. Mitigation measures should therefore emphasize structural resilience, code-compliant improvements, floodplain management, and protection of homes in hazard-prone areas.

Critical Infrastructure and FEMA Lifelines

The LHMP assesses municipal infrastructure in alignment with FEMA Lifelines, including safety and security; food, hydration, and shelter; health and medical services; energy; communications; transportation; hazardous materials; and water systems. Critical facilities such as hospitals, police facilities, emergency centers, shelters, and related assets are mapped and evaluated to understand their exposure and role in supporting emergency response and community recovery. This lifeline-based approach helps identify where mitigation investments can protect essential services and reduce cascading impacts during hazard events.

Recent Development

Recent development in Barranquitas includes residential, commercial, infrastructure, and public-facility investments documented through approved construction permits from 2020 through 2026. Exposure maps indicate that new development occurs across the municipality and may overlap areas affected by earthquake ground motion, landslide susceptibility, flooding, tropical-cyclone winds, and the potential Carite Dam impact area. Integrating hazard information into permitting, land-use decisions, infrastructure design, and capital investment will help prevent the creation of new risks.

Hazard Profiles and Risk Assessment

The LHMP evaluates nine hazards: earthquake, landslides, flooding, tropical cyclones and extreme winds, extreme heat, drought, wildfire, pandemic and epidemic, and high hazard potential dams. Each profile addresses hazard characteristics, location and extent, previous occurrences, probability of future events, exposure, potential losses, social vulnerability, critical infrastructure and FEMA Lifelines, recent development, and natural or cultural resources where applicable.

Earthquake

Puerto Rico's location near the boundary of the Caribbean and North American

tectonic plates makes earthquake risk a continuing concern for Barranquitas. The 2026 assessment evaluates spectral acceleration, spectral displacement, building exposure, population exposure, critical infrastructure, and recent development using current seismic data and HAZUS 6.1 outputs.

Earthquake shaking may affect the entire municipality, including buildings, roadways, utilities, public facilities, and essential services. Potential impacts may be amplified by older construction, steep terrain, transportation constraints, poverty, and residents who may require additional assistance. Because earthquake events can disrupt multiple FEMA Lifelines simultaneously, priorities include structural resilience, emergency preparedness, protection of critical facilities, and continuity of essential services.

Recent seismic activity, including the significant 2020 southwestern Puerto Rico earthquake sequence, demonstrates that earthquake hazards remain an ongoing concern for the municipality. Because of Puerto Rico's tectonic setting, future earthquake risk is expected to remain high, requiring continued attention to structural resilience, emergency preparedness, critical facility protection, and mitigation measures that reduce potential damages and service disruptions.

Landslides

Landslides are a major concern in Barranquitas because of its steep mountainous terrain, highly weathered soil, intense rainfall, road cuts, drainage conditions, and development along slopes and narrow transportation corridors.

Although precise monetary loss estimates are not available for landslides, the hazard can disrupt transportation corridors, utility systems, emergency access, and other essential services. Social vulnerability is closely tied to geographic isolation, road access limitations, infrastructure fragility, and the ability of residents to receive timely assistance during and after hazard events.

Widespread slope failures were documented in Barranquitas after Hurricane María in 2017. Community input also identified landslides, erosion, fallen trees, damaged roads, and limited emergency access in several sectors. Landslide mitigation should therefore remain a priority through slope stabilization, drainage improvements, road and bridge maintenance, debris management, land-use controls, emergency access planning, and public awareness.

Flooding

Flooding in Barranquitas includes riverine and flash flooding associated with intense rainfall and tropical weather systems. Flood hazard areas are concentrated along mapped river and stream corridors within the Río Grande de Manatí, Río de la Plata, and Río Coamo–Río Seco watershed systems, including areas associated with the Río Barranquitas, Río Hondo, Río Usabón, Río Cañabón, Río Frío, and their tributaries.

The flood assessment identifies exposed structures, estimated building losses, critical infrastructure, population, and recent development using FEMA flood data and HAZUS 6.1. Both the 1% annual-chance and 0.2% annual-chance flood scenarios may damage buildings, interrupt transportation and utilities, isolate communities, and affect emergency response. Continued NFIP participation, drainage improvements, bridge and roadway projects, floodplain management, and protection of essential facilities are central mitigation priorities.

Social vulnerability to flooding is especially high among low-income residents, mobility-limited populations, and households with limited access to transportation or financial resources. These conditions can affect the ability of residents to evacuate, protect property, obtain insurance, or recover after flood events. As a result, flood mitigation remains a central priority for reducing losses, protecting public health, and strengthening community resilience.

Tropical Cyclones/Extreme Winds

Tropical cyclones and extreme winds are among the most widespread hazards affecting Barranquitas. The entire municipality is exposed to tropical-storm and hurricane winds, and related rainfall may also trigger flooding, landslides, debris accumulation, utility failures, and transportation disruptions.

Hurricanes Irma and María in 2017 demonstrated the municipality's vulnerability to severe wind, prolonged power and communications outages, damaged roads and structures, and extended recovery needs. The risk assessment uses HAZUS 6.1 to evaluate building damage and economic losses for 100-year and 500-year tropical-cyclone scenarios. Because these events can affect every FEMA Lifeline, mitigation requires coordinated improvements to buildings, utilities, communications, transportation, shelters, water systems, and emergency operations.

Social vulnerability is considered widespread due to the municipality-wide exposure of residents, housing, infrastructure, and essential services.

Extreme Heat

Extreme heat consists of prolonged periods of abnormally high temperatures, often combined with high humidity. Although Barranquitas has a mountainous setting, developed areas and locations with limited vegetation or shade may experience increased heat exposure. Heat can affect public health, energy demand, transportation, communications, water systems, and outdoor work.

Older adults, children, people with chronic health conditions or disabilities, outdoor workers, low-income households, and residents with limited access to cooling, healthcare, or transportation may face greater risk. Mitigation priorities include public information, accessible cooling strategies, urban greening and shade, protection of critical facilities, and coordination with health and emergency-management partners.

Future projections indicate that temperatures and the frequency of extreme heat events are expected to rise, reinforcing the need for mitigation actions such as public outreach, urban greening, shade improvements, cooling strategies, and infrastructure adaptation. These measures can reduce exposure, improve preparedness, and protect vulnerable residents during periods of excessive heat.

Drought

Drought in Barranquitas may result from prolonged precipitation deficits and can affect potable-water supplies, agriculture, ecosystems, public health, household finances, and continuity of essential services. The municipality experienced severe drought conditions and water rationing during the 2014–2016 drought period identified in the previous LHMP.

Drought conditions can lead to water rationing, affect economic and agricultural activities, increase stress on households and businesses, and contribute to increased wildfire potential. Previous drought events have been documented through federal declarations, demonstrating that the hazard has affected Puerto Rico in the past and remains relevant to local mitigation planning.

Future drought conditions may increase pressure on regional water systems and

contribute to wildfire potential. Priorities include water conservation, emergency water-supply planning, infrastructure resilience, public outreach, and coordination with regional water providers. Older adults, low-income households, and people with health-related needs may require additional support during prolonged service interruptions.

Wildfire

Wildfire includes uncontrolled fires in vegetated areas and at the wildland–urban interface. In Barranquitas, wildfire conditions may be influenced by drought, dry vegetation, steep terrain, limited access, and the proximity of homes and infrastructure to forested or agricultural land.

Barranquitas has generally experienced a comparatively low incidence of wildfire, but recorded events and community concerns—particularly in sectors such as Los Aguirre in Helechal—show that the hazard remains locally relevant. Wildfire may threaten homes, ecosystems, transportation access, utilities, and emergency response. Mitigation priorities include public education, defensible space, vegetation management, reliable emergency access, and interagency coordination.

Social vulnerability to wildfire is associated with poverty, disability prevalence, limited evacuation capacity, and constraints on household preparedness. Although current wildfire incidence is comparatively low, future risk may increase as dry conditions become more frequent and vegetation stress intensifies. Mitigation measures such as public education, defensible space practices, vegetation management, emergency access improvements, and interagency coordination can reduce potential impacts.

Pandemic/Epidemic

Pandemic and epidemic hazards include localized disease outbreaks and widespread events that may affect residents, workplaces, schools, healthcare providers, government operations, and essential services throughout Barranquitas. The entire municipality is considered exposed because infectious diseases are not confined to a specific geographic area.

Puerto Rico has experienced outbreaks including cholera, measles, influenza, polio, dengue, chikungunya, Zika, and COVID-19. The COVID-19 pandemic demonstrated the potential for substantial health, social, and economic disruption. Barranquitas residents without health insurance may face additional barriers to preventive care

and treatment; ACS data indicate that young adults account for the largest uninsured age group identified in the plan.

During pandemic and epidemic events, the healthcare lifeline is typically the most directly affected; however, other FEMA Lifelines may also experience disruptions, including communications, transportation, food supply, shelter operations, public safety, and continuity of government functions. Future pandemic risk remains elevated due to changing environmental conditions, population characteristics, travel patterns, and the continued emergence of infectious diseases. Mitigation and preparedness efforts should therefore emphasize public health coordination, risk communication, continuity planning, support for vulnerable populations, and sustained emergency management capacity.

High Hazard Potential Dams

The 2026 update adds high hazard potential dams as a municipal hazard. The assessment focuses on Carite Dam, located outside Barranquitas, and the potential downstream impact area that extends into portions of the municipality. A dam-related emergency could affect population, roads, utilities, critical infrastructure, community lifelines, and recent development within the mapped impact area.

Mitigation priorities include coordination with dam owners and state and federal agencies, emergency-action and evacuation planning, warning and communication systems, public awareness, protection of exposed infrastructure, and incorporation of dam-risk information into municipal emergency management and land-use decisions.

Hazard Prioritization

The Planning Committee used the hazard profiles and risk assessment to establish mitigation priorities for Barranquitas. As documented in Table 45, prioritization considers the likelihood of future events, potential impacts on people and property, disruption of critical infrastructure and FEMA Lifelines, and the needs of socially vulnerable populations. These results guide the selection and sequencing of mitigation actions in Chapter 6 and should be revisited as new data, projects, and community concerns emerge.

Municipal Capabilities

Barranquitas relies on a combination of federal, Puerto Rico, and municipal authorities, plans, regulations, programs, and administrative practices to support mitigation. Relevant mechanisms include the Joint Regulation for Permits, the Special Flood Hazard Areas Regulation, the Puerto Rico Building Code, stormwater and environmental requirements, the Barranquitas Territorial Plan, the Emergency Operation Plan, participation in the National Flood Insurance Program, and municipal capital-investment and recovery-planning processes. These mechanisms provide opportunities to integrate hazard information into land use, permitting, infrastructure maintenance, emergency management, and long-term investment decisions.

Municipal technical and administrative capacity is distributed among offices responsible for permits and territorial planning, emergency management, federal programs, public works, finance, and related functions. Implementation capacity may be strengthened through staff training, interagency agreements, updated data and procedures, and continued pursuit of FEMA, HUD, and other federal or Puerto Rico funding sources, including HMGP, FMA, BRIC, CDBG-DR, and CDBG-MIT.

Public outreach and capacity development are integral to the LHMP. Barranquitas uses municipal meetings, social media, printed notices, online resources, surveys, and stakeholder correspondence to share information and receive input. Continued outreach should be accessible, inclusive, and responsive to local conditions, including residents with disabilities, limited transportation, limited internet access, or other barriers to participation. Community concerns documented during the planning process should continue to inform mitigation implementation and future updates.

Mitigation Action Plan

The Mitigation Action Plan establishes goals, objectives, and actions to reduce hazard impacts, protect life and property, strengthen critical infrastructure and community lifelines, improve public knowledge, and enhance emergency response and recovery. Strategies are organized under prevention, property protection, structural projects, natural-resource protection, emergency services, and community awareness and information. Actions include integrating risk information into plans and permits, improving drainage, roads, bridges, slopes, utilities, and warning systems, supporting resilient buildings and critical facilities, addressing extreme heat and wildfire, and maintaining preparedness for public-health and dam-related emergencies.

Overall, the 2026 Barranquitas LHMP integrates updated hazard and risk information, municipal capabilities, public and stakeholder input, and an actionable mitigation strategy into a single planning framework. Its implementation will help Barranquitas reduce future losses, protect vulnerable residents and essential services, guide development and public investment, and strengthen the municipality's capacity to prepare for, withstand, and recover from natural hazards and public-health emergencies.

1. Introduction and Background

The Municipality of Barranquitas and the Puerto Rico Planning Board (PRPB) are dedicated to protecting the well-being of Puerto Ricans by fostering cultural, social, and economic growth while prioritizing public health and safety. In this effort, the Municipality and the PRPB have agreed to undertake a joint effort to update the Municipality's Local Hazard Mitigation Plan (LHMP). The LHMP provides a structured and comprehensive approach to reducing risks associated with natural hazards and strengthening overall community resilience. In recent years, Barranquitas has faced considerable impacts from natural disasters, emphasizing the urgent need for proactive actions to reduce vulnerabilities and safeguard critical infrastructure. These experiences highlight the importance of implementing a coordinated and systematic hazard mitigation strategy that is consistent with federal, state, and local policies.

An LHMP identifies and evaluates potential natural hazards and defines actions designed to reduce or eliminate risks to people, property, and the environment. The plan supports the municipality's land use planning efforts by establishing measures that assist Barranquitas in achieving its long-term sustainability and resilience objectives.

This LHMP complies with the requirements set forth by the Robert T. Stafford Disaster Relief and Emergency Assistance Act (Stafford Act) and the federal regulations derived from it. Under this legislation, local governments in states and territories are required to develop and formally adopt a hazard mitigation plan as a condition for eligibility to receive certain types of funding administered by the Federal Emergency Management Agency (FEMA).

Risk mitigation plays a critical role in guiding future development and enhancing existing municipal infrastructure. To ensure an effective mitigation strategy, the LHMP is regularly updated to reassess natural hazards that may threaten the lives and property of residents and to incorporate appropriate and responsive mitigation measures.

This document represents the fourth revision of the LHMP for the Municipality. The original plan received FEMA approval in 2005, the second update was approved in 2012 and the third revision approved in 2020. This 2026 update reflects evolving conditions and circumstances that have influenced the municipality over the past five years and incorporates newly enacted laws, programs, and regulatory requirements. Through

this update, Barranquitas aims to preserve its eligibility for federal mitigation funding prior to future catastrophic events and to present a strengthened plan aligned with current standards and best practices.

The development of this plan was conducted through a coordinated process that incorporated input from state and local agencies, non-governmental organizations, and the public. The overarching goal is to enhance the municipality's capacity to anticipate, reduce, and effectively respond to natural hazards that may affect its jurisdiction.

The primary objectives of the LHMP are to:

- Identify and evaluate natural hazards that pose risks to the municipality.
- Establish strategies and actions to reduce or eliminate long-term threats to life, property, and critical services.
- Encourage interagency coordination and promote community involvement in disaster preparedness and mitigation initiatives.

1.1 Applicable Public Policies

This section outlines the relevant federal and state public policies that guide the development of the 2026 Barranquitas LHMP. The overview provided is not intended to be comprehensive. Additional public policies are referenced throughout the document, particularly in Section 5.1.

1.1.1 Federal Policies

The following federal policies establish the framework for hazard mitigation planning and resilience efforts.

1.1.1.1 Federal Laws

Stafford Act

The Stafford Act is primarily aimed at reducing loss of life and property, alleviating human suffering, minimizing economic impacts, and lowering the costs associated with disaster assistance. In 1988, Congress amended the Act to create the Hazard Mitigation Grant Program (HMGP), which became the principal source of federal

mitigation funding following a disaster declaration by the President of the United States. Through this program, funds are made available to states and territories to implement cost-effective measures that reduce the risk of damage and losses from future hazard events.

Disaster Mitigation Act of 2000

Enacted on October 30, 2000, the Disaster Mitigation Act of 2000 (DMA 2000) further amended the Stafford Act to enhance disaster planning, response, and recovery at all levels of government. This legislation establishes eligibility requirements for municipalities to access federal mitigation funding, including the preparation and adoption of a Local Hazard Mitigation Plan (LHMP). An LHMP demonstrates a jurisdiction's commitment to reducing risks associated with natural hazards and serves as a decision-making tool for implementing preventive and mitigation actions. It also provides a framework for the State to deliver technical assistance and establish funding priorities.

In accordance with DMA 2000 requirements, this LHMP is comprehensive and coordinated, incorporating the participation of state, local, and regional agencies, non-governmental organizations, and members of the public.

National Flood Insurance Act

The National Flood Insurance Act established the National Flood Insurance Program (NFIP) to provide affordable flood insurance coverage to homeowners, businesses, and renters located in flood-prone areas. The program was designed to reduce the financial burden on individuals and the federal government in the aftermath of flood-related disasters.

The Act also encourages participating communities to adopt and enforce minimum floodplain management standards aimed at reducing future flood risks. Communities that comply with these requirements become eligible for NFIP benefits and programs.

Access to flood insurance enables property owners to recover more rapidly following flood events without relying solely on federal disaster assistance. Supporting legislation, such as the Flood Disaster Protection Act of 1973, further requires federally regulated lenders to mandate flood insurance coverage for properties located in high-risk flood zones and financed through federally backed mortgages.

The Federal Emergency Management Agency (FEMA) has recognized the Municipality as part of the region that is within the PRPB's coverage within the National Flood Insurance Program. The municipality can request updates and amendments to flood hazard maps utilized by the NFIP through the PRPB.

Additionally, through participation in the Flood Mitigation Assistance Program, the municipality has identified specific mitigation strategies to reduce flood-related risks. Funding has also been allocated for the acquisition of structures located in high-risk flood areas as part of ongoing efforts to decrease vulnerability and exposure to future flood events.

1.1.1.2 Federal Regulations

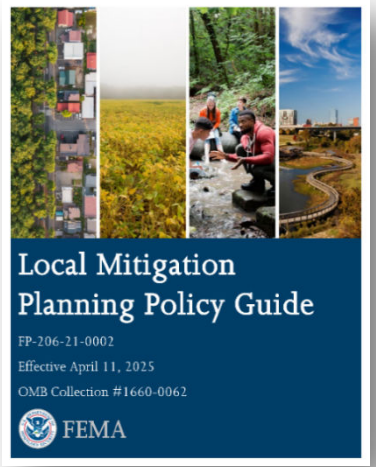
Mitigation Planning - 44 CFR Part 201

This section of the Code of Federal Regulations describes the rules and procedures governing hazard mitigation planning as mandated under the Stafford Act. It outlines the requirements for the preparation and adoption of mitigation plans, which serve as the primary tool for reducing risks posed by natural hazards at the local level. Additionally, this section establishes the policies and planning processes that guide hazard mitigation efforts, underscoring the role of mitigation plans in directing the effective allocation of resources for disaster risk reduction.

FEMA Local Hazard Mitigation Planning Guide

The Local Hazard Mitigation Planning Policy Guide published by FEMA establishes the official framework and guidance that local governments are required to follow when preparing, reviewing, and updating their Local Hazard Mitigation Plans (LHMPs). This guidance is designed to ensure compliance with the requirements set forth in the Code of Federal Regulations (44 CFR Part 201).

Figure 1: Cover of FEMA's Local Mitigation Planning Policy Guide



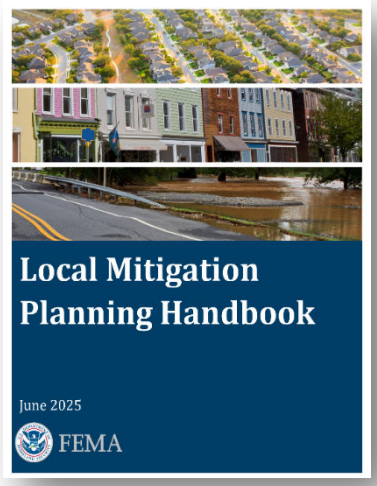
The policy guide emphasizes data-driven planning tailored to local capacities while prioritizing equity and inclusive stakeholder participation. It encourages communities to integrate hazard mitigation into broader planning and decision-

making processes, thereby strengthening long-term resilience and reducing vulnerability to natural hazards (FEMA, Local Mitigation Planning Policy Guide, 2025).

The guide identifies the essential components that every mitigation plan is required to address. In addition, it provides practical resources such as resolution templates, checklists, and plan review criteria to support local governments throughout the planning process. The guide also explains FEMA's plan review and approval process, which may result in full approval, conditional approval pending formal adoption, or return of the plan for revisions and corrections.

Local Mitigation Planning Handbook

Figure 2: Cover of FEMA's Local Mitigation Planning Policy Guide



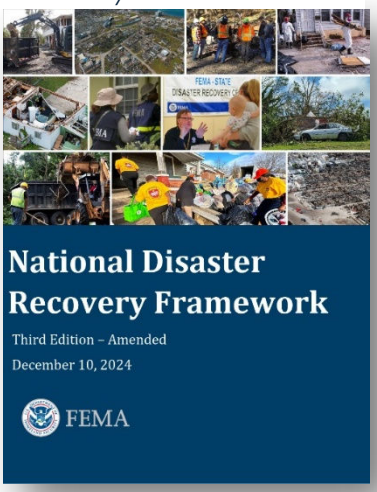
The *Local Mitigation Planning Handbook* is an operational resource developed by FEMA to assist local governments, including municipalities and special districts, in developing or updating their Local Hazard Mitigation Plans. This handbook serves as a companion to FEMA's mitigation planning policy guidance and offers a detailed, step-by-step methodology for complying with the requirements outlined in Title 44 of the Code of Federal Regulations, Part 201.

The primary purpose of the handbook is to support communities in identifying the natural hazards they face, evaluating institutional and administrative capabilities, and formulating effective strategies to reduce disaster-related impacts (FEMA, 2025). Ultimately, the handbook promotes the creation of safer and more resilient communities that are better prepared to anticipate, withstand, and recover from adverse events.

National Disaster Recovery Framework

The National Disaster Recovery Framework (NDRF) is a guide created by FEMA in the United States that establishes how recovery should be organized and coordinated after a disaster. Its main objective is to help affected communities rebuild in a stronger, more equitable, and more resilient way, involving all levels of government—

Figure 3: National Disaster Recovery Framework Cover



local, state, tribal, territorial, and federal—along with private and community organizations.

This framework promotes recovery that not only restores what was lost but also improves pre-disaster conditions. To achieve this, the NDRF defines guiding principles, specific roles for the actors involved, and coordination structures that facilitate collaboration among agencies. It also emphasizes the importance of planning before a disaster occurs and ensuring that recovery goals are defined by the affected communities themselves.

National Flood Insurance Program

The National Flood Insurance Program (NFIP), administered by FEMA, provides affordable flood insurance coverage to property owners, renters, and businesses while encouraging effective floodplain management practices to reduce future flood risks. Established in 1968, the NFIP supports communities in minimizing flood-related losses by requiring the adoption and enforcement of local floodplain management regulations. The program also offers insurance coverage for both structures and their contents in more than 22,000 participating communities nationwide.

Because most standard homeowners' insurance policies do not cover flood damage, the NFIP plays a critical role in protecting lives and property while reducing long-term disaster recovery costs. Additional information regarding the Municipality of Barranquitas participation in the NFIP is provided in Section 4.2 of this plan.

National Earthquake Hazards Reduction Program

The National Earthquake Hazards Reduction Program (NEHRP) was established under the Earthquake Hazards Reduction Act of 1977 to advance the development, dissemination, and application of knowledge, tools, and practices that reduce risks associated with seismic events. This objective is achieved through coordinated, multidisciplinary, and interagency collaboration among NEHRP's participating federal agencies and partners, including local jurisdictions such as the Municipality of Barranquitas.

The National Institute of Standards and Technology (NIST), within the U.S. Department of Commerce, serves as the lead agency for NEHRP. The program is further supported by three cooperating federal agencies: the Federal Emergency Management Agency (FEMA), the National Science Foundation (NSF), and the United States Geological Survey (USGS). Each agency contributes expertise and complementary activities related to research, preparedness, mitigation, and public safety.

National Dam Safety Program

The National Dam Safety Program (NDSP), administered by FEMA, works collaboratively with states, federal agencies, tribal governments, and other partners to improve dam safety and reduce risks to people, property, and the environment. Created in 1996, the program provides grants, technical assistance, research, and training to strengthen state dam safety programs and support the rehabilitation of high-hazard potential dams.

The NDSP also emphasizes public education, emergency preparedness, and risk communication. In support of these efforts, FEMA maintains resources such as the National Inventory of Dams, which assists in monitoring dam conditions and enhancing resilience to prevent catastrophic dam failures nationwide.

National Incident Management System

The National Incident Management System (NIMS) is a standardized framework developed by the U.S. Department of Homeland Security and administered by FEMA to guide incident management across the nation. Its purpose is to enable effective coordination and cooperation among governmental agencies, private sector organizations, and community-based entities at all jurisdictional levels during the prevention, preparedness, response, and recovery phases of emergencies and disasters.

NIMS establishes a common organizational structure, terminology, and set of processes to ensure seamless coordination regardless of the incident's type, size, or complexity. Core components of the system include resource management, interoperable communications, ongoing preparedness activities, and the Incident Command System (ICS), which defines clear roles, responsibilities, and command structures during emergency operations.

Implementation of NIMS is also a prerequisite for jurisdictions seeking access to certain federal preparedness and response funding. By adopting NIMS, jurisdictions enhance

operational efficiency, reduce duplication of efforts, and promote the effective and coordinated use of available resources.

1.1.2 Government of Puerto Rico Policies

The following Government of Puerto Rico policies provide guidance for the development and implementation of the 2026 Barranquitas LHMP.

1.1.2.1 Puerto Rico Laws

Act No. 161-2009, as Amended

Act No. 161-2009, known as the *Puerto Rico Permits Reform Act*, establishes a modern legal and administrative framework designed to comprehensively restructure the Commonwealth's permitting system. The primary goal of the Act is to create a transparent, efficient, and streamlined process for the submission, evaluation, approval, or denial of permits issued by the Government of Puerto Rico.

To accomplish this objective, the law created the Office of Permits Management (OPM), consolidating permitting responsibilities that were previously distributed across multiple agencies. This centralization reduced procedural delays and improved consistency in the application of permitting standards. The Act also introduced specialized roles—including Authorized Professionals, Permit Managers, Service Representatives, and Permit Officers—each with defined responsibilities intended to expedite reviews and professionalize the permitting process.

A further objective of Act No. 161-2009 is to enhance oversight, accountability, and transparency within the permitting system. By strengthening internal controls and standardizing procedures, the Act seeks to ensure compliance while reducing administrative inefficiencies.

From a public policy perspective, the Act aims to promote economic development while safeguarding environmental protection. Legislative intent emphasizes that an efficient permitting system is essential to attract investment, encourage construction activity, support long-term job creation, and eliminate bureaucratic barriers that previously hindered economic growth. Analyses of the Act also highlight its role in centralizing governmental functions and implementing an Integrated Permitting

System to reduce fragmentation, improve interagency coordination, and ensure regulatory uniformity throughout Puerto Rico.

Act No. 33-2019, as Amended

Act No. 33-2019 establishes the public policy of the Government of Puerto Rico regarding mitigation, adaptation, and resilience in response to observed variations in temperature and precipitation patterns. The legislation formally recognizes the need for integrated governmental action, including at the municipal level, to address the impacts of environmental instability.

This Act calls for the incorporation of concrete mitigation, adaptation, and resilience measures into territorial and land use planning instruments. By doing so, it promotes a proactive approach that strengthens communities' capacity to withstand environmental stressors and reduces long-term risks to public safety, infrastructure, and natural resources.

Act No. 107-2020, as Amended

Act No. 107-2020, as amended, known as the *Puerto Rico Municipal Code*, significantly expands the authority, responsibilities, and operational autonomy of municipal governments. The Code promotes local self-governance and enhances municipalities' capacity to manage their own affairs, including disaster preparedness and risk reduction.

Among the responsibilities granted to municipalities is the authority to design and implement programs and measures to prevent, respond to, and recover from emergencies, natural disasters, catastrophic accidents, and other hazardous events. This expanded role reinforces the importance of municipal governments in protecting public safety and community well-being.

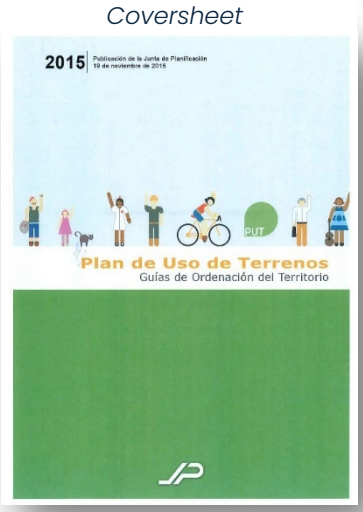
The Municipal Code also grants municipalities enhanced autonomy over land use regulation within their jurisdictions. This authority includes the application of tools such as the transfer of development rights and the evaluation and issuance of construction permits, enabling municipalities to incorporate hazard mitigation principles directly into development decisions. These powers are essential for reducing exposure to natural hazards and safeguarding lives and property.

Overall, the Municipal Code recognizes territorial planning as a critical instrument for risk mitigation and establishes a legal framework that enables municipalities to take proactive, locally tailored actions to protect their communities from natural hazards and other adverse events.

1.1.2.2 Puerto Rico Regulations

Puerto Rico Land Use Plan (PUT-PR by its Spanish acronym) - 2015

Figure 4: Puerto Rico PUT Coversheet



In compliance with Act No. 550-2004, as amended, the Puerto Rico Land Use Plan (PUT, by its Spanish acronym) constitutes the primary territorial planning instrument prepared by the Puerto Rico Planning Board. The Plan is intended to direct land use, development, and conservation activities throughout the island in a coordinated, sustainable, and resilient manner, guided by a long-term planning horizon of ten (10) years (PRPB, 2015).

One of the primary functions of the Puerto Rico Land Use Plan (PUT) is to classify land throughout the Commonwealth into specific land use categories. Land classification serves as a land administration framework that establishes the types of zoning districts and allowable uses that may be applied to individual parcels. Under the PUT, land is classified according to the following scheme:

- Urban Land (SU, by its Spanish acronym):
  This category includes areas that are already developed and served by the necessary infrastructure and public services.

- Land for Development:
  This classification applies to land identified as suitable for future development and is subdivided into two categories:
    - Programmed Development Land (SUP, by its Spanish acronym): Land scheduled for development under established programs or plans.
    - Non-Programmed Development Land (SUNP, by its Spanish acronym): Land available for development that has not yet been assigned to a specific development program.

- Rustic Land:
  Rustic lands are designated for protection, conservation, or limited use due to their environmental, agricultural, or ecological value. This classification is further subdivided into:
    - Common Rustic Land (SRC, by its Spanish acronym): Areas suitable for limited, low-intensity uses.
    - Specially Protected Rustic Land (SREP, by its Spanish acronym): Areas subject to heightened protection due to their environmental, natural, or cultural significance.

The PUT-PR aims to coordinate and harmonize land use planning efforts among state agencies and municipalities. It serves as the foundation for the preparation of municipal Land Use Plans (Planes de Ordenación Territorial, POT, by its Spanish acronym), which are adopted for an eight-year planning period (PRPB, 2015).

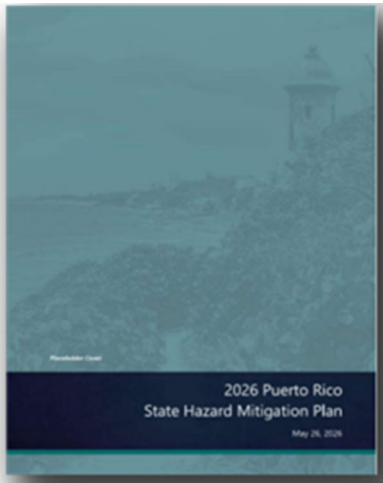
Currently, the PUT-PR is in the process of being updated for the 2026-2032 planning cycle. This revision will incorporate robust citizen participation, clearly defined compliance and performance metrics, and an inclusive planning approach that integrates economic development, green infrastructure, sustainable transportation systems, and the conservation of natural resources.

Puerto Rico State Natural Hazard Mitigation Plan (2026)

Like requirements for local jurisdictions, the Stafford Act mandates that states and territories develop a hazard mitigation plan covering their entire jurisdiction. In the case of Puerto Rico, the most recent State Hazard Mitigation Plan was completed in 2026. The Puerto Rico 2026 State Hazard Mitigation Plan outlines long-term strategies to address natural hazards that have the potential to disrupt daily activities, damage property, and threaten human life. These hazards—which in many cases are intensified by changing environmental conditions—can escalate into disasters that affect not only individuals, but entire communities, with wide-ranging impacts on

public health, infrastructure, economic stability, and natural ecosystems(NMEAD, 2026).

Figure 5: Puerto Rico SHMP Cover

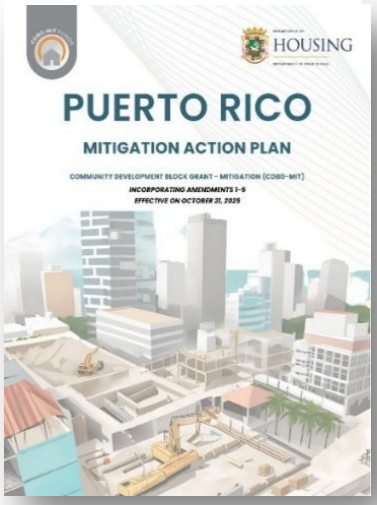


This plan provides a comprehensive framework for identifying risks and implementing actions aimed at reducing vulnerability to these hazards. Through its emphasis on mitigation, the plan seeks to increase community resilience, protect critical infrastructure and systems, and promote sustainable development throughout Puerto Rico (NMEAD, 2026).

The Municipality of Barranquitas reviewed the 2026 Puerto Rico State Hazard Mitigation Plan during the preparation of this LHMP update. The relevant risk profiles, state capabilities, mitigation goals, and state actions were considered during the risk assessment, capability assessment, and development of the municipal mitigation strategy.

Puerto Rico Mitigation Action Plan, CDBG-DR MIT (2021, 2025)

Figure 6: Puerto Rico Mitigation Action Plan Cover



Originally approved by the U.S. Department of Housing and Urban Development (HUD) in 2021 and subsequently amended in August 2025, the Puerto Rico Mitigation Action Plan for the Community Development Block Grant–Mitigation (CDBG-MIT) Program is a strategic planning document prepared by the Puerto Rico Department of Housing (PRDOH). The plan establishes the framework for the administration and management of federal mitigation funds allocated by HUD under the CDBG-MIT program.

Its primary objective is to reduce risks and vulnerabilities to future disasters by enhancing the resilience of infrastructure, communities, and critical systems. Although these funds were appropriated to Puerto Rico following Hurricanes Irma and María in 2017, CDBG–MIT funding differs from CDBG–Disaster Recovery (CDBG-DR) in that it is specifically focused on preventing and mitigating future impacts. Accordingly, CDBG-MIT resources are directed toward sustainable, high-impact mitigation projects and are not required to be directly linked

to disaster recovery activities associated with those hurricanes (PRDOH, 2025). This plan is designed to reduce exposure to hazards, safeguard lives and property, and enhance emergency response capabilities through targeted investments in infrastructure, housing, and land-use planning (PRDOH, 2025).

Other relevant planning regulations will be discussed as part of section 4.16.

1.1.3 Municipal Policies

Barranquitas Local Hazard Mitigation Plan (2020)

Adopted by the Municipal Legislature on 8/5/2020 and signed by the mayor on 8/6/2020, this is the most recent Hazard Mitigation Plan for the Municipality of Barranquitas. FEMA and the Government of Puerto Rico approved the plan on 8/10/2020, and it remained valid through 8/9/2025.

Figure 7: Barranquitas Hazard Mitigation Plan Cover



Some of the highest-priority hazards proposed by this plan are:

- **Flooding:** Development and updating of stormwater management measures, hydrologic studies, bridge and roadway improvements, enforcement of floodplain regulations, and continued participation in the National Flood Insurance Program (NFIP).

- **Hurricanes/Strong Winds:** Barranquitas has repeatedly experienced severe impacts from tropical storms and hurricanes. Due to Puerto Rico's location in the Caribbean hurricane corridor, these events have a high probability of recurring.

- **Landslides:** Barranquitas is in Puerto Rico's Central Mountain Range and is characterized by steep slopes, highly weathered soil, intense rainfall during tropical events and extensive road networks cut into mountainous terrain.

- **Earthquakes:** Puerto Rico is located near the boundary of the Caribbean and

North American tectonic plates.

- **Droughts:** The plan highlights the 2014-2016 drought, which was one of the most severe drought events experienced in Puerto Rico in recent history. During 2015, Barranquitas was classified under severe drought conditions and was subjected to water rationing.

- **Extreme Heat:** The Barranquitas Hazard Mitigation Plan identifies extreme heat as an emerging climate-related hazard that poses increasing risks to public health, agriculture, water resources, and vulnerable populations.

Barranquitas Municipal Recovery Plan

As part of the CDBG-DR funds assigned by Congress to Puerto Rico in the aftermath of hurricanes Irma and María, municipalities were able to develop a recovery plan to guide recovery efforts and resiliency in the event of future stressors. In essence, the Municipal Recovery Plans:

- Establish a long-term recovery and resilience vision for Barranquitas by integrating disaster recovery, economic development, infrastructure improvements, and community well-being into a single strategic framework.

Figure 8: Barranquitas Municipal Recovery Plan Cover



- Prioritize resilient infrastructure investments, including transportation, drainage, public facilities, utilities, and critical services, to reduce future disaster impacts and improve municipal operations.

- Promote sustainable economic and community development through downtown revitalization, support for local businesses, tourism enhancement, housing improvements, and quality-of-life projects.

- Strengthen the municipality's ability to withstand and recover from future hazards by identifying projects and actions that address vulnerabilities, protect natural resources, and enhance emergency management and institutional capacity.

Each Municipal Recovery Plan has a list of recovery and resiliency projects that might be considered as new mitigation strategies for the LHMP.

1.2 Scope and Previous Versions

1.2.1 Primary Objectives

The primary objectives of the LHMP are to:

- Identify and assess natural hazards that pose a risk to the municipality.
- Develop strategies and actions to reduce or eliminate long-term risks to life, property, and essential services.
- Promote interagency coordination and community engagement in disaster preparedness and mitigation efforts.

1.2.2 Previous FEMA Comments

The following recommendations and requirements were made by FEMA upon approving the previous 2020 LHMP for Barranquitas:

- Diversify public outreach methods and participation opportunities.
- Provide more detailed hazard extent and location information.
- Keep RL, SRL, and NFIP datasets current.
- Demonstrate how local capabilities, programs, and resources can be expanded or improved.
- Better document public input and how it influenced mitigation objectives.
- Consider urban reforestation and heat-island reduction strategies.
- Consider resilient emergency communication initiatives.
- Include formal adoption ordinances in the final submitted plan.

1.3 LHMP Organization

Table 1 shows the organization of the 2026 of Barranquitas LHMP. To help LHMP reviewers and the public understand compliance, the table includes a column specifying which FEMA-required element (FEMA, 2025) is addressed by each section.

Table 1: LHMP Organization

Chapter #	Title	Description	Review Tool Elements met
N/A	Executive Summary	This section summarizes the principal findings of the planning process, including the hazards affecting the Municipality of Barranquitas, the results of the risk assessment, and the mitigation priorities established through the LHMP update.	Local Element
Chapter 1:	Introduction and Background	This chapter presents the purpose, scope, organization, and regulatory context of the 2026 Barranquitas LHMP. It also summarizes the significant changes made since the 2020 Plan and explains how the updated plan addresses applicable federal, state, and municipal planning requirements.	E2-a
Chapter 2	Planning Process	This chapter describes the process followed to update the LHMP, including the organization of the Planning Committee, coordination with stakeholders, opportunities for public participation, review of existing plans and technical information, and documentation of the meetings and activities conducted during the planning process.	A1-a, A1-b, A2-a, A3-a, A4-a
Chapter 3	Municipal Profiles	This chapter describes the Municipality of Barranquitas, including its geographic and physical characteristics, land use,	E1-a, A1-a, A1-b, A2-a, A3-a

Chapter #	Title	Description	Review Tool Elements met
		population, housing, socioeconomic conditions, infrastructure, community lifelines, and other characteristics relevant to hazard mitigation planning.	
Chapter 4	Hazard Profiles and Risk Analysis	This chapter identifies and profiles the hazards affecting Barranquitas and evaluates their location, extent, previous occurrences, probability of future events, and potential effects on people, structures, infrastructure, community lifelines, and other municipal assets.	B1-a, B1-b, B1-c, B1-d, B1-e, B2-a, B2-b, HHPD1-a, HHPD1-b, HHPD2-a, HHPD2-b
Chapter 5	Municipal Capacities	This chapter evaluates the municipality's existing authorities, policies, plans, programs, personnel, technical resources, and financial capabilities to implement hazard mitigation measures. It also identifies opportunities to strengthen local mitigation capabilities.	C1-a, C1-b
Chapter 6	Mitigation Action Plan	This chapter establishes the municipality's mitigation goals and presents the actions proposed to reduce or avoid long-term risks associated with the identified hazards. It also documents the status of mitigation actions from the 2020 Plan and explains how the updated actions were evaluated, prioritized, and incorporated into the 2026 LHMP.	C2-a, C3-a, C4-a, C4-b, C5-a, C5-b, E2-b
Chapter 7	Plan Maintenance	This chapter establishes the procedures for monitoring, evaluating, and updating the LHMP. It also explains how the municipality will continue public participation and incorporate the plan's requirements and mitigation	D1-a, D2-a, D2-b, D2-c, D3-a

Chapter #	Title	Description	Review Tool Elements met
		actions into other municipal planning mechanisms and programs.	
Chapter 8	Adoption and Approval	This chapter documents the municipality's formal adoption of the LHMP, FEMA's approval of the plan, and the effective and expiration dates of the 2026 Barranquitas LHMP.	F1-a, F1-b
N/A	References	This section presents the sources used in updating the plan.	A4-a
N/A	Appendixes	This section includes all appendices and supplementary information related to the planning process of the Plan.	

1.4 Changes to the Barranquitas LHMP (E2-a)

Table 2 shows the most significant changes between the 2026 and 2020 versions.

Table 2: Changes to the Barranquitas LHMP

Element	Justification
Plan Language	In accordance with the Presidential Executive Order #14224, the 2026 version of Barranquitas LHMP was prepared in English for submission and review by FEMA. A non-certified Spanish translation of the final draft for public discussion and the final approved LHMP will be prepared for the benefit of individuals with limited English proficiency.
Plan organization	The organization and chapters of the document follow the template used in local mitigation plans prepared by the Puerto Rico Planning Board in 2019. However, some additions have been made to comply with current FEMA LHMP guidance.
Discussion of FEMA Lifelines	In accordance with FEMA's local hazard mitigation policy, FEMA Lifelines are discussed as well as the strategies to mitigate hazard impacts on them.

Element	Justification
Elimination of non-applicable public policy	For clarity and better readability, references to redundant public policy gaps have been removed.
Change to the name of extreme winds	The hazard identified in the 2020 Plan as Extreme Winds has been changed to Tropical Cyclones and Extreme Winds because, unlike previous versions HAZUS 6.1 can model hurricane impacts.
Update of census data	The municipality and PRPB have chosen to use the most recent version of the American Community Survey for evaluating demographic data. In this case, the PRBP have chosen to evaluate the data sets from the 202-2024 Five-Year American Community Survey. The five-year survey was selected because it provides more information than the one-year survey. If any other dataset is used, it will be indicated in a footnote.
New Hazard: High Hazard Potential Dams	Given the age of dams upstream from the municipality and the experience with the partial failure the Guajataca dam after Hurricane María, the municipality considers it appropriate to include the assessment of this hazard.
Action Plan	The Mitigation Strategies Table in Chapter 6 has been redesigned to allow for more detailed information.
Throughout the LHMP	Attention has been given to ensure that the content of the Plan does not reveal any personally identifiable information (PII).

2. Planning Process

2.1 Planning Process Regulation

This LHMP was updated in accordance with the applicable public policies and procedures identified in Chapter 1.

This LHMP seeks to aid municipality in preventing the loss of life and property from the effects of natural hazards. Chapter 1 serves as a general introduction while Chapter 2 discusses the planning process followed, including stakeholder involvement and public participation involvement. The LHMP provides a general profile of the municipality using information provided by the U.S. Census Bureau, such as population distribution, employment, housing stock, etc. (see Chapter 3 for more information). After describing the Municipalities general profile, the Plan goes on to evaluate all identifiable natural hazards that can affect the municipality and its population, including the effects on lifelines, properties, population exposure, natural resources, etc. (see Chapter 4 for more information).

Chapter 5 defines the capabilities that the municipality has for implementing the LHMP. While Chapter 6, establishes the mitigation actions that the municipality will execute for the next five years. Chapter 7 discusses the provisions for LHMP Maintenance and Chapter 8 discusses the adoption and approval of the LHMP. The appendices contain supporting information.

2.2 History of the LHMP

The original LHMP was approved by FEMA in October 2005. The first revision was completed in July 2012, and a second revision was approved in August 2020. This new 2026 version responds to changes in conditions and circumstances that have affected the municipality over the past five years. It also reflects changes based on updated FEMA Guidelines published in 2025.

2.3 Plan Preparation, Revision Schedule and Methodology (A1-a)

In accordance with federal law, local hazard mitigation plans must be updated every five (5) years for the municipality to remain eligible for federal mitigation funding. To

prepare the 2026 LHMP, the Municipality hired AtkinsRéalis Caribe, LLP as an external consultant to provide professional mitigation planning services.

The Municipality and its consultants followed the natural hazard mitigation planning process established by FEMA through the Local Hazard Mitigation Planning Guide and the Local Hazard Mitigation Planning Handbook, as well as the recommendations provided by the mitigation planning staff of COR3. The Local Mitigation Plan Review Tool provides a summary of FEMA's current minimum standards for compliance with mitigation planning requirements and identifies where each requirement is addressed within this plan.

The planning process for the 2026 update of the Barranquitas Local Hazard Mitigation Plan (LHMP) officially began with the execution of a Letter of Agreement between the Municipality of Barranquitas and the Puerto Rico Planning Board (PRPB), which was signed on December 16, 2025. A copy of the signed agreement is included in Appendix B.

Subsequently, a kickoff meeting was held on February 9, 2026, bringing together representatives from the Municipality and the PRPB to discuss the planning process, project objectives, and coordination efforts. Following this initial coordination phase, the PRPB retained AtkinsRéalis Caribe, LLP to provide technical and planning support for the development of the 2026 LHMP update and related mitigation planning activities.

The revision phase reached completion upon the official delivery of the final draft to the State Hazard Mitigation Officer (SHMO), within the Central Office for Recovery, Reconstruction and Resiliency (COR3), on Click or tap to enter a date. The revision process lasted ___ days.

2.4 Planning Committee (A1-a, A1-b)

To support the revision of the Barranquitas LHMP, a Planning Committee was established, composed of representatives from several municipal dependencies who were designated to guide the process. The members of the committee are:

Table 3: LHMP Planning Committee

Name	Position
Yamilet Guzmán Cartagena	Executive Officer for Evaluation and Compliance of Federal Funds
José Rivera Vázquez	Executive Assistant to the Mayor
Miguel A. Zayas Vázquez	Director, Office of Federal Programs
Edwin Ríos Aponte	Director, Office of Permits and Territorial Planning

The designation letter for the Planning Committee is included in Appendix B. This appendix also contains the meeting minutes, documentation of the materials discussed throughout the process, and accompanying photographic evidence.

2.5 Citizen Participation (A3-a)

2.5.1 Community Outreach and Public Participation Strategies

The public participation approach selected for this LHMP revision incorporated the following activities:

- Distribution of notification letters to agencies, neighboring municipalities, community leaders, nonprofit organizations, neighborhood associations, business or industrial groups, and other interested stakeholders, informing them that the LHMP revision process had commenced and inviting their input. Documentation of these communications is included in Appendix C.

- Publication of notices on the Municipality's website and official social media platforms to inform the public that the LHMP revision was underway. These postings also provided an email address for submitting comments and made a virtual survey to gather information regarding the community's experiences with natural hazards. Evidence of these public notices is included in Appendix C.

- Holding an initial community meeting to introduce the LHMP revision process. This step involved:

- Issuing a public announcement in a newspaper, on the Municipality's website, and across official social media channels at least 15 days before the meeting.
- Providing notice of a 15-day period for the public to submit comments or suggestions via email or in person at a specified location.

- Holding a second community meeting to present the draft LHMP for public review and discussion. This stage included:

  - Publishing a newspaper announcement and posting notices on the Municipality's website and official social media outlets at least 15 days before the meeting.
  - Confirming in the announcement that the draft plan was available for review in printed and online versions.
  - Providing an additional 15-day comment window for the community to offer feedback, either by email or by visiting the designated address.

- Holding a third community meeting to discuss the draft LHMP and the proposed mitigation strategies. This stage included the following:
  - Publishing a newspaper announcement and posting notices on the Municipality's website and official social media outlets at least 15 days before the meeting.
  - Confirming in the announcement that the draft plan was available for review in printed and online versions.
  - Providing an additional 15-day comment window for the community to offer feedback, either by email or by visiting the designated address.

2.5.2 Community Outreach and Public Participation Results

First Public Meeting Results

A public meeting notification announcing the initiation of the LHMP update process was published on February 18, 2026, in the local newspaper called "El Nuevo Día." The notification informed the public that the meeting would be held on March 9, 2026, *Centro de Recepciones y Bellas Artes*, Barranquitas, Puerto Rico, at 6:00pm. Based on the community comment forms gathered from this meeting, the following is a summary of each comment:

- Palo Hincado (Puente Cato): Deteriorated bridges, clogged drainage, and limited emergency access.
- Animal Sanctuary: Flooding and runoff threaten animal safety and facility operations.
- La Cantera (Cañabón): Landslides, flooding, and fallen trees affect access roads.
- Los Muñoz (Palo Hincado): Erosion and a single access route leave residents vulnerable to isolation.
- Torre Alta (Palo Hincado): Flooding, landslides, and falling trees/poles disrupt transportation.
- Bejucos (Palo Hincado): Slope instability and erosion damage roads and affect travel.
- Los Aguirre (Helechal): Wildfire risk, landslides, and fallen trees threaten homes and access.

In response, the Municipality incorporated these concerns into the hazard identification, risk assessment, and mitigation strategy development process. Community comments were evaluated as part of the assessment of landslide hazards and post-disaster debris management challenges. Input received during the meeting also supported the consideration of mitigation actions related to slope stabilization, reduction of landslide risks, emergency preparedness, infrastructure resilience, and debris removal following future disaster events.

Appendix C includes the notes prepared by the planning consulting firm during the activity, along with supporting evidence. All documentation complies with PII protection requirements.

Second Public Meeting Results

A public meeting notification to present the draft LHMP was published on Click or tap to enter a date. via _____. The notification informed the public that the meeting would take place on Click or tap to enter a date. in _____ at _____. It also stated that a printed copy of the draft LHMP would be available at_____ during regular work hours. Additionally, the public had the option of accessing the draft LHMP through the website _____. Copies of the public notification are included in Appendix C.

During this meeting, participants expressed the following concerns: _____.

The Municipality took the following measures to address these concerns: _____.

Appendix D includes the notes documented by the planning consulting firm during the activity, along with supporting evidence. All documentation complies with PII protection requirements.

2.6 Stakeholder Involvement (A2-a)

The Municipality carried out outreach efforts to external stakeholders, including government agencies and neighboring municipalities, through formal correspondence addressed to agency heads and mayors. Copies of these invitation letters are provided in Appendix D. Stakeholders were encouraged to submit input either via email or through participation in the public involvement process.

Input from internal stakeholders was obtained through the Planning Committee. Appendix D also includes any written correspondence received from stakeholders during this outreach process.

2.7 Hazard Analysis Data Sources

The following table presents the datasets utilized for the evaluation of each hazard. Table 4 identifies the hazards considered in this LHMP and the corresponding data sources used to support their assessment.

Table 4: Hazard and Risk Assessment of Data Sources

Hazard	Data Sources	Comments
Earthquake	United States Geological Survey (USGS), FEMA	HAZUS 6.1 was used
Landslides	USGS	
Flooding	FEMA	HAZUS 6.1 was used
Tropical Cyclones/Extreme Winds	FEMA	HAZUS 6.1 was used
Extreme Heat	National Oceanic and Atmospheric Administration	

	(NOAA)	
Drought	National Drought Index Monitor (NDIM)	
Pandemic/Epidemic	Puerto Rico Department of Health	
High Hazard Potential Dams	NID	

2.8 FEMA Lifelines

The Local Mitigation Planning Handbook and the Local Hazard Mitigation Planning Policy Guide highlight the importance of integrating critical lifelines into the hazard mitigation planning process. FEMA defines lifelines as essential services that sustain public safety, economic stability, and the continuity of government and daily life before, during, and after an emergency or disaster. These lifelines serve as a framework for prioritizing resources and actions that are essential to reducing loss of life and property and to support efficient and rapid recovery following hazard events (FEMA, 2023).

FEMA identifies eight primary lifelines:

- Safety and Security: Includes law enforcement, fire services, search and rescue operations, government services, and community safety functions.
- Food, Hydration, and Shelter: Encompasses food systems, water access, emergency shelter, and agricultural resources.
- Health and Medical: Includes medical care, public health services, patient movement, medical supply chains, and healthcare facility management.
- Energy: Covers the electrical power grid and fuel supply systems.
- Communications: Includes communications infrastructure, responder communications, alert and warning systems, financial services, 911 operations, and emergency dispatch.
- Transportation: Encompasses highways, motor vehicle systems, mass transit, railways, aviation, and maritime transportation.
- Hazardous Materials: Includes facilities and systems associated with hazardous materials, pollutants, and contaminants.
- Water Systems: Includes potable water infrastructure and wastewater collection and treatment systems.

Each of these lifelines is supported by sub-lifelines that allow jurisdictions to more precisely identify vulnerabilities and prioritize recovery actions. Together, they enable

emergency managers and decision-makers to rapidly assess conditions, focus response operations on the most critical needs, and coordinate actions that directly affect human life and community stability.

By monitoring the status and functionality of lifelines, jurisdictions can respond more effectively during emergencies, minimize cascading impacts, and accelerate a more resilient recovery. A detailed discussion of lifelines and their relevance to the Municipality of Barranquitas is provided in Section 3.5.

3. Municipal Profile

The Municipality of Barranquitas is in the central mountain region of Puerto Rico. It borders the following municipalities: to the north, Corozal and Naranjito; to the east, Comerío and Cidra; to the south, Coamo and Aibonito; and to the west, Orocovis.

Barranquitas is further subdivided into eight wards (barrios): Barrio-Pueblo, Barrancas, Cañabón, Helechal, Honduras, Palo Hincado, Quebrada Grande, and Quebradillas. Map 1 shows the municipality of Barranquitas and adjacent municipalities. Map 2 shows the ward subdivisions of the Municipality of Barranquitas. Map 3 shows the physiography of Barranquitas.

3.1 Data Sources for Municipal Profiles

The Barranquitas LHMP has been updated using the most current demographic and socioeconomic data available. The municipal profile and its demographic and socioeconomic analyses rely primarily on the 2020–2024 Five-Year American Community Survey (ACS). When specific information is not available through the ACS, alternative data sources are identified and cited in the corresponding footnotes.

In addition, the plan reflects the most up-to-date knowledge on hazards and mitigation practices. References to relevant plans, studies, and technical reports are provided in page-level footnotes and consolidated in the References section.

Most Geographic Information System (GIS) layers included in Chapter 3 were provided by the PRPB's GIS Office.

3.2 Brief Historical Background

The Municipality of Barranquitas originated as a ward of the Municipality of Coamo in 1804. Originally, it was composed of the following barrios: (1) Pueblo; (2) Helechal; (3) Palo Hincado; (4) Barrancas; (5) Quebradillas; (6) Quebrada Grande; (7) Honduras; (8) Río Hondo; (9) Comerío Alto; (10) Comerío Bajo; and (11) Orocovis. However, by 1853, its legal boundaries had been established substantially as they remain today. In 1902, this municipality, along with others, was suppressed as a municipality by virtue of the Law for the Consolidation of Certain Municipal Terms of Puerto Rico. It was not until 1905 that a new law was enacted revoking that decision and reconstituting

Barranquitas as a municipality (PRPB, 2020)[1].

The municipality has an approximate area of 34.28 square miles, of which 0.03 square miles consist of bodies of water. Since the beginning of the 16th century, there was a need to connect the southern and northern regions of the Island by crossing the Central Mountain Range. This was ultimately achieved with the establishment of the route Coamo–Barranquitas–Comerío–Barranquitas. Hence the need to establish a stopping point and shelter, which was established in Barranquitas (PRPB, 2020).

3.3 Geography

It is estimated that Puerto Rico acquired its present geographic form some 10,000 to 12,000 years ago and was shaped by a tectonic pillar that exhibits significant erosion. This resulted in an island of nearly rectangular shape, whose highest point is Cerro Punta in Jayuya, with an elevation of 4,369 feet, and lateral trenches that reach depths of 31,700 feet (Schuchert, 1968). With respect to its relief, 85% of the island lies at less than 500 meters above sea level. Approximately 14% of the land lies between 500 and 1,000 meters in elevation. The geological formations are distributed along three geomorphological regions: the central mountainous interior zone, the karst zone, and the coastal plains, with the Municipality of Barranquitas located in the central mountainous interior region (PRPB, 2020).

The rocks exposed in the Municipality of Barranquitas are the product of processes associated with subduction margins, where extrusive and intrusive igneous activity has determined the nature of the geological materials. Although the area in which the municipality is located is of volcanic origin, some Cretaceous limestones are found in deposits of limited extent. In addition, four geological formations corresponding to the Lower and Upper Cretaceous and the Quaternary periods are represented in the Municipality of Barranquitas. The Lower Cretaceous formations (K), dating from 135 to 100 million years ago, consist of lavic and volcaniclastic materials, including lava flows, breccia, tuff, and tuff breccias, deposited mainly in a marine environment, with some fine sandstones that are currently highly weathered. The geology of Barranquitas is characterized by approximately 11.72% eroded volcanic material, 22% of Formation L (mostly lavic deposits), and 50% of the Robles and Pre-Robles Formation. This formation is composed mostly of breccia or agglomerate (consolidated rock fragments, generally cemented by fine materials), as well as tuffs (volcanic igneous

[1] Many of the resources used to prepare the LHMP update are in Spanish. For uniformity, the bibliographical entries and citations of the sources will be translated into English.

rocks resulting from the consolidation of pyroclastic materials). In addition, there are small alluvial deposits (Qa) in the narrow alluvial plains of some rivers. (PRPB, 2020)

According to the previous LHMP, the municipal territory has a mountainous topography with large interior valleys due to its geological origin (Briggs & Gelabert, 1962)– (Briggs, Geologic Map of the Orocovis Quadrangle, Puerto Rico, 1971). Its mountainous relief is cut by deep valleys that dissect what was originally part of the Barranquitas Erosion Surface, which represents an ancient, elevated plain that was transformed into a plateau by the effect of an arching of the longitudinal tectonic-structural axis of Puerto Rico, as well as rapid weathering processes (Monroe, 1977). Its highest points are Cerro Farallón at 787 meters and Cerro La Torrecilla at 943 meters (PRPB, 2020).

Map 1 illustrates the geographic location and boundaries of the Municipality of Barranquitas in the central region of Puerto Rico. Barranquitas is bordered by Corozal to the north, Naranjito and Comerío to the northeast and east, Cidra to the southeast, Aibonito to the south, Coamo to the southwest, and Orocovis to the west. The municipality is highlighted with a dark boundary and satellite imagery, distinguishing it from the surrounding neighboring municipalities. An inset map indicates Barranquitas' location within Puerto Rico.

Map 2 illustrates the ward (barrio) boundaries within the Municipality of Barranquitas. The municipality is divided into eight wards: Barrio Pueblo, Barrancas, Cañabón, Helechal, Honduras, Palo Hincado, Quebrada Grande, and Quebradillas. Ward boundaries are shown in orange, while the municipal boundary is highlighted in black. The map also shows Barranquitas' location relative to neighboring municipalities, including Corozal, Naranjito, Comerío, Cidra, Aibonito, Coamo, and Orocovis. An inset map identifies the municipality's location within Puerto Rico.

Map 1: Geographic Area

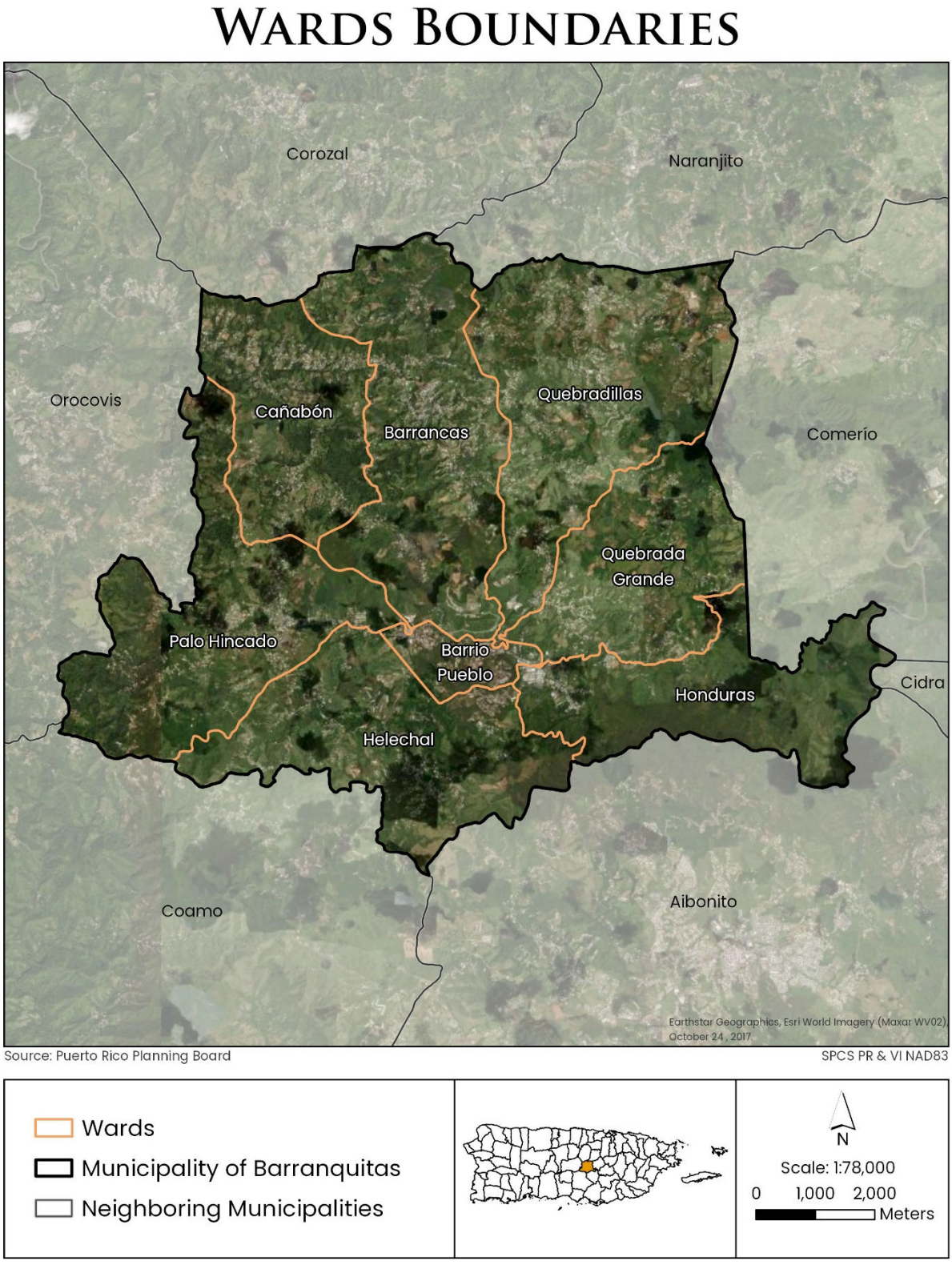
GEOGRAPHIC AREA



Source: Puerto Rico Planning Board

SPCS PR & VI NAD83

Map 2: Wards Boundaries



3.3.1 PHYSIOGRAPHY

Barranquitas is located within the Cordillera Central in Puerto Rico's central mountainous region. The municipality covers approximately 86 km² (33 mi²) and is characterized by rugged topography consisting of steep hills, narrow ridges, deep valleys, and dissected terrain. Elevations range from about 220 m (720 ft) to over 900 m (3,000 ft) above mean sea level, with an average elevation of approximately 600 m (2,000 ft) (Topographic-map.com, n.d.).

The municipality is drained by several tributaries of the La Plata River basin and contains numerous small streams and ravines that contribute to rapid runoff during heavy rainfall events. Prominent physiographic features include the San Cristóbal Canyon, which lies along the boundary with Aibonito and is one of the deepest canyons in the Caribbean region. The combination of steep slopes, highly dissected terrain, and abundant rainfall makes portions of Barranquitas susceptible to erosion, slope instability, and landslides, particularly during tropical storms and hurricanes (Wikipedia, n.d.).

The municipality's mountainous landscape supports predominantly forested and agricultural land uses, while urban development is concentrated along ridge tops and valley corridors. This physiographic setting strongly influences local drainage patterns, transportation networks, and natural hazard vulnerability (Wikipedia, n.d.).

Map 3 depicts the elevation patterns within the Municipality of Barranquitas. Elevation ranges from approximately 148 meters to 932 meters, with lower elevations shown in green and higher elevations shown in brown tones. Higher elevations are concentrated in the western, southwestern, and central portions of the municipality, particularly within Palo Hincado, Cañabón, and parts of Barrancas, while lower elevations are more prominent in the eastern and southeastern areas, including Honduras and portions of Quebrada Grande. Ward boundaries are delineated with dashed lines, illustrating the distribution of terrain across the municipality.

Map 3: Physiography

PHYSIOGRAPHY



Source: Puerto Rico Planning Board and United States Geological Survey

SPCS PR & VI NAD83

Elevation (Meters)
932.247
148.319

Wards
Municipality of Barranquitas
Neighboring Municipalities



N

Scale: 1:78,000

0 1,000 2,000 Meters

3.3.2 Soil Types

The soils within the municipal territory are composed, for the most part, of the Humatas, Múcara, Maricao, and Caguabo associations. These soils are derived from igneous, metamorphic, and sedimentary rocks of the Cretaceous Period. The Múcara-Caguabo associations inlcude soils ranging from shallow to moderately deep, with slopes ranging from moderately inclined to steep (5% to 90%). These soils are well drained due to their formation from the decomposition of volcanic rock. The Consumo-Humatas associations are distinguished by leached, loamy, and clayey soils that are sticky and plastic, lying over hard and/or weathered rock in a humid to very humid climate (Quiñones & Palacios, 2004). Within these associations, the municipal territory is composed predominantly of the following series:

- Humatas (clay) – 39% of the soil. The Humatas series consists of very deep, well-drained soils with moderately slow permeability. They are formed in clayey and silty material weathered from igneous rocks. The average annual precipitation in the areas where this soil is most prevalent is approximately 78 inches, and the average annual temperature is approximately 75°F. Slopes range from 20 to 60 percent.

- Múcara (clay) – 20% of the soil. The Múcara series consists of moderately deep, well-drained, moderately permeable soils located on the summits and side slopes of hills, mountains, and humid interior valleys. They are formed from the weathering of basalt lava and breccia. In this area, the average annual temperature is approximately 77°F and the average annual precipitation is approximately 57 inches. Slopes range from 12 to 60 percent.

- Maricao (clay) – 18% of the soil. The Maricao series consists of very deep, well-drained, moderately permeable soils on the summits and side slopes of mountains and humid interior valleys. They are formed from residues of weathered basalt. The average annual temperature in these areas is approximately 71°F, and the average annual precipitation is approximately 77 inches. Slopes range from 20 to 60 percent.

- Caguabo (clay) – 9% of the soil. The Caguabo series consists of shallow, well-drained, and moderately permeable soils on the side slopes of strongly dissected uplands. They formed from the weathering of basalt. The average annual precipitation in these areas is approximately 80 inches, and the average

annual temperature is 76ºF. Slopes range from 40 to 60 percent (United States Department of Agriculture (USDA, 2018).

3.3.3 Hydrography

Due to the steepness of most of the municipal territory, Barranquitas exhibits an extensive dendritic drainage pattern. The municipality's streams range from first- to fourth-order streams (Strahler, 1952). Because of tectonic deformation structures and their erosion dynamics, formations such as the San Cristóbal Canyon have developed, whose channel forms part of the municipal boundary of Aibonito, and Las Bocas Canyon, which lies along the municipal boundary with Comerío (PRPB, 2020).

The Río Grande de Manatí originates in Barrio Barrancas, at an elevation of 2,224 feet (678 m) above sea level and has an approximate length of 25 miles (40.2 km) from its source to its mouth in the Atlantic Ocean. This river passes through the municipalities of Barranquitas, Corozal, Orocovis, Morovis, Ciales, Manatí, and Barceloneta. The Río Grande de Manatí watershed also includes the municipalities of Florida and Jayuya and ranks third in streamflow in Puerto Rico and among similar watersheds (PRPB, 2020).

The Río Barranquitas originates between Barrios Palo Hincado and Helechal and is a tributary of the Río Usabón, which, together with geological processes, contributed to the formation of the San Cristóbal Canyon. This river constitutes the physical boundary between Aibonito and Barranquitas and is, in turn, an important tributary of the Río La Plata, which is temporarily impounded in the La Plata Reservoir and ultimately empties into the Atlantic Ocean (PRPB, 2020).

The Río Cañabón originates in the barrio of the same name and is a tributary of the Río Botijas. The Río Botijas forms the physical boundary between Barrio Botijas in the Municipality of Orocovis and the Barrios Palo Hincado and Cañabón of Barranquitas, where it originates. This river is another important tributary of the Río Grande de Manatí (PRPB, 2020).

The Río Frío and Río Caliente are other principal tributaries of the Río Hondo, which is itself an important tributary of the Río de La Plata. The former originates in Barrio Quebradillas, while the Río Hondo originates in Barrio Palomas in Comerío, but with the tributaries in Barranquitas (PRPB, 2020).

Although the Río Aibonito originates in Barrio Llanos of the municipality of the same name, it is an important tributary of the Río Usabón (PRPB, 2020).

In addition to these important rivers, Barranquitas has other significant bodies of water, such as Quebrada Helechal, Quebrada Grande, and Quebrada Padilla. The first is a tributary of the Río Usabón, the second is a tributary of the Río Hondo, and the latter is a tributary of the Río Barranquitas (PRPB, 2020).

There are also other streams, such as Quebrada Higüero, which is located in Comerío, although its catchment area lies between Barranquitas and Comerío; Quebrada La Revés, which falls within the jurisdiction of Orocovis but has its catchment area in Barranquitas; Quebrada Prieta, which originates in Barranquitas and flows toward Comerío; Quebrada Tigre, which originates in Barranquitas and flows along the municipal boundary with Comerío; and Quebrada Alicia, which originates in Barranquitas and flows toward Aibonito (PRPB, 2020).

Map 4 shows an extensive network of rivers and streams distributed throughout the Municipality of Barranquitas. Major watercourses labeled on the map include Río Cañabón along the western boundary, Río Frío in the northeastern sector, Río de Barranquitas in the central portion of the municipality, and Río Usabón and Río La Plata along the southeastern boundary. Numerous tributaries branch across the municipality, forming a dense drainage network that extends throughout Barranquitas and connects to the primary rivers shown on the map.

Map 4: Hydrography

HYDROGRAPHY



Source: Puerto Rico Planning Board and United States Geological Survey

SPCS PR & VI NAD83

Hydrography
Municipality of Barranquitas
Neighboring Municipalities



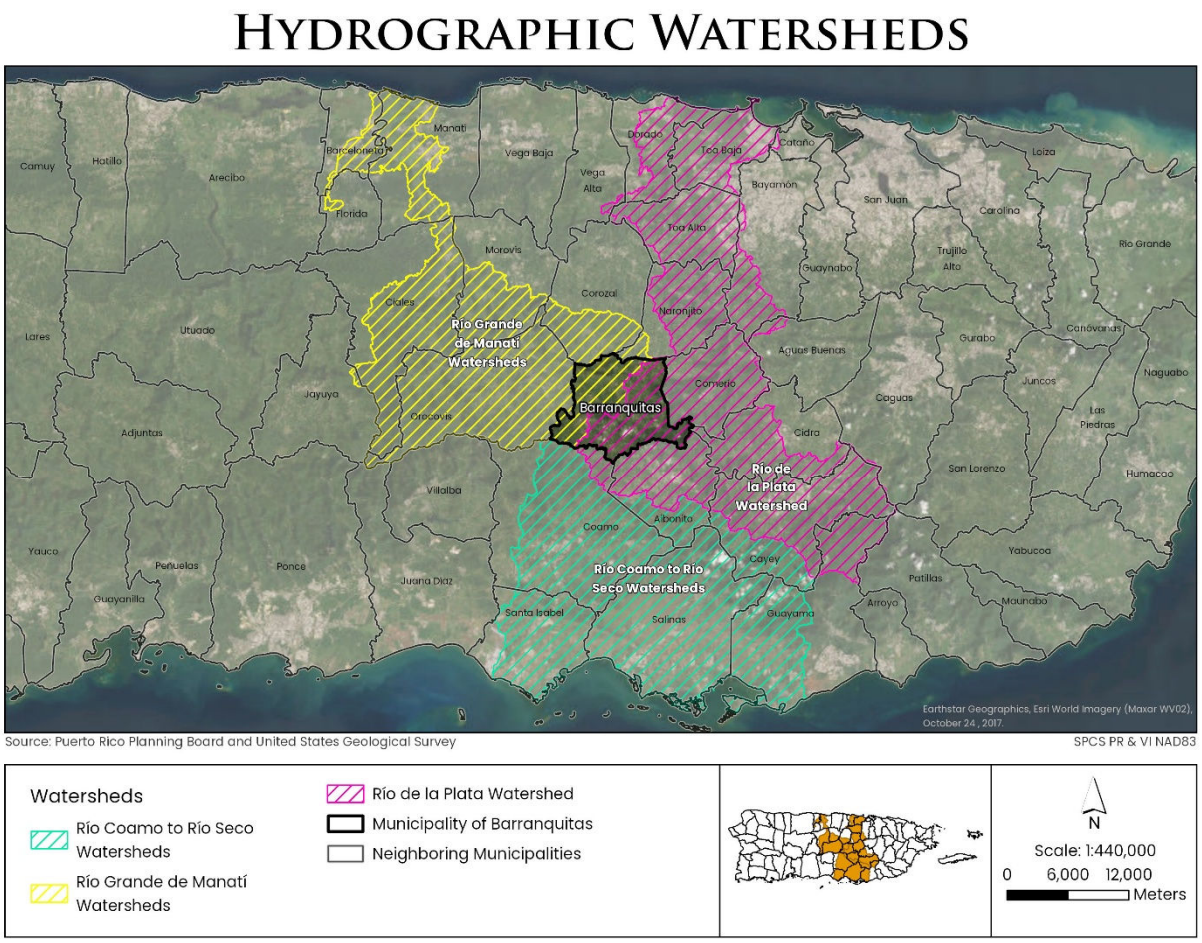
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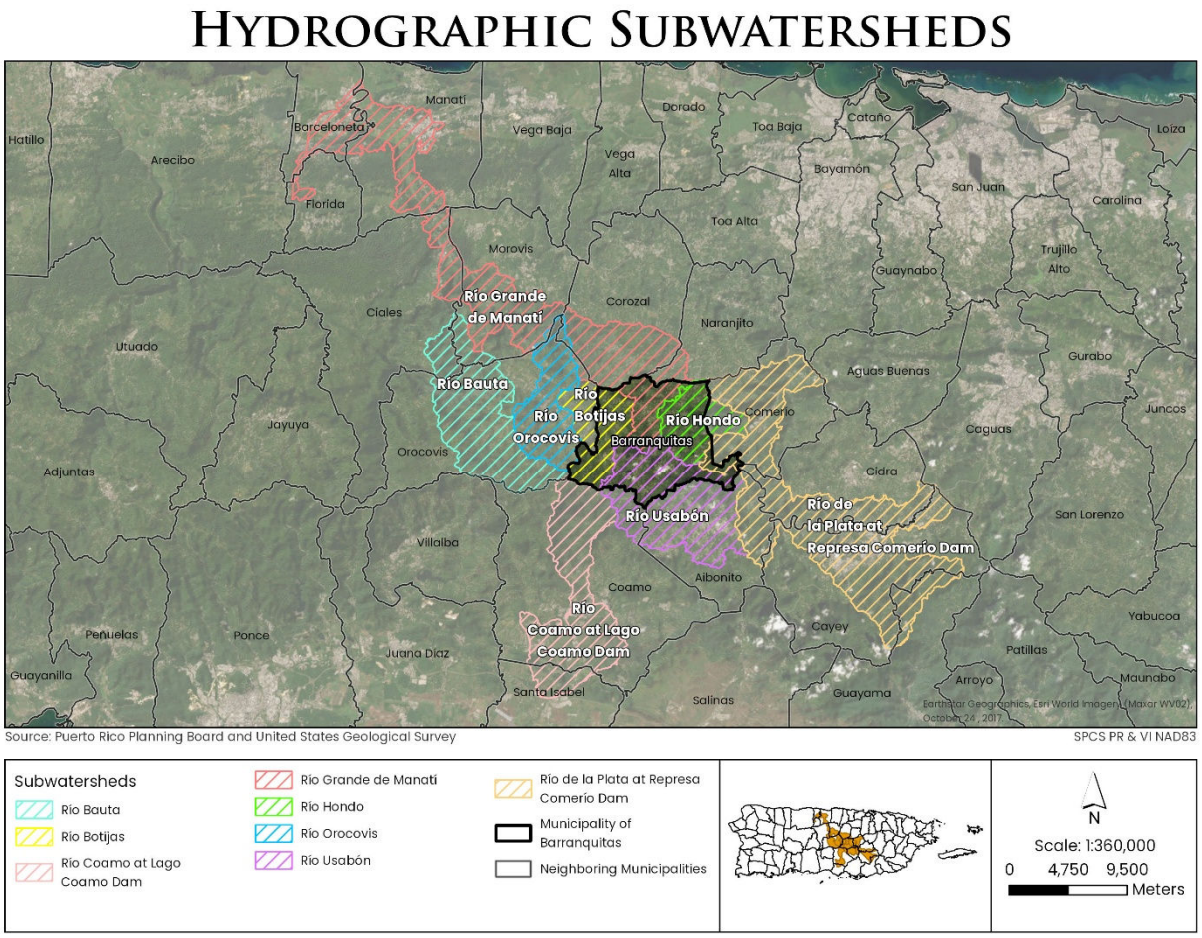
Meters

Map 5: Hydrographic Watersheds



The map shows the location of Barranquitas relative to three major watersheds in Puerto Rico. The municipality is situated at the intersection of the Río Grande de Manatí Watersheds (yellow), the Río de la Plata Watershed (magenta), and the Río Coamo to Río Seco Watersheds (cyan). The municipal boundary overlaps portions of all three watershed areas, indicating that Barranquitas spans multiple watershed systems.

Map 6: Hydrographic Sub-Watersheds



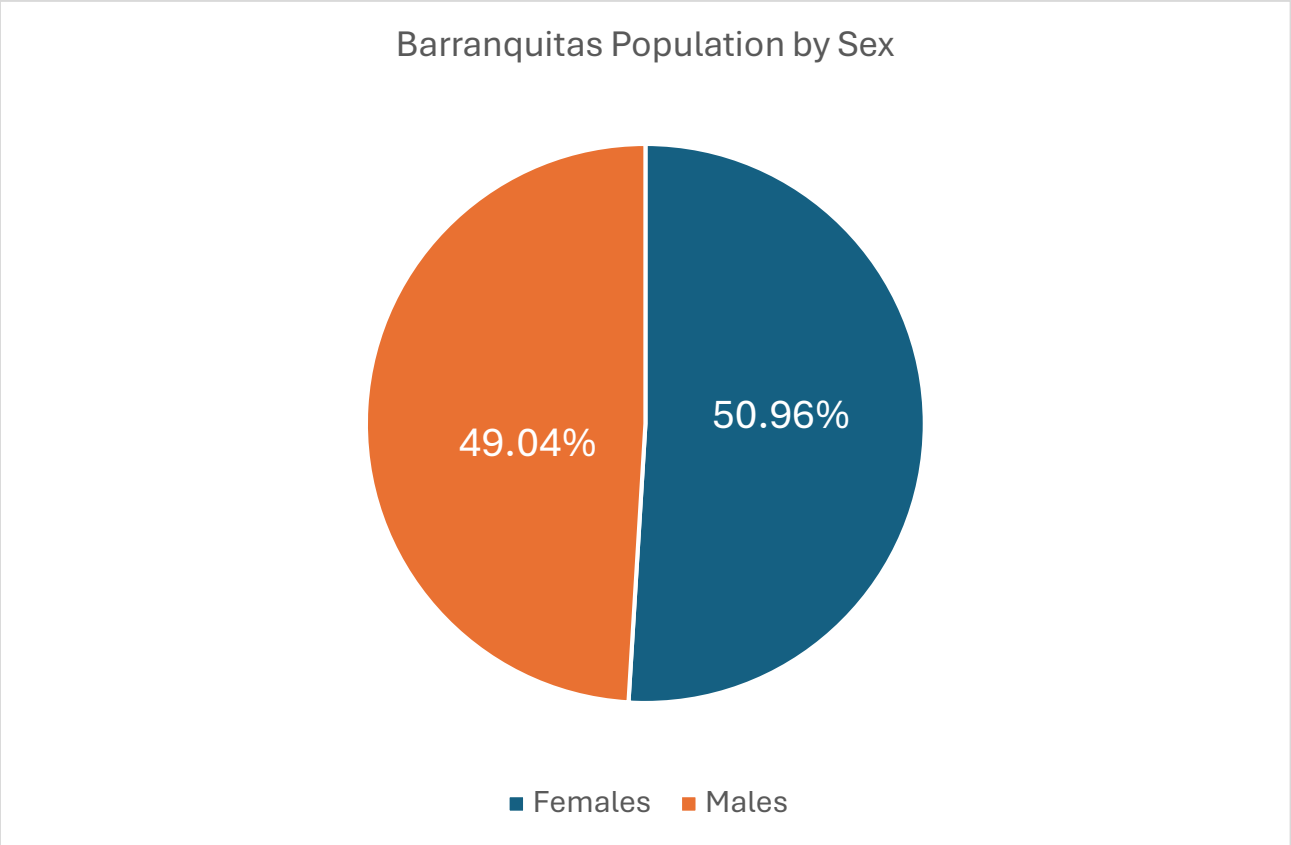
The map shows the location of the Municipality of Barranquitas within several hydrologic subwatersheds. The municipality overlaps portions of the Río Hondo, Río Botijas, Río Orocovis, and Río Usabón subwatersheds, while also bordering the Río Grande de Manatí, Río Coamo at Lago Coamo Dam, and Río de la Plata at Represa Comerío Dam subwatersheds. The municipal boundary is outlined in black, and the surrounding subwatersheds are distinguished by different colors and patterns.

3.4 Demographics

3.4.1 Current Population

According to the 2020-2024 American Community Survey, Five-Year Estimates (ACS 2024)[2] the total population of Barranquitas is 29,054. Of these, 14,247 persons are male and 14,807 are female. The percentage split is 49.04 percent male, 50.96 percent female. The sex ratio is 96.20 males per 100 females (US Census Bureau, 2025).

Figure 9: Barranquitas Population by Sex (2024 ACS)



According to the 2024 ACS, a total of 5,629 people in Barranquitas were 65 or older (19.37%). This constitutes approximately one-fifth of the total population of Barranquitas. Meanwhile, 2,512 people, representing 8.64% of the population, are 75 years of age or older.

Among the younger age groups, Barranquitas has 6,330 (21.79%) people who are 19

[2] Unless otherwise stated, all data and analysis are from the 2024 Five-Year American Community Survey (ACS) Data Set for Barranquitas.

years old or younger. Of those, 2,868 (9.87%) are 9 years old or younger. This LHMP considers people younger than 18 and older than 64 as vulnerable. Accordingly, 11,959 residents of Barranquitas (41.16% of the population) are especially vulnerable to the effects of a natural disaster.

The following table distributes the current population of Barranquitas by age groups in five-year cohorts and compares the rate of change between 2024 and 2019. For example, the total rate of change in Table 5 tells us that Barranquitas experienced a 2.33 percent increase in total population between 2019 and 2024. Figure 10 shows the same age group distribution as a bar chart. Figure 11 shows the population pyramid for Barranquitas, illustrating a larger share of the population concentrated in older age groups compared to younger age groups within the municipality.

Table 5: Population by Age Group 2024 ACS vs 2019 ACS

Age Cohort	Population 2024	Percentage 2024	Population 2019	Percentage 2019	Net Change	Rate of Change
Under 5 years	1,093	3.76%	1,575	5.55%	-482	-30.60%
5 to 9 years	1,775	6.11%	1,816	6.40%	-41	-2.26%
10 to 14 years	1,633	5.62%	1,828	6.44%	-195	-10.67%
15 to 19 years	1,829	6.30%	2,079	7.32%	-250	-12.03%
20 to 24 years	1,899	6.54%	2,235	7.87%	-336	-15.03%
25 to 29 years	2,100	7.23%	2,088	7.35%	12	0.57%
30 to 34 years	2,032	6.99%	1,826	6.43%	206	11.28%
35 to 39 years	2,123	7.31%	2,010	7.08%	113	5.62%
40 to 44 years	1,521	5.24%	1,274	4.49%	247	19.39%
45 to 49 years	1,578	5.43%	1,688	5.95%	-110	-6.52%
50 to 54 years	1,762	6.06%	2,005	7.06%	-243	-12.12%
55 to 59 years	2,102	7.23%	1,933	6.81%	169	8.74%
60 to 64 years	1,978	6.81%	1,739	6.12%	239	13.74%
65 to 69 years	1,731	5.96%	1,331	4.69%	400	30.05%
70 to 74 years	1,386	4.77%	1,176	4.14%	210	17.86%
75 to 79 years	1,273	4.38%	805	2.84%	468	58.14%
80 to 84 years	707	2.43%	545	1.92%	162	29.72%
85 years and over	532	1.83%	440	1.55%	92	20.91%
Total	29,054		28,393		661	2.33%

Source: US Census ACS 2020-2024

Findings show that Barranquitas population increased from 28,393 residents in 2019 to 29,054 residents in 2024, representing a net increase of 661 residents, or 2.33%. Despite this overall growth, the younger population generally declined. The population under 5 years of age experienced the largest decrease, falling by 30.60%, while the populations aged 5 to 9 and 10 to 14 decreased by 2.26% and 10.67%, respectively. Declines were also observed among residents aged 15 to 24, including decreases of 12.03% for those aged 15 to 19 and 15.03% for those aged 20 to 24. However, several working-age groups increased, particularly those aged 40 to 44, which grew by 19.39%.

In contrast, all age groups 60 years and older experienced population growth. The most substantial increase occurred among residents aged 75 to 79, whose population grew by 58.14%. Other notable increases occurred among residents aged 65 to 69 at 30.05%, those aged 80 to 84 at 29.72%, and those aged 85 years and older at 20.91%. These patterns indicate that, although the municipality experienced modest overall population growth, its age distribution is shifting toward older age groups, which may affect future healthcare needs, emergency preparedness, workforce availability, and community services

Figure 10 shows the same age group distribution in a bar chart form. Figure 11 shows the population pyramid for Barranquitas. As can be seen in Figure 11 in the irregular population pyramid shows the higher population share of the older groups versus the younger groups in the municipality.

Figure 10: Barranquitas Population by Age Group (ACS 2024)

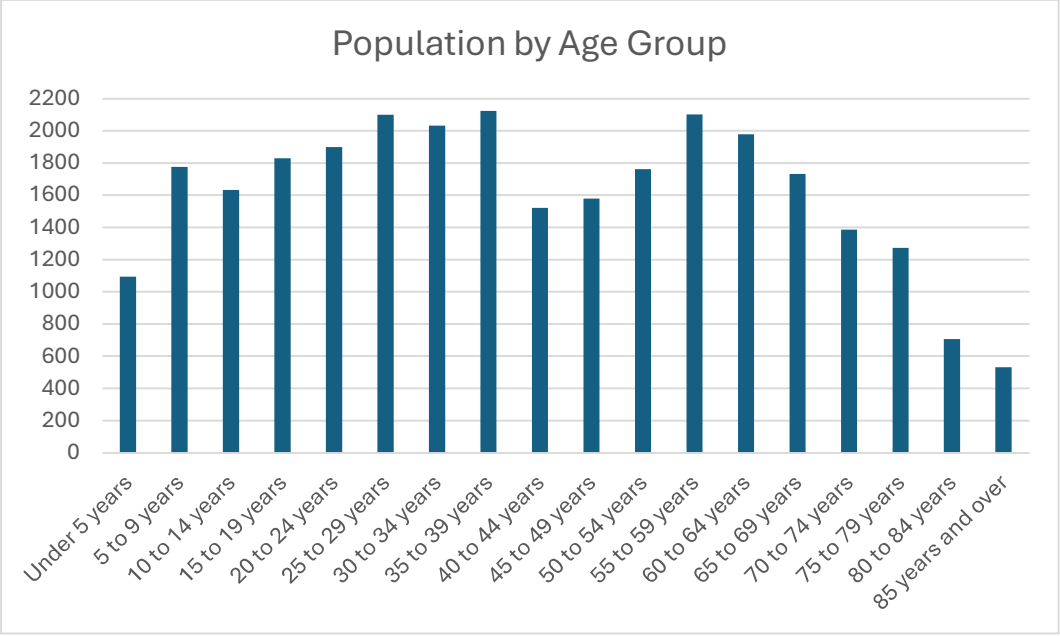
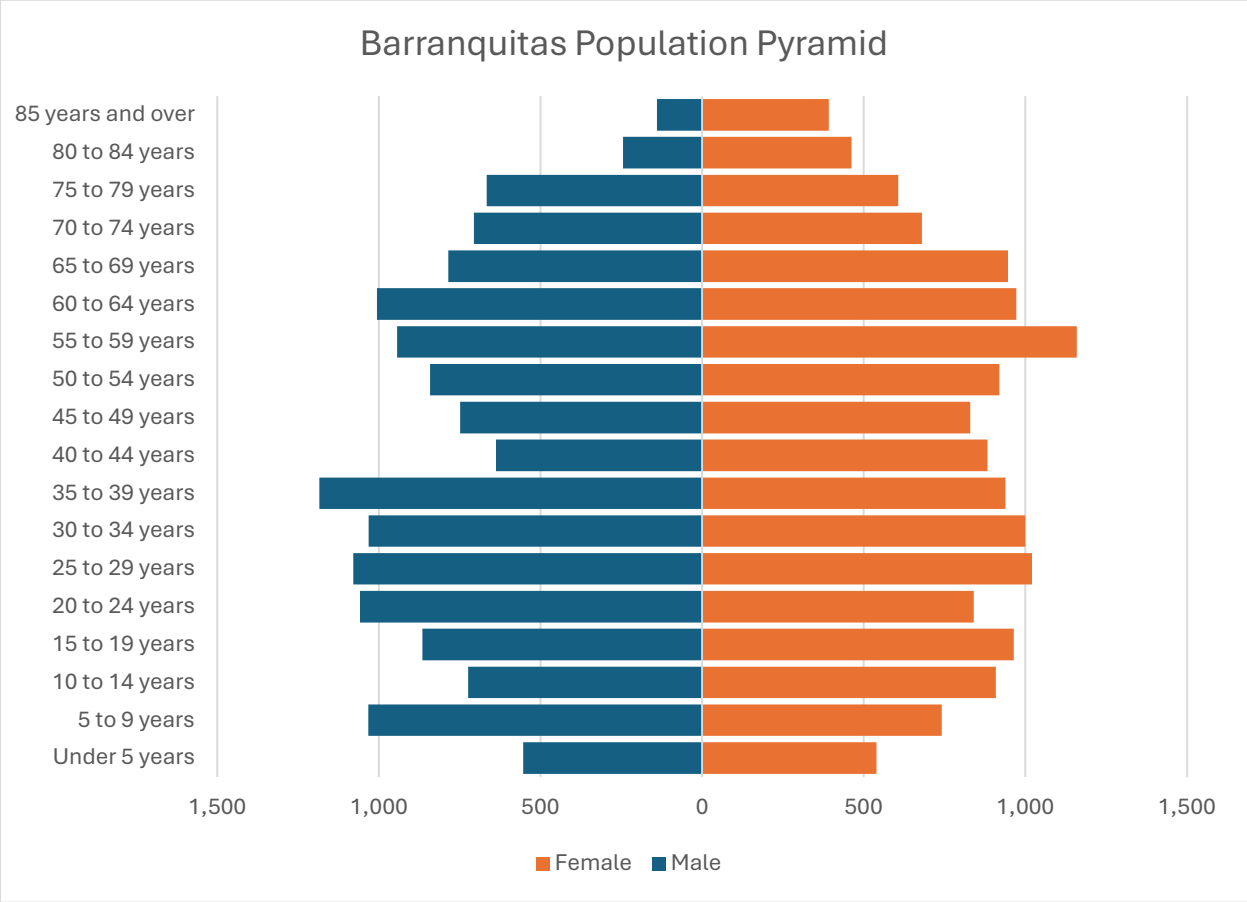
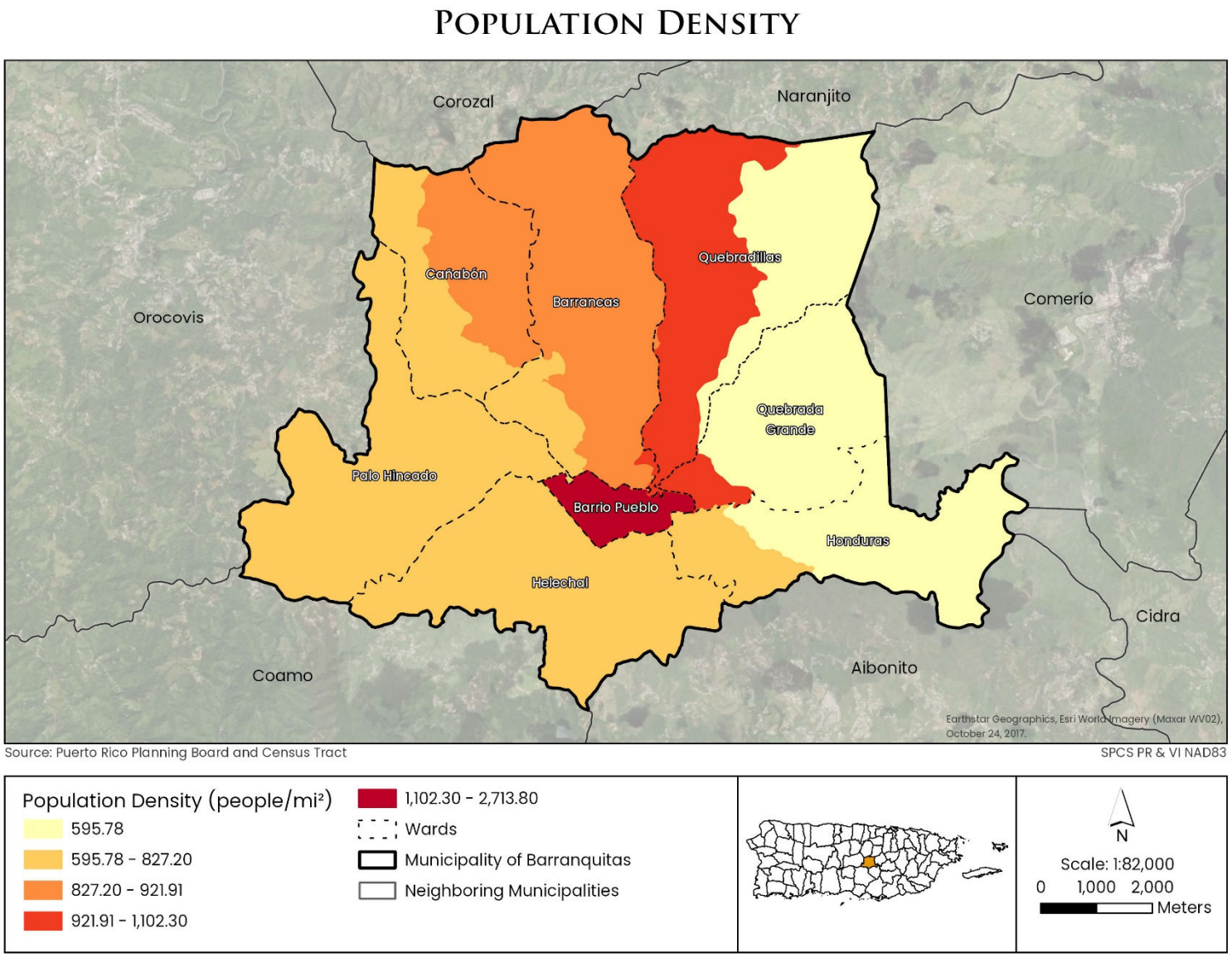


Figure 11: Barranquitas Population Pyramid (2024 ACS)



Map 7: Population Density by Census Tract



The population density map shows variations in population density across the wards of Barranquitas. The highest population densities are concentrated in Barrio Pueblo and portions of Quebradillas, while lower population densities are present in Honduras, Quebrada Grande, Palo Hincado, and Helechal. Population density values range from approximately 595.78 to 2,713.80 people per square mile, with darker shades representing areas of greater population concentration. Ward boundaries and the municipal boundary are also displayed, along with neighboring municipalities.

3.4.2 Socio-economic Characteristics

3.4.2.1 Employment

Table 6 shows the employment status for the municipality according to the 2020-2024 Five-Year ACS.

Table 6: Current Labor Force Statistics[3]

Variable	Estimate 2024	Percentage 2024
Population 16 years and over	24,152	
In Labor Force	10,849	44.92%
Civilian Labor Force	10,819	44.80%
Employed	9,443	39.10%
Unemployed	1,376	5.70%
Armed Forces	30	0.12%
Not in Labor Force	13,303	55.08%
Unemployment rate		12.68%

Source: US Census ACS 2020-2024

According to the 2020-2024 ACS 5-Year Estimates, Barranquitas had a labor force participation rate of 44.92 percent among the population aged 16 years and older, indicating that fewer than half of working-age residents were employed or actively seeking employment. The remaining 55.08 percent of the population aged 16 and over was not participating in the labor force. Compared with the 2015-2019 ACS 5-Year Estimates, the municipality's labor force participation rate increased from 37.08 percent to 44.92 percent. Despite this improvement, Barranquitas continues to have a slightly lower labor force participation rate than Puerto Rico overall, which reported a participation rate of 46.40 percent. Lower labor force participation may indicate a reduced economic base and a greater proportion of residents who could face challenges in preparing for, responding to, and recovering from hazard events.

[3] US Census Table DP03: Selected Economic Characteristics. The civilian labor force includes non-institutionalized civilians aged 16 years and older who are either employed or actively seeking employment. The labor force is broader, as it includes both the civilian labor force and members of the Armed Forces on active duty. Institutionalized individuals, such as those residing in prisons or nursing homes, are not included in either category.

The 2024 ACS showed an unemployment rate for the municipality of 12.68%. This represents a 5.43% decrease regarding the 2015-2019 Five-Year ACS unemployment rate which was 18.11%. Compared with Puerto Rico the unemployment rate is higher (12.68% for Barranquitas vs 10.70% for Puerto Rico).

The following table presents employment by industry within the municipality, comparing data from the ACS 2020-2024 Five-Year Estimates with the 2015-2019 Five-Year Estimates. The final column reflects the percentage change in employment by industry between the two survey periods.

Table 7: Employment by Industry 2024 ACS vs 2019 ACS

Industry	ACS 2024 Five Year	Percentage 2024	ACS 2019 Five Year	Percentage 2019	Net Change between 2024 and 2019[4]	Rate of Change
Agriculture, forestry, fishing and hunting and mining	245	2.59%	94	1.35%	151	160.64 %
Construction	1,227	12.99%	718	10.35%	509	70.89%
Manufacturing	914	9.68%	774	11.16%	140	18.09%
Wholesale Trade	342	3.62%	158	2.28%	184	116.46%
Retail Trade	1,311	13.88%	840	12.11%	471	56.07%
Transportation and warehousing, and utilities	350	3.71%	195	2.81%	155	79.49%
Information	40	0.42%	111	1.60%	-71	-63.96%
Finance and Insurance, and real estate and rental and leasing	110	1.16%	166	2.39%	-56	-33.73%
Professional, scientific, and management, and administrative and waste management services	969	10.26%	561	8.09%	408	72.73%
Educational services, health care and social assistance	2,285	24.20%	1,890	27.24%	395	20.90%
Arts, entertainment, recreation, and accommodation and food services	456	4.83%	645	9.30%	-189	-29.30%

[4] Rate of percentage change is calculated as $Percentage\ Change = \frac{new\ value - original\ value}{original\ value} \times 1$

Industry	ACS 2024 Five Year	Percentage 2024	ACS 2019 Five Year	Percentage 2019	Net Change between 2024 and 2019[4]	Rate of Change
Other services, except public administration	567	6.00%	321	4.63%	246	76.64%
Public administration	627	6.64%	465	6.70%	162	34.84%
Total employee population 16 years and over	9,443	-	6938	-	2,505	36.10%

Source: US Census ACS 2020-2024 5 years Estimates

Table 7 shows the following employment characteristics for Barranquitas:

According to the 2020-2024 ACS 5-Year Estimates, Educational Services, Health Care, and Social Assistance remained the largest employment sector in Barranquitas, accounting for 2,285 workers, or 24.20 percent of total employment. Although this sector continued to represent the largest share of the employed population, its share declined from 27.24 percent in 2019 to 24.20 percent in 2024. Nevertheless, employment in the sector increased by 395 workers, representing a 20.90 percent increase over the period.

Other major employment sectors in 2024 included Retail Trade (13.88 percent), Construction (12.99 percent), Professional, Scientific, Management, Administrative, and Waste Management Services (10.26 percent), and Manufacturing (9.68 percent). Together, these sectors accounted for nearly half of the municipality's employed population.

Comparison with the 2015-2019 ACS 5-Year Estimates indicates that employment increased in 10 of the 13 industry categories evaluated. The largest percentage increases were recorded in Agriculture, Forestry, Fishing and Hunting, and Mining (160.64 percent), Wholesale Trade (116.46 percent), Transportation and Warehousing and Utilities (79.49 percent), Other Services except Public Administration (76.64 percent), Professional, Scientific, Management, Administrative, and Waste Management Services (72.73 percent), and Construction (70.89 percent). The largest numerical increases occurred in Construction (+509 workers), Retail Trade (+471 workers), Professional, Scientific, Management, Administrative, and Waste Management Services (+408 workers), and Educational Services, Health Care, and Social Assistance (+395 workers).

Employment declines were limited to three sectors. The Information sector experienced the largest decline, decreasing by 71 workers or 63.96 percent, followed by Finance and Insurance, Real Estate, and Rental and Leasing, which declined by 56 workers or 33.73 percent, and Arts, Entertainment, Recreation, Accommodation, and Food Services, which declined by 189 workers or 29.30 percent.

Overall, the employed population increased from 6,938 workers in 2019 to 9,443 workers in 2024, representing a net increase of 2,505 workers and a 36.10 percent increase. These trends indicate broad employment growth across most sectors of the municipality's economy during the study period.

3.4.2.2 Poverty Level

The table below summarizes poverty estimates for Barranquitas based on the 2020-2024 ACS 5-Year Estimates. Poverty levels are an important indicator of socioeconomic vulnerability because they can affect a household's ability to prepare for, withstand, and recover from hazard events. The data indicate that approximately 49 percent of the municipality's population lived below the poverty level during the survey period, representing nearly one-half of all residents. This high poverty rate may increase the vulnerability of the population to the impacts of natural hazards.

Table 8: 2024 ACS Poverty Level

Total Population	Number of Individuals below the poverty level during the last 12 months	Percentage of the Population below the poverty level in the last twelve months
28,977	14,057	48.50%

Source: US Census ACS 2020-2024

3.4.2.3 Income

According to the 2024 ACS, the median household income for Barranquitas was $23,047, while the mean household income was $34,619. The following table shows the estimated income and benefits for households in the municipality.

Table 9: 2024 ACS Income and Benefits per Household

Category	Number of Households	Percentage
Less than $10,000	2,449	24.46%
$10,000 to $14,999	854	8.53%
$15,000 to $24,999	1,934	19.31%
$25,000 to $34,999	1,473	14.71%
$35,000 to $49,999	1,347	13.45%
$50,000 to $74,999	1,030	10.29%
$75,000 to $99,999	393	3.92%
$100,000 to $149,999	380	3.79%
$150,000 to $199,999	116	1.16%
$200,000 or more	38	0.38%
Total Households	10,014	100.00%

Source: US Census ACS 2020-2024

Table XX summarizes household income distribution in Barranquitas based on the 2020-2024 ACS 5-Year Estimates. The data indicates that 24.46 percent of households reported annual income below $10,000, while 52.30 percent reported annual income below $25,000. Although a substantial portion of households remained within the lower-income categories, these percentages represent an improvement compared with the 2015-2019 ACS 5-Year Estimates, when 31.40 percent of households reported incomes below $10,000 and 63.78 percent reported incomes below $25,000.

Comparison of the 2020-2024 and 2015-2019 ACS 5-Year Estimates suggests a shift toward higher household income ranges within the municipality. The most notable growth occurred among households with annual incomes between $150,000 and $199,999, which experienced the largest increase during the study period. Overall, the distribution reflects a decrease in the proportion of households in the lowest income categories and an increase in the number of households within higher income brackets.

3.4.2.4 Population with Disabilities

Table 10 presents data on individuals living with disabilities based on the 2020–2024 and 2015–2019 Five-Year Estimates from the American Community Survey datasets. It shows that overall, Barranquitas experienced net decrease of 950 people living with disabilities in the municipality. All age groups experienced a reduction in their population except for the age group of 65-to-74-year age group (with a rate of

change 14.59%) and the 75 years and over (rate of change 42.36%). This data is particularly important for the LHMP update as the relevant literature shows that people with disabilities are especially vulnerable to natural hazard events.

Table 10: Population living with disabilities

Age Group	2024	2019	Net change	Rate of change
Under 5 years	22	27	-5	-18.52%
5 to 17 years	421	755	-334	-44.24%
18 to 34 years	445	509	-64	-12.57%
35 to 64 years	2,178	3,337	-1159	-34.73%
65 to 74 years	1,304	1,138	166	14.59%
75 years and over	1,499	1,053	446	42.36%
Total Population living with a disability	5,869	6,819	-950	-13.93%

Source: US Census ACS 2020-2024 and 2015-2019 5-years Estimates

3.4.2.5 Population receiving supplemental nutritional support

Table 11 provides information on households in Barranquitas that receive food assistance, based on data from the 2020–2024 and 2015–2019 American Community Survey (US Census Bureau, 2025).

Table 11: Population receiving food aid

Data Set	2024	2019	Net Change	Rate of Change
Total Households in the municipality	10,014	8,720	1,294	14.84%
Households receiving food assistance	6,216	4,923	1,293	26.26%
Percent of Households receiving food assistance	62.10	56.50	-	-
Households with children under 18	3,011	2,859	152	5.32%
Married Couple	1,059	996	63	6.33%
Male Householder, no spouse present	1,023	429	594	138.46%
Female Householder, no spouse present	1,280	1,434	154	-10.74%
Households with one or more people 60 years and over	5,063	4,097	966	23.58%

Source: US Census ACS 2020-2024 and 2015-2019 5-years Estimates

As shown in the table above, the number of households in Barranquitas increased by 14.84 percent between 2015-2019 and 2020-2024 ACS 5-Year Estimates. During the

same period, the number of households receiving food assistance increased by 26.26 percent. Because participation in food assistance programs grew at a faster rate than the overall number of households, a larger share of households relied on nutritional assistance in 2024 than in 2019. This trend may indicate that economic challenges continue to affect a significant portion of the municipality's population despite overall household growth.

3.4.2.6 Health Insurance Coverage

The next table shows the 2020-2024 health insurance coverage for the municipality.

Table 12: 2024 ACS Health Insurance Data

Variable	Estimate 2024	Percentage 2024
Civilian noninstitutionalized population	28,964	
With health insurance coverage	28,213	97.41%
With private health insurance	8,242	28.46%
With public coverage	21,719	74.99%
No health insurance coverage	751	2.59%

Source: US Census ACS 2020-2024

The data show that 751 people (2.59%) in Barranquitas have no health insurance coverage. Meanwhile, almost three-quarters (74.99%) have public health coverage. This data will be revisited when discussing the hazard of pandemic/epidemic.

3.4.3 Housing Stock and other Related Details

According to the 2024 ACS, Barranquitas had 11,843 housing units of which 1,829 were vacant. Vacant housing units account for approximately one-sixth of the municipality's total housing inventory.

The next table shows the year of construction of the housing units by range.

Table 13: 2024 ACS- Housing Units by Year of Construction

Year Structure Built	Housing Units	Percentage
Built 2020 or later	41	0.30%
Built 2010 to 2019	765	6.50%
Built 2000 to 2009	1,606	13.60%
Built 1990 to 1999	1,953	16.50%
Built 1980 to 1989	2,531	21.40%
Built 1970 to 1979	2,191	18.50%
Built 1960 to 1969	1,552	13.10%
Built 1950 to 1959	460	3.90%
Built 1940 to 1949	288	2.40%
Built 1939 or earlier	456	3.90%
Total	11,843	100%

Source: US Census ACS 2020-2024

The 2024 ACS shows that more than half of the housing stock was built between 1970 and 1999. The latest Building Code was adopted by the government of Puerto Rico in 2018, before that, the most recent version of the Building Code was adopted in 2011. This means that at least 93.19% of the housing stock was built before the current and immediately preceding building codes.

The following table shows the vehicles available per occupied housing units.

Table 14: 2024 ACS Vehicle per occupied housing unit

Variable	Occupied Housing Units	Percentage
No vehicles available	924	9.20%
1 vehicle available	3,803	38.00%
2 vehicles available	3,435	34.30%
3 or more vehicles available	1,852	18.50%
Total	10,014	

Source: US Census ACS 2020-2024

The 2024 ACS shows that there are 924 occupied housing units (9.20%) have no vehicle available in Barranquitas. This represents significant mobility concern since the development pattern in the municipality is rural and/or suburban, where

vehicular transportation is necessary for mobility.

3.5 Infrastructure

Infrastructure refers to the essential physical and organizational systems that support the effective functioning of a society or economy. It includes critical networks such as transportation systems (roads, bridges, railways), energy generation and distribution, water supply, telecommunications, and other services that sustain economic activity and daily life. Collectively, infrastructure serves as the foundational framework that enables communities and economies to operate reliably and efficiently (NIST, n.d.). Infrastructure is commonly classified into two categories: hard infrastructure and soft infrastructure.

Hard infrastructure refers to the physical facilities and networks that underpin the functioning of a modern society and economy. This includes transportation systems such as roads, bridges, railways, and airports, as well as water systems, electrical grids, and telecommunications networks. These tangible assets enable the movement of people and goods, the distribution of energy and water, and the transmission of information.

Soft infrastructure refers to the institutions, services, and systems that support economic stability, public health, social order, and cultural development. This category includes educational institutions, healthcare systems, law enforcement agencies, emergency response services, parks, and recreational facilities. Unlike hard infrastructure, soft infrastructure is characterized by organizational frameworks and human-centered services that contribute to community well-being and effective governance.

Appendix F below contains a table with the infrastructure assets that are considered critical for Barranquitas.

As described in Section 2.8, FEMA defines Community Lifelines as the most essential services and systems necessary to sustain the uninterrupted operation of critical government and business functions, while also protecting public health, safety, and economic security. These lifelines constitute the fundamental components of a community and once stabilized, enable all other sectors of society to function effectively. During disaster events, any disruption to these lifelines requires immediate and coordinated action to restore stability and reduce cascading impacts.

Accordingly, the assessment of existing infrastructure will be conducted in alignment with FEMA's Community Lifelines framework.

3.5.1 Lifeline: Safety and Security



The purpose of the Safety and Security Lifeline is to protect life and property while maintaining social stability during emergency situations. This lifeline focuses on reducing immediate risks to public safety and personal security through the operation of public safety agencies, controlled access to affected areas, and the prevention of crime, civil unrest, and violence. It also encompasses ensuring safety and security at emergency shelters, distribution centers, and other critical facilities during disaster response and recovery operations.

FEMA indicates that disruption of this lifeline can result in social disorder and heightened community vulnerability, making rapid restoration a critical priority. Response actions require close coordination among federal, state, and local agencies, the deployment of security personnel, the implementation of traffic control measures, and the protection of critical infrastructure.

Map 8 illustrates the Safety and Security Lifeline facilities are concentrated within Barrio Pueblo, near the municipality's principal roadway network. Their central location supports accessibility and coordination of emergency response, public safety, and security services for residents throughout Barranquitas and surrounding communities.

3.5.2 Lifeline: Food, Hydration and Shelter



The Food, Hydration, and Shelter Lifeline is intended to ensure that disaster-affected populations have prompt access to essential necessities, including food, potable water, and safe shelter. This lifeline encompasses the provision of ready-to-eat meals, water distribution, the establishment of temporary shelters, and coordination with governmental and volunteer organizations to meet basic human needs. Disruptions to this lifeline pose an immediate threat to life; therefore, rapid response actions are prioritized to restore food availability and housing stability as quickly as possible.

Map 8 shows the Food, Hydration, and Shelter Lifeline facilities are concentrated in

Barrio Pueblo, with additional facilities located throughout the municipality along major transportation corridors. Their distribution supports access to emergency sheltering and essential resources, helping to meet residents' basic needs during and after hazard events.

3.5.3 Lifeline: Health and Medicine



The purpose of this lifeline is to ensure the continuity of essential medical services and the protection of public health during emergencies and disasters. It focuses on stabilizing healthcare delivery, ensuring access to hospitals, clinics, medications, and healthcare personnel, and maintaining the capacity to respond effectively to life-threatening conditions

FEMA indicates that disruption of this lifeline can have serious consequences; therefore, priority actions focus on restoring medical facilities, deploying emergency response teams, ensuring the availability of critical medical supplies, and coordinating efforts among federal, state, and local agencies.

Map 8 shows the Food, Hydration, and Shelter Lifeline facilities are concentrated in Barrio Pueblo, with additional facilities located throughout the municipality along major transportation corridors. Their distribution supports access to emergency sheltering and essential resources, helping to meet residents' basic needs during and after hazard events.

3.5.4 Lifeline: Energy



The Energy Lifeline is designed to ensure the reliable and safe delivery of electricity, gas, and essential fuels during emergencies and disaster events. This lifeline is vital to sustaining the operation of critical facilities and services, including hospitals, water and wastewater systems, telecommunications, and other infrastructure that depend on uninterrupted energy supply.

FEMA recognizes that disruptions to energy services pose a direct threat to life safety and community stability. Accordingly, priority response actions include the rapid restoration of the electrical grid, the deployment of generators to critical facilities, coordination with fuel suppliers, and the implementation of temporary measures to maintain service continuity. Map 11 illustrates the distribution of gas stations within the

municipality and indicates a notable lack of fueling facilities in the southwestern portion of the jurisdiction.

Map 8 shows that the Energy Lifeline facilities are primarily located within Barrio Pueblo and along major roadway corridors. Their centralized distribution supports the delivery of energy services and facilitates access for response and recovery operations following hazard events, helping maintain essential power infrastructure throughout the municipality.

3.5.5 Lifeline: Communications



The purpose of this lifeline is to ensure the availability and reliability of essential communication systems during emergencies and disaster events. These systems include telephone networks, internet services, radio, television, and public alert and warning platforms, all of which are critical for coordinating response activities, disseminating timely information, and maintaining communication between authorities and the public.

FEMA indicates that disruption of the Communications Lifeline can severely impair life-saving operations and effective resource management. Accordingly, priority actions include the restoration of telecommunications infrastructure, deployment of temporary communication solutions such as satellite systems, ensuring redundancy within critical networks, and maintaining accessible communication channels for the public.

Map 8 shows that the Communications Lifeline facilities are primarily located within Barrio Pueblo and are connected to the municipality's main transportation network. Their centralized distribution supports the dissemination of critical information and facilitates communication among emergency management agencies, first responders, and residents before, during, and after disasters.

3.5.6 Lifeline: Transportation



The purpose of the Transportation Lifeline is to ensure the safe and efficient movement of people, goods, and essential services during emergencies and disaster events. This lifeline supports the continued operation or rapid restoration of land, air, and maritime transportation routes, enabling access to critical resources such as food, potable water, medical care, and emergency response equipment.

FEMA indicates that disruptions to transportation systems directly affect the ability to save lives and distribute essential supplies. Accordingly, priority actions include reopening roadways, repairing damaged bridges, restoring airport and port operations, and coordinating with state and private entities to maintain the logistics chain. Map 9 illustrates the roadway network of the Municipality of Barranquitas. The primary transportation corridors within the municipality are described below.

Map 9 illustrates that the road network in Barranquitas consists of a combination of secondary and tertiary routes that provide connectivity among the municipality's wards and neighboring municipalities. Secondary routes identified on the map include PR-152, PR-156, PR-143, PR-162, PR-719, and PR-779. These routes traverse multiple wards and converge near Barrio Pueblo, forming the municipality's principal road junction.

PR-152 extends through the central and northeastern portions of the municipality, connecting areas within Quebradillas, Quebrada Grande, and Barrio Pueblo. PR-156 crosses the municipality from west to east through Palo Hincado, Helechal, Barrio Pueblo, and Honduras. Additional secondary routes, including PR-143, PR-162, and PR-719, provide connections within the southern portion of the municipality, while PR-779 is in the northeastern sector.

The map also identifies an extensive network of tertiary routes distributed throughout all wards. These routes include, among others, PR-749, PR-769, PR-770, PR-771, PR-772, PR-773, and PR-7773, which connect local areas to the secondary roadway system.

Connectivity Patterns

The highest concentration of roadway intersections occurs within and around Barrio Pueblo, where several secondary routes converge. The road network extends outward

from this area into the surrounding wards of Barrancas, Cañabón, Quebradillas, Quebrada Grande, Honduras, Helechal, and Palo Hincado.

The map indicates that Barranquitas maintains roadway connections with neighboring municipalities, including Corozal, Naranjito, Comerío, Cidra, Aibonito, Coamo, and Orocovis. Secondary and tertiary routes provide connectivity throughout the municipality and link the urban center with surrounding wards.

3.5.7 Lifeline: Hazardous Materials



The purpose of this lifeline is to prevent hazardous material releases, control spills, and protect communities located near industrial facilities, chemical plants, and hazardous materials transportation corridors.

FEMA indicates that disruption or failure of the Hazardous Materials Lifeline can result in severe consequences, including widespread contamination and the impairment of essential services. Accordingly, priority actions include identifying hazardous materials, activating specialized Hazardous Materials (HazMat) response teams, coordinating with federal and state agencies, and implementing rapid response protocols. Although hazardous materials may be present throughout the municipality, incidents involving hazardous materials are more likely to occur within industrial areas.

Map 8 shows that the Hazardous Materials Lifeline facilities are primarily located within and around Barrio Pueblo, near the municipality's secondary roadway network. Their central location provides connectivity to key transportation routes and places them in proximity to other critical infrastructure that supports emergency response and municipal operations during hazard events.

3.5.8 Lifeline: Water Systems

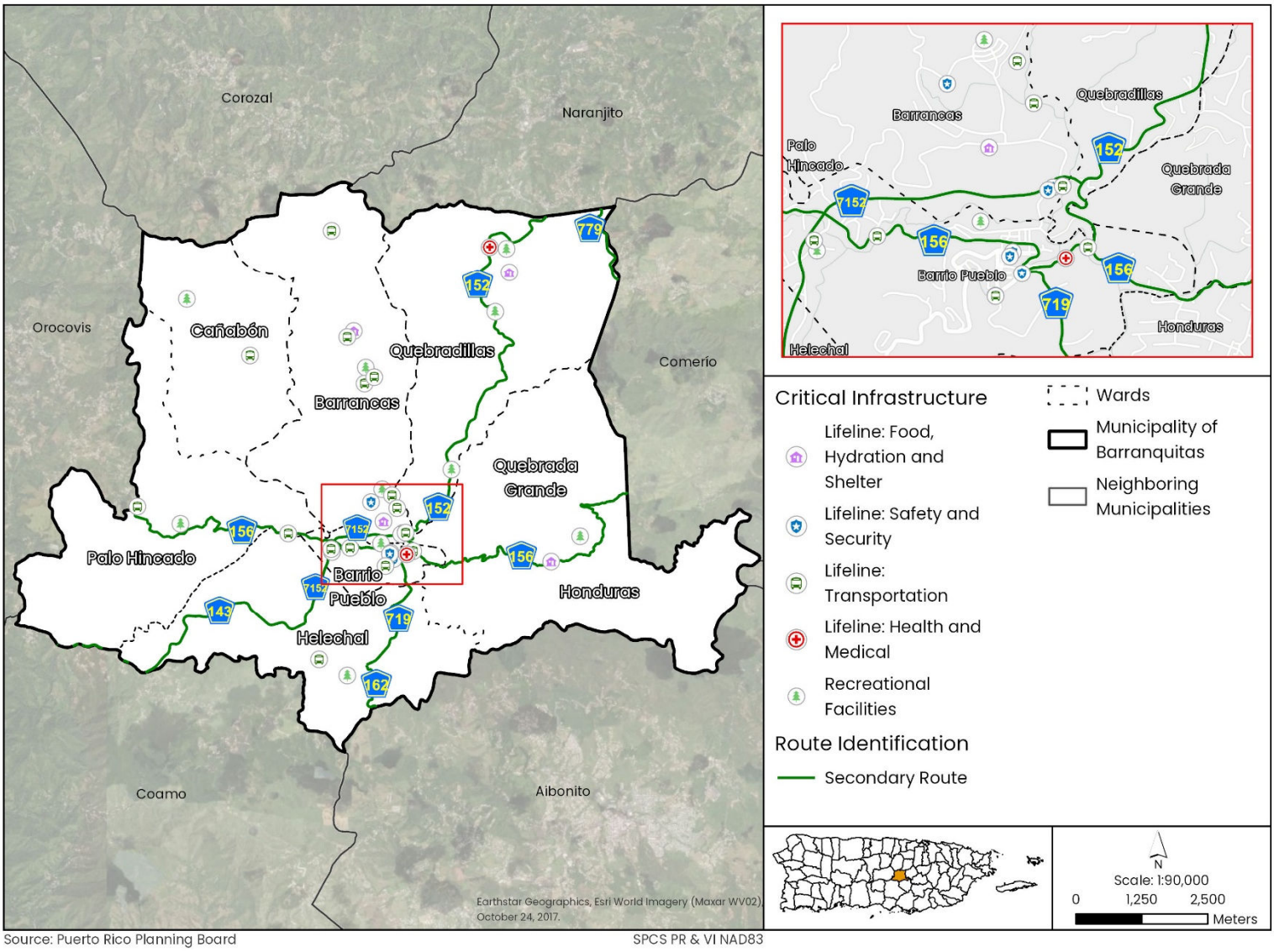


This lifeline highlights the critical role of water infrastructure in disaster response and recovery. Its primary objective is to ensure reliable access to and the timely restoration of drinking water and wastewater services, which are essential to public health, safety, and economic stability. The Water Systems Lifeline is structured around two core components: Potable Water Infrastructure, which includes water

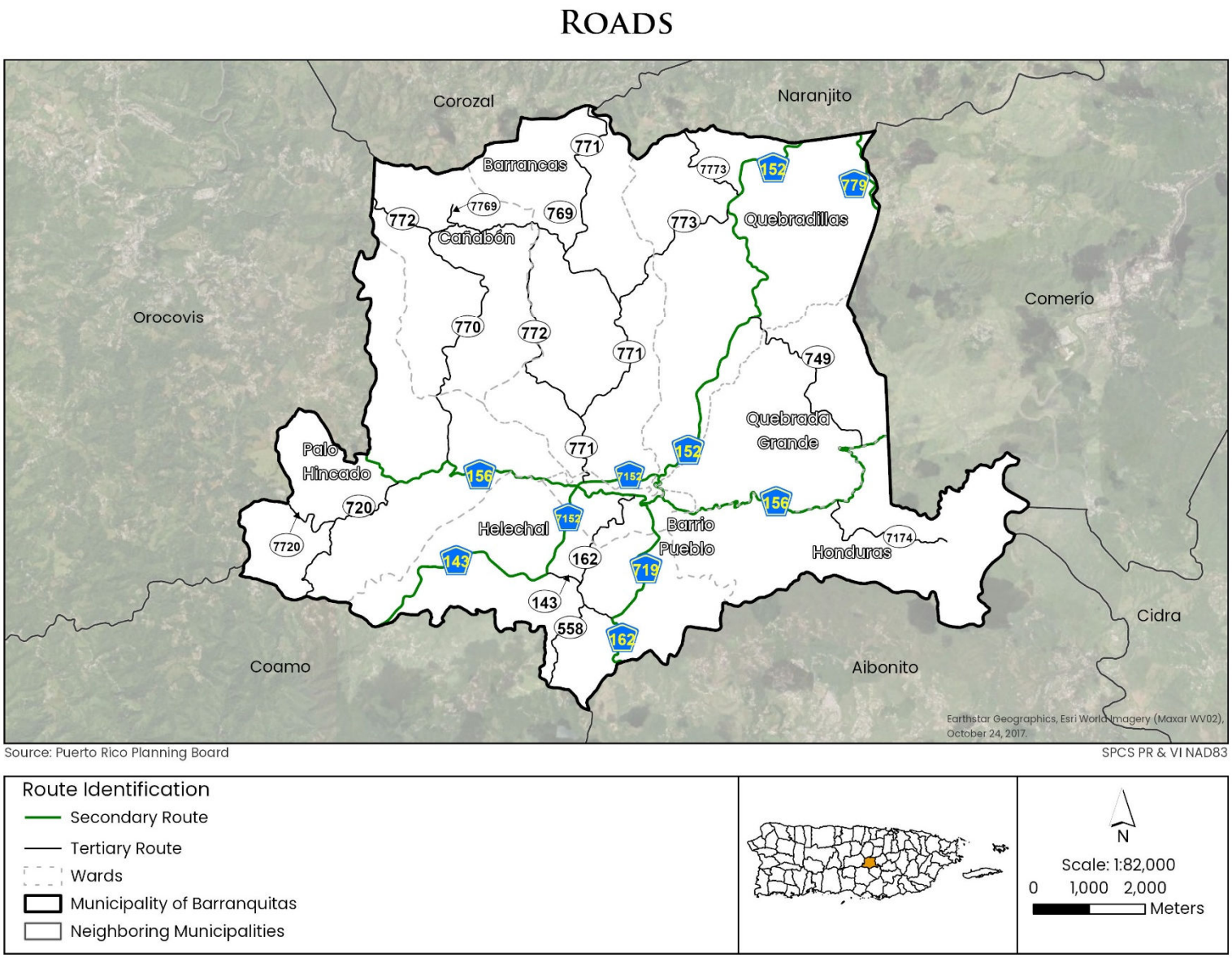
intake, treatment, storage, and distribution; and Wastewater Management, encompassing the collection, storage, treatment, and discharge of wastewater. By prioritizing the protection and functionality of water systems, FEMA seeks to maintain sanitation, support healthcare services, and minimize cascading impacts on food safety and overall community resilience.

Map 8 shows the Water Systems Lifeline facilities are distributed throughout Barranquitas, with several facilities concentrated near Barrio Pueblo and additional facilities located across multiple wards. Their location along the municipality's secondary roadway network provides connectivity between the urban center and surrounding communities, supporting the operation of water-related infrastructure throughout the municipality.

Map 8: Critical Infrastructure by Lifeline



Map 9: Critical Infrastructure by Lifeline



3.6 Recent Development (E1-a)

Hazard mitigation planning must also account for future development conditions. To assess anticipated development trends within the municipality, historical patterns were evaluated using data on construction permits approved between 2020 and 2026. This period begins with the year of approval of the previous hazard mitigation plan. It should be noted that data for 2026 include permits approved through June 30, 2026.

Construction permit activity in Barranquitas fluctuated between 2020 and 2025. The number of approved permits increased from 38 in 2020 to 63 in 2021 and reached a peak of 66 in 2022. Approvals subsequently decreased to 43 in 2023 before increasing to 64 in 2024 and remaining relatively high at 60 in 2025. Although these figures indicate sustained construction activity during most of the period, additional analysis would be necessary to determine whether this pattern was associated with post-disaster reconstruction, federal recovery funding, economic stimulus programs, or other factors.

Based on the annual data presented for 2020 through 2026, Barranquitas recorded an average of approximately 50.1 approved construction permits per year and a median of 60 permits. Annual totals ranged from 17 permits in 2026 to 66 permits in 2022. However, because the 2026 total represents a partial year, it should not be directly compared with the completed annual totals. Excluding the partial 2026 data, the municipality averaged approximately 55.7 approved permits per year between 2020 and 2025. During that six-year period, permit approvals reached 60 or more in four years, indicating generally sustained construction activity despite year-to-year fluctuations.

Table 15 and Figure 12 present the number of constructions permits approved between 2020 and 2026. Maps 10 and 11 illustrate the spatial distribution of these permits. To enhance legibility, the permits are depicted on two separate maps: one showing permits issued from 2020 to 2022, and another showing permits issued from 2023 to 2026.

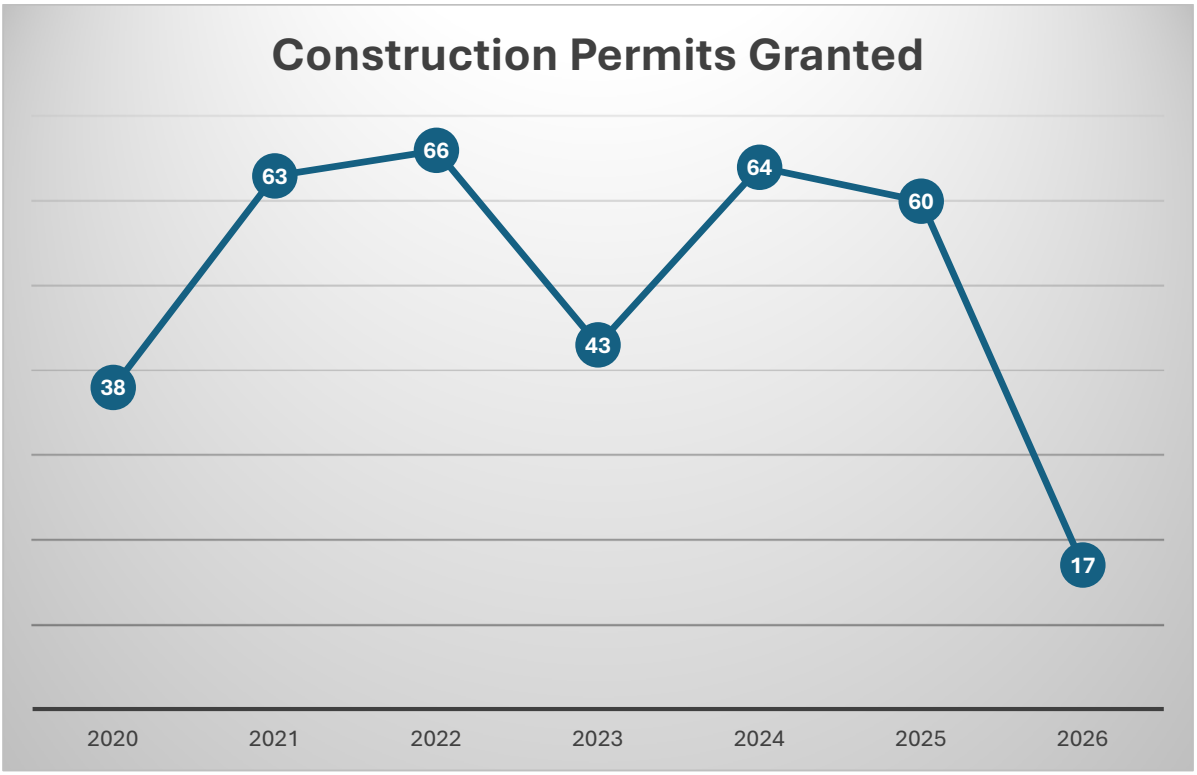
Table 15: Approved Construction Permits, 2020-2026[5]

Approved Construction Permits 2020-2026	
Year	Permits Approved
2020	38
2021	63
2022	66
2023	43
2024	64
2025	60
2026	17

Source: Puerto Rico Planning Board

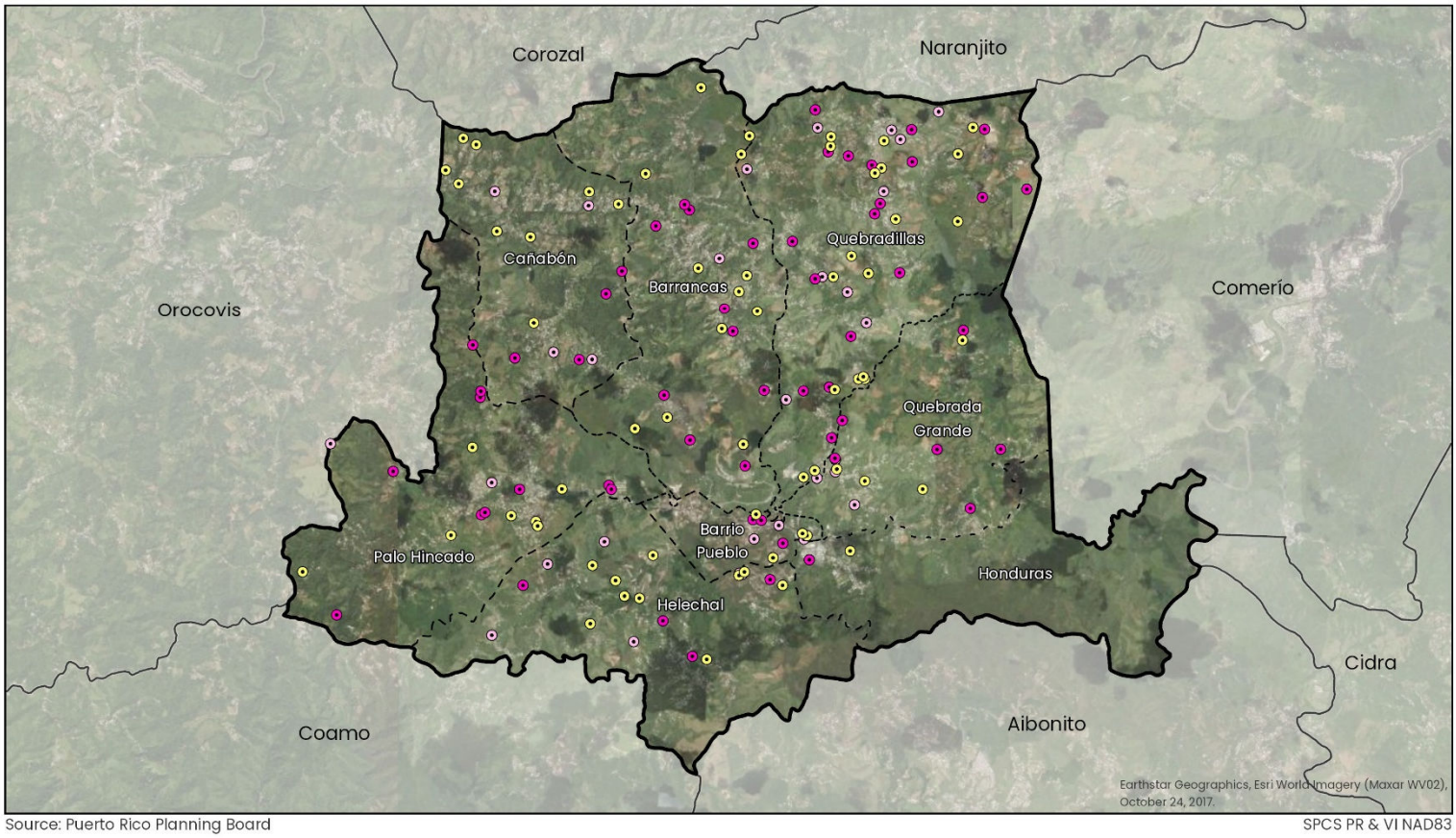
[5] 2025 total only accounts for permits up to June 30, 2026

Figure 12: Approved Construction Permits 2020-2026



Map 10: Recent Development 2020-2022

Recent Development 2020 - 2022



Source: Puerto Rico Planning Board

SPCS PR & VI NAD83

Construction Permits Granted

Year Created and Count

- 2020 (38)
- 2021 (62)
- 2022 (66)

- Wards
- Municipality of Barranquitas
- Neighboring Municipalities



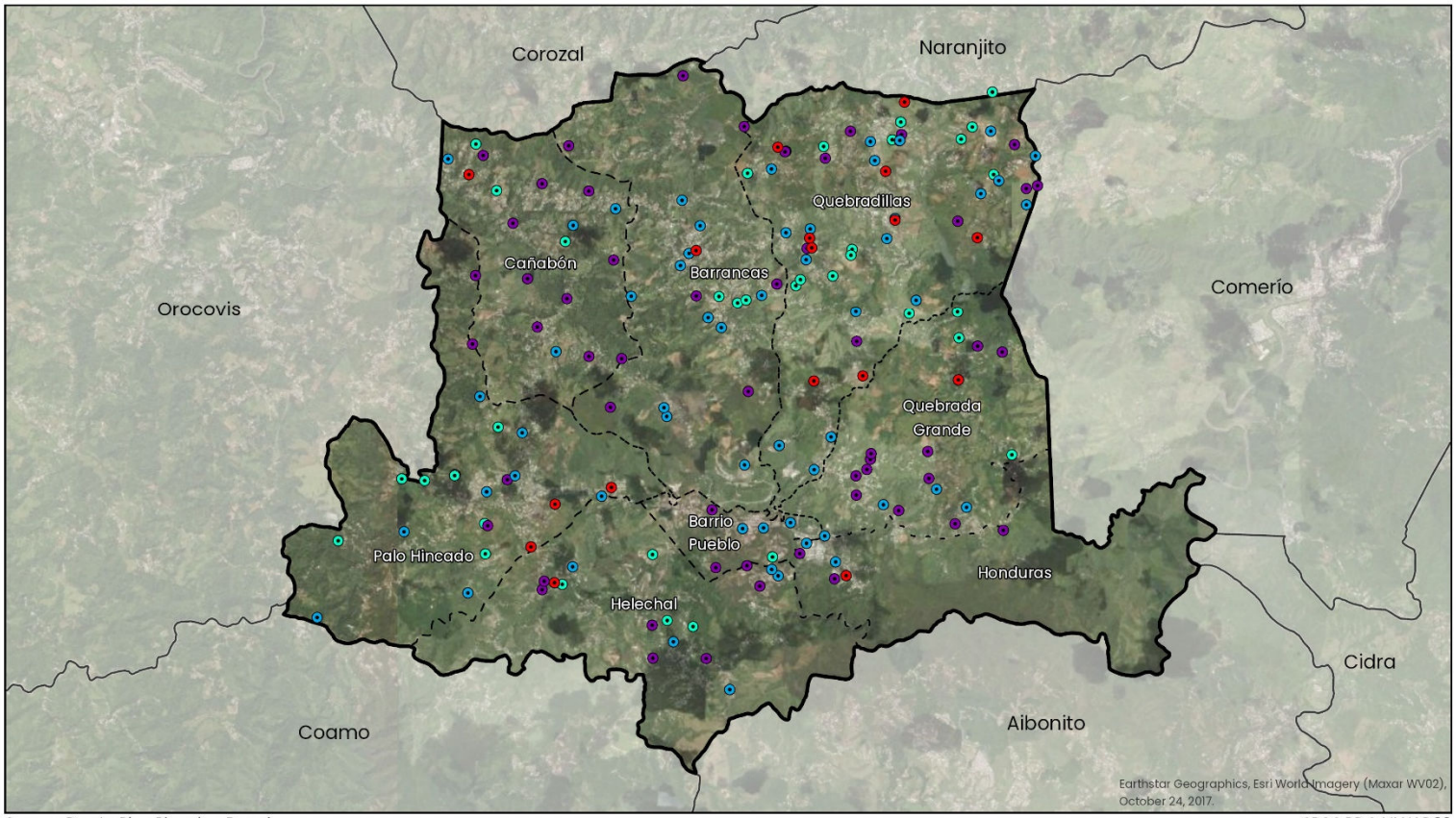
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Scale: 1:82,000

0 1,000 2,000 Meters

Map 11: Recent Development 2023-2026

Recent Development 2023 - 2026



Source: Puerto Rico Planning Board

SPCS PR & VI NAD83

Construction Permits Granted

Year Created and Count

- 2023 (43)
- 2024 (64)
- 2025 (60)
- 2026 (17)
- Wards
- Municipality of Barranquitas
- Neighboring Municipalities



N

Scale: 1:82,000

0 1,000 2,000

Meters

4. Hazards Profiles and Risks Analysis

4.1 Note on the Discussion of Hazards

The 2020 LHMP divided the discussion of the hazards evaluated in the plan into two separate and nonconsecutive sections. This arrangement made the analysis of each hazard cumbersome because the reader had to go back and forth between two different sections of the document. To improve readability and organization, the updated LHMP discusses both the profile of the hazard and the risk associated in one single section.

4.2 Regulatory Requirements

Federal regulation 44 C.F.R. § 201.6(c)(2) establishes the requirements related to hazard identification and risk assessment for LHMP. The Plan LHMP must include the following:

- An assessment that provides the basis for identifying the proposed activities aimed at reducing losses associated with the identified hazards. Local risk assessments must provide sufficient information to enable the jurisdiction to identify and prioritize appropriate mitigation actions to reduce losses related to the identified hazards. The hazard assessment must include:
    - A description of the type, location, and extent of all natural hazards that may affect the jurisdiction. It must contain information on previous occurrences of hazard events and the probability of future hazards.
    - A description of the jurisdiction's vulnerability to the identified hazards. This description must include a comprehensive summary of each hazard and its impact on the community. This Plan must describe vulnerability in terms of:
        - The number of existing structures, infrastructure, and critical facilities located within identified hazard areas;
        - An estimate of the potential monetary losses to structures identified as vulnerable, along with a description of the methodology used to prepare the estimate; and, lastly,

- A general description of land use and development patterns within the community so that mitigation options can be considered in future land-use decisions.
- A description of all structures insured under the National Flood Insurance Program (NFIP) that have experienced repetitive damage from different flood events. It must explicitly indicate whether the community participates in the NFIP and complies with its regulations. It must also include a table showing repetitive property losses along with a table of NFIP claims and losses.

4.3 Hazards that can Affect the Municipality

To select the Hazards to be addressed in this LHMP, the Municipality gathered information from the current 2026 Puerto Rico State Hazard Mitigation Plan, the 2020 Barranquitas LHMP and the current LHMP from the Municipalities that share a border with Barranquitas. The following table summarizes the hazard discussed in those HMPs. A check marks " ✓" in the table means that a hazard was discussed in the corresponding hazard mitigation plan, " ✗ " means indicates that it was not..

Table 16: Hazard Inventories

Hazard	2026 PRSHMP	2020 Barranquitas LHMP	Neighboring Municipalities
Earthquake/Liquefaction	✓	✓	✓
Landslides	✓	✓	✓
Flooding	✓	✓	✓
Extreme Winds Hazard	✓	✓	✓
Extreme Heat	✓	✓	✓
Drought	✓	✓	✓
Wildfire	✓	✓	✓
Tropical Cyclones	✓	✓	✓
Pandemic/Epidemic	✓	✗	✗
Epidemic Contagious Disease	✓	✗	✗
High Hazard Potential Dams	✓	✗	✓
Tsunami	✗	✗	✗
Coastal Erosion	✗	✗	✗
Sea Level Rise	✗	✗	✗

Hazard	2026 PRSHMP	2020 Barranquitas LHMP	Neighboring Municipalities
Storm Surge	✘	✘	✘

After reviewing the hazards profiles in these documents, the Municipality of Barranquitas has decided that the following hazards shall be assessed and evaluated for the 2026 LHMP:

Table 17: Hazards to be included in the Barranquitas 2026 LHMP

Hazard	Included in Barranquitas 2026 LHMP?	Comments
Earthquake	✓	It is included given Puerto Rico's location among major fault lines and the 2020 Seismic activity.
Landslides	✓	It is included given the high propensity for landslides in Barranquitas territory.
Tsunami	✘	The risk was not evaluated in this plan as the municipality has no direct risk exposure within its territory.
Flooding	✓	It is included given the presence of flood zones in the municipality.
Tropical Cyclone/Extreme Winds	✓	It is included given that the southeastern region of Puerto Rico has been the most recurrent point-of-entry for hurricanes that make landfall in Puerto Rico in recorded history. (National Oceanic and Atmospheric Administration, 2026).
Storm Surge	✘	The risk was not evaluated in this plan as the municipality has no direct risk exposure within its territory.
Long Term Coastal Modification	✘	The risk was not evaluated in this plan as the municipality has

Hazard	Included in Barranquitas 2026 LHMP?	Comments
		no direct risk exposure within its territory.
Extreme Winds	✓	Included as part of the discussion on tropical cyclones.
Extreme Heat	✓	This hazard is included as the municipality continues to face recurrent events of extreme temperatures.
Drought	✓	This risk is included given the 2014-2016 droughts and recent periods of moderate drought.
Wildfire	✓	Various of Barranquitas neighboring communities included this hazard.
Pandemic/Epidemic	✓	The municipality of Barranquitas included this in the previous LHMP. It will be considered by the LHMP update given the COVID -19 emergency declaration of 2020.
High Hazard Potential Dam	✓	It is included because potential inundation from upstream or nearby dam infrastructure could threaten residents, transportation corridors, public facilities, and utilities within Barranquitas.

For the rest of this document the hazards shall be considered in the following order:

Table 18: Order of Hazards to be Assessed

Classification	Hazard
Geological Hazards	Earthquake
	Landslides
Hydrological Hazards	Flooding
Meteorological Hazards	Extreme Winds Event
	Extreme Heat
	Drought
Environmental Hazards	Wildfire

Classification	Hazard
Biological Hazards	Pandemic/Epidemic
Anthropogenic Hazards	High Hazard Potential Dam

4.4 Chronology of Events

To prevent duplication of data and for easy reference in the discussion of each hazard profile the reader will find a chronology of events in the discussion of the hazard itself.

4.4.1 Risk Assessment Methodology

This section outlines the different methodologies used to assess the hazards. Because each hazard type has unique characteristics, data requirements, and levels of uncertainty, various approaches were applied to ensure accurate and comprehensive risk assessment.

4.4.1.1 HAZUS 6.1

HAZUS is a Geographic Information System (GIS)-based risk assessment tool developed by FEMA to estimate potential losses from natural hazards. It uses scientific modeling and spatial data to analyze the impacts of events such as earthquakes, floods, hurricanes, and tsunamis on buildings, infrastructure, populations, and the economy. Hazus provides detailed estimates of physical damage, economic losses, and social consequences, supporting hazard mitigation planning, emergency preparedness, and recovery strategies. By integrating hazard intensity, exposure, and vulnerability data, Hazus enables decision-makers to prioritize mitigation actions and allocate resources effectively. The following hazards were evaluated using HAZUS 6.1 software:

- Earthquake
- Tropical Cyclone/Extreme Winds
- Flooding

4.4.1.2 Alternative GIS Modeling

There are some hazards that currently are not modeled by HAZUS, but they can be assessed by alternative GIS techniques. ESRI® ArcGIS PRO™ 3.6 was used to assess

hazard vulnerability by utilizing digital risk data and the previously mentioned hazard information database. Using these data layers, vulnerability was quantified by estimating the number of critical facilities and buildings located in hazard-prone areas. Note that this method can overestimate risk exposure. In this LHMP the following hazards were assessed using this technique:

- Landslides
- HHPD

4.4.1.3 Stochastic Risk Assessment

The stochastic risk assessment methodology was applied to evaluate hazards not addressed by existing hazard risk models or GIS-based analyses. This method is particularly suited for hazards lacking clear geographic boundaries, which are therefore excluded from GIS analysis. This approach can incorporate estimates of annual losses and impact data. However, the assessment result will be very dependent on the availability of data.

In the case of this LHMP, the hazards evaluated using this methodology are:

- Extreme Heat
- Drought
- Wildfire
- Pandemic/Epidemic

This methodology is particularly appropriate for hazards that lack clearly defined geographic boundaries and therefore cannot be evaluated through GIS-based analysis. It allows for the incorporation of estimated annual losses and impact data; however, the accuracy of the assessment is highly dependent on the availability and quality of the underlying datasets.

4.4.1.4 High Hazard Potential Dams

Please refer to Section 4.14.2.1 for details regarding the methodology used to assess high hazard potential dam risks.

4.5 Earthquake

4.5.1 Description (B1-a)

An earthquake is a sudden movement of the earth that occurs because of waves or vibrations spreading in all directions from the focus or point of origin of the earthquake (FEMA, 1997). The focus represents the place where the movement of rocks originates when they shift along faults. The epicenter, on the other hand, refers to the point on the earth's surface located directly above the focus (Puerto Rico Seismic Network, 2019). Earthquakes can occur because of changes in pressure experienced by the earth's crust, whether due to tectonic plate movement or rock rupture, a volcanic eruption, a landslide, or the collapse of caverns or cavities in underground land.

Most earthquakes are caused by the release of accumulated pressure resulting from the displacement of rocks along faults in the earth's outer crust. These faults are typically found along the edges of the earth's ten tectonic plates. The areas of greatest tectonic instability occur at the perimeters of plates that move slowly, as these places are subjected to the extreme force of plates traveling in opposite directions and at different speeds. Deformation along plate boundaries causes stress in the rock and the consequent accumulation of energy. When the accumulated stress exceeds the resistance strength of the rocks, a rupture occurs, releasing the stored energy and producing seismic waves, which generate an earthquake (NMEAD, 2021).

Earthquakes can affect hundreds of thousands of square miles and cause property damage amounting to tens of billions of dollars, loss of life and injuries to hundreds of thousands of inhabitants and disrupt the social and economic functioning of affected areas. Most property damage and earthquake-related deaths are caused by the collapse of structures due to ground movements (NMEAD, 2021). The level of damage experienced will depend on the amplitude and duration of the shaking, which is directly related to the size of the earthquake, the distance from the fault where it occurs, and the location and regional geology of the area where it is felt (NMEAD, 2021). Other negative effects caused by the earthquake include landslides, the movement of soil and rock toward lower areas (mountainous regions and along slopes), and liquefaction, a process by which soil loses its rigidity and begins to behave like a fluid. In the case of liquefaction, anything that depends on the rigidity of the substrates for support can shift, tilt, break, or collapse.

Puerto Rico is located near the boundary between the North American and Caribbean tectonic plates, a subduction zone where one plate slowly moves downward beneath

the other. These subduction zones are subject to substantial seismic activity and lateral displacement. Furthermore, the relative speed between the movement of these two plates is 2 centimeters (cm) per year (Puerto Rico Seismic Network, 2019).

According to the Puerto Rico Seismic Network, seismic activity is concentrated in eight (8) zones:

- The Puerto Rico Trench to the North
- The North and South Slope Faults of Puerto Rico
- The "Sombrero Zone", to the Northeast
- The Mona Passage and Mona Canyon to the West
- The Virgin Islands and Anegada depressions to the East
- The Muertos Trough to the South
- In the Southwest of Puerto Rico

To describe earthquake sizes, seismology has established three (3) terms: (1) earthquake intensity; (2) earthquake magnitude; and (3) acceleration. Intensity measures the shaking of structures and nature in a particular area. Intensity will vary according to the distance from the focus and the duration of the event. On the other hand, the magnitude of an earthquake refers to the measure of energy provided by seismometers, that is released during the event. Finally, ground acceleration is used to express the size of an earthquake (PRSN, 2019).

Some consequences of earthquakes include liquefaction, landslides, amplification, and tsunamis. For the purposes of this analysis, the main hazard to be addressed is liquefaction caused by earthquakes. This is because liquefaction is a hazard for which mitigation strategies can be established, as susceptible areas can be identified and marked for risk mitigation purposes. Liquefaction is the process by which certain soil behaves like a dense fluid, reducing its usual load-bearing capacity (PRSN, 2019). Liquefaction occurs mainly in places where there is medium to fine sandy soil, saturated with water, and of recent geological age. These deposits are mostly located on river margins and Quaternary (Q) age alluvial deposits. Another hazard to be considered is the amplification of seismic waves. Seismic wave amplification occurs in thick alluvial deposits where seismic waves slow down, amplifying their oscillation and causing the ground in these places to shake more strongly and for a longer time.

4.5.1.1 Affected Area (B1-B)

The following maps measure the spectral acceleration and spectral displacement in HAZUS run scenarios.

Spectral Acceleration

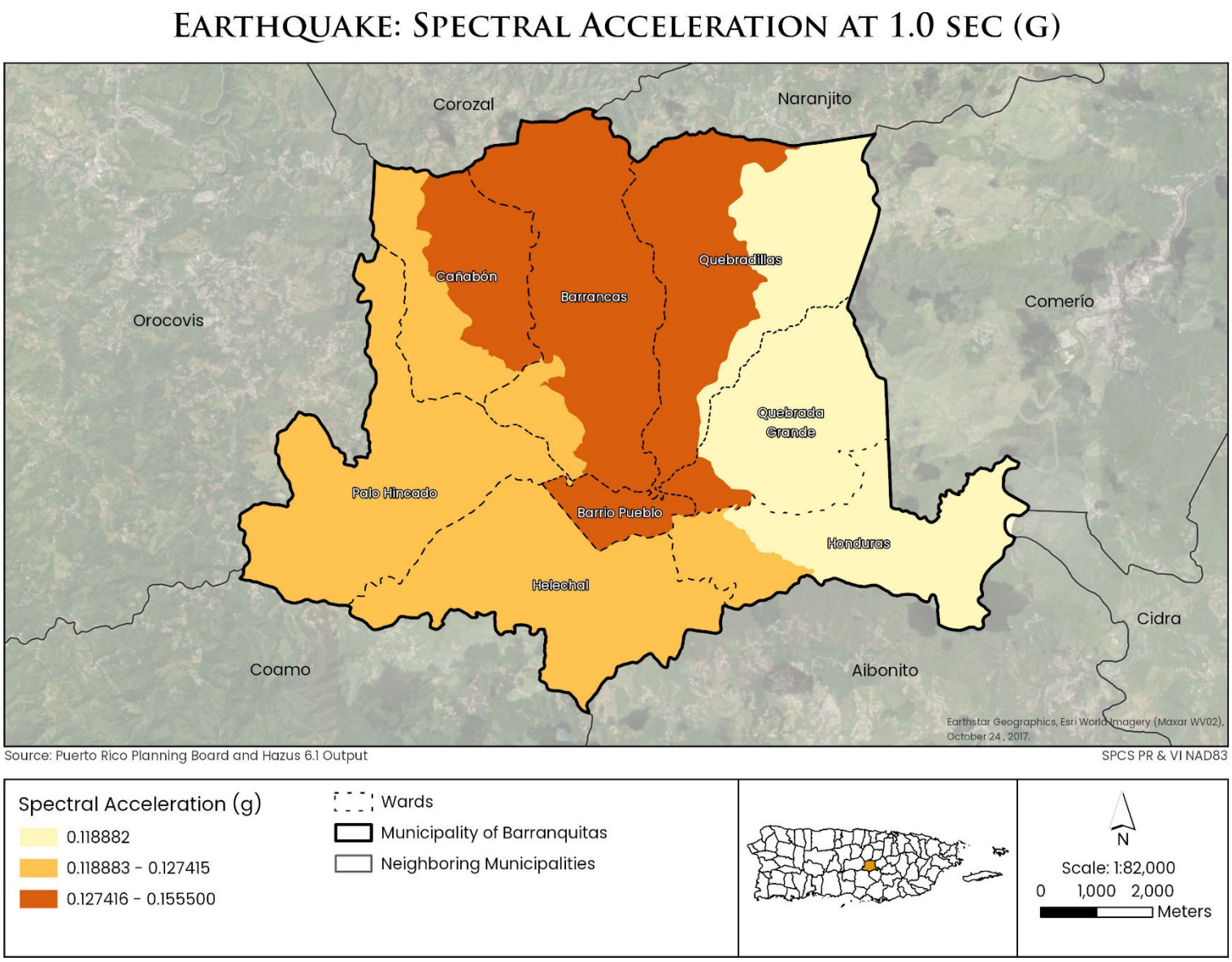
Spectral Acceleration is measure used mainly in earthquake engineering to describe how strongly the ground motion from an earthquake would accelerate a structure with a specific natural period. This measure answers the question ""If a building (or any structure) vibrates naturally at a certain period, how much acceleration would it experience during an earthquake?" or , how hard the ground is pushing on the building at a specific vibration period? The higher the spectral acceleration, stronger the forces acting on the structure will be, which can cause structural failure if the building isn't designed for it (USGS, 2019).

Spectral Displacement

Spectral Displacement measures how far a structure is expected to move (deform) during an earthquake, based on its natural vibration period and damping. In other words, it answers: "For a building with a given natural period, what is the maximum displacement it would experience during earthquake shaking?" (National Institute of Building Sciences, 2020).

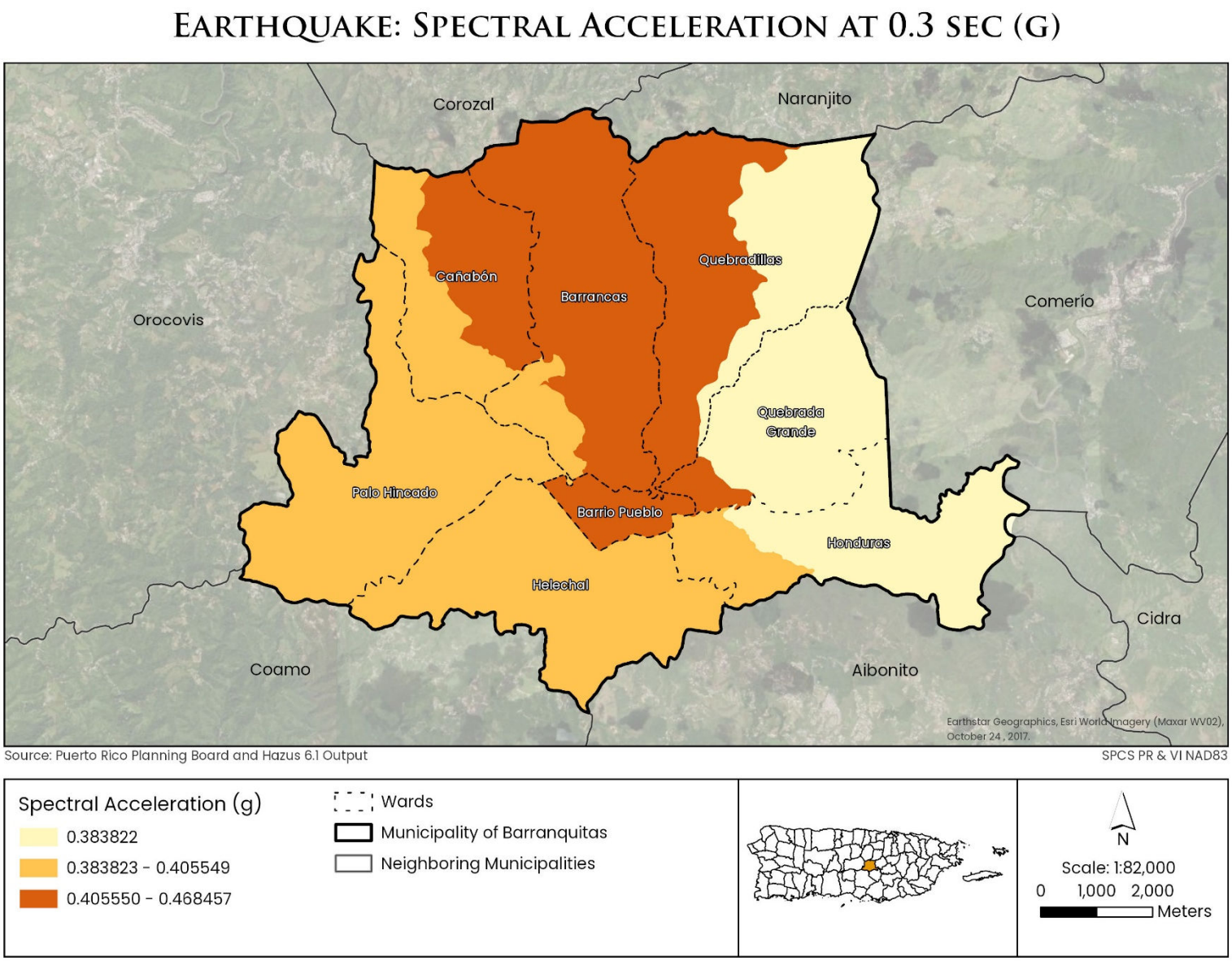
Furthermore, maps 12 and 13 show the Hazus scenario for .03 seconds and 1.0 seconds. The difference relates to how an earthquake impacts different types of structures based on the natural vibration period the building. The maps showing the 0.3-second scenario can affect buildings that are short, stiff structures like 1 or 2-story buildings. These buildings are rigid, so they vibrate quickly when the ground shakes. While the 1.0-second scenario that is more important for buildings are taller, more flexible structures, like mid- to high-rise buildings. These buildings are taller and less stiff and therefore sway more slowly (over a longer period) during an earthquake (FEMA, Hazus Earthquake Model User Guidance, 2024).

Map 12: Earthquake: Spectral Acceleration at 1.0 sec (G)



As shown on Map 12, the highest spectral acceleration values at 1.0 second are concentrated in the central and northern portions of Barranquitas, including Barrancas, Quebradillas, Cañabón, and Barrio Pueblo. Moderate values occur across Palo Hincado and Helechal, while the lowest spectral acceleration values are in the eastern and southeastern areas of the municipality, particularly within Quebrada Grande and Honduras.

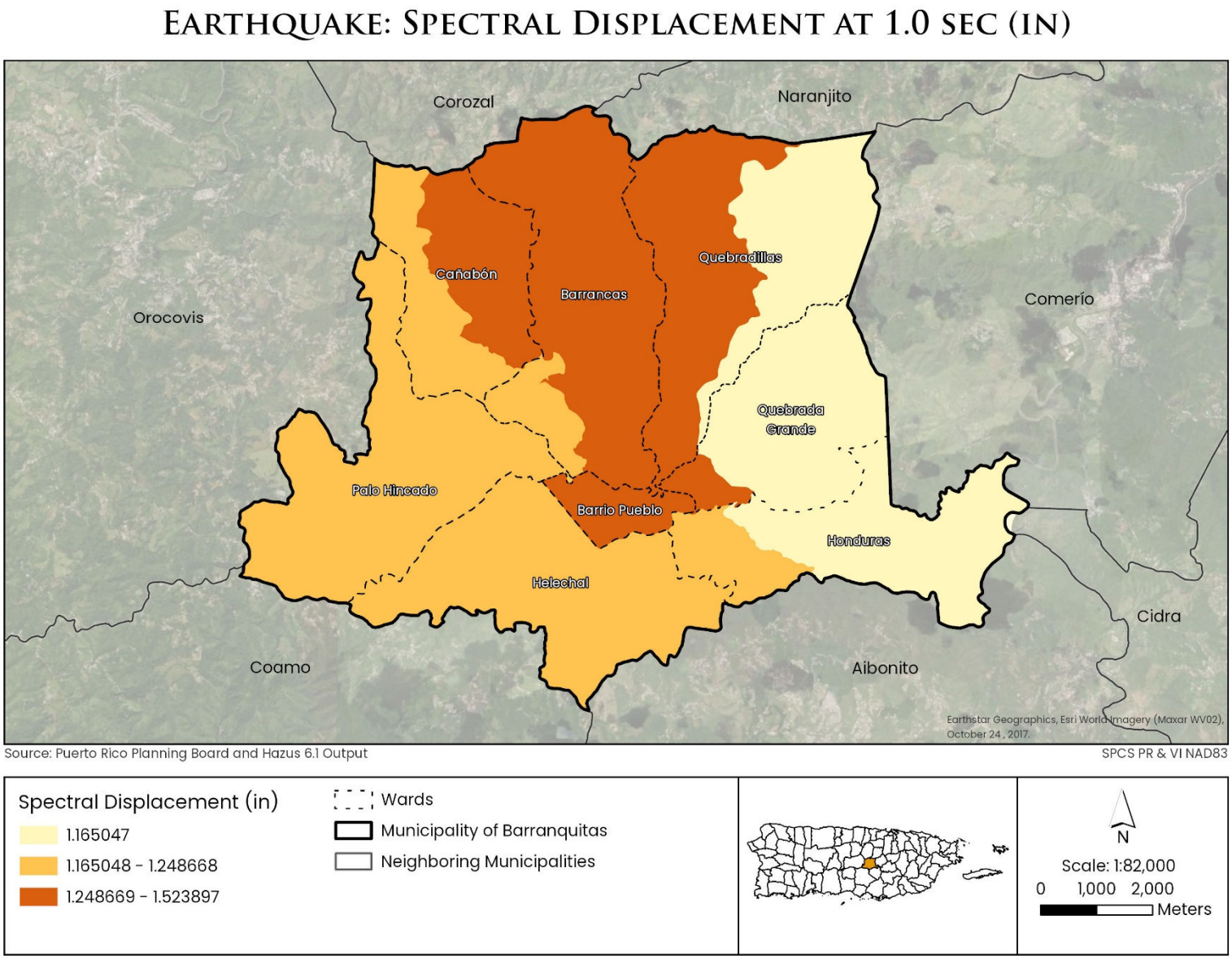
Map 13: Earthquake: Spectral Acceleration at 0.3 sec (G)



Map 13 illustrates that the highest spectral acceleration values at 0.3 seconds are concentrated in the central and northern portions of Barranquitas, including Barrancas, Quebradillas, Cañabón, and Barrio Pueblo. Moderate values are present across Palo Hincado and Helechal, while the lowest spectral acceleration values occur in the eastern and southeastern wards, particularly Quebrada Grande and Honduras.

Maps 14 and 15 illustrate the spectral displacement expected during an earthquake, which represents the degree of movement or sway that buildings may experience. The spatial distribution of displacement closely mirrors the patterns observed in spectral acceleration, as higher acceleration levels generally correspond to greater structural sway.

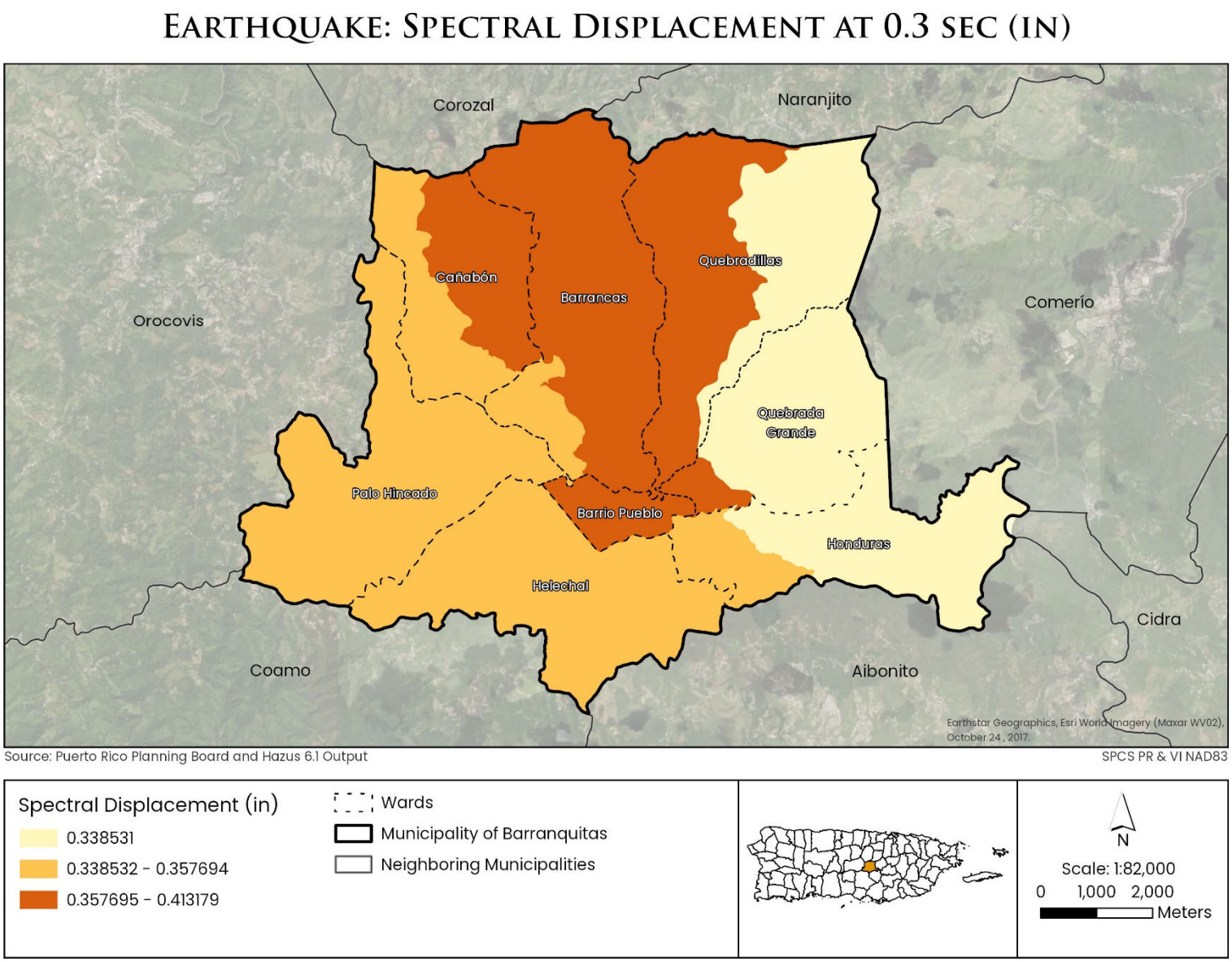
Map 14: Earthquake Spectral Displacement at 1.0 sec (IN)



Map 14 illustrates that the highest spectral displacement values at 1.0 second are concentrated in the central and northern portions of Barranquitas, including Barrancas, Quebradillas, Cañabón, and Barrio Pueblo. Moderate values occur across

Palo Hincado and Helechal, while the lowest spectral displacement values are found in the eastern and southeastern wards, particularly Quebrada Grande and Honduras.

Map 15: Earthquake: Spectral Displacement at 0.3 sec (IN)



Map 15 illustrates that the highest spectral displacement values at 0.3 seconds are concentrated in the central and northern portions of Barranquitas, including Barrancas, Quebradillas, and Barrio Pueblo. Moderate values occur across Palo Hincado and Helechal, while the lowest spectral displacement values are found in the eastern and southeastern wards, particularly Quebrada Grande and Honduras.

4.5.1.2 Risk Magnitude (B1-C)

The size of an earthquake, commonly associated with the Richter Scale, is widely recognized but often misunderstood. The concept of a logarithmic magnitude scale was first introduced by Charles Richter in the 1930s to measure earthquakes in Southern California using high-frequency recordings from nearby seismograph stations. This original scale, designated as ML where "L" stands for "local" eventually became known as the Richter magnitude scale.

As global seismic monitoring networks expanded, it became evident that the Richter method was accurate only within specific frequency and distance ranges. To accommodate a broader range of seismic signals recorded worldwide, additional magnitude scales were developed as extensions of Richter's original concept, including the body-wave magnitude (Mb) and the surface-wave magnitude (Ms). Each of these scales applies to a particular frequency range and type of seismic waves, and within their respective valid ranges, they provide magnitudes equivalent to the Richter scale. (USGS, 2024)

Due to the limitations of the ML, Mb, and Ms scales, a more universally applicable scale moment magnitude (Mw) was developed. For large-magnitude earthquakes, Mw provides the most accurate and reliable estimate of earthquake size.

Moment is a physical quantity proportional to the amount of slip that occurs along a fault multiplied by the area of the fault surface that undergoes rupture. It reflects the total energy released by an earthquake. Moment can be derived from seismogram data and geodetic measurements and subsequently converted into a magnitude value using a standardized formula. The resulting measure, known as moment magnitude, provides a consistent and comparable estimate of earthquake size across the full range of magnitudes a capability that earlier scales do not offer (USGS, 2024). Table 19 below shows the Moment – Magnitude.

Table 19: Moment - Magnitude Scale[6]

Range	Description
Mw < 3.0	Usually not felt by people.
Mw 3.0 – 4.9	Minor earthquakes, often felt but rarely cause damage.
Mw 5.0 – 5.9	Moderate, can cause slight damage to poorly built structures.

[6] Source: USGS, 2025

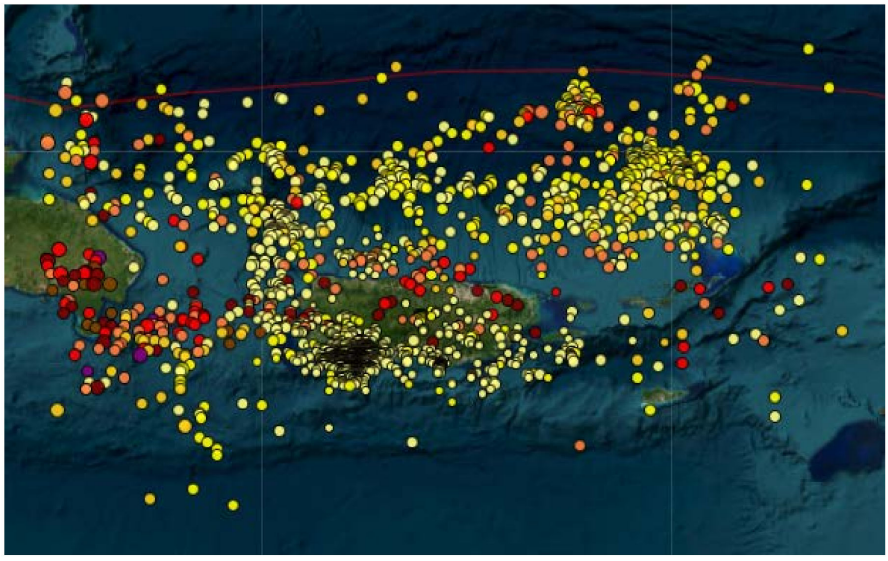
Range	Description
Mw 6.0 – 6.9	Strong, can cause significant damage in populated areas.
Mw 7.0-7.9	Major, serious damage over large areas.
Mw ≥ 8.0	Great earthquakes, catastrophic damage over very large regions.

4.5.1.3 Past Events (B1-d)

Earthquakes occur naturally daily, and their impacts increase significantly with greater magnitude. High-magnitude events can be particularly destructive, causing extensive property damage, loss of life, and severe disruption to affected regions. Puerto Rico is located near several active seismic zones including the Puerto Rico Trench, the Mona Canyon, the Anegada Trough, the Muertos Trough, and the southern fault system placing the island at heightened risk for seismic events. Seismicity in the southeastern region of Puerto Rico is primarily associated with faults in the Virgin Islands and Anegada depressions. In the southwestern region, activity is influenced by the Punta Montalva fault (Roig Silva, 2010), an area that has experienced a notable increase in seismic activity in recent years (Weilert & Laó-Dávila, 2023).

Figure 13 is a screengrab sourced from a report published by the Puerto Rico Seismic Network (in Spanish). This report illustrates the epicenters of earthquakes recorded in the Puerto Rico and U.S. Virgin Islands region in 2024 (PRSN, 2025).

Figure 13: PRSN - 2024 Earthquakes Epicenter (PRSN, 2025)



Earthquake Chronology

Table 20 below shows the chronological list of the seismic activity in Puerto Rico for the period of 2012 to 2024 as reported by the PRSN (PRSN, n.d.).

Table 20: Puerto Rico Seismic Activity 2013-2024

Year	Description of seismic events
2024	The largest earthquake of 2024 occurred on May 14, 2024, at 8:30:11 p.m. (Puerto Rico local time). The magnitude 5.6 Ml earthquake was located 94.3 km north-northwest of Aguadilla (PR) at a depth of 7 km. This moderate earthquake was widely felt throughout Puerto Rico, with a maximum intensity of V (Modified Mercalli Intensity Scale, MMI) in Aguadilla (PR). During 2024, aftershocks from the South-Southwest Puerto Rico seismic sequence continued. This sequence began on December 28, 2019, with a magnitude 4.7 Ml earthquake. The main event of this sequence occurred on January 7, 2020, in the southern region of Puerto Rico, 12.7 km south of Guayanilla, with a magnitude of 6.4 Mw. This strong earthquake, at a depth of 7 km, had a maximum intensity of VIII in Guánica, Puerto Rico, and caused major damage across the island. From the start of the South-Southwest Puerto Rico seismic sequence in 2019 through April 2024, 27,497 earthquakes associated with this sequence have been processed (Figure 2). More than 1,688 felt earthquakes and over 492 significant events with magnitudes greater than 3.5 have been recorded. Of these, 42 earthquakes had magnitudes greater than 4.5.
2023	The largest earthquake of 2023 occurred on December 9, 2023, at 10:27:22 a.m. (Puerto Rico local time). The magnitude 5.7 Ml earthquake was located 192.28 km east-northeast of San Juan, PR, at a depth of 7 km. This moderate earthquake was widely felt throughout Puerto Rico and the Virgin Islands, with a maximum intensity of V (Modified Mercalli Intensity Scale, MMI) in St. Thomas (USVI). During 2023, aftershocks from South-Southwest Puerto Rico seismic sequence continued. This sequence began on December 28, 2019, with a magnitude 4.7 Ml earthquake. The main event of this sequence occurred on January 7, 2020, in the southern region of Puerto Rico, 12.7 km south of Guayanilla, with a magnitude of 6.4 Mww. This strong earthquake, at a depth of 7 km, had a maximum intensity of VIII in Guánica, Puerto Rico, and caused major damage across the island.
2022	The seismic sequence in the South-Southwest region of Puerto Rico, which began on December 28, 2019, continues. From its onset until the March 2022

Year	Description of seismic events
	report by the Puerto Rico Seismic Network, a total of 19,436 earthquakes associated with this sequence had been recorded. In that report, 1,502 events were documented for 2022, of which 30 were reported as felt. The regions with the highest seismic activity during March 2022 were in the southern area of Puerto Rico.
2021	The largest earthquake of 2021 occurred on January 24, 2021, at 7:21:41 p.m. (Puerto Rico local time). The magnitude 5.4 Ml earthquake was located 44.82 km southeast of Virgin Gorda, BVI, at a depth of 94 km. This moderate earthquake was widely felt throughout Puerto Rico and the Virgin Islands, with a maximum intensity of V (Modified Mercalli Intensity Scale, MMI) in Tortola, British Virgin Islands.
2020	The year 2020 was marked by significant seismic activity. An earthquake of magnitude 5.8 was recorded on January 6, 2020, followed by another of 6.5 on January 7, 2020, located 8 km from Indios, Puerto Rico. It is important to clarify that, starting from the 4.7 magnitude event recorded on December 28, 2019, up to October 22, 2020, approximately over 1,200 earthquakes of magnitude 2.0+ have been felt on the island. Tectonic activity in Puerto Rico is dominated by the convergence between the North American and Caribbean plates, with the island compressed between the two. To the north of Puerto Rico, the North American plate subducts beneath the Caribbean plate along the Puerto Rico Trench. To the south of the island, and south of the January 7 earthquake, the upper crust of the Caribbean plate subducts beneath Puerto Rico in the Muertos Trough. However, the January 6 earthquake and other recent events are occurring in the offshore deformation zone, connected by the Punta Montalva fault on land and the Guayanilla Canyon offshore. Between December 28, 2019, and January 23, 2020, southern Puerto Rico recorded 90 seismic events of magnitude 4.0 or greater, including the 6.5 magnitude earthquake on January 7, 2020, according to the USGS. These seismic movements led state authorities to request a disaster declaration from the President of the United States. This Disaster Declaration was issued on January 16, 2020, under number DR-4473. The Municipality of Barranquitas was not included among those designated to receive Individual Assistance funds from FEMA.
2019	During 2019, the Puerto Rico Seismic Network (PRSN) located a total of 6,510 earthquakes in the Puerto Rico and Virgin Islands region (our seismic responsibility area, between latitudes 17°N–20°N and longitudes 63.5°W–69°W). Compared to 2018 (3,974 earthquakes), the detected and located seismicity in 2019 increased. The year 2019 ended with 2,536 more earthquakes than the previous year. In 2019, the month with the highest

Year	Description of seismic events
	activity was December with 1,291 earthquakes, while August had the lowest seismicity with 303 earthquakes. The region with the highest recorded seismicity during 2019 was the Mona Canyon with 1,288 seismic events, followed by the southern region of Puerto Rico with 885 earthquakes (Table 3). Earthquake depths ranged from 1 km to 191 km, and magnitudes varied from 0.34 Md to 6.0 Mw. Of the total earthquakes in 2019, 70 were reported as felt. On December 28, 2019, an active period of seismic activity began, with a 4.7 magnitude earthquake, followed several hours later by another 5.0 magnitude south of the island.
2018	During 2018, the Puerto Rico Seismic Network (PRSN) located a total of 3,974 earthquakes in the Puerto Rico and Virgin Islands region (our seismic responsibility area, between latitudes 17°N–20°N and longitudes 63.5°W–69°W). Compared to 2017 (3,129 earthquakes), the detected and located seismicity increased by 845 more earthquakes than the previous year. In 2018, the month with the highest activity was December with 549 earthquakes, while February had the lowest seismicity with 227 earthquakes. The region with the highest recorded seismicity during 2018 was the southern region of Puerto Rico with 412 seismic events, followed by the 19°N Fault Zone with 349 earthquakes. Earthquake depths ranged from 2 km to 185 km, and magnitudes varied from 0.63 Md to 4.67 Md. Of the total earthquakes in 2018, 29 were reported as felt within our area of responsibility.
2017	During 2017, the Puerto Rico Seismic Network (PRSN) located a total of 3,129 earthquakes in the Puerto Rico and Virgin Islands region (our seismic responsibility area, between latitudes 17°N–20°N and longitudes 63.5°W–69°W). Compared to 2016 (3,948 earthquakes), the detected and located seismicity decreased by 20%, which means 819 fewer earthquakes than the previous year. In 2017, the month with the highest activity was April with 518 earthquakes, while October had the lowest seismicity with 48 seismic events. The region with the highest recorded seismicity during 2017 was the Sombrero Seismic Zone with 856 seismic events, followed by the Virgin Islands Platform with 327 earthquakes. Earthquake depths ranged from 1 km to 180 km, and magnitudes varied from 0.85 Md to 4.8 Mb. Of the total earthquakes in 2017, 24 were reported as felt within our area of responsibility.
2016	During 2016, the Puerto Rico Seismic Network (PRSN) located a total of 3,947 earthquakes in the Puerto Rico and Virgin Islands region (our seismic responsibility area, between latitudes 17°N–20°N and longitudes 63.5°W–69°W). Compared to 2015 (3,235 earthquakes), the detected and located seismicity increased by 22.0%, or 712 more earthquakes than the previous year. In 2016, the month with the highest activity was September with 566 earthquakes, while March had the lowest seismicity with 169 earthquakes.

Year	Description of seismic events
	The region with the highest recorded seismicity during 2016 was the Sombrero Seismic Zone with 973 seismic events, followed by the Virgin Islands Platform with 497 earthquakes. Earthquake depths ranged from 1 km to 177 km, and magnitudes varied from 0.76 Md to 4.6 Ml. Of the total earthquakes in 2016, 28 were reported as felt within our area of responsibility.
2015	During 2015, the Puerto Rico Seismic Network (PRSN) located a total of 3,235 earthquakes in the Puerto Rico and Virgin Islands region (our seismic responsibility area, between latitudes 17°N–20°N and longitudes 63.5°W–69°W). Compared to 2014 (3,420 earthquakes), the detected and located seismicity decreased by 5.4%, or 185 fewer earthquakes than the previous year. In 2015, the month with the highest activity was July with 473 earthquakes, while April had the lowest seismicity with 157 earthquakes. The region with the highest recorded seismicity during 2015 was the Sombrero Seismic Zone with 588 seismic events, followed by the 19°N Fault Zone with 477 earthquakes. Earthquake depths ranged from 1 km to 211 km, and magnitudes varied from 0.80 Md to 4.80 Md (duration magnitude). Of the total earthquakes in 2015, 23 were reported as felt within the area of responsibility.
2014	During 2014, the Puerto Rico Seismic Network (PRSN) located a total of 3,420 earthquakes in responsibility (AOR) known as the Puerto Rico and Virgin Islands Region (latitude 17.00˚ to 20.00˚N and longitude 63.50˚ to 69.00˚W). Compared to 2013 (2,293 earthquakes), the detected and located seismicity increased by 49%, which is 1,127 more earthquakes than the previous year. In this year, the month with the highest seismicity was January with 709 earthquakes, and the month with the lowest seismicity was November with 192 earthquakes. Of the total seismicity in 2014, 29 earthquakes (0.85%) were reported as felt, all located within our AOR. The magnitudes (Md) of the seismic events calculated for this year by PRSN ranged from 1.0 to 6.4, although for felt events they ranged from 2.53 Md to 6.4 Mwp. During 2014, depths varied between 1 km and 182 km, while for felt earthquakes they ranged from 6 km to 134 km. Earthquakes with depths of 0 to 25 km were the most frequent with 1,385 events, while those between 175 km and 200 km were the least frequent this year. The region with the highest recorded seismicity during 2014 was the 19°N Fault Zone with 905 seismic events, followed by the Sombrero Seismic Zone with 483 earthquakes.
2013	During 2013, the Puerto Rico Seismic Network (PRSN) located a total of 2,293 earthquakes in the Puerto Rico and Virgin Islands region (latitude 17.00˚ to 20.00˚N and longitude 63.50˚ to 69.00˚W). Compared to 2012 (2,852 earthquakes), the detected and located seismicity decreased by 20%, which is 559 fewer earthquakes than the previous year. In this year, the month with

Year	Description of seismic events
	the highest seismicity was September with 272 earthquakes, and the month with the lowest seismicity was February with 114 earthquakes. Of the total seismicity in 2013, 44 earthquakes (1.92%) were reported as felt, all located within the Puerto Rico and Virgin Islands region. The magnitudes of the seismic events calculated for this year by PRSN ranged from 1.0 to 5.12, although for felt events they ranged from 2.36 to 5.12. During 2013, depths varied between 1 km and 182 km, while for earthquakes they ranged from 4 km to 112 km. The region with the highest recorded seismicity during 2013 was the Sombrero Seismic Zone with 504 seismic events, followed by the Virgin Islands Platform with 246 earthquakes. Through its educational program, PRSN reached 14,099 people in Puerto Rico and the U.S. and British Virgin Islands during 2013.

2020 Seismic Sequence

In early January 2020, Puerto Rico experienced a significant seismic sequence that began with a series of foreshocks and culminated in a powerful earthquake on January 7. The main shock registered a magnitude of 6.4 Mw, striking near the island's southern coast, particularly affecting the municipalities of Guayanilla, Ponce, and Yauco. This event was preceded by a 5.8 Mw earthquake on January 6, which caused widespread concern and structural damage (USGS, n.d.). The seismic activity was linked to the complex interaction between the Caribbean and North American tectonic plates, an area known for its subduction zones and fault systems. The shaking was felt across the island, leading to power outages, school closures, and the collapse of several buildings, including homes and public structures.

The aftermath of the earthquake revealed extensive damage to infrastructure and homes, displacing thousands of residents and prompting a federal emergency declaration. The southern region faced prolonged aftershocks, some exceeding magnitude 5.0, which continued for weeks, heightening anxiety among the population. The event underscored Puerto Rico's vulnerability to seismic hazards and the importance of preparedness and resilient construction practices. This seismic event received a Presidential Disaster Declaration under the Stafford Act - DR-4473-PR (FEMA, n.d.). Although the Municipality of Barranquitas was not included in the Disaster Declaration, the municipality is aware that due to Puerto Rico' s position along an active tectonic boundaries seismic events can cause millions of dollars in damage, disrupting daily life.

According to the Puerto Rico Seismic Network (PRSN), from the onset of the South–Southwest Puerto Rico seismic sequence in 2019 through April 2024, a total of 27,497 earthquakes associated with this sequence were recorded and processed. Of these events, more than 1,688 were reported as felt, and over 492 registered magnitudes greater than 3.5. Additionally, 42 earthquakes reached magnitudes exceeding 4.5.

4.5.1.4 Future Event Probabilities (B1-e)

Contrary to atmospheric events, currently there is no scientific way to predict earthquakes. However, current technical state of knowledge allows for scientific forecasts. Between 1670 and today, Puerto Rico has experienced four significant, destructive earthquakes in the years 1670, 1787, 1867, and 1918. This historical record suggests a recurrence cycle ranging from 51 to 117 years, with an average of 83 years for destructive earthquakes. However, it is important to note that each of these events occurred along different faults; therefore, calculating a precise recurrence rate cannot rely solely on these events.

For more comprehensive studies, geologic maps of specific zones are analyzed, focusing on active faults and other structural features. These are correlated with historical earthquake intensity distributions, seismic attenuation models, and statistical data. The result is a map of seismically active zones, identifying regions where varying degrees of strong earthquakes may occur. Identifying these high-risk zones is essential for land-use planning and emergency preparedness.

In the case of Puerto Rico, PRSN quotes a a probabilistic seismic hazard study conducted in 1987 by Dr. William McCann that estimated a 33–50% probability of a strong earthquake (Intensity VII or higher on the Modified Mercalli Scale) occurring in different parts of the island within a 50-year period (PRSN, 2025).

Further research by the U.S. Geological Survey in 2003 revealed that an area west-southwest of Puerto Rico is the most likely location for strong earthquakes on the island. This probabilistic analysis does not account for secondary effects such as tsunamis, liquefaction, and seismic wave amplification, which primarily impact low-lying coastal zones and highland areas prone to landslides.

Though the Municipality of Barranquitas has not been directly impacted by earthquakes in the recent past, this type of information is relevant to identify actionable mitigation strategies and proactively address them.

4.5.2 Risk Analysis (B2-a, B2-b)

4.5.2.1 Estimated Losses

Municipal Exposure

The Federal Emergency Management Agency's Hazus Earthquake Analysis provides estimates of Annualized Earthquake Losses—representing the long-term average economic impact of earthquakes on the general building stock within a specific geographic area for any given year—as well as an annualized estimate of population loss.

The Annualized Earthquake Loss is calculated using the Riemann Sums Method. This approach averages the annual losses associated with multiple return periods, then multiplies each return period's averaged loss by its differential probability to generate a single loss value for each Census tract. (FEMA, National Risk Index Data - Technical Documentation, 2025).

Table 21 shows the Exposure to Earthquake Hazards. Here we must clarify that although it might be difficult to precise the value of a human life, following FEMA guidance population loss is converted into a monetary value using a "population equivalence" approach based on the Value of Statistical Life (VSL). Under this method, each fatality—or every ten injuries—is assigned an economic loss of $13.7 million, which reflects FEMA's inflation-adjusted VSL estimate. All historical loss values are further adjusted to December 2024 dollars to account for inflation.

The HAZUS 6.1 analysis shows that the total exposure of the municipality to an earthquake event is $339,316,189,000. This includes $3,113,389,000 exposure of building value and $336,202,800 population exposure.

Table 21: Exposure to Earthquake Hazard

Exposure - Impacted Area (sq mi)	Exposure - Building Value	Exposure - Population	Exposure - Population Equivalence	Exposure - Total
34.628821	$3,113,389,000	28,983	$336,202,800,000	$339,316,189,000

Source FEMA's NRI

Annual Expected Loss

The Federal Emergency Management Agency's Hazus Earthquake Analysis provides estimates of Annualized Earthquake Losses—representing the long-term average economic impact of earthquakes on the general building stock within a specific geographic area for any given year—as well as an annualized estimate of population loss.

The Annualized Earthquake Loss is calculated using the Riemann Sums Method. This approach averages the annual losses associated with multiple return periods, then multiplies each return period's averaged loss by its differential probability to generate a single loss value for each Census tract (FEMA, National Risk Index Data - Technical Documentation, 2025).

The expected annual loss for the jurisdiction represents the average yearly economic impact, expressed in dollars, anticipated from natural hazard events. Table 22 presents the expected annual earthquake-related losses for both buildings and population for the whole municipality.

Table 22: Expected Annual Loss to Earthquake

Expected Annual Loss - Building Value	Expected Annual Loss - Population	Expected Annual Loss - Population Equivalence	Expected Annual Loss -Total
$2,053,864	0.155256	$1,800,968	$3,854,831

Source FEMA's NRI

The results indicate an average annual building-related loss of approximately $2 million due to earthquake events. In addition, the estimated annual population loss is 0.155256 population equivalents, which FEMA converts to an annualized economic loss of approximately $1.8 million using its population equivalence methodology. Combined, these values result in a total expected annual earthquake loss of approximately $3.9 million. These estimates represent the long-term average annual impact of earthquake events and provide an indication of the municipality's relative earthquake risk and potential future economic losses.

4.5.2.2 Lifelines and Critical Infrastructure

Earthquakes can impact a community's lifeline in the following matter:

- Safety and Security – An earthquake can lead to the structural collapse of critical facilities such as police and fire stations, increased demand for search and rescue operations and population displacement requiring emergency sheltering. Potential challenges could happen maintaining public order and security.

- Food, Hydration, and Shelter – A seismic event can damage to water treatment plants and distribution systems, leading to contamination or loss of potable water. There could also be disruption of food supply chains due to damaged transportation routes and storage facilities. There can be increased need for temporary shelters because of widespread structural damage. Finally, loss of refrigeration capacity can lead to loss of perishable goods.

- Health and Medicine - Hospitals and clinics may suffer structural damage or lose operational capacity. Surge in injuries requiring emergency medical care may overburden existing medical facilities. Disruption of pharmaceutical supply chains and medical logistics can also happen. Elevated risk of disease outbreaks in shelters due to compromised sanitation is also a possibility.

- Energy - Damage to power plants, substations, and transmission lines, will create widespread outages. Gas line ruptures can create fire and explosion hazards. There can also be interruptions in fuel supply for generators and emergency vehicles.

- Communications - Damage to cell towers, fiber-optic cables, and communication hubs, resulting in connectivity loss. Overloaded networks due to emergency call volume. Impaired coordination for emergency response operations.

- Transportation - Collapse or severe damage to roads, bridges, and tunnels can restrict mobility. Airports and seaports may become inoperable due to runway or dock damage. Rail systems (Tren Urbano) can be disrupted by track deformation or landslides.

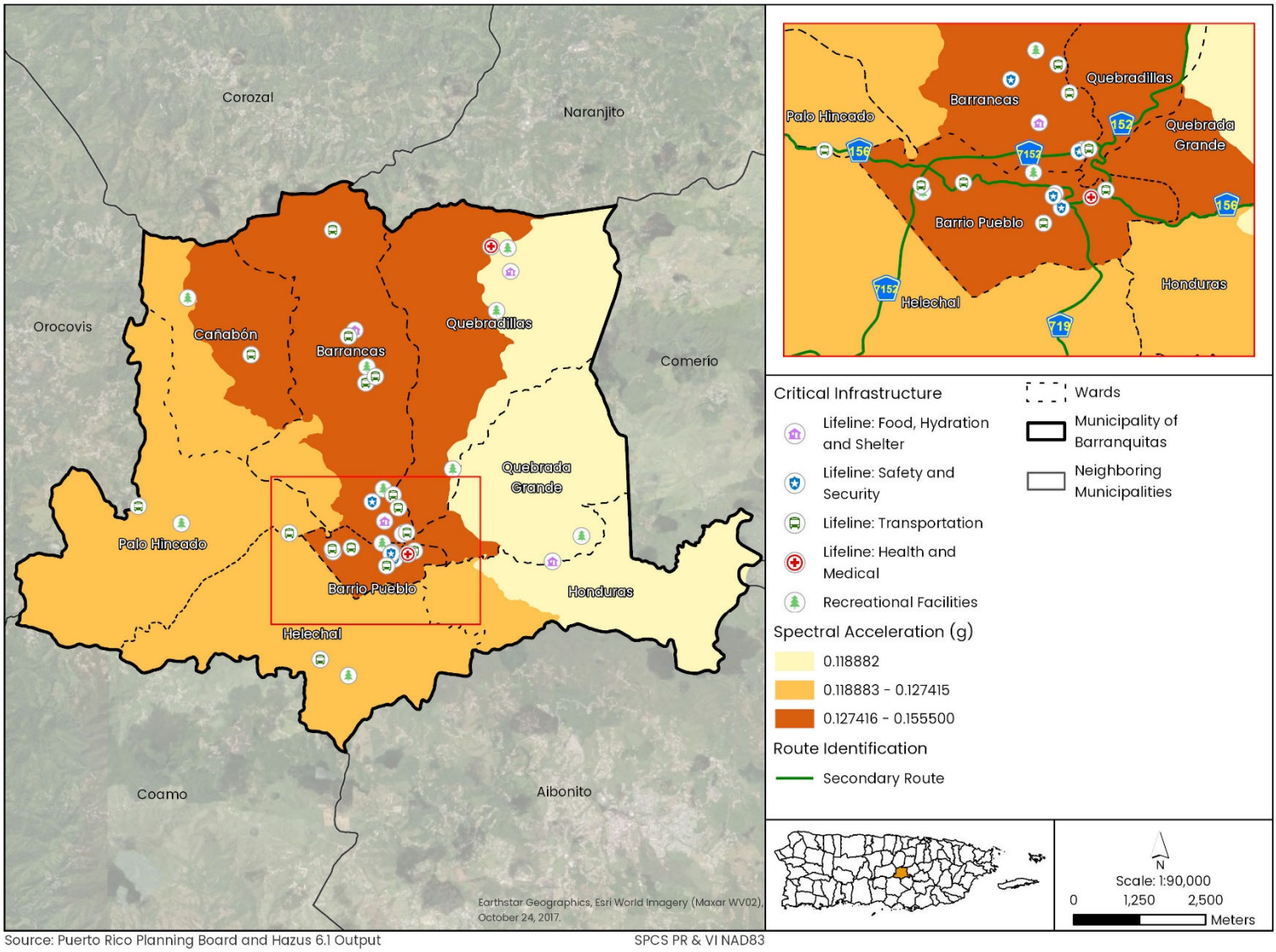
- Hazardous Materials – An earthquake may lead to spills from industrial facilities, chemical plants, or storage tanks. This can lead to Increased risk of environmental contamination in air, soil, and water. Fires or explosions from damaged hazardous material sites can also happen.

- Water Systems - Breakage of water mains and sewer lines can cause flooding and contamination. There can also be reduced firefighting capability due to lack of water pressure as well as long-term disruption of sanitation services.

Maps 16 and 17 show the identified critical infrastructure location in respect to the spectral acceleration areas shown in section 4.6.1.1.

Map 16: Earthquake: Critical Facilities Exposure to Spectral Acceleration at 1.0 sec (G)

Earthquake: Critical Facilities Exposure to Spectral Acceleration at 1.0 sec (G)

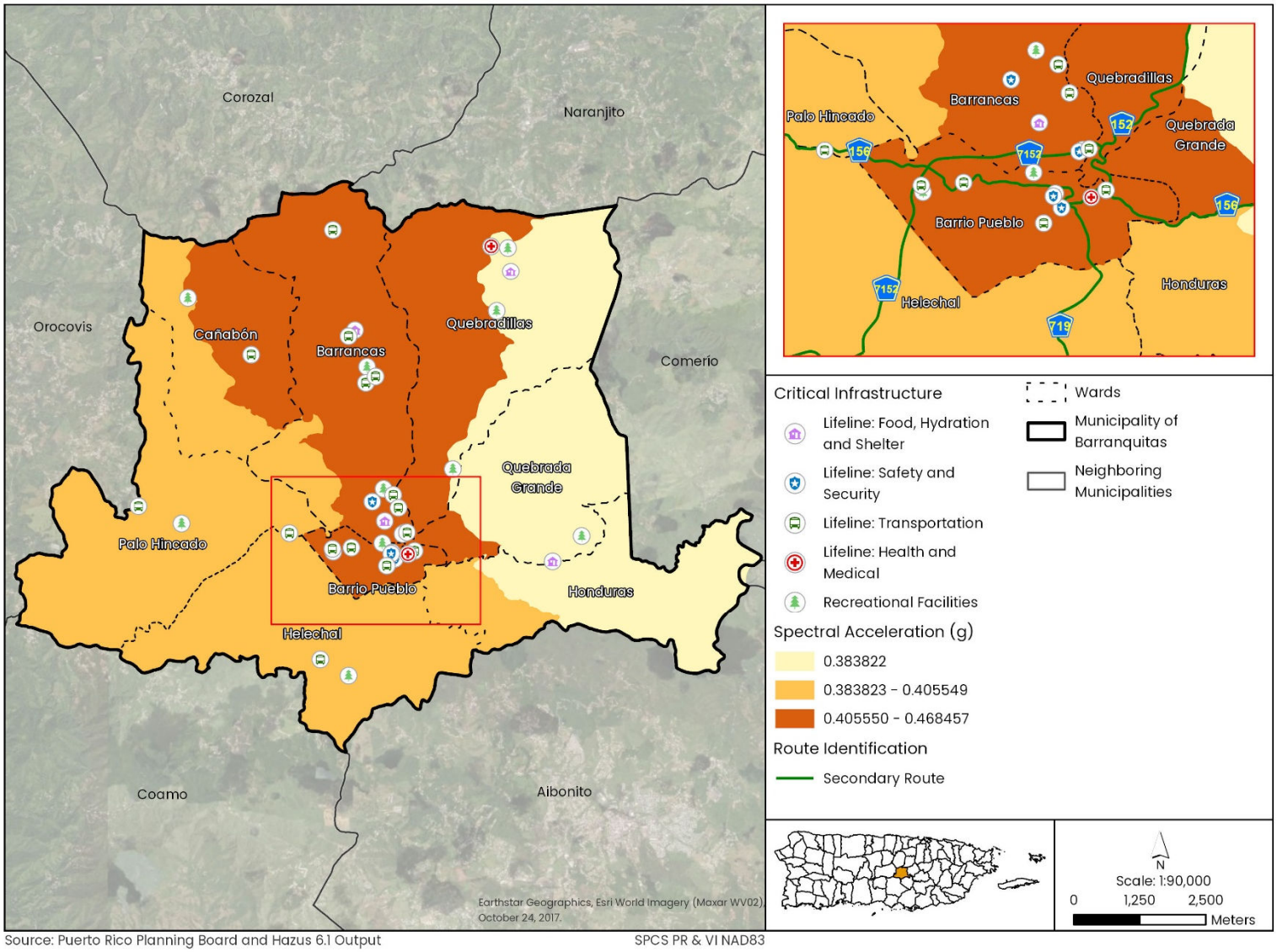


Source: Puerto Rico Planning Board and Hazus 6.1 Output SPCS PR & VI NAD83

Map 16 illustrates that the highest spectral acceleration values at 1.0 second are concentrated in the central and northern portions of Barranquitas, including Barrancas, Portions of Cañabón, Quebradillas, and Barrio Pueblo. Several critical facilities are located within these higher-value areas, particularly in and around Barrio Pueblo, while additional facilities are distributed throughout the municipality in areas mapped with moderate and lower spectral acceleration values.

Map 17: Earthquake: Critical Facilities Exposure to Spectral Acceleration at 0.3 sec (G)

Earthquake: Critical Facilities Exposure to Spectral Acceleration at 0.3 sec (G)



Source: Puerto Rico Planning Board and Hazus 6.1 Output

SPCS PR & VI NAD83

Map 17 illustrates that the highest spectral acceleration values at 0.3 seconds are concentrated in the central and northern portions of Barranquitas, including Barrancas, portions of Cañabón, Quebradillas, and Barrio Pueblo. Numerous critical facilities are located within these higher-value areas, particularly in and around Barrio Pueblo, while additional facilities are distributed throughout the municipality in areas characterized by moderate and lower spectral acceleration values.

4.5.2.3 Social Vulnerabilities

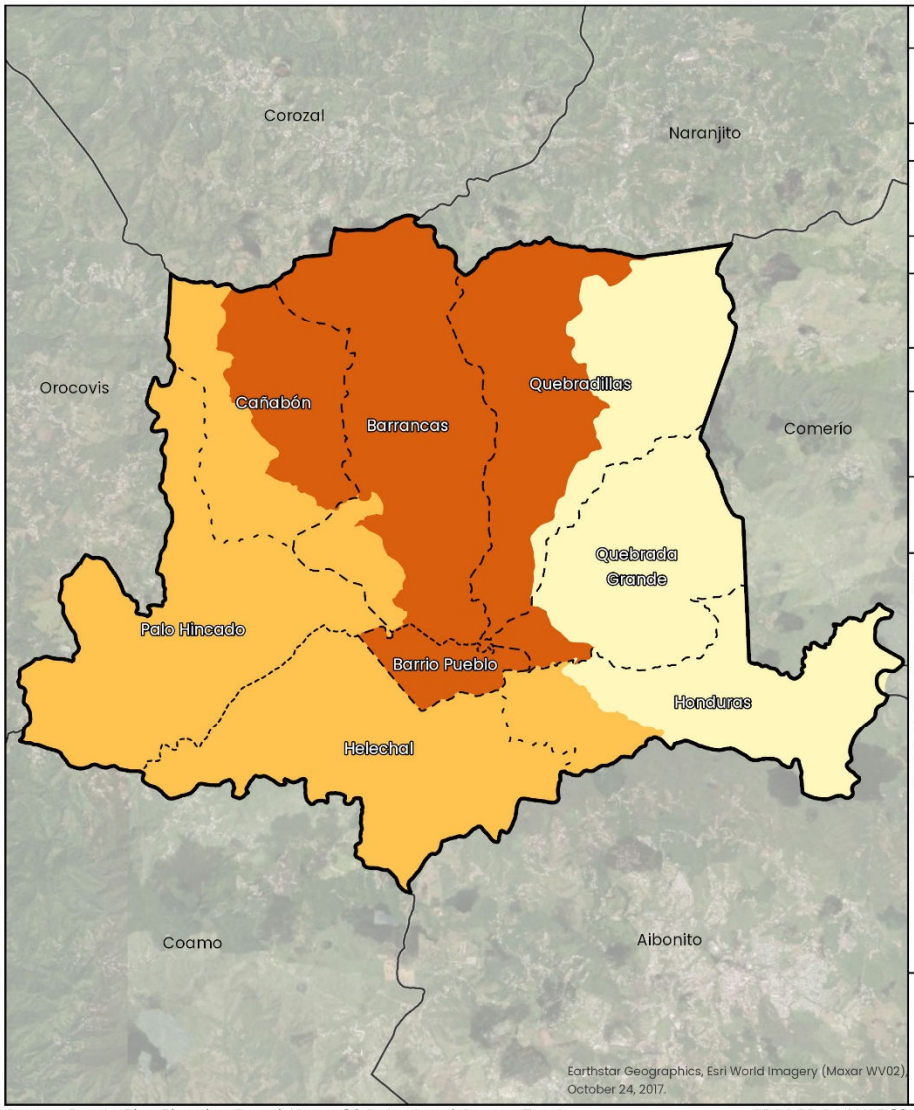
Social vulnerability to earthquakes in Puerto Rico is shaped by high levels of poverty, aging infrastructure, and limited access to essential resources, all of which disproportionately affect the ability of communities to withstand and recover from seismic events. Many residents face compounding disadvantages—such as disability, low educational attainment, and limited vehicle access—that reduce their capacity to evacuate, access information, or secure aid after a damaging earthquake. Research on disaster governance also shows that systemic governmental neglect and energy insecurity intensify the impacts of disasters, leaving communities with fewer resilience mechanisms in the aftermath of earthquakes.

Puerto Rico's disaster research literature identifies long-standing structural inequities that heighten vulnerability, including political and economic marginalization that limit long-term recovery and exacerbate risk accumulation across hazard types. Federal assessments further find that many census tracts exhibit high social vulnerability scores (US Census Bureau, 2024), (US Census Bureau, 2025), meaning that an earthquake's impacts are likely to intersect with broader socio-economic fragility. Overall, these combined factors demonstrate that earthquakes in Puerto Rico pose not only a physical hazard but also a deep social challenge tied to historical, economic, and infrastructural conditions that shape uneven disaster outcomes. For more details about Social Vulnerabilities see section 3.4.

Maps 18 and 19 show the municipality's exposure to an earthquake by ward for a spectral acceleration event of 1.0 sec. (g) and 0.3 sec (g) periods, respectively. The maps indicate that population vulnerability varies among wards according to the level of spectral acceleration and the number of residents within each risk category.

Map 18: Earthquake: Population Exposed to Spectral Acceleration at 1.0 sec (G)

Earthquake: Population Exposure to Spectral Acceleration at 1.0 sec (G)



Wards	Risk Category	Population
Barrancas	Medium	574
	High	4,627
Barrio Pueblo	High	2,037
Cañabón	Medium	1,347
	High	1,748
Helechal	Medium	4,018
Honduras	Low	1,813
	Medium	769
Palo Hincado	Medium	4,435
Quebrada Grande	Low	1,971
	High	360
Quebradillas	Low	1,639
	High	3,859

Spectral Acceleration (g)
- 0.118882 (Low)
- 0.118883 - 0.127415 (Medium)
- 0.127416 - 0.155500 (High)
- Wards
- Municipality of Barranquitas
- Neighboring Municipalities



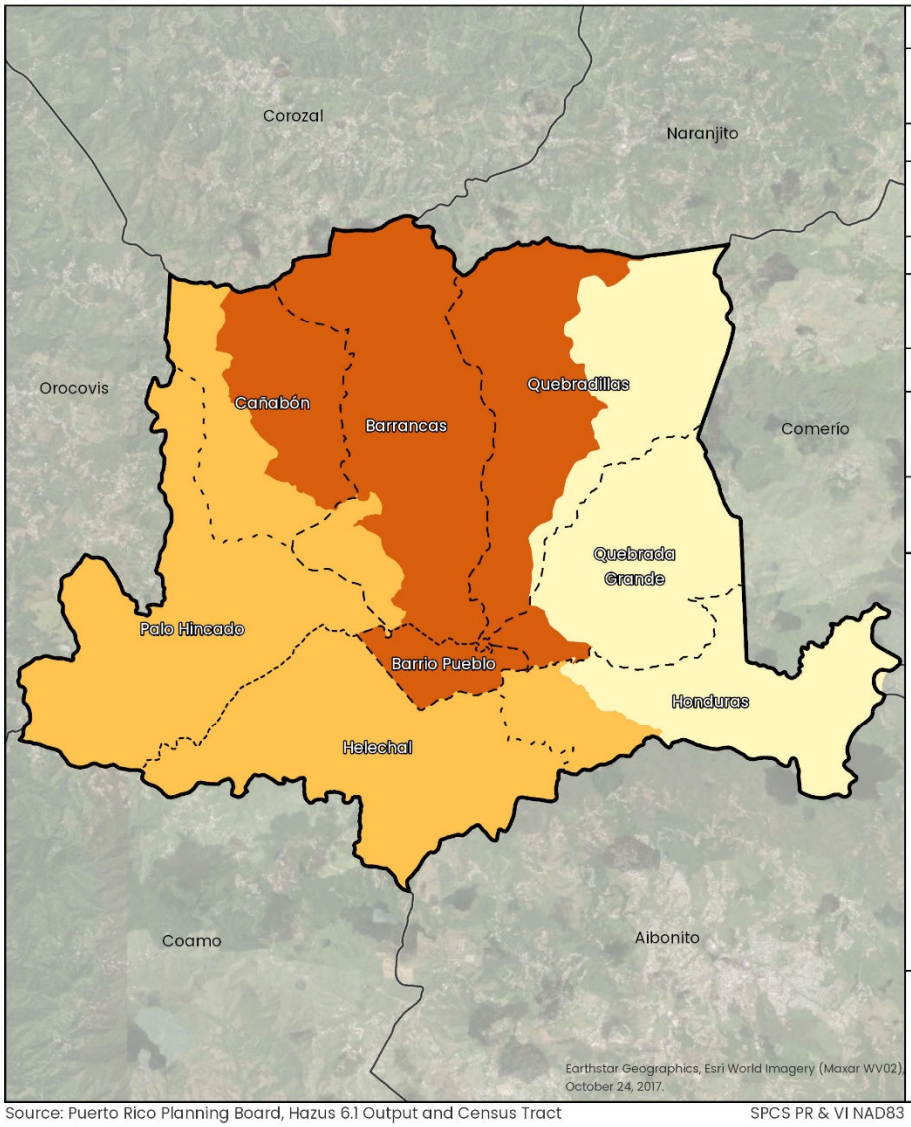
N
Scale: 1:90,000
0 1,250 2,500
Meters

Source: Puerto Rico Planning Board, Hazus 6.1 Output and Census Tract SPCS PR & VI NAD83

Map 18 illustrates that high spectral acceleration values at 1.0 second are concentrated in Barrancas, Barrio Pueblo, and portions of Cañabón and Quebradillas. According to the map table, Barrancas contains the largest population within the high exposure category (4,627 people), followed by Quebradillas (3,859 people) and Barrio Pueblo (2,037 people). Medium exposure areas are primarily located in Palo Hincado and Helechal, while low exposure areas are concentrated in Quebrada Grande, Honduras, and portions of Quebradillas.

Map 19: Earthquake: Population Exposure to Spectral Acceleration at 0.3 sec (G)

Earthquake: Population Exposure to Spectral Acceleration at 0.3 sec (G)



Wards	Risk Category	Population
Barrancas	Low	1,639
	Medium	1,854
Barrio Pueblo	High	22
Cañabón	Medium	574
	High	4,586
Helechal	High	2,037
Honduras	Medium	4,018
	High	3,837
Palo Hincado	Medium	2,116
Quebrada Grande	Low	1,813
	High	41
Quebradillas	Low	1,971
	High	2,108

Spectral Acceleration (g)
- 0.383822 (Low)
- 0.383823 - 0.405549 (Medium)
- 0.405550 - 0.468457 (High)
- Wards
- Municipality of Barranquitas
- Neighboring Municipalities



N
Scale: 1:90,000
0 1,250 2,500
Meters

Source: Puerto Rico Planning Board, Hazus 6.1 Output and Census Tract SPCS PR & VI NAD83

Map 19 illustrates that the highest spectral acceleration exposure zone is concentrated across the central portion of Barranquitas, including most of Barrancas and Quebradillas, as well as portions of Cañabón, Barrio Pueblo, Honduras, and Quebrada Grande. Medium exposure areas are primarily located in the southern and western wards, including Helechal, Palo Hincado, and parts of Cañabón and Honduras. Low exposure areas are concentrated in the eastern sector, particularly within Quebrada Grande and portions of Quebradillas. According to the map table, the largest populations in the high exposure category are in Cañabón (4,586 people) and Honduras (3,837 people), while Barrancas contains both high and medium exposure

areas with a combined exposed population of 3,493 people.

4.5.2.4 Natural and Cultural Resources

Earthquakes can produce a wide range of impacts on natural and cultural resources:

- Landslides and Soil Instability: Earthquakes can trigger landslides, rockfalls, and soil liquefaction, altering landscapes and damaging habitats.
- Water Quality and Hydrology: Ground shaking may disrupt river courses, damage aquifers, and cause sedimentation in water bodies, reducing water quality and affecting aquatic ecosystems.
- Vegetation and Wildlife: Habitat destruction and fragmentation can occur due to ground deformation and secondary hazards such as flooding or fires.
- Coastal and Marine Environments: Submarine earthquakes can lead to tsunamis, causing erosion, coral reef damage, and loss of coastal ecosystems.

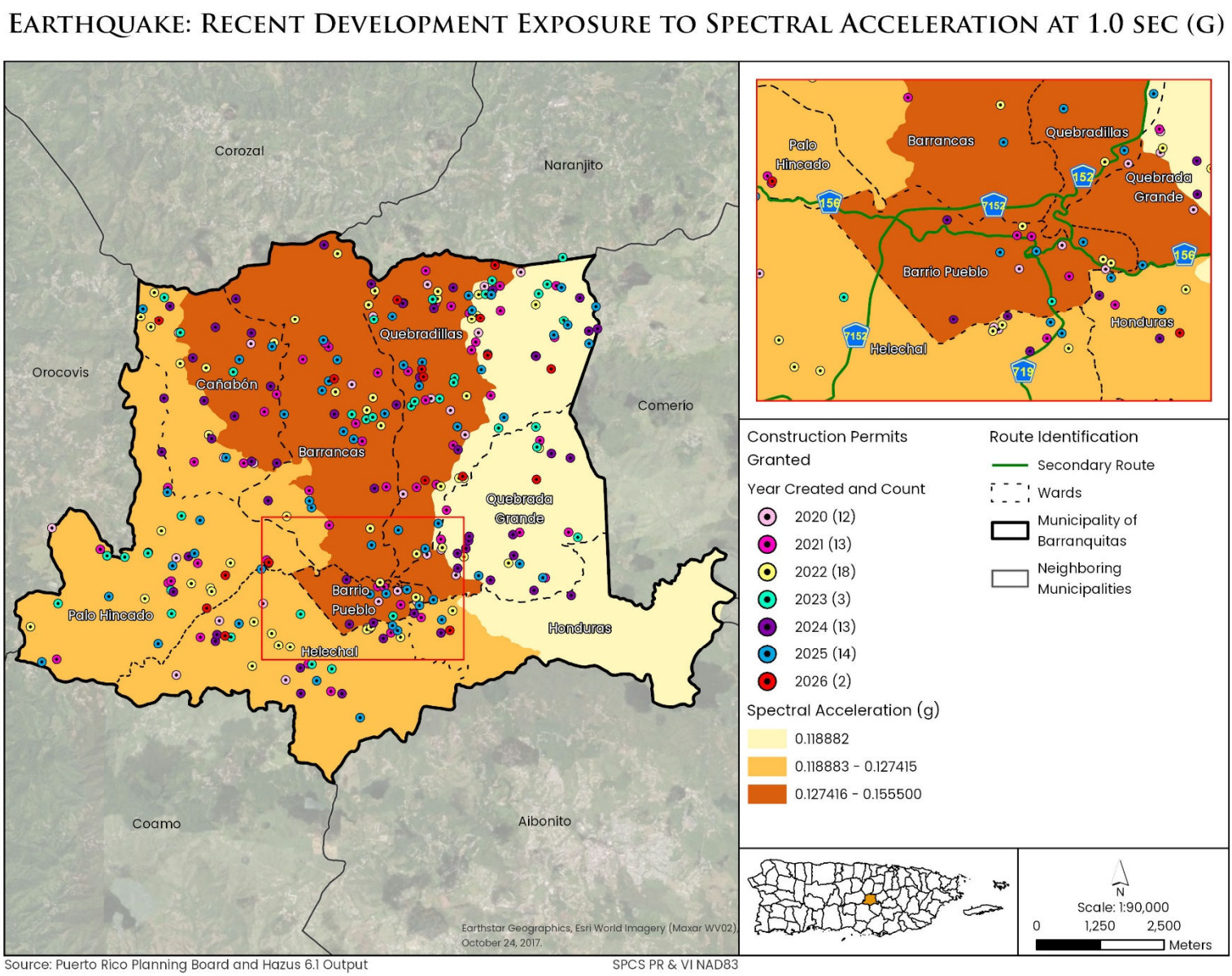
While the following damage can happen to Cultural Resources:

- Historic Buildings and Monuments: Structural damage or collapse of heritage buildings, archaeological sites, and monuments due to seismic forces.
- Museums and Archives: Loss or deterioration of artifacts, documents, and collections caused by building failure or inadequate seismic protection.
- Community Identity and Tourism: Damage to culturally significant sites can impact local identity and reduce tourism revenue, affecting economic stability.

4.5.2.5 Future Conditions (E1-a)

As discussed in Section 3.6, the elevated number of construction permits issued by the Municipality reflects a sustained level of economic activity. To further support this analysis, Maps 20 and 21 highlight the areas with the highest spectral acceleration values at 0.3 and 1.0 seconds alongside the distribution of authorized construction permits. Taken together, these findings indicate that future exposure to earthquake hazards is unlikely to diminish in the near term, as development continues to expand within zones of elevated seismic vulnerability.

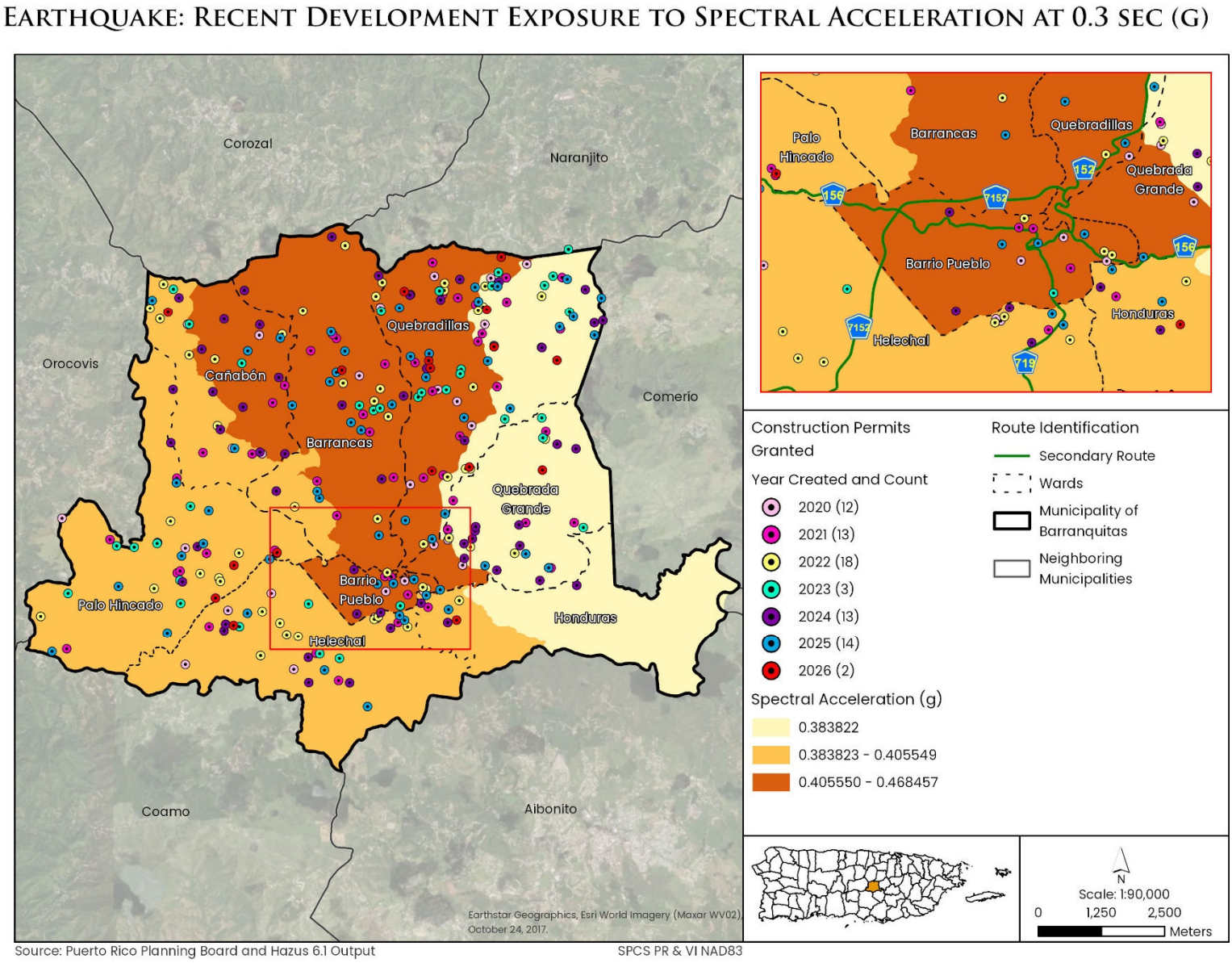
Map 20: Earthquake: Recent Development Exposure to Spectral Acceleration at 1.0 sec (G)



Map 20 illustrates that recent development permits are distributed throughout Barranquitas, with the highest concentration located in the central portion of the municipality, particularly within Barrancas, Quebradillas, and Barrio Pueblo, which are mapped within the highest spectral acceleration zone (0.127416–0.155500 g). Additional recent development is present in Cañabón, Helechal, Palo Hincado, Honduras, and Quebrada Grande, primarily within the medium and low spectral acceleration zones. The inset map highlights a cluster of permitted developments along the road network crossing Barrio Pueblo, Barrancas, Quebradillas, and Quebrada Grande, were recent construction activity overlaps areas of higher

earthquake spectral acceleration.

Map 21: Earthquake: Recent Development Exposure to Spectral Acceleration at 0.3 sec (G)



Map 21 illustrates that recent development permits are distributed across all wards of Barranquitas, with the greatest concentration occurring in the central and northern portions of the municipality. Numerous permits are located within the high spectral acceleration zone (0.405550–0.468457 g) covering much of Barrancas, Quebradillas, Cañabón, and Barrio Pueblo. Additional recent development is present within the medium spectral acceleration zone in Helechal and Palo Hincado, while Quebrada Grande and Honduras contain development areas primarily within the low spectral

acceleration zone. The inset map highlights a concentration of recent construction permits along the road network in and around Barrio Pueblo, Barrancas, Quebradillas, and Quebrada Grande, where development overlaps the higher spectral acceleration areas.

4.6 Landslides

4.6.1 Description (B1-a)

Landslides are classified as a natural process caused by the downward movement of a mass of earth triggered by the instability of a given terrain. Landslides or slope failures occur when conditions converge so that the force of gravity exerts its influence on the materials of the Earth's crust beyond the natural inertia of those materials. The term "landslide" includes a wide variety of ground movements, such as rockfalls, slope failures, and debris flows. These ground movements endanger life and property and can also interrupt traffic on roadways and drag along trees, houses, bridges, and cars, among others (FEMA, 1997).

The passage of meteorological phenomena that cause prolonged and intense rainfall, such as tropical waves, troughs, and tropical cyclones, are major causes that can trigger landslide events. Likewise, population growth and informal construction increase the municipality's susceptibility to the effects of landslides. Potable water supply and waste management systems (sanitary pipes, septic tanks, and storm sewers), both in authorized and informal constructions, aggravate the conditions that cause landslides. The probability of landslides occurring increases if these systems leak or are poorly located or constructed (USGS, n.d.).

Among the many factors that cause landslide formation are soil type, slope or inclination of the terrain, water saturation of the soil, erosion, the presence of depressions or cavities, human activities, and the occurrence of earthquakes. As stated in the Building Performance Assessment Report (BPAR), prepared after Hurricane Georges, "landslides will become a major problem in the future as more houses are built and more development occurs in areas susceptible to these risks" (FEMA, 1997).

Many of the landslides that occur in Puerto Rico falls into a special category of landslides known as "debris flows." The flow occurs in mountainous areas with significant slopes during intense rainfall. Rain saturates the soil and causes the flat subsurface to lose solidity and detach, usually where this subsurface meets the

bedrock. There are many types of landslides; however, those associated with water saturation of the ground are as follows (PREMB, 2021):

- Slow landslide: Slow and sustained movement of earth or rock descending down the slope. Recognized by its content of tree trunks, pieces of twisted fences or retaining walls, and leaning posts or fences.

- Debris flow: A mass of rapid movement in which loose soils, rocks, organic matter combine with infiltrated air and water to form a viscous flow sliding down the hillside.

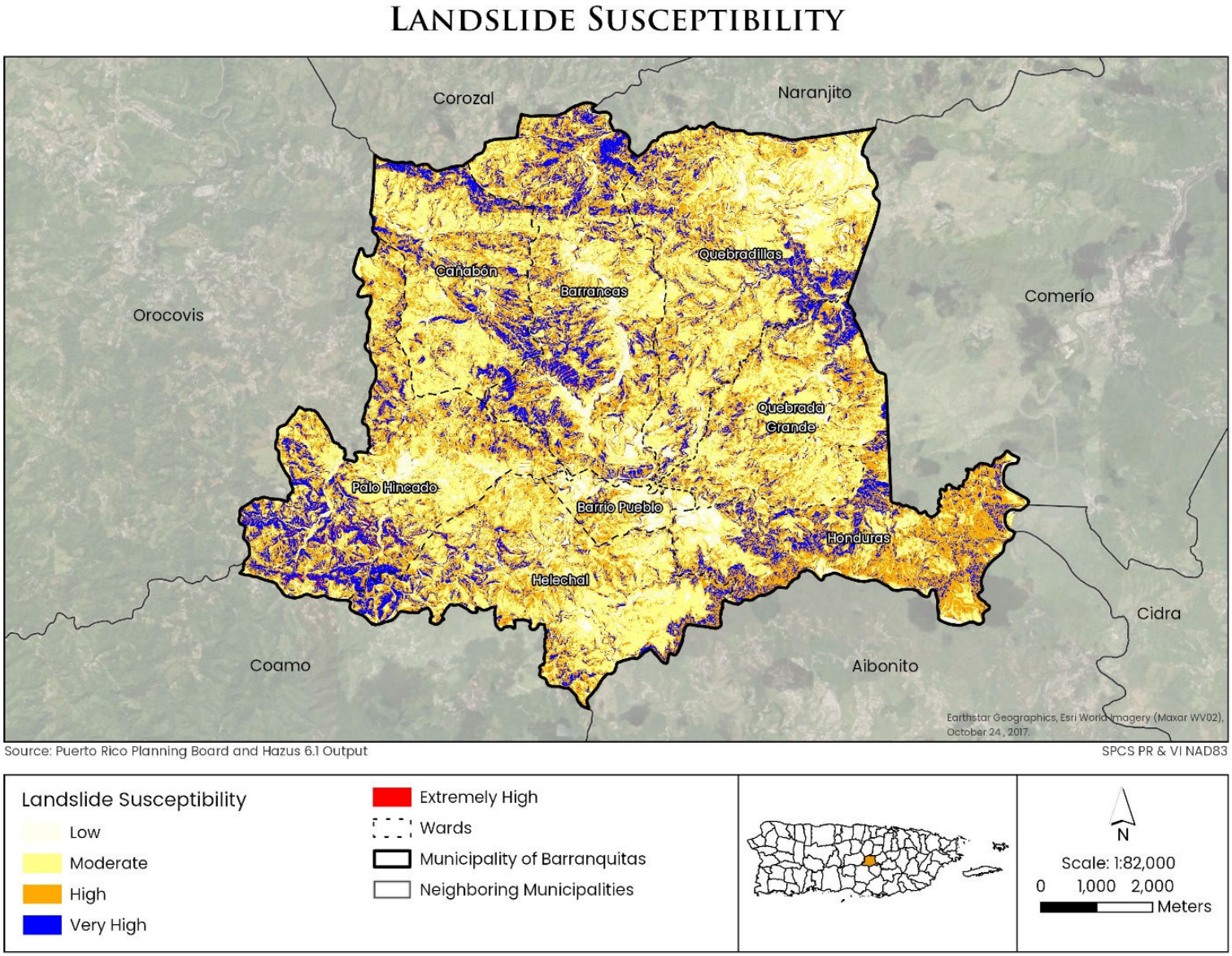
- Debris avalanche: A variety of very fast or extremely fast debris flow.

- Mudflow: A mass of rapid flow containing wet material of at least 50 percent sand, silt, and clay particles.

4.6.1.1 Affected Area (B1-B)

As with all municipalities within Puerto Rico's mountainous region, Barranquitas has experienced a high volume of landslides in recent years. Map 22 shows the areas considered moderately and highly susceptible to landslides in Barranquitas. The following map identifies the areas with the highest susceptibility to landslide events.

Map 22: Landslide Susceptibility



The landslide susceptibility map illustrates that moderate susceptibility is the predominant classification across Barranquitas. Areas of high and very high susceptibility are dispersed throughout all wards, forming linear and clustered patterns across the municipality. Concentrations of very high susceptibility are particularly evident in portions of Palo Hincado, Cañabón, Barrancas, Quebradillas, Quebrada Grande, and Honduras. Low susceptibility areas are scattered and generally limited to extent. No areas classified as extremely high susceptibility are visible on the map.

4.6.1.2 Risk Magnitude (B1-C)

Landslides commonly occur in steep mountainous areas during periods of intense rainfall. Rain saturates the soil and causes natural drainage to lose its structural capacity and fail. Some areas tend to be more prone to landslides than others. Sites with greater slope are among the most susceptible to landslides. Vegetation contributes to how soil remains compacted, helping resist surface erosion. Slopes without vegetation tend to be more prone to erosion than vegetated slopes. The shape and condition of a slope can affect stability. Factors that influence slope stability include height, inclination, vegetation, and geology. In general, an increase in height and slope correlates with reduced terrain stability. Below are factors that influence the occurrence of landslides:

- The base of inclined terrain
- Near the base of small hollows where drainage is nearby
- The base of a slope that has fill material
- The base or crest of a very steep slope
- Areas with previous landslides
- Hillsides that have been developed and where septic systems have been used
- Steep slopes in clayey soils
- Hills or slopes with an inclination greater than 12 degrees and an elevation over 300 meters

Hazard categories come from the index used by the USGS. These categories are based on slope and soil characteristics as defined by the federal agency. Table 23 provides a description of the event according to the categories: low, moderate, high, and very high.

Table 23: Landslide Risk Categories

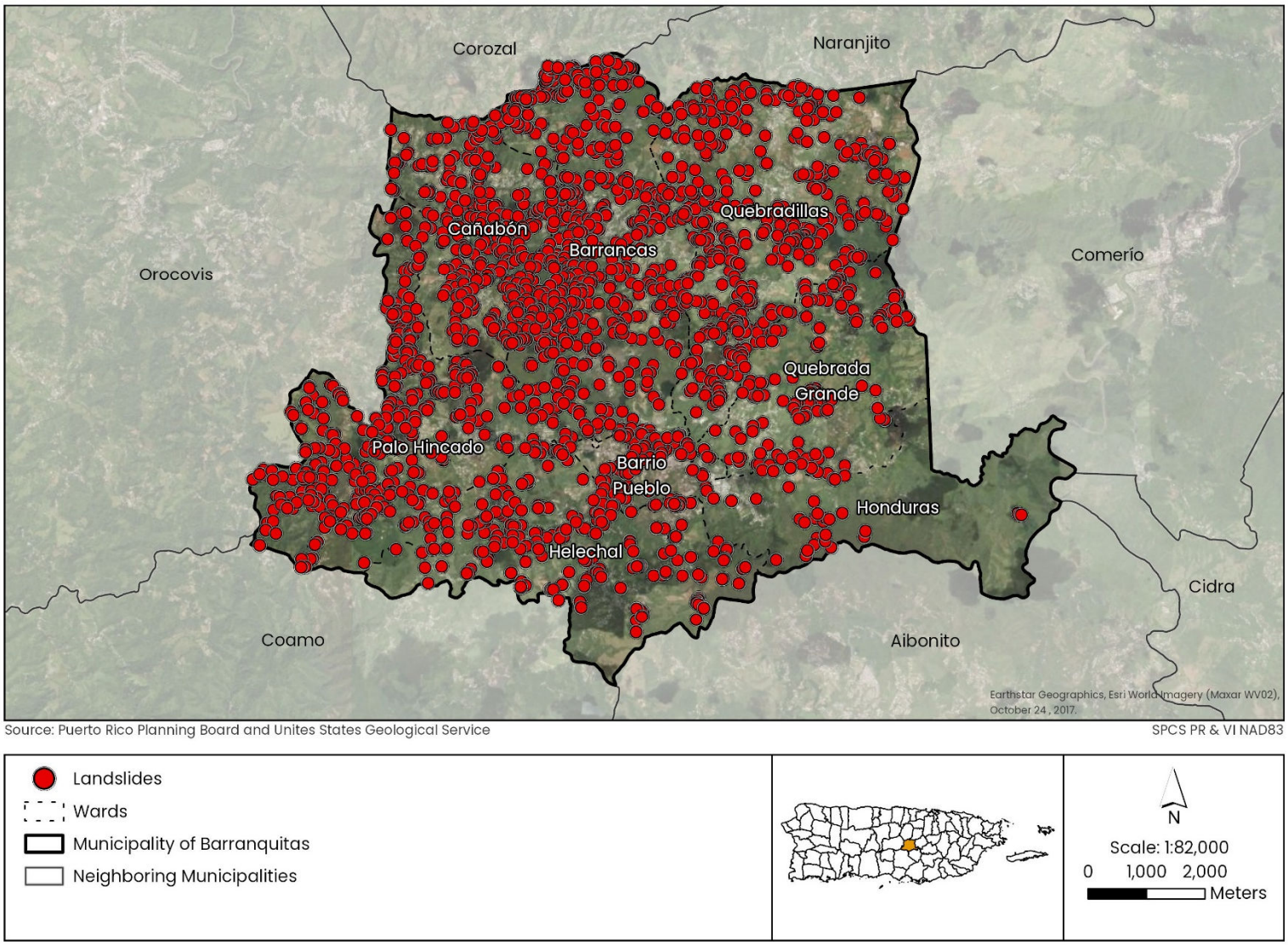
Category	Description
Low	Areas with minimal slopes and stable soil; landslides are unlikely except under extreme conditions.
Moderate	Areas with some susceptibility; landslides may occur during prolonged or intense rainfall.
High	Areas with significant susceptibility; landslides are likely during heavy rain or seismic activity.
Very High	Areas extremely prone to landslides; frequent events during storms or earthquakes.

The municipality considers landslide prevention and mitigation as part of its Earthquake protocol.

4.6.1.3 Past Events (B1-d)

As stated above, landslides are frequently associated with heavy rainfall events. Map 23 illustrates the landslides reported following Hurricane María in 2017, which are distributed throughout Barranquitas. Map 33 shows particularly dense concentrations of reported landslides across Barrancas, Cañabón, Quebradillas, Palo Hincado, Helechal, and Quebrada Grande, with fewer but still widespread occurrences in Barrio Pueblo and Honduras. The spatial distribution of reported landslides generally corresponds with the areas identified as having high and very high landslide susceptibility on the susceptibility map, indicating a strong overlap between documented landslide occurrences and the municipality's most susceptible areas.

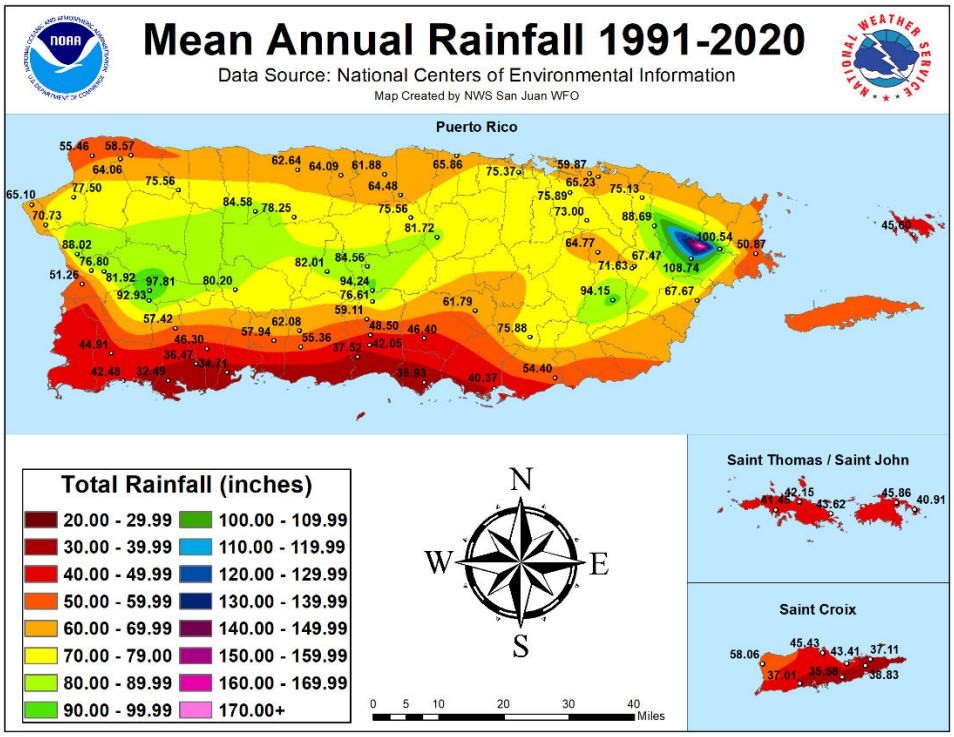
Map 23: Landslides Reported in the Aftermath of Hurricane María



4.6.1.4 Future Event Probabilities (B1-E)

Though landslides can be caused by earthquakes or anthropogenic factors, most of the landslides in Puerto Rico are caused by rain events. As shown before landslides can happen by any type of rain event. Figure shows the Mean Annual Rainfall for Puerto Rico and the US Virgin Islands from 1991 to 2020. The Municipality of Barranquitas is wholly in an area where the annual mean rainfall varies between 60.00-69.00 inches and 70.00-79.00 in some areas.

Figure 14: Mean Annual Rainfall 1991-2020 (PR & USVI)[7]



4.6.2 Risk Analysis

4.6.2.1 Estimated Losses

In the Municipality of Barranquitas as in much of Puerto Rico, landslides typically occur during or after major storms with torrential rainfall. The occurrence of rainfall-induced landslides is closely associated with severe storms or sequential rain events that saturate vulnerable steep soils.

[7] Obtained from https://www.weather.gov/sju/climo_pr_usvi_normals

Currently, there are no standardized models to estimate structural and content losses caused by landslides and other mass movements. For this reason, susceptibility indices from the USGS were empirically applied using the best available data to assess potential losses from mass movements in Barranquitas. These indices are categorized into four risk levels: low, moderate, high, and very high. Due to limited data, it is not possible to estimate monetary losses for building damage currently.

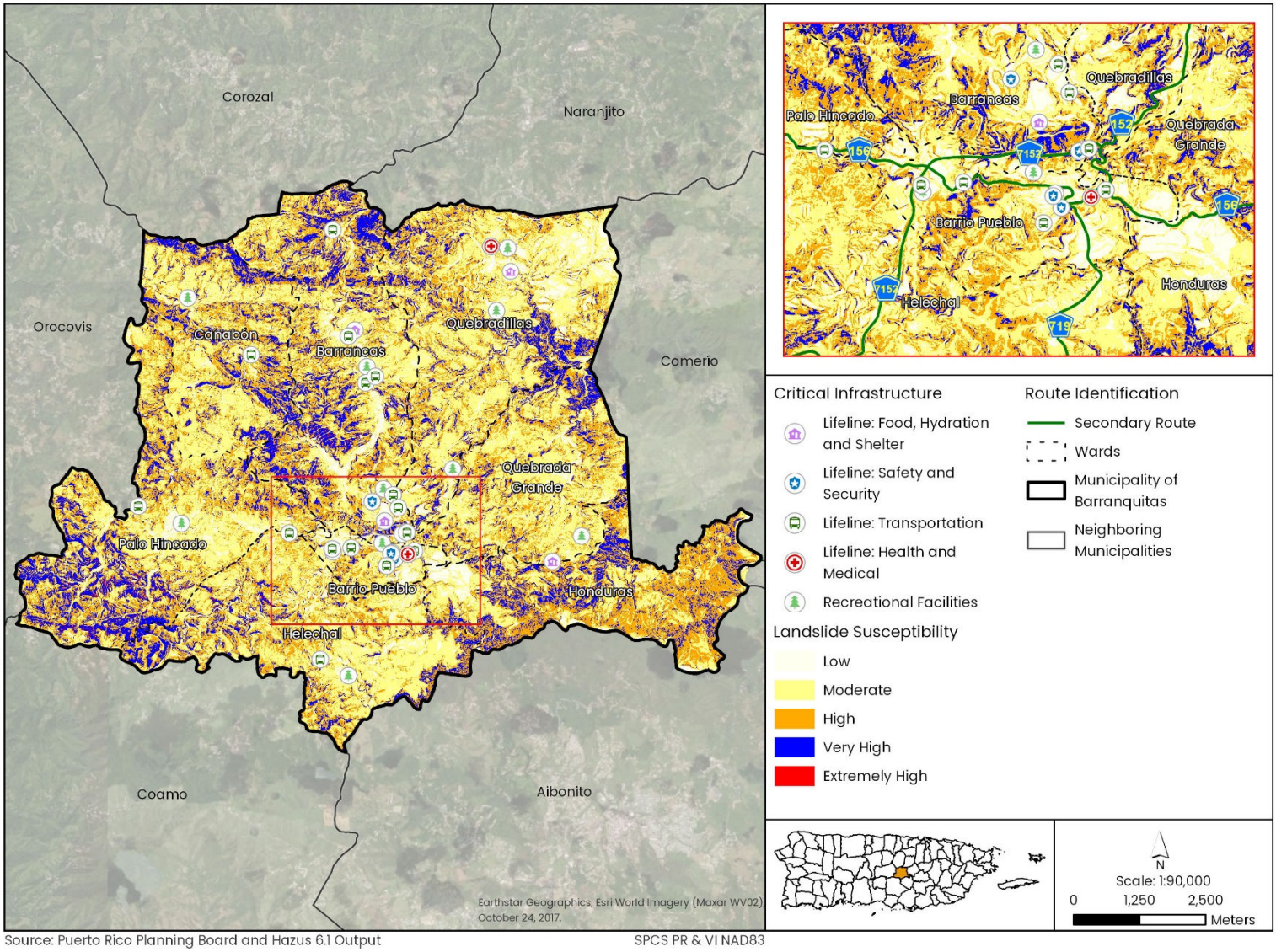
4.6.2.2 Lifelines and Critical Infrastructure

Landslides can affect FEMA Lifelines in the following ways:

- Safety and Security - Landslides can entrap and kill individuals through rapid debris movement, complicate rescue efforts, and lead to loss of life and security threats due to isolated or destroyed emergency services (Center for Disaster Resilient Communities, n.d.).
- Food, Hydration, and Shelter - Destruction of homes and agricultural land leads to displacement and food insecurity; disruption of local water and sanitation increases contamination risks, particularly in temporary shelter settings (IFRC, 2023).
- Health and Medicine - Direct injuries (e.g., trauma, suffocation) occur during landslides; longer-term impacts include outbreaks of waterborne and vector-borne diseases, and psychological trauma among survivors (Center for Disaster Resilient Communities, n.d.).
- Energy Landslides can damage power lines, substations, and fuel infrastructure, causing wide-ranging electrical outages hindering both public and emergency responses.
- Communications Cable disruptions, toppled poles, and blocked access to telecom facilities can impair alert systems, responder coordination, and public information networks.
- Transportation - Roads, railways, bridges, and tunnels can become impassable or destroyed due to landslide deposits, severely restricting mobility for both the public and emergency services.
- Hazardous Materials - Landslides may rupture containment units, pipelines, tanks, or industrial facilities, release chemicals or pollutants and create HAZMAT emergencies (FEMA, 2024).
- Water Systems - Damage to water intake, treatment, distribution, sewage collection, and treatment facilities can result in contamination, reduced water pressure, and service interruption (IFRC, 2023).

Map 24 shows the identified critical infrastructure that could be affected by Landslides. The map illustrates that the critical infrastructure facilities are distributed throughout Barranquitas, with the highest concentration located in and around Barrio Pueblo, extending into portions of Helechal, Barrancas, Quebradillas, and Quebrada Grande, as highlighted in the inset map. Most facilities are situated within areas mapped as moderate landslide susceptibility, while several transportation, health and medical, safety and security, recreational, and food, hydration, and shelter facilities are located adjacent to or within high and very high susceptibility zones. Critical infrastructure is also present in Cañabón, Palo Hincado, and Honduras, where facilities are interspersed among areas of varying landslide susceptibility.

Map 24: Landslide: Critical Infrastructure Exposure



Source: Puerto Rico Planning Board and Hazus 6.1 Output SPCS PR & VI NAD83

4.6.2.3 Social Vulnerabilities

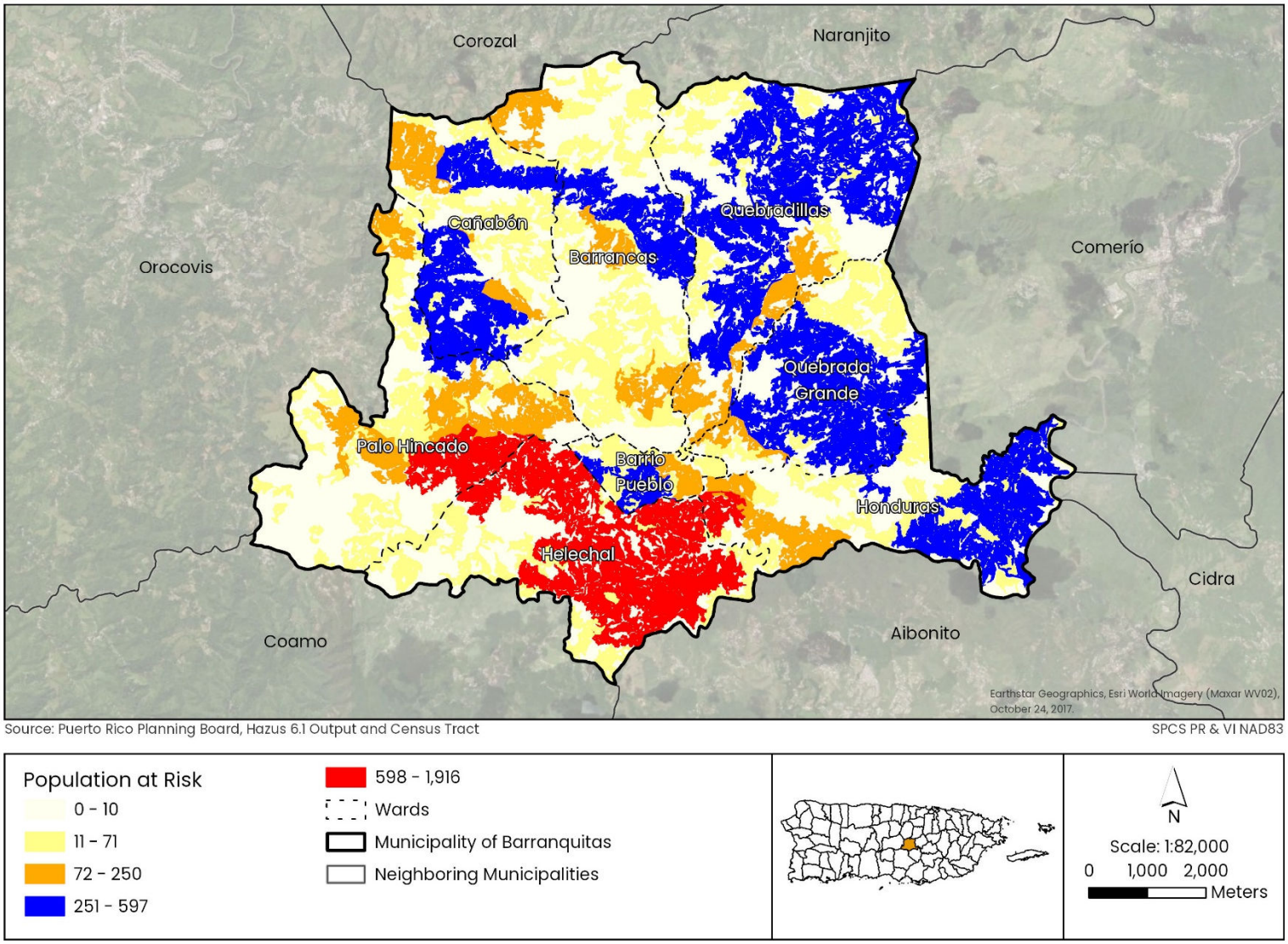
Social vulnerability to landslides in Puerto Rico is the product of topography, poverty, aging populations, fragile infrastructure, and geographic isolation, all of which shape the severity of impacts after major storms or seismic events. Academic and federal analyses consistently show that landslides disproportionately burden communities that already struggle with access to transportation, healthcare, income stability, and emergency response. Addressing these vulnerabilities requires hazard mitigation strategies that integrate geospatial risk analysis, social vulnerability indicators,

community-based planning, and infrastructure reinforcement tailored to rural and mountainous municipalities (West, Rodríguez Cruz, & Hughes, 2023).

Focus groups on the municipality of Utuado highlighted that landslides cut off access to medical facilities, emergency response, and even water and food, sometimes for months. Given the municipality's mountainous terrain and similar dependence on roadway access, comparable impacts could occur in Barranquitas following major landslide events. This creates immediate life-threatening conditions for people with health conditions, mobility limitations, or emergency medical needs (West, Rodríguez Cruz, & Hughes, 2023).

Map 25 illustrates that the landslide population exposure is concentrated in several areas of Barranquitas. The highest population-at-risk category (598–1,916 people) is primarily located in Helechal, extending into portions of Palo Hincado and the area south of Barrio Pueblo. Areas classified in the 251–597 people category are concentrated in Quebradillas, Quebrada Grande, Honduras, and portions of Cañabón. Moderate exposure areas (72–250 people) are scattered throughout the municipality, while the lowest population exposure categories dominate much of Barrancas and other central areas. Overall, the map shows that the southern and eastern portions of the municipality contain the largest continuous areas with higher levels of population exposure to landslides.

Map 25: Landslide: Population Exposure



4.6.2.4 Natural and Cultural Resources

Landslides represent one of the most destructive natural hazards, with consequences that extend beyond immediate physical damage (Eliot, Cloyd, & Philbin, 1994). Their effects on natural resources are profound and often irreversible. When a landslide occurs, vast areas of vegetation are uprooted or buried, leading to the loss of critical habitats and a decline in biodiversity. The displacement of soil not only strips away fertile layers essential for agriculture but also introduces large volumes of sediment into rivers and reservoirs. This sedimentation degrades water quality, disrupts aquatic

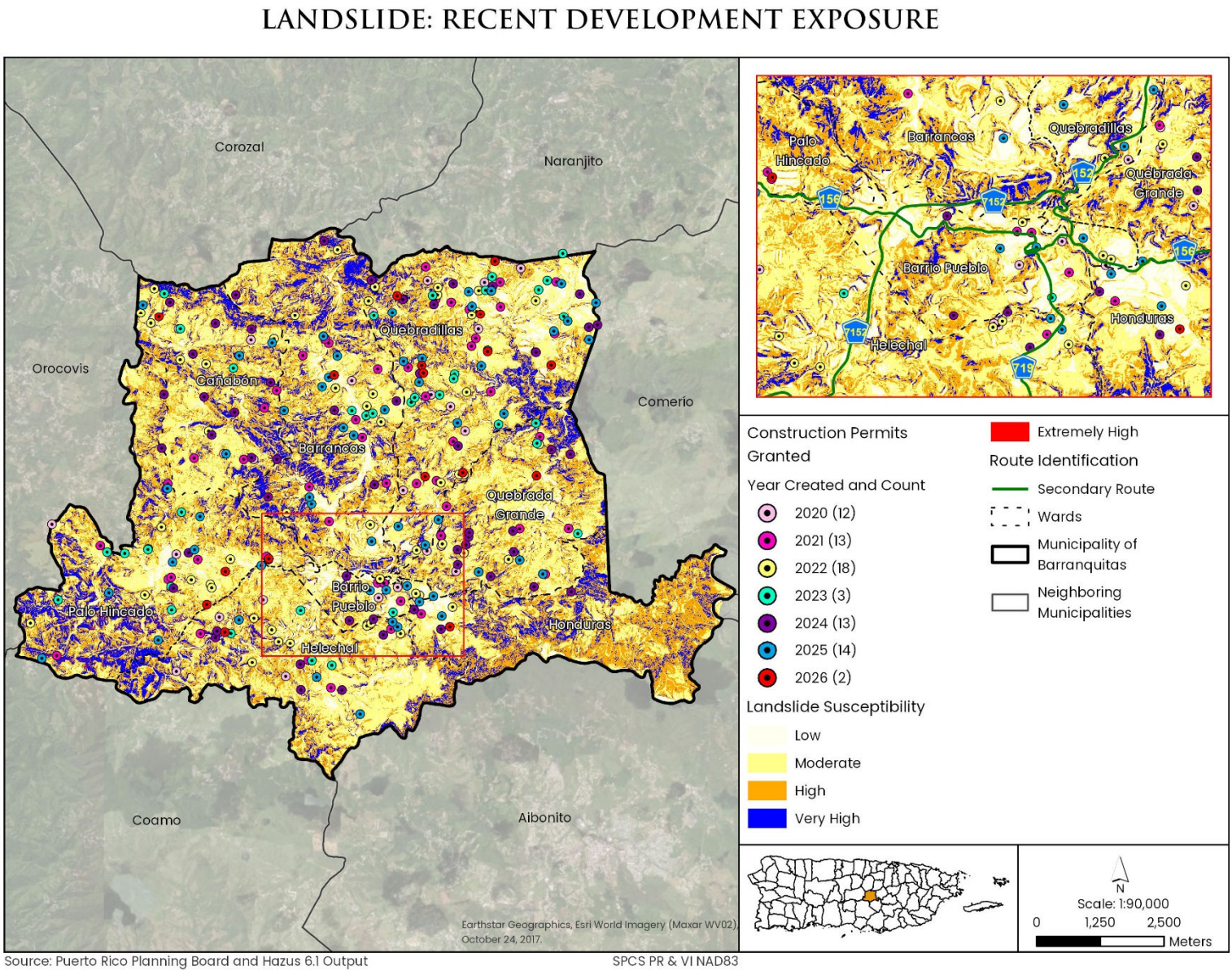
ecosystems, and can compromise drinking water supplies. Furthermore, landslides frequently alter hydrological systems by blocking river channels, creating temporary dams that increase flood risk and modify groundwater recharge patterns.

The cultural dimension of landslide impacts is equally significant. Archaeological sites, historic monuments, and culturally significant landscapes are highly vulnerable to burial or destruction during such events. These losses are irreplaceable, erasing tangible links to the past and diminishing cultural heritage. In many regions, landslides have damaged centuries-old structures, including churches, colonial buildings, and sacred sites, resulting in costly restoration efforts or permanent loss. Beyond physical damage, the alteration of cultural landscapes such as terraced fields or ceremonial grounds undermines community identity and traditions deeply tied to the land. Economically, these impacts ripple through local economies dependent on cultural tourism, reducing visitor numbers and income for communities that rely on heritage-based activities.

4.6.2.5 Future Conditions (E1-a)

Map 26 shows that recent development permits are distributed throughout Barranquitas and are located across areas with varying levels of landslide susceptibility. A concentration of recent development is visible in the central portion of the municipality, particularly around Barrio Pueblo, Helechal, Barrancas, Quebradillas, and Quebrada Grande, as highlighted in the inset map. Numerous permits are located within areas classified as moderate landslide susceptibility, while others are situated adjacent to or within high and very high susceptibility zones. Recent development is also present in Cañabón, Palo Hincado, and Honduras, indicating that construction activity is occurring throughout the municipality in areas with differing levels of landslide susceptibility.

Map 26: Landslide: Recent Development Exposure



Source: Puerto Rico Planning Board and Hazus 6.1 Output SPCS PR & VI NAD83

4.7 Flooding

4.7.1 Description (B1-a)

Floods, generally caused by excessive rainfall (FEMA, 1997), are classified into two main categories: general floods and flash floods.

- General floods are long-duration events that can last several days and include riverine, coastal, and urban floods. Coastal floods are associated with storm

surges, waves, and heavy rains generated by hurricanes and tropical storms, while urban floods result from the alteration of natural drainage due to urban development. Riverine floods occur when rivers overflow due to excessive water runoff though rainfall or structural failures, causing water to spill into surrounding land. Flash floods often stem from stationary storms, hurricanes, or dam failures, affecting both mountainous areas and urbanized zones.

- Flash floods happen when prolonged rainfall falls over a watershed (water basin). The latter result from intense precipitation over a short period in specific areas. The magnitude of flash floods events depends on factors such as basin topography and physiography, weather patterns, soil saturation, and surface impermeability. Flash floods mainly originate from slow-moving storms over specific areas or from intense rainfall associated with hurricanes and tropical storms (NMEAD, 2021). However, they can also occur after the collapse of dams or levees within minutes or hours, due to extreme rainfall or the sudden release of water from retention basins or other stormwater control facilities. Although more frequent in mountain streams, these events can occur in urban areas where impermeable surfaces limit infiltration.

The periodic flooding of land adjacent to rivers, streams, and coasts, known as floodplains, is a predictable natural phenomenon based on recurrence intervals. These intervals represent the average time, in years, between events of equal or greater magnitude. The longer the recurrence interval, the greater the magnitude of the event, which implies a significant increase in risk and the extent of the affected area. Floodplains flood periodically according to recurrence intervals, defined as the average time between events of equal magnitude. For example, a 100-year flood has a 1% annual probability, while a 500-year flood corresponds to 0.2%. These frequencies are calculated through statistical analysis of historical flow records and extreme events.

Table 24 shows the different flood zone classifications for Puerto Rico adopted by the PRPB (PRPB, 2021).

Table 24: Puerto Rico Flood Zones

Flood Zone	Description
Zone A	Special Flood Hazard Area with a recurring period of one hundred (100) years determined by using approximate methodologies with no base flood elevation or Floodway determined.

Zone AE	Special Flood Hazard Areas with a recurring period of one hundred (100) years determined by detailed methodologies with base flood elevations indicated. According to the scope of the study, may include the Floodway determination.
Zone AO/AH	Shallow Special Flood Hazard Areas with a recurring period of one hundred (100) years with a base flood depth fluctuating between 0.30 meters (one (1) foot) and 0.91 meters (three (3) feet). The average flood depths are obtained from detailed hydraulic analysis.
Zone A99	areas prone to flooding from a flooding event with a one percent (1%) annual chance of occurring. These special areas are within a flood protection or control system where enough progress has been made in its construction, even though it has not been completed, but specific statutory progress has been reached to complete it. This zone does not detail base flood elevations or flooding depths, so it is recommended to use, if required, the previous flood elevation for Zone 99. Mandatory flood insurance purchase requirements apply.
Zone D	Flooding area that is not determined but is possible.
Zone VE	Coastal high flood hazard area with a recurring period of one hundred (100) years with velocity and energy (storm surge) and a determined base flood elevation.
Zone X Shaded	flooding area with 0.2% chance of occurring each year or the one hundred (100) year flood with a water depth of less than 0.3 meters, with drainage areas of less than 2.6 square kilometers or areas protected by levees against the one hundred (100) year flood.
Zone X (unshaded)	Area determined to be outside the five hundred (500) year storm flood.

4.7.1.1 Affected Area (B1-B)

Flood Hazard Insurance Map

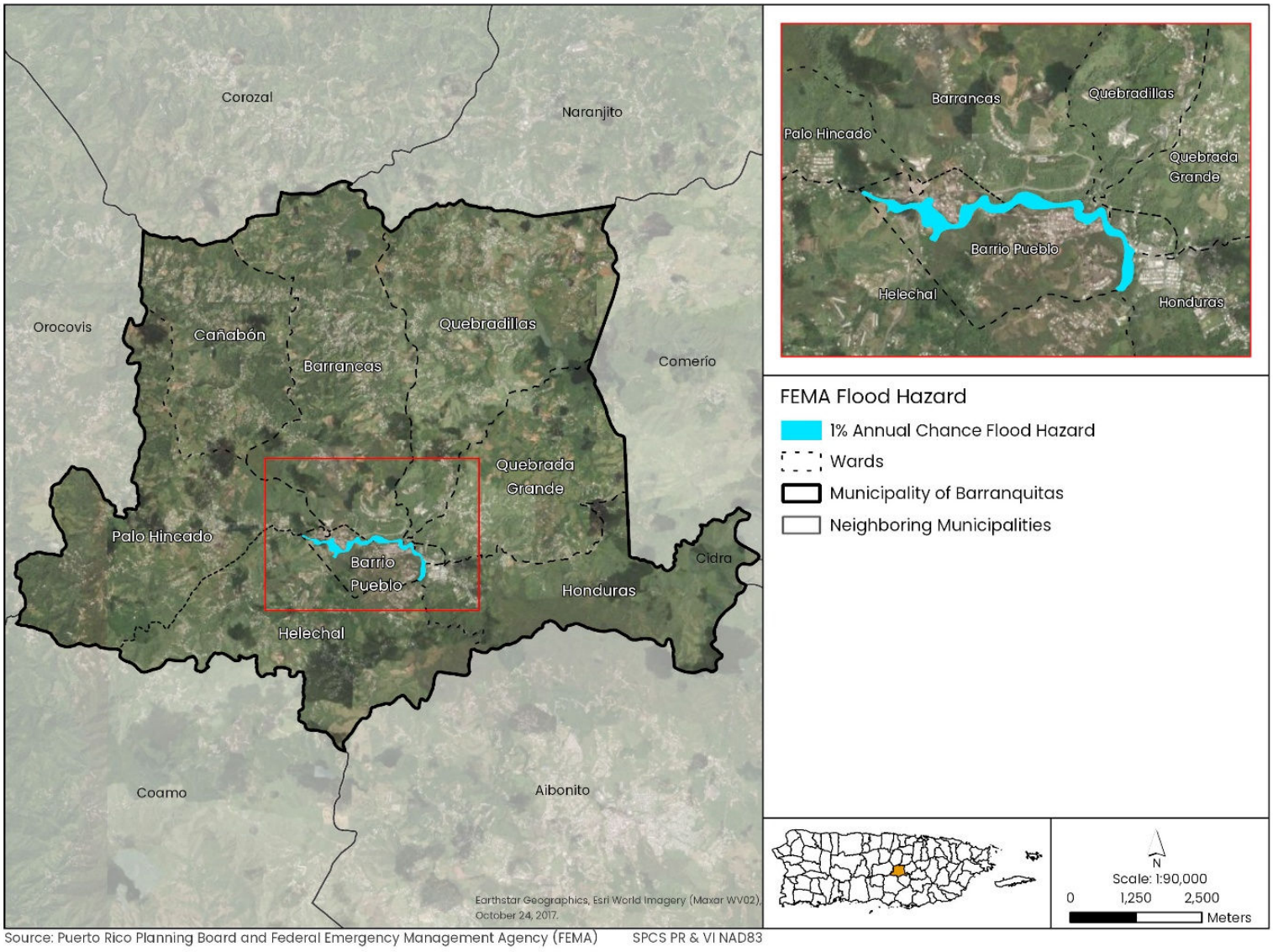
Map 27 illustrates that the 1% annual chance flood hazard area is limited to a narrow corridor in the central portion of Barranquitas. This flood-prone area extends primarily through Barrio Pueblo and into adjacent portions of Barrancas, Quebradillas, Quebrada Grande, Helechal, and Honduras, following a linear pattern visible in the inset map. No FEMA-mapped flood hazard zones are shown in Cañabón or Palo Hincado, and most of the municipality lies outside the mapped flood hazard area.

Figures 15 to 16 shows various FIRMette that shows specific areas of flooding in the Municipality.

- Figure 15 shows the FIRMette for Barranquitas Centro Urbano indicates the presence of a Zone A Special Flood Hazard Area (SFHA) extending through the central urban area. The mapped floodplain follows a drainage corridor that traverses the downtown district and affects developed areas located adjacent to the channel. Because Zone A floodplains are areas subject to inundation by the 1-percent-annual-chance flood event where detailed hydraulic analyses have not been performed, no Base Flood Elevations (BFEs) are shown on the map. The flood hazard has the potential to affect nearby residential, commercial, transportation, and public-service facilities located within or adjacent to the mapped floodplain. The concentration of development within the urban center may increase exposure to flood-related impacts, particularly during periods of intense rainfall. The flooding is likely associated with overflow of local drainage channels and runoff conveyed from the surrounding steep upland terrain that characterizes the municipality. Areas immediately adjacent to the mapped floodplain corridor are considered most vulnerable to flood-related impacts.

- Figure 16 the FEMA FIRMette indicates that a Zone A Special Flood Hazard Area extends along a drainage corridor north of Barranquitas Centro Urbano. The floodplain borders developed portions of the urban center and may affect nearby residential, commercial, institutional, and transportation assets during significant rainfall events. The municipality's mountainous topography and steep slopes contribute to rapid runoff that can increase flood risk within areas adjacent to the mapped floodplain.

Map 27: Flood Hazard Zones



Source: Puerto Rico Planning Board and Federal Emergency Management Agency (FEMA) SPCS PR & VI NAD83

Figure 15: National Flood Hazard Layer FIRMette

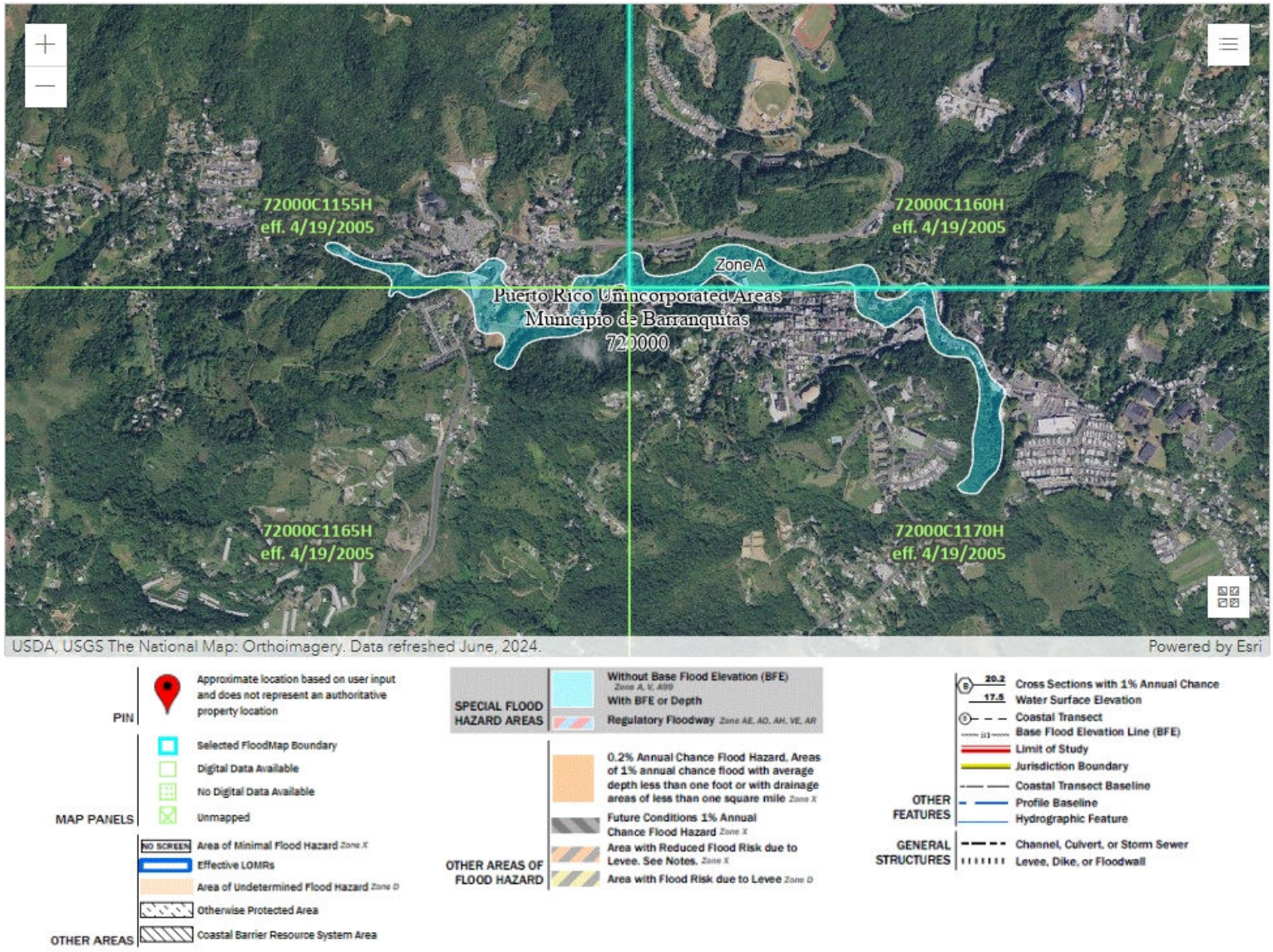
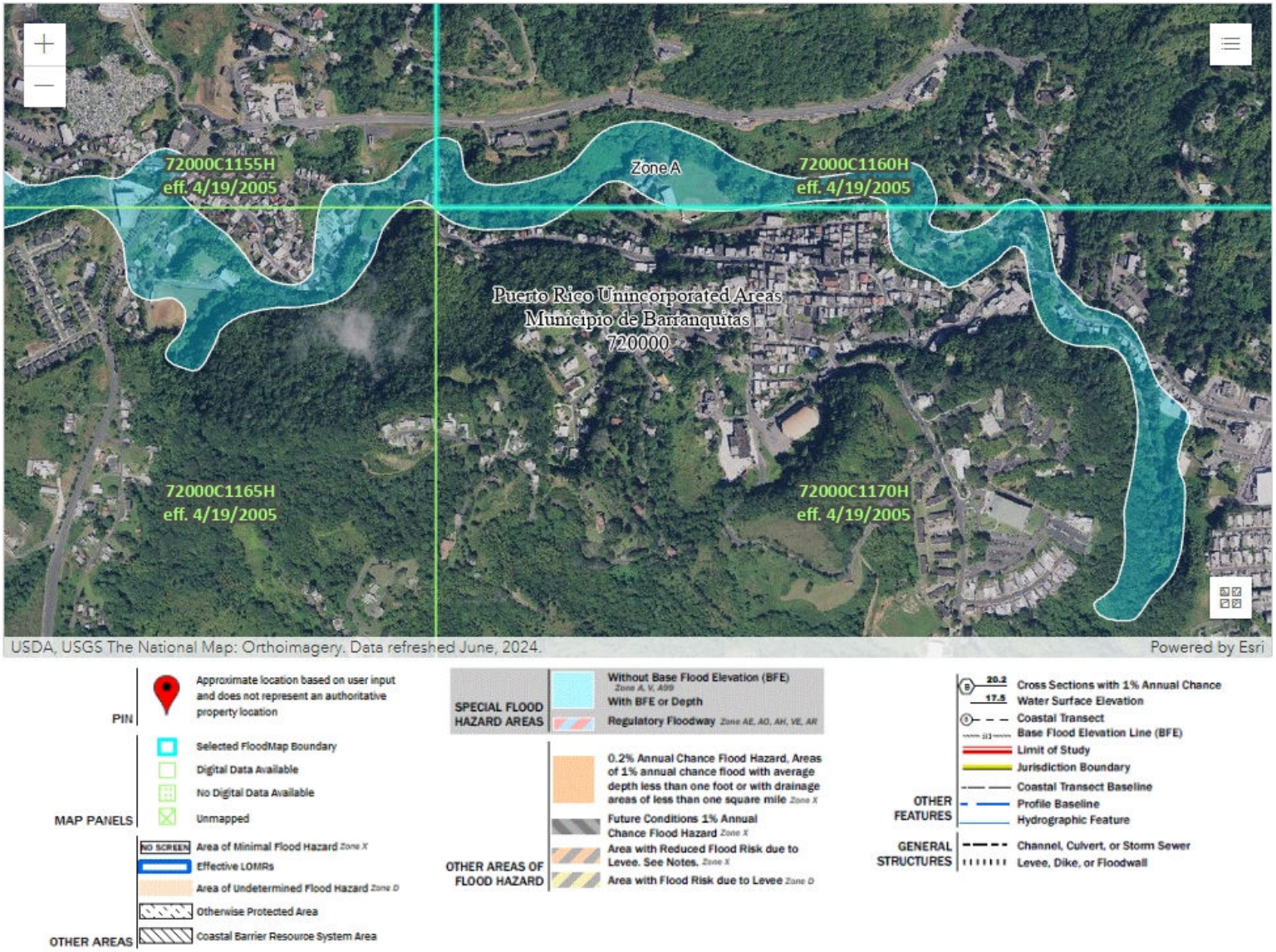


Figure 16: National Flood Hazard Layer FIRMette (Casco Urbano)



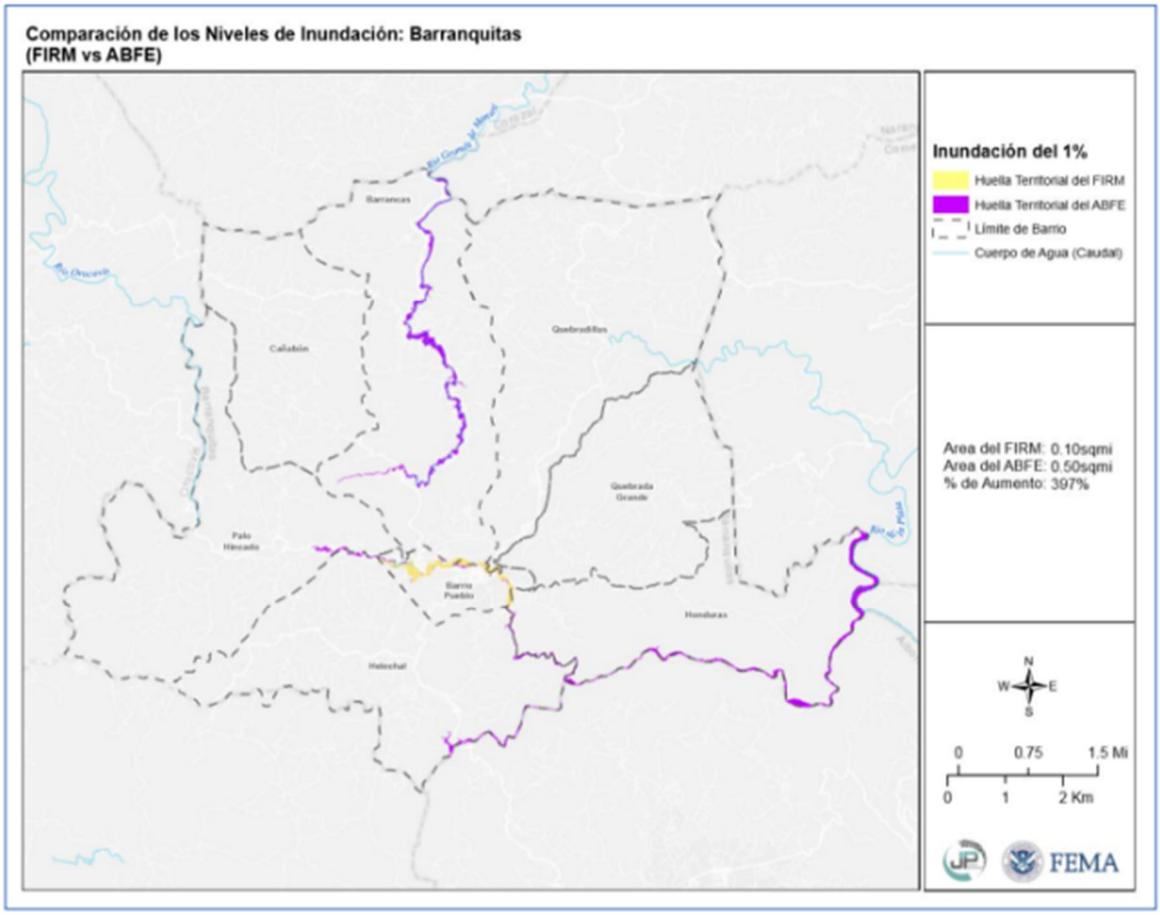
Advisory Base Flood Elevation (ABFE)

Likewise, FEMA uses another type of map for the purpose of developing regulations and construction permits known as the Advisory Base Flood Elevation Maps (ABFE). ABFEs are developed after the occurrence of a high-impact atmospheric event, and several factors related to the latest engineering analysis are taken into consideration to determine whether an analysis is necessary. Some of the factors considered in the analysis include the age of the analysis, the territory covered by the analysis, and the engineering models/data used in the analysis. ABFEs have been produced for states such as Mississippi (Hurricane Katrina), New York, and New Jersey (Hurricane Sandy). Following Hurricane María's passage through Puerto Rico in 2017, and due to the availability of better data, FEMA developed ABFEs for Puerto Rico. It should be noted that the Puerto Rico Planning Board adopted the ABFEs on an emergency basis in March 2018. At present, Puerto Rico has two (2) types of flood maps: the FIRMs (2009), which are used solely for flood insurance rates, and the ABFEs (2018), which are used to regulate construction on the Island.

For comparison purposes, this subsection includes the difference in the extent of land affected by flooding based on the FIRMs prior to Hurricane María in September 2017 and the ABFEs developed by FEMA for Puerto Rico. After Hurricane María in 2017, the areas designated as flood-prone throughout the Island increased by 20%. Thus, this reflected an increase of 41%.

The next Figure (in Spanish) shows the comparison between the FIRM and ABFE 1% annual chance flood extent maps shows that the ABFE flood footprint is larger than the FIRM flood footprint in Barranquitas. The map indicates that the FIRM flood extent covers approximately 0.34 square miles, while the ABFE flood extent covers approximately 0.52 square miles, representing a 55% increase. The most noticeable differences occur along the mapped river corridors in the central and southern portions of the municipality, where the ABFE flood extent extends beyond the limits of the FIRM flood extent.

Figure 17: ABFE vs FIRM 1% (100 years)



As instructed by PRPB the hazard analysis was made using the ABFE maps.

HAZUS Modeling

Flooding source identification and hazard loss estimation were performed using Federal Emergency Management Agency's (FEMA) Hazus platform, a nationally standardized tool for multi-hazard risk assessment. The Hazus flood module was used to delineate streams in areas where no engineering studies have been developed and used to estimate potential monetary losses associated with structural damage.

Input data included depth grids produced by a Base Level Engineering (BLE) study in 2018 post hurricanes Irma and Maria. This BLE study did not review all potential riverine flooding sources so additional modeling was developed with Hazus hydrology and hydraulics to review other potential losses associated with streams with drainage areas of one square mile or more.

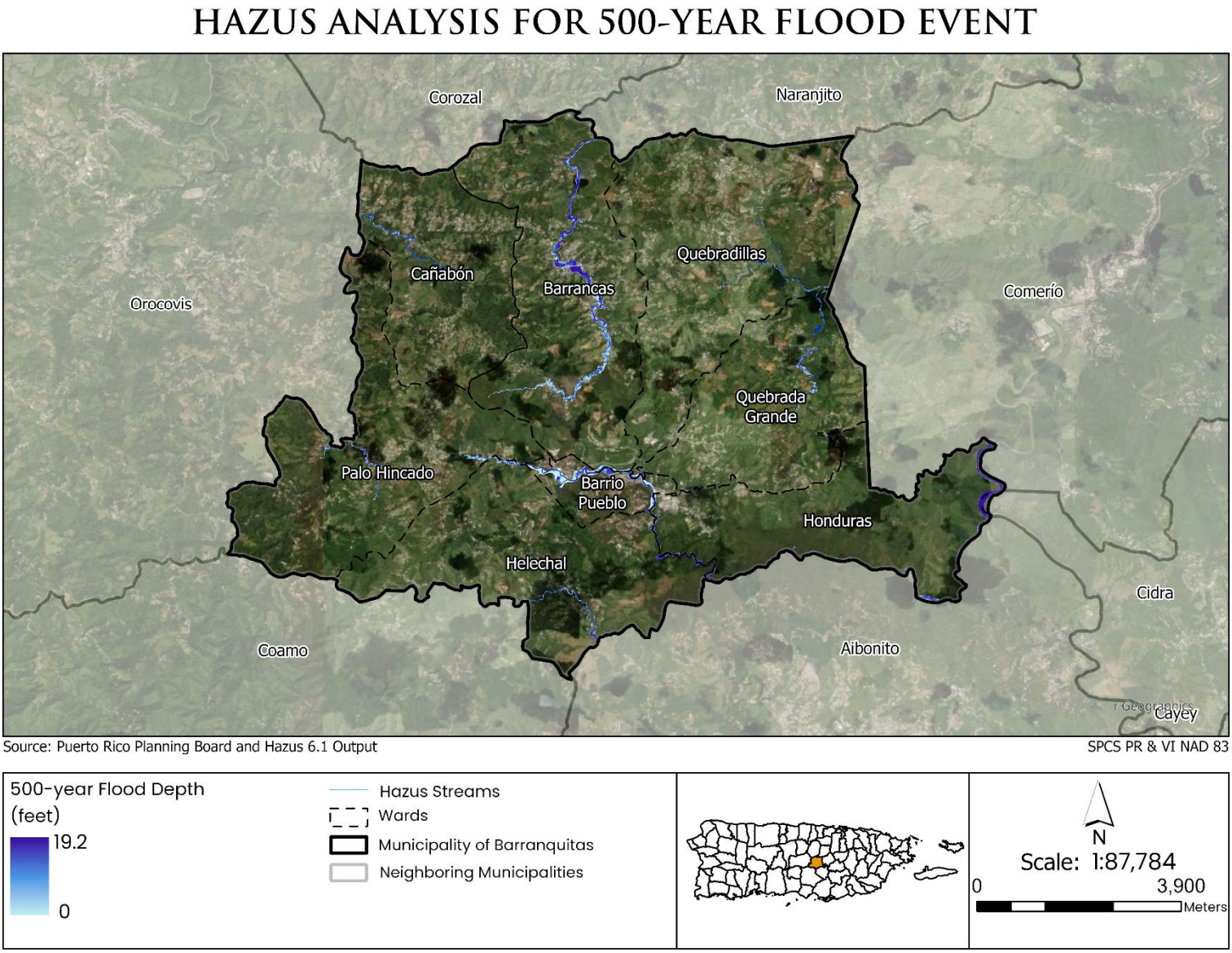
Topographic data used by Hazus for depth calculations and damage estimation was sourced from the USGS 3D Elevation Program (3DEP) seamless 1/3 arc-second Digital Elevation Model (DEM), at an approximate resolution of 10 feet. This dataset provides current coverage of Puerto Rico and its surrounding islands.

The 3DEP seamless DEM for Puerto Rico is derived from two lidar collection efforts: a 2016–2017 USGS lidar survey and a 2018 USGS post-Hurricane Maria lidar survey. The 2018 collection, conducted following the significant coastal geomorphic changes caused by Hurricane Maria, represents the most current available terrain data for the island and forms the primary basis of the 3DEP elevation layer used in this analysis.

The areas documented in the maps included within the LHMP may have streamlines represented but with no depth grids associated with them. Due to the inconsistency of available regression equations and other data necessary for computation of flood risk and losses with Hazus's hydrology and hydraulics models, some streams that were delineated were unable to be completed during modeling runs. These stream areas may need to be reviewed for future flood studies and potential flood risk identification but, due to the lack of data, they were unable to be included in the Hazus studies.

The following map shows the result of the Hazus Run. The most up to date Hazus Run shows that flooding may extend beyond what was determined in the 2018 ABFE.

Map 28: Hazus Analysis for 500-Year Flood Event



The HAZUS 500-year flood event analysis shows flood depths concentrated along the municipality's stream network. Areas with mapped flood depths follow river and stream corridors that extend through Barrancas, Quebradillas, Quebrada Grande, Barrio Pueblo, Helechal, Honduras, Palo Hincado, and Cañabón. The most extensive flood-prone corridors are visible in the central and eastern portions of the municipality, particularly near Barrio Pueblo, where multiple stream channels converge. Outside of these stream corridors, most of the municipality does not display mapped 500-year flood depths on the map.

4.7.1.2 Risk Magnitude (B1-C)

Flood events can represent one of the most severe atmospheric threats, as there is no other event worldwide that causes greater loss of life (FEMA, 1997). This is due to the high frequency of such events and the population's lack of awareness regarding the magnitude of the damage they can cause, whether physical harm or property damage. It should be noted that most disaster declarations in the U.S. are related to flood events. Most flood-related incidents involve people being swept away, along with their vehicles, by water currents (FEMA, 1997). Each year, the devastation caused by floods results in billions of dollars in asset losses. Regions with the highest population density are areas at high risk of flash floods, as the construction of buildings, roads, and parking lots create impermeable surfaces, reducing the land's ability to absorb water (NSWL, n.d.).

Floods are the most common natural disaster, occurring when water overflows and submerges land that is typically dry. They are often triggered by heavy rainfall, rapid snowmelt, or storm surges from tropical cyclones or tsunamis in coastal regions.

Floods can cause extensive destruction, including loss of life and severe damage to homes, property, and critical public health infrastructure. Between 1998 and 2017, floods impacted more than 2 billion people worldwide. Those living in floodplains, in poorly constructed buildings, or without access to warning systems and hazard awareness are the most vulnerable (WHO, 2025).

Three common types of floods include:

- Flash floods: Result from sudden, intense rainfall that rapidly raises water levels, overwhelming rivers, streams, channels, or roads.
- River floods: Occur when prolonged rainfall or snowmelt causes rivers to exceed their capacity.
- Coastal floods: Caused by storm surges linked to tropical cyclones or tsunamis.

Regarding the impact on life, property, and operations, floods cause loss of life and property damage, including residences, buildings, infrastructure, agriculture, and sanitation and drainage systems. After a flooding event, the aftermath can increase the occurrence of various diseases, such as leptospirosis, and lead to rises in contaminated water (Malilay, 2000).

According to a Congressional Budget Office (CBO) report "Over the past 10 years, damage from flooding in the United States has averaged $46 billion per year (in 2023

dollars)" (CBO, 2024). This estimate includes costs such as:

- "The replacement of residential and commercial property;
- Repairs for or rebuilding of public infrastructure;
- Emergency response measures;
- Costs associated with the ongoing loss of the use of property (for example, the provision of temporary housing);
- Losses in the commercial sector due to business interruptions.
- Damage to crops, livestock, and timber;" (CBO, 2024)

Although the impact of adaptation projects can vary significantly, Corps estimates suggest that about two-thirds of its projects, excluding the top and bottom sixth in benefit-cost ratios—are expected to reduce flood damage by $2 to $6 for every dollar spent over a 50-year lifespan (CBO, 2024).

4.7.1.3 Past Events (B1-D)

For the most part flooding events in Puerto Rico are related to tropical systems (tropical waves, tropical depressions, tropical storms and hurricanes). As such flooding hazards occur mostly within the hurricane season that runs from June 1 to November 30.

However, flooding events can occur outside this window as shown in the case of the April- May 2024 Floods, the February 2022 floods and the Three Kings' Flooding of 1992.

The next table shows the major flooding events in the period of 2010–2025.

Table 25: Major flooding events in Puerto Rico 2010-2025

Event	Date	Disaster Declaration Number	Barranquitas Included?	Description
Tropical Storm Ernesto	8/14/2025 – 8/16/2025	DR-4850- PR	Public Assistance – Yes Individual Assistance - No	The storm's slow movement and moisture-rich environment contributed to prolonged precipitation, particularly in central and eastern municipalities. Parts of Central Puerto Rico recorded 12–14 inches of rainfall in localized areas. The municipality of Barranquitas measured 11.20 inches over a 48-hour period, while Villalba reported 10.20 inches. Eastern municipalities, including Vieques and Culebra, observed 8–10 inches of rain. Multiple rivers exceeded their banks, including the La Plata River, resulting in significant inundation of adjacent communities. Flash flooding occurred in urban and rural areas, rendering primary and secondary roads impassable. Floodwaters caused structural failures in bridges and washed-out critical road segments,

Event	Date	Disaster Declaration Number	Barranquitas Included?	Description
				isolating several communities. Stormwater drainage systems in metropolitan areas, notably San Juan, were overwhelmed, leading to localized urban flooding. Emergency Response and Disruptions Evacuations were conducted in flood-prone areas such as Toa Baja to mitigate loss of life.
Puerto Rico Severe Storms, Flooding, Landslides, and Mudslides	4/29/2024 – 5/10/2024	DR-4808-PR	Public Assistance – No Individual Assistance - No	In April 2024, Puerto Rico was struck by a series of severe storms that delivered prolonged heavy rainfall—some areas received more than 10 inches—leading to widespread flooding and landslides. Central and western municipalities saw rivers overflow, with the Manatí and Cibuco rivers breaching their banks and inundating highways like PR-2. Urban areas, especially in the southwest (Cabo Rojo, Mayagüez, Ponce), faced flash flood warnings as heavy afternoon downpours overwhelmed drainage systems. Floodwater turned streets into torrents, trapping residents on rooftops and prompting emergency evacuations in over 20 municipalities.

Event	Date	Disaster Declaration Number	Barranquitas Included?	Description
Hurricane Fiona	9/17/2022-9/21/2022	DR-4671-PR	Public Assistance – Yes Individual Assistance - Yes	Hurricane Fiona struck Puerto Rico in September 2022, unleashing torrential rains—up to 31.22 inches of rainfall over 72 hours in Ponce, nearly matching the accumulation from Hurricane Maria. This deluge led to catastrophic flooding, with 7 to 20 inches common across most of the island and localized spots exceeding 30 inches.
Puerto Rico Severe Storm, Flooding and Landslide	2/4/2022 – 2/6/2022	DR-4649-PR	Public Assistance - No Individual Assistance - No	In February 2022, Puerto Rico experienced a severe storm that brought prolonged heavy rainfall, causing widespread flooding across the island. Rainfall totals ranged from 3 to 10 inches in many areas, with localized peaks reaching up to 16 inches in Toa Alta. The intense precipitation overwhelmed drainage systems, leading to urban flooding in San Juan, Guaynabo, and coastal towns such as Dorado and Vega Baja. Rivers swelled beyond their banks, inundating roads and isolating communities, while landslides compounded the damage in mountainous regions. Emergency responders issued flash flood warnings and conducted evacuations as homes

Event	Date	Disaster Declaration Number	Barranquitas Included?	Description
				and businesses were submerged.
Puerto Rico Severe Storm and Flooding	9/13/2020	DR-4571-PR	Public Assistance - No Individual Assistance - No	Puerto Rico was battered by a severe storm and flooding on September 13, 2020, resulting in widespread flood damage and infrastructure disruption. Torrential rains overwhelmed drainage systems and caused rivers to overtop in areas like Arecibo, where one home was destroyed, over 100 suffered major damage, and more than 20 experienced minor flooding. Roads and bridges were submerged or damaged, isolating communities and impeding emergency response efforts. Floodwaters inundated homes and public facilities, prompting evacuation orders and flash flood warnings across several municipalities.
Tropical Storm Isaías	7/29/2020 - 7/30/2020	DR-4560-PR	Public Assistance - No Individual Assistance - No	Although the center of Tropical Storm Isaías did not make landfall on the island, the system left a large amount of rain in its path, causing flooding throughout Puerto Rico. Rainfall accumulation of up to 10 inches was recorded around the island.
Hurricane María	9/20/2017	DR-4339-PR	Public Assistance – Yes	Widespread flooding severely affected the whole Island. For example, in San Juan, water levels reached up to 6 feet in

Event	Date	Disaster Declaration Number	Barranquitas Included?	Description
			Individual Assistance - Yes	some areas and numerous structures losing their roofs. The coastal neighborhood of La Perla was largely destroyed, while Cataño suffered extensive damage, with the Juana Matos community estimated to be 80% destroyed. Strong winds, heavy rains, and flash floods near the La Plata Lake dam in Toa Baja impacted thousands of residents. Survivors reported that floodwater rose 6 feet in just 30 minutes, and some areas experienced depths of up to 15 feet (4.6 m).
Hurricane Irma	9/5/2017	DR-4336-PR	Public Assistance – Yes Individual Assistance - No	On September 5, 2017, Hurricane Irma impacted Puerto Rico; an Emergency Declaration was issued for the Island. On September 6, 2017, a Major Disaster Declaration was issued following Hurricane Irma's passage. Two people died due to torrential rains before the hurricane: a man died in Orocovis after falling from his ladder while repairing his roof; another man on the coast in Capitanejo died after being struck by lightning. Wave heights in Puerto Rico reached 9 meters, and sustained winds of 111 mph were recorded

Event	Date	Disaster Declaration Number	Barranquitas Included?	Description
				in Culebra.
Tropical Storm María[8]	9/8/2011 – 9/114/2011	DR-4040-PR	Public Assistance - No Individual Assistance - No	Tropical Storm (later Hurricane) Maria formed in early September 2011 and passed near Puerto Rico, bringing significant heavy rainfall and tropical storm conditions to the island. The storm caused widespread flooding that inundated numerous roadways and homes; floodwaters near Patillas destroyed several homes and bridges, and approximately 150 houses in Yabucoa were flooded and damaged.
Hurricane Irene	8/22/2011	DR-4017-PR	Public Assistance - Yes Individual Assistance - No	Total rainfall reached 22 inches over three days, with the eastern region being the most affected—the same area that had already received over 6 inches earlier in August during the close passage of Tropical Storm Emily. The Río Grande de Manatí in Manatí recorded its third-highest level in history, surpassed only during Hurricane Hortense (1996) and Hurricane Georges (1998). The Puerto Nuevo River near Hato Rey reached its fourth-highest level on record. Flooding

[8] Tropical Storm María was a tropical system that pass to the northeast of Puerto Rico in 2011 and that caused flooding in the Island. Not to be confused with the 2017 Hurricane María. The name "María" was retired from the official Atlantic hurricane season list of names after 2017.

Event	Date	Disaster Declaration Number	Barranquitas Included?	Description
				was severe enough to cause infrastructure stress and dangerous conditions across multiple municipalities. Tragically, there was one direct fatality attributed to Irene, due to drowning.
Puerto Rico Severe Storms, Flooding. Mudslides and Landslides	5/20/2021 – 6/8/2021	DR-4004-PR	Public Assistance - No Individual Assistance - No	In May 2021, Puerto Rico experienced a series of intense rainfall events that caused flash flooding, river overflows, mudslides, and landslides, particularly in mountainous and interior regions. Although May is normally one of the wettest months of the year, several storm systems produced short-duration but high-intensity rainfall, overwhelming local drainage systems and destabilizing steep terrain.
Sub-Tropical Storm Otto	10/3/2010 – 10/8/2010	DR-1946-PR	Public Assistance - No Individual Assistance - No	An extensive rain band covered Puerto Rico while Otto moved as a distant tropical cyclone north of the Island (NOAA). This resulted in heavy and continuous rainfall that caused serious flooding (Eco Exploratorio).
Puerto Rico Severe Storms and Flooding	5/26/2010 – 5/31/2010	DR-1919-PR	Public Assistance - Yes Individual Assistance - No	In May 2010, Puerto Rico was hit by a series of severe storms that produced torrential rainfall and widespread flooding across the island. Rainfall exceeded 12 inches in some areas,

Event	Date	Disaster Declaration Number	Barranquitas Included?	Description
				overwhelming drainage systems and causing rivers to overflow their banks. Low-lying communities and urban centers experienced significant inundation, with roads submerged and bridges damaged, isolating several municipalities. Flash floods swept through residential areas, forcing evacuations and leaving homes and businesses underwater. Landslides triggered by saturated soil compounded the crisis, blocking access routes and delaying emergency response efforts. The event resulted in extensive infrastructure damage and highlighted the island's vulnerability to prolonged heavy rain events during the wet season.

In summary, in the 2010-2025 period there have been a total of 13 major disaster declarations caused by flooding or events that had flooding related damage. Of those the municipality of Barranquitas was eligible for either public assistance or individual assistance in six instances.

4.7.1.4 Special Considerations: Karst Formation

The karts formation in Puerto Rico is a limestone region that covers about 27.5% of the island's surface and includes northern, southern, and scattered limestone areas, with karst features present throughout. The most pronounced karst topography occurs in the northern limestone, known as the "karst belt," which spans approximately 142,544 hectares, or 65% of that region. Tropical solution processes have shaped this belt into a landscape of mogotes, cone hills, sinkholes, blind valleys, caves, rugged canyon walls, and disappearing streams, formed by the dissolution of Oligocene and Miocene limestone under tropical conditions (Lugo, et al., 2021) (PRPB, 2014). This terrain supports the island's largest freshwater aquifers, mature forests, wetlands, estuaries, and extensive cave systems, all vital to hydrology and biodiversity. Its rugged topography and shallow soils have limited agriculture and dense settlement, leaving much of the area relatively undisturbed. However, the karst region remains vulnerable to human activities such as vegetation clearing, wetland drainage, paving, groundwater extraction, and pollution, which threaten its stability and ecological functions. (Lugo, et al., 2021) (PRPB, 2014).

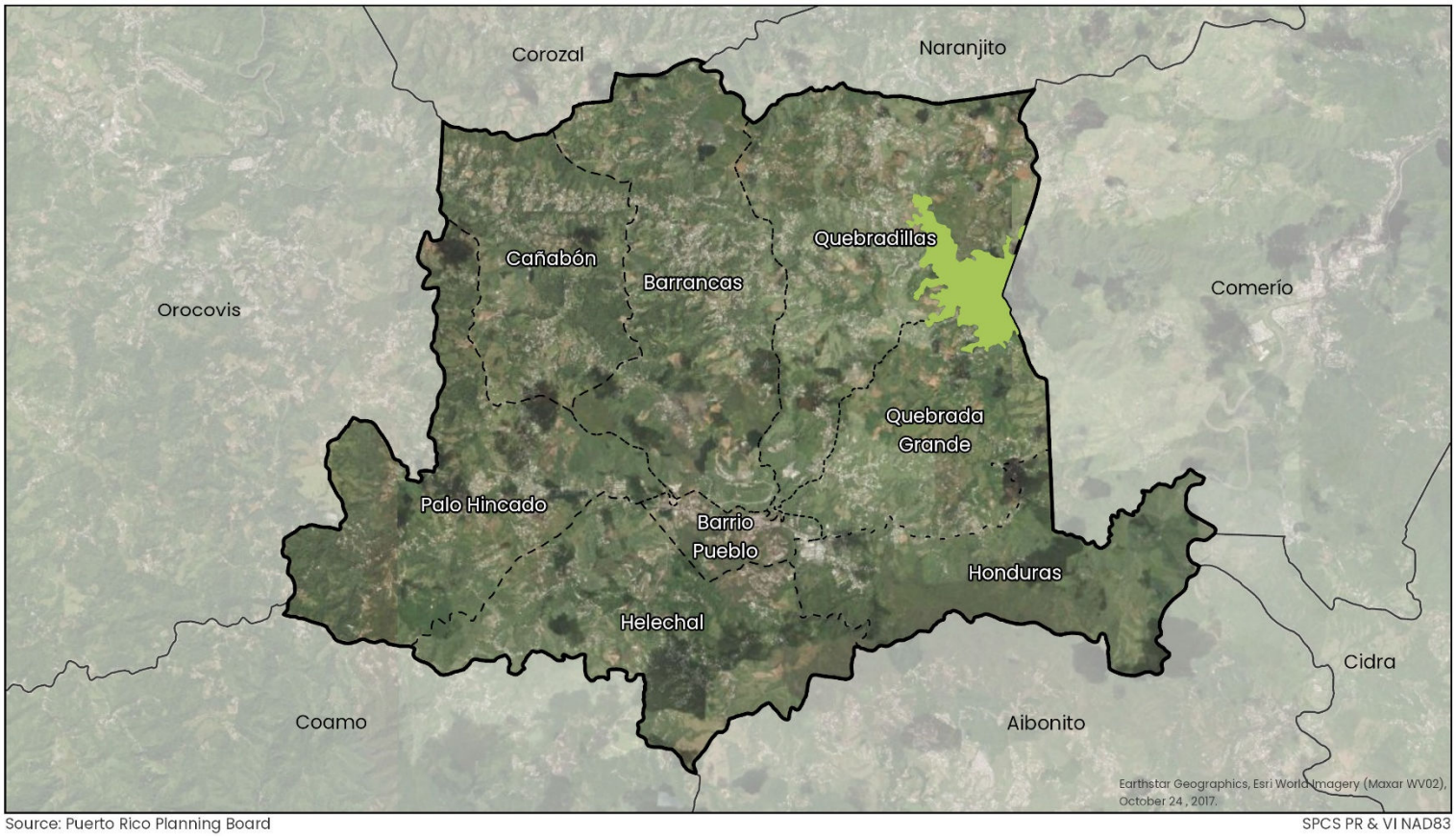
The karst belt is in northern Puerto Rico, of which part is in Barranquitas. Karst is a unique limestone landscape shaped by tropical solution processes, featuring mogotes, sinkholes, caves, and underground aquifers. It provides the island's largest freshwater reserves, supports mature forests, wetlands, and diverse ecosystems, and plays a critical role in maintaining water quality and biodiversity (Lugo, et al., 2021) (PRPB, 2014).

Economically, the region reduces flood risks, sustains agriculture in surrounding areas, and offers recreational and tourism opportunities. Its rugged terrain has limited urban development, preserving ecological integrity, but it remains vulnerable to deforestation, groundwater extraction, and pollution (Lugo, et al., 2021) (PRPB, 2014). According to Lugo, et al. protecting this region is essential for water security.

For Barranquitas, the Restricted Special Planning Area of the Karst is in the eastern portion of Barranquitas, primarily within Quebradillas and extending into the northeastern part of Quebrada Grande.

Map 29: Karst Formation

Karst Region



Source: Puerto Rico Planning Board

SPCS PR & VI NAD83

Restricted Special Planning Area of the Karst
Wards
Municipality of Barranquitas
Neighboring Municipalities



N

Scale: 1:82,000

0 1,000 2,000

Meters

4.7.1.5 Special Consideration: Floods by Stormwater Management Deficiencies

Urban drainage systems—natural or constructed—carry surface water to receive bodies of water. When storm drains, channels, or swales become obstructed or insufficient due to heavy rainfall or urbanization, they can overflow and flood surrounding areas. Floodwaters may spread beyond FEMA's mapped floodplains, even entering zones typically considered low or moderate risk (Zones B, C, or X) (FEMA, Reducing Damage from Localized Flooding, 2025).

Puerto Rico's stormwater runoff is conditioned by the island's climate, topography and land cover. Annual rainfall varies from less than 1,000 millimeters (mm) to over 4,000 mm (40 to 157 inches). Its largely mountainous watersheds are characterized by relatively steep slopes. Stream valleys are usually well-incised and narrow, and major storms tend to be intense but brief; hence, flooding is rapid with peak discharges several orders of magnitude above base discharge. All of Puerto Rico's watersheds have experienced significant alterations It is estimated that more than 11% of the island is composed of developed surfaces, reaching up to 40% in regions such as the San Juan Metropolitan Area. These changes have significantly modified stormwater drainage patterns and downstream floodwater levels (FEMA, 2024).

Paved surfaces severely limit the infiltration of rainwater. This not only increases the volume of runoff that moves initially as sheet flow over land, but also its velocity. Storm drains can easily become overwhelmed by the resulting augmented flows. In addition, stormwater flowing over paved surfaces reaches streams and rivers much faster, overwhelming the capacity of these water bodies to receive and manage a greater volume of water within their existing channel configurations, which could lead to more frequent and higher flood levels along adjoining lands. Moreover, contaminants from both point and non-point sources of pollution are more likely to reach surface water bodies when transported by runoff over paved surfaces instead of being partially or totally degraded by vegetated soils. Higher flows also have a greater capacity to remove and transport soil and other loose materials from streambanks and riverbeds, facilitating erosion and scouring (FEMA, 2024).

Paradoxically, river flow tends to be lower between rain events after urbanization. Paved surfaces act as a barrier that isolates the soil, preventing the infiltration of rainwater that otherwise would have gradually discharged from the ground and into streams days later, a process that is critical for maintaining base flows for riparian fish and wildlife species, but also to sustain public water supply. In response, various hard infrastructure measures (flood control pump stations, curved side gutters, concrete trapezoidal channels, etc.) have been widely adopted across the island to address stormwater runoff-related flooding with minimal consideration to ecological, social, cultural, or aesthetic impacts. These practices often involve significant operation and maintenance costs and, in many instances, could even promote erosion, scouring and water quality impairments farther downstream and in other receiving water bodies.

A possible alternative would be to take advantage of the ecological services that green areas and other sustainable practices offer to manage runoff flows and

improve water quality is more vital than ever before to safeguard the wellbeing of communities, especially against the increasing water-related impacts associated with climate change in Puerto Rico (FEMA, 2024).

4.7.1.6 Future Event Probabilities (B1-e)

A sustained historical increase in the frequency of extreme rainfall events has been identified in recent decades as stated above the Island of Puerto Rico has had 13 flood – related flood major disaster declaration in the last fifteen years. This means that the average frequency of a flooding event is approximately every 14 months.

Any mitigation action adopted to reduce the effects of flooding in the Municipality of Barranquitas must consider, for example, that 100-year return events or those with a 1% annual probability could become 50-year return events or have a 2% annual probability in the future. This means that flood events of a certain magnitude and impact on the municipality may increase, particularly in high-risk areas. Though there are many floods control t projects in Barranquitas, the probability of future events is considered high."

4.7.2 Risk Analysis (B2-a, B2-b)

4.7.2.1 Estimated Losses

Map 30 shows the estimated building loss resulting from a 500-year flood event in Barranquitas, distributed by census tract, indicates that potential flood-related building losses are distributed across multiple wards of Barranquitas. The highest loss categories are concentrated in portions of Barrancas, Barrio Pueblo, and Helechal, where darker shaded areas are shown. Additional areas of elevated building loss are present in Quebrada Grande, Honduras, Palo Hincado, and Cañabón. Lower loss categories are more widespread throughout the municipality, while localized pockets of higher losses occur primarily along the central and southern portions of Barranquitas.

Map 31 shows the estimated building loss from a 100-year flood in Barranquitas, distributed by census tract. The highest loss category ($5,000,001–$5,454,000) is concentrated in Barrancas, with additional high-loss areas located in Barrio Pueblo and Helechal. Moderate to high loss categories are also present in Quebrada Grande, Honduras, Palo Hincado, Cañabón, and Quebradillas. Lower loss categories are more widely distributed across the municipality, while areas of greater potential building

losses are concentrated primarily in the central and southern portions of Barranquitas.

As a reminder, this map does not measure extent of flooding, but rather the estimated economic losses resulting from flooding.

The following table shows the municipality's exposure to flood according to the NRI.

Table 26: Flood Exposure

Exposure - Impacted Area (sq mi)	Exposure - Building Value	Exposure - Population	Exposure - Population Equivalence	Exposure - Total
0.041504	$36,780,886	245.238772	$2,844,769,751	$2,881,550,637

Source FEMA's NRI

Table 27 presents the expected annual flood-related losses for both buildings and population.

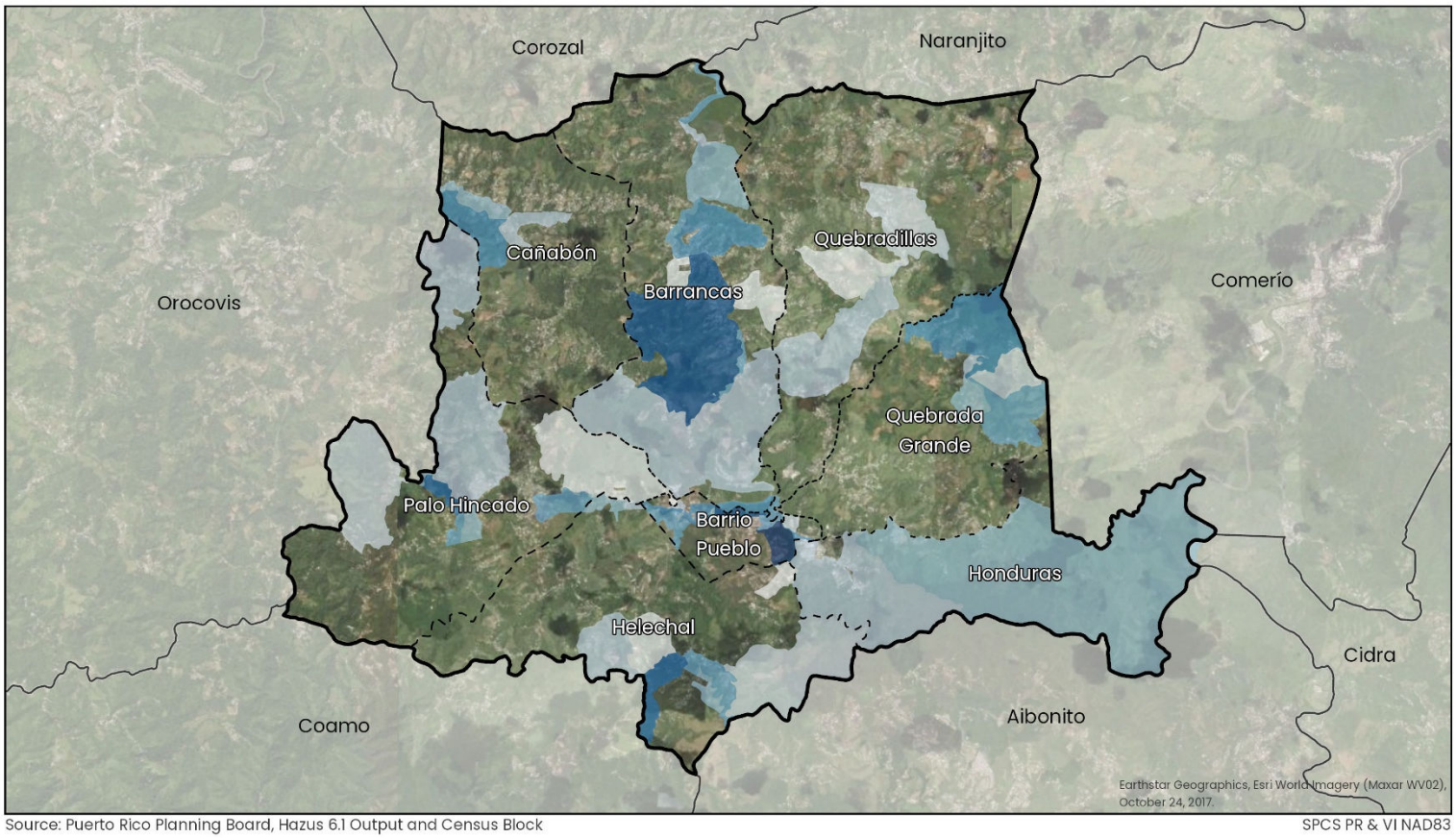
Table 27: Expected Annual Loss to Flood

Expected Annual Loss - Building Value	Expected Annual Loss - Population	Expected Annual Loss - Population Equivalence	Expected Annual Loss -Total
$96,330	0.000279	$3,239	$99,568

Source FEMA's NRI

Map 30: Building Loss to Flood Exposure 500 – Year Flood

Building Loss to Flood Exposure 500-Year Flood



Source: Puerto Rico Planning Board, Hazus 6.1 Output and Census Block

SPCS PR & VI NAD83

Building Loss 500-Year Flood ($)
- $0 - $10,000
- $10,001 - $50,000
- $50,001 - $100,000
- $100,001 - $250,000
- $250,001 - $500,000
- $500,001 - $1,000,000
- $1,000,001 - $2,500,000
- $2,500,001 - $5,000,000
- $5,000,001 - $5,609,000
- Wards
- Municipality of Barranquitas
- Neighboring Municipalities

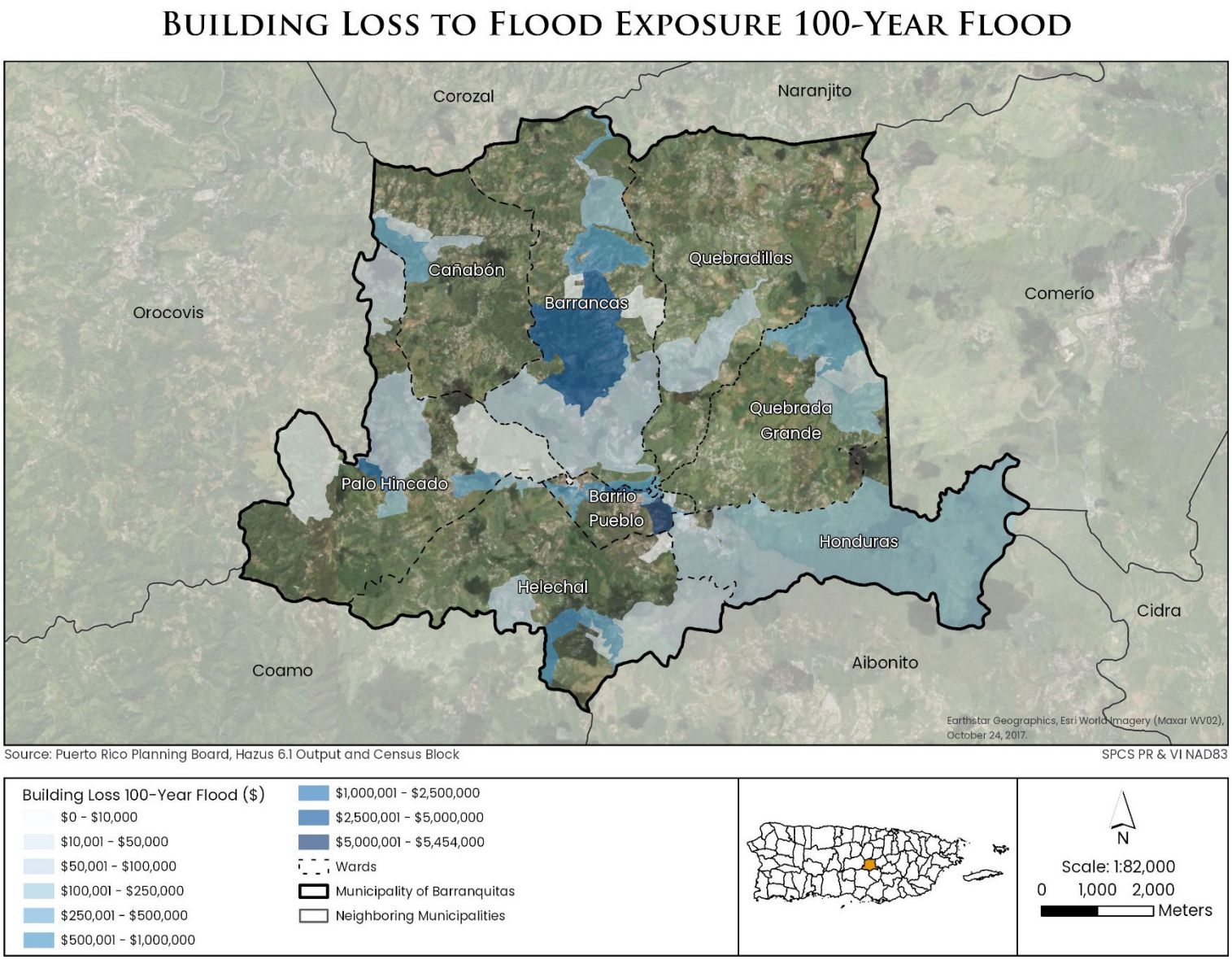


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Scale: 1:82,000

0 1,000 2,000 Meters

Map 31: Building Loss to Flood Exposure 100–Year Flood



After running the Hazus model, the following losses were determined for flooding in Barranquitas:

- A total of 12,876 structures would experience losses (see Table 28).
- An estimated total of $25,561,000.00 in losses is projected for a 100-year event (1%) and $29,481,000.00 for a 500-year event (0.2%) (see Table 29).
- Specifically, for nonresidential structures, total losses are estimated at $9,067,000.00 for 100-year events (1%) and $9,281,000.00 for 500-year events (0.2%) (see Table 30).

- For residential uses, losses are estimated at $16,494,000.00 for 100-year events (1%) and $20,200,000.00 for 500-year events (0.2%) (see Table 31).

Table 28: Total Structures at Risk

Structures	
Non-Residential	31
Residential	12,845
Total	12,876

Table 29: Aggregated Dollar Losses for 1% (100-year) and 0.2% (500-year) events

Occupancy Type	Losses in Dollars. 1% Event	Losses in Dollars. 0.2% Event
Non-Residential	$9,067,000.00	$9,281,000.00
Residential	$16,494,000.00	$20,200,000.00
Total	$25,561,000.00	$29,481,000.00

Table 30: Detailed Loss for Non-Residential Buildings

Occupancy	Losses in Dollars, 1% Event	Losses in Dollars, 0.2% Event
Commercial	$188,000.00	$190,000.00
Education	$8,042.00	$8,227,000.00
Government	$837,000.00	$864,000.00
Religious	$0	$0
Agriculture	$0	$0
Industrial	$0	$0
Total	$9,067,000.00	$9,281,000.00

Table 31: Detailed Loss for Residential Buildings

Residential, Detailed Losses	Losses in Dollars, 1% Event	Losses in Dollars, 0.2% Event
Structure	$6,910,000.00	$8,856,000.00
Contents	$3,645,000.00	$4,627,000.00
Relocation	$4,283,000.00	$4,890,000.00
Rental Income	$1,656,000.00	$1,827,000.00
Total	$16,494,000.00	$20,200,000.00

4.7.2.2 Lifelines and critical infrastructure

Flooding is among the most disruptive natural hazards, affecting all eight FEMA Community Lifelines. These lifelines represent essential services that support public health, safety, and economic stability. Below is an analysis of some of the impacts that flooding can have on lifelines:

- Safety and Security - Flooding can damage emergency services infrastructure such as police stations, fire departments, and emergency operations centers. Blocked evacuation routes and submerged roads hinder rescue efforts, while prolonged outages increase vulnerability to crime and civil unrest.

- Food, Water, Shelter - Floodwaters often contaminate drinking water supplies and damage water treatment facilities. Food distribution networks are disrupted when warehouses and grocery stores are flooded. Residential destruction leads to mass displacement, creating urgent demand for temporary shelters.

- Health and Medical - Hospitals and clinics may become inaccessible or lose power during floods. Waterborne diseases and mold-related illnesses increase significantly. Medical supply chains are disrupted, delaying emergency care and routine treatments.

- Energy (Power and Fuel) - Flooding can submerge electrical substations and transformers, causing widespread outages. Fuel distribution networks are interrupted due to impassable roads, and prolonged power loss affects critical facilities such as hospitals and water treatment plants.

- Communications - Flood damage to cell towers, fiber-optic cables, and emergency communication systems reduces the ability to coordinate rescue and recovery operations. This disruption can delay critical information sharing during emergencies.

- Transportation - Roads, bridges, and rail lines are often washed out or blocked by floodwater. Airports and seaports may close, delaying evacuation and the delivery of emergency supplies. Transportation disruptions amplify the overall impact of the disaster.

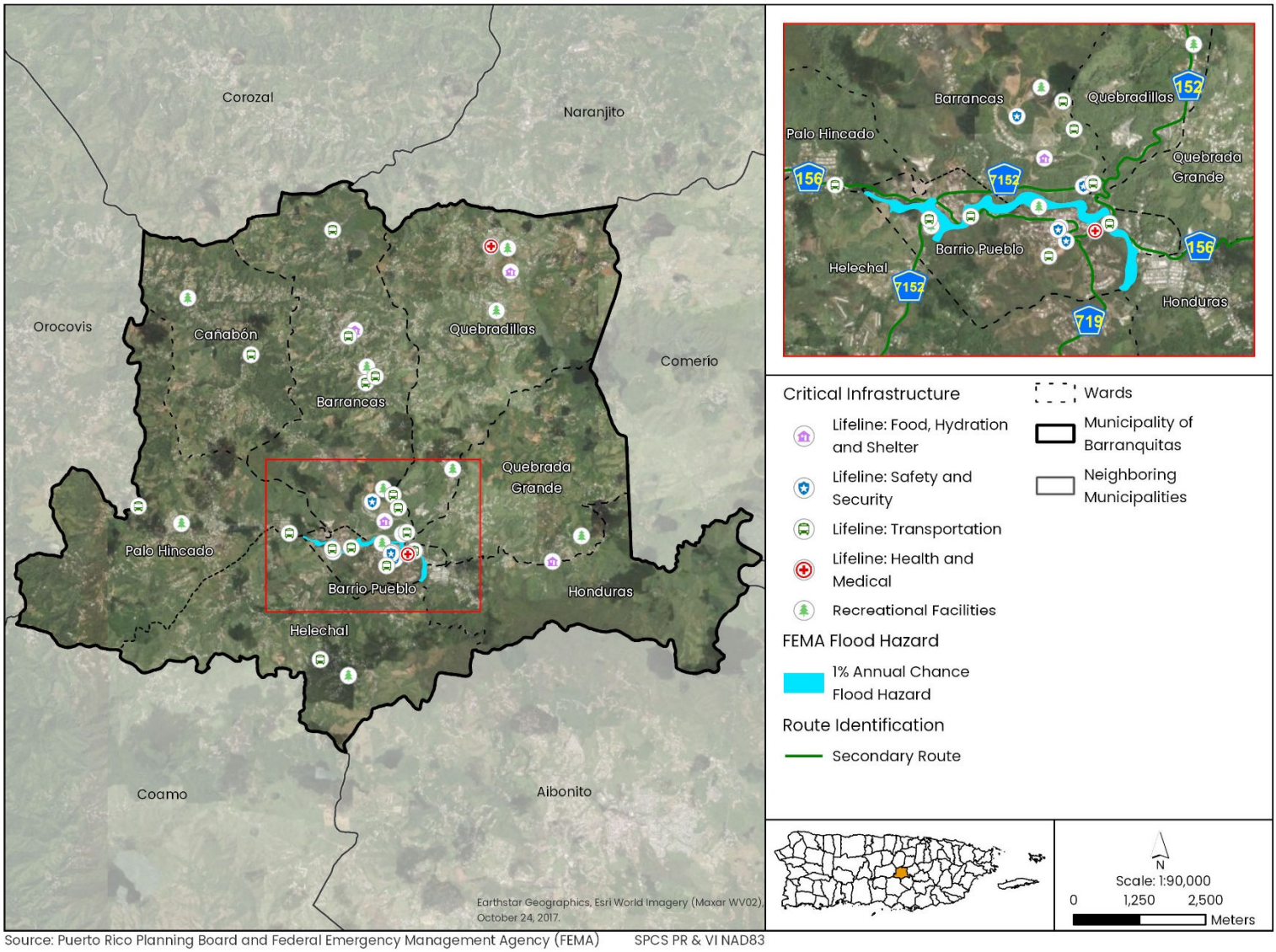
- Hazardous Materials Floodwaters can spread chemicals from industrial sites, sewage systems, and fuel tanks, increasing the risk of environmental contamination. Cleanup efforts become costly and time-consuming, posing long-term health hazards.

- Water Systems - Floodwaters often contaminate drinking water supplies and damage water treatment facilities. Excessive inflow from floodwaters overwhelms sewer systems, causing untreated sewage to backflow into streets and homes. Flooding exceeds the design capacity of storm drains and retention basins, resulting in urban flooding and infrastructure damage. Sediment and debris clog drainage systems, reducing effectiveness and increasing flood risk during subsequent storms.

The flood critical infrastructure exposure map, Map 32, shows that the 1% annual chance flood hazard area is concentrated in the central portion of Barranquitas, primarily within Barrio Pueblo and extending into adjacent portions of Barrancas, Quebradillas, Quebrada Grande, Helechal, and Honduras. The inset map indicates that numerous critical infrastructure facilities, including transportation, safety and security, health and medical, food, hydration and shelter, and recreational facilities, are located adjacent to or within the mapped flood hazard corridor. The greatest concentration of flood-exposed critical infrastructure is located around Barrio Pueblo, where the flood hazard area intersects the municipality's principal infrastructure cluster.

Map 32: Flood: Critical Infrastructure Exposure

Flood: Critical Infrastructure Exposure



Source: Puerto Rico Planning Board and Federal Emergency Management Agency (FEMA) SPCS PR & VI NAD83

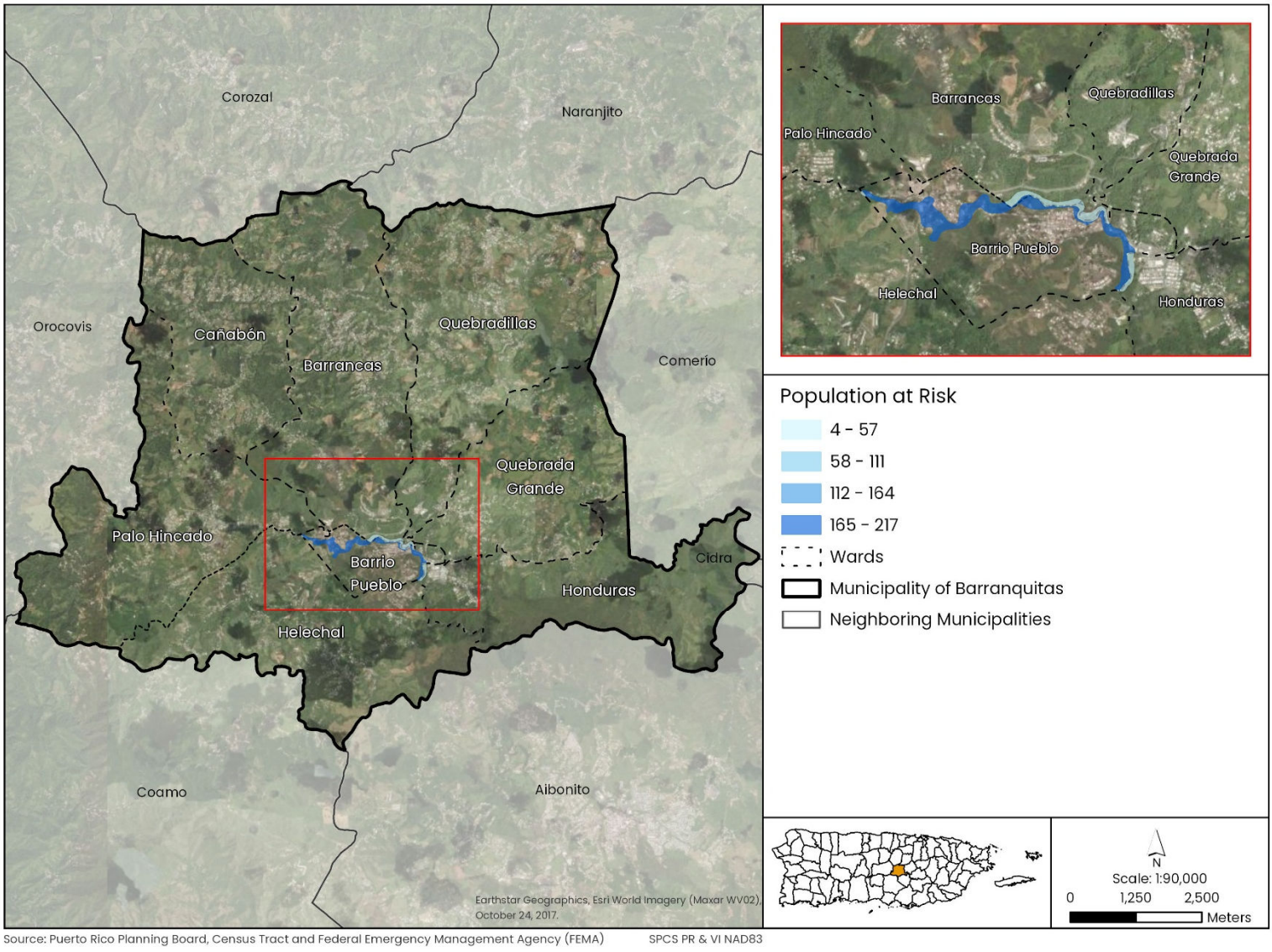
4.7.2.3 Social Vulnerabilities

Map 33 shows the population at risk of displacement in the event of a 500-year return flood by census tract. The areas with populations at risk are concentrated within the 1% annual chance flood hazard corridor in the central portion of Barranquitas. The exposed population extends through Barrio Pueblo and adjacent portions of Barrancas, Quebradillas, Quebrada Grande, Helechal, and Honduras, as shown in the inset map. The highest population-at-risk categories are located along sections of this flood corridor, while no mapped flood population exposure is shown in Cañabón

or Palo Hincado.

Research in flood-prone Puerto Rican communities shows that access to economic, material, and social resources strongly influences adaptive capacity, with low-income residents facing significant barriers to elevating homes, purchasing insurance, or relocating away from high-risk zones. These same communities frequently experience "false security" due to structural flood-control measures that reduce perceived risk but do not eliminate underlying exposure, which can worsen long-term vulnerability when residents underestimate future flood potential. Flood impacts also disproportionately affect individuals with limited mobility—including older adults, disabled residents, and those with chronic medical conditions—who may be unable to evacuate rapidly or access emergency shelters during rising waters. The Census Bureau's Community Resilience Estimates indicate that vehicle access, caregiver support, health insurance gaps, and disability prevalence are among the most widespread vulnerability components in the commonwealth, factors that directly shape whether individuals can flee or recover from flooding (US Census Bureau, 2024), (López Marrero, 2010) .

Map 33: Flood: Population Exposure



4.7.2.4 Natural and Cultural Resources

In most flood events, water resources are exposed to high levels of contaminants associated with rising water, sewage accumulation, and other hazardous or toxic substances left behind by flooding(Malilay, 2000) This situation fosters the spread of diseases in municipal water bodies and can negatively impact local flora and fauna, including humans. For example, prolonged stagnant water after a flood can promote diseases such as dengue and leptospirosis. Following Hurricane María, stagnant water contributed to leptospirosis outbreaks and increased mosquito breeding, highlighting

the potential public health consequences associated with post-flood environmental conditions. Leptospirosis is a bacterial disease that affects both humans and animals and can spread through urine from infected animals. These contaminated residues often remain in stagnant water after flooding events.

Floods also lead to the accumulation of debris, including structural remnants, soil, sediments, organic waste, and personal belongings. If not properly managed, this debris can contaminate land and water when burned, abandoned, buried, or dumped into water bodies.

4.7.2.5 Special Consideration: Repetitive Losses and Severe Repetitive Losses

In Barranquitas there are properties insured under the National Flood Insurance Program (NFIP). Section 6.5 provides further details on how the municipality can use the NFIP as a mechanism for mitigation planning.

The Municipality has included properties that have experienced repetitive losses and/or severe repetitive losses located in identified flood hazard areas. These properties currently lack descriptions of the type of structures (residential, commercial, institutional, among others). Including this information helps to understand the vulnerability of properties affected by flooding within the jurisdiction and increases the likelihood of qualifying for flood control or prevention grants through programs such as Flood Mitigation Assistance (FMA), Hazard Mitigation Grant Program (HMGP), Housing and Urban Development (HUD), CDBG-DR, and others.

As of December 2025, the information regarding NFIP coverage for the Municipality of Barranquitas is as follows:

Table 32: NFIP Policies in Force and coverage

Amount of NFIP Policies	Total Disbursement for both RL and SRL Loses
5	$19,903.00

Source: Puerto Rico Planning Board

This information includes properties covered by the NFIP that have experienced repetitive losses (RL) and/or severe repetitive losses (SRL) located in identified flood hazard areas.

Table 33: NFIP Repetitive Losses

Structures with Repetitive Losses (RL)	Insured Structures (RL)	Total Repetitive Losses (RL)
2	0	4

Source: Puerto Rico Planning Board

Table 34: NFIP Severe Repetitive Losses

Structures with Severe Repetitive Loses (SRL)	Insured Structures (SRL)	Total Repetitive Losses (SRL)
0	0	0

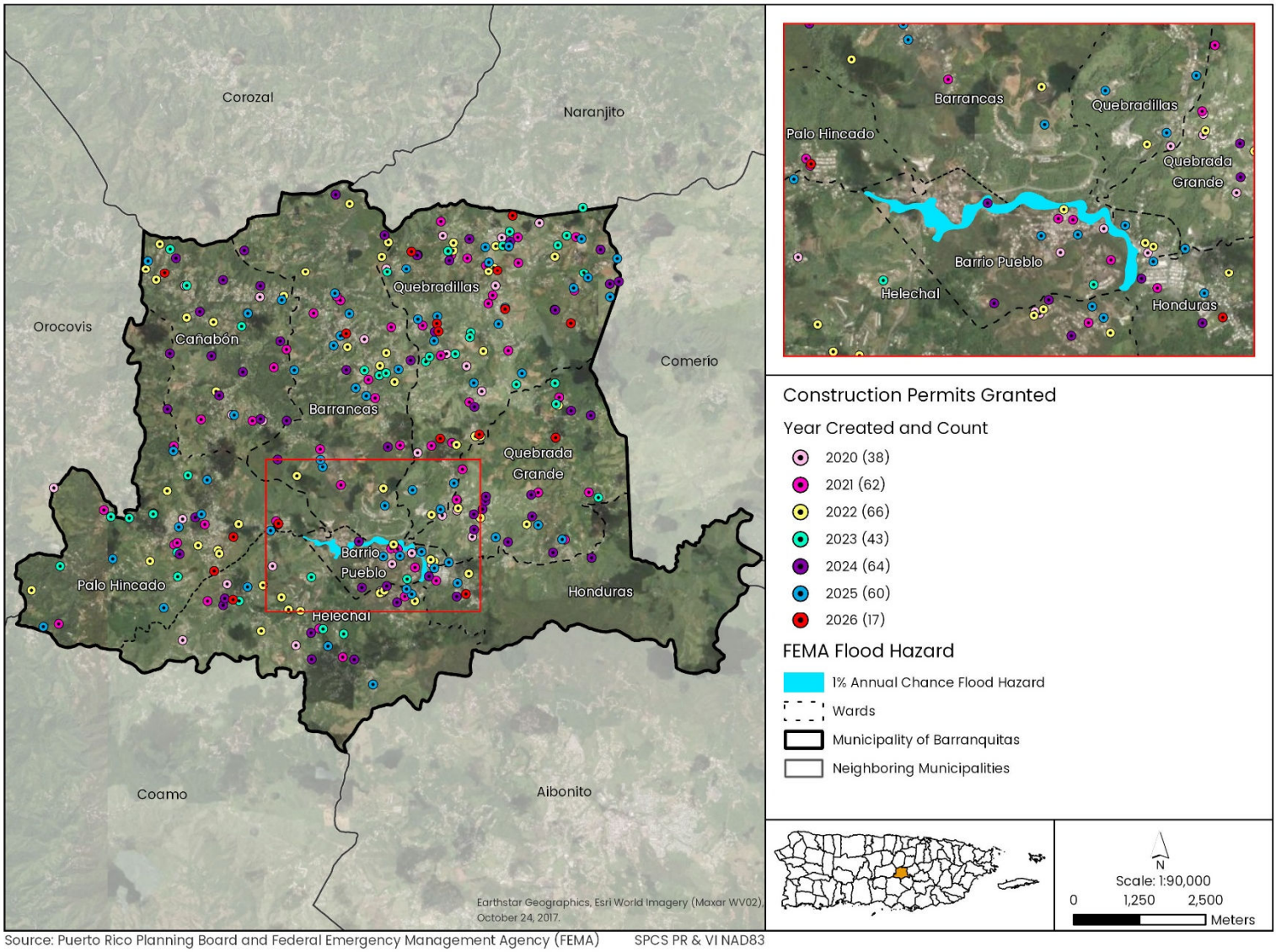
Source: Puerto Rico Planning Board

4.7.2.6 Future Conditions (E1-a)

The following map shows the locations of recent development permits issued between 2020 and 2026 distributed throughout the municipality of Barranquitas in relation to the mapped 1-percent annual chance flood hazard area. Development points are present across all wards, with notable concentrations in Barrio Pueblo, Quebradillas, Barrancas, and Quebrada Grande. The mapped 1% Annual Chance Flood Hazard areas are limited in extent and are primarily located around Barrio Pueblo, extending into portions of Barrancas, Honduras, and Quebrada Grande, as highlighted in the inset map. Several recent development locations are situated within or immediately adjacent to these mapped flood hazard areas, particularly in and around Barrio Pueblo.

Map 34: Flood: Recent Development Exposure

Flood: Recent Development Exposure



Source: Puerto Rico Planning Board and Federal Emergency Management Agency (FEMA) SPCS PR & VI NAD83

4.8 Tropical Cyclones and other Extreme Weather Events

4.8.1 Description (B1-a)

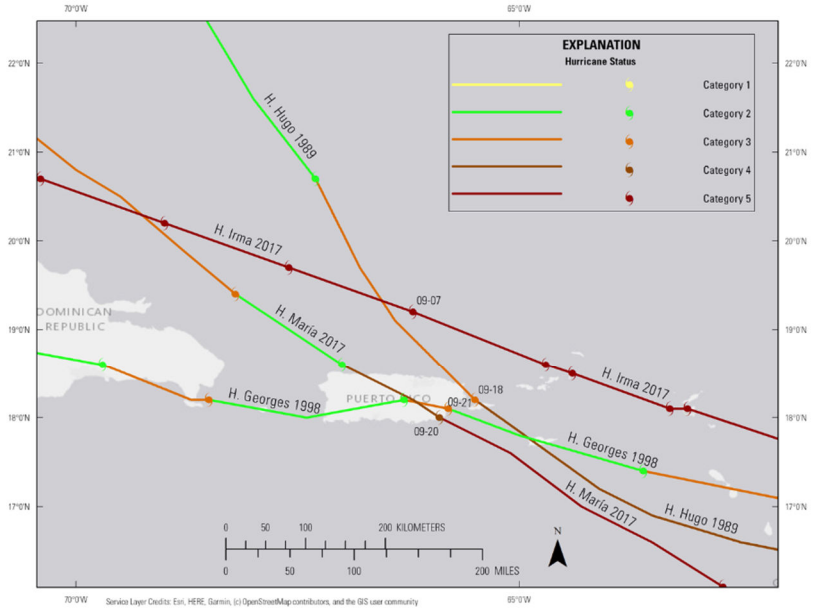
Winds are air currents generated in the atmosphere due to variations in pressure. Although these currents are constantly present, when their intensity increases, they can become a high-level hazard. For the purposes of this Plan, we will focus on events

capable of producing severe winds, specifically tropical cyclones and their extreme force (Castro Rivera & López Marrero, Cartilla de los Ciclones, 2018).

This sub-chapter has been named tropical cyclones to include phenomena such as tropical storms and tropical depressions; however, hurricanes are particularly hazardous due to their destructive potential, their ability to impact large areas, their spontaneous formation, and their unpredictable movement. Hurricanes are often accompanied by high tides, storm surges, and heavy rainfall, which can trigger landslides and flooding from river overflow. Since these accompanying hazards are addressed in separate sections, this section will focus exclusively on the effects of wind on the municipality.

Figure 18 shows the path of hurricanes category 2–5 that have affected Puerto Rico since 1993.[9]

Figure 18: Hurricane Tracks 1989-2017 (only Cat 2-5) [10]



Sources/Usage: Public Domain. View Media Details

Figure 1. *Hurricane tracks for Hugo (1898), Georges (1998), Irma (2017) and Maria (2017). Data provided by NOAA. Base image is intellectual property of Esri and is used herein under license. Copyright Esri and its creator.*

Figura 1: *Trayectorias de los huracanes Hugo (1989), Georges (1998), Irma (2017) y María (2017). Datos provistos por la NOAA. La imagen de base es propiedad intelectual de Esri y se usa aquí bajo licencia. Los derechos de autor y reproducción son propiedad de Esri y sus licenciatarios.*

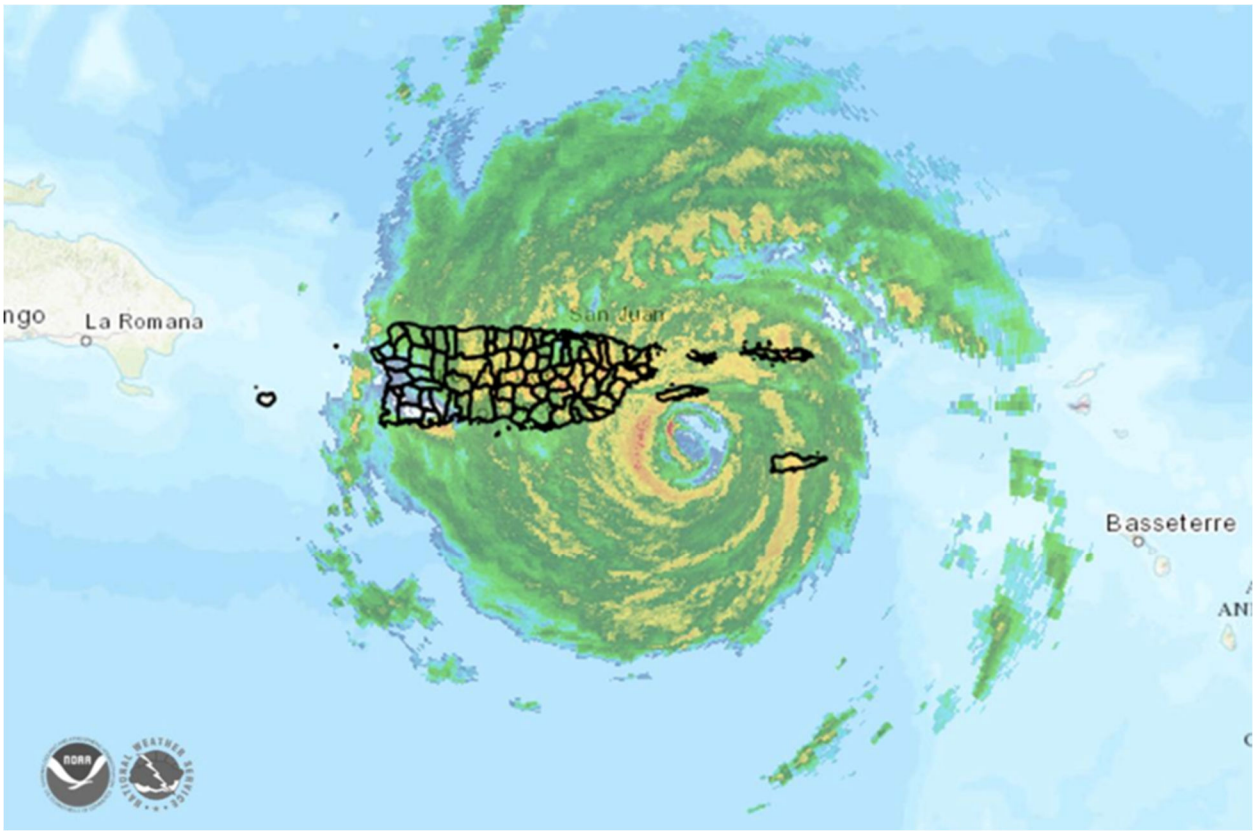
[9] Hortense (1996) and Fiona (2022) are not shown since they were category 1 hurricanes when they hit Puerto Rico.

[10] htt.s://www.usgs/gov/mission-areas/natural-hazards/science/Puerto-rico-natural-hazards-hurricanes-peligros-naturales-de

4.8.1.1 Affected Area (B1-b)

Tropical Cyclones are atmospheric systems that can affect the whole island. For example, Figure 19 shows the size of hurricane María (2017) as it approached Puerto Rico.

Figure 19: Hurricane María (2017) as it approaches Puerto Rico[1]



4.8.1.2 Risk Magnitude (B1-c)

Tropical cyclones are the most frequent natural hazard in Puerto Rico, with hurricanes being the most dangerous. Hurricanes are tropical atmospheric systems characterized by sustained wind speeds exceeding seventy-four (74) miles per hour. They develop over warm ocean waters and result from instability caused by the interaction of warm and cool air masses. Tropical cyclones are classified according to sustained wind intensity as follows:

- Tropical Depression: An organized system of clouds with a defined circulation and maximum sustained winds below 39 mph. This represents the formative stage of a tropical cyclone.

- Tropical Storm: An organized system of clouds with a defined circulation and maximum sustained winds ranging from 39 to 73 mph.
- Hurricane: The most intense form of a tropical cyclone, with sustained winds of 74 mph or greater. Hurricanes have a well-defined center with very low barometric pressure. They are categorized from one (I) to five (V), and the strongest can reach wind speeds exceeding 155 mph (Castro Rivera & López Marrero, Cartilla de los Ciclones, 2018).

Table 35 shows the Saffir - Simpson Scale of Hurricanes and gives historical examples of those hurricanes passing through or near Puerto Rico.

Table 35: Saffir-Simpson Hurricane Scale

Category	Wind Speed	Description	Historical Example
Tropical Storm	39 – 73 mph	Strong enough to cause tree damage, power outages, and localized flooding, but generally less destructive than a hurricane.	Jeanne (2004) Irene (2011) Isaias (2020) Federik (1979) Claudette (1979) Eloise (1975)
1	74–95 mph	Winds can cause minor damage to roofs, siding, and trees, with potential for power outages.	Santa Clara[11] (1956) Hortense (1996) Fiona (2022)
2	96–110 mph	Strong winds can cause extensive damage to roofs and trees, leading to widespread power loss.	Marilyn (1995)
3	111–129 mph	Devastating winds can destroy roofs and walls of homes, uproot trees, and cause prolonged outages.	Hugo (1989) Georges (1998)
4	130–156 mph	Catastrophic winds can cause severe structural damage, most trees snapped or uprooted, and power outages lasting weeks.	San Ciriaco (1899) San Ciprian (1932) Donna (1960) David (1979) María (2025)
5	157 mph or higher	Catastrophic winds can result in total roof failure and building collapse, rendering areas uninhabitable for weeks or months.	San Felipe II (1928) Irma (2017)

[11] Officially known as Hurricane Betsy

To assess the vulnerability posed by hurricanes this LHMP will use 100–Year wind event and 500-Year wind event. A 100-Year wind event refers to a wind speed that has a 1% chance of equaling or exceeding in any given year, while a 500-Year wind event has a 0.2% chance per year. These terms are based on statistical probabilities, not actual time intervals, and are used in engineering, risk assessment, and building codes to design structures that can withstand rare but severe windstorms. The calculation involves analyzing historical wind data and applying extreme value statistical models to estimate wind speeds for specific return periods.

These values are critical for structural design standards like the American Society of Civil Engineers Standard 7 (ASCE 7), which specify wind loads for different risk categories, and for insurance companies assessing potential storm damage. For example, typical 3-second gust wind speeds at 33 ft above ground (Exposure Category C) are about 100 mph for a 100-year event and approximately 110–115 mph for a 500-year event. These design speeds ensure safety for buildings, bridges, and critical infrastructure, and help guide emergency planning and financial risk management.

4.8.1.3 Past Events (B1-d)

The following table shows the extreme wind events that received a declaration of disaster between 1989 and 2025. One column identifies whether the Municipality of Barranquitas was designated for Public Assistance (PA), Individual Assistance (IA), or both under each declaration. Table 36 shows a list of presidential disaster declarations since 1987.

Table 36: Tropical Cyclone Disaster Declarations

Event	Date	Disaster Declaration Number	Barranquitas Included?	Description
Tropical Storm Ernesto	8/14/2024 – 8/16/2024	DR-4850- PR	Public Assistance – Yes Individual Assistance - No	The storm's slow movement and moisture-rich environment contributed to prolonged precipitation, particularly in central and eastern municipalities. Parts of Central Puerto Rico recorded 12–14 inches of rainfall in localized areas. The municipality of Barranquitas measured 11.20 inches over a 48-hour period, while Villalba reported 10.20 inches. Eastern municipalities, including Vieques and Culebra, observed 8–10 inches of rain. Multiple rivers exceeded their banks, including the La Plata River, resulting in significant inundation of adjacent communities. Flash flooding occurred in urban and rural areas, rendering primary and secondary roads impassable. Floodwater caused structural failures in bridges and washed-out critical road segments, isolating several communities. Stormwater drainage systems in metropolitan areas, notably San Juan, were overwhelmed, leading to localized urban flooding. Emergency Response and Disruptions

Event	Date	Disaster Declaration Number	Barranquitas Included?	Description
				Evacuations were conducted in flood-prone areas such as Toa Baja to mitigate loss of life.
Hurricane Fiona	9/17/2022 - 9/21/2022	DR-4671-PR	Public Assistance – Yes Individual Assistance - Yes	Hurricane Fiona struck Puerto Rico in September 2022, unleashing torrential rains—up to 31.22 inches of rainfall over 72 hours in Ponce, nearly matching the accumulation from Hurricane Maria. This deluge led to catastrophic flooding, with 7 to 20 inches common across most of the island and localized spots exceeding 30 inches.
Tropical Storm Isaías	7/29/2020-7/30/2020	DR-4560-PR	Public Assistance - No Individual Assistance - No	Although the center of Tropical Storm Isaías did not make landfall on the island, the system left a large amount of rain in its path, causing flooding throughout Puerto Rico. Rainfall accumulation of up to 10 inches was recorded around the island.
Hurricane María	9/20/2017	DR-4339-PR	Public Assistance – Yes Individual Assistance - Yes	Widespread flooding severely affected the whole Island. For example, in San Juan, water levels reached up to 6 feet in some areas and numerous structures losing their roofs. The coastal neighborhood of La Perla was largely destroyed, while Cataño suffered extensive damage, with the Juana Matos community estimated to be 80% destroyed. Strong winds, heavy rains, and flash floods near the La Plata Lake dam in Toa Baja impacted thousands of residents.

Event	Date	Disaster Declaration Number	Barranquitas Included?	Description
				Survivors reported that floodwater rose 6 feet in just 30 minutes, and some areas experienced depths of up to 15 feet (4.6 m).
Hurricane Irma	9/5/2017	DR-4336-PR	Public Assistance – Yes Individual Assistance - No	On September 5, 2017, Hurricane Irma impacted Puerto Rico; an Emergency Declaration was issued for the Island. On September 6, 2017, a Major Disaster Declaration was issued following Hurricane Irma's passage. Two people died due to torrential rains before the hurricane: a man died in Orocovis after falling from his ladder while repairing his roof; another man on the coast in Capitanejo died after being struck by lightning. Wave heights in Puerto Rico reached 9 meters, and sustained winds of 111 mph were recorded in Culebra.
Tropical Storm María[12]	9/8/2011 – 9/114/2011	DR-4040-PR	Public Assistance - No Individual Assistance - No	Tropical Storm (later Hurricane) Maria formed in early September 2011 and passed near Puerto Rico, bringing significant heavy rainfall and tropical storm conditions to the island. The storm caused widespread flooding that inundated numerous roadways and homes; floodwaters near Patillas destroyed several homes and

[12] Tropical Storm María was a tropical system that pass to the northeast of Puerto Rico in 2011 and that caused flooding in the Island. Not to be confused with the 2017 Hurricane María. The name "María" was retired from the official Atlantic hurricane season list of names after 2017

Event	Date	Disaster Declaration Number	Barranquitas Included?	Description
				bridges, and approximately 150 houses in Yabucoa were flooded and damaged.
Hurricane Irene	8/22/2011	DR-4017-PR	Public Assistance - Yes Individual Assistance - No	Total rainfall reached 22 inches over three days, with the eastern region being the most affected—the same area that had already received over 6 inches earlier in August during the close passage of Tropical Storm Emily. The Río Grande de Manatí in Manatí recorded its third-highest level in history, surpassed only during Hurricane Hortense (1996) and Hurricane Georges (1998). The Puerto Nuevo River near Hato Rey reached its fourth-highest level on record. Flooding was severe enough to cause infrastructure stress and dangerous conditions across multiple municipalities. Tragically, there was one direct fatality attributed to Irene, due to drowning.
Tropical Storm Jeanne	9/14/2004 – 9/19/2004	DR-1552-PR	Public Assistance - Yes Individual Assistance - Yes	Tropical Storm Jeanne crossed Puerto Rico on September 15, 2004, as a strong tropical storm with maximum sustained winds around 70 mph (110 km/h), producing gusts up to 72 mph (≈116 km/h). The winds caused widespread power and water outages, with numerous reports of structural damage to homes, uprooted trees, fallen utility poles, and significant impacts on infrastructure across the island.

Event	Date	Disaster Declaration Number	Barranquitas Included?	Description
				The storm resulted in eight fatalities in Puerto Rico—four direct and four indirect, including deaths during preparations and carbon monoxide poisoning. Damages were estimated at approximately $169.5 million (2004 USD), making Jeanne the most destructive tropical cyclone to impact Puerto Rico since Hurricane Georges in 1998.

4.8.1.4 Tornadoes

According to NOAA's National Centers for Environmental Information (NCEI), No tornado has been registered in Barranquitas.

4.8.1.5 Future event probabilities (B1-e)

According to the Colorado State University Tropical Cyclones, Radar, Atmospheric Modeling and Software Team, the following average annual probabilities apply for storms coming ashore or passing within 50 miles of Puerto Rico: (Colorado State University, 2026)

- Average probability of a named storm coming ashore or within 50 miles of Puerto Rico: 40%.
- Average probability of a hurricane coming ashore or within 50 miles of Puerto Rico: 24%.
- Average probability of a major hurricane coming ashore or within 50 miles of Puerto Rico: 9%.

4.8.2 Risk Analysis (B2-a, B2-b)

4.8.2.1 Estimated Losses

Table 37 presents the exposure to tropical cyclones, as registered in FEMA National Risk Index.

Table 37: Tropical Cyclone Exposure

Exposure - Impacted Area (sq mi)	Exposure - Building Value	Exposure - Population	Exposure - Population Equivalence	Exposure - Total
34.62882	$3,113,350,157	28,930.56	$335,594,478,218	$338,7074,828,376

The expected annual loss for each Census tract or jurisdiction represents the average yearly economic impact, expressed in dollars, anticipated from natural hazard events.

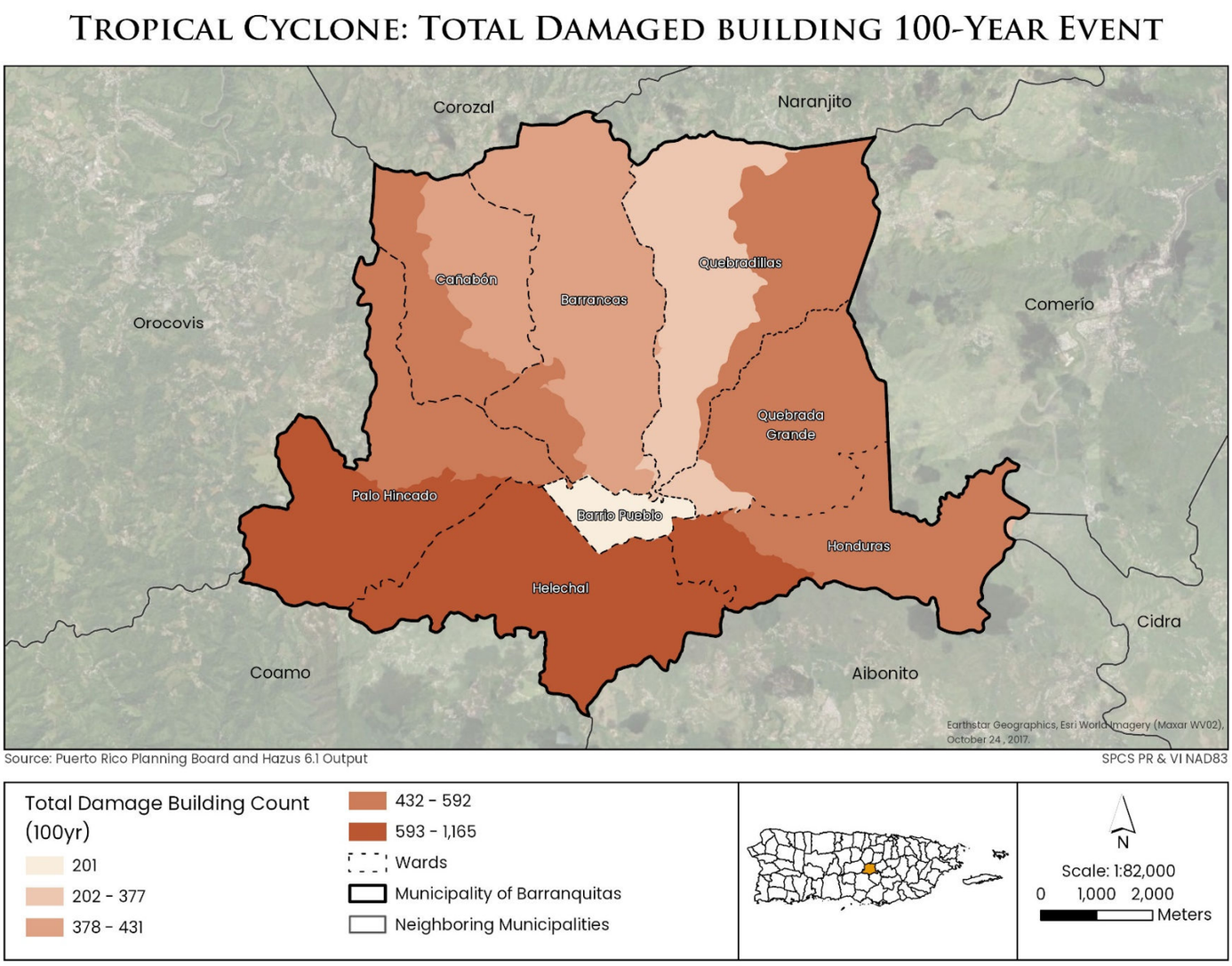
Table 38 presents the expected annual tropical cyclone-related losses for both buildings and population.

Table 38: Expected Annual Loss to Tropical Cyclones

Expected Annual Loss - Building Value	Expected Annual Loss - Population	Expected Annual Loss - Population Equivalence	Expected Annual Loss -Total
$12,861,217	0.048084	$557,772	$13,418,989

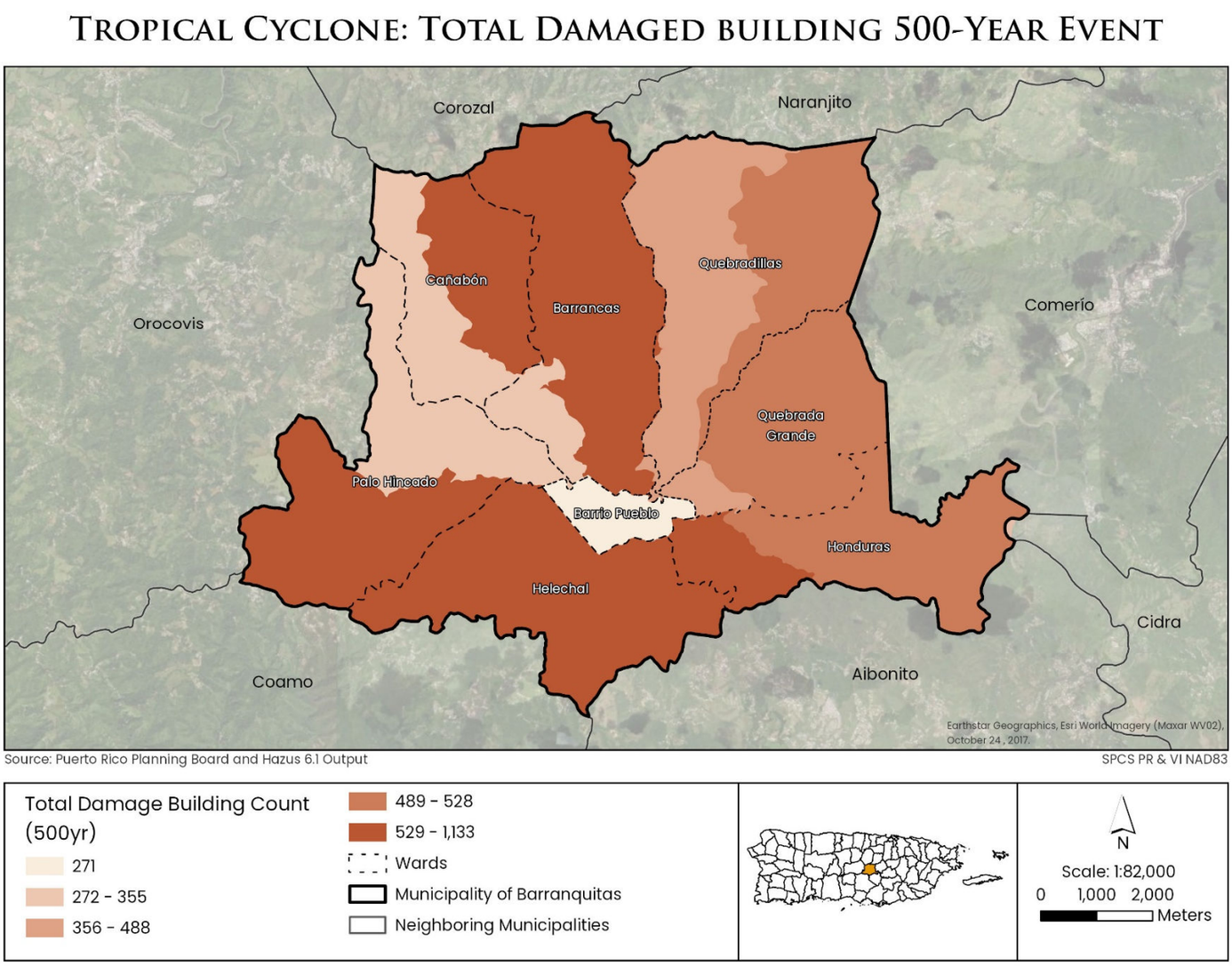
The following maps show the expected losses from the impact of a hurricane.

Map 35: Tropical Cyclone: Total Damaged Buildings 100 – Year Event



Map 35 illustrates the spatial distribution of estimated damaged building counts associated with a 100-year tropical cyclone event across the wards of Barranquitas. The highest damage class (593–1,165 buildings) is mapped in Palo Hincado, Helechal and portions of Honduras. Moderate damage classes (432–592 buildings) are present in Cañabón, Quebrada Grande, and most of Honduras, while Barrancas and Quebradillas are mapped within lower damage ranges. Barrio Pueblo is shown with the lowest estimated damage count (201 buildings) among all wards.

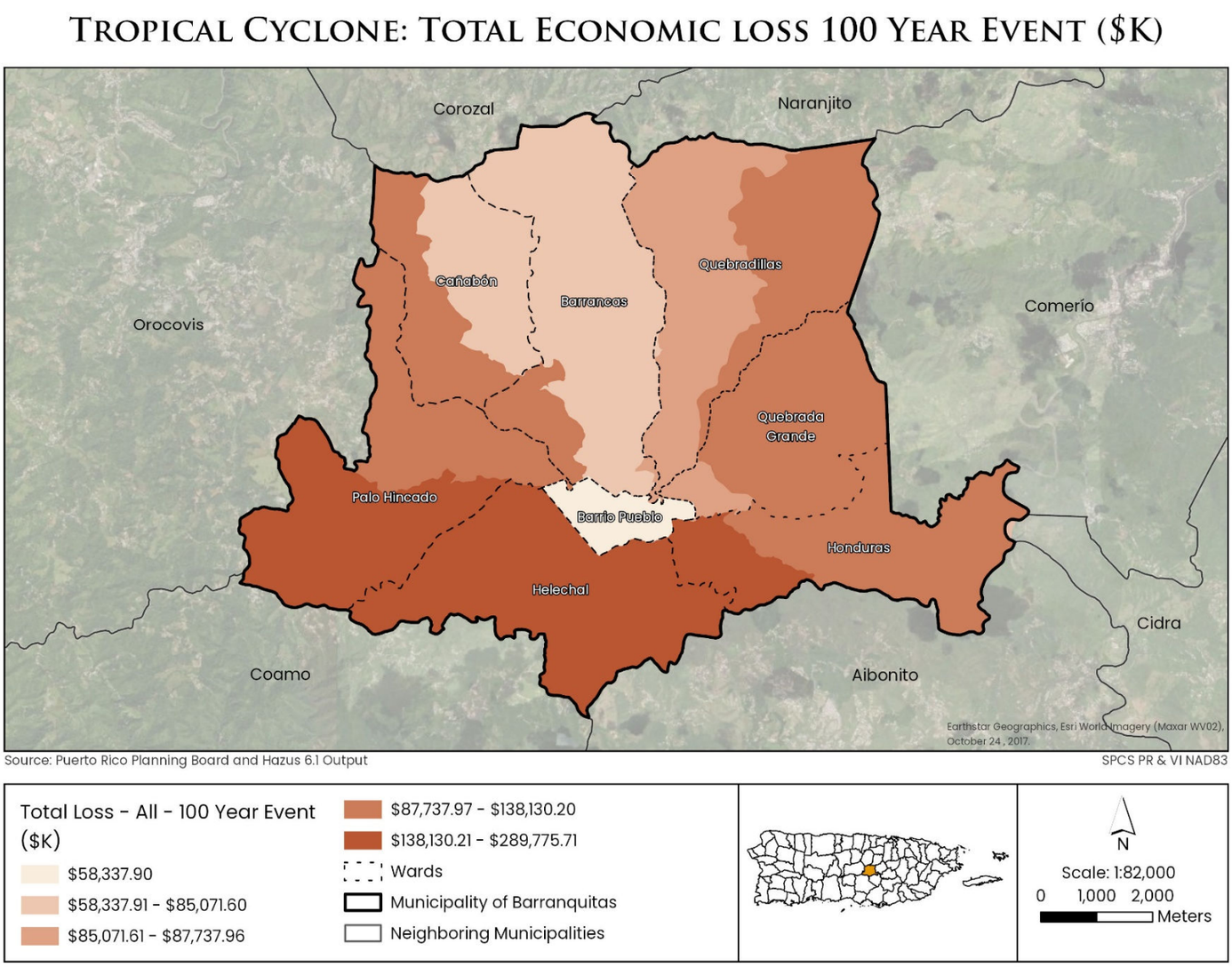
Map 36: Tropical Cyclone: Total Damaged Buildings 500 – Year Event



The 500-year event shows results like the 100-year event map. Map 36 illustrates that the highest damage class (529–1,133 buildings) is mapped in Barrancas, Palo Hincado, and Helechal. Quebrada Grande and Honduras fall within the 356–488 buildings damage range, while Cañabón and Quebradillas are mapped within lower damage classes. Barrio Pueblo is shown with the lowest estimated damaged building count (271 buildings) in the municipality.

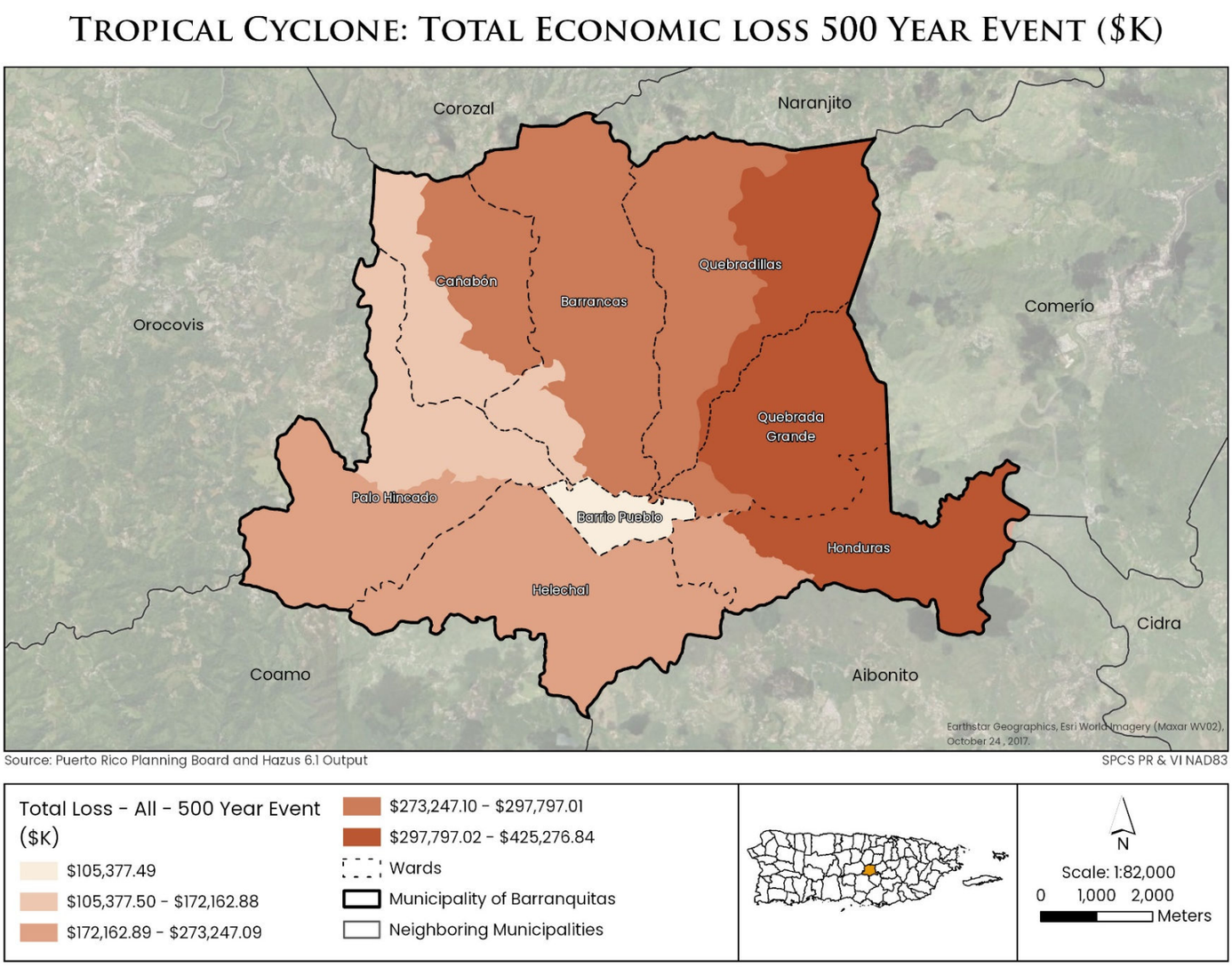
The following maps illustrate the projected economic losses, and asset exposure associated with tropical cyclone wind events in Barranquitas under various recurrence interval scenarios.

Map 37: Tropical Cyclone Total Economic Loss 100-Year Event



Map 37 illustrates the projected total economic loss associated with a 100-year tropical cyclone event. The highest projected losses ($138,130.21-$289,775.71 thousand) are mapped in Palo Hincado, Helechal, and Honduras. Losses ranging from $87,737.97-$138,130.20 thousand occur in Quebradillas, Quebrada Grande, and portions of Cañabón. Lower projected losses ($85,071.61-$87,737.96 thousand) are found in Barrancas and portions of Cañabón, while the lowest projected losses ($58,337.90 and $58,337.91-$85,071.60 thousand) are concentrated in Barrio Pueblo and adjacent areas, as shown on the map.

Map 38: Tropical Cyclone Total Economic Loss 500-Year Event



Map 38 illustrates the projected total economic loss associated with a 500-year tropical cyclone event. The highest projected losses ($297,797.02-$425,276.84 thousand) are mapped in Quebrada Grande and Honduras. Losses ranging from ($273,247.10-$297,797.01) occur in Barrancas, Quebradillas, and portions of Cañabón. Lower projected losses ($172,162.89-$273,247.09) are found in Helechal and portions of Quebradillas and Cañabón, while the lowest projected losses ($105,377.49 and $105,377.50-$172,162.88) are concentrated in Barrio Pueblo, Palo Hincado, and the western portion of Cañabón, as shown on the map.

4.8.2.2 Lifelines and Critical Infrastructure

Hurricane winds have profound effects on all eight FEMA Community Lifelines, disrupting essential services and infrastructure.

- Safety and Security systems are compromised when high winds damage police stations, fire departments, and emergency operations centers, while debris and fallen power lines obstruct emergency routes, delaying rescue efforts.
- Food, Hydration, and Shelter lifelines suffer as winds destroy agricultural fields, damage food storage facilities, and tear roofs off homes and shelters, leaving communities vulnerable and displacing thousands.
- In the Health and Medicine sector, hospitals and clinics experience roof failures and structural damage, forcing evacuations and interrupting critical care, while pharmacies and supply chains face severe disruptions.
- The Energy lifeline is particularly vulnerable, as hurricane winds topple transmission towers, snap utility poles, and damage substations, causing widespread power outages that cascade into other lifelines.
- Communications systems fail when telecommunication towers and antennas are blown down, severing cellular and internet connectivity and hindering emergency coordination.
- Transportation networks are crippled by blocked roads, damaged bridges, and wind-related destruction at airports and seaports, delaying relief efforts and supply deliveries.
- Facilities handling Hazardous Materials face increased risks when wind-driven debris ruptures tanks or pipelines, creating environmental hazards and complicating cleanup operations.
- Finally, Water Systems are disrupted as treatment plants and pumping stations sustain roof and equipment damage, while elevated storage tanks and distribution infrastructure collapse, interrupting access to clean water for drinking and sanitation. These cascading failures underscore the critical need for wind-resistant design standards and proactive planning to protect lifelines and maintain community resilience during hurricane events.

For planning purposes this LHMP shall assume that all critical infrastructure is equally exposed to this hazard.

4.8.2.3 Social Vulnerabilities

As discussed before in Section 4.9.1.1 a tropical cyclone can impact the whole island. For this LHMP we are going to assume that all the population of Barranquitas is vulnerable to this hazard. For further details on the Municipality's social vulnerability see section 3.4.4.

4.8.2.4 Natural and Cultural Resources

Hurricane winds caused extensive damage to both natural and cultural resources by exerting extreme mechanical forces on landscapes and built environments. In natural settings, strong winds uproot trees, strip foliage, and break branches, leading to deforestation and habitat loss. This disruption affects biodiversity and can alter ecosystem functions for years. Coastal vegetation such as mangroves is particularly vulnerable, as wind-driven forces weaken root systems and reduce their ability to

protect shorelines. Agricultural areas also suffer severe losses, with crops flattened or destroyed, impacting food supply and local economies.

Cultural resources, including historic buildings, monuments, and archaeological sites, are equally at risk from hurricane winds. High wind speeds can dislodge roofing materials, collapse walls, and damage structural integrity, especially in older or unreinforced constructions. Museums, archives, and heritage sites may experience irreparable harm if protective measures are inadequate. The loss of these cultural assets not only affects community identity but also has economic implications for tourism and preservation efforts. Understanding wind speed thresholds and incorporating them into design standards and conservation planning is essential to mitigate these risks and safeguard both natural and cultural heritage.

4.8.2.5 Future Conditions (E1-a)

The risk of hurricane is a municipal – wide risk. Every part of the recent development approved by the municipality is equally in risk of being affected by a tropical cyclone.

4.9 Extreme Heat

4.9.1 Description (B1-a)

There is no universally accepted definition for extreme heat or heat waves. For the purposes of this Plan, the definition adopted by the Department of Homeland Security (DHS) is used. It is defined as a prolonged period of 48 to 72 hours of intense heat and humidity, with temperatures above 90 ºF. Under these conditions, evaporation is reduced and the body is forced to make a significant effort to maintain its normal temperature, which has caused the death of many people in attempts to stabilize physically. In general, extreme heat represents the highest rate of deaths among weather-related hazards.

The study titled Heat Risk Perception and Vulnerability in Puerto Rico: Insights for Climate Adaptation in the Caribbean, published in the academic journal International Journal of Environmental Research and Public Health, analyzes how Puerto Rico residents perceive health risks associated with extreme heat and how these perceptions relate to vulnerability and protective behaviors during extreme heat events that occurred in the summer of 2020 (Guzmán-Colon, Guido, Amaya-Ardilla, Cabrera-Rivera, & Méndez-Lázaro, 2025). The research was conducted through a cross-sectional telephone survey of 500 adults in metropolitan and non-metropolitan areas. This study defined the metropolitan area as the municipalities of Bayamón, Carolina, Cataño, Toa Baja, and Trujillo Alto. The non-metropolitan zone consists of the remaining municipalities of Puerto Rico.

The questionnaire included sociodemographic variables, health status, prior heat exposure, risk perception, and mitigation strategies. Statistical analysis employed chi-square tests and multinomial and logistic regression models. The results reveal that, although most participants expressed concern about climate change and high temperatures, less than half perceived heat as a high health risk, and only one-fourth considered it likely to suffer a heat-related illness in the next five years. Risk perception was significantly higher among men, people aged 50 to 64, the unemployed, individuals with fair health, multiple chronic conditions, and those who had

experienced heat-related symptoms. In contrast, older adults (65+) reported low levels of risk perception despite their high vulnerability.

Forty-four percent of respondents indicated having suffered heat-related symptoms during the summer, and 68% reported nighttime thermal discomfort, a factor closely linked to health problems. The most common strategies to mitigate heat were the use of fans (84%) and air conditioning (64%), although economic limitations and instability of the electrical system reduced their effectiveness. Regional differences were also notable: residents in non-metropolitan areas showed greater risk perception than those in metropolitan zones.

The study concludes that there is a significant gap between actual vulnerability and risk perception, especially among older adults. It recommends strengthening risk communication targeted at vulnerable groups, addressing nighttime heat exposure, and improving electrical infrastructure to ensure equitable access to cooling systems. Proposed solutions include decentralized energy systems, cooling centers with backup power, and passive designs that reduce electrical dependence, thus contributing to community resilience in the face of increasing extreme heat events.

4.9.1.1 Affected Area (B1-B)

Extreme heat events can impact the entire municipality, particularly in urbanized areas where the heat island effect may occur. Based on previously presented information, adverse climate effects have been observed, including severe droughts, increased frequency of strong wind events and flooding, higher heat index levels, among others. Due to the municipality's geography and location, the entire region is highly susceptible to extreme heat conditions.

Urban heat island refers to Urbanized areas where structures such as buildings, roads, and other infrastructure absorb and emit the sun's heat more than natural landscapes such as forests and water bodies. Daytime temperatures in urban areas are about 1–7 ºF higher than temperatures in outlying areas; nighttime temperatures are about 2–5 ºF higher (EPA, 2025).

Heat islands develop due to a combination of factors:

- Loss of Natural Landscapes – Urban areas often replace trees, vegetation, and water bodies—natural elements that cool the air through shade, transpiration, and evaporation—with hard, dry surfaces like roads, rooftops, and parking lots. These surfaces provide little shade or moisture, leading to higher temperatures.
- Properties of Urban Materials – Common construction materials such as asphalt and concrete absorb and retain more heat than natural surfaces. They reflect less solar energy and release heat slowly, causing temperatures to remain elevated, especially after sunset.
- Urban Design and Geometry – The layout of buildings affects airflow and heat retention. Dense developments with narrow streets and tall structures create "urban canyons" that trap heat and block cooling winds, turning buildings into thermal masses that release heat gradually.
- Human-Generated Heat – Activities such as transportation, industrial operations, and air conditioning add waste heat to the environment, intensifying the heat island effect.

- Weather and Geographic Conditions – Clear, calm weather amplifies heat islands by maximizing solar energy absorption and limiting heat dispersion. Conversely, wind and cloud cover help reduce the effect. Geographic features like mountains can also influence wind patterns, either blocking cooling breezes or channeling heat through urban areas (EPA, 2025).

According to the Plan Territorial del Municipio de Barranquitas, approximately 8.92 percent of the municipality's territory is classified as Urban Land (Suelo Urbano). As a result, only a limited portion of the municipality is likely to be directly affected by urban heat island conditions typically associated with densely developed areas. However, the occurrence and intensity of extreme heat are influenced by a complex interaction of factors, including land cover, vegetation, topography, building density, and population distribution. Therefore, a more detailed urban-scale analysis would be required to fully assess the extent to which extreme heat may affect residents, infrastructure, and developed areas within the municipality.

4.9.1.2 Risk Magnitude (B1-c)

Local NWS offices often work with community agencies to decide when heat alerts should be issued. Because the United States is so geographically and culturally diverse, heat tolerance varies by region. For example, residents of Puerto Rico are generally more accustomed to temperatures above 90°F than those living in Alaska.

Nevertheless, the NWS uses the following standard alerts (NWS, n.d.):

- Excessive Heat Warning – Issued 12 hours before dangerous heat conditions are expected. This occurs when the heat index is forecast to reach 105°F or higher for more than three hours over two consecutive days, or 115°F or higher for any period.
- Excessive Heat Watch – Issued when an extreme heat event is possible within the next 24 to 72 hours.
- Heat Advisory – Issued 12 hours before conditions where the heat index is at least 105°F but less than 115°F for three consecutive days.
- Extreme Heat Outlook – Issued when there is potential for extreme heat within the next three to seven days, providing advance notice for those who need extra time to prepare.

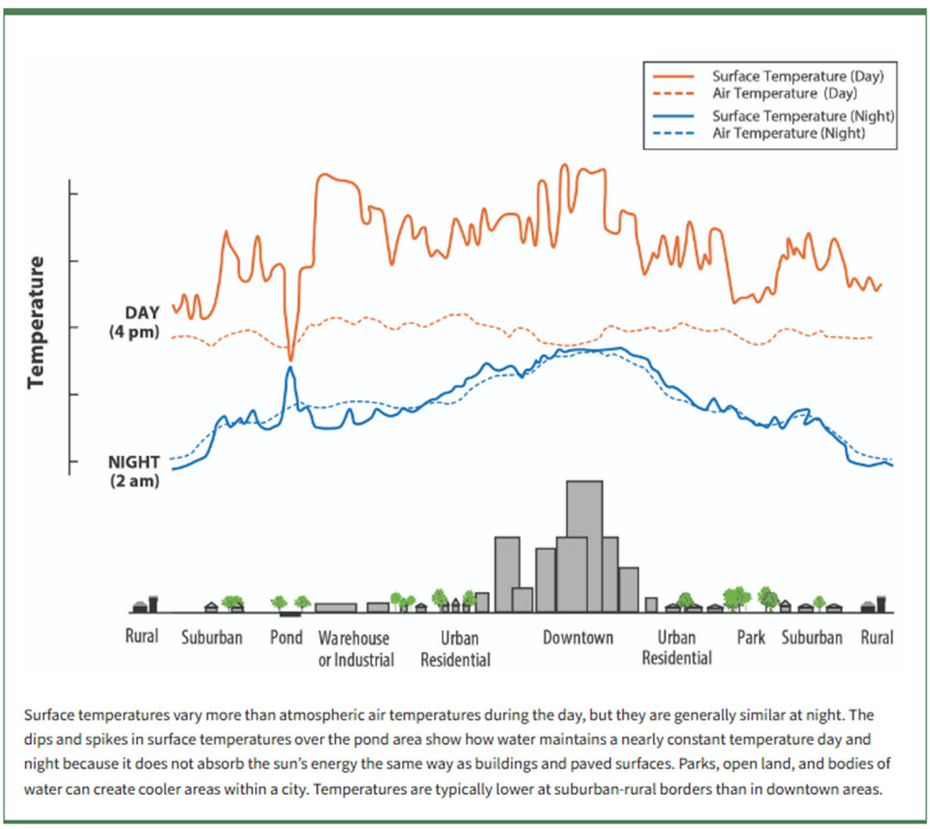
It must be emphasized that Urban Heat islands (UHI) phenomena can occur regardless of whether there is an extreme heat warning event. UHI is a relative temperature difference between urban and surrounding rural areas caused by factors like heat-absorbing surfaces, lack of vegetation, and human activities. It exists year-round, even during mild or cool weather, because cities consistently retain more heat than natural landscapes. Extreme heat events can amplify UHI, making UHI effects more dangerous, but UHI does not require extreme heat to form—it simply means urban areas are warmer than their surroundings under similar conditions.

UHIs are typically assessed by comparing temperatures in urban areas to those in surrounding regions. Even within a city, temperatures can vary significantly. Some neighborhoods are hotter due to dense concentrations of heat-absorbing surfaces like buildings and pavements, while areas with trees and greenery remain cooler. These variations create what are known as intra-urban heat islands. In diagrams

illustrating this effect, urban parks, ponds, and residential zones generally appear cooler than central downtown districts.

The following diagram, taken from an EPA website, shows a diagram of how a heat island effect behaves in temperature.

Figure 20: Heat Island Effect Diagram (EPA, 2025)



4.9.1.3 Past Events (B1-d)

Méndez Lázaro et al. (2015) identified several years in which extreme heat temperatures were recorded in the San Juan metropolitan area. According to their findings, periods of extreme heat occurred in 1983, 1995, 2012, and 2013. Notably, the summer of 2012 was the hottest in a century, with 42 days of extreme temperature values. During June, July, and August, the maximum heat index reached 98.06° F, 98.96° F, and 102.02° F, respectively (Méndez Lázaro et al., 2015).

4.9.1.4 Future event probabilities (B1-e)

Official NOAA assessments in the 2018 Puerto Rico and U.S. Virgin Islands State Climate Summary report an increase in both average temperature (≈1.5°F since 1950) and the frequency of extreme heat events (NOAA, 2022). Additionally, climate projections from CMIP6 (via the World Bank's Climate Change Knowledge Portal) show steady rises in summer and annual maximum temperatures for Puerto Rico, further indicating elevated future risk for heat waves (World Bank, n.d.).

4.9.2 Risk Analysis (B2-a, B2-b)

4.9.2.1 Estimated Losses

Extreme Heat primarily causes material and system stress rather than immediate structural failure. For example:

- Roads and Pavements: Asphalt can soften and deform under prolonged high temperatures, leading to rutting and surface damage (Highways Industry, n.d.) (EPA, 2012).
- Rail Systems: Steel tracks expand in extreme heat, which can cause buckling and derailment risks (USDOT - FRA, 2013).
- Power Infrastructure: Electrical grids experience higher loads from air conditioning demand, and transformers or cables can overheat, reducing efficiency or causing outages.
- Building Materials: Expansion and contraction of concrete, steel, and glass can lead to cracks or joint failures over time. Roofing materials may degrade faster under intense heat.
- Cooling Systems: HVAC systems work harder, increasing energy consumption and risk of failure, which can compromise indoor comfort and safety.

While heat waves rarely cause buildings to collapse, they accelerate wear and tear, increase maintenance costs, and can lead to system failures that disrupt essential services. As of now the municipality does not have a method to calculate losses from extreme heat events.

4.9.2.2 Lifelines and Critical Infrastructure

Extreme heat poses systemic risks across energy, transportation, and communications systems, creating compound failures precisely when demand for services peaks. In Energy Lifeline, high temperatures drive sharp increases in electricity demand for cooling while simultaneously decreasing generation and delivery efficiency. Thermoelectric plants may be forced to curtail output when cooling water is too warm, solar panels produce less electricity at elevated module temperatures, and transmission lines lose carrying capacity as conductors heat and sag—conditions that heighten the likelihood of voltage drops and blackouts during heat waves (Jessen, 2025). The combination of record cooling loads and diminished supply underscores a growing "peak risk" problem for grids that were not designed for today's heat extremes (Jessen, 2025) (American Society of Civil Engineers, 2024).

Similarly, the Transportation Lifeline is similarly vulnerable. Prolonged high surface temperatures soften asphalt, accelerating rutting and deformation; steel rails thermally expand and can buckle, prompting heat-related slow orders that disrupt service; and catenary or other overhead lines can sag in the heat, further constraining operations. Airports face dual constraints: runway pavements can deform under extreme heat, and reduced air density on hot days impairs aircraft performance, affecting takeoff weight and scheduling. These effects are now commonly observed across U.S. systems during sustained heat events, requiring operational restrictions and emergency maintenance that ripple through supply chains and passenger mobility (American Society of Civil Engineers, 2024).

Communication Lifeline also faces mounting heat stress. Data centers, switching facilities, and network nodes rely on continuous cooling; overheating elevates outage risks and can degrade equipment lifespans. Heat-related disruptions to power supply and localized microclimate conditions compound these risks, with cascading impacts across other lifeline sectors that depend on connectivity for operations and emergency response. Federal assessments underscore that extreme weather—including extreme heat—can interrupt fiber networks, degrade wireless performance,

and limit access to data centers, affecting each of the other critical infrastructure sectors and complicating disaster response coordination (Public-Private Analytic Exchange Program, 2025).

Overall, extreme heat acts as a stress multiplier: it pushes materials beyond design thresholds, reduces equipment efficiency, and narrows operational safety margins, all while increasing demand for services. The evidence from engineering organizations and energy market observers indicates that without targeted adaptation—such as heat-resilient design standards, strategic grid reinforcement, enhanced thermal management for digital infrastructure, and heat-aware operations—systems will face more frequent service disruptions and higher lifecycle costs as heat events intensify (American Society of Civil Engineers, 2024).

4.9.2.3 Social Vulnerabilities

A recent academic study examines the relationship between heat stress and mortality in Puerto Rico (Méndez - Lázaro, et al., 2025). Researchers analyzed hourly 2-meter air temperature data from ERA5 reanalysis for 2015–2020 and derived daily minimum, maximum, and mean values to calculate two heat stress indices: the Heat Index (HI) and the Universal Thermal Climate Index (UTCI). Findings show that extreme heat conditions are common for eight months of the year, with August and September being the hottest months, and that urban heat island effects exacerbate exposure in metropolitan areas. (Méndez - Lázaro, et al., 2025) Mortality risk increased significantly on days with high heat stress: deaths were 23% higher in the highest HI tertile and 47% higher in the highest UTCI tertile compared to the lowest. Cardiovascular and cerebrovascular diseases, heart failure, and respiratory conditions were among the leading causes of death associated with heat stress. The study highlights Puerto Rico's socio-economic vulnerabilities, aging population, and limited infrastructure amplifying health risks during extreme heat events (Méndez - Lázaro, et al., 2025).

4.9.2.4 Natural and Cultural Resources

Extreme heat, specifically Urban Heat Islands can pose the following impacts on the natural resources:

- Increased Energy Consumption – Heat islands increase electricity demand for air conditioning and peak energy demand. Increased electricity demand for air conditioning ranges from 1–9% for each 2°F increase in temperature, with the highest increase in countries where most buildings have air conditioning, such as the United States.[3] This increased demand contributes to higher electricity expenses. Peak demand generally occurs on exceptionally hot afternoons, when offices and homes are running air-conditioning systems, lights, and appliances. This increased demand can overload systems and require a utility to institute controlled brownouts or blackouts to avoid power outages.

- Elevated Emissions of Air Pollutants – To meet electricity needs, utility companies typically rely on fossil fuel power plants as a power source. Increased use of fossil fuels increases emissions of air-borne pollutants, such as carbon dioxide, which can have health concerns, especially in people living with respiratory diseases.

- Compromised Human Health and Comfort – Hot weather events contribute to heat-related deaths and heat-related illnesses. Areas experiencing heat islands further contribute to higher daytime temperatures and reduced nighttime cooling. Heat is of greatest concern for groups such as older adults, young children, populations with low-income, people who work outdoors, and people with chronic health conditions, disabilities, mobility constraints, or taking certain medications. From 2004 to 2018 the Centers for Disease Control and Prevention recorded an average of 702 heat deaths per year.

- Impaired Water Quality – High temperatures of pavement and rooftop surfaces can heat stormwater runoff, which drains into storm sewers. This runoff raises water temperatures as it is released into streams, rivers, ponds, and lakes. Water temperature affects the metabolism and reproduction of many aquatic species.

Rapid temperature changes can also be stressful, and even fatal, to aquatic life. One study found that urban streams have more frequent temperature surges than streams in forested areas. Temperature surges in urban streams were as much as 18°F higher due to heated runoff from urban areas, higher discharge volumes due to impervious surfaces, and warmer baseline stream temperatures (EPA, 2025).

4.9.2.5 Future Conditions (E1-a)

The approved construction permits map (Section 3.6) indicates that many recent developments in Barranquitas have occurred within or adjacent to existing developed areas, while the Municipality's Land Use Plan identifies additional lands designated for future urban development, including Non-Programmed Urbanizable Land (Suelo Urbanizable No Programado, SUNP), which could contribute to the expansion of the urban footprint over time.

Only a limited portion of the municipality is currently expected to experience urban heat island conditions typically associated with concentrated urban development. However, future changes in land use could alter these conditions. The Land Use Plan identifies areas designated for future urban development, including lands classified as Non-Programmed Urbanizable Land (Suelo Urbanizable No Programado, SUNP), which may contribute to the expansion of the urban footprint over time. In addition, recently approved development permits may result in increased impervious surface coverage and reductions in vegetative cover in specific areas. Collectively, these factors could increase localized heat retention and potentially intensify urban heat island conditions in the future. Therefore, continued monitoring of development trends and more detailed urban-scale analyses are recommended to evaluate the potential effects of future growth on extreme heat exposure and vulnerability. This means that urban heat island effect will continue to be present in the municipality.

4.10 Drought

4.10.1 Description (B1-a)

Drought is described as a temporary irregularity in rainfall or natural water flow, where a prolonged lack of precipitation leads to a significant hydrological imbalance. This condition may or may not result in interruptions to regular drinking water service, crop failures, and adverse effects on wildlife and vegetation. The severity of a drought is

determined by the level of moisture deficiency, its duration, and the geographic extent of the affected area (Colón, 2009).

Drought represents one of the most complex climatological risks and one of the most severe events (DRNA, 2016). Drought is the result of a natural reduction in the expected amount of precipitation over a prolonged period, usually a season or longer. High temperatures, strong winds, and low humidity levels can exacerbate the effects of drought in areas where they are already prevalent. Likewise, drought can lead to severe wildfires (FEMA, 1997). Human actions and the demands they place on water resources can accelerate drought-related impacts. Droughts occur in different forms across the island, meaning that some regions may experience greater impact while others remain normal.

According to FEMA there are four types of droughts (FEMA, 1997):

Table 39: Types of Droughts

Meteorological Drought	A period characterized by a significant deficiency in precipitation compared to normal conditions over a specific timeframe (e.g., monthly, seasonal, yearly).
Agricultural Drought	Occurs when soil moisture becomes insufficient to support crops or livestock needs, typically following meteorological drought.
Hydrological Drought	Defined by reduced water levels in streams, rivers, reservoirs, and groundwater systems, often lagging meteorological drought.
Socioeconomic Drought	Reflects the impact on human systems and the economy, arising when water supply shortages—due to any form of drought—fail to meet societal demand for water and other resources

In 1999, the Federal Drought Monitor program was implemented, a tool that publishes data and maps on drought conditions in the United States, including Puerto Rico and Hawaii. This system integrates information from various agencies, such as NOAA, the United States Department of Agriculture (USDA), and the National Drought Mitigation Center at the University of Nebraska-Lincoln. In addition, the monitor has developed standardized indicators that allow drought categories to be classified at the national level, providing a uniform reference for risk assessment and management.

The short-term drought indicator focuses on precipitation over 1–3 months. The long-term drought indicator focuses on a period of 6–60 months. Additional indices used, especially during the growing season, include the "USDA/NASS Topsoil Moisture," the Keetch-Byram Drought Index (KBDI), and NOAA/NESDIS satellite vegetation health indices. Other indicators include groundwater levels, reservoir capacity, and pasture conditions.

In Puerto Rico, the Puerto Rico Aqueduct and Sewer Authority (PRASA), the Puerto Rico Electric Power Authority (PREPA), and the Department of Natural and Environmental Resources (DNER) are responsible for constantly monitoring the dams and reservoirs used for potable water supply. Once critical levels are reached, the first strategy adopted at the supply system level is reducing water pressure. If adequate levels are not restored, water rationing begins. This is implemented in phases lasting 12 hours and, in extreme cases, up to 48 hours. The affected area is divided into sectors, and the different rationing phases of a given duration are initially implemented locally, usually in municipalities with the highest consumption. In extreme circumstances, several municipalities and entire regions may be affected.

4.10.1.1 Affected Area (B1-b)

Barranquitas administrative boundary is uniquely influenced by its topography, as it largely coincides with the natural limits of the watersheds formed by the surrounding mountainous terrain. The municipality's steep ridges and enclosed valleys define drainage patterns in such a way that most surface water flow originates and remains within its own territory, rather than receiving significant inflows from external watersheds. While this configuration helps contain runoff during rainfall events, it also creates heightened vulnerability during periods of drought. Because Barranquitas depend primarily on the precipitation that falls within its boundaries, prolonged dry conditions can significantly reduce water availability, with limited opportunity to offset shortages through inflows from neighboring regions. This makes localized droughts particularly critical, as water supply becomes directly tied to internal climatic conditions and the capacity of local watersheds to sustain demand.

4.10.1.2 Risk Magnitude (B1-c)

Drought is a slow-onset hazard, but over time, it can have highly detrimental effects on crops, municipal water supplies, recreational uses, and wildlife. If drought conditions persist for several years, the direct and indirect economic impact can be significant. Drought can also potentially provide favorable conditions for another hazard to occur, wildfire.

The National Drought Monitoring Center uses the following categories to describe the magnitude of drought conditions (US Drought Monitor, 2025).

Table 40: US Drought Monitor Categories

Category	Description	Typical Impacts
None	Normal/Wet Conditions	No drought impacts
D0 - Abnormally Dry	Early signs of dryness may slow planting, affect surface water	Short-term dryness; minor stress
D1 - Moderate Drought	Noticeable soil moisture depletion; low water; voluntary restrictions	Crop stress; reduced streamflow
D2 - Severe Drought	Common water shortages; likely crop/pasture losses	Mandatory restrictions possible
D3 - Extreme Drought	Major crop/pasture losses; widespread restrictions	Fire bans; severe water stress
D4 - Exceptional Drought	Exceptional and widespread losses; water emergencies	Emergency measures; critical impacts

4.10.1.3 Past Events (B1-d)

Puerto Rico has a humid tropical climate characterized by two well-defined seasons: a rainy season, which extends from May to November, and a dry season, which runs from December to April. The eastern and western interior regions record the highest annual rainfall, while the northern zone receives significantly more rain than the south. USGS identified that major drought conditions have occur in 1967 – 1969, 1974, 1994, 1997, 2001-2002 and 2013 -2016 (USGS, 2014), (DNER, 2016). According to historical

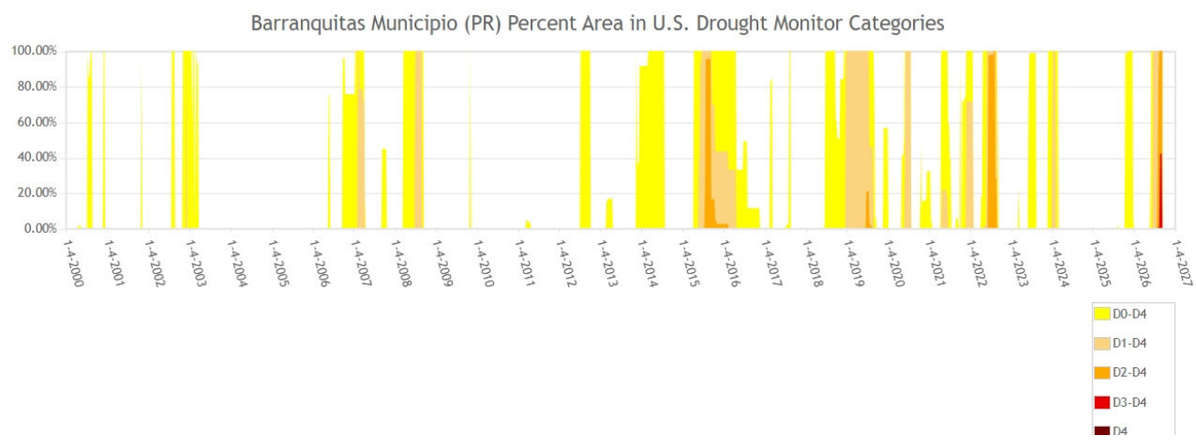
records the federal government has activated its resources to deal with drought conditions;

- Puerto Rico Extreme Drought Conditions (DR-170-PR) – Date of Declaration May 26, 1964.
- Puerto Rico Impact of Drought (EM-3002-PR) - Date of Declaration August 29, 1974.

During the rainy season, precipitation mainly comes from local convection processes, orographic effects, tropical waves, and cyclones. In contrast, rainfall during the dry season is mostly associated with the influence of cold fronts and troughs (CEACC, 2024).

Figure 21 shows shows the percentage of Barranquitas classified within U.S. Drought Monitor categories from 2000 through 2026.

Figure 21: Barranquitas Municipio Percent Area in U.S. Drought Monitor Categories



Source US Drought Monitor

From the graph we may appreciate that drought conditions are intermittent throughout the period, with several years showing portions of the municipality affected by drought categories ranging from D0-D4. The highest percentages of drought coverage are visible during portions of 2000–2003, 2006–2008, 2014–2016, 2019–2020, and 2022–2023, when drought conditions affected large portions or nearly all the municipality. More severe drought categories (D2-D4 and D3-D4) appear in limited periods, particularly during 2015–2016, 2019–2020, 2022–2023, and 2026.

4.10.1.4 Future Event Probabilities (B1-e)

USGS reports that in Puerto Rico, drought has an occurrence of 15 of 18 years (USGS, 2016), (USGS, 2014). Recent scientific data shows that the Caribbean region faces increased vulnerability to drought hazards. (USGCRP, 2018). The probability of drought occurrence is difficult to forecast or foresee in a long-term perspective. Though as figure 22 shows, moderate droughts periods have become more prevalent since 2018.

4.10.2 Risk Analysis (B2-a, B2-b)

If drought results in potable water rationing, the municipality could experience economic losses to the extent that services are immediately affected by the partial or total closure of schools, businesses, industrial areas, and public and private offices.

The potential economic impact of a prolonged drought would arise from the need to mobilize the municipality to meet the basic needs of its population during the emergency period. This cost is associated with mobilizing resources such as personnel and equipment for the distribution of water to communities and municipal facilities. However, the municipality has not been able to quantify the economic impact of this expense, nor the impact on agriculture, due to a lack of information. Since drought is a hazard that does not directly affect structures, no dollar estimate of structural losses is generated.

Among other effects, it results in increased food prices, loss of agricultural production, impacts on the industrial, commercial, and service sectors, losses in hydroelectric energy, and losses in the tourism industry, whether domestic tourism or foreign visitors.

4.10.2.1 Estimated Losses

Documenting the fiscal impact of a drought is a complex process due to the wide range of ways this climate event affects society (DNER, 2015). For example, during the 2015 drought (see Figure 22) a potable water rationing plan was implemented for the San Juan Metropolitan Area (SJMA) of which is Barranquitas is a part of.

Another way to document the losses caused by drought period is by looking at the impact on the agricultural sector. The PR Department of Agriculture reported that the 2015 drought had a net cost of $14,000,000.00 impact on the agricultural sector.

4.10.2.2 Lifelines and Critical Infrastructure

Drought can severely strain critical infrastructure by reducing water availability for municipal systems, forcing rationing and service interruptions. Prolonged water shortages can disrupt operations in schools, hospitals, and businesses, leading to economic losses and reduced public services. Energy infrastructure is also affected, as hydroelectric power generation declines when reservoir levels drop, increasing reliance on costly alternatives. Transportation systems may suffer indirect impacts, such as road damage from soil shrinkage and increased wildfire risk near highways. Communication and emergency services face challenges when water scarcity limits cooling systems and firefighting capabilities. Overall, drought creates cascading effects across infrastructure networks, amplifying vulnerabilities and requiring coordinated mitigation strategies.

As mentioned above, if a drought occurs that results in potable water rationing, the municipality will suffer economic losses to the extent that the normal functioning of government operations is immediately affected by the partial or total closure of schools, businesses, industrial areas, and public and private offices. This has a direct effect mainly on the normal operations of assets, since the services they provide are negatively impacted by rationing or lack of water services. As drought events increase, their impact on these operations becomes greater. However, drought does not have a direct effect on the municipality's critical facilities and assets.

4.10.2.3 Social Vulnerabilities

As mentioned in Section 3.4.2 the estimated vulnerable population of Barranquitas is 41.16%. If the pattern that began in 2019 continues, the vulnerable population of

Barranquitas will continue to face major challenges regarding access to potable water. Communities will experience a decrease in water availability, which is essential for industrial and agricultural production, as well as for personal use by residents. It can also affect public health. This results in a reduction in quality of life, mental and physical stress, and social discomfort, with potential risks of malnutrition, dehydration, and disease. Since the effects of a drought period can have effects on the whole population (even drought periods that do not directly affect the municipality's territory, it is recommendable for the municipal administration to consider the whole population of Barranquitas as exposed to this hazard.

4.10.2.4 Natural and Cultural Resources

When a region experiences prolonged and cumulative periods of little or no rainfall, a drought begins. This natural hazard has adverse effects on biodiversity and water supplies. For instance, a precipitation deficit reduces water levels in surface water bodies, including rivers, streams, and reservoirs, affecting local ecosystems and associated flora and fauna. Damage to vegetation directly affects animal habitats, creating an imbalance in food availability for wildlife. Agriculture in the area is also severely affected due to the lack of water.

When rainfall is significantly below normal levels, it causes severe hydrological imbalances that negatively affect land productivity systems. Similarly, crop growth and harvests decline, along with the availability and quality of drinking water. Drought can also lead to ecosystem degradation, loss of biodiversity and species, wind erosion, and increased wildfire risk.

4.10.2.5 Future Conditions

In the long term, the challenges posed by droughts might grow due to changes in rainfall patterns. This means that when droughts occur, they could be more intense, last longer, and cover larger geographic areas than those experienced in the past, thereby increasing population vulnerability.

Overall, population trends in the Municipality of Barranquitas show a decline in neighborhood-level population patterns. However, it is estimated that the municipal population aged 65 and older grew (see Section 3.4). This increase in the elderly population, a sector that is particularly vulnerable, requires special attention when addressing drought risk.

As future structures are developed, it is critical to note that approving projects near sinkholes or those using septic systems increases the potential for contamination. In drought conditions, this greatly limits the use of groundwater. Another factor reducing groundwater availability as an alternative source during drought is soil surface impermeabilization and the obstruction or filling of sinkhole openings. These actions often increase surface runoff and reduce natural aquifer recharge.

4.11 Wildfire (E1-a)

4.11.1 Description (B1-a)

Wildfires are uncontrolled fires that spread through vegetative fuel, threatening and potentially consuming structures, while also impacting human health and

ecosystems. These fires often start unnoticed and spread rapidly. They are typically characterized by dense smoke covering surrounding areas. Wildfires can occur under various weather conditions at any time of the year, but the highest activity happens when fine fuels are dormant and at their driest due to low precipitation.

In 2021, the Puerto Rico Department for Natural and Environmental Resources published its Forest Action Plan (DNER, 2021). In this document, the agency argues Wildfire management is a pressing issue at both local and global levels due to the complex interactions among human activity, fire dynamics, and natural landscapes. While research has established that fire influences ecosystem structure and function, its effects on ecosystem services remain uncertain because of interrelated factors such as land cover changes, invasive species, and extreme climate (Gould, 2008).

A clear understanding of the ecological and social impacts of wildfire in Puerto Rico's natural ecosystems is essential for guiding effective conservation and management strategies. Prevention efforts must extend to private forest owners and the public, as most fires on the island are human caused (Gould, 2008). Historically, fire monitoring and research in the region have received limited attention. Currently, fires occur predominantly in dry forest zones, where the risk is highest. However, extreme climate, prolonged droughts, and human-induced landscape fragmentation could expand fire-prone conditions into moist and wet tropical forests, as well as into areas traditionally unaffected by fire (Gould, 2008).

Most fires are found in dry forest areas. However, increasing temperatures, more frequent droughts, and the spread of invasive species are making forests more susceptible to wildfires. This shift is already evident throughout Puerto Rico, where fires are becoming more frequent and occurring in areas with no prior history of such events (Robbins, Eckelmann, & Quiñones, 2009). Extreme climate, prolonged droughts, and landscape fragmentation caused by human actions have expanded fire-prone areas, including humid tropical forests and non-forested regions that traditionally faced little fire risk (DNER, 2021).

Increasing temperatures, more frequent droughts, and the spread of invasive species are making forests more susceptible to wildfires. This shift is already evident in Puerto Rico, where fires are becoming more frequent and occurring in areas with no prior history of such events (Robbins, Eckelmann, & Quiñones, 2009).

4.11.1.1 Risk Magnitude

The United States Forest Service main classification for fire types (USFS, n.d.) are;

- **Ground Fire** - Fire that burnt in the organic material below the litter layer, mostly by smoldering combustion. Fires in duff, peat, dead moss and lichens, and punky wood are typically ground fire. This type of fire affects low vegetation (grasslands, shrubs, and tree bases). Depending on environmental factors (vegetation composition and density, slope orientation and steepness, wind speed, among others), these fires can vary in intensity but generally release less thermal energy than fires that spread through tree canopies.

- **Crown Fires** – Fire that burnt in the crowns of trees and shrubs. This type of fire is usually ignited by a surface fire. Crown fires are common in coniferous forests and chaparral-type shrublands In Crown Fires, Fire climbs through lower

branches until reaching the tree canopy. However, its spread remains primarily surface-based, often because trees are sparse and their canopies are too far apart.

- Surface Fire - Fire that burnt in litter and other live and dead fuels at or near the surface of the ground, mostly by flaming combustion.

While FEMA follows a four-classification typology (FEMA, 1997):

- **Wildfires** – Fueled almost exclusively by natural vegetation. They typically occur in forests and national parks, where federal agencies are responsible for fire management and suppression.

- **Interface or Intermixed Fires** – Fires that occur in urban and/or wildland areas where vegetation and integrated surroundings provide the fuel.

- **Firestorms** – Events of such extreme intensity that effective suppression is virtually impossible. Firestorms occur under severe weather conditions and generally burn until conditions change, or available fuel is exhausted.

- **Intentional and Prescribed Burns** – Fires caused by human intervention and natural fires intentionally allowed to burn vegetation for management purposes.

Another typology is the distinction between wildfires and wildland-urban interface (WUI) fires. Wildfires occur in areas with minimal development, except for infrastructure such as roads or power lines. WUI fires, on the other hand, involve situations when fire spreads into areas with structures or other human developments. In WUI fires, flames feed on both vegetation and structural elements of urban areas. The US Fire Administration defines WUI as the zone or area where human structures and developments meet or intermingle with wildland vegetation and fuels (US Fire Administation, 2025).

Wildfires tend to be associated with template climate areas, like California or Canada. However, the recent experience in the State of Hawai'i showed that rapid and deadly wildfire can occur even in tropical humid locations. The catastrophic Lahaina Fire of August 2023 sent swift, devastating flames through densely built neighborhoods, revealing severe vulnerabilities in early warning systems, evacuation planning, and community preparedness. Fueled by dry vegetation, strong winds, and record-setting drought conditions, the blaze rapidly ignited structures and overwhelmed emergency response efforts. Independent investigation by the Fire Safety Research Institute highlights that inadequate infrastructure resilience, insufficient communication networks, and a lack of coordinated interagency planning significantly amplified the disaster's impact.

As Puerto Rico faces similar wildfire threats, especially in southern coastal plains, this tragedy underscores the need to strengthen detection systems, bolster community evacuation routes, and elevate public education about fire safety. Building codes that emphasize fire-resistant materials and defensible space strategies around homes and critical facilities can reduce structural losses under extreme wildfire conditions.

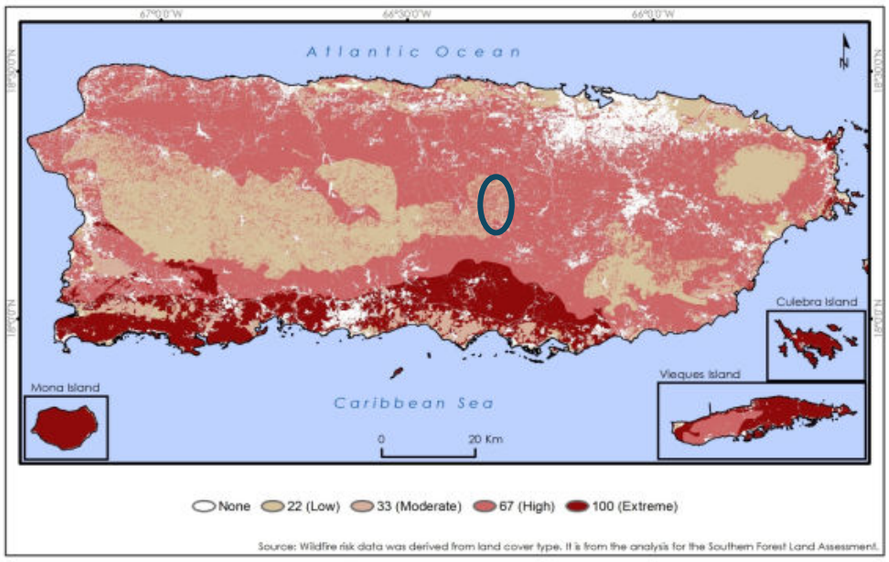
The importance of integrated land management also emerges, encouraging Puerto

Rico to limit development in WUI zones and maintain vegetation buffers. The Lahaina lessons highlight that rapid, well-coordinated suppression and resilient communications systems are vital to curbing wildfire escalation. Investing in cross-agency collaboration and emergency training at the local level will help Puerto Rican municipalities respond more effectively. Ultimately, Lahaina serves as a stark wake-up call, emphasizing that proactive planning, robust infrastructure, and community resilience are essential to preventing a similar wildfire catastrophe in Puerto Rico.

4.11.1.2 Affected Area (B1-b)

Figure 22 (DNER, 2021) provides an overview of areas in Puerto Rico, Vieques, and Culebra under varying levels of wildfire incidence, as defined by Southern Federal Land Assessment (SFLA). This information provides the state of knowledge of what is known as fire-prone landscapes. The combination of human presence, dry fuels, and climatic conditions accounts for the high number of fires in the southern coastal plain.

Figure 22: Overview of areas of Puerto Rico, Vieques and Culebra under different levels of wildlife incidence accounting to SFLA



The map indicates that Barranquitas is located within an area classified as high wildfire susceptibility (67). The municipality is situated within a broad band of high susceptibility that extends across much of the interior of Puerto Rico. Areas of extreme susceptibility (100) are mapped primarily to the south of Barranquitas, while areas of moderate (33) and low (22) susceptibility occur in other portions of the island.

4.11.1.3 Past Events (B1-d)

Citing data from the Puerto Rico Firefighters Bureau (PRFB), The Puerto Rico Forest Action Plan states that a total of 7,099 wildland fires were reported across Puerto Rico between 2018 and 2020. The highest number of incidents occurred in 2020, with 5,077 recorded fires. The regions most affected were Ponce, Guayama, and Mayagüez (DNER, 2021).

Within the Department of Natural and Environmental Resources (DNER) Protected Natural Areas, fire incidence increased in 2019 compared to 2018. Notable affected sites included Guánica State Forest, Boquerón Wildlife Refuge, Punta Cuchara Natural

Reserve, Caño Tiburones Natural Reserve, and Tortuguero Lagoon Natural Reserve. Most of these fires were linked to human activities, such as unattended campfires, discarded cigarettes, intentional burning, improper waste burning, and poorly managed prescribed burns in pasturelands (DNER, 2021).

The high frequency of wildfires in Puerto Rico highlights the urgent need for targeted education and public outreach efforts to raise awareness. When combined with active land management and a landscape-scale conservation approach, these initiatives can help reduce the occurrence of fires and mitigate additional pressures on forest ecosystems.

Based on the information available from the Puerto Rico Fire Bureau, wildfire incidents were reported during 2024. Because the records may not represent a complete accounting of all wildfire occurrences, the following table summarizes the incidents for which information was available at the time of this Plan update.

Table 41: Registered Wildfires

Case Number	Discovery Date	Containment Date	Incident Coordinates
PR012024-612	2024-01-20 13:28:52.225000	2024-01-20 15:03:27.925000	-66.34693, 18.2197
BPR011824-438	2024-01-18 11:14:14.840000	2024-01-18 11:34:13.860000	-66.3106, 18.2043
PR022024-593	2024-02-20 13:02:03.253000	2024-02-20 14:00:16.091000	-66.31846, 18.2298
BPR061224-824	2024-06-12 15:09:14.735000	2024-06-12 15:39:20.395000	0, 0
PR062724-801	2024-06-27 15:27:25.600000	2024-06-27 16:06:44.842000	-66.28458, 18.2115
BPR101524-327	2024-10-15 09:11:07.401000	2024-10-15 09:41:55.565000	-66.3106, 18.2043
PR101724-491	2024-10-17 11:17:41.679000	2024-10-17 11:43:44.218000	-66.31996, 18.2272

Source: Puerto Rico Fire Bureau

4.11.1.4 Future Event Probability (B1-e)

Long-term trends in rain patterns, such as those caused by fluctuations in the El Niño–Southern Oscillation (ENSO), may lead to extended dry periods (CCOF, 2026), reduced soil moisture, and increased vegetation stress. When combined with rising temperatures, these conditions accelerate evapotranspiration and further dry out fuels, significantly increasing the likelihood of ignition and fire spread. As a result, areas that have not historically been prone to wildfires may become increasingly susceptible under these changing climate conditions.

4.11.2 Risk Analysis (B2-a, B2-b)

4.11.2.1 Estimated Losses

Wildfires are caused by both natural factors, such as certain plant species, and intentional actions, where humans deliberately use fire. These variables play a critical role in determining the magnitude of a wildfire event. Potential losses increase based on population density, the number of structures, and ecosystems located within the

affected area. The extent and severity of wildfire largely depend on climate conditions and human activity.

Currently insufficient data to estimate monetary losses from building damage caused by this hazard. Likewise, at the time of updating this Plan, the municipality did not have an official damage estimate. The municipality will take a proactive approach and include this information in the next Plan update, if available.

4.11.2.2 Lifelines and Critical Infrastructure

Wildfires pose a significant threat to critical infrastructure, creating cascading impacts across power systems, communications, water supply, transportation, and the built environment. The electric grid is particularly vulnerable. Research from Sandia National Laboratories (Sandia National Laboratories, n.d.) and other institutions shows that wildfire can both damage grid components and be ignited by them, as seen in the 2018 Camp Fire, which caused $9.3 billion in damages. To address this, the U.S. Department of Energy has invested $3.46 billion through its Grid Resilience and Innovation Partnerships program (DOE, 2023), funding projects that include undergrounding power lines, installing fire-resistant poles, and deploying advanced sensors.

Communications infrastructure faces similar risks. A study conducted by University of Wisconsin–Madison researchers found that although cell towers often remain physically intact during fires, service disruptions are widespread because of power outages (Anderson, Barford, & Barford, 2020).

Water systems and watersheds are also significantly affected. After a fire, vegetation loss and the development of water-repellent soils increase the likelihood of flooding and debris flow. These processes can introduce sediment, nutrients, and heavy metals into water supplies.

Transportation infrastructure experiences both direct and indirect impacts. Roads, bridges, and drainage systems are frequently damaged or weakened by post-fire flooding and debris flows. At the same time, buildings and other structures located in the wildland–urban interface face increasing risk as climate change and urban expansion continue to raise exposure to wildfire hazards.

Overall, wildfires create complex and interconnected threats to critical infrastructure. Addressing these risks requires a combination of engineering solutions, advanced modeling, policy reforms, and active community engagement. Both academic and governmental sources highlight the importance of proactive measures such as strengthening infrastructure, improving land management practices, and implementing resilience planning to reduce vulnerability and support recovery.

Wildfires in Puerto Rico occur most frequently during drought periods, particularly in the southern region of the island. These events have substantial social and economic consequences, mainly due to damage or loss of property and infrastructure. When affected areas function as economic or employment centers, fires can result in job losses and broader economic disruption. In addition, increased wildfire risk often leads to higher insurance premiums as demand for coverage rises to offset potential losses. Collectively, these impacts place significant strain on local economies and communities and contribute to broader social decline.

4.11.2.3 Social Vulnerability

Social vulnerabilities play a critical role in shaping how communities experience and recover from wildfire events. Research consistently shows that populations with higher levels of poverty, older adults, individuals with disabilities, limited English proficiency, and households without reliable transportation face greater challenges preparing for, evacuating from, and recovering after wildfires. The CDC/ATSDR Social Vulnerability Index (SVI) identifies these demographic and socioeconomic conditions as key factors that increase susceptibility to disaster impacts, including wildfires, by constraining a community's adaptive and coping capacity before, during, and after an event. National-scale studies further demonstrate that U.S. communities experiencing wildfire occurrence or exposure tend to have systematically higher levels of social vulnerability, including higher unemployment, lower educational attainment, and greater concentrations of medically or socially dependent populations (Schumann, III, et al., 2024).

Wildfires also exacerbate existing inequalities through indirect impacts such as prolonged displacement, loss of livelihoods, and health effects from smoke exposure. Peer-reviewed studies show that socially vulnerable populations experience disproportionate health burdens from wildfire smoke, including higher rates of respiratory and cardiovascular illness and increased mortality risk, due to pre-existing health conditions and limited access to medical care. FEMA and the U.S. Fire Administration emphasize that older adults, low-income households, people living in mobile homes, and individuals without access to private vehicles face heightened risk of injury or death during wildfire evacuations, underscoring the importance of incorporating social vulnerability into wildfire mitigation, evacuation planning, and recovery strategies (Dennin, Nock, Muller, Akindele, & Adams, 2025). A significant portion of Barranquitas population is considered vulnerable (41.16%), and increased wildfire risk may disproportionately impact these residents by threatening homes, limiting access to essential services, and exacerbating health risks associated with heat and smoke exposure.

4.11.2.4 Natural and Cultural Resources

The severity, scale, and consequences of wildfire can be grouped into the following categories:

- Impact on Landscape - The most visible effect after a wildfire is the loss of scenic quality caused by the destruction of vegetation cover and its regression to earlier ecological stages.

- Impact on Wildlife - Wildfires immediately affect fauna, killing animals unable to escape—such as invertebrates, small vertebrates, young animals with limited mobility, and even large herbivores and carnivores trapped by flames and fencing. Fires also lead to migration due to the loss of pastures, habitats, and endangered species.

- Impact on Soil - Wildfires alter soil structure and greatly increase its vulnerability to erosion. Organic matter is lost through combustion, destabilizing soil aggregates and causing progressive disintegration. Solid particles are then removed by rain or

wind erosion. Hydrophobic layers often form, caused by water-repellent organic substances and changes in mineral composition, preventing water infiltration and accelerating erosion. Significant losses of soil and organic matter reduce nutrient levels, lowering fertility. Heat also kills many organisms, reducing biological activity and disrupting biogeochemical cycles. However, not all effects are negative. Naturally occurring fires (now increasingly rare) can benefit forest health by mobilizing nutrients and controlling pests. Low-intensity fires help retain carbon in the soil, preventing its release as carbon dioxide.

- Alteration of the Water Cycle - Soil loss drastically changes the hydrological cycle. Reduced infiltration lowers groundwater reserves that feed aquifers essential for agriculture and urban use. Surface runoff increases, intensifying erosion and contributing to flooding after heavy rain.

- Increase in Carbon Emissions - Combustion during wildfires releases carbon dioxide (CO_2), methane (CH_4), and suspended particles. These emissions cause significant environmental damage and negatively affect people with respiratory illness (Asthma, COPD, etc.).

Wildfires can lead to numerous environmental consequences, including the destruction of vegetation cover, the death or displacement of wildlife, the loss of fertile soil, and an increase in erosion events. They can also cause significant loss of life and property, resulting in substantial economic costs associated with firefighting and recovery efforts.

The impact of wildfires on ecosystems is severe and varies depending on the magnitude and frequency of these events. They cause extensive damage to vegetation, disrupt ecosystems, and lead to the loss of wildlife in affected areas. Additionally, wildfires contribute to increased soil erosion, alterations in the hydrological cycle, and higher emissions of carbon dioxide into the atmosphere. These factors collectively accelerate environmental and soil degradation.

As for cultural resources, Wildfires pose a serious threat to cultural resources, including historic buildings, and archaeological sites. Intense heat and flames can destroy irreplaceable structures, artifacts, and archives, erasing centuries of heritage in a matter of hours. Smoke and water used in firefighting efforts can further damage delicate materials, while erosion and flooding after fires may expose or wash away archaeological remains. In addition, the loss of cultural landmarks disrupts community identity and traditions, impacting tourism and local economies. Protecting these resources requires proactive planning, fire-resistant measures, and collaboration between emergency agencies and cultural preservation experts.

Beyond physical damage, the loss of cultural landmarks disrupts can community identity and traditions, while also affecting tourism and local economies. Protecting these resources requires proactive planning, fire-resistant measures, and collaboration between emergency agencies and cultural preservation experts.

4.11.2.5 Future Conditions (E1-a)

Puerto Rico already experiences a high annual probability of wildfire-supporting conditions. According to the World Bank–supported Think Hazard! platform, Puerto Rico's wildfire hazard is classified as High, meaning there is a greater than 50%

probability in any given year of weather conditions capable of supporting a significant wildfire that could cause impacts to life or property. This assessment incorporates historical fire occurrence, climate variables, vegetation type, and drought conditions and is widely used in infrastructure and hazard mitigation planning worldwide (World Bank, n.d.).

Taken together, the best available scientific evidence indicates that Puerto Rico currently faces a probability exceeding 50% annually of wildfire-supportive weather conditions, with future probability and severity expected to increase due to rising temperatures, expanded drylands, and longer seasonal droughts. While precise ignition probability percentages cannot be reliably projected at the municipal scale, confidence is high that wildfire occurrence, fire weather days, and burned area will increase by mid-century, particularly in southern, western, and interior regions of the island (World Bank, n.d.).

4.12 Pandemic/Epidemic

4.12.1 Description (B1-a)

An epidemic occurs when the incidence of a disease or health-related event rises suddenly and significantly above what is expected in a specific community or region. According to the CDC, an epidemic represents a sudden increase in cases over the normal baseline in a population, and outbreaks—often used interchangeably—refer to such events in more limited geographic areas (CDC, 2012).

A pandemic is essentially an epidemic that has expanded to span multiple countries or continents, affecting a large portion of the global population. The CDC describes it as an epidemic with broad geographic spread, while the World Health Organization defines it as the worldwide transmission of a new disease to which people generally have little or no immunity (CDC, 2012).

These terms emphasize both the magnitude of cases and their geographical distribution: an epidemic is localized, but a pandemic reaches across international borders and impacts global public health systems. Emergency responses must therefore be scaled from regional interventions during epidemics to coordinate global action in pandemics.

4.12.1.1 Affected Area (B1-b)

This LHMP considers that all areas of the municipality are equally vulnerable to the Epidemic/Pandemic Hazard.

4.12.1.2 Risk Magnitude (B1-c)

Though all can cause loss of life and economic disruption it is important to clarify terms:

- Epidemic refers to a sudden increase in the number of disease cases beyond what is normally expected within a specific population and geographic area.
- Outbreak shares the same definition as epidemic but is typically used for a more localized area.
- Cluster describes a grouping of cases in a particular place and time that appears to exceed the expected number, even if that expected number is unknown.

- Pandemic refers to an epidemic that has spread across multiple countries or continents, usually affecting a large population (CDC, 2012).

4.12.1.3 Past Events (B1-D)

The following table listing epidemics and pandemics in Puerto Rico has been collected from various sources. This list does not intend to be exhaustive:

Table 42: Pandemics and Epidemic in Puerto Rico 1855 – 2020

Disease	Date	Clasification	Description
Cholera Epidemic	1855 - 1856	Epidemic	Between 1855 and 1856, Puerto Rico suffered a major cholera outbreak that claimed over 25,820 lives, representing approximately 4–10% of the island's population at the time. (Vega Lugo, 2021)
Measles and Malnutrition	1917 - 1918	Epidemic	A severe measles outbreak occurred between 1917 and 1918, resulting in nearly 9,000 cases and approximately 2,000 deaths. High infant mortality—59% of deaths within six months were in children under two—was driven by malnutrition and poor living conditions (Rigau-Pérez & Vallejo - Calzada, 2020).
Spanish Flu (A/H1N1 influenza pandemic)	1918 - 1919	Pandemic	Puerto Rico was affected by the global A/H1N1 influenza pandemic, also known as the Spanish flu. Beginning around June 1918, community spread produced as many as 1,000 cases in four days in areas like Puerta de Tierra. Misdiagnosis as dengue initially obscured the true impact (Rosario Urrutia, 2021).
Poliomyelitis	1960	Epidemic	The 1960 polio epidemic in Puerto Rico was the most severe paralytic polio outbreak in the Western Hemisphere at the time. It impacted 68 of 76 municipalities, causing 495 cases of paralysis, predominantly among school-age children (Timothee, Morris, Filiberti, & Mainardi, 1963).
Dengue	2013, 2024	Outbreak	Dengue is endemic in Puerto Rico, with significant outbreaks occurring in 2013 and again in 2024. The 2024 outbreak triggered a public health emergency, with 6,291 confirmed cases, a 4.2% rate of severe dengue, and 11 deaths reported (Rodríguez, et al., 2024) (Ware-Gilmore, et al., 2025)

Disease	Date	Clasification	Description
Chikungunya	2014	Epidemic	The first locally acquired chikungunya case in Puerto Rico was confirmed on May 5, 2014, triggering expanded surveillance efforts using Puerto Rico's dengue infrastructure. Between May 5 and August 12 of that year, 10,201 suspected cases (approximately 282 per 100,000 residents) were reported, of which 1,975 (68%) were laboratory-confirmed. During this period, four deaths were also recorded. (Sharp, et al., 2014)
Zika	2015 - 2016	Epidemic	The first locally transmitted Zika case in Puerto Rico was reported in December 2015. By April 2016, over 6,000 suspected cases had been evaluated, with 683 confirmed cases. Pregnant women and related neurological issues (e.g., Guillain-Barré syndrome) were of particular concern. (Thomas, et al., 2016) (Dirlikov, et al., 2016)
COVID - 19	2020 - 2022	Pandemic	See narrative below

COVID-19 Pandemic

Puerto Rico confirmed its first COVID-19 case—a European tourist—on March 8, 2020, leading the governor to declare an emergency on March 12 and implement early measures including airport screening and mandatory isolation, as outlined in the Puerto Rico Department of Health's epidemic situation reports (PRDH, 2022), (COR3, n.d.). By April 6, 2022, official data reported 270,485 confirmed cases and 4,171 deaths due to COVID-19 in Puerto Rico, according to detailed government spreadsheets and dashboards maintained by the Puerto Rico Health Department (PRDH, 2022), (COR3, n.d.).

The territory experienced significant economic and social disruptions: a Bayesian analysis revealed a clear causal relationship between rising COVID-19 infections and increased unemployment, and engineering studies from the University of Puerto Rico–Mayagüez estimated that unemployment soared above 17%, also noting elevated operating costs for businesses due to PPE and safety measures (Hernández - Padilla & Méndez-Piñero, 2020).

Subsequent public health research revealed widespread mental health consequences: one study found that 31% of healthcare workers scored in the range of depressive symptomatology following combined stress from prior disasters (e.g., hurricanes) and the pandemic; another identified high levels of anxiety (26.9%) and stress (69.9%) among physicians during the second COVID-19 wave (Hernández - Torres, et al., 2023), (Sánchez - Plazas, García - De Jesús, Martínez - González, Amaya - Ardila, & Almodóvar - Rivera, 2024).

4.12.1.4 Future Events Probability (B1-e)

Puerto Rico's susceptibility to future pandemics or epidemics is underscored by its subtropical climate, population distribution, and healthcare infrastructure. A university-developed emergency preparedness model—commissioned by Puerto Rico's Department of Health—simulated influenza pandemics and demonstrated how variations in disease transmissibility, healthcare capacity, and mitigation efforts can significantly influence outbreak trajectories and the likelihood of healthcare system overload. Furthermore, the U.S. Department of Health and Human Services' Hospital Preparedness Program (HPP) in Puerto Rico operates under the Assistant Secretary for Preparedness and Response, with coordinated health care coalitions and special pathogen systems explicitly designed to reduce pandemic risk by strengthening surge capacity and infection-control readiness. These combined efforts reflect a data-driven recognition that, without sustained investment in public health infrastructure and preparedness modeling, Puerto Rico remains at an elevated probability for experiencing another epidemic or pandemic (Hirsh & Centeno - Marín, 2015), (ASPR, n.d.).

4.12.2 Risk Analysis (B2-a, B2-b)

4.12.2.1 Estimated Losses

The COVID-19 pandemic resulted in significant mortality across Puerto Rico, underscoring the importance of public health hazards in local mitigation planning. Official data from the Puerto Rico Department of Health indicate that COVID-19 mortality is tracked through an epidemiological surveillance system that compiles death certificate data and case investigations and is made publicly available through government data portals. At the territorial level, thousands of deaths have been attributed to COVID-19 since 2020, as reported in official datasets and federal summaries. However, cumulative mortality totals for individual municipalities, including Barranquitas, revision are not consistently published as single static figures in official reports. Instead, municipality-level death counts must be obtained by querying downloadable datasets provided by the Puerto Rico Department of Health, which allow users to filter results by municipality.

These datasets are considered provisional and subject to due to reporting delays and ongoing validation of death records, as acknowledged by public health authorities. Consequently, while Barranquitas -specific COVID-19 mortality was not recorded as fixed published figure. Based on the currently available data, the total number of COVID-19-related deaths in the municipality cannot be reliably determined.

4.12.2.2 Lifelines and Critical Infrastructure

The most affected lifeline in the case of a pandemic or epidemic is the healthcare and medicine lifeline. This is so because in response to a pandemic/epidemic hospitals, clinics and other healthcare facilities can be overwhelmed by the high demand of services. There are shortages of PPE, medical devices (ventilators in the case of COVID-19) and medical staff. Since the pandemic/epidemic is the priority there will be delays in non-related medical care. Finally, there can be serious challenges in the management of mortality services.

However other lifelines can be affected such as the Food, Hydration and Shelter Lifeline, due to increase food insecurity from unemployment and economic shutdowns ort closed or reduced shelters due to infection control requirements. The Safety and Security Lifelines can be affected by high absenteeism due to illness, quarantine or caregiving responsibilities and increase levels of stress and burnout among first responders and law enforcement officers.

Other lifelines and critical infrastructures can be affected by increased demand, like increased residential water demand) or the lack of trained personnel to maintain existing operations.

4.12.2.3 Social Vulnerability

For this hazard, the whole population of Barranquitas is considered equally vulnerable. Nonetheless, besides factors of age and poverty, the 2024 ACS shows that a total of 751 people in Barranquitas did not have health insurance coverage (US Census Bureau, 2025). This means that 2.6% of the total population of Barranquitas is uninsured.

Of those most of the uninsured group belonged to the 26-to-34-year cohort (229 persons) followed by the cohort of 55 to 64 years (170 persons). The results given by the ACS show that the young adult comprise the age group with the largest number of uninsured residents in Barranquitas, which may increase their vulnerability during a pandemic or epidemic due to limited access to healthcare services.

Table 43 shows the breakdown of uninsured people in Barranquitas according to the 2020-2024 ACS.

Table 43: Number of People in Barranquitas without Healthcare Coverage

Age Cohort	Number of people uninsured
Under 6 years	35
6 to 18 years	94
19 to 25 years	0
26 to 34 years	229
35 to 44 years	92
45 to 54 years	109
55 to 64 years	170
65 to 74 years	11
75 years or older	11

Source: US Census 2020-2024 American Community Survey

This would be considered population at risk in case of a pandemic or epidemic. Further information regarding social vulnerability can be found in Section 3.4.4.

4.12.2.4 Natural and Cultural Resources

The scientific literature shows that the COVID-19 Pandemic was a mixed bag for the environment. On one hand the unprecedented pandemic-related lockdowns had negative effects on the physical environment. These impacts included increased pollution from the widespread use of personal protective equipment, deforestation, illegal poaching and logging, overfishing, and disruptions to conservation programs and projects. The findings also note that the spread of pandemics may be intensified by environmental pollution and rapid global population growth (Muche, Yemata, Molla, Muasya, & Tsegay, 2022), (Guo & Lee, 2021).

At the same time, despite these adverse impacts, the period of reduced human activity—often referred to as the *anthropause*—also produced several positive effects on natural resources. These included short-term reductions in indoor and outdoor air pollutants ($PM_{2.5}$, PM_{10}, NO_2, SO_2, CO, and CO_2) and decreases in noise pollution from ships, boats, vehicles, and aircraft. Collectively, these changes benefited aquatic ecosystems and water quality, influenced bird behavior, supported wildlife biodiversity, and contributed to temporary ecosystem recovery. (Muche, Yemata, Molla, Muasya, & Tsegay, 2022).

When it comes to cultural and heritage sites a report from UNESCO states that crisis has produced both negative and positive effects across different types of World Heritage properties (UNESCO, 2021). The sudden cessation of travel and tourism disrupted visitor flows and eliminated a critical source of revenue for many sites, where tourism income is essential to supporting conservation activities, routine maintenance, and staff salaries. Local communities surrounding these properties were similarly affected, with widespread loss of employment and income.

Conversely, in some cases the reduced level of human activity enabled rehabilitation and restoration efforts to proceed more efficiently, while anthropogenic pressures were temporarily reduced across many natural areas. This contrast highlights the diverse and uneven impacts of the crisis on World Heritage properties. At the same time, it presents an opportunity to build on the benefits associated with the easing of specific pressures at certain sites, while advancing targeted research and strategic recovery planning (Guo & Lee, 2021) (Guibert & Hyde, 2021), (UNESCO, 2021).

4.12.2.5 Future Conditions (E1-a)

Puerto Rico faces structural and environmental conditions that elevate its exposure and vulnerability to future pandemics relative to many mainland U.S. locations. As a tropical island with high population density in urban corridors, frequent international travel, and climatic conditions favorable to vectors and pathogens, Puerto Rico is particularly susceptible to emerging and re-emerging infectious diseases, especially those with zoonotic or vector-borne origins. The CDC and peer-reviewed research document ongoing transmission of diseases such as dengue and previous outbreaks of Zika and Chikungunya, demonstrating the island's continued exposure to pathogens with outbreak and epidemic potential. This exposure holds regardless of the development pattern of the municipality.

4.13 High Hazard Potential Dams

The Robert T. Stafford Act, as amended by the Disaster Mitigation Act of 2000 (DMA2K), established mitigation planning as the cornerstone for reducing disaster risk. Local governments with a mitigation plan that identifies natural hazards, assesses risks and vulnerabilities, and outlines strategies for implementing mitigation actions are eligible for FEMA mitigation grants. Specific requirements for these plans are detailed in the Code of Federal Regulations[13] and further supported by FEMA policies and guidance (FEMA, 2024).

The National Dam Safety Act, as amended, created the Rehabilitation of High Hazard Potential Dams (HHPD) Grant Program. Funding for HHPD projects first became available in Fiscal Year 2020 (FY20) and has increased since then. Eligibility criteria for these grants, as they relate to mitigation planning, are outlined in FEMA's Local Mitigation Planning Policy Guide (FEMA, 2024).

It is important to emphasize that a dam with HHPD status does not necessarily mean that a dam failure is imminent.

The Association of State Dam Safety Officials (ASDSO), provided the following classification of dam hazard (ASDSO, 2022):

- High Hazard Potential – "Typically defined as a dam whose failure or mis-operation will cause loss of human life and significant property destruction".
- Significant Hazard Potential – "Typically defined as a dam whose failure or mis-operation will cause significant property destruction".
- Low Hazard Potential – "Typically defined as a dam whose failure or mis-operation will cause minimal property destruction".

According to ASDSO, out of the 37 dams reported in Puerto Rico, 36 are considered HHPD.

4.13.1 Description (B1-a)

Act 133-1986 as amended defines a dam as an artificial barrier, together with its accessory works, built for the purpose of retaining, storing, or diverting water or any other liquid or semi-liquid, and whose height exceeds twenty-five (25) feet from the natural bed of the water body or the natural ground level. While a reservoir is defined as an artificial basin where the waters of a river or stream, or stormwater runoff, are collected and that exceeds a volume of fifty (50) acre-feet.[14] Dams can represent a potential hazard in cases of dam failure (breach) or mis-operation (such as unscheduled or uncontrolled releases. (FEMA, 2024).

4.13.1.1 Affected Areas (HHPD2-a)

As stated in Section 3.3.3, the Municipality of Barranquitas contains a dense network of streams and rivers distributed throughout its territory. The hydrography map identifies the Río Cañabón in the northwestern portion of the municipality, the Río Frío in the northeastern area, the Río de Barranquitas across the central region, and the Río de la Plata and Río Usabón along the eastern and southeastern portions of the municipality.

[13] 44 CFR § 201.6
[14] 22 L.P.R.A. § 401

The following tables summarize the available information from the National Inventory of Dams (NID) for dam structures associated with these watersheds and their respective subwatersheds. The following tables show the available information in the National Inventory of Dams for the dam structures that could have an impact on Barranquitas in the event of a dam breach in (USACE, 2022).

Carite Reservoir Dam

Table 44: Carite Dam NID Data

Carite Dam	
Watershed	La Plata River
Purposes	Hydroelectric, Irrigation, Recreation, Water Supply
Main Body of Water	La Plata River
Municipality	Guayama
Date of Completed Construction	1913
Dam Type	Earth
Hazard Potential Classification	High
NID ID	PR00021
Coordinates as per NID	18.0764357, -66.1062362
Height as per NID	104 ft
Storage as per NID	17,349 Acre Ft.
Emergency Action Plan	Yes
Last Recorded NID Inspection	12/15/2021
Condition Assessment	Poor
Operator	Puerto Rico Electric Power Authority (PREPA)

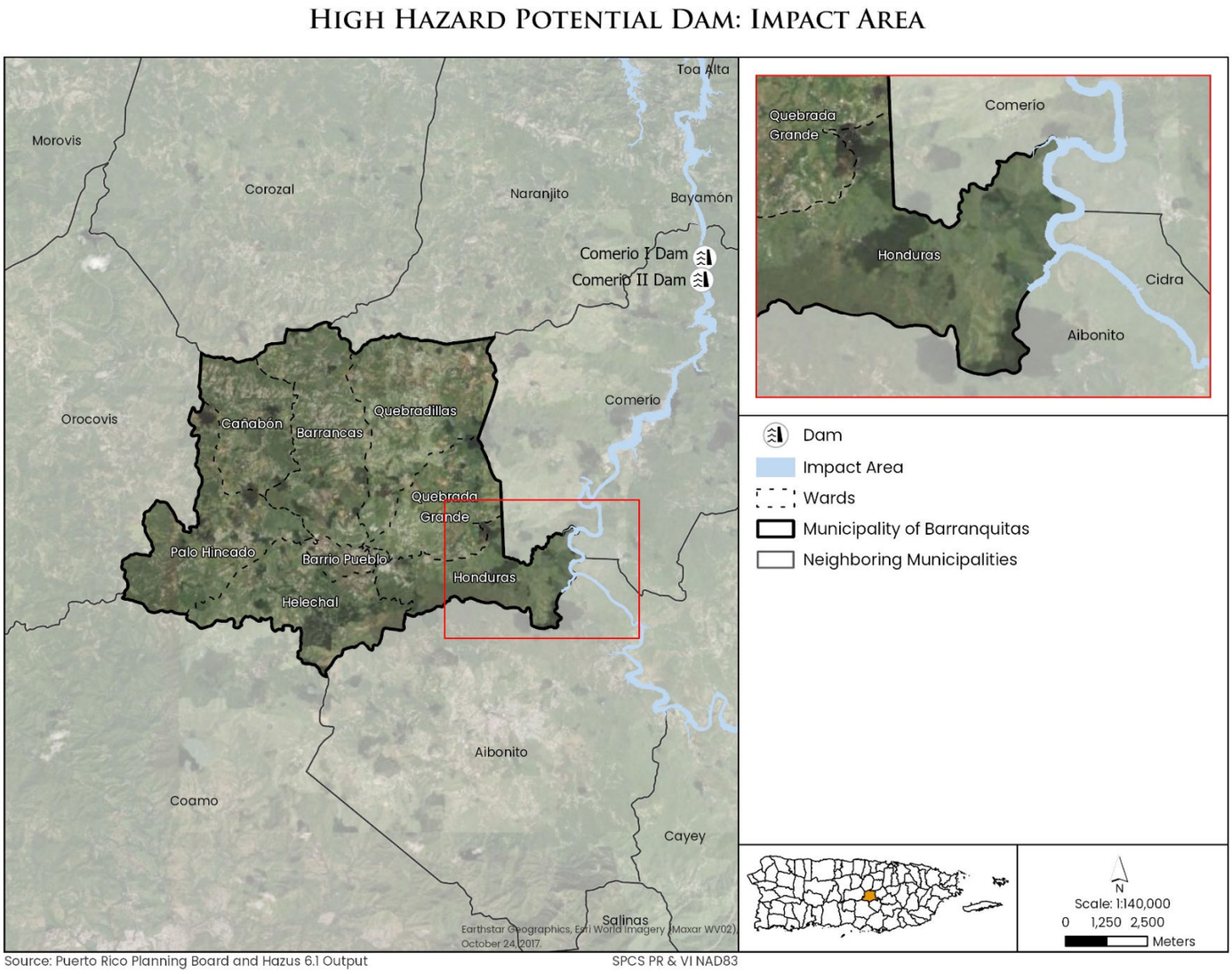
Figure 23 shows the Carite Reservoir as it appears in the latest USGS Topographic map.

Figure 23: Carite Reservoir USGS[1] Comerío 2026 Topographic Quadrangle



Map 39 shows the Sunny Day Dam Breach scenario developed for the Cidra Dam. This scenario was modeled using DSS-WISE software. The map shows that the mapped dam impact area is limited to a small portion of the eastern municipality, primarily within Honduras Ward, along the municipal boundary with Comerío, Cidra, and Aibonito. This is a mostly inhabited section of the municipality. The remainder of Barranquitas is outside the delineated impact area.

Map 39: High Hazard Potential Dam: Impact Area



4.13.1.2 Risk Magnitude (B1-B)

Multiple factors influence both the exposure to and the overall impact of dam-related risks. Each dam is unique and requires an individual assessment to understand the risks it poses and those it faces. Dams may also operate in series, where water released from an upstream dam affects the performance of a downstream dam. In such cases, modeling the dams together is recommended (AtkinsRéalis, 2024).

Risk exposure can result from hazard creep, upstream flooding, large reservoir releases, controlled or partial breaches, design or construction flaws, cascading storm impacts, seismic activity, landslides, wildfires, and deferred maintenance or rehabilitation. These risks can affect populations, infrastructure, critical facilities, economic stability, environmental and social resources, and may lead to multi-jurisdictional consequences (AtkinsRéalis, 2024).

Dam risk consists of three primary components: incremental risk, non-breach risk, and residual risk.

- Incremental risk refers to the likelihood and consequences for the reservoir area and downstream floodplain that result from the presence of the dam if it fails—whether due to overtopping, structural malfunction, or mis-operation. These

consequences go beyond what would occur without a dam breach and typically involve downstream flooding, though loss of the reservoir can also significantly impact upstream areas.

- Non-breach risk is the risk associated with normal dam operations or scenarios where the dam overtops without failing. For example, a gated dam may release water ahead of a storm to manage inflows, which could lead to downstream flooding if releases exceed channel capacity.
- Residual risk is the remaining risk after all mitigation and risk-reduction measures have been implemented. FEMA defines this as "risk remaining at any time," meaning the remote risk tied to conditions judged not to be credible dam safety issues after prudent actions have been taken (AtkinsRéalis, 2024).

Although dams are not natural hazards themselves, they can be affected by natural hazard events. Under extreme conditions, a dam may fail, causing flooding in the downstream inundation zone. Hazards such as flooding, landslides, wildfires, earthquakes, high winds, and drought can all compromise dam safety. Each hazard introduces risks that may lead to cascading impacts associated with dam incidents.

- **Flooding:** Puerto Rico's dams have historically been vulnerable to flooding. Heavy rainfall from tropical cyclones, severe thunderstorms, or stalled systems can affect multiple dams simultaneously, creating hydrologic emergencies. When several dams are impacted at once, resources are strained, and prioritizing response becomes difficult without clear information on dam conditions and potential consequences. Many dams in Puerto Rico are arranged in series, meaning releases from an upstream dam can affect downstream dams, requiring coordinated emergency actions.
- **Landslides:** Landslides can alter stream channels upstream or downstream, affecting reservoir inflows and outflows. Slides near a dam can undermine its stability, potentially leading to failure. Landslides within the reservoir can also generate overtopping waves that damage or breach the dam.
- **Wildfires:** Fires can change watershed characteristics by removing vegetation, reducing water absorption, and increasing runoff speed and volume. Post-fire conditions heighten risks of flash floods, mudslides, and debris flows, all of which can threaten dam operations and structural integrity.
- **Seismic Events:** Earthquakes can compromise dam stability and, like floods, may impact multiple dams across a wide area.
- **Wind:** Hurricanes and tornadoes can uproot trees, weaken dam structures and increase seepage or erosion risks. Combined with heavy rainfall, wind damage can significantly threaten dam safety.
- **Drought:** Extended droughts lower reservoir levels, potentially rendering water supply dams inoperable. Drought also reduces vegetation cover, increasing susceptibility to flash flooding and debris flows when rains return—like post-wildfire conditions.
- **Dam Deficiencies:** Beyond natural hazards, structural deficiencies pose serious risks. Aging dams require increased maintenance; without it, they may develop cracks, seepage, or erosion issues. Malfunctioning gates can prevent controlled releases before floods or remain open, causing low reservoir levels and downstream flooding. Mis-operation can also compromise structural integrity or trigger downstream impacts.

Failure Modes

Failure modes are plausible physical processes that can lead to dam failure due to an existing weakness or defect. These may stem from natural foundation conditions, design flaws, construction issues, material deficiencies, operational or maintenance problems, or aging, and can result in an uncontrolled release of the reservoir. For example, a crack in the dam may worsen under extreme rainfall, ultimately causing failure. While failure mode analysis is highly technical and requires detailed investigation, for hazard mitigation planning purposes, failure modes are generally grouped into three categories: static, hydrologic, and seismic.

Static failure modes include (but are not limited to):

- Internal erosion
- Slope stability issues such as sinkholes, landslides, and cracks
- Gate or equipment malfunction
- Scour or erosion

Hydrologic failure modes include (but are not limited to):

- Overtopping
- Elevated reservoir levels exceeding structural capacity
- Rapid drawdown
- Spillway failure
- Impact loads during flooding

Seismic failure modes include (but are not limited to):

- Liquefaction
- Slope failures

4.13.1.3 Past Events (B1-c)

Built in 1928, the Guajataca Dam is 984 feet long, 120 feet tall earthen dam, located in the island's northwestern region between the municipalities of San Sebastián, Camuy, Quebradillas and Isabela. On September 20, 2017, Hurricane Maria caused the failure of the spillway structure and damaged both the water supply line and the dam outlet works. On October 3, 2017, FEMA assigned USACE a Mission Stafford Act to prevent the dam's failure, which posed an immediate threat to about 1,000 residents downstream and risked cutting off water to over 250,000 people. The Stafford Act provided USACE with the authority and funding to execute these measures (USACE, 2023).

USACE addressed the situation at Guajataca Dam in three risk-based stages:

- Stage 1: Threat of Imminent Flooding
- Stage 2: Implementation of Interim Risk Reduction Measures (IRRMs)
- Stage 3: Permanent Repairs

During Stage 1, USACE performed limited emergency stabilization to prevent dam failure. However, the spillway remained at an unacceptable risk of failure during future flooding events. Consequently, six critical IRRMs were implemented in Stage 2:

- Grouting voids beneath the concrete spillway
- Installing anchors to stabilize the spillway

- Repairing outlet gates
- Reconnecting the water-supply line
- Reinforcing the spillway and channel
- Stabilizing slopes near the inlet tower

By the end of 2018, four IRRMs were completed, achieving approximately a 100-year level of flood protection. The remaining two were finalized in September 2019, increasing protection to about a 1,000-year level and further reducing public risk. The estimated cost of these works was between $900 million and $1.1 billion (USACE, 2023).

Figure 24: Social Media Post from NWS warning about the Guajataca Dam Breach[1]

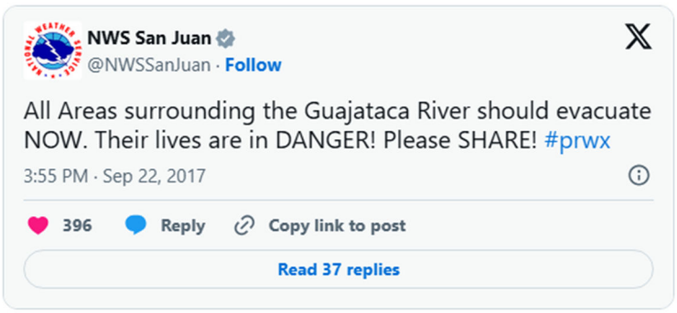


Figure 25: Guajataca Dam Breach 9/23/2017[1]



4.13.1.4 Future Event Probabilities (B1-E)

Puerto Rico faces significant risks of future dam failures due to aging infrastructure, environmental hazards, and operational challenges. The island has 36 dams, all classified as high-hazard potential, meaning that any failure could result in severe loss of life and property (National Inventory of Dams, 2022). Many of these structures are decades old and have been rated in poor or unsatisfactory condition, indicating

critical deficiencies that require immediate attention (Puerto Rico Dam Safety Program, 2022).

Climate-related threats further exacerbate these risks. Hurricanes and extreme rainfall events, such as those experienced during Hurricanes Maria (2017) and Fiona (2022), have placed immense stress on dam systems. Although no failures occurred during these storms, emergency water releases were necessary to prevent overtopping. Future projections of more intense precipitation events will increase the likelihood of flash floods, challenging spillway capacity and structural resilience (Argonne National Laboratory & FEMA, 2023; Torres-Alavez et al., 2023).

Seismic activity adds another layer of vulnerability. Puerto Rico lies in a seismically active zone with an estimated 5–10% annual probability of a magnitude 7.0 earthquake. Such events could compromise dam foundations and structural integrity (FEMA, 2022). Additionally, satellite-based studies have detected subsidence and differential settlement in some dams, signaling gradual instability that could lead to failure over time (De la Paz-Bonilla et al., 2021; Virginia Tech, 2022).

Monitoring and early-warning systems have improved since Hurricane Maria, with FEMA supporting the installation of sensors, communication upgrades, and sirens for high-risk dams. However, coverage remains incomplete, leaving gaps in real-time monitoring and emergency preparedness. Budget constraints and limited staffing further hinder consistent inspections and maintenance, increasing operational risk (FEMA, 2022; USACE, 2023).

In summary, Puerto Rico's dams face converging hazards: aging infrastructure, climate-driven flooding, seismic threats, and geotechnical instability. While modernization efforts, structural repairs, and risk management programs are underway, comprehensive upgrades and robust emergency planning are essential to safeguard communities and ensure the long-term reliability of these critical water and energy assets.

4.13.2 Risk Analysis (B2-a, B2-b)

The following section discusses an analysis of sunny day – scenario breach at the Carite Dam. The risk analysis for this hazard differs from the other hazards because it is following a different recommended format developed for Puerto Rico.

4.13.2.1 Risk Assessment Methodology and Limitations (HHPD2-a & HHPD-b)

This analysis corresponds to a sunny-day scenario executed between September 23, 2017, and September 25, 2017, to quantify the effects of possible dam breaches in Puerto Rico due to Hurricanes Irma and Maria. STARR II engineers and GIS specialists prepared these files, reports, and graphics at the request of FEMA Region. II under Contract Number HSFE60-15-D-0005, Task Order Number HSFE60-17-J-0008.

The decision support system for water infrastructure security parentheses (DSS-WISE) is a FEMA funded, web-based system for automatic dam break and levy failure flood modeling mapping and human consequence analysis to support emergency planning and infrastructure resiliency. Developed by the National Center for

Computational Hydroscience and Engineering (NCCHE) at the University of Mississippi, DS- wise provide 2-dimensional flood modeling and mapping without requiring advanced numerical modeling expertise from users. It is funded and supported by FEMA to enhance emergency preparedness hazard assessment, and risk informed decision making.

DSS-WISE models dam-break events using a scenario-based decision support framework rather than acting as a stand-alone hydraulic flood model. First, users define dam-failure scenarios (such as overtopping, structural failure, or earthquake-induced collapse) along with dam characteristics, reservoir levels, and triggering conditions. DSS-WISE then incorporates dam-break outputs from external hydraulic models (for example, flood extent, depth, velocity, and arrival time generated by specialized flood modeling software) as input datasets. These results are evaluated within DSS-WISE using risk and consequence metrics, including impacts to population, critical infrastructure, environmental resources, and economic assets. The tool applies multi-criteria decision analysis to compare dam-break scenarios, mitigation options, and emergency response strategies under uncertainty. By integrating modeling results with expert judgment and stakeholder priorities, DSS-WISE helps decision-makers understand relative risks and trade-offs associated with dam-break hazards. In essence, DSS-WISE translates technical dam-break modeling outputs into actionable planning and safety decisions.

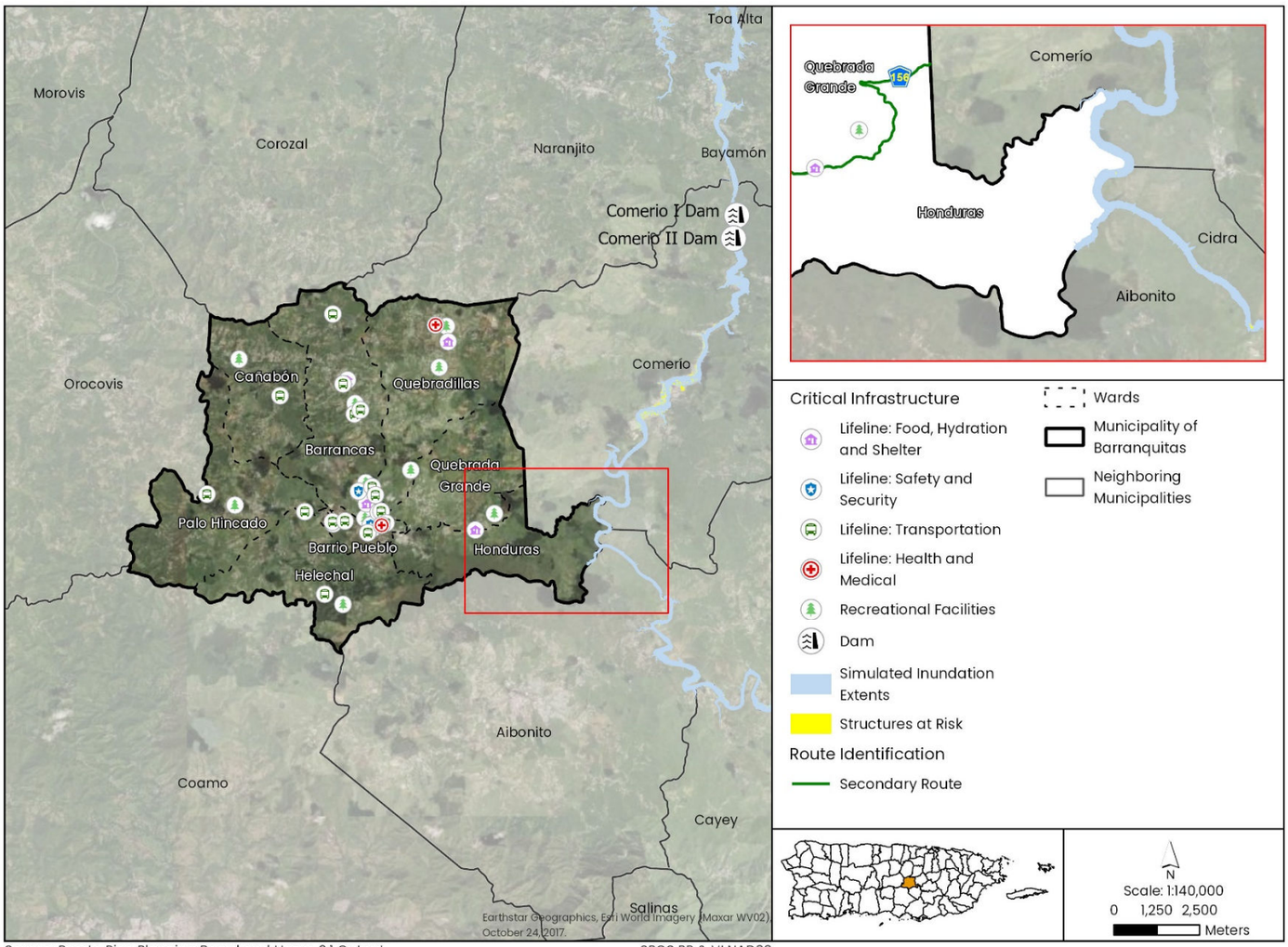
In the case of the 2017 modeling exercise, input data for the simulations was obtained from 2013 United States Geologic Survey (USGS) LIDAR for Puerto Rico, with a 10-meter cell spacing, and from the databases contained within DSS-WISE for dam sizes, bridge sizes, and terrain. There were occasional conflicts between these two sources of information. However, all were able to be successfully resolved to generate dam breach simulations. The most frequent conflict was differences in the top elevation of the dam from the LIDAR data versus the DSS-WISE reservoir elevation data. This was resolved by computing a hydrograph using the following spreadsheet from the U.S. Natural Resources Conservation Service (NRCS).

4.13.2.2 Estimated Losses (HHPD2-a)

The sunny – day scenario ran in 2026 does not include an estimation of losses. It is recommended that this be done as a future project for this municipality.

4.13.2.3 Critical Infrastructure (HHPD2-a)

Map 40: High Hazard Potential Dam: Critical Infrastructure Exposure



Source: Puerto Rico Planning Board and Hazus 6.1 Output SPCS PR & VI NAD83

According to map 40 most mapped critical infrastructure facilities are concentrated in the central portion of Barranquitas, particularly around Barrio Pueblo, with additional facilities distributed across other wards. The simulated dam inundation extent is limited to the eastern portion of the municipality within Honduras Ward, where a secondary route and a small number of structures at risk are also identified.

4.13.2.4 Social Vulnerability

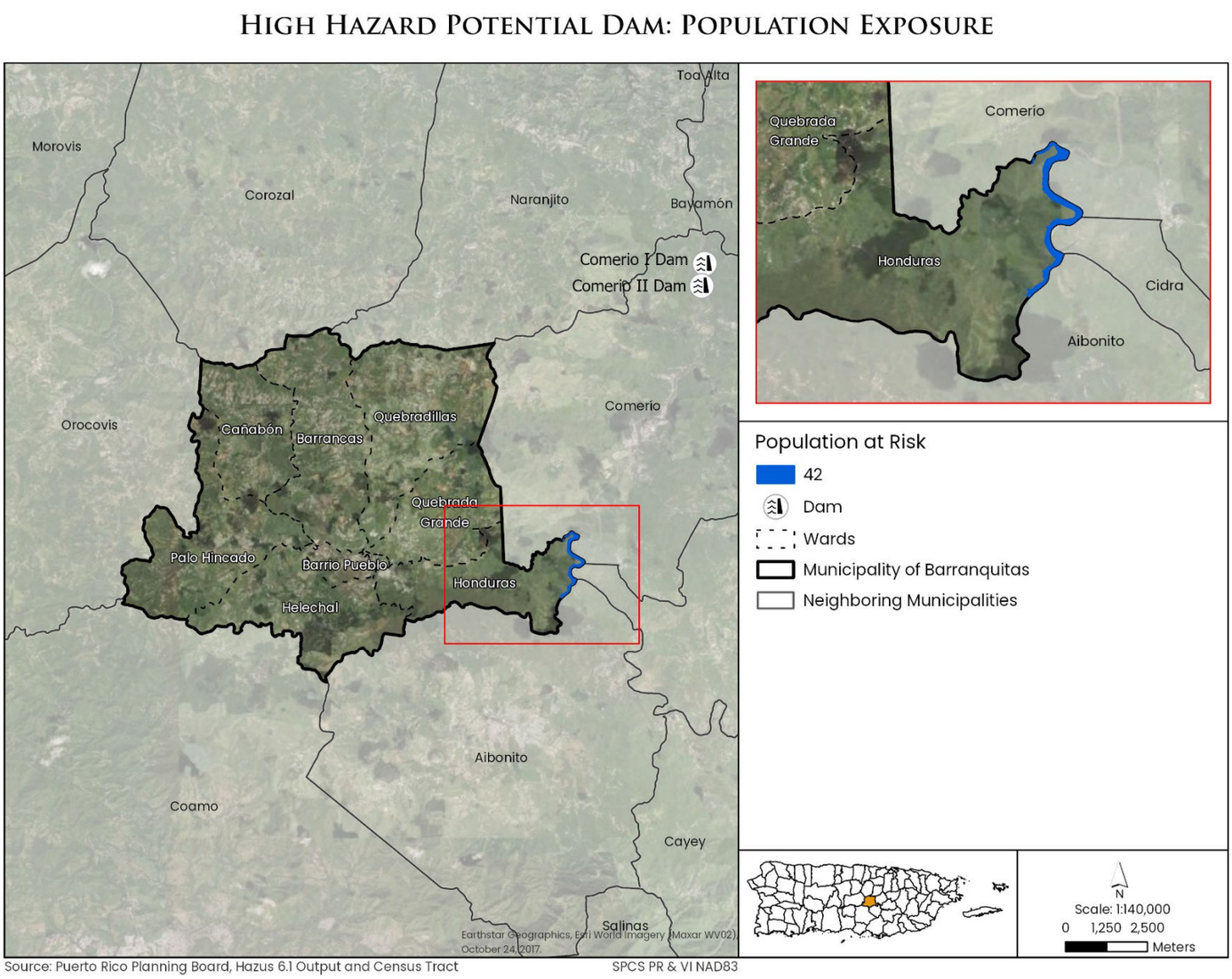
Social vulnerability strongly influences how communities experience flooding resulting from a dam breach, often determining who is most at risk of injury or loss of life. Research shows that low-income households, elderly populations, and people with disabilities are more likely to live in high-hazard areas and face greater challenges in receiving warnings and evacuating quickly (Cutter, Boruff, & Shirley, 2003). Language barriers and limited access to transportation further reduce the effectiveness of emergency communications during rapidly developing dam-break floods (Baker, Cohen, Coulson, Durden, & Rossman, n.d.). The Social Vulnerability Index (SoVI), developed by Cutter and colleagues, highlights how socioeconomic status, age, and housing conditions increase susceptibility to flood impacts (Cutter, Boruff, & Shirley, 2003). FEMA and USACE guidance emphasize that socially vulnerable populations often have less capacity to respond during the short warning times typical of

dam-failure events. As a result, dam-breach risk is not only a hydraulic issue but also a significant social and equity concern (Cutter, Emrich, Morath, & Dunning, 2013).

Following a dam-breach flood, socially vulnerable communities often experience disproportionate and prolonged recovery challenges. Studies show that low-income and rented households face greater difficulties accessing disaster assistance, replacing lost housing, and returning to normal economic activity. Disruptions to healthcare, education, and critical infrastructure tend to have lasting effects in communities that already lack robust social support systems. Academic research demonstrates that flood losses compound existing social inequalities by increasing poverty and reducing long-term resilience. USACE guidance stresses the importance of identifying and engaging socially vulnerable populations during dam safety planning to reduce inequitable outcomes. Incorporating social vulnerability into dam-breach risk assessments helps decision-makers design more effective emergency planning, mitigation, and recovery strategies (Aqilah, Karmilla, Tamanna, Ali, & Mat, 2024).

Map 41 shows a population-at-risk area associated with the dam impact zone located in the eastern portion of Barranquitas, within Honduras Ward near the municipal boundaries with Comerío, Cidra, and Aibonito. The mapped exposure area contains a population at risk of 42 people.

Map 41: High Hazard Potential Dam: Population Exposure



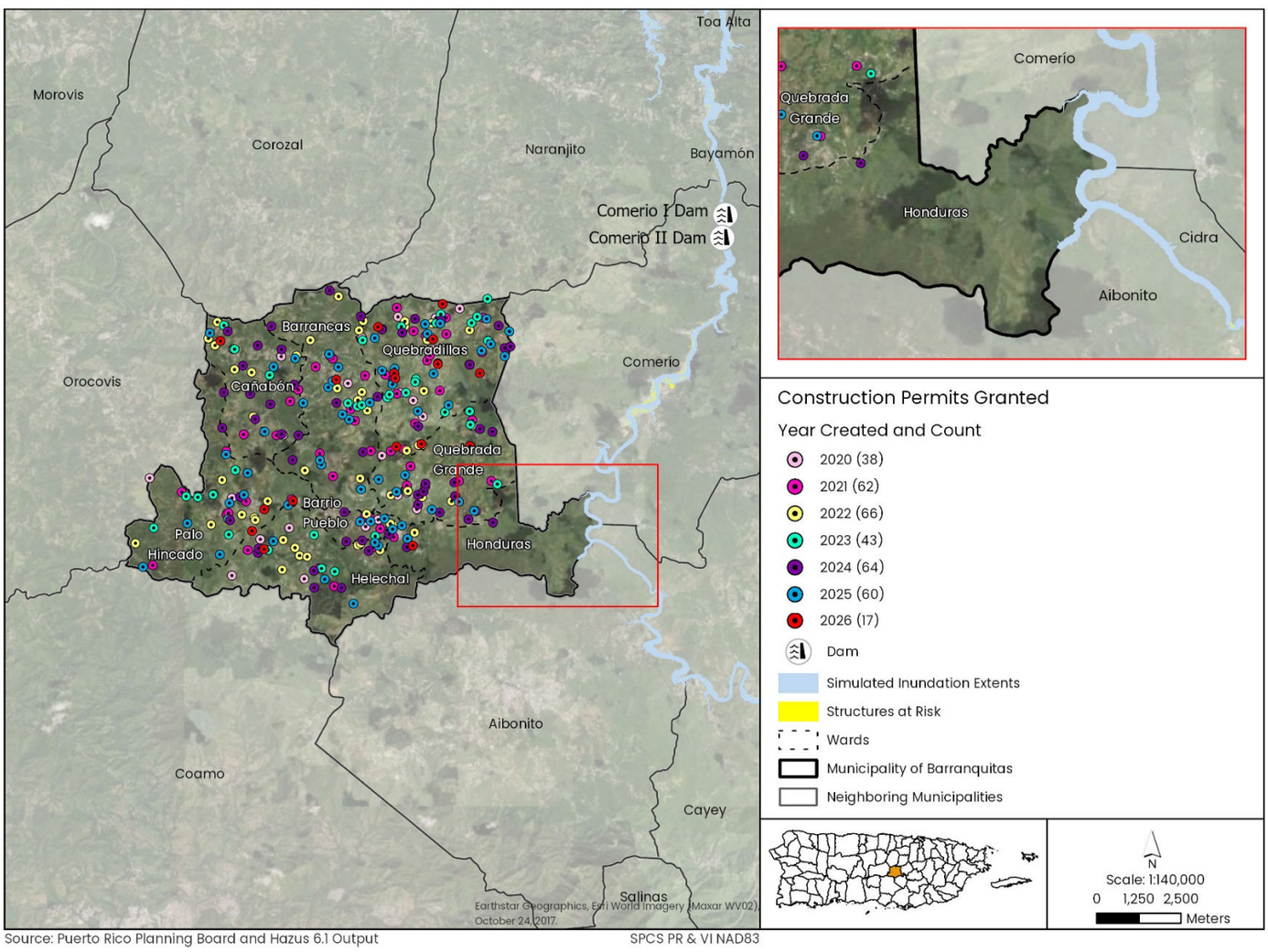
Source: Puerto Rico Planning Board, Hazus 6.1 Output and Census Tract SPCS PR & VI NAD83

4.13.2.5 Future Conditions (E1-a)

The following map shows the recent development exposure for a sunny day dam breach scenario. It shows construction permits issued between 2020 and 2026 distributed throughout Barranquitas, with concentrations visible in Barrio Pueblo, Quebradillas, Barrancas, Cañabón, Palo Hincado, Helechal, Quebrada Grande, and surrounding wards. The simulated dam inundation extent is limited to the eastern portion of Honduras Ward, where few recent development points are shown within or adjacent to the mapped impact area.

Map 42: High Hazard Potential Dam: Recent Development Exposure

High Hazard Potential Dam: Recent Development Exposure



Source: Puerto Rico Planning Board and Hazus 6.1 Output

SPCS PR & VI NAD83

4.13.2.6 Special Considerations: Coordination with Local Dam Owners and State Dam Safety Agencies (HHPD1-a & HHPD1-b)

Effective interagency coordination is widely recognized as essential for preventing, mitigating, and managing dam breaks and levee breaches, because these events involve rapid onset, cascading impacts, and shared responsibilities across jurisdictions. Federal guidance emphasizes that dam and levee risks cannot be managed by a single entity and instead require collaboration among dam owners, state dam safety offices, emergency management agencies, hydrologic forecasting organizations, and local governments (FEMA, 2025) (USACE, n.d.). Best practices begin during preparedness, when agencies establish clear roles and responsibilities through Emergency Action Plans (EAPs), memoranda of understanding, and formal

communication protocols (FEMA, 2013). Research has shown that jurisdictions with predefined coordination frameworks experience faster decision-making and fewer communication breakdowns during flood emergencies (Cutter, Emrich, Morath, & Dunning, 2013). Regular joint training, tabletop exercises, and scenario simulations help agencies build shared understanding and operational trust. These preparatory actions form the foundation for effective prevention, response, and recovery.

Prevention and mitigation activities benefit from coordinated, risk-informed planning across agencies. The USACE Dam Safety Program promotes the use of shared risk assessment frameworks that integrate structural condition, hydrologic loading, and downstream consequences, with life safety identified as the highest priority (USACE, 2016; USACE, 2020). Academic literature indicates that using common analytical tools—such as inundation mapping and consequence analysis—improves transparency and consistency in prioritizing mitigation investments (Cutter et al., 2015). Coordination with land-use planners and transportation agencies reduces future exposure by discouraging development in high-hazard inundation zones (FEMA, Reducing Damage from Localized Flooding, 2025). Joint risk communication by technical and emergency management agencies improves public understanding and trust, particularly for low-probability, high-consequence events such as dam failures. When mitigation strategies are developed collaboratively, they are more likely to address both physical risk and social vulnerability.

During imminent failure threats or actual dam breaks and levee breaches, interagency coordination must transition rapidly to operational alignment. FEMA guidance identifies the Incident Command System (ICS) as the standard framework for managing multi-agency flood emergencies, enabling unified objectives, shared situational awareness, and coordinated resource deployment (FEMA, National Incident Management System, 2021). USACE dam safety guidance stresses the importance of timely information sharing between technical experts and emergency managers, particularly regarding breach development, flood arrival times, and risk to downstream populations (USACE, 2016). Studies of flood disasters consistently show that unclear command structures and fragmented communication are major contributors to increased loss of life during rapidly developing events (Cutter et al., 2017). Coordinated evacuation planning involving law enforcement, transportation, and public works agencies is critical to ensuring safe and timely movement of at-risk populations. Consistent public messaging across agencies further reduces confusion and increases compliance with emergency directives.

Recovery and long-term learning are equally important components of interagency coordination. FEMA and USACE both recommend structured after-action reviews following dam- or levee-related incidents to document lessons learned and update EAPs, mapping products, and communication procedures (FEMA, 2013); (USACE, 2020). Research indicates that coordinated recovery efforts accelerate infrastructure repair and reduce long-term social and economic impacts, particularly for socially vulnerable communities (Fox, Agyemang, Hawker, & Neal, 2024). Integrating post-event findings into training and planning supports adaptive risk management and continuous improvement. Transparency and interagency collaboration during recovery also help rebuild public trust. Ultimately, best practice treats dam and levee safety as a shared, continuous responsibility rather than a sequence of isolated agency actions.

In the case of _____ the _____ dam is operated by the _____. The risk

management protocol is described in the _____ Emergency Operations Plans. Highlights for this Plan are_____.

4.14 Hazard Prioritization

After receiving feedback from the public and stakeholders (see sections 2.6-2.7) along with their own expertise the planning committee has determined that the following is the prioritization for the hazard discussed in this LHMP.

Table 45: Hazard Prioritization

Hazard	Priority
Earthquake	Low Priority
Landslide	High Priority
Flooding	Mid Priority
Tropical Cyclones and Extreme Winds	High Priority
Extreme Heat	Low Priority
Drought	Mid Priority
Wildfire	Low Priority
Pandemics	Mid Priority

4.15 Planning Mechanism

Understanding and recognizing regulatory and planning capacities enables more effective management of land use and economic growth. These capacities consist of the legal frameworks and public policy provisions that influence land use to guide sustainable development, while also supporting actions that mitigate the vulnerability of communities and their resources to natural hazards.

Besides the Public Policies already discussed in Section 1.1, what follows is a list in chronological order of the regulatory and planning mechanisms available to the municipality for the implementation of this LHMP.

4.15.1 Karst Special Planning Area Plan and Regulation (PRAPEC, by its Spanish Acronym) – 2014)

Figure 26: (PRAPEC, by its Spanish Acronym) Coversheet



In compliance with Act 292-1999, this plan and regulation establish two overlayed districts in the karst zones of Puerto Rico. The Restricted Karst Special Planning Area (APE-RC) overlayed district aims to protect the land within the Restricted Karst Area. According to Act 292-1999, lands under this district cannot be used for the extraction of materials from the earth's crust, except in cases where such activities had already been recognized by the competent authorities at the time of the adoption of PRAPEC. Additionally, the APE-RC imposes other restrictions, such as prohibitions on subdivision in certain underlying districts.

On the other hand, the Special Planning Area for the Karst Zone (APE-ZC) overlayed district includes lands within the karst physiography that are not part of the APE-RC. Its purpose is to allow the extraction of materials from the earth's crust for commercial purposes under appropriate conditions, in areas of the karst zone that are not within the APE-RC, and to address lands that, although part of the karst physiography, are not included in the restricted area.

4.15.2 Joint Regulation for the Evaluation and Issuance of Permits Related to Development, Land Use, and Business Operations (2023)

The Joint Regulation for the Evaluation and Issuance of Permits Related to Development, Land Use, and Business Operations (*Reglamento Conjunto* in Spanish) is a regulatory instrument created by the Planning Board in compliance with Law No. 161, as amended. Its main purpose is to regulate land use, territorial planning, and the granting of permits related to development, construction, and business operations within a uniform and centralized framework. The Joint Regulation aims to harmonize public policy on land use planning with the principles of sustainable development, seeking a balance between economic growth, environmental protection, and social well-being. This regulation establishes the rules to classify land, define zoning districts, regulate zoning, and determine the permitted uses in each category. Additionally, it sets the procedures to evaluate projects, issue permits, and monitor compliance with the applicable provisions. Its purpose is to provide a uniform regulatory framework for the evaluation and issuance of permits, ensure the proper use of land, protect natural resources, and facilitate economic development under criteria of competitiveness and sustainability, integrating planning with permit management.

Figure 27: Joint Regulation Cover



Of particular importance in the Joint Regulation is the zoning district *Distrito de Riesgo para Espacios Abiertos*– Open Space (RE-A).[19] The RE-A zoning district is established to identify lands designated as open space in accordance with federal regulations (44 CFR Part 80) or another federal program, due to the presence of a risk condition resulting from a natural event. These spaces may include, but are not limited to, severe flooding and landslides. There are conditions in these areas that are unfavorable or harmful to health, safety, or general welfare, and there may be a risk of loss of life and property. Land within this district may be susceptible to one or more of the identified hazards.

The purpose of the district is to preserve the open space condition established in perpetuity by federal regulation, which the government or the community must uphold, with the objective of protecting health, life, and property; preventing severe losses and repetitive use of affected properties; reducing the investment of public and federal funds in mitigation; and limiting rescue efforts, among other goals.

4.15.3 Special Flood Hazards Areas Regulation (2021)

The 2021 regulation was adopted by the Puerto Rico Planning Board under its authority from Public Law No. 75 of 1975 and Public Law No. 3 of 1961 to control development in flood-prone zones. It aligns Puerto Rico's floodplain management requirements with the minimum standards of the National Flood Insurance Program (NFIP), administered by FEMA. The regulation establishes updated criteria for construction, land use, and development within Special Flood Hazard Areas (SFHAs), including requirements such as elevating structures above Base Flood Elevation and submitting technical certifications. It applies to new construction, substantial improvements, and land-use changes across designated flood zones such as AE and VE, using FEMA Flood Insurance Rate Maps (FIRMs) and Flood Insurance Studies (FIS) for zone identification. The revision clarifies and expands regulatory provisions to enhance public safety and prevent harmful development in high-risk areas.

4.15.4 Puerto Rico Building Code

The Puerto Rico Building Code sets minimum requirements for the design, construction, modification, and upkeep of buildings to ensure the safety, health, and well-being of the public. It is derived from nationally and internationally recognized model codes and is updated periodically to incorporate improvements in construction practices and lessons learned from past hazard events. The code includes provisions addressing structural safety, fire protection, accessibility, energy conservation, and resistance to natural hazards such as earthquakes, hurricanes, floods, and strong winds. Adherence to the Building Code is mandatory for all new construction and substantial renovations throughout Puerto Rico. Enforcement is carried out through local permitting, planning review, and inspection processes to verify compliance with established standards. Overall, the Puerto Rico Building Code is a key instrument for advancing resilient, safe, and sustainable development across the island.

4.15.5 Regulation for the Design, Operation Criteria and Maintenance of Stormwater Systems in Puerto Rico

Figure 28: Regulation 40 Cover Page



Adopted in 2023 as Planning Regulation No. 40, this regulation updates and replaces the island's outdated 1975 standards to address current engineering practices, environmental considerations, and increased flood risk. The regulation is designed to provide developers, engineers, contractors, and municipalities with modern technical criteria for designing, operating, and maintaining public and private stormwater systems, incorporating updated scientific knowledge and methodologies necessary for managing stormwater infrastructure under present-day conditions. Its objectives include minimizing flood-related damage, improving the capture and management of runoff, reducing impacts to water resources and ecosystems, and supporting safer, more resilient community development. The regulation integrates risk management principles and aligns with Puerto Rico's climate adaptation policies,

requiring consideration of urban flooding, karst hydrology, low-impact development practices, and stormwater control structures such as retention and detention systems. It also establishes minimum design considerations for all land development projects and provides a comprehensive framework for planning, monitoring, and maintaining stormwater systems across the island.

4.15.6 Barranquitas Territorial Plan (2011)

Figure 29: Barranquitas Land Use Cover Page



As per the Puerto Rico Municipal Code and the territorial planning framework established by the Puerto Rico Planning Board (JP), the Municipality of Barranquitas is in the process of reviewing and updating its Territorial Plan (PT). The Territorial Plan is a strategic and comprehensive instrument for organizing land use within the municipality. It covers the entire municipal territory and establishes the fundamental elements for land-use planning, as well as the programs, policies, and actions required for its implementation and long-term development. The currently adopted PT for Barranquitas was approved in 2011.

4.15.7 Barranquitas Emergency Operation Plan

This Emergency Operation Plan (EOP) describes how emergency operations are structured through the Incident Command System, enabling unified command and efficient allocation of resources. It details the activation levels of the Municipal Emergency Operations Center, which escalates from routine monitoring to full 24/7 multi-agency disaster response. The municipality highlights the importance of interagency collaboration, including coordination with state and federal agencies when local capabilities are exceeded. Community involvement, public information, and support for vulnerable populations—such as individuals with disabilities, children, and the elderly—are essential components woven into all phases of emergency management. Additionally, the plan incorporates long-term recovery strategies, emphasizing damage assessments, restoration of critical services, and alignment with federal assistance processes. Ultimately, it presents a structured, community-centered approach to ensure Barranquitas can respond to, withstand, and recover from a wide range of emergencies.

4.15.8 National Flood Insurance Program

The National Flood Insurance Program falls within the category of planning mechanisms, as it imposes certain floodplain management requirements. FEMA provides flood insurance to communities that are following the NFIP criteria. This includes adopting and enforcing floodplain management practices that promote appropriate development in these flood-prone areas.

The National Flood Insurance Program of the Federal Emergency Management Agency allows homeowners, business owners, and renters in participating NFIP communities to purchase federally backed flood insurance. This insurance aids help

cover the costs of repairing damage caused by flooding to buildings and their contents. This is an insurance program established to help property owners, renters, and businesses recover more easily and at a lower cost. Likewise, the program aims to reduce the impact of flooding on both public and private structures. These efforts help mitigate the effects of flooding on new and improved structures within each community.

The NFIP has several components, including:

- Floodplain management — for which the community must adopt and enforce measures for managing flood-prone lands in accordance with NFIP regulations;
- The preparation of Flood Insurance Rate Maps (FIRMs); and
- Flood insurance.

The Municipality of Barranquitas has a collection of FIRM maps that can be consulted to determine whether your property is in a high-risk area or in a low- to moderate-risk zone. FIRMs refer to the official map developed and approved by FEMA and adopted by the Puerto Rico Planning Board to designate areas at risk of a 100-year flood (or a 1% annual chance of occurrence). In addition, these maps serve as a tool for managing special areas due to their susceptibility to flooding events.

While the Write Your Own Program (WYO) began in 1983 as a partnership between insurance companies and FEMA. This arrangement allows property and casualty insurance companies to underwrite and service federal flood insurance policies in their own company name. A key feature of this type of policy is that all companies participating in the WYO program provide the same coverage, and their rates must comply with NFIP rules and regulations.
Communities, for their part, adopt and require compliance with the NFIP's minimum standards for construction and development in designated Special Flood Hazard Areas. However, many communities seek to achieve a higher level of safety and protection for their residents beyond the NFIP minimum standards. For this purpose, communities have the option of participating in the NFIP's Community Rating System (CRS), which allows them to obtain reductions in flood insurance premiums.

This is because the CRS recognizes additional community efforts to: 1) Reduce flood damage to insurable property; 2) strengthen and support NFIP insurance provisions; and 3) encourage a comprehensive approach to floodplain management. These additional efforts provide residents with greater safety, reduce property damage, enhance community resilience, and promote a better quality of life. The municipality's participation in the NFIP will be discussed in Section 6.6 .

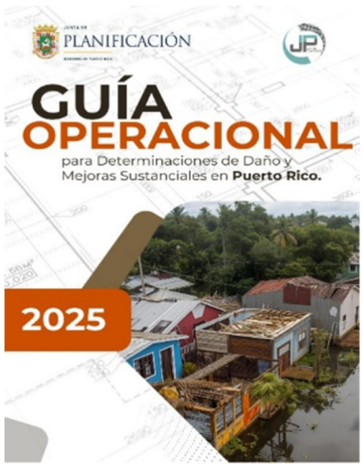
4.15.9 National Pollutant Discharge Elimination System (NPDES)

The NPDES is a program authorized under the United States Clean Water Act and administered by the Environmental Protection Agency (EPA). This program requires Municipal Separate Storm Sewer Systems (MS4s) to obtain a permit for the discharge of stormwater into water bodies. In the case of Puerto Rico, the EPA issued a general permit in 2016, under which municipalities can obtain coverage by submitting a Notice of Intent (NOI) and adopting a Stormwater Management Program (SWMP). If any of the mitigation measures listed in Section 6.5 modify the NOI or the SWMP, they will be

properly amended.

4.15.10 Operational Guidelines for Determining Damages and Substantial Improvements in Puerto Rico (2025)

Figure 30: Operational Guides



The Floodplain Administrator or the Participating Community may review, require, and audit permits in accordance with the provisions of Act No. 3 of September 27, 1961, known as the "Floodplain Building Control Act"; Act No. 75, the "Puerto Rico Planning Board Organic Act"; Act No. 161 of December 1, 2009, as amended, the "Puerto Rico Permit Process Reform Act"; and Act No. 38 of June 30, 2017, the "Uniform Administrative Procedure Act of the Government," as amended, and in compliance with the regulations of the National Flood Insurance Program (NFIP) of the Federal Emergency Management Agency (FEMA), Title 44 of the Code of Federal Regulations (CFR), Part 60.3 [d, e, and Subpart B], and its related sections. As of the effective date of this guidance, an evaluation of substantial damage or substantial improvement will be required as part of the permitting requirements in Special Flood Hazard Areas. The Floodplain Administrator will require that both new structures and substantial improvements be constructed in a manner that minimizes or prevents damage during a regulatory flood.

4.15.11 Green Infrastructure and Nature Based Solutions

Section 502 of the United States Clean Water Act defines green infrastructure as the range of measures that use plant or soil systems, permeable pavement or other permeable surfaces or substrates, stormwater harvesting and reuse, or landscaping to store, infiltrate, or evapotranspiration stormwater and reduce flows to sewer systems or surface waters.

Green infrastructure is a cost-effective and resilient approach to managing wet weather impacts that provide many benefits to the community. While conventional single-purpose gray stormwater infrastructure (such as pipe drainage and water treatment systems) is designed to move urban stormwater away from the built environment, green infrastructure reduces and treats stormwater at its source while providing environmental, social, and economic benefits.

Stormwater runoff is a major cause of water pollution in urban areas. When it rains on rooftops, streets, and parking lots in cities and suburbs, the water cannot soak into the ground as naturally would. Instead, stormwater drains through gutters, storm sewers, and other collection systems and is discharged into nearby water bodies. This runoff carries trash, bacteria, heavy metals, and other pollutants from the urban landscape. Higher flows resulting from heavy rainfall can also cause erosion and flooding in urban streams, damaging the environment, property, and infrastructure.

When rain falls in undeveloped natural areas, the water is absorbed and filtered by soil and vegetation. Stormwater runoff is cleaner and less problematic. Green infrastructure uses vegetation, soil, and other elements and practices to restore some

of the natural processes needed to manage water and create healthier urban environments. At the municipal scale, green infrastructure is a network of natural areas that provide habitat, flood protection, cleaner air, and cleaner water. At the neighborhood, development, or sector scale, managing stormwater systems in a way that mimics natural processes help absorb and store runoff that can otherwise cause localized flooding (EPA, 2019).

Some green infrastructure measures that may be considered to mitigate flooding problems include:

- Rainwater harvesting
- Rain gardens (bio-retention/bio-infiltration)
- Urban rain gardens ("planter boxes")
- Bioswales
- Porous pavements
- Green streets
- Green parking lots
- Green roofs
- Land conservation
- Creation or maintenance of urban tree canopy
- Wetland restoration
- Riparian area rehabilitation
- Sand dune restoration, among others.

The Municipality will consider green infrastructures measures when developing or championing flood control measures with the state or the federal government. In addition to flood control, green infrastructure provides benefits such as improved water quality, enhanced water supply, reduced stormwater management costs (public and private), improved habitat quality, increased spaces for recreation and physical activity, job creation in the maintenance of natural areas, and increased property values (EPA, 2019).

4.15.12 Four – Year Investment Program

The Four-Year Investment Program 2022–2023 to 2025–2026 (hereinafter, the PICA) is a short- and medium-term planning instrument designed to guide, coordinate, and direct public investments during the period it covers. Through this instrument, the Planning Board integrates the efforts of various government entities aimed at improving the quality of life of the people of Puerto Rico, in line with established public policies.

The Framework of Reference for the Four-Year Investment Program for the period 2022–2023 to 2025–2026 guides agencies and public corporations in preparing their investment and capital improvement programs. The framework includes a demographic and socioeconomic profile of Puerto Rico as a whole and by regional organization, a diagnosis of the recent performance of the economy, and information on development patterns and priority projects for the competitive Puerto Rico to which all aspire.

The full PICA document for the 2022–2023 to 2025–2026 period incorporates all information on capital improvement projects to be carried out by government entities.

It includes a detailed analysis of the distribution of recommended resources by program areas and the origin of those resources. This analysis is the result of an integration process designed to guide budget recommendations formulated by the Office of Management and Budget regarding the Annual Capital Improvements Program included in Puerto Rico's budget.

This program serves as a short- and medium-term planning tool to guide, coordinate, and direct public investments during its period of effectiveness. It uses Puerto Rico's demographic and socioeconomic profile, along with a regional analysis as established by the Planning Board (JP, 2022).

With respect to the municipality's Hazard Mitigation Plan, the PICA is used to integrate information on the current performance of Puerto Rico's economy, including data on public debt and development trends, as well as projects designated as priorities for implementation on the Island. Within this framework, the PICA provides municipalities with information from government entities regarding funding allocations and investments in improvements they are responsible for implementing, which contribute to municipal efforts to mitigate natural hazards.

As part of the projects influencing all Functional Areas of Puerto Rico, the review of municipal Mitigation Plans is included. The Planning Board was designated by the Government Authorized Representative (GAR) as the agency responsible for reviewing and developing Hazard Mitigation Plans in coordination with the 78 municipalities [20].

5. Municipal Capacities

5.1 Regulatory and Planning Mechanism (C1-a)

These capabilities refer to the legal provisions that influence land used to manage economic growth and that could support the municipality in its efforts to mitigate the vulnerability of its communities and resources to natural hazards. The municipality identified existing regulations and planning documents that could support its actions, as well as opportunities to promote the development of studies or plans for the same purpose of advancing its mitigation goals. These regulatory and planning tools are described in Section 4.15.

5.2 Technical and Administrative Capacities (C1-a)

The Municipality of Barranquitas is well staffed to implement this LHMP. The Municipality has fully staffed office of . Copy of this organigram can be found as part of Appendix E.

Table 46 shows the Municipality's Technical and Administrative Capacity

Table 46: Municipal Technical and Administrative Human Resources

Personnel Team / Resources	Yes	No	Future Positions	Department or Agency	Opportunities to Integrate into LHMP	Comments
Planners with experience in land use and mitigation		X	Through contract services if needed	N/A	N/A	Currently the municipality does not have a planning department. Any planning related issue is worked through the mayor's office, or subcontracted staff.
Engineers or professionals trained in construction practices related to buildings and infrastructure		X	Through contract services if needed	N/A	N/A	Currently the municipality does not have this staff. If the need arises this position will be procured by external professional services.
Planners or engineers with a broad understanding of natural hazards		X	Through contract services if needed	N/A	N/A	Currently the municipality does not have this staff. If the need arises this position will be procured by

Personnel Team / Resources	Yes	No	Future Positions	Department or Agency	Opportunities to Integrate into LHMP	Comments
						external professional services.
Emergency Manager	X		Director of the Municipal Emergency Management Office	Municipal Emergency Management Office, Department of Public Safety	The LHMP may be used to update the EOP	None
Scientists familiar with natural hazards		X	Through contract services if needed	University of Puerto Rico, Puerto Rico Seismic Network, other universities in Puerto Rico		Currently the municipality does not have this staff. If the need arises this position will be procured by external professional services.
Personnel with expertise or education regarding the vulnerabilities and natural hazards affecting the community		X	Community Representative	N/A	N/A	Currently the municipality does not have this staff. If the need arises this position will be procured by external professional services.
Resource development staff or grant writers		X	Director of Municipal Federal Programs	Municipal Federal Programs Office	This staff may write and administer grants to cover the mitigation strategies mentioned below.	N/A

5.3 Financial Capacity (C1-b)

The Municipality has experience administering federal funds from various streams and maintains a dedicated office responsible for the administration and oversight of federally funded programs.

5.3.1 FEMA Funding Streams

For hazard mitigation projects the municipality has identified the following FEMA – administered possible funding streams which it could draw from.

Stafford Act - Section 404

Section 404 refers to Section 404 of the Robert T. Stafford Disaster Relief and Emergency Assistance Act, which authorizes the Hazard Mitigation Grant Program (HMGP), administered by FEMA. Its primary purpose is to reduce future disaster losses by funding long-term mitigation projects after a major disaster is declared.
Under Section 404, funding is made available to states, territories, tribes, and local governments to implement mitigation measures that lessen the impacts of future hazards such as floods, earthquakes, hurricanes, wildfires, and droughts. Unlike Section 406, Section 404 projects do not have to be tied to facilities that were damaged by the declared disaster. This allows communities to take a proactive approach by investing in mitigation actions that address known risks before damage occurs.

Eligible projects under Section 404 may include activities such as elevation or acquisition of flood-prone structures, drainage improvements, seismic retrofits, safe rooms, wildfire mitigation measures, and hazard mitigation planning. Projects must be cost-effective, technically feasible, and consistent with an approved Hazard Mitigation Plan. The program typically provides up to 75 percent federal funding, with the remaining share provided by non-federal sources.

Under Section 404 is also the Hazard Mitigation Grant Program (HMGP) that can support plan development, data collection, risk assessments, and engagement activities required to maintain FEMA approval following a presidential disaster declaration.

Stafford Act – Section 406

Section 406 of the Stafford Act supports mitigation projects by allowing hazard-mitigation measures to be incorporated directly into the repair or replacement of public facilities damaged during a declared disaster. This provision enables communities to strengthen damaged infrastructure against future hazards, such as elevating flood-damaged buildings, reinforcing structures to withstand high winds, or improving drainage systems during repairs. Mitigation measures funded under Section 406 must be cost-effective and directly related to the damaged facility. By integrating mitigation into recovery activities, Section 406 helps reduce the likelihood of repetitive damage and future repair costs. Overall, it ensures that rebuilding efforts contribute to long-term resilience rather than simply restoring pre-disaster conditions.

Stafford Act - Section 428

Section 428 of the Stafford Act can support mitigation projects by allowing communities to integrate hazard-resilient and risk-reduction measures directly into disaster recovery projects funded through FEMA's Public Assistance Program. Through its alternative procedures, Section 428 enables flexible project design, fixed-cost funding, and consolidation of damaged facilities, making it easier to incorporate mitigation improvements such as relocation, elevation, floodproofing, or structural hardening. Applicants may also reinvest cost savings from efficiently managed projects into additional mitigation features, if project objectives are met. By emphasizing outcomes rather than strict cost reimbursement, Section 428 encourages rebuilding that reduces future risk rather than simply restoring pre-disaster conditions. This approach allows mitigation to become an integral part

of recovery, strengthening resilience and reducing the likelihood of repetitive losses.

Flood Mitigation Assistance Program

The Flood Mitigation Assistance (FMA) Program reduces flood hazards by providing funding to help communities identify and implement measures that lessen long-term flood risk to National Flood Insurance Program (NFIP)insured properties. The program focuses on projects such as elevating, acquiring, relocating, or floodproofing flood-prone structures, with priority given to repetitive loss and severe repetitive loss properties. By mitigating flood damage before disasters occur, FMA helps protect lives and property, reduces future flood insurance claims, and lowers the overall cost of disaster assistance. The program encourages proactive risk reduction by aligning mitigation investments with floodplain management and local hazard mitigation planning.

Stafford Act – Section 203 (BRIC)

The Building Resilient Infrastructure and Communities (BRIC) program supports mitigation projects by providing pre-disaster funding to help communities reduce risks from natural hazards before disasters occur. Administered by FEMA, BRIC focuses on long-term, cost-effective investments that enhance the resilience of critical infrastructure, lifelines, and communities. The program funds activities such as infrastructure retrofits, flood control projects, seismic upgrades, and nature-based solutions, as well as hazard mitigation planning and capacity building. BRIC emphasizes innovative, large-scale projects that address multiple hazards and provide measurable community benefits. By investing in mitigation prior to disasters, the BRIC program helps protect lives and property, reduce future disaster costs, and support more resilient and sustainable development.

5.3.2 Non-FEMA Federal Funding Streams

Non-FEMA federal Funding Streams can include:[15]

CDBG-DR

The Department of Housing and Urban Development's Community Development Block Grant–Disaster Recovery (CDBG-DR) program can fund hazard mitigation planning and projects by supporting activities that reduce long-term disaster risk and address unmet recovery needs following a major disaster. CDBG-DR funds may be used to develop or update hazard mitigation plans, conduct risk assessments, and support resilience and mitigation planning efforts that guide future investments. In addition, the program can finance mitigation projects such as drainage improvements, flood control infrastructure, elevation or acquisition of flood-prone properties, utility hardening, and other measures that reduce vulnerability to natural hazards. Unlike some recovery programs, CDBG-DR allows communities to target mitigation actions even if facilities were not damaged in the most recent disaster, if the activities address identified risks.

CDBG-MIT

[15] Please note that the following list is not intended to be exhaustive.

The Department of Housing and Urban Development's Community Development Block Grant–Mitigation (CDBG-MIT) program supports hazard mitigation planning and projects by providing federal funding specifically dedicated to reducing future disaster risks in communities that have experienced major disasters. CDBG-MIT funds can be used for mitigation planning activities such as risk assessments, data analysis, and development of strategies that guide long-term resilience investments. The program also finances a wide range of mitigation projects, including flood risk reduction, stormwater management, wildfire mitigation, resilient infrastructure upgrades, and nature-based solutions. CDBG-MIT emphasizes addressing identified vulnerabilities and repetitive loss areas, even if they were not directly damaged in a recent disaster. By focusing on forward-looking risk reduction, the program helps communities proactively adapt to climate impacts and future hazards. Overall, CDBG-MIT integrates mitigation into long-term recovery and development efforts, strengthening community resilience and reducing future disaster losses.

It should be noted that CDBG-DR and CDBG-MIT differ primarily in their purpose and how they support hazard mitigation planning and projects. CDBG-DR focuses on post-disaster recovery, with mitigation activities integrated into rebuilding efforts to address unmet needs and reduce future risk as communities recover. Under CDBG-DR, mitigation planning and projects must be closely tied to disaster recovery goals and justified by disaster impacts or recovery assessments. In contrast, CDBG-MIT is specifically dedicated to hazard mitigation and long-term risk reduction, allowing communities to fund mitigation planning and projects even if areas or facilities were not damaged in the most recent disaster.

Resilience and Emergency Relief Programs

The Federal Highway Administration (FHWA) Resilience and Emergency Relief Programs support Hazard Mitigation Plans by promoting the identification and reduction of risks to transportation infrastructure from natural hazards. Through the Emergency Relief Program, FHWA allows mitigation and resilience measures—such as improved drainage, roadway elevation, and bridge reinforcement—to be incorporated into post-disaster repairs. FHWA resilience initiatives also encourage vulnerability assessments and risk-based planning that align with the risk assessment and mitigation strategy components of FEMA-approved HMPs. By integrating hazard mitigation and climate resilience into transportation planning, these programs help ensure that roads and bridges are addressed as critical lifelines. Overall, FHWA programs complement Hazard Mitigation Plans by supporting transportation-focused mitigation actions that reduce future disruption and repair costs.

National Resource Conservation Service

The Environmental Quality Incentives Program (EQIP) and the Watershed and Flood Prevention Operations (WFPO) program support hazard mitigation projects by addressing risks at the landscape and watershed scale through conservation and infrastructure improvements. EQIP, administered by the USDA Natural Resources Conservation Service (NRCS), provides financial and technical assistance to landowners to implement conservation practices that reduce erosion, manage runoff, improve soil health, and mitigate risks from flooding, drought, and wildfires. These practices—such as vegetation management, streambank stabilization, and water retention—help lessen downstream flood impacts and enhance resilience to climate

variability. The Watershed and Flood Prevention Operations program support larger-scale mitigation through structural and non-structural measures, including small dams, floodwater retarding structures, channel improvements, and watershed planning. Together, these programs reduce hazard exposure upstream, protect communities and infrastructure downstream, and integrating natural resource management into long-term flood and drought mitigation strategies.

5.3.3 Local Funds

Barranquitas, like other municipalities in Puerto Rico, receive revenue from the Municipal Revenue Collection Center (MRCC). Other funding sources include revenue from the Sales and Use Tax (IVU, by its Spanish acronym), legislative funds that might be assigned from time to time and other sources. Depending on the state of municipal finances, the municipality might determine that there are some funds that can be used to pay for or cover local funds match for mitigation projects.

However, most major capital improvement projects depend on federal funds transfers. The use of federal funds varies widely from year to year. In some cases, these funds are used to cover costs associated with the creation and monitoring of specific programs (for example, Section 8 or housing programs). In other cases, the funds are used to finance major capital improvement projects.

5.4 Outreach and Communications (C1-a)

Building robust outreach and communication capacity is essential to the successful implementation of a Hazard Mitigation Plan, as effective risk communication enables residents to recognize their risks, actively participate in planning processes, and make informed decisions to reduce potential impacts. FEMA guidance underscores the importance of early and thoughtfully designed engagement strategies to ensure that key stakeholders exchange information at the right time, promoting shared awareness of hazards and broad support for mitigation actions. Communication is a fundamental preparedness capability because it provides timely, practical information that helps individuals and communities act to limit harm. Research further demonstrates that outreach efforts are most successful when messages are clearly defined, customized for specific audiences, and conveyed through trusted sources. Communities that prioritize outreach—by collaborating with local leaders, leveraging a variety of communication channels, and tailoring messages to different population groups—tend to achieve higher public involvement and more effectively incorporate community feedback into hazard mitigation planning. These practices ultimately contribute to more effective plans and more resilient communities (FEMA, 2025).

The Municipality demonstrates adequate capacity to conduct effective outreach and communication activities. The Office of _____ is responsible for coordinating these efforts, and an organizational chart for this office is provided in Appendix E. The Municipality utilizes both social media platforms for real-time communication and traditional methods to disseminate information to the public. In addition, the Planning Office administers the Community Board responsible for land-use decisions, which is largely composed of municipal residents. This board serves as an important forum for public engagement and provides an opportunity to further expand and strengthen the Municipality's outreach and communication capacity.

Table 47 details the communication tools available to the municipality.

Table 47: Outreach and Communications Tools

Tool or resource	Present or not present	Description	Agency in Charge	Comments
Municipal social media	X	Facebook Page	Municipality	N/A
Planning Board Print Material	X	Print Material regarding hazard mitigation, focused on flood hazard	Planning Board	N/A
Community Meetings	X	Community Outreach Meeting to reach people that do not have access to social media	Non – Governmental Organizations	N/A

5.5 Capacity Development (C1-b)

Strengthening institutional and technical capacity is vital to the successful implementation of a Hazard Mitigation Plan, as communities must have the expertise, resources, and organizational frameworks needed to move from planning to sustained risk-reduction actions. FEMA guidance stresses that effective mitigation planning relies on well-coordinated teams, access to reliable technical data, and the ability to collaborate across agencies and stakeholders—all of which directly affect the execution of mitigation strategies. National evaluations have shown that local and state governments often face challenges in implementing mitigation projects not due to a lack of commitment, but because of limited technical assistance, constrained administrative capacity, and insufficient engagement with federal support programs. Studies focused on low-capacity communities further demonstrate that gaps in technical knowledge, training, and leadership involvement can significantly hinder mitigation outcomes. These findings highlight the importance of strengthening workforce skills, enhancing guidance and tools, and reinforcing institutional support to achieve long-term resilience.

The Municipality continues to enhance its mitigation capacity by retaining qualified professionals as staff or contractors as needs arise. It also actively participates in training and continuing education opportunities offered through Commonwealth agencies and academic institutions to build and maintain the technical and institutional expertise necessary to support hazard mitigation efforts.

6. Mitigation Action Plan

The goals, objectives, and mitigation actions outlined in this Plan are based on discussions held by the designated Mitigation Plan Committee, as well as the public-participation activities conducted to date.

6.1 Mitigation Goals (C3-a)

6.1.1 Municipal Goals and Objectives

The Municipality of Barranquitas adopts the following goals as part of their mitigation efforts:

- **Promote the principle of prevention** by identifying where and how damage from emergencies and disaster events occurs and promptly take appropriate measures to minimize those impacts.
- **Reduce costs** associated with emergencies and disasters through preparation and prevention.
- **Lower the amount and severity of damage** that may result from recognized risks by strengthening prevention, preparedness, and mitigation efforts.
- **Educate the community** so that residents can provide initial response to an emergency or disaster, recognizing that state and federal assistance is often insufficient to cover the full extent of physical and economic losses.
- **Improve response time** and accelerate recovery after an emergency or disaster, whether the risks are natural or human-caused.
- **Promote an ongoing process of planning, participation, and execution** among municipal officials and community leaders who share responsibility and interest in coordinated efforts aimed at avoiding or reducing the impact of identified hazards.
- **Achieve rapid social and economic recovery** following an emergency or disaster. Barranquitas has already demonstrated its ability to recover from adversity and develop creative solutions to both natural and human challenges with the goal of building a resilient municipality.

The Mitigation Objectives presented below express the Municipality of Barranquitas commitment to protecting its residents and infrastructure, reducing response and recovery costs in the event of a disaster, and minimizing disruptions to normal daily activities afterward.

Objective 1: Minimize losses to existing and future structures located within hazard zones.

Supporting activities

- Reduce damage to homes located in flood-prone areas.
- Address flash-flood issues caused by stormwater runoff.
- Strengthening existing buildings to withstand the impact of earthquakes.
- Strengthening existing buildings to resist hurricane-force winds.
- Assess the structural condition of properties located on slopes greater than 35 degrees to identify appropriate mitigation measures, which may include reinforcing foundations and structures or relocating families.
- Minimize losses to current and future structures, especially those designated as critical facilities.

Objective 2: Maintain and enhance the Emergency Management capability of the Municipality of Barranquitas and its operational units through continuous and ongoing efforts to reduce vulnerability.

Supporting activities:

- Establish risk mitigation as public policy, supported by routine public education and inspections of conditions related to recognized hazards.
- Formalize a budget allocation to address deficiencies identified for each type of risk.
- Provide better resources and expanded training opportunities for the Municipal Emergency Management Agency.
- Maximize the use of advanced technology.
- Maintain ongoing community visits to identify potential risks and recommend actions.

Objective 3: Increase public awareness of risks to support the adoption of precautionary, preventive, and mitigation measures.

Supporting activities:

- Identify hazards and specific risks in each community.
- Increase public awareness of these risks.
- Develop educational programs accessible to all residents, especially those living in high-risk areas.
- Promote and publicize citizen participation in risk-mitigation activities.
- Encourage businesses and private property owners to adopt appropriate mitigation measures.

Objective 4: Minimize disruptions to economic and commercial activity in the Municipality, reducing financial losses during disasters.

Supporting activities:

- Provide safety and security for businesses during emergency events.
- Promote the development and implementation of emergency preparedness plans.
- Offer technical assistance to business sectors so they can access available economic aid before, during, and after an emergency or disaster.

Objective 5: Ensure that public funds are used as efficiently as possible.

Supporting activities:

- Prioritize mitigation projects in areas facing the greatest threat to life, health, and property.
- Use public funds to protect public services and critical facilities.
- Direct public financing to projects on private property when collective benefits outweigh the costs.
- Maximize the use of external funding sources.
- Encourage and maximize participation from property owners in mitigation efforts to protect their assets.

Objective 6: Improve coordination and communication with other relevant organizations.

Supporting activities:

- Establish and maintain long-term partnerships that enable coordinated action among citizens, the private sector, and government entities to jointly reduce risks and promote mitigation.

- Integrate risk-mitigation considerations into the activities of all institutional and socioeconomic sectors within the Municipality.

Objective 7: Promote sustainable development to improve quality of life.

Supporting Activities:

- Develop parks, open spaces, and recreational areas in risk zones.
- Adopt measures to conserve and protect natural resources.
- Prohibit new residential development (particularly high-density housing and elderly housing) in high-risk areas.

Source: *Municipio de Barranquitas Plan de Mitigación contra Peligros Naturales 2020*, Chapter 6, "Estrategias de Mitigación".

6.1.2 National Mitigation Investment Strategy

The Municipality also adopts the National Mitigation Investment Strategy and the following goals.

- **Goal 1**: Show How Mitigation Investments Reduce Risk - The whole community will build a shared understanding of mitigation investment and its value. Specifically, the whole community will understand how effective mitigation investments can protect people, homes, neighborhoods, cultural and historic resources, ecosystems and lifelines (for example, communications, energy, transportation and water). The federal government and its non-federal partners will create a shared vocabulary and common measures to communicate information about risk and find opportunities to educate, hire, train and develop a base of qualified mitigation professionals.

- **Goal 2**: Coordinate Mitigation Investments to Reduce Risk - The whole community will coordinate mitigation investments through shared risk information, reinforced strategies for risk reduction, and easier access to existing funding. Such coordination will help the whole community justify mitigation investments and choose the most cost-effective and reasonable actions.

- **Goal 3**: Make Mitigation Investment Standard Practice The whole community will factor mitigation into investment decisions, especially for buildings and infrastructure. The federal government and its non-federal partners will use and expand financial products and approaches for mitigation investment, including funding, incentives and financial risk transfer opportunities. The federal government and its non-federal partners also will make mitigation standard professional practice critical to safeguarding lifelines, services, and national safety and security.

6.2 Mitigation Strategy Selection Criteria

The following methodologies were used to select the mitigation actions:

- The Planning Committee reviewed mitigation actions from the previous Mitigation Plan.

- The Committee evaluated those actions and determined which ones were appropriate to include in the current Plan. Actions were excluded if:
    - The measure had already been implemented during the previous plan's period and was not a recurring or ongoing action.
    - The measure was no longer necessary or useful based on new information. This applies to mitigation actions linked to identified hazards, risks, and vulnerabilities.

- The Committee considered the Letters of Intent (LOIs) submitted by the municipality to COR3 in 2019 to participate in the Hazard Mitigation Grant Program. These projects were incorporated into the current Plan, ensuring no duplication of projects included in the previous Plan.,

- Committee members evaluated and added new measures. These new actions were proposed based on the Committee members' professional experience and suggestions received from community members.

The mitigation strategies of the Municipality of Barranquitas were evaluated by the Committee using the STAPLEE tool. This tool provides the selection criteria used to assess the projects included in the preceding section. The technique applies to seven evaluation criteria:

- S – Social: The proposed action must be socially acceptable.
- T – Technical: The proposed action must be technically feasible.
- A – Administrative: The community must have the capacity to implement the action (for example, determining whether the responsible agency can supervise the mitigation project).
- P – Political: Mitigation actions must be politically acceptable.
- L – Legal: The community must have the authority to implement the proposed action.
- E – Economic: Economic considerations must include the current economic base, projected growth, and opportunity costs.
- E – Environmental: The environmental impact must be considered, given statutory requirements and the public's interest in maintaining sustainable and environmentally healthy communities.

6.3 Mitigation Strategy Categorization

- Prevention - Prevention activities aim to keep hazards from creating or worsening problems. These actions are typically carried out through government programs or regulatory measures that guide land-use development and building practices. Prevention is especially effective for reducing future vulnerability in areas that have not yet been developed. Examples include:

    - Planning and zoning
    - Building codes
    - Open-space preservation
    - Floodplain regulations
    - Stormwater management regulations
    - Maintenance of drainage systems
    - Capital improvement programming

- Riverbank realignment
- Projects addressing fault zones

- Property protection – measures involve modifying existing buildings and structures so they can withstand natural hazards, or removing structures located in high-risk areas. Examples include:

  - Acquisition of properties
  - Relocation
  - Elevating structures
  - Protection of critical facilities
  - Structural retrofits (wind protection, floodproofing, seismic techniques)
  - Safe rooms, shutters, impact-resistant windows
  - Insurance policies

- Natural resource protection – activities reduce the impact of natural disasters by preserving or restoring natural areas that offer protective benefits. These areas include flood plains, wetlands, steep slopes, and sand dunes. Parks, recreational agencies, and conservation organizations commonly implement measures such as:

  - Flood protection
  - Watershed management
  - Riparian buffers
  - Forest and vegetation management (including wildfire and fuel-load control)
  - Erosion and sediment control
  - Wetland preservation and restoration
  - Habitat preservation
  - Slope stabilization

- Structural mitigation – Projects aim to reduce the impact of disasters by controlling or altering the natural flow of hazard events through engineered construction. These projects are usually designed by engineers and maintained by public works teams. Examples include:

  - Reservoirs
  - Dams, levees, and retaining walls
  - Diversion, detention, and retention systems
  - Channel modifications
  - Stormwater drainage systems
  - Installation of storm drains and related infrastructure

- Emergency Services - Although not typically classified as mitigation, emergency management measures reduce the human, and property impacts of natural hazards. These actions occur immediately before, during, or after a disaster. Examples include:

  - Warning systems
  - Evacuation management and planning
  - Emergency response drills and training
  - Flood-fighting measures

- Installation of shutters,

- Public awareness and outreach - Efforts to help inform residents, elected officials, business owners, homebuyers, and visitors about hazard-prone areas and mitigation techniques they can use to protect themselves and their property. Examples include:

  - Outreach projects
  - Demonstration events and guest presentations
  - Hazard information materials
  - Property-specific risk information
  - Library materials
  - Educational programs for children
  - Exposure to risk-related information

6.4 Mitigation Strategies (C4-a, C4-b, C5-a, C5-b, E2.b)

To improve tracking and updating each mitigation strategy has been giving a unique id. The following figure shows the meaning of the nomenclature.

Figure 31: Unique Id Nomenclature

Each identified mitigation strategy shall include

- Assigned category,
- Hazard(s) Mitigated
- Priority
- Responsible entity
- Founding source
- Estimated cost (when available)
- Qualitative Benefit
- Time Horizon
- Status
- Location in 2018 (if applicable)

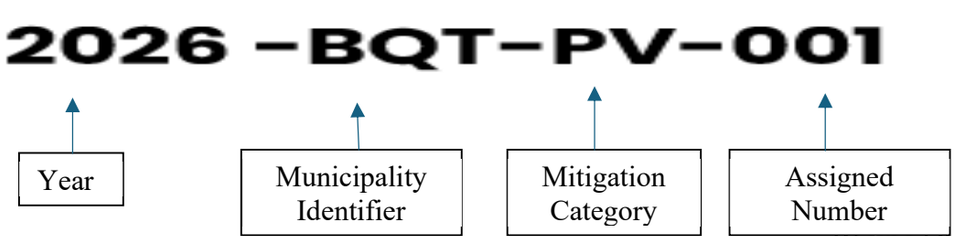


Table 48: Mitigation Strategies – Prevention (Local Policies and Regulations)

New ID	Old ID	Description	Hazard	Priority	Lifeline	Leading Municipal Office	Possible Funding Source	Implementation Term	Current Status and Expected Benefits
2026-BAR-LP-01	P-1	To convene the Planning Committee to begin outlining the work and the implementation program of the strategies. Territorial Planning and Permits, in conjunction with the Municipal Emergency Management Office, will oversee the implementation and execution of the 2020 Plan. Under the direction of Territorial Planning and Permits, the actions that can be implemented immediately and those that require studies, designs, permits, formulation of proposals to provide funds to the municipality for their compliance will be defined. The priority or its potential execution will depend on the immediate impact on the risk to life and property considering its economic, administrative, social, technical, legal and environmentally permissible.	All	High	Safety & Security	Planning & Permitting Emergency Management, Public Works, Sanitation, Federal Programs, Mayor's Office	Municipality of Barranquitas	Medium	Current Status: Meetings were held where mitigation actions were evaluated. The change of personnel in both offices caused a disruption in meetings until a new committee was appointed. Qualitative Benefit: Coordination, execution and maintenance of the Mitigation Plan.
2026-BAR-LP-02	P-2	Incorporate all findings and recommendations from this Natural Hazard Mitigation Plan into preparedness, response, and recovery plans within the context of mitigation against multiple natural hazards.	All	Moderate	Safety & Security	Territorial Planning and Permitting, Emergency Manageme	Municipality of Barranquitas	Medium	Current Status: This is an activity of an ongoing nature. With the update of the plan, all activities are evaluated in such a way that they adjust to the new reality of the population and its exposure to risks.

New ID	Old ID	Description	Hazard	Priority	Lifeline	Leading Municipal Office	Possible Funding Source	Implementation Term	Current Status and Expected Benefits
						nt, Municipal Public Works, Federal Programs and the Mayor's Office			continuous nature. Qualitative Benefit: Improves and ensures the execution and maintenance (updating) of the Mitigation Plan.
2026-BAR-LP-03	P-3	Promote mitigation policies through land-use planning, including the revision of existing regulations so that development is directed to suitable areas, where new public infrastructure and reduce its exposure to the various risks identified in this Plan.	All	Moderate	Safety & Security	Office of Territorial Planning and Permits	Municipality of Barranquitas	Short	Current Status: The municipality is in the process of a comprehensive review of the Territorial Planning Plan (RIPOT), so all the actions defined in this plan that affect the regulation of land uses will be considered. Qualitative Benefit: Protection of public and private infrastructure, reducing your exposure to risks.
2026-BAR-LP-04	P-4	Implement, within the context of the Territorial Plan, risk mitigation policies in areas that are already exposed to the effect of multiple risks, as well as in areas that may aggravate the dangerous conditions of these. These policies may include; standards for	All	Moderate	Safety & Security	Office of Planning and Permitting, Mayor's Office	Municipality of Barranquitas, FEMA	Medium	Current Status: The municipality is in the process of a comprehensive review of the Territorial Planning Plan (RIPOT), so all the actions defined in this plan that affect the regulation of land uses will be considered.

New ID	Old ID	Description	Hazard	Priority	Lifeline	Leading Municipal Office	Possible Funding Source	Implementation Term	Current Status and Expected Benefits
		strengthening and/or modifying existing structures, the development of a post-disaster reconstruction plan (including the implementation of moratoriums on development and encouraging reconstruction outside of high-risk areas), the transfer of development rights to safe places, acquisition of undeveloped land, acquisition of development rights, relocation of buildings, acquisition, demolition of high-risk structures or implementation of fiscal and contributory policies that reduce the taxes paid for open land located in areas potentially dangerous.							Qualitative Benefit: Temper the POT with mitigation policies for risks of different types.
2026-BAR-LP-05	P-5	The incorporation of the risk mitigation perspective in the next update of the POT to ensure that future developments are more resistant to risks. The Territorial Planning Plan (POT) of Barranquitas was approved in 2011 and requires that it be reviewed, comprehensively, every eight (8) years. The analysis of this Mitigation Plan will be incorporated into the update so that qualification codes and development guides can be defined in line with reality current.	All	Moderate	Safety & Security	Office of Territorial Planning and Permits	Municipality of Barranquitas, Planning Board	Medium	Current Status: In progress. The municipality signed an agreement with the Puerto Rico Planning Board for the comprehensive review of the Territorial Planning Plan (RIPOT). This action had not able to be carried out due to budget considerations. The tasks for the updating of the POT have already begun and all the actions defined in this plan and that affect the regulation of land use will be considered. The revision of the POT

New ID	Old ID	Description	Hazard	Priority	Lifeline	Leading Municipal Office	Possible Funding Source	Implementation Term	Current Status and Expected Benefits
									is expected to have been completed by the end of 2026. Qualitative Benefit: Updating the existing conditions of qualification and classification, as well as the programmed and planned development of the municipality. Integration of mitigation policies as a regulatory axis.
2026-BAR-LP-06	P-6	Inventory of households in Special Communities that are vulnerable to structural damage from hurricane winds for structural reinforcement. This activity needs to be expanded to include commercial, industrial and critical facilities. Although it is an ambitious effort, the size of the municipality would allow for a general inventory of structures in which their condition and construction material can be determined. The inventory will be created through a Geographic Information System (GIS).	Tropical Storms	Moderate	Housing	Office of Spatial Planning and Permitting, Office of Municipal Emergency Management, Federal Programs, and Citizen and Family Services	Municipality of Barranquitas, FEMA	Medium	Current Status: In progress. This action is very ambitious and has had to be modified due to lack of funds and trained personnel to be able to carry out the tasks described in the action. An inventory began to be drawn up with the location (geographical coordinates), name of the facility, type and address. Qualitative Benefit: Inventory of structures to determine risk and exposure.
2026-BAR-LP-07	P-7	Requirement that all new construction be in accordance with the International Building Code (IBC), International	Tropical Storm, Flooding	Moderate	Safety & Security, Housing	Territorial Planning and	The financing of the works will be by private	Immediate	Current Status: This measure has been reached, but it is maintained as an update of the building codes

New ID	Old ID	Description	Hazard	Priority	Lifeline	Leading Municipal Office	Possible Funding Source	Implementation Term	Current Status and Expected Benefits
		Residential Code (IRC) and the construction regulations in force in Puerto Rico. This will allow all new structures to contemplate a greater degree of protection and resilience than those already built, minimizing the risk of damage in this type of event. Currently, all legal construction must be governed by the regulations established in the Puerto Rico Building Code 2011 (amended 2012) and other current regulations. The Office of Territorial Planning and Permits has adopted this code guide and intends to do the same once are updated.				Permits of the Municipality and the Office of Permit Management	and/or public investment, as applicable.		is expected. The municipality, through its permitting office, maintains faithful compliance with current building regulations and codes. Qualitative Benefit: Guarantee that all new construction complies with current standards in a way that protects the integrity of the property guaranteeing its resilience.
2026-BAR-LP-08	P-8	Incorporate regulations in the revision of the Barranquitas Territorial Plan regarding the regulation of construction in areas of high seismic risk. In the next update of the Barranquitas Territorial Plan, the necessary regulations must be incorporated to safeguard compliance with all current construction regulations. Based on the analyses of this Plan, development in high-risk areas must be prevented seismic.	Earthquake	Moderate	Safety & Security	Office of Territorial Planning and Permits	Municipality of Barranquitas	Medium	Current Status: The municipality is in the process of a comprehensive review of the Territorial Planning Plan (RIPOT), so all the actions defined in this plan that affect the regulation of land uses will be considered. The cost associated with the revision of the POT is being subsidized by the Puerto Rico Planning Board. Qualitative Benefit: Prevent development in areas with significant seismic hazard

New ID	Old ID	Description	Hazard	Priority	Lifeline	Leading Municipal Office	Possible Funding Source	Implementation Term	Current Status and Expected Benefits
									exposure.
2026-BAR-LP-09	P-9	Preparation of a hydrological/hydraulic (HH) study for the urban area of the Municipality of Barranquitas. A hydrological/hydraulic study will allow determining the runoff flows under existing conditions and severity. With this study, flood mitigation and control alternatives can be evaluated.	Flooding	Moderate	Transportation, Safety & Security	Office of Territorial Planning and Permits and Municipal Public Works	FEMA, EPA, DRNA, University Institutions	Long	Current Status: The municipality will carry out an evaluation of this measure to identify priority and more specific areas. No funds have yet been identified for this activity. The analysis and determination of areas will be carried out in the first 12 months after the approval of the plan. QualitativeBenefit: Mitigate flood-prone areas, preventing flood development and assessing potential damage to properties already built.
2026-BAR-LP-10	P-10	Requirement that all new construction be in accordance with the International Building Code, International Residential Code, and the building regulations in force in Puerto Rico. Through the implementation of Regulation #13 (Regulations for Flood Control) of the Planning Board and the "International Building Code", parameters will be established so that structures and	Flooding	Moderate	Housing, Safety & Security	Office of Territorial Planning and Permits	Municipality of Barranquitas	Immediate	Current Status: This measure has been reached, but it is maintained as an update of the building codes is expected. The municipality, through its permitting office, maintains faithful compliance with current building regulations and codes. During the implementation of this measure, no problems have been identified with properties

New ID	Old ID	Description	Hazard	Priority	Lifeline	Leading Municipal Office	Possible Funding Source	Implementation Term	Current Status and Expected Benefits
		facilities are built or rehabilitated in accordance with the established requirements. Likewise, compliance with the National Flood Insurance Program is ensured (NFIP).							within the flood zone of the municipality. Qualitative Benefit: Mitigate flood-prone areas, prevent flood development and assess potential damage to properties already built.
2026-BAR-LP-11	P-11	Develop strategies to manage the effect of a prolonged drought. Develop a plan that facilitates communication between PRASA and the municipality, so that the community can be kept informed. Coordinate with PRASA the response to prolonged drought situations that require the establishment of water rationing and the establishment of oases or water distribution locations. Given the importance of the agricultural industry in the municipality, support mechanisms will be designed to be able to maintain this industry in the event of prolonged drought.	Drought	Moderate	Food, Hydration, Shelter	Mayor's Office and City Emergency Management	Municipality of Barranquitas, AAA	Short	Current Status: The municipality has been coordinating with PRASA the supply of water during drought events as well as in situations of interruptions of drinking water service. This is an ongoing measure, so it remains in this plan. Qualitative Benefit: Mitigate damage to the agricultural sector. Provide water supply alternatives to the community in general.
2026-BAR-LP-12	P-12	Establish the necessary regulation, through the POT, to encourage the use of permeable surfaces in parking areas. Every developed area has an impact on	Droughts, Flooding	Low	Transportation, Safety & Security	Territorial Planning and Permitting Offices	Municipality of Barranquitas	Medium	Current Status: The municipality is in the process of a comprehensive review of the Territorial Planning Plan (RIPOT), so all the actions

New ID	Old ID	Description	Hazard	Priority	Lifeline	Leading Municipal Office	Possible Funding Source	Implementation Term	Current Status and Expected Benefits
		the way and way soils are waterproofed, which does not allow aquifers to be recharged. This in turn causes rainwater runoff to cause flooding or simply be discharged to a larger tributary without the opportunity to nourish the subsoil. This problem is most clearly visible in parking lots, which are waterproof in large areas. Providing this type of permeable infrastructure would improve the quality of life and general aesthetics in the developments while providing protection and recharge our aquifers. In the same way, it would contribute to the fulfillment of the Management Plan for Storm Runoff (SWWMP).							defined in this plan that affect the regulation of land uses will be considered. The measure is expected to be implemented once the review of the POT begins and after the approval of the Plan. Qualitative Benefit: Minimize the direct flow of surface runoff. Avoid contamination of water bodies and improve their quality.
2026-BAR-LP-13	P-13	Inventory of facilities that handle hazardous and/or toxic products. The Municipality of Barranquitas has industries, state facilities and businesses which maintain and work with hazardous, volatile or toxic materials. Examples of this are water treatment plants, service stations and factories, among others. Using the EPA's CERCLA inventory and the general infrastructure inventory as a basis, those industries or businesses within the	All	Moderate	Hazardous Materials, Health & Medical, Safety & Security	Mayor's Office, Office of Territorial Planning and Permits, Office of Emergency Management and Municipal	Municipality of Barranquitas, FEMA, EPA, JCA	Short	Current Status: Completed. The EPA CERCLA inventory map has already been completed and incorporated into the municipality's planning framework. Qualitative Benefit: Avoid potential spills or environmental accidents that put the life and property of the inhabitants of Barranquitas at risk.

New ID	Old ID	Description	Hazard	Priority	Lifeline	Leading Municipal Office	Possible Funding Source	Implementation Term	Current Status and Expected Benefits
		municipal scope that may be at risk during a disaster event will be documented. In this way, the best techniques can be coordinated with these industries of response in the event of a disaster.				Public Works.			
2026-BAR-LP-14	P-14	Maintain an inventory in the Municipal Emergency Management Office of the occurrence of fires in the Municipality of Barranquitas.	Wildfires	Low	Safety & Security, Housing	Municipal Emergency Management Office in collaboration with the Fire Department of Puerto Rico	Federal State Municipal	Short	Current Status: In progress. This is an activity of an ongoing nature. Information was requested from the Fire Department and OMME. Qualitative Benefit: Avoid potential spills or environmental accidents that put the life and property of the inhabitants of Barranquitas at risk.

Table 49: Mitigation Strategies - Property Protection

New ID	Old ID	Description	Hazard	Priority	Lifeline	Leading Municipal Office	Possible Funding Source	Implementation Term	Current Status and Expected Benefits
2026-BAR-PP-01	PP-1	Implementation of a modernization or upgrade program to make critical facilities resilient hurricane-force winds. This activity requires consideration of the effects of hurricane-force winds on facilities critical to the functioning of the municipality and its response capacity. An evaluation of the facilities and the type of measure will be carried out, such as; storm shutters, installation of electric generators and any other action that reduces vulnerability to this type of event. Priority facilities will be identified, and the most recent events (Hurricane Irma and Maria) will be used as a frame of reference, as well as the most recent building codes.	Tropical Storms	Moderate	Safety & Security, Energy, Health & Medical	Mayor's Office, Office of Planning and Permitting, Federal Programs, and Office of Citywide Emergency Management	Municipality of Barranquitas, FEMA	Medium	Current Status: In progress. HMGP projects 4339-0221 (OMME) and 4339-0222 (Municipal Command): storm shutter projects for both facilities, in progress. It is expected to be completed in or before October 2026. Projector 4339-0153 (OPP) was completed in November 2024. In the same way, the Mirador was enabled with storm shutters as part of its renovation and repair of post-Maria damage. Qualitative Benefit: Protection and security of the municipality's property and personnel.
2026-BAR-PP-02	PP-2	Inventory of municipal facilities to determine their seismic-resistant capacity and develop recovery and reconstruction strategies after an earthquake. Due to the date of construction in combination with the local geology, all municipal structures are exposed to substantial damage in	Earthquake	Moderate	Safety & Security, Housing	Territorial Planning and Permits, Municipal Emergency Managem	Municipality of Barranquitas, FEMA	Long	Current Status: This measure has been discarded due to the cost of it. It will be resumed if the source of funds is identified.

New ID	Old ID	Description	Hazard	Priority	Lifeline	Leading Municipal Office	Possible Funding Source	Implementation Term	Current Status and Expected Benefits
		a seismic event. Municipal facilities will be evaluated, starting with those that are critical and of priority; to determine the need to carry out structural reinforcement works ("retrofitting"). Also, non-structural reinforcement works will be evaluated in the interiors of municipal facilities, such as the attachment of archives, shelves and furniture. To observe the faithful compliance with the current standards of seismic-resistant construction as established in the most recent "International Building Code", "International Residential Code" and the construction regulations in force in Puerto Rico.				ent and Municipal Public Works			
2026-BAR-PP-03	PP-3	Coordination of multi-agency efforts for the inspection and certification of seismic resistance to all public schools in the Municipality of Barranquitas. Currently, the municipality's public schools, which are operating, serve as shelters for disaster events. To safeguard the lives of students and preserve disaster shelters in optimal conditions, it is necessary to evaluate all public schools and determine which ones need structural reinforcement	Earthquake	Moderate	Safety & Security, Food, Hydration, Shelter	Mayor's Office, Office of Municipal Emergency Management, and Department of Education	FEMA, Department of Education, CDBG-R	Short	Current Status: This measure was reached. The Department of Education carried out mitigation of the short columns in the two schools that are active and open in the municipality. Qualitative Benefit: Protection and security of the municipality's property and personnel.

New ID	Old ID	Description	Hazard	Priority	Lifeline	Leading Municipal Office	Possible Funding Source	Implementation Term	Current Status and Expected Benefits
		measures ("retrofitting") and non-structural.							
2026-BAR-PP-04	PP-4	Inventory of properties in areas identified as having high potential for landslides. An inventory of properties located in areas of high risk of landslides will be created and a priority will be assigned according to vulnerability and the total number of families/individuals affected. This inventory will serve as a tool to determine the actions necessary to protect the lives of citizens. Actions can range from construction of support elements to the relocation of families.	Landslide	Moderate	Safety & Security, Housing	Mayor's Office, Office of Spatial Planning and Permitting, Office of Municipal Emergency Management, Citizen and Family Services.	Municipality of Barranquitas, CIAPR, Puerto Rico Seismic Network, Junior Institutions, FEMA	Long	Current Status: This measure has been discarded due to the cost of it. It will be resumed if the source of funds is identified.
2026-BAR-PP-05	New	Establish energy resilience for the municipality (Finance Office) through the incorporation of a system of plates and electric generator that guarantees the continuity of operations during events of lack of power and disasters.	All	High	Energy	Finance Office	FEMA, CDBG-DR	Medium	Current Status: This is a new measure that arises from the need for continuity of services in events of general blackouts or disasters. Estimated cost is $200,000.00. Qualitative Benefit: Maintain the continuity of the municipality's

New ID	Old ID	Description	Hazard	Priority	Lifeline	Leading Municipal Office	Possible Funding Source	Implementation Term	Current Status and Expected Benefits
									critical infrastructure for the continuity of operation in the event of disasters.
2026-BAR-PP-06	New	Establishment of a municipal ordinance to address the problem of public nuisances. Public nuisances are a threat to public health and safety, so they will establish the mechanisms in law for their elimination.	All	High	Safety & Security, Health & Medical	Mayor's Office	Municipal, collaborative agreements	Immediate	Current Status: In progress. On September 25, 2025, Ordinance Number 1 Series: 2025-2026 was approved, establishing a Program for the Eradication of Public Nuisances. Qualitative Benefit: Address public health and safety issues. Improve the quality of life of communities.

Table 50: Mitigation Strategies - Structural Projects

New ID	Old ID	Description	Hazard	Priority	Lifeline	Leading Municipal Office	Possible Funding Source	Implementation Term	Current Status and Expected Benefits
2026-BAR-SP-01	SP-1	Structural projects for mitigation in areas impacted by landslides. In the previous Plan, some 13 projects were defined to mitigate landslides under emergency declaration #4017-2011 (Hurricane Irene). These projects totaled approximately $301,000.00. They	Landslide	Moderate	Safety & Security, Transportation	Office of Territorial Planning and Permits	Municipality of Barranquitas, FEMA	Medium	Current Status: Action completed. Qualitative Benefit: Restoration and improvements to municipal infrastructure.

		had been defined in activities #42 to #52. As for disaster declaration #4339 (Hurricane Maria), a total of 180 projects were identified to be carried out under Category C and 72 facilities for a total of 252. The details of each of these intervention projects can be found in Appendix B.3 of this document.							
2026-BAR-SP-02	SP-2	Structural projects for mitigation in areas impacted by floods. The municipality has identified places that have been affected by the floods, caused by the effects of hurricanes Irma and Maria. These projects, for the most part, consist of bridges that provide access to communities which are isolated, causing interruption of services and their daily lives. For the 2012 Plan, the municipality had identified some 31 bridge replacement projects that were affected by Hurricane Irene (emergency declaration #4017-2011). These projects totaled approximately $1,300,00.00. The details of each of these intervention projects can be found in the Appendix B.3 to this document.	Flooding	Moderate	Transportation, Safety & Security	Office of Territorial Planning and Permits	Municipality of Barranquitas, FEMA	Medium	Current Status: In progress. As of today, 23 projects (Category C) have been completed for a total of $2,934,000.00. Currently, there are 96 projects (Maria and Fiona) in different stages of progress (design, construction, etc.). Qualitative Benefit: Mitigation of areas vulnerable to flooding.

Table 51: Mitigation Strategies: Natural Resources Protection

New ID	Old ID	Description	Hazard	Priority	Lifeline	Leading Municipal Office	Possible Funding Source	Implementation Term	Current Status and Expected Benefits
2026-BAR-NR-01	NR-1	Study on climate change and its potential for damage to the municipality. The Municipality of Barranquitas has a large agricultural area. This can be affected by climate change, creating a socioeconomic dislocation in the population. Both periods of intense rainfall and prolonged droughts are some of the effects of climate change. These directly impact the economy of the municipality. For this reason, a detailed study should be carried out aimed at mitigating the impact of events, specifically, in this commercial area of the municipality.	Climate Change	Low	Food, Hydration, Shelter	Mayor's Office, Office of Spatial Planning, and Federal Permits and Programs	Municipality of Barranquitas, FEMA, EPA, USDA, University Institutions	Long	Current Status: This action is withdrawn due to the new federal policy that restricts access to funds for this type of activity. Alternatives will be sought with the Inter-American University and the Department of Agriculture to determine if there are previous studies and actions that address this problem.
2026-BAR-NR-02	NR-2	Encourage the use of technologies that reduce greenhouse gas emissions and fossil fuel consumption. The municipality will establish public policy to direct efforts to reduce emissions of gases that contribute to the greenhouse	Climate Change	Moderate	Energy	Mayor's Office, Office of Planning and Permitting, Federal Programs	Municipality of Barranquitas, FEMA, EPA, CDBG-R, Senate of Puerto Rico, University Institutions.	Long	Current Status: Withdrawn. This action has been postponed until funds can be identified for its implementation and that it is in line with federal public policy. Law No. 33 of May 22, 2019, better known as the "Puerto Rico Climate Change

New ID	Old ID	Description	Hazard	Priority	Lifeline	Leading Municipal Office	Possible Funding Source	Implementation Term	Current Status and Expected Benefits
		effect, acquiring vehicles that are more economical and efficient. In the same way, municipal facilities will be evaluated so that technologies that reduce the carbon footprint can be incorporated (photovoltaic cells, LEED lighting, etc.). Currently, Senate Bill 773 is under evaluation and is aimed at addressing the effect of climate change over Puerto Rico.				and Municipal Public Works			Mitigation, Adaptation and Resilience Act". Qualitative Benefit: Improve air quality and the environment in general. Contribute to the reduction of greenhouse gases by reducing the consumption of fossil fuels.
2026-BAR-NR-03	NR-3	Reforestation and greening campaigns of public and private areas. Due to recent climatic events, the island in general has lost much of its forests and vegetative cover. For this reason, coordination between state agencies and the municipality should begin with reforestation in public areas, with suitable trees and plants. In this way, a more pleasant atmosphere can be created, thus eliminating the "heat island" effect. In the private sector, companies, businesses and citizens can be incorporated to encourage and educate them	Extreme heat	Moderate	Health & Medical	Recycling Office	Municipality of Barranquitas, DNER, EPA, Para La Naturaleza, Conservation Trust	Short	Current Status: Task continues. The organization Para La Naturaleza has carried out reforestation campaigns since 2020, achieving the planting of 19,609 native and/or endemic trees in the municipality of Barranquitas. Mostly around the San Cristobal Canyon and some schools. Qualitative Benefit: Conservation of resources, improving the quality of the environment by reforesting and conserving green areas.

New ID	Old ID	Description	Hazard	Priority	Lifeline	Leading Municipal Office	Possible Funding Source	Implementation Term	Current Status and Expected Benefits
		on the importance of reforestation and conservation of green areas.							
2026-BAR-NR-04	NR-4	Storm-Water Management (SWM) Plan and the adoption of SWM regulations for consideration of future urban developments. The Runoff Water Management Plan (SWWMP) was developed in 2014 and is continuously implemented. This plan is part of compliance with the federal regulation of "Clean Water Act"; but its application impacts the management of rainwater runoff and therefore addresses part of the flooding problems throughout the Municipality. The plan functions as a mechanism for identifying problems, outlining solutions, and establishing construction costs for stormwater system improvements. The purpose of this plan is the elimination of polluting sources that affect the different bodies of water and through the execution of this program, the risk of flooding.	Flooding	Moderate	Safety & Security, Transportation	Municipal Public Works and Territorial Planning and Permits	Municipality of Barranquitas, EPA„CDBG-R	Short	Current Status: In progress. Some goals and actions contained in the plan have been completed, such as inventories of storm drains and discharge areas ("outfalls"). A comprehensive review of the plan for 2027 is proposed but will depend on the identification and allocation of funds. Qualitative Benefit: Improves water quality through the identification and mitigation of pollutant sources, while reducing flood risk by enhancing stormwater management and drainage system performance.

Table 52: Mitigation Strategies - Emergency Services

New ID	Old ID	Description	Hazard	Priority	Lifeline	Leading Municipal Office	Possible Funding Source	Implementation Term	Current Status and Expected Benefits
2026-BAR-ES-01	ES-1	Establishment of a robust and resilient municipal communication network that allows operation after a disaster. Recent events have shown that traditional communications were affected to the point of being totally cut off between the different departments of the municipality and outside the municipality. It is intended to acquire and establish radio frequency equipment which can be used during a disaster event ("Public Safety Radios"). In addition, coordination between operators of local radio ("Amateur Radio a.k.a ham radio").	All	Moderate	Communications, Safety & Security	Mayor's Office, Municipal Emergency Management Office	Municipality of Barranquitas, FEMA, Homeland Security	Short	Current Status: Action achieved. The municipality has a communication network (radio) that provides communication to the different agencies in times of emergency or disaster. Qualitative Benefit: Maintain constant communication during an emergency.

Table 53: Mitigation Strategies – Education and Outreach

New ID	Old ID	Description	Hazard	Priority	Lifeline	Leading Municipal Office	Possible Funding Source	Implementation Term	Current Status and Expected Benefits
2026-BAR-EO-01	CAI-1	Preparation of an educational portal on the Internet where all the information concerning how to mitigate the effects associated with the risks identified for the area of the Municipality of Barranquitas will appear.	All	High	Communications, Safety & Security	Mayor's Office, Office of Emergency Management and Spatial Planning and Permitting	Municipality of Barranquitas	Medium	Current Status: Action completed. This measure is modified to establish the municipality's social networks as a mechanism for disseminating information. Currently, the municipality transmits important information through Facebook and Instagram. Qualitative Benefit: Keep the communities that make up the municipality informed and alert.
2026-BAR-EO-02	CAI-2	Implement local emergency response and recovery planning programs for businesses and industries in Barranquitas. Barranquitas has an important industrial base among which are educational services, retail trade and agriculture as main components. In coordination between the Mayor's Office and Municipal Emergency Management, orientation activities will be carried out regarding the risks associated with the different events analyzed in the Plan. In addition, they will work on disaster	All	Moderate	Safety & Security	Mayor's Office and the Municipal Emergency Management Office	Municipality of Barranquitas	Immediate	Current Status: In continuous execution. Annually, the OMME conducts emergency management drills in schools and NGO's. Qualitative Benefit: Maintain familiarity with all the tools and policies for responding to different events.

New ID	Old ID	Description	Hazard	Priority	Lifeline	Leading Municipal Office	Possible Funding Source	Implementation Term	Current Status and Expected Benefits
		response plans that ensure the continuity of services and operations of the different components of the economy municipal.							
2026-BAR-EO-03	CAI-3	Conduct educational and informational campaigns on the effects and dangers of extreme heat. According to recent studies, extreme heat is a risk factor for the population of Puerto Rico. Infants and older adults will be more susceptible to extreme heat conditions. As a measure of protection, notices and bulletins will be established, through the media and social networks, to alert citizens during these events. Activities, workshops, orientations and educational campaigns will be developed on the effects and dangers of extreme heat.	Extreme Heat	Moderate	Health & Medical, Safety & Security	Mayor's Office, Office of City Emergency Management, and Citizen and Family Services.	Municipality of Barranquitas	Short	Current Status: In continuous execution. Alerts and information are established through the municipality's social networks and eventually, on the website. Qualitative Benefit: Communicate and educate about the dangers of extreme heat, especially to the most vulnerable people.
2026-BAR-EO-04	CAI-4	Orientation activities and workshops for the community in general to raise awareness about the importance of its properties and content being seismic-resistant. Most of the residential properties in the municipality were built prior to the seismic-resistance codes. For this reason, workshops will be offered to residents, merchants, industrialists and	Earthquake	High	Safety & Security	Mayor's Office, Office of Planning and Permitting, Office of Municipal Emergency Management	Municipality of Barranquitas, College of Engineers and Land Surveyors , Puerto Rico Seismic Network,	Short	Current Status: In continuous execution. They promote and participate in all the activities of the Puerto Rico Seismic Network (Caribe Wave) annually. Qualitative Benefit: Maintain awareness and education about seismic events.

New ID	Old ID	Description	Hazard	Priority	Lifeline	Leading Municipal Office	Possible Funding Source	Implementation Term	Current Status and Expected Benefits
		the community in general, so that they can assess the vulnerability of their properties and take the necessary corrective measures. Drills will be carried out on how to act during and after a seismic event, as well as publications of brochures on the different social networks. The carrying out of an annual activity will be coordinated during the term of the Plan.					College of Architects and Landscape Architects of Puerto Rico, University Institutions		
2026-BAR-EO-05	CAI-5	Carry out prevention and awareness campaigns about forest or brush fires. Cleaning and maintenance campaigns for green areas will be established, as well as the removal of abandoned structures, accumulation of waste and other materials that can serve as accelerants in a fire. Coordination will be done with the Puerto Rico Fire Department for the maintenance and overhaul of hydrants, as well as routine inspections of the area that are most prone to these types of events. Collaborative agreements will be established so that the municipality to serve as direct support in the response and management of the event.	Wildfires	Low	Safety & Security	Municipal Emergency Management Office	Municipality of Barranquitas, Puerto Rico Fire Department	Short	Current Status: Between 2021 and 2025, the Puerto Rico Fire Department reported a total of 236 fires. Now there is no data on how many of these fires were forest fires. Qualitative Benefit: Prevention and awareness of forest and brush fires that can affect life and property.
	CAI-6		Drought	High			Municipality	Immediate	

New ID	Old ID	Description	Hazard	Priority	Lifeline	Leading Municipal Office	Possible Funding Source	Implementation Term	Current Status and Expected Benefits
2026-BAR-EO-06		Awareness and education to the public about the importance of the natural resource water. Provide workshops and talks on the importance of water resources (water). Coordinate with state agencies to establish collaborative agreements to bring information to the community in a more agile way. Educate communities on the most effective ways to conserve water, as well as protect water quality by avoiding contamination of water bodies.			Food, Hydration, Shelter, Health & Medical	Mayor's Office, Municipal Emergency Management Office	of Barranquitas, AAA, JCA, EPA		Current Status: In continuous execution. Recycling Office- constantly and throughout the year, talks are given to students about the importance of protecting water resources through the proper management of waste and pollutants that may reach the tributaries. Qualitative Benefit: Awareness about the use and management of water resources, with special attention during drought events.

6.5 Participation in NFIP (C2-a)

Covered under the PRPB, the Municipality maintains continuous participation in the National Flood Insurance Program (NFIP) and remains committed to meeting all program requirements to reduce flood risk and protect life and property. Ongoing participation in the NFIP enables residents and businesses to access federally backed flood insurance while promoting sound floodplain management practices. The PRPB, on the municipality's behalf, enforces floodplain management regulations consistent with FEMA requirements, including the adoption and use of Flood Insurance Rate Maps (FIRMs) and Flood Insurance Studies (FIS) for development decisions. Local permitting, inspection, and enforcement activities help ensure that new construction and substantial improvements in Special Flood Hazard Areas comply with applicable elevation and floodproofing standards. The Municipality also supports public awareness and education activities related to flood risk, insurance requirements, and mitigation measures. Continued compliance with the NFIP strengthens eligibility for federal hazard mitigation funding and supports the long-term reduction of flood-related damages.

7. Plan Maintenance

This chapter outlines the actions required to ensure that the Plan's activities are effectively implemented, kept up to date, and aligned with the mitigation goals and objectives. In some cases, updating the Plan may involve amending proposed activities due to changes in on-site conditions that could increase or decrease the level of risk to which certain areas are exposed.

In accordance with federal requirements, the Local Hazard Mitigation Plan (LHMP) review process must include the following elements:

- A section describing the method and schedule for monitoring, evaluating, and updating the Mitigation Plan within a five-year period.
- A process for integrating the Mitigation Plan's requirements into other local planning mechanisms, such as comprehensive plans or capital improvement plans, when appropriate.
- A discussion of how the community will continue to participate in the Plan's review process.

7.1 Point of Contact

The designated point of contact for the monitoring, revision and update of the Barranquitas LHMP is:

Table 54: Point of Contact Information

Name	
Position	
Office	
Telephone Number	
Email	

7.2 Public Participation Continuation (D1-a)

The Municipality of Barranquitas is committed to ensuring ongoing public participation by implementing the following engagement methods:

- Public education and awareness initiatives

- Surveys
- Community workshops and meetings held throughout the municipality

Accordingly, the municipality commits to fostering public participation and community education. This commitment is reflected in several mitigation strategies described in this Plan. The public is encouraged to provide comments and take part in the LHMP's updates at any time, including requesting a copy of the LHMP—both during its development and throughout its monitoring and maintenance phases.
Additionally, each time a progress report is completed for this Plan, a copy will be made available for public review. Progress will also be periodically discussed in public meetings and shared through various social media and communication channels. The municipality will ensure that public participation notices are disseminated throughout the Plan's monitoring and oversight stages.

The municipality will also provide regular presentations to community groups regarding the LHMP's content and the progress of mitigation strategy implementation. These groups may include elected officials, schools, and other community organizations. Furthermore, the municipality will continue to promote civic engagement and community education by offering courses and workshops—such as CERT—focused on preparedness and response to hazardous events, as well as informing residents about components of the NFIP and other relevant programs.
These natural hazard-mitigation efforts must be adapted to the specific vulnerabilities and needs of each community. This approach will help build a more prepared and resilient population. This principle underpins the municipality's commitment to ensuring that the community remains engaged throughout the Plan's update cycle, its effective period, and subsequent processes following the Plan's adoption

7.3 LHMP Oversight (D2-a)

The municipality's review strategy for implementation, monitoring, and evaluation provides a framework that encourages collaboration, information-sharing, and innovation. Through multiple implementation methods, the municipality—acting through its Planning Committee, which is composed of representatives from various municipal agencies and departments—will work with its partners and residents to apply a localized approach to loss reduction while addressing community needs through coordinated efforts. This strategy aims to break the cycle of disasters and strengthen the municipality's ability to withstand future events.

The Plan will be monitored:

- To maintain accurate information regarding hazards and risks.
- To ensure that mitigation strategies reflect the priorities of participating communities and stakeholders.
- To comply with federal and Puerto Rico government requirements for LHMP review.
- To maintain eligibility for mitigation funding.
- To ensure that the Plan remains aligned with other planning efforts.

To ensure efficient and effective implementation, the municipality will make use of its existing capabilities and infrastructure planning processes. The municipality intends to carry out the mitigation strategies identified as immediate or short – term in the LHMP over the next five (5) years, or for as long as funding and resources allow.

7.4 LHMP Evaluation and Monitoring

The evaluation of the LHMP will be continuous. In addition to the five-year review required by FEMA, the municipality will conduct an annual review of the LHMP, or more frequently if circumstances require it. A meeting of the Planning Committee will be held after each annual review to approve a yearly progress report. Each year, a progress report will be prepared and submitted to the Office of the Mayor, documenting any updates to its information as well as any progress made toward achieving the mitigation goals and objectives. This report will be available to the public

A preliminary schedule to hold the Planning Committee report is as follows:

Table 55: Preliminary Planning Committee Meeting Schedule

Time Period	Participants	Purpose of the Meeting
Annual Meeting (2027)	Planning Committee (Can be open to the public if deemed necessary)	The Committee members will hold the first annual meeting to identify the funding needed to implement the mitigation measures included in this LHMP, reassess the municipality's priorities regarding natural hazards or risk areas, and develop a strategy for submitting proposals to various state and federal programs. In addition, site visits will be conducted to review at-risk areas, monitor project progress, and establish direct communication with the communities.

Time Period	Participants	Purpose of the Meeting
Annual Meeting (2028)	Planning Committee (Can be open to the public if deemed necessary)	The Committee will hold the annual meeting during the second year of the LHMP's approval to review the status of mitigation strategy implementation, identify emerging risks, and assess community needs. Site visits to at-risk areas will also be conducted, as needed, to track project progress and maintain direct engagement with the communities.
Annual Meeting (2029)	Planning Committee (Can be open to the public if deemed necessary)	The Committee will meet to confirm the status of mitigation action implementation and determine whether additional funding is required to continue progress.
Annual Meeting (2030)	Planning Committee (Can be open to the public if deemed necessary)	The Committee will hold its final meeting before the next LHMP review/update to verify the implementation status of mitigation actions, which will be documented in the upcoming Plan revision.

7.5 LHMP Update and Revision (D2-c, D3-a)

7.5.1 Revision Following a major disaster

Should a future emergency or disaster declaration include the municipality in the five-year term of the LHMP, the Planning Committee—together with stakeholders, community representatives, and nonprofit organizations—will convene a meeting to identify new risk areas, affected communities, opportunities to implement mitigation strategies, and to update the municipality's mitigation priorities. This process will also help capture lessons learned from the event and support the updating of this document. This meeting will replace the annual meeting scheduled for that year.

7.5.2 Five – Year Comprehensive Update

As per federal guidance, this LHMP will be updated five (5) years after its approval and will be submitted to the SHMO and the Federal Emergency Management Agency (FEMA) for the corresponding review and approval. This update will include a comprehensive review of the whole LHMP, including, but not limited to municipal profile, risk assessment and mitigation strategies. Approximately eighteen (18) months

before the LHMP's expiration date, the Planning Committee and the municipality will begin the review process, paying particular attention to any new requirements and guidance.

7.6 LHMP Integration with other Planning Mechanisms (D3-a)

The following public policies and planning documents were considered in the development of this LHMP:

Commonwealth Level:

- Puerto Rico Land Use Plan (PUT-PR)
- Barranquitas Territorial Plan (PT)
- Karst Special Planning Area Plan and Regulation
- Joint Regulation for the Evaluation and Issuance of Permits
- Special Flood Hazard Areas Regulation (2021)
- Stormwater System Design, Operation, and Maintenance Regulation
- Barranquitas Emergency Operations Plan

Following adoption, the LHMP will guide updates to the Territorial Plan, special area plans, and urban expansion plans, and will inform municipal budget priorities. Once FEMA approval is received, a digital copy of the Plan will be submitted to the Puerto Rico Planning Board to support updates to the PUT-PR and other relevant Commonwealth planning documents.

8. Adoption and Approval (F1-a, F1-b)

8.1 LHMP Adoption

Federal policy establishes LHMPs must include "Documentation that the LHMP has been formally adopted by the governing body of the jurisdiction requesting approval of the Plan. The municipality has one (1) year to adopt the Plan once it receives an Approval Pending Adoption (APA)16.

This LHMP was adopted by the Municipality of Barranquitas on XXXXXX. A copy of Resolution, titled "To Adopt the 2026 Natural Hazard Mitigation Plan of the Municipality of Barranquitas and for Other Related Purposes," is included as part of Appendix A.

8.2 LHMP Approval

This LHMP was approved by FEMA and the SHMO on **XXXXX**. A copy of the Approval Letter, titled *"Approval of the Local Hazard Mitigation Plan, Municipality of Bayaón,"* is included in **Appendix A**. FEMA's approval of the Plan is valid for a period of **five (5) years**, through **XXXXXX**

[16] 44 C.F.R. §201.6(c)(5)

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Appendix A: Adoption and Approval

Adoption

To be included in the Final Version

Approval by FEMA

To be included in the final version

FEMA APA Letter FEMA

To be included in final version

Review Tool Sheet

To be included after the second public meeting.

Appendix B: Planning Committee

Commitment letter

JUNTA DE
PLANIFICACIÓN
GOBIERNO DE PUERTO RICO

Carta de Compromiso sobre el Plan de Mitigación Municipal

El Municipio de Barranquitas, representado en este acto por su alcalde, Hon. Elliot Colón Blanco, mediante el presente documento denominado carta de compromiso se compromete en conjunto con la Junta de Planificación de Puerto Rico (JPPR) trabajar en la revisión y actualización del plan de mitigación contra peligros naturales municipal (Plan). El mismo tiene el objetivo de identificar actividades y medidas dirigidas a la mitigación de peligros naturales tales como huracanes, inundaciones, sequías, terremotos, deslizamientos, tsunami entre otros que apliquen. El Plan tiene dentro de sus prioridades la reducción de pérdidas de vida y propiedad asociado a los diferentes peligros naturales e identificar medidas para atender las necesidades del municipio y sus residentes de manera planificada y ordenada, promoviendo así el desarrollo sostenido mediante la preservación de la función natural y los beneficios de la conservación de los recursos naturales y la infraestructura.

Observando los planes que se han vencido, y están próximos a vencer, la *Oficina Central de Recuperación, Reconstrucción y Resiliencia* (COR3 por sus siglas en inglés) procedió asignar presupuesto a la JPPR para atender la revisión y actualización de los Planes de Mitigación Contra Peligros Naturales de los municipios. Es importante destacar que los planes de mitigación deberán estar aprobados por la Agencia Federal para el Manejo de Emergencias (FEMA por sus siglas en inglés) para evitar que los municipios pierdan los fondos asignados para la ejecución de los proyectos. Por lo tanto, recae sobre el municipio la responsabilidad de gestionar adecuadamente su plan, ya que la falta de vigencia conllevaría la pérdida de dichos fondos.

La JPPR está facultada para asistir a los municipios, conforme a la Ley Orgánica de la Junta de Planificación de Puerto Rico, Ley Núm. 75 del 24 de junio de 1975, según enmendada, 23 LPRA., sección 62 (k). Asimismo, la JPPR podrá hacer uso de recursos externos para la elaboración del plan de mitigación.

A su vez el Municipio está facultado a realizar acuerdos con cualquier agencia del Gobierno Central para que este desarrolle o lleve a cabo, en beneficio del Municipio, cualquier estudio, trabajo, obra o mejora pública municipal conforme a lo establecido en la ley Código Municipal de Puerto Rico, Ley Núm. 107 del 13 de agosto de 2020, según enmendada.

Es esencial que este plan cumpla con los requisitos del Acta de Mitigación de Desastre, la cual establece que los gobiernos municipales y estatales que hayan adoptado sus planes de mitigación contra peligros naturales serán elegibles para fondos de mitigación pre-desastre (Pre-disaster Mitigation Act) y post desastre a través del Programa de Subvención para la Mitigación de Riesgos (HMGP), el Predisaster Mitigation (PDM) y el Flood Mitigation Assistance Program (FMAP).

Por lo tanto, el municipio reconoce que la JPPR se comprometerá a coordinar junto al municipio la aprobación del Plan; coordinar la evaluación del Plan por parte del COR3 y FEMA; y efectuar la entrega del Plan aprobado por COR3 y FEMA al municipio.

P.O. Box 41119, San Juan PR, 00940-1119 • 787.723.6200 • jp.pr.gov

El Municipio asignará una persona contacto o empleado municipal designado por el alcalde que será el contacto oficial (POC) del municipio para la coordinación, ejecución y la elaboración de la actualización del plan de mitigación. Esta persona trabajará directamente con el personal designado por la Junta de Planificación en este proyecto.

Asimismo, el Municipio agilizará y tramitará la adopción del plan mediante Orden Ejecutiva o a través de la Legislatura Municipal mediante Ordenanza Municipal. También coordinará en conjunto con la JPPR o el personal autorizado, el proceso de participación ciudadana dentro del término de seis (6) meses para cumplir con lo requerido por la oficina de COR3.

Se coordinará por parte del municipio la recopilación de información necesaria que sea requerida, incluyendo:

- Identificación de todos los Riesgos locales – Descripción de los diferentes eventos ocurridos en el Municipio y los impactos que han tenido en la comunidad.
- Identificación de inventario de activos del Municipio, de considerarse el activo como uno crítico favor de identificar el mismo como activo-crítico.
- Información necesaria para complementar la Tabla de análisis de capacidad.
- Identificación e Implantación de las Medidas / actividades de Mitigación: Lista de proyectos y Plan de Acción describiendo cómo los proyectos serán implantados por prioridades, cómo serán administrados, si son costo-beneficiosos.
- Evaluación del Plan Preliminar.
- Evaluación del Borrador del Plan.
- Evaluación del Borrador Final del Plan.
- Implementación del Plan de Mitigación - Monitoreo, Evaluación y Actualización.
- Realizar los esfuerzos educativos y comunicación necesarios a los diferentes sectores de la ciudadanía de este proceso de actualización del plan.
- La JPPR coordinará con el municipio respecto a cualquier otra información que se requiera.

Este compromiso no implica la erogación de fondos públicos por parte del municipio ni de la JPPR. A su vez, podrá ser terminado por la JPPR o por el Municipio, mediante comunicación escrita dirigida al presidente de la JPPR o al alcalde, según corresponda.

Por lo que, de acuerdo con este compromiso, yo, Hon. Elliot Colón Blanco lo firmo conforme a los mejores intereses del pueblo de Barranquitas.

En San Juan, Puerto Rico, hoy 16 de diciembre de 2025.

Alcalde

Planning Committee Appointments

MUNICIPIO AUTÓNOMO DE BARRANQUITAS
UN GOBIERNO PARA TODOS
787-857-2065 | Apartado 250
Barranquitas, Puerto Rico 00794

NOTIFICACIÓN DE DESIGNACIÓN
Comité de Planificación del Municipio de Barranquitas

Yo, Elliot J. Colón Blanco, alcalde del Municipio de Barranquitas, designo a los siguientes funcionarios y representantes como integrantes del *Comité de Planificación para la actualización del Plan de Mitigación contra Peligros Naturales del Municipio de Barranquitas*, con el deber de apoyar, asesorar, coordinar y evaluar los trabajos de revisión, actualización, implementación y monitoreo del Plan mencionado.

Nombre	Puesto y Oficina	Correo electrónico	Teléfono (Ext.)
Yamilet Guzmán Cartagena	Ejecutiva de Evaluación y Cumplimento de Fondos Federales	yguzman@barranquitas.pr.gov	787-516-6967
Jose Rivera Vazquez	Ayudante Ejecutivo del Alcalde	jrivera@barranquitas.pr.gov	787-376-4351
Miguel A. Zayas Vazquez	Director Oficina Programas Federales	mzayas@barranquitas.pr.gov	787-384-3452
Edwin Rios Aponte	Director Oficina de Permisos y Ordenación Territorial	edrios@barranquitas.pr.gov	939-290-2607

Funciones principales del Comité:

- Coordinar con los trabajos relacionados con la actualización del Plan de Mitigación.
- Participar de talleres, presentaciones y reuniones sobre la actualización del Plan de Mitigación de Riesgos
- Proporcionar información, y datos sobre la evaluación de los riesgos y vulnerabilidades del municipio, así como las capacidades y los proyectos prioritarios de mitigación.
- Asegurar el cumplimiento con los requisitos estatales y federales para la elegibilidad de fondos de mitigación.
- Ayudar a diseñar y proponer acciones y proyectos de mitigación al municipio para fortalecer la resiliencia y reducir los riesgos de desastres.

- Mantener comunicación con la ciudadanía y promover la participación comunitaria en el proceso de mitigación.
- Apoyar la adopción e implantación del Plan de Mitigación.

Esta designación tendrá vigencia inmediata y se mantendrá en efecto hasta que se notifique lo contrario.

Firmada hoy, 18 de febrero de 2026.

Elliot J. Colón Blanco
Nombre

Firma_____
Alcalde Municipio de Barranquitas

JUNTA DE
PLANIFICACIÓN
GOBIERNO DE PUERTO RICO

FORMULARIO PARA DESIGNAR PERSONA(S) CONTACTO(S)
PLAN DE MITIGACIÓN CONTRA PELIGROS NATURALES

Municipio: Barranquitas

	Nombre	Teléfono	Correo electrónico
Personal Designado	Yamilet Guzmán	787-516-6967	yguzman@barranquitas.pr.gov
Personal Alterno	Miguel Zayas	787-384-4352	mzayas@barranquitas.pr.gov

Elliot J. Colón Blanco
Nombre (letra de molde)
Alcalde

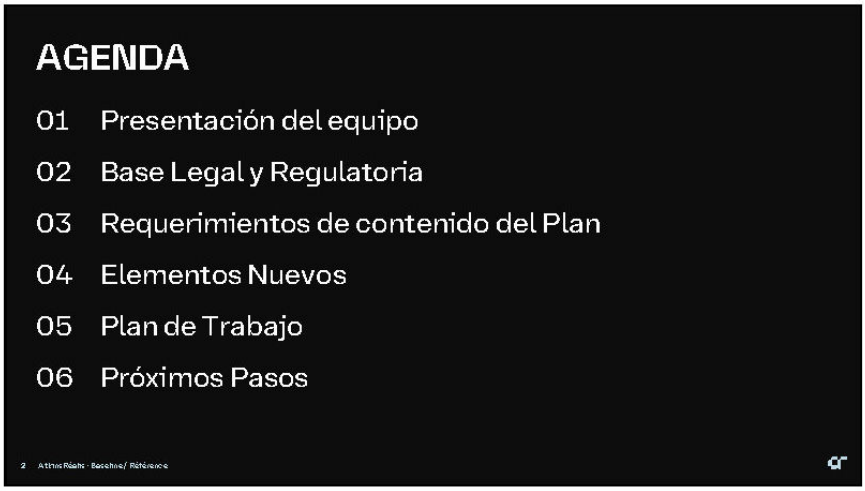
Firma
Alcalde

Fecha: 9 de diciembre de 2025

02/03/2026

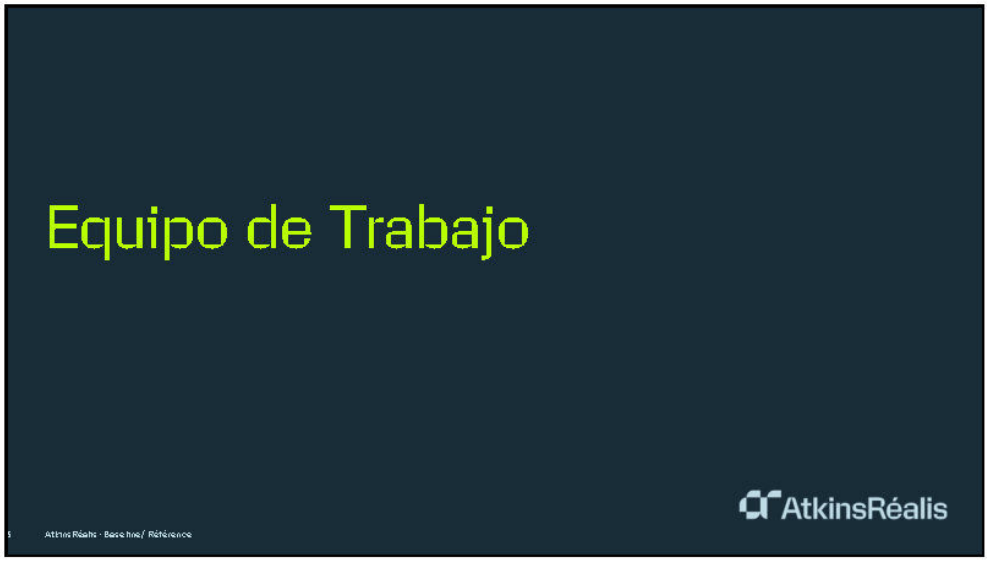


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2

1


Equipo de Trabajo
AtkinsRéalis

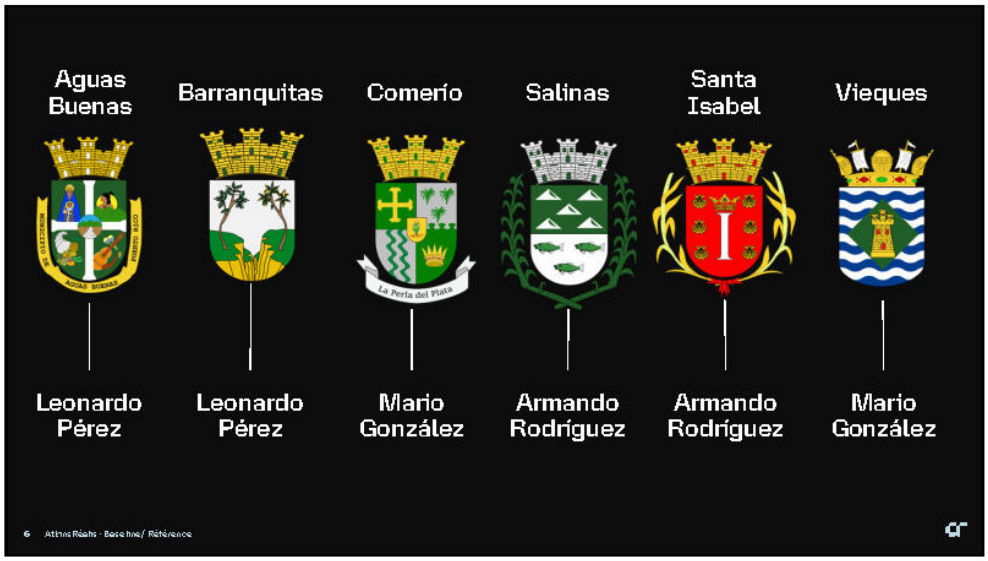
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Equipo de Trabajo
William Pitre, Senior Planner
Ivelisse Gorbea, Senior Planner
Celso Ruiz, Data Analyst
Marsha Caride, Administrative Assistant

4


Equipo de Trabajo
Mario González, Analista de Planificación
Yashira Santos, Analista de Planificación
Leonardo Pérez, Analista de Planificación
Armando Rodríguez, Analista de Planificación
Juan Rotger, Analista de Planificación

5


Aguas Buenas
Barranquitas
Comerío
Salinas
Santa Isabel
Vieques
Leonardo Pérez
Leonardo Pérez
Mario González
Armando Rodríguez
Armando Rodríguez
Mario González

6

Base Regulatoria

7

Base Legal y Regulatoria

- **Robert T. Stafford Disaster Relief and Emergency Assistance Act (Stafford Act), as amended**

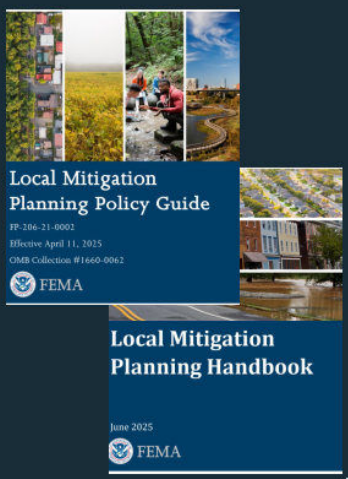
- PL 100-707, signed into law November 23, 1988; amended the Disaster Relief Act of 1974, PL 93-288.
- National Flood Insurance Act of 1968, as amended.
- National Dam Safety Program Act (Pub. L. 92-367), as amended.
- Regulation: 44 CFR Part 201 Mitigation Planning.



8

Requerimientos del Plan de Mitigación

- Elemento A: Proceso de Planificación
- Elemento B: Identificación de Peligros y Evaluación de riesgos
- Elemento C: Estrategias de Mitigación
- Elemento D: Plan de Seguimiento e Implementación
- Elemento E: Actualización del Plan
- Elemento F: Adopción del Plan
- Elemento G: Peligros Potenciales ante fallos en Represas (opcional)
- Elemento H: Requisitos Estatales Adicionales



9

Elementos nuevos del Plan

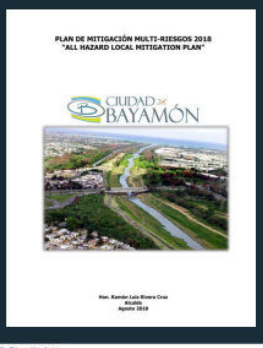
1. **Identificación y evaluación de riesgos**
   - Se clasifica la infraestructura crítica por servicio vital o línea de vida
   - Se analiza su exposición y vulnerabilidad
   - Se prioriza por línea de vida
2. **Evaluación de capacidades**
   - Se evalúa la capacidad local para proteger servicios vitales
   - Se identifican brechas y se proponen acciones
3. **Estrategia de Mitigación**
   - Se incluyen acciones específicas para proteger, estabilizar y restaurar servicios vitales
4. **Participación de Partes Interesadas**
   - Se invita a agencias responsables o representantes de servicios vitales y se documenta su participación
   - Se comunica al público y recopila retroalimentación sobre los servicios vitales



10

Elementos nuevos del Plan

- **Actualización del Plan:**
  "Review Tool" especifica los elementos que se deben documentar para reflejar los cambios
  - El Plan describe los cambios en las áreas propensas a peligros (ha incrementado o disminuido la vulnerabilidad o peligro)
  - Deberá reflejar los cambios en prioridades y progreso de los esfuerzos locales de mitigación.



Element E: Plan Update

Element E Requirements	Location in Plan (section and/or page number)	Met / Not Met
E1. Was the plan revised to reflect changes in development? (Requirement 44 CFR § 201.6(d)(3))		
E1-a. Does the plan describe the changes in development that have occurred in hazard-prone areas that have increased or decreased each community's vulnerability since the previous plan was approved?	Click or tap here to enter text.	Choose

11 Attiros Réalté - Baseline / Référence

11

Proceso del Plan de Mitigación

Step 1. Organize the Planning Process and Resources	Step 2. Assess Risks	Step 3. Develop a Mitigation Strategy	Step 4. Adopt and Implement the Plan
Task 1. Determine the Planning Area and Resources	Task 4: Conduct a Risk Assessment	Task 5: Review Community Capabilities	Task 7: Review and Adopt the Plan
Task 2: Build the Planning Team		Task 6: Develop a Mitigation Strategy	Task 8: Keep the Plan Current
Task 3: Create an Outreach Strategy			Task 9: Create a Safe and Resilient Community

12 Attiros Réalté - Baseline/ Référence

Local Mitigation Planning Handbook

12

Riesgos a Evaluar

13

Peligros a considerar


Terremoto


Modificaciones costeras


Marejada Ciclónica


Fuego Forestal


Deslizamientos


Inundaciones


Calor Extremo


Pandemia/ Epidemia


Tsunami


Ciclones Tropicales


Sequías

14

Represas





Aguas Buenas



Comerío

16 Attiras Réalis - Base line / Référence

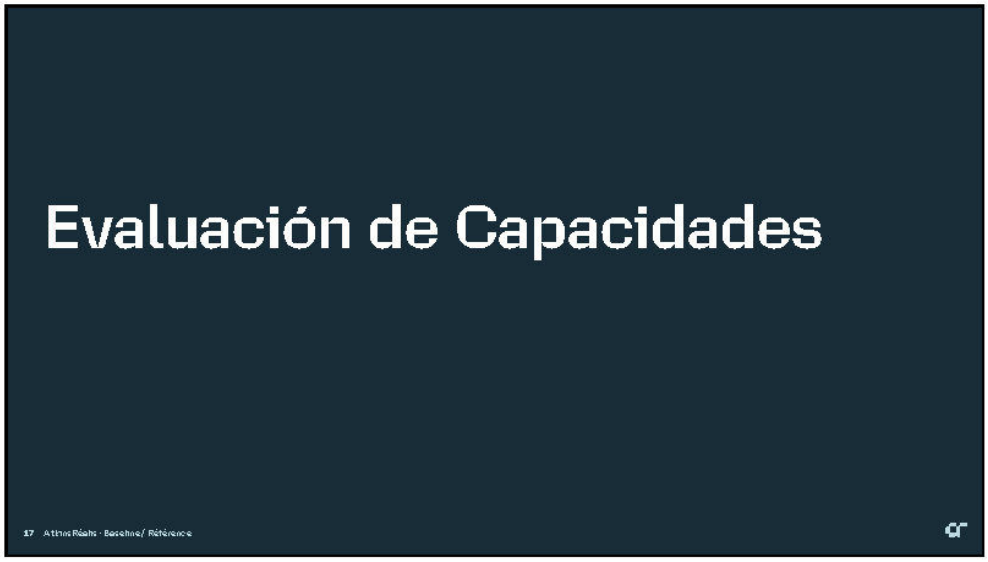
15

¿Qué necesitamos del Municipio?

- Designación del Comité de Planificación
- Apoyo en la actualización de las estrategias de mitigación del plan anterior.
- Incorporación de nuevas estrategias de mitigación.
- Actualizacion de capacidades

16 Attiras Réalis - Base line / Référence

16


Evaluación de Capacidades
17 Attina Réalis - Baseline/ Référence

17


Capacidades
Planificación y Reglamentación
Técnica
Financiera
Alcance Comunitario
Desarrollo de Capacidades
18 Attina Réalis - Baseline/ Référence

18

Participación Ciudadana

19

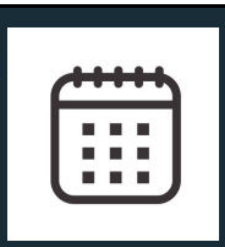
Participación Ciudadana

- Dos reuniones de participación ciudadana.
- Notificación sera publicada por Junta de Planificación.
- Publicar 15 días antes de la reunion
- Se otorga 15 días para comentarios
- Para la Segunda reunion se discute el primer borrador.
- El primer borrador sera comentado por el publico, el municipio y la Junta de Planificación



20

Ventana para la primera actividad de participacion ciudadana



2 de marzo al 13 de marzo

Debe informar su fecha de reunion antes del lunes 9 de febrero.

Favor proveer varias fechas para que su analista de Planificación pueda estar.

De no recibir las fechas en o antes del lunes 9, su reunión será calendarizada después de las de otros municipios.

21 Attmo Réalis - Baseline/ Référence

21

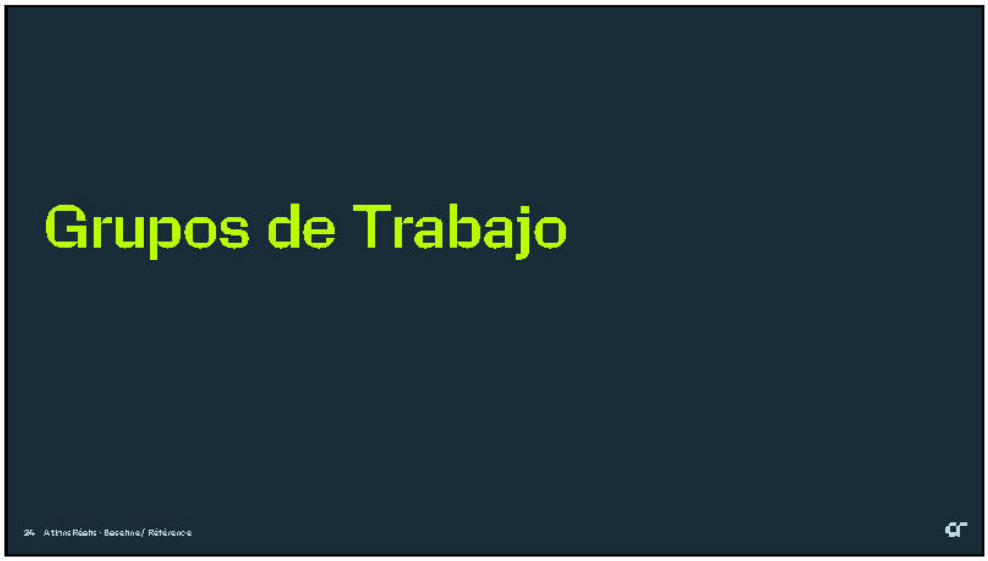
Comunicación

22 Attmo Réalis - Baseline/ Référence

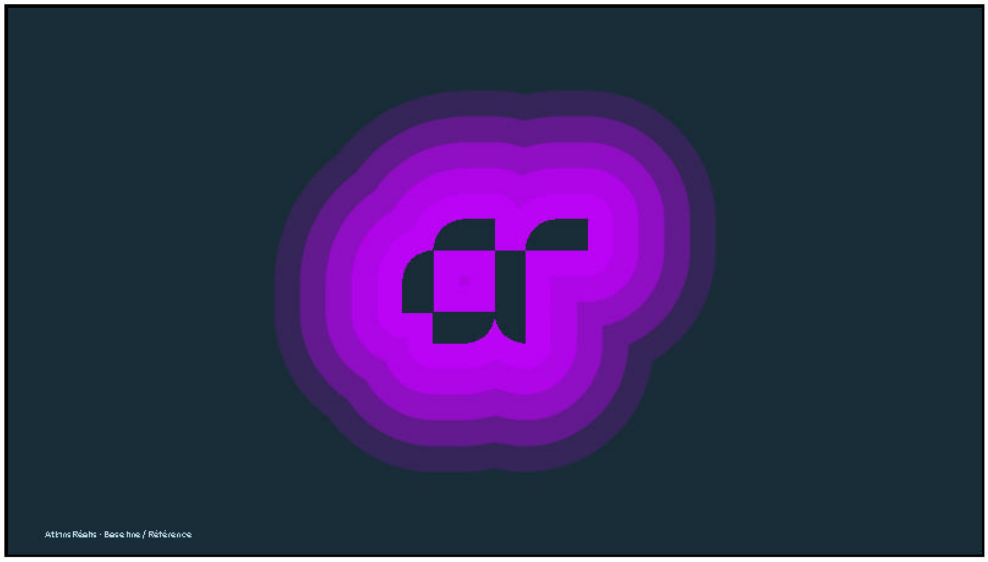
22


JUNTA DE
PLANIFICACION
Información de Contacto
Programa
Junta de Planificación
prpb.lhmp@atkinsrealis.com
Plan. Ivette Colón
Junta de Planificación
colon_i@jp.pr.gov
Plan. William Pitre
AtkinsRéalis Caribe
William.Pitre@atkinsrealis.com /+19392051336
Pedimos que el título de todo correo comience únicamente con el nombre del municipio.
Ej.: "San Germán – Tablas de Mitigación Actualizadas"
Solicitamos que en todo correo electrónico relacionado con el programa se copie siempre al correo oficial:
prpb.lhmp@atkinsrealis.com

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Grupos de Trabajo

24



25

MINUTA

PROYECTO:	PRPB 25 LHMP Update		
TITULO:	First Committee Meeting		
LUGAR DE LA REUNIÓN:	Centro Gubernamental Minillas	**# REUNIÓN:**	01
FECHA Y HORA:	02/09/2026 – 8:30am	**MINUTA POR:**	Juan P. Rotger Sánchez

Lista de Asistencia:

NOMBRE	INICIALES	COMPAÑÍA
Yamilet Guzmán	YG	Municipio de Barranquitas
William Meléndez	WM	Municipio de Barranquitas
Juan P. Rotger Sánchez	JPR	AtkinsRéalis

Asuntos Discutidos:

ID	ASUNTOS DISCUTIDOS
AD-1	Aprobación de Minuta Reunión Anterior: • N/A
AD-2	Asunto Relacionado con Alcance de Servicio Contratado y Entregables • N/A
AD-3	Plan de Trabajo Propuesta (Two Weeks Ahead / Four Week Ahead) • N/A
AD-4	Asuntos Nuevos • La reunión dio inicio con una presentación a cargo del planificador William Pitre, de AtkinsRéalis, en la cual se explicó el alcance del proyecto, las actividades a realizar, los requisitos aplicables y el proceso mediante el cual la Junta de Planificación y AtkinsRéalis estarán desarrollando el Plan de Mitigación para los municipios.

NOTA A LOS DESTINATARIOS:
Estas notas de la reunión reflejan la interpretación de AtkinsRéalis sobre la reunión y las acciones previstas que se derivan de la misma. Se asumirá su conformidad en que estas notas constituyen un registro fiel de lo discutido, a menos que se reciban comentarios adversos por escrito dentro de los cinco (5) días posteriores a su recepción.

PLANIFICACIÓN AtkinsRéalis

1

ID	ASUNTOS DISCUTIDOS
	• Luego, se procedió con la mesa de trabajo junto al municipio de Barranquitas. • J. Rotger se presentó y ofreció un resumen de su rol dentro del programa, así como su experiencia previa. Posteriormente, cada uno de los integrantes del municipio se presentó. • J. Rotger solicitó a los integrantes que designaran un Punto de Contacto (POC) principal para facilitar una comunicación más efectiva. Sin embargo, al concluir la reunión aún no se había identificado dicho contacto, ya que el equipo indicó que necesitaba discutirlo previamente con el resto del comité. • Se procedió a preguntar cuán familiarizados estaban o si habían trabajado directamente con el Local Hazard Mitigation Plan (LHMP) anterior, con el fin de identificar el estatus de los proyectos incluidos en dicho plan. • El equipo del municipio indicó que no había trabajado directamente con el LHMP anterior y que tampoco estaba familiarizados con los planes establecidos. Acordaron reunirse con el resto de su comité para revisarlo, identificar el estatus de los proyectos y poder discutirlos en la próxima reunión. • De manera breve, J. Rotger repasó la lista de acciones del plan anterior para que los participantes se familiarizaran con su contenido y, al discutirla, pudieran recordar el estatus de alguno de los proyectos. • J. Rotger preguntó si el municipio contaba con un Plan de Ordenamiento Territorial, y el equipo respondió que actualmente se encuentra en proceso de actualización • Como parte del proceso y con el propósito de motivar a los presentes a reflexionar sobre proyectos de mitigación relevantes para su municipio, se llevó a cabo una dinámica en la que J. Rotger compartió una lista de peligros naturales identificados. Se les solicitó que los clasificaran del uno (1) al tres (3), siendo tres (3) el de mayor impacto, según su percepción. Los participantes coincidieron en que los deslizamientos representan la prioridad más alta, seguidos por los ciclones tropicales y, en tercer lugar, las inundaciones. • Una vez concluida la dinámica, J. Rotger recalcó que para enviar o solicitar información el correo electrónico del proyecto es prpb.lhmp@atkinsrealis.com.
AD-5	Discusión de Acciones por Tomar • Tabla Inferior
AD-6	Coordinación Próxima Reunión • TBD

Acciones Por Tomar:

NOTA A LOS DESTINATARIOS:
Estas notas de la reunión reflejan la interpretación de AtkinsRéalis sobre la reunión y las acciones previstas que se derivan de la misma. Se asumirá su conformidad en que estas notas constituyen un registro fiel de lo discutido, a menos que se reciban comentarios adversos por escrito dentro de los cinco (5) días posteriores a su recepción.

ID	ACCIONES POR TOMAR	FECHA LÍMITE	ENTIDAD RESPONSABLE
AT-1	Confirmación de fecha, hora y lugar para reunión comunitaria.	02/03/2026	Municipio de Barranquitas
AT-2	Envío de logo el municipio.	02/03/2026	Municipio de Barranquitas

Acuerdos/Aclaraciones:

ID	DESCRIPCIÓN
AC-1	N/A

Anejos:

ID	DESCRIPCIÓN ANEJO	NÚMERO DE PÁGINAS
AN-1	N/A	N/A

PRÓXIMA REUNIÓN:	TBD		
MEDIO DE DISTRIBUCIÓN:	Email		
FECHA DISTRIBUCIÓN:	02/05/2026	**ARCHIVO DE REFERENCIA:**	First Planning Committee Meeting

NOTA A LOS DESTINATARIOS:
Estas notas de la reunión reflejan la interpretación de AtkinsRéalis sobre la reunión y las acciones previstas que se derivan de la misma. Se asumirá su conformidad en que estas notas constituyen un registro fiel de lo discutido, a menos que se reciban comentarios adversos por escrito dentro de los cinco (5) días posteriores a su recepción.

PLANIFICACIÓN

AtkinsRéalis

3

ID	DESCRIPCIÓN ANEJO	NÚMERO DE PÁGINAS
AN-1	N/A	N/A

PRÓXIMA REUNIÓN:	Por definir.		
MEDIO DE DISTRIBUCIÓN:	Correo Electrónico.		
FECHA DISTRIBUCIÓN:	02/11/2026	**ARCHIVO DE REFERENCIA:**	First Planning Committee Meeting

NOTA A LOS DESTINATARIOS:
Estas notas de la reunión reflejan la interpretación de AtkinsRéalis sobre la reunión y las acciones previstas que se derivan de la misma. Se asumirá su conformidad en que estas notas constituyen un registro fiel de lo discutido, a menos que se reciban comentarios adversos por escrito dentro de los cinco (5) días posteriores a su recepción.

Second Planning Committee Meeting

Presentation

To be completed after the next Planning Committee Meeting

Documentation

To be completed after the next Planning Committee Meeting

Appendix C: Public Participation and Outreach

First Public Meeting

Notification



EL NUEVO DÍA Miércoles, 18 de febrero de 2026 38

JUNTA DE PLANIFICACIÓN

AVISO PÚBLICO

PRIMERA REUNIÓN DE PLANIFICACIÓN CON LA COMUNIDAD

La Junta de Planificación, junto al Municipio de Barranquitas, invitan a los organismos gubernamentales, entidades privadas, dueños de negocios, líderes comunitarios y ciudadanía en general a participar de la 1ra reunión de Planificación con la Comunidad para la revisión del Plan de Mitigación contra Peligros Naturales.

Los peligros naturales pueden causar la pérdida de vida y propiedad y tener consecuencias nefastas. La mitigación de riesgos es el esfuerzo de nuestra comunidad por reducir los daños o riesgos ocasionados por peligros naturales mediante el diseño de medidas que reduzcan su impacto.

El Plan de Mitigación contra Peligros Naturales para el Municipio de Barranquitas tiene el propósito de guiar al gobierno municipal en el desarrollo y adopción de estrategias dirigidas al manejo de peligros, tales como inundaciones, huracanes, sequías, deslizamientos, terremotos y otros.

FECHA: 9 DE MARZO DE 2026
HORA: 6:00 PM
LUGAR: CENTRO DE RECEPCIONES Y BELLAS ARTES DE BARRANQUITAS
PR-152 RAMAL, KM 2.5
BARRANQUITAS, PR

PLANES DE MITIGACIÓN CONTRA PELIGROS NATURALES
Planificar para proteger

BARRANQUITAS

PARA MÁS INFORMACIÓN, ACCEDA: JP.PR.GOV

JUNTA DE PLANIFICACIÓN

AVISO PÚBLICO

PRIMERA REUNIÓN DE PLANIFICACIÓN CON LA COMUNIDAD

La Junta de Planificación, junto al Municipio de Isabela, invitan a los organismos gubernamentales, entidades privadas, dueños de negocios, líderes comunitarios y ciudadanía en general a participar de la 1ra reunión de Planificación con la Comunidad para la revisión del Plan de Mitigación contra Peligros Naturales.

Los peligros naturales pueden causar la pérdida de vida y propiedad y tener consecuencias nefastas. La mitigación de riesgos es el esfuerzo de nuestra comunidad por reducir los daños o riesgos ocasionados por peligros naturales mediante el diseño de medidas que reduzcan su impacto.

El Plan de Mitigación contra Peligros Naturales para el Municipio de Isabela tiene el propósito de guiar al gobierno municipal en el desarrollo y adopción de estrategias dirigidas al manejo de peligros, tales como inundaciones, huracanes, sequías, deslizamientos, terremotos y otros.

FECHA: 5 DE MARZO DE 2026
HORA: 6:00 PM
LUGAR: ANFITEATRO JUSTO MÉNDEZ CABRERA
106 CALLE ROMÁN ESQ. CALLE SAN ANTONIO
ISABELA, PR

PLANES DE MITIGACIÓN CONTRA PELIGROS NATURALES
Planificar para proteger

ISABELA

PARA MÁS INFORMACIÓN, ACCEDA: JP.PR.GOV

AVISO DE DINERO Y OTROS BIENES NO RECLAMADOS EN PODER DE LA COOPERATIVA DE AHORRO Y CRÉDITO DE CAMUY

CAMUY COOPERATIVA

Este informe es publicado en cumplimiento con los procedimientos establecidos en el Artículo 6.09 de la Ley 255, Ley de Sociedades de Cooperativas de Ahorro y Crédito de 2002, y en la Ley 81 de 2 de junio de 2008, según enmendada. Si su nombre está en el informe deberá reclamar su dinero. Las Cantidades No reclamadas en los próximos de 90 días, contados a partir de la fecha de esta publicación, serán objeto de transferencia a las reservas de capital. Este informe está disponible para inspección y conocimiento público en todas nuestras sucursales y oficinas de servicio.

NOMBRE	DIRECCIÓN / NÚMERO DE CHEQUE	CANTIDAD
ACEVEDO ROSARIO, JULIO	PASEOS DE JACARANDA 15406 CALLE FLAMBOYA SANTA ISABEL PR 00757	$266.78
ALEQUIN VEGA, FRANKLIN	PO BOX 185 CAMUY PR 00627	$226.54
ARIANO TORRES, FLAVIO E.	4619 SUNFLOWER RD APT 20 ROCKVILLE TN 37869-3429	$230.76
AVILES ROSARIO, MYRNA	HC 5 BOX 92969 ARECIBO PR 00612-9559	$175.73
BENITEZ OLIVERAS, JOSE A.	URB SANTA ROSA 37 19 CALLE 23 BAYAMON PR 00959	$206.38
BUTLER VAZQUEZ, GLORIMAR	4206 CINNAMON FERN CT SAINT CLOUD FL 34772	$154.04
CABAN MEDINA, PELEGRIN	URB PASEO LAS FLORES 4633 CALLE ADONAI ISABELA PR 00662	$186.60
CALVO RIVERA, EDNEE	5910 CANAL DR J 21 BRADENTON FL 34207	$2,862.46
CRESPO MONROIG, MARIO A.	PO BOX 194 CAMUY PR 00627	$312.73
CRUZ VALENCIA, JULISSA I.	213 CALLE LOS RIVERA ARECIBO PR 00612	$335.49
DELGADO CRUZ, RAFAEL	279 URB ALTAMONTE CAMUY PR 00627	$12,505.08
DIAZ CRUZ, LIZZETTE	PO BOX 212 CAMUY PR 00627	$174.96
FELICIANO COLON, ALBERTO	HC 6 BOX 6515 CAMUY PR 00627-9457	$142.76
FRANQUI QUIJANO, MARIA	HC 3 BOX 12800 CAMUY PR 00627	$401.74
GALARZA GONZALEZ, EDWIN G.	PO BOX 143172 ARECIBO PR 00614	$7,261.77
GONZALEZ QUINONES, AMILCAR	PO BOX 35 HATILLO PR 00659	$143.55
GONZALEZ, ADELAIDA	759 BO. PUENTE PENA INT CAMUY PR 00627	$4,472.56
HERNANDEZ ARROYO, ABIMAEL	URB CAMINO DEL VALLE # 38 ARECIBO PR 00612	$4,944.06
HERNANDEZ NIEVES, ULISES	HC 3 BOX 15240 QUEBRADILLAS PR 00678	$3,126.19
IBARRA SANTOS, ADRIANA	URB VISTA AZUL CALLE 2 AD 17 Arecibo PR 00612	$173.78
IRIZARRY RIOS, VICTOR M.	PASEO LAS HISTAS D81 CALLE 3 SAN JUAN PR 00926	$201.02
LANDRON SANDIN, ANGEL M.	PASEO DEL PRADO C17 CAMINO LAS PALMAS SAN JUAN PR 00926	$201.06
LEGAL & COMPLIANCE SOLUTIONS I	CK. 5110825/15/20	$299.00
LOPEZ ACEVEDO, CARMEN I.	PO BOX 407 CAMUY PR 00627-0407	$8,361.95
LOPEZ TORRES, MARILYN	4051 CALLE RAMON SOTOMAYOR UTUADO PR 00641	$28,133.91
MALDONADO CORDERO, HILDA	VISTA MAR #5 PUENTE CAMUY PR 00627	$174.80
MARTINEZ NAVEDO, PAULO J.	PASEO LOS CIDRALES 549 CALLE MAR CARIBE DORADO PR 00646-4505	$210.35
MEDINA NIEVES, OTILIA	HC 2 BOX 7504 CAMUY PR 00627	$837.93
MENDEZ GUERRERO, ANGEL O	CK. 4985 10/15/20	$1,474.53
MONTALVO RAMOS, STEPHANIE M.	817 EXT DEL CARMEN CAMUY PR 00627	$530.11
MONTANEZ DE LEON, LUIS D.	URB PRADO ALTO K18 CALLE 6 GUAYNABO PR 00966	$266.91
MORALES RAMOS, NORAIMA J.	PO BOX 185 CAMUY PR 00627-0185	$867.95
MORALES RAMOS, NORAIMA J.	PO BOX 185 CAMUY PR 00627-0185	$1,253.58
MORALES RAMOS, NORAIMA J.	PO BOX 185 CAMUY PR 00627-0185	$1,309.97
NIEVES GONZALEZ, MARIA T.	HC 03 BOX 15471 QUEBRADILLAS PR 00678	$278.80
NIEVES, MICHELLE M.	499 GLEN ST NEW BRITAIN CT 06051	$337.87
NUNEZ MARTINEZ, SARA I.	URB. CAMINO DEL SOL # 602 VEGA BAJA PR 00693	$8,550.84
ORTIZ RIVERA, MAGDALIA	2022 BOGART AVE., BRONX NY 10462	$49,057.80
PEREZ CARDONA, EYNETT	25 WESTMINSTER ST WESTERLY RI 02891	$174.48
RIESTRA RIVERA, SUGELY	3460 GREENSIDE CT DACULA GA 30019	$538.80
RIGAU OYOLA, ALBERTO	URB LAS VEGAS I 4 CALLE 10 CASAS PR 00962	$233.56
RIOS GONZALEZ, GELDINA J.	PO BOX 328 CAMUY PR 00627-0328	$11,327.20
RIOS ROMERO, LOURDES	191 QUINCY ST 1 A BROOKLYN NY 11221	$165.44
RIVERA ASSOCIATES	CK. 29483 6/30/20	$134.00
RIVERA AVILES, VICTOR R.	PO BOX 8422 BAYAMON PR 00960	$396.04
RIVERA LOPEZ, GENOVEBA	CK. 6804 9/15/20	$2,500.00
RIVERA RODRIGUEZ, GLADYS R.	HC 3 BOX 12934 CAMUY PR 00627-9828	$655.54
ROSADO, CAROLINA	122 CATANIA WAY ROYAL PALM BCH FL 33411	$205.98
ROSARIO SERRANO, MERCEDES	HC 3 BOX 12165 CAMUY PR 00627-7328	$667.86
SANCHEZ CORDOVA, SANDRA E.	CALLE GREGORIO MARANON 299 JARDIN ESCORIAL TOA ALTA PR 00953	$403.41
SANTIAGO NEVES, REBECCA	HC 2 BOX 16261 ARECIBO PR 00612-9186	$1,028.85
SANTIAGO SANTIAGO, SANDRA L.	HC 1 BOX 3479 CAMUY PR 00627-9219	$1,011.26
SCHARON CRUZ, ANGEL M.	BRISAS DE MONTECASINO 465 CALLE HAMACA TOA ALTA PR 00953	$201.66
SERRANO FRANQUI, CINDY	HC 4 BOX 17346 CAMUY PR 00627	$183.03
SOLER PEREZ, DANIEL	SECT PENA 526 AVE BALTAZAR JIMENEZ CAMUY PR 00627-2104	$581.67
SOTO DIVIDA, LUIS G.	URB. BRISAS DE CAMUY C 7 CAMUY PR 00627	$586.66
SOTO MIRANDA, KEYLA D.	URB BRISAS DE MAR CHIQUITA 70 CALLE SOL MAMATE PR 00674	$205.46
SOTO VELEZ, ARMANDO	PO BOX 509 SAN SEBASTIAN PR 00685	$201.83
SOTOMAYOR OCASIA, LILLIAM M.	SECTPR PENA 905 BOX PUENTE CAMUY PR 00627-2924	$401.22
SYNCHRONY BANK/JCP	CK. 286877 1/28/20	$107.25
TORRES HERNANDEZ, PAMELA	PO BOX 270 429 SAN JUAN PR 00928	$265.58
TORRES PEREZ, RALPH	URB PALMA REAL 167 CALLE COLA DE PESCADO GUAYNABO PR 00969-5858	$201.81
TORRES VELEZ, JENNIFFER O.	PO BOX 250 SABANA HOYOS PR 00688-0250	$182.79
VALENCIA QUINTERO, LUIS E	VISTA AZUL M 15 CALLE 9 ARECIBO PR 00612	$240.62
VALENTIN RIOS, JANICE M.	URB LANTIGUA 43 VILLA ATENAS TRUJILLO ALTO PR 00976-6103	$215.44
VALENTINE, EMMA	135-28 118 Street SOUTH OZONE PARK NY 11420	$171.39

COSSEC Camuy Cooperativa no está asegurada por el Gobierno Federal. Las Acciones y Depósitos están asegurados hasta $250,000 por la Corporación para la Supervisión y Seguros de Cooperativas (COSSEC).

(787) 898-4970 | www.camuycooperativa.com | info@camuycoop.com

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JUNTA DE
PLANIFICACIÓN
GOBIERNO DE PUERTO RICO
REVISIÓN Y ACTUALIZACIÓN DEL PLAN DE MITIGACIÓN CONTRA PELIGROS NATURALES


AGENDA DE LA REUNIÓN
Trasfondo y conceptos básicos
Proceso de planificación para la mitigación contra peligros naturales
Proyecto para la actualización de los planes de mitigación:
• Descripción del proyecto
• Alcance de trabajo
• Esfuerzos de divulgación/Participación ciudadana
• Flujograma de las actividades del Proyecto
PLANIFICACIÓN
PLANES DE MITIGACIÓN
CONTRA PELIGROS NATURALES
Planificar para proteger

TRASFONDO

Ley de Mitigación de Desastres de 2000 (DMA2K)

Requiere un plan de mitigación aprobado y adoptado para recibir financiamiento federal a través de:

- ❑ Programa de subvenciones para mitigación de peligros
- ❑ mitigación previa al desastre, y
- ❑ asistencia para mitigar inundaciones.



(d) ***Local governments.*** The key responsibilities of local governments are to:

(1) Prepare and adopt a jurisdiction-wide natural hazard mitigation plan as a condition of receiving project grant funds under the HMGP, in accordance with § 201.6.

(2) At a minimum, review and update the local mitigation plan every 5 years from date of plan approval of the previous plan in order to continue program eligibility.

Regulation: 44 CFR Part 201 Mitigation Planning.

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PLANES DE MITIGACIÓN CONTRA PELIGROS NATURALES
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CONCEPTOS IMPORTANTES

Peligros naturales	Eventos o sucesos naturales que amenazan vidas, bienes materiales, infraestructura, el ambiente y otros activos. Tienden a ocurrir repetidamente en las mismas zonas geográficas. Ej. Terremotos, deslizamientos de tierra, hundimientos, Inundaciones, tsunamis, huracanes, erosión, incendios, etc.
Mitigación de riesgos	Esfuerzo o acciones para reducir la pérdida de vida y propiedad reduciendo el impacto de los peligros naturales.
Plan de mitigación contra peligros naturales	Documento donde se evalúan la vulnerabilidad del municipio ante los peligros naturales y se identifican acciones para minimizar las pérdidas de vida y propiedad ante un evento futuro.

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PLANES DE MITIGACIÓN CONTRA PELIGROS NATURALES
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Ciclo para el manejo de emergencias



JUNTA DE PLANIFICACIÓN
GOBIERNO DE PUERTO RICO

PLANES DE MITIGACIÓN CONTRA PELIGROS NATURALES
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Proceso de Planificación para la Mitigación

1. Coordinación con Municipio
2. Evaluación de riesgos
3. Evaluación de capacidad
4. Estrategias de mitigación
5. Mantenimiento del plan
6. Documentación del plan



JUNTA DE PLANIFICACIÓN
GOBIERNO DE PUERTO RICO

PLANES DE MITIGACIÓN CONTRA PELIGROS NATURALES
Planificar para proteger

Coordinación con Municipio

- Carta de compromiso
- Designar el Comité de Planificación de Mitigación de Peligros del municipio.
- Reunión inicial ("kick off meeting").
- La participación pública y divulgación a las principales partes interesadas.
- La recopilación y el análisis de datos.
- Preparación y presentación del plan.

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Planes de Mitigación contra Peligros Naturales
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Evaluación de Riesgos


Terremoto


Erosión costera/ modificaciones costeras


Marejada Ciclónica


Deslizamientos


Inundaciones


Calor Extremo


Tsunami


Ciclones Tropicales


Sequías


Fuego Forestal


Pandemia/ Epidemia

Junta de Planificación

Planes de Mitigación contra Peligros Naturales
Planificar para proteger

Evaluación de capacidad

- Mide la capacidad para implementar el plan de mitigación de peligros.
- El propósito es establecer la capacidad municipal para la planificación, determinación de la capacidad financiera, la asistencia técnica y la necesidad de adiestramiento.
- Las capacidades evaluadas son las siguientes:



Junta de Planificación

Planes de Mitigación contra Peligros Naturales
Planificar para proteger

Resultado de Evaluación



Junta de Planificación

Estrategias de Mitigación

- Describir las metas y objetivos específicos para minimizar el impacto en el municipio.
- Identificar acciones de mitigación específicas y proyectos.
- Estas pueden incluir:
  - **Prevención**- actividades tales como planificación usos terrenos, regulaciones, mantenimientos, etc.
  - **Protección de propiedades**- mejoras de diseños, relocalización, adquisición, etc.
  - **Proyectos de estructura**- ej. Diques, muros de contención, alcantarillado pluvial, etc.
  - **Servicios de emergencia**- alertas, sistemas de advertencias, manejo y planes de desalojo, ejercicios de respuesta a emergencias, etc.
  - **Educación y concientización pública.**

Mantenimiento y documentación del Plan

- **Monitoreo:** Identificar frecuencia para verificar el progreso de las acciones en el plan.
- **Evaluación:** Determinar si el plan sigue siendo viable, si las acciones aún tienen sentido, etc.
- **Actualización:** Si se determina que algo debe cambiarse en el proceso de evaluación, identificar persona a cargo (comité de planificación) para la actualización cada 5 años.
- **Adopción del Plan por el municipio:** ordenanza de la legislatura municipal u orden ejecutiva del alcalde.
- **Revisión, certificación y aprobación de FEMA.**

Proyecto actualización de los Planes de Mitigación

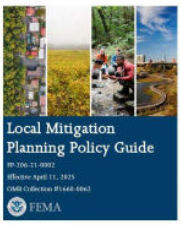


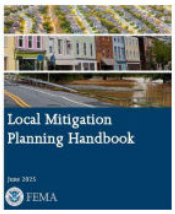
Junta de Planificación

Planes de Mitigación contra Peligros Naturales
Planificar para proteger

Alcance del trabajo

1. Revisar y actualizar los planes de mitigación contra peligros naturales de acuerdo con las nuevas guías y regulaciones.
2. Coordinar las actividades y trabajos en conjunto con el municipio y la Junta de Planificación.
3. Promover la participación ciudadana.
   - Reuniones de planificación con la comunidad
   - Página cibernética JP (www.jp.pr.gov)



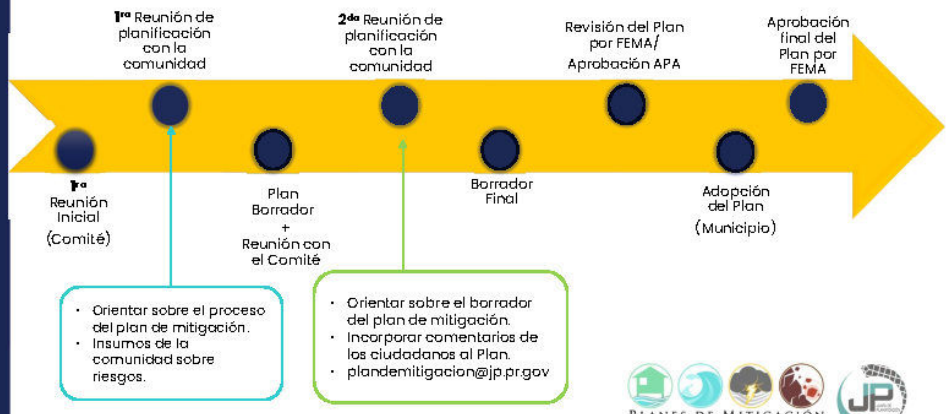


plandemitigación@jp.pr.gov

Junta de Planificación

Planes de Mitigación contra Peligros Naturales
Planificar para proteger

ACTIVIDADES DEL PROYECTO



JUNTA DE PLANIFICACIÓN

PLANES DE MITIGACIÓN CONTRA PELIGROS NATURALES
Planificar para proteger

ENCUESTA DE LA COMUNIDAD

JUNTA DE PLANIFICACIÓN

PLANES DE MITIGACIÓN CONTRA PELIGROS NATURALES
Planificar para proteger

BOLETA DE COMENTARIOS COMUNITARIOS

Plan de Mitigación contra Peligros Naturales Barranquitas
Municipio

Nombre (Opcional): Ramón J. Vélez Colón

Comentario relacionado a temas de mitigación de peligros naturales:
(Describa inquietudes, riesgos identificados, sugerencias o situaciones que afecten su comunidad)

El Sector consta con 3 puentes los cuales están en malas condiciones los mismos están casi intransitables uno está con desnivel otro tapado de el agua pero por encima el 3ro. está con desnivel. Esta carretera es usada por muchas personas incluyendo gente de edad ya que esta carretera a conecta con Orocovis. Tenemos muchas personas de edad avanzada y esto le dificulta el transitar por la misma.
¿Cómo se afectó?
Y estos puentes o carretera fue afectada por el huracán María desde ese momento hasta el día de hoy no ha sido arreglados.

Fecha: 9/marzo/26

atrás →

Durante el huracán María los puentes fueron afectados a tal magnitud que no podíamos salir del área. Una persona tiene un problema de salud el cual la ambulancia no pudo llegar a casa y esta falleció. Actualmente los caminos están llenos de escombros (tierra y basura vegetal) cuando llueve el agua corre por la carretera y esta sigue afectando los puentes ya que el agua socabando. Uno está completamente tapado y el otro está caído de un lado. Actualmente el municipio no ha dado que está en diseño (Esto desde 2017)

BOLETA DE COMENTARIOS COMUNITARIOS

Plan de Mitigación contra Peligros Naturales Barranquitas
Municipio

Nombre (Opcional): Santuario Animales de Barranquitas

Barrio

Secto

Carre

Refer

Comentario relacionado a temas de mitigación de peligros naturales:
(Describa inquietudes, riesgos identificados, sugerencias o situaciones que afecten su comunidad)

Nuestro Santuario está ubicado en un lugar que al llover copiosamente, las escorrentías inundan nuestro terreno, poniendo en riesgo la vida y seguridad de nuestros rescates. El lugar donde se supone nuestros perritos socialicen, están en desuso ya que el agua convierte el piso en fango, además de las enfermedades que estas aguas atrae.

¿Cómo se afectó?

En caso de tormenta o huracanes, tenemos que mover todos los perros, ya que se pone en riesgo su seguridad.

Fecha: 9-marzo-26

*Se necesita un tipo de tormenteras, porque aunque el edificio es en cemento, las aguas entran por las ventanas porque no tenemos nada para cubrirlas.

Se necesita que tanto el estacionamiento, como áreas adyacentes sean asfaltado para el mejor manejo en el caso de una emergencia.

COMENTARIOS DE LA COMUNIDAD

Plan de Mitigación contra Peligros Naturales Barranquitas
Municipio

Nombre (Opcional): Bernio

Comentario relacionado a temas de mitigación de peligros naturales:
(Describa inquietudes, riesgos identificados, sugerencias o situaciones que afecten su comunidad)

Se afectó por derrumbes Huracán María.
Peligro árbols, tierra

¿Cómo se afectó?

Al puente se afectó, por inundarse.
No pudo salir de su casa y requirió limpiar el
acceso de su casa a la 772

Fecha: 9 de marzo de 2026

BOLETA DE COMENTARIOS COMUNITARIOS

Plan de Mitigación contra Peligros Naturales Bqtas
Municipio

Nombre (Opcional): Ariana Muñoz Rodríguez (787-374-6370)

Barrio: Palo Hincado

Sector: La Tiza

Carretera y Kilómetro: Carr. 720 km 2.6

Referencia relativa del lugar: Camino Los Muñoz

Comentario relacionado a temas de mitigación de peligros naturales:
(Describa inquietudes, riesgos identificados, sugerencias o situaciones que afecten su comunidad)

-Mas del 75% personas mayores de 60 años.
-Condiciones especiales (equipo especial) requieren
Erosión de terreno, una sola entrada/misma salida.
recurrente. Residencias cercanas a quebradas...

¿Cómo se afectó?

Comunidad quedó incomunicada y privada de todos los servicios esenciales -
por más de un año (2017), 6 meses (agua), comida (7 días)
Recibimos artículos por helicóptero, no faltó gente por accesos
interrumpidos - no recibir tratamiento especiales

Fecha: 03-04-26

BOLETA DE COMENTARIOS COMUNITARIOS

Plan de Mitigación contra Peligros Naturales Bajos

Comentario relacionado a temas de mitigación de peligros naturales:
(Describa inquietudes, riesgos identificados, sugerencias o situaciones que afecten su comunidad)

1. Necesidad de mitigar cause río Bajo en Palo Hincado y manantial zona alta de la Urbanización Paraíso Tome Alta. / Ubicación Sector Puente Roto de Palo Hincado
2. Deslizamiento en carretera PR 170 Km 2.1
3. Árboles y poste del tendido telefónico se caen con vientos e interrumpen tránsito en PR-156 y PR 170

¿Cómo se afectó?
Inundaciones y deslizamiento incomunican residentes.

Fecha: 9-marzo-2026

BOLETA DE COMENTARIOS COMUNITARIOS

Plan de Mitigación contra Peligros Naturales Barranquitas
Municipio

Nombre (Opcional): Yanylette Rosado Robles

Barrio: P. H (Palo Hincado)

Sector: Bejucos

Carretera y Kilómetro: 156 Km. 10.7

Referencia relativa del lugar: Lechonera Malavé.

Comentario relacionado a temas de mitigación de peligros naturales:
(Describa inquietudes, riesgos identificados, sugerencias o situaciones que afecten su comunidad)

Es una zona humeda por lo que el terreno tiende a deslizarse y esto provoca que las carreteras se deterioren con facilidad y la tierra obstruya el paso.

¿Cómo se afectó?
Afecta en el flujo de vehículos para llegar a sus hogares.

Fecha: 09. Marzo. 26.

BOLETA DE COMENTARIOS COMUNITARIOS

Plan de Mitigación contra Peligros Naturales Barranquitas
Municipio

Nombre (Opcional): Zomida Santos Colón

Comentario relacionado a temas de mitigación de peligros naturales:
(Describa inquietudes, riesgos identificados, sugerencias o situaciones que afecten su comunidad)

Riesgo de incendios, deslizamientos, obstrucción al camino por caída de árboles

¿Cómo se afectó?

En el caso de los incendios casi llegan a mi casa en 3 ocasiones distintas.

Fecha: 9 de marzo de 2026

Attendance Sheet

JUNTA DE PLANIFICACIÓN
GOBIERNO DE PUERTO RICO

PLANES DE MITIGACIÓN CONTRA PELIGROS NATURALES
Planificar para proteger

HOJA DE ASISTENCIA

Asunto: 1era Reunión de Planificación con la Comunidad- Municipio de Barranquitas — Fecha: 9 de marzo de 2026

Lugar: Centro de Recepciones y Bellas Artes de Barranquitas — Hora: 6:00 pm

Nombre completo (en letra de molde)	Municipio/Barrio/ Comunidad	Teléfono	Correo electrónico	Firma
Samuel Vázquez	Bgtas (La Torre)			
Zenaida Santos Colón	Bgtas. Bo. Helechal			
Carmen Z Pagán	Barranquitas			
Lianabel Colón Rivera	Barranquitas			
Edwin Ríos	Barranquitas			
Elliot Colón	Bgtas			
Ruth Melissa Aguayo	Bgtas			
Ariana Muñoz	Bgtas/Honduras/El portón			
Jacinto Santos Colón	Barranquitas			
Armando Irizarry	Bgtas			

Covered for PII Protection

JUNTA DE PLANIFICACIÓN
GOBIERNO DE PUERTO RICO

PLANES DE MITIGACIÓN CONTRA PELIGROS NATURALES
Planificar para proteger

HOJA DE ASISTENCIA

Asunto: 1era Reunión de Planificación con la Comunidad- Municipio de Barranquitas — Fecha: 9 de marzo de 2026

Lugar: Centro de Recepciones y Bellas Artes de Barranquitas — Hora: 6:00 pm

Nombre completo (en letra de molde)	Municipio/Barrio/ Comunidad	Teléfono	Correo electrónico	Firma
Miguel A. Zayas Vázquez	Barranquitas			
Yanilette Rosado Robles	Barranquitas			
Yanilet Carmen Cintrón	Barranquitas			
Carlos Berrios Rivera	Barranquitas			
Anabel Aponte Zayas	Bo. Pala Ubinada			
Aquiles L. Vélez Colón	Bo. Helechal Abajo. Pala			
Carlos A. Vélez Torres	Barranquitas			
Cordis Vázquez Cotrón	Barranquitas / Tres Cruces			
Irma I. Rodríguez	Barranquitas			
Adelia Berrios Ríos	La Torre			

Covered for PII Protection

JUNTA DE PLANIFICACIÓN
GOBIERNO DE PUERTO RICO

PLANES DE MITIGACIÓN
CONTRA PELIGROS NATURALES
Planificar para proteger

HOJA DE ASISTENCIA

Asunto: 1era Reunión de Planificación con la Comunidad- Municipio de Barranquitas
Fecha: 9 de marzo de 2026
Lugar: Centro de Recepciones y Bellas Artes de Barranquitas
Hora: 6:00 pm

Nombre completo (en letra de molde)	Municipio/Barrio/ Comunidad	Teléfono	Correo electrónico	Firma
José J. Rivera Vazquez	Barranquitas / Alda. Grande			
Ivette Colón Meléndez	Junta de Planificación			

Covered for PII Protection

Photographic records




PLANIFICACIÓN
REVISIÓN Y ACTUALIZACIÓN DEL PLAN DE MITIGACIÓN CONTRA PELIGROS NATURALES
MUNICIPIO AUTÓNOMO DE
BARRANQUITAS



Second Public Meeting

Notification

To be included after the second public meeting.

Documentation

Presentation

To be included after the second public meeting.

Meeting Notes

Attendance Sheet

To be included after the second public meeting.

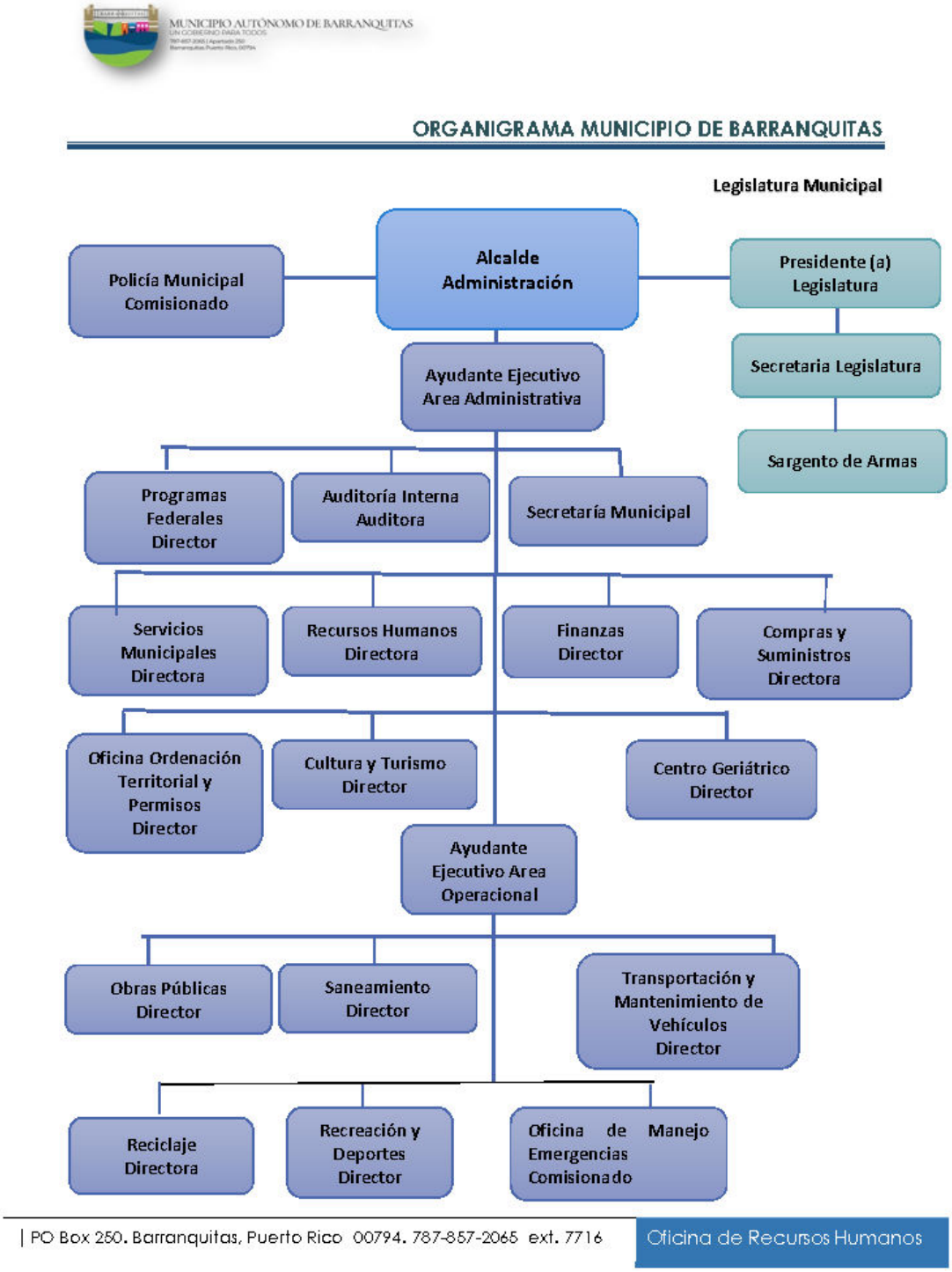
Photographic Record

To be included after the second public meeting.

Appendix D: Stakeholder Involvement

To be included after the second Community Planning Meeting

Appendix E: Organization Chart



Appendix F: List of Critical Infrastrcture by Lifeline

The following table provides a list of Barranquitas Critical Infrastructure as reported by the Puerto Rico Planning Board.

Table 56: Critical Infrastructure by Lifeline

Facility Name	Address	Y Coordinate	X Coordinate	Lifeline	Sub-Category
0Ff PR-156 Km. 13.50		18.189397	-66.324856	Lifeline: Transportation	Transportation Systems
Casa Alcaldía	calle Muñoz Rivera # 18	18.186108	-66.306515	Lifeline: Safety and Security	Government Service
Centro de Salud Integral la Montaña (SIM) Centro 330	PR 156 km 16.4	18.185807	-66.303656	Lifeline: Health and Medical	Medical Care
Centro Geriátrico La Hermandad	Bo. Quebradillas PR 152 km 6.4	18.22741	-66.28778	Other Facilities	Recreational Facilities
Coliseo Municipal de Barranquitas	PR152 KM 3.0 INTERIOR	18.196997	-66.308039	Other Facilities	Recreational Facilities
Community Assets Cañabón	PR 772 km 6.9	18.229609	-66.343011	Other Facilities	Recreational Facilities
Community Assets El Hotel	PR 152 km 2.3	18.20035	-66.295606	Other Facilities	Recreational Facilities
Community Assets Helechal	PR 558 km 0.5 interior	18.164969	-66.314306	Other Facilities	Recreational Facilities
Community Assets La Loma	PR 156 km 20.9 interior	18.188853	-66.27256	Other Facilities	Recreational Facilities
Community Assets La Vega	PR 156 km 14.3 interior	18.186203	-66.317026	Other Facilities	Recreational Facilities
Community Assets Los López	PR 152 km 8.7 interior	18.23823	-66.285749	Other Facilities	Recreational Facilities
Community Assets Melitón Perélez	PR 156 km 15.5	18.187686	-66.308237	Other Facilities	Recreational Facilities

Community Assets Palo Hincado	PR 156 km 10.5	18.191089	-66.344153	Other Facilities	Recreational Facilities
Community Assets Riquelmer	PR 771 km 4.1 interior	18.217834	-66.310969	Other Facilities	Recreational Facilities
Complejo Deportivo Pista Atlética	PR152 KM 3.0 INTERIOR	18.195911	-66.306261	Lifeline: Transportation	Transportation Systems
Cuartel de la Policía Estatal	PR 156 km 16.2	18.185006	-66.30602	Lifeline: Safety and Security	Law Enforcement
Edificio de Finanzas	Calle Antonio Vazquez # 5	18.185894	-66.306665	Lifeline: Safety and Security	Government Service
Edificio Gubernamental (Rosaida)	PR 156 km 16.2	18.183847	-66.307429	Lifeline: Safety and Security	Government Service
Esc. Antonio Vázquez	Bo. Quebrada Grande PR 156 km 20.0	18.184586	-66.277766	Lifeline: Food, Hydration and Shelter	Shelters
Esc. Francisco Paco López	PR-152, Km. 7.5, Int. Las Orquídeas	18.234171	-66.285251	Lifeline: Food, Hydration and Shelter	Shelters
Esc. Ramón T. Rivera	Bo. Barrancas PR 771 km 5.3	18.224125	-66.313107	Lifeline: Food, Hydration and Shelter	Shelters
Esc. Superior Luis Muñoz Marín	Bo. Barrancas Sector Nuevo Barranquitas	18.191481	-66.307785	Lifeline: Food, Hydration and Shelter	Shelters
Estación de Bomberos y Base de Emergencias Médicas Estatal	Ave. José Zayas Green Ramal 152	18.189438	-66.304335	Lifeline: Safety and Security	Fire Station Facilities
Grupo Médico Emanuel	Bo. Quebradillas PR 152 km 8.0	18.238559	-66.288717	Lifeline: Health and Medical	Medical Care
La Hacda St Km. 0.1		18.186725	-66.317183	Lifeline: Transportation	Transportation Systems

Local Road		18.215094	-66.311181	Lifeline: Transportation	Transportation Systems
Local Road		18.183833	-66.307433	Lifeline: Transportation	Transportation Systems
Obras Públicas Municipal	PR152 KM 3.0 INTERIOR	18.19475	-66.310028	Lifeline: Safety and Security	Government Service
Oficina de Manejo de Emergencias (OMME)	Ave. José Zayas Green Ramal 152	18.189286	-66.304611	Lifeline: Safety and Security	Government Service
PR 152R		18.1895	-66.303819	Lifeline: Transportation	Transportation Systems
PR 152R Km. 1.4		18.193747	-66.305369	Lifeline: Transportation	Transportation Systems
PR 156		18.186939	-66.313794	Lifeline: Transportation	Transportation Systems
PR 156		18.186358	-66.302472	Lifeline: Transportation	Transportation Systems
PR 156 Km. 9.5		18.194	-66.351872	Lifeline: Transportation	Transportation Systems
PR 558 Km. 0.2		18.167689	-66.319353	Lifeline: Transportation	Transportation Systems
PR 770		18.219925	-66.331683	Lifeline: Transportation	Transportation Systems
PR 771		18.241392	-66.317083	Lifeline: Transportation	Transportation Systems
PR 771		18.223058	-66.314253	Lifeline: Transportation	Transportation Systems
PR 771		18.216211	-66.309433	Lifeline: Transportation	Transportation Systems
0Ff PR-156 Km. 13.50		18.189397	-66.324856	Lifeline: Transportation	Transportation Systems

Appendix G: DSS-WISE Simulation Methodology for Puerto Rico Hazard Mitigation Plan Update

AtkinsRéalis

DSS-WISE Simulation Methodology for Puerto Rico Hazard Mitigation Plan Update

Overview

This document describes the methodology applied to run dam breach scenarios for the 14 dams requested in Puerto Rico in support of the hazard mitigation plan updates.

Scope

Fourteen (14) dams were identified for evaluation. PTS partners had existing 2D dam breach simulation results for four (4) dams within the La Plata watershed that were leveraged for the study. The remaining ten (10) dams were modelled using DSS-WISE.

Methodology

The National Center for Computational Hydroscience and Engineering (NCCHE) developed the (Decision Support System for Water Infrastructure Security (DSS-WISE) tool with funding from FEMA for the purpose of evaluating the consequences of floods relating to dams and levees.

For hazard mitigation planning, it is advised to account for the maximum event. Thus, this inundation mapping exercise will simulate a complete dam failure event assuming failure at top of dam elevations.

Hydraulic Model Outputs

Hydraulic model outputs from dam breach simulations were employed when available. The dams along the La Plata watershed included La Plata Dam, Comerio I Dam, Comerio II Dam, and Carite Dam. These dams followed the same stream

DSS-WISE Inputs

The best available data is captured in the National Inventory of Dams, captured by the United States Army Corps of Engineers (USACE). Table 1 describes how the DSS-WISE inputs are estimated.

Table 1. DSS-WISE Inputs and Assumptions

DSS-WISE Parameters	Inputs
Reservoir Name	NID field for NID ID
Reservoir Point	Identified around NID field for Latitude and Longitude
Normal Pool Elevation (ft NAVD88)	Normal Depth = {NID field for Normal Storage} / {NID field for Surface Area} Normal Pool Elevation = {estimated Ground Elevation} + {Normal Depth}
Normal Pool Volume (ac-ft)	NID field for Normal Storage

- Dam crest elevation used is reasonable.
- DSS-WISE inputs align with the calculated inputs.
- Breach hydrograph, if provided, is reasonable and aligns with the calculation spreadsheet.
- Reservoir volume fills to 100% and drains throughout the simulation.
- Simulation results are complete and reasonable.

GIS Processing

The finalized inundation extents were used to identify impacted points of infrastructure. A visual inspection also evaluated to include structures with a point location that may be outside the inundation area but its associated structure or accessibility would be impacted by a dam breach event.

The impacted points of infrastructure are summarized by the intersecting municipality.

Points

All points of critical infrastructure are provided in the results shapefile. Points are identified by dam breach inundation zone they fall within with a "Y" or "N" in the respective dam's name field. These dams are summarized in the "Dams_List" field that concatenates the dams that may inundate the point of critical infrastructure.

Lines

The lines of critical infrastructure are clipped to the dam inundation extents. These dams responsible for inundation the lines are summarized in the "Dams_List" field that concatenates the dams that may inundate the point of critical infrastructure. For the Primary and Secondary Roads features, duplicate roadways are summarized with alternate names provided for the stretch.

Polygons

Polygons are only provided where they intersect a dam inundation extent. Polygons are identified by dam breach inundation zone they fall within with a "Y" or "N" in the respective dam's name field. These dams are summarized in the "Dams_List" field that concatenates the dams that may inundate the point of critical infrastructure.

Where polygons intersect multiply municipalities, they are duplicated such that they are present for each municipality.

Data Sources

Data was leveraged from numerous federal sources, such as the FEMA Resilience Analysis and Planning Tool (RAPT) and the Federal Geographic Data Committee (FGDC) National Geographic Data Asset (NGDA). These datasets are described in Table #.

Dataset	Description	Source
Critical Infrastructure	Points of critical infrastructure, provided by the Caribe team's contacts.	Junta de Planificación de Puerto Rico (2026)
Municipalities	Polygon boundaries of municipalities, provided by the Caribe team's contacts.	Junta de Planificación de Puerto Rico (2026)

DSS-WISE Parameters	Inputs
Maximum Pool Elevation (ft NAVD88)	Maximum Pool Elevation = {estimated Ground Elevation} + {NID field for Dam Height}
Maximum Pool Volume (ac-ft)	NID field for Maximum Storage
Failure Pool Elevation (ft NAVD88)	Same value as Maximum Pool Elevation
Failure Pool Volume (ft NAVD88)	Same value as Maximum Pool Volume
Dam Name	NID field for Dam Name
Dam Crest Line	Drawn following aerial or terrain imagery around NID field for Latitude and Longitude
Crest Elevation (ft NAVD88)	Same value as Maximum Pool Elevation
Hydraulic Height (ft)	NID field for Dam Height
NID ID	NID field for NID ID
Structures Type	NID field for Primary Dam Type
Breach Center Point	Located at a reasonable point, likely along the middle of the crest line
Breach Type	"Reservoir", or "Hydrograph" if Reservoir Breach Type does not fully drain reservoir.
Breach Outflow Hydrograph	If "Hydrograph" Breach Type is selected, use inputs from NRCS TR60 Breach Peak with TR66 Breach Hydrograph worksheet.
Failure Type	"Sudden & Complete Failure"
Domain Buffer Distance (miles)	20 miles (and extended if needed)
Cell Size (ft)	15 ft
Project Name	NID field for NID ID and Dam Name (e.g., "PR#######_Dam_Name")
Scenario Name	Default name
Scenario Description	Default description

Dam Crest Elevation Selection

The dam crest was selected by using the Elevation Profile tool in DSS-WISE Beta 4.0 version to identify the lowest point along the dam crest line.

Where dams were removed from the terrain, the dam crest elevation was selected from the fragments still in the terrain. Where the DSS-WISE simulation failed to match the filled reservoir volume at 100%, the simulation was iterated to identify the elevation to the nearest half-foot to match the filled reservoir volume corresponding to the maximum storage volume indicated in the National Inventory of Dams. Simulations were also performed using a dam crest elevation adding the ground elevation with the dam height.

Hydrograph Breach Simulation

For dams that were unable to fully drain under the reservoir breach scenarios on DSS-WISE, the NRCS TR60/TR66 Breach Hydrograph Worksheet was employed to generate the breach hydrograph for DSS-WISE. Inputs were derived from accessible information online, the NID, or the report from a previous DSS-WISE simulation.

Simulation Quality Checks

The DSS-WISE simulations were independently checked for quality, where the reviewer checked for the following items:

Dataset	Description	Source
USA Structures (Puerto Rico)	Polygon boundaries of building footprints for structures larger than 450 square feet, generated from a collaboration of FEMA, Oak Ridge National Laboratory, and the U.S. Geological Survey	FEMA (2025)
RAPT Colleges and Universities	Point locations of post-secondary education facilities, as defined by the Integrated Post Secondary Education System from the National Center for Education Statistics in the U.S. Department of Education for the 2019-2020 school year, collected for the Homeland Infrastructure Foundation-Level Data	FEMA (2025)
RAPT Hospitals	Point locations of hospital facilities acquired from various state departments or federal sources, collected for the Homeland Infrastructure Foundation-Level Data	FEMA (2025)
RAPT Local Law Enforcement Locations	Point locations of law enforcement agencies as defined by the U.S. Department of Justice – Bureau of Justice Statistics for their Census of State and Local Law Enforcement Agencies, collected for the Homeland Infrastructure Foundation-Level Data	FEMA (2025)
RAPT Public Schools	Point locations of public elementary and secondary education facilities as defined by the Common Core of Data from the National Center for Education Statistics in the U.S. Department of Education for the 2022-2023 school year, collected for the Homeland Infrastructure Foundation-Level Data	FEMA (2025)
RAPT Wastewater	Point locations of wastewater treatment plants compiled from the U.S. Environmental Protection Agency Facility Registry Service and Integrated Compliance Information System, collected for the Homeland Infrastructure Foundation-Level Data	FEMA (2025)
RAPT Nursing Homes	Point locations of facilities that house elderly adults, collected for the Homeland Infrastructure Foundation-Level Data	FEMA (2025)
RAPT Power Plants	Point locations of operable electric generating plants by energy source as defined by the Energy Information Administration, collected for the Homeland Infrastructure Foundation-Level Data	FEMA (2025)
RAPT Prison Boundaries	Polygon boundaries of where the incarcerated population is located with fence lines or building footprints for federal (excluding military) to local government jurisdictions, collected for the Homeland Infrastructure Foundation-Level Data	FEMA (2025)
RAPT Public Health Departments	Point locations of public health department locations downloaded in 2024, collected for the Homeland Infrastructure Foundation-Level Data	FEMA (2025)
RAPT Dialysis Centers	Point locations of dialysis centers identified by Rx Open downloaded in 2023, collected for the Homeland Infrastructure Foundation-Level Data	FEMA (2025)

Garzas Dam (PR00006)

The Garzas Dam runs in series upstream of Adjuntas Dam and Dos Bocas Dam. Since the terrain is steep, these dams are modelled independently. The normal and maximum storage volumes were identical, so the maximum pool elevation was also leveraged for the normal pool elevation.

Adjuntas Dam (PR00007)

The Adjuntas Dam runs in series between Garzas Dam and Dos Bocas Dam. Since the terrain is steep, these dams are modelled independently. The Adjuntas Dam crest elevation was unable to be identified from the terrain, and the sum of the ground elevation and dam height did was unable to acceptably fill the reservoir volume to match the NID data. Thus, the simulation was iterated to find the nearest elevation (to the half-foot) that would fill the reservoir.

Pellejas Dam (PR00008)

The Adjuntas Dam runs in series upstream of Dos Bocas Dam. Since the terrain is steep, these dams are modelled independently. The Pellejas Dam crest elevation was unable to be identified from the terrain, and the sum of the ground elevation and dam height did was unable to acceptably fill the reservoir volume to match the NID data. Thus, the simulation was iterated to find the nearest elevation (to the half-foot) that would fill the reservoir.

Dos Bocas Dam (PR0009)

The Dos Bocas Dam was modelled using the methods described in this report.

Vivi Dam (PR00010)

The Vivi Dam runs in series upstream of Dos Bocas Dam. Since the terrain is steep, these dams are modelled independently. The Pellejas Dam crest was elevation unable to be identified from the terrain, so the dam crest elevation was estimated by adding the dam height to the ground elevation.

Caonillas Dam (PR00011)

The Caonillas Dam was modelled using the methods described in this report.

La Plata Dam (PR00017)

The La Plata Dam was modelled in series with Carite Dam, Comerio I Dam, and Comerio II Dam and is the most significant dam in this series. This dam breach scenario was modelled as a probable maximum flood event by Freese and Nichols, Inc. in October 2024 as part of the February 2024 Puerto Rico Dam Safety Under Extreme Rainfall Final Assessment Report by ARC.

The associated model includes the hydrologic (probable maximum flood event) for the full basin from Carite down, but only the La Plata dam is breached in this model. Thus, points of critical infrastructure upstream of the La Plata Dam may be attributed to the La Plata Dam.

Comerio II Dam (PR00018)

The Comerio II Dam was modelled as a probable maximum flood event by Freese and Nichols, Inc. in October 2024 as part of the February 2024 Puerto Rico Dam Safety Under Extreme Rainfall Final Assessment Report by ARC. The model terminates with ponding in the La Plata Dam.

Dataset	Description	Source
RAPT Pharmacies	Point locations of pharmacies identified by Rx Open downloaded in 2023, collected for the Homeland Infrastructure Foundation-Level Data	FEMA (2025)
RAPT Transmission Lines	Lines of electric power transmission lines, collected for the Homeland Infrastructure Foundation-Level Data	FEMA (2025)
NGDA Medical Emergency Response Structures	Point locations of hospitals, medical centers, ambulance services, fire stations, and EMS stations from the U.S. Geological Survey	FGDC (2025)
NGDA Law Enforcement Structures	Point locations of police and prison landmarks from the U.S. Geological Survey	FGDC (2025)
NGDA Recreation Structures	Point locations of campgrounds, trailheads, and visitor information centers from the U.S. Geological Survey	FGDC (2026)
NGDA Landmarks and Government Buildings	Point locations of cemeteries, post offices, city/town halls, and courthouses from the U.S. Geological Survey	FGDC (2025)
NTAD Runways	Polygon boundaries of runways identified from the Federal Aviation Administration	USDOT (2026)
NTAD Aviation Facilities	Point locations of airport locations identified from the Federal Aviation Administration	USDOT (2026)
TIGER/Lines Primary and Secondary Roads (Puerto Rico)	Lines indicating roads part of main artery systems, including interstate highways, U.S. highways, state highways, and county highways.	U.S. Census Bureau (2026)

Results

Results for dam inundation breaches are summarized by HUC10 watershed level. The modeling inputs for the dam breach events modeled on DSS-WISE are also summarized in the DSS-WISE simulation reports.

Guajataca Dam (PR00001)

Guajataca Dam was unable to fully drain under the reservoir breach scenarios on DSS-WISE. The NRCS TR60/TR66 Breach Hydrograph Worksheet was employed to generate the breach hydrograph for DSS-WISE. USACE included a figure of the maximum cross-section of the dam with values to input in the Breach Hydrograph Worksheet, such as the crest width, downstream stability berm width, upstream slope, and downstream slope. The remaining TR60/TR66 inputs were derived from the NID or the report from a previous DSS-WISE simulation.

Guayo Dam (PR00005)

The Guayo Dam was modelled using the methods described in this report.

Comerio I Dam (PR00019)

Comerio I Dam is a very small, run-of-river style dam. Model results are not provided for this dam breach since the inundation results captured by the dams upstream and downstream of Comerio I Dam will capture the hazard of a dam breach.

Cidra Dam (PR00020)

The Cidra Dam crest elevation was unable to be identified from the terrain, and the sum of the ground elevation and dam height did was unable to acceptably fill the reservoir volume to match the NID data. Thus, the simulation was iterated to find the nearest elevation (to the half-foot) that would fill the reservoir.

Carite Dam (PR00021)

The Carite Dam was modelled as a sunny day failure event by Freese and Nichols, Inc. in October 2024 as part of the February 2024 Puerto Rico Dam Safety Under Extreme Rainfall Final Assessment Report by ARC. The model terminates with ponding in the La Plata Dam.

Patillas Dam (PR00023)

The Patillas Dam was modelled using the methods described in this report.

Discussion

Of the 25 municipalities of focus, the dam breaches impacted the following municipalities: Adjuntas, Aguas Buenas, Añasco, Arecibo, Arroyo, Barranquitas, Cataño, Comerío, Dorado, Isabela, Las Marías, Patillas, and Utuado.

The 12 municipalities not impacted by the dam breaches include: Aguada, Ceiba, Hatillo, Jayuya, Peñuelas, Rincón, Salinas, San Germán, Santa Isabel, Vega Alta, Vieques, and Yabucoa.

Recommendations

It is recommended to visually evaluate the identified critical infrastructure impacted, based on local knowledge. There may be schools identified through multiple datasets (Inf_Critica_Final provided by the PRPB LHMP, Schools idenfied by the FGDC NGDA, and Public Schools identified by the FEMA RAPT datasets). All datasets are provided in case one includes details not provided by another dataset. Additional investigation should be employed to determine if the additional data is applicable.

Check the dam breach results are reasonable for the dam's location. The La Plata Dam model extends upstream of the La Plata Dam due to the PMF breach results form the Carite Dam, so those reports should be adjusted accordingly.

If these files are converted to shapefiles, the field names may be truncated to accommodate the shapefile 10-character limit.

SQL Queries

SQL queries are provided below to best understand how to identify different points of relevance.

Definition Query

To remove extraneous point features that are not associated with an existing dam inundation extent using the following definition query:

Dams_List IS NOT NULL

By Municipality

To identify the mileage of roads impacted by municipality, the "municipio" field can be leveraged for querying. For example, the following steps will identify the road names, mileage, and associated dam breaches that impact a road:

1. "Select By Attribute":
    a. Selection Type: "New selection"
    b. Where: "municipio = 'Aguas Buenas' "

By Dam Breach

To identify features impacted by specific dams, the dam can be queried depending on the type of feature, as described below:

1. For discrete point and polygon features: "Select By Attribute":
    a. Selection Type: "New selection"
    b. Where: "Adjuntas_Dam = 'Y'"
2. For line features: "Select By Attribute:"
    a. Selection Type: "New selection"
    b. Where: "Dams_List LIKE '%Adjuntas_Dam%' ESCAPE '\'" (this selects where the Dams_List field contains the text "Adjuntas_Dam")

Visual Inspection Additions

To identify features that were identified through visual inspection, use the following selection steps:

1. "Select By Attribute":
    a. Selection Type: "New selection"
    b. Where: "Dams_List IS NOT NULL"
2. "Select By Location":
    a. Selection Type: "Select subset from the current selection
    b. Invert Spatial Relationship
    c. Relationship: Intersect

d. Selecting Features: merged floodplain shapefile

This step can be modified by first setting a definition query to the "Select By Attribute" query and then selecting by location with a new selection.