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LOCAL HAZARD MITIGATION PLAN

Municipality of Aguas Buenas



LOCAL HAZARD
MITIGATION PLANS

Protect Through Planning

AtkinsRéalis - Baseline / Référence

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 Aguas Buenas was approved
by FEMA on

STATEMENT OF FUNDING

This Local Hazard Mitigation Plan was prepared for the Municipality of Aguas Buenas 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 Aguas Buenas 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

AMMED	Municipal Agency for Disaster and Emergency Management, by its Spanish Acronym
CEACC	Comité de Expertos y Asesores sobre Cambio Climático, by its Spanish Acronym
DHS	Department of Homeland Security
DNER	Department of Natural and Environmental Resources
DPS	Department of Public Safety
DTPW	Department of Transportation and Public Works
EPA	Environmental Protection Agency
FEMA	Federal Emergency Management Agency
FHWA	Federal Highway Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
IFRC	International Federation of the Red Cross
IRRM	Interim Risk Reduction Measures
LUMA	Luma Energy
mph	Miles per hour
NDRF	National Disaster Recovery Framework
NIMS	National Incident Management System
NIST	National Institute of Standards and Technology
OPM	Municipal Public Works, by its Spanish acronym
PRASA	Puerto Rico Aqueduct and Sewer 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
SFLA	Southern Federal Land Assessment
UHI	Urban Heat Island

USACE	United States Army Corps of Engineers
USDOT	United States Department of Transportation
USGS	United States Geological Survey

EXECUTIVE SUMMARY

This document is the 2026 update of the Local Hazard Mitigation Plan (LHMP) for the Municipality of Aguas Buenas, Puerto Rico. It is prepared to reduce risks associated with natural hazards and enhance community resilience by identifying hazards, assessing risks, and proposing mitigation strategies. The plan complies with federal regulations, including the Stafford Act and Disaster Mitigation Act of 2000, and incorporates public participation and interagency coordination. It is funded by a grant from the Puerto Rico Planning Board and prepared by AtkinsRéalis Caribe, LLP.

Introduction and Background

The Municipality of Aguas Buenas and the Puerto Rico Planning Board are committed to protecting residents by updating the LHMP, which provides a structured approach to hazard mitigation consistent with federal, state, and local policies. The plan identifies natural hazards, evaluates risks, and supports land use planning to achieve sustainability and resilience. It also complies with FEMA requirements to maintain eligibility for federal funding and is regularly updated to reflect evolving conditions.

This plan follows the following objectives:

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

Public Policy

- The plan aligns with federal, Puerto Rico, and municipal policies guiding hazard mitigation and resilience for example.
- 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 and National Incident

Management System that support seismic risk reduction and emergency response.

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 Aguas Buenas LHMP (2020) and Municipal Recovery Plan establishes prior mitigation frameworks and recovery priorities.

Planning Process

The 2026 LHMP update follows FEMA guidelines and includes a Planning Committee with municipal officials, public outreach through meetings and notifications, and stakeholder involvement. Public participation included three community meetings with opportunities for feedback. The plan integrates FEMA Lifelines (Safety and Security, Food, Hydration and Shelter, Health and Medicine, Energy, Communications, Transportation, Hazardous Materials, Water Systems) to prioritize critical services.

Municipal Profile

The Municipality of Aguas Buenas is a predominantly rural municipality located in the central-eastern mountainous region of Puerto Rico. Established in 1838, the municipality is composed of ten barrios and encompasses approximately 30 square miles. Key findings of the municipal assessment include:

Demographics

According to the 2024 ACS, the Municipality of Aguas Buenas has a population

characterized by a significant proportion of vulnerable residents, including children, youth, and older adults. Demographic trends indicate an aging population, highlighting the need for targeted emergency preparedness, evacuation support, healthcare services, and resilience strategies to address the needs of at-risk groups during hazard events.

Socioeconomic Conditions

Aguas Buenas faces socioeconomic challenges that may affect disaster preparedness and recovery, including high poverty levels, reliance on food assistance, disability-related needs, and limited access to resources. These conditions underscore the importance of mitigation actions that enhance community resilience and support vulnerable populations.

Housing

The housing profile of Aguas Buenas reflects a predominantly residential community with an aging housing stock and socioeconomic factors that may increase vulnerability to hazard events. These conditions highlight the importance of mitigation measures that protect residential structures, reduce potential losses, and support long-term community resilience.

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 Aguas Buenas reflects ongoing investments in housing, infrastructure, and public facilities. Incorporating hazard mitigation considerations into future growth and development will help reduce risk and strengthen community resilience.

Hazard Profiles and Risk Assessment

The LHMP evaluates eight prioritized hazards: earthquake, landslides, flooding, tropical cyclones/extreme winds, extreme heat, drought, wildfire, and pandemic/epidemic. Each hazard is described with its characteristics, affected areas, risk magnitude, past events, future probabilities, risk analysis, social vulnerabilities, and impacts on natural and cultural resources.

Earthquake

Puerto Rico is located within a tectonically active region characterized by multiple fault systems, making earthquake risk a significant concern for Aguas Buenas. The assessment considers earthquake intensity, magnitude, spectral acceleration, and ground motion as key indicators of potential impacts.

Estimated annualized earthquake losses are approximately \$3.3million, reflecting the potential for substantial damage to buildings, infrastructure, and essential services. Earthquakes may affect all FEMA Social vulnerability is heightened by poverty, aging infrastructure, limited household resources, and the presence of residents who may require additional assistance during response, and recovery.

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 in Aguas Buenas are primarily triggered by intense rainfall and are influenced by slope conditions, soil characteristics, geology, land cover, drainage patterns, and human activity.

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.

Past landslide impacts were notably observed after Hurricane María in 2017, when intense rainfall produced slope failures across many areas of Puerto Rico. Given the municipality's terrain, rainfall patterns, and the presence of development in susceptible areas, landslide risk is expected to continue and should remain a priority for mitigation, land use planning, infrastructure maintenance, and emergency response coordination.

Flooding

Flooding in Aguas Buenas includes both general flooding and flash flooding, most often associated with tropical weather systems and intense rainfall events. Flood hazard areas are mapped extensively along the Río Bayamón to Río Hondo Watersheds.

The risk assessment identifies flooding as a high-probability hazard with the potential to cause significant property damage, health risks, and infrastructure impacts. Estimated flood exposure includes more than \$18 million in building value.

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 wind events represent some of the most frequent and damaging hazards affecting Aguas Buenas. These events range from tropical storms to Category 5 hurricanes, as classified by the Saffir-Simpson Hurricane Wind Scale. The entire municipality is considered exposed to their impact.

Historic hurricanes, including Irma and María in 2017, demonstrate the municipality's exposure to severe wind that can cause power outages, infrastructure damage, economic disruption, and extended recovery needs. The risk assessment maps estimated building damage and economic losses for both 100-year and 500-year events, illustrating the potential severity of future hurricane impacts.

Because tropical cyclones can affect all FEMA Lifelines, including energy,

communications, transportation, safety and security, health and medical services, food and shelter, water systems, and hazardous materials, their impacts can cascade across the community. Social vulnerability is considered widespread due to the municipality-wide exposure of residents, housing, infrastructure, and essential services.

Extreme Heat

Extreme heat is defined as prolonged periods of temperatures above 90 degrees Fahrenheit combined with high humidity, conditions that can increase health risks and place stress on infrastructure systems. Developed areas may experience higher temperatures due to the urban heat island effect, increasing exposure for residents in more urbanized portions of the municipality.

Extreme heat can affect public health, energy demand, transportation systems, communications, and other essential services. Older adults and other vulnerable populations may face elevated risk, particularly when risk perception is low or when access to cooling, medical care, or reliable transportation is limited. Health impacts may include heat-related illness and increased mortality among sensitive populations.

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 Aguas Buenas is characterized by prolonged precipitation deficits that can affect water supply, agricultural activity, economic conditions, and the continuity of essential services. This hazard may occur as a meteorological, agricultural, hydrological, or socioeconomic drought. All these types of droughts can impact water availability and community functions.

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 frequency is expected to increase, reinforcing the need to strengthen water conservation, emergency water supply planning, infrastructure resilience, public awareness, and coordination with regional water providers. Social vulnerability is particularly important for elderly residents and low-income households, which may have fewer resources to adapt to water interruptions, higher utility costs, or related public health and economic impacts.

Wildfire

Wildfire consists of uncontrolled fires that may occur in vegetated or dry forest areas and may be intensified by drought conditions and long-term climate trends. Wildfire behavior may include surface fires, crown fires, ground fires, and interface fires where developed areas meet wildland vegetation, creating potential risks to residents, structures, infrastructure, and natural resources.

Aguas Buenas has historically experienced a relatively low incidence of wildfire; however, some areas near municipal borders present higher potential risk. Wildfires can threaten natural ecosystems, cultural resources, public infrastructure, transportation access, and nearby communities. Recent 2024 wildfire data identified multiple small incidents, indicating that the hazard should continue to be monitored as part of the municipality's risk profile.

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 as well as widespread events that can extend across regions, nations, or globally. For planning purposes, the entire municipality is considered vulnerable because infectious disease impacts can affect residents, institutions, workplaces, schools, healthcare providers, and essential services throughout Aguas Buenas.

Puerto Rico has experienced several historic outbreaks, including cholera in 1855, measles in 1917, the Spanish Flu in 1918, polio in 1960, as well as, dengue, chikungunya, Zika, and COVID-19 in recent years. The COVID-19 pandemic produced significant health, economic, and social impacts locally and illustrated how disease events can disrupt normal community functions, increase demand for public health services, and affect vulnerable populations.

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.

Hazard Prioritization

The Planning Committee used the results of the hazard profiles and risk assessment to establish mitigation priorities for the Municipality of Aguas Buenas. Based on the analysis, earthquakes, landslides, flooding, tropical cyclones and extreme winds, extreme heat, drought, and wildfire were identified as high-priority hazards. Pandemic and epidemic hazards were categorized as mid-priority. This prioritization exercise conducted with the planning committee was a qualitative exercise which takes into consideration the municipality's exposure, potential impacts to people and property, effects on critical infrastructure and FEMA Lifelines, and the needs of socially vulnerable populations.

Municipal Capabilities

The LHMP is supported by a range of planning mechanisms, regulatory frameworks, and municipal capacities that guide land use, permitting, floodplain management, infrastructure investment, emergency response, and long-term resilience. These include the Karst Special Planning Area Plan, the Joint Regulation for Permits, the Special Flood Hazard Areas Regulation, the Puerto Rico Building Code, the Stormwater Systems Regulation, the Aguas Buenas Territorial Plan, and the Aguas Buenas Emergency Operation Plan. The municipality also participates in the National Flood Insurance Program and complies with the Clean Water Act's NPDES program. In

addition, the plan recognizes the value of green infrastructure and nature-based solutions for stormwater management, while the Four-Year Investment Program (PICA) serves as a tool to align public investment with hazard mitigation priorities.

Aguas Buenas technical and administrative capacity is supported by municipal offices with responsibilities related to planning, land use, emergency management, and federal programs. These include a staffed Planning and Land Use Office, Emergency Management Office, and Federal Programs Office. The municipality's financial capacity is strengthened by positive fund balances and access to federal funding sources, including FEMA's Hazard Mitigation Grant Program (HMGP), Flood Mitigation Assistance (FMA), Building Resilient Infrastructure and Communities (BRIC), and HUD's CDBG-DR and CDBG-MIT programs.

Public outreach and capacity development are also central components of the LHMP. The municipality uses social media, printed materials, and community meetings to inform residents, gather input, and promote public participation in the mitigation planning process. Capacity-building efforts include staff training and collaboration with academic institutions, supporting the municipality's ability to implement mitigation actions and strengthen institutional knowledge. The plan emphasizes clear, inclusive, and accessible communication to improve hazard awareness, encourage preparedness, and increase community participation.

Mitigation Action Plan

The Mitigation Action Plan establishes goals and objectives to reduce hazard impacts, protect life and property, strengthen infrastructure, increase public knowledge, and improve recovery capacity. Its objectives include preventing loss of life and property, improving municipal program implementation, educating residents and businesses about hazard risks, and strengthening emergency response and intergovernmental coordination. Mitigation strategies are organized into categories such as prevention, property protection, natural resource protection, structural mitigation, emergency services, and public awareness and outreach. These strategies include updating land use and emergency management plans, improving stormwater management, conducting hazard drills, supporting infrastructure resilience, and addressing extreme heat through urban greening and response planning among others.

Overall, the 2026 Aguas Buenas LHMP update integrates hazard assessments, policy frameworks, municipal capabilities, community input, and actionable mitigation strategies into a comprehensive planning tool. Through this integrated approach, the

municipality seeks to reduce risk, protect essential services, guide future investments, and strengthen resilience to natural hazards and public health emergencies over the coming years.

The Municipality of Aguas Buenas 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 on 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, Aguas Buenas 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 Aguas Buenas 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 third revision of the LHMP for the Municipality of Aguas Buenas. The original plan received FEMA approval in 2013, and a second update was approved in 2020 (Autonomous Municipality of Aguas Buenas, 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, Aguas Buenas 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.

4.15 Overview of Federal and State Public Policies

This section outlines the relevant federal and state public policies that guide the development of the 2026 Aguas Buenas LHMP. The overview provided is not intended to be comprehensive. Additional public policies are referenced throughout the document, particularly in Section 4.16.

4.15.1 Overview of Federal Public Policies

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

4.15.1.1 Stafford Act

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.

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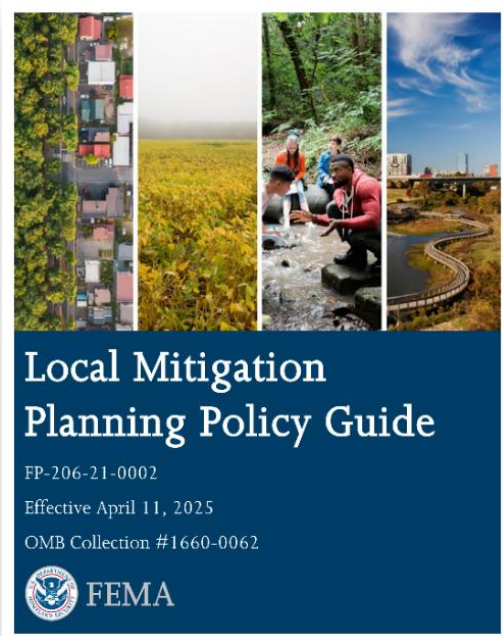
Mitigation Planning – 44 CFR Part 201

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

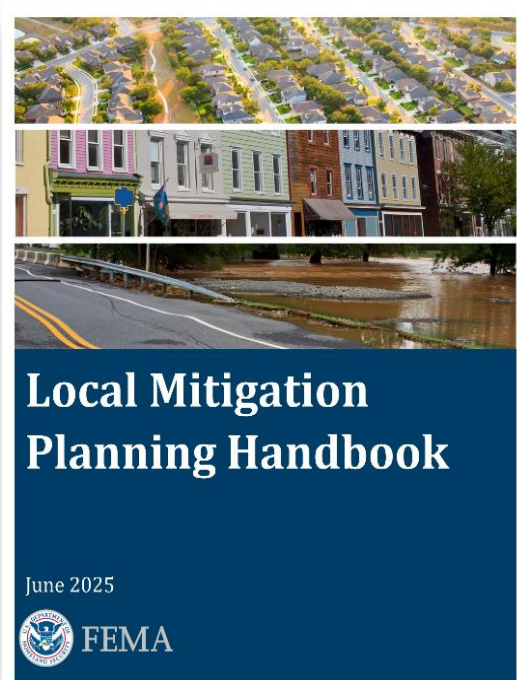


The policy guide emphasizes data-driven planning tailored to local capacities, while prioritizing equity and inclusive stakeholder participation. It encourages communities to integrate hazard mitigation into broader planning and decision-making processes, thereby strengthening long-term resilience and 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 Handbook



The *Local Mitigation Planning Handbook* is an operational resource developed by FEMA to assist local governments, including municipalities and special districts, in the development or update of 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.

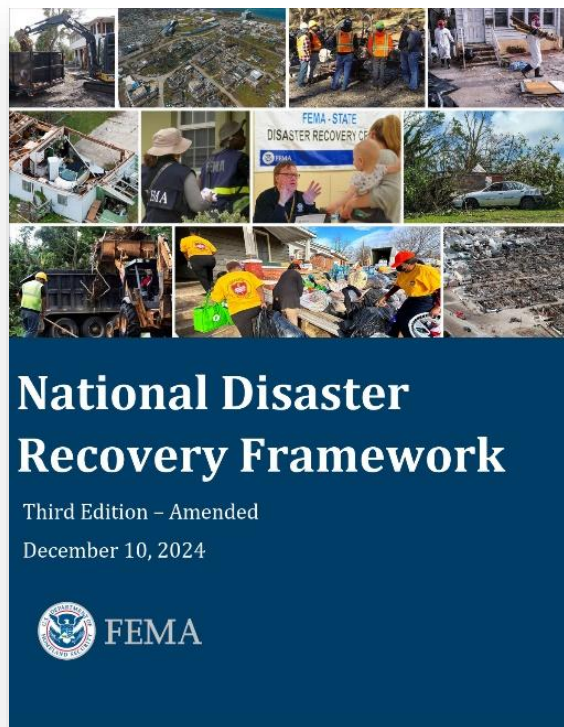
The primary purpose of the handbook is to support communities in identifying the natural hazards they face, evaluating institutional and administrative capabilities, and formulating effective strategies to reduce disaster-related impacts (FEMA, 2025). Ultimately, the

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

Figure 3: National Disaster Recovery Framework Cover



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 Aguas Buenas participation in the NFIP is provided in Section 6.5 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 Aguas Buenas.

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.

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

1.1.0.1 N CPRM P AM J _ U Q

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.

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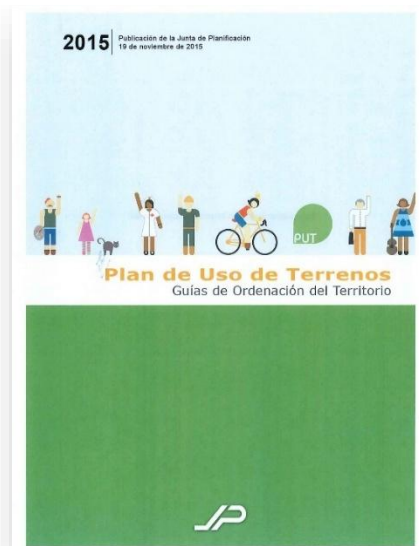
Puerto Rico Land Use Plan (PUT-PR by its Spanish acronym) - 2015

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):

Figure 4: Puerto Rico PUT Coversheet



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)

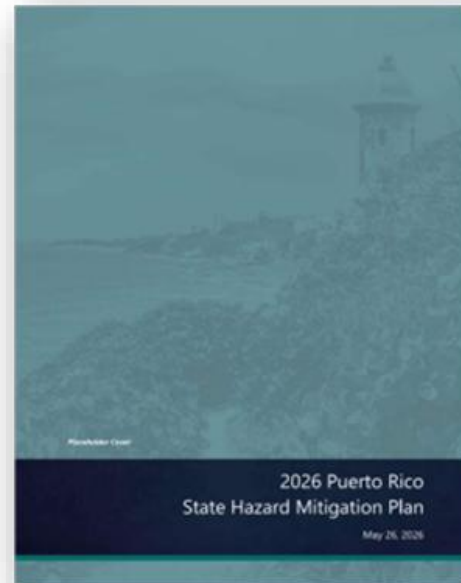
Like local jurisdictions, the Stafford Act requires states and territories to develop and maintain a hazard mitigation plan that addresses risks across their entire jurisdiction. In Puerto Rico, the 2021 Puerto Rico State Hazard Mitigation Plan established a long-term framework for identifying natural hazards and implementing mitigation measures to reduce risk. The plan recognized that natural hazards have the potential

to disrupt daily activities, damage property, threaten human life, and affect public health, infrastructure, economic stability, and natural ecosystems (NMEAD, 2021).

In 2026, the Commonwealth updated the State Hazard Mitigation Plan to reflect current hazard conditions, risk assessments, capabilities, mitigation priorities, and ongoing resilience initiatives. The updated plan continues to provide a comprehensive framework for reducing vulnerability to natural hazards, enhancing community resilience, protecting critical infrastructure, and supporting sustainable development throughout Puerto Rico (NMEAD, 2026).

During the preparation of this LHMP update, the Municipality of Aguas Buenas reviewed the 2026 Puerto Rico State Hazard Mitigation Plan. Relevant hazard data, risk assessments, mitigation goals, state capabilities, and mitigation actions identified in the 2026 update were considered during the municipal risk assessment, capability assessment, and development of the mitigation strategy.

Figure 5: Puerto Rico SHMP Cover



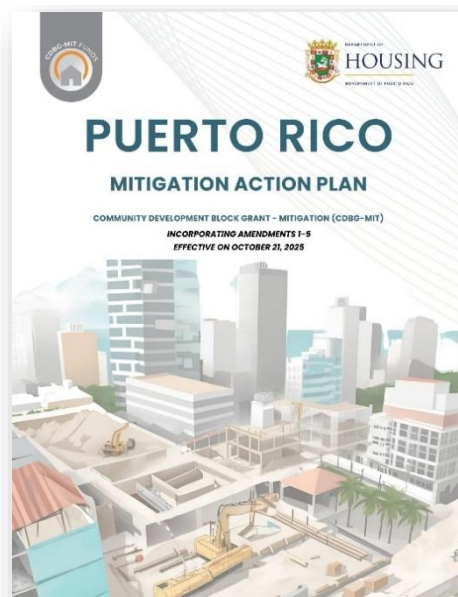
Puerto Rico Mitigation Action Plan, CDBG-DR MIT (2021, 2025)

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 by Congress 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).

Figure 6: Puerto Rico Mitigation Action Plan Cover



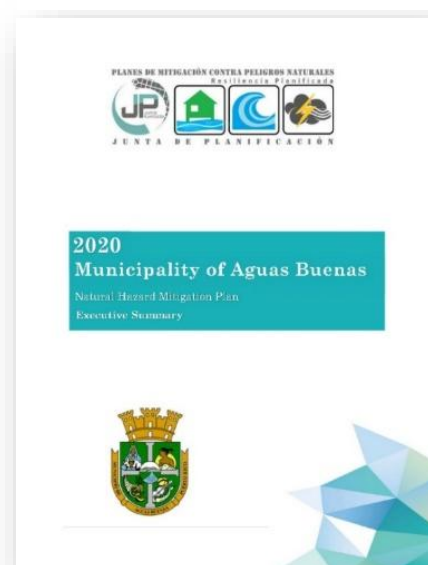
Other relevant planning regulations will be discussed as part of section 4.16.

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Aguas Buenas Local Hazard Mitigation Plan (2020)

Adopted by the Municipality on June 6, 2020, this is the most recent Hazard Mitigation Plan for the Municipality of Aguas Buenas. The identified hazards are divided into natural and anthropogenic.

Figure 7: Aguas Buenas Hazard Mitigation Plan Cover



Some of the mitigation strategies proposed by this plan are:

- **Flooding:** Projects include dredging the Aguas Buenas River and improving stormwater systems in Quebrada Cataluña.

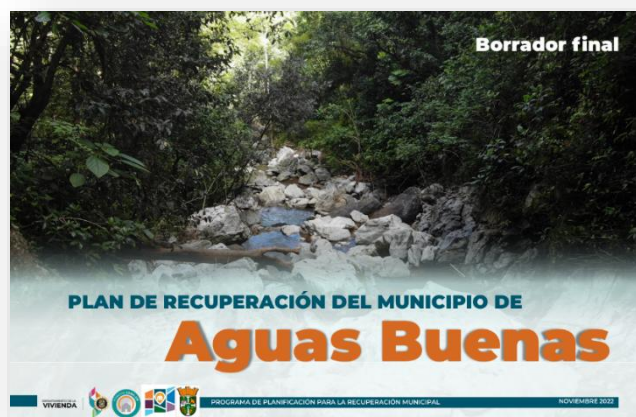
- **Hurricanes:** Reinforcement of power lines, underground cabling, and educational campaigns.
- **Landslides:** Slope stabilization and relocation of families in critical areas.
- **Earthquakes:** Bridge inspections, evacuation routes, and alert systems.
- **Droughts:** Construction of wells and cisterns, and installation of meteorological stations.

Aguas Buenas 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:

- Identify local post-disaster needs created or worsened by Irma and María.
- Establish short, medium, and long-term recovery priorities.
- Integrate resilience and hazard mitigation strategies.
- Serve as a policy and project roadmap for future funding decisions.

Figure 8: Aguas Buenas Municipal Recovery Plan Cover



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

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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.

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The following recommendations and requirements were made by FEMA upon approving the previous 2020 LHMP for Aguas Buenas.

- **Improve Coordination with Neighboring Municipalities**

FEMA recommended documenting comments and input received from neighboring municipalities in a dedicated section of the plan. This would help demonstrate regional coordination, show how hazards affect adjacent communities, and support the development of multi-jurisdictional mitigation projects.

- **Better Address Karst Hazards and Sinkholes**

Although the plan discussed karst-related risks, FEMA noted that the hazard summary table did not adequately reflect sinkholes and associated hazards such as drainage issues, flooding, and landslides. Future updates should explicitly include sinkholes and their potential impacts.

- **Expand Economic Loss Estimates**

FEMA found that detailed financial loss estimates were provided primarily for flooding and earthquakes, while other hazards were described mainly in terms of affected population or area. Future plans should estimate economic losses and potential dollar damage for additional hazards whenever feasible or explain why such estimates cannot be developed.

- **Strengthen Documentation of Existing Capabilities**

The plan identified municipal resources, programs, and capabilities, but FEMA noted that some tables lacked complete information. Future updates should clearly identify available resources, how they contribute to risk reduction, and what resources are specifically dedicated to mitigation activities.

- **Revise Mitigation Goals to Be More Action-Oriented**

FEMA recommended making mitigation goals more specific and implementation focused. Instead of broad statements about reducing vulnerability, goals should identify clear actions that directly address the municipality's specific hazards and risks.

- **Improve Mitigation Action Documentation**

For the mitigation action table, FEMA suggested adding a separate column describing the benefits of each project. This would make it easier to understand the purpose and expected outcomes of proposed mitigation measures.

- **Make Planning Integration Discussion More Municipality-Specific**

The section discussing open space, Special Flood Hazard Areas (SFHAs), and other risk areas was considered too general. FEMA recommended providing more specific information on how Aguas Buenas used local hazard data and planning mechanisms to guide mitigation planning decisions.

- **Include Adoption Documentation in the Final Plan**

FEMA noted that the municipality had adopted the plan through Executive Order No. 6 (Series 2020-2021) on September 11, 2020, and recommended including the adoption ordinance/executive order within the final plan document submitted to FEMA.

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Table 1 shows the organization for the 2026 of Aguas Buenas 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 Aguas Buenas, 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 Aguas Buenas LHMP. It also summarizes the significant changes made since the 2020 Plan and explains how the updated plan	E2-a

Chapter #	Title	Description	Review Tool Elements met
		addresses applicable federal, state, and municipal planning requirements.	
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 Aguas Buenas, including its geographic and physical characteristics, land use, population, housing, socioeconomic conditions, infrastructure, community lifelines, and other characteristics relevant to hazard mitigation planning.	E1-a, A1-a, A1-b, A2-a, A3-a
Chapter 4	Hazard Profiles and Risk Analysis	This chapter identifies and profiles the hazards affecting Aguas Buenas 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 #	Title	Description	Review Tool Elements met
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 actions into other municipal planning mechanisms and programs.	D1-a, D2-a, D2-b, D2-c, D3-a
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 Aguas Buenas 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.	

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Table 2 shows the most significant changes that the 2026 version has from the 2020 version.

Table 2: Changes to the Aguas Buenas LHMP

Element	Justification
Plan Language	Following Presidential Executive Order #14224, the 2026 version of Aguas Buenas LHMP has been originally

Element	Justification
	prepared in English for submission and consideration of FEMA. A non-certified translation of the final draft for public discussion and the final approved LHMP to Spanish will be prepared for the benefit of the population that are not English proficient.
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 LHMP FEMA Guidelines
Discussion of FEMA Lifelines	As per Local Hazard Mitigation Policy, FEMA Lifelines are discussed as well as the strategies to mitigate hazard impacts on them.
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 have been changed to Tropical Cyclones and Extreme Winds since unlike previous versions HAZUS 6.1 can modeled 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 it has chosen to evaluate the data sets from the 2024 five-year American community survey. The five-year survey is chosen since there is more information in them than in 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 Cidra Dam upriver from the municipality and the experience with the partial dam collapse of the dam after hurricane María, the municipality considers 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.
All the LHMP	Attention has been given to ensure that the content of the Plan does not reveal any personally identifiable information (PII).

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This LHMP was updated following the above-mentioned applicable public policies and procedures mentioned in Chapter 1.

This LHMP seeks to aid municipality in the task of preventing loss of life and property by the effects of natural hazards. Chapter 1 serves as a general introduction, Chapter 2 discusses the planning process followed, as well as stakeholder and public participation involvement. The LHMP identifies a general profile of the municipality using information provided by the US Census, such as population distribution, employment, housing stock, etc. (see Chapter 3 for more information). After describing the Municipality's 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 various appendixes hold supporting information.

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This document represents the third revision of the LHMP for the Municipality of Aguas Buenas. The original plan received FEMA approval in 2013, and a second update approved in 2020 (Autonomous Municipality of Aguas Buenas, 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.

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Following 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, AtkinsRéalis Caribe, LLP under contract with the Puerto Rico Planning Board, provided professional mitigation planning services to support the development of the Municipality's plan update.

The Municipality and its consultants followed the natural hazard mitigation planning process as established by FEMA in 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 to comply with mitigation planning requirements and identifies where each requirement is addressed within this Plan.

The planning process for the 2026 update of the Aguas Buenas Local Hazard Mitigation Plan (LHMP) officially began with the execution of a Letter of Agreement between the Municipality of Aguas Buenas and the Puerto Rico Planning Board (PRPB), which was signed on December 17, 2025. A copy of the signed agreement is included in Appendix B.

Subsequently, a kickoff meeting was held on February 6, 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.

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To support the revision of the Aguas Buenas LHMP, a Planning Committee was established, comprised 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
Gerardo Cardona	Planning Office Director
Melissa García	Planning Office Secretary
Iliana Aponte	Federal Programs Office Director
Juan Ortíz Rivera	Finance Office Director

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

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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 available a virtual survey to gather information regarding the community's experiences with natural hazards. Evidence of these public notices is also maintained and included in Appendix C.
- Convening 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 an additional 15-day period for the public to submit comments or suggestions via email or hand delivered to the municipality.
- 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 7-day comment window for the community to offer feedback, either by email or by visiting the designated address.

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First Public Meeting Results

A public meeting notification announcing the initiation of the LHMP update process was published on 2/18/2026 via a local newspaper called “El Nuevo Día”. The notification informed the public that the meeting would be held on 3/6/2026 in Casa de Arte y Cultura, Calle Salas Torres # 4, Bo. Pueblo at 6:00pm.

During this meeting, participants raised concerns about the cleanup and removal of debris in the aftermath of Hurricanes Irma, María, and Fiona. Landslides were highlighted as one of the greatest risks facing the municipality.

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 documented 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 of 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 webpage _____. 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 citizen 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.

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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 by participating in the public involvement process.

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

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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 used
Landslides	USGS	
Flooding	FEMA	HAZUS 6.1 used
Tropical Cyclones/Extreme Winds	FEMA	HAZUS 6.1 used
Extreme Heat	National Oceanic and Atmospheric Administration (NOAA)	
Wildfires	Puerto Rico Fire Bureau	
Drought	National Drought Index Monitor (NDIM)	
Pandemic/Epidemic	PR Department of Health	
High Hazard Potential Dams	NID	

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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 supporting efficient and rapid recovery following hazard events (FEMA, 2023).

FEMA identifies eight (8) 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 decisionmakers 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 more resilient recovery. A detailed discussion of lifelines and their relevance to the Municipality of Aguas Buenas is provided in Section 3.5.

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The Municipality of Aguas Buenas is situated in the central-eastern portion of Puerto Rico. It is bounded by the municipalities of Bayamón, Guaynabo, and Gurabo to the north, Caguas to the east, Cidra to the south, and Comerío to the west. The municipality is composed of ten (10) barrios, including Aguas Buenas Pueblo, Bairoa, Bayamoncito, Cagüitas, Jagüeyes, Juan Asencio, Mula, Mulita, Sonadora, and Sumidero.

Map 1 shows the municipality of Aguas Buenas and adjacent municipalities. Map 2 shows the wards (barrios) into which Aguas Buenas is subdivided.

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The Aguas Buenas LHMP has been updated using the most current demographic and socioeconomic data available. Municipal profiles and risk assessments 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.

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

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The Municipality of Aguas Buenas was officially founded on May 25, 1838, under the administration of Don Miguel López de Baños, when the region of Aguas Claras ultimately became the Municipality of Aguas Buenas (and its residents came to be known as *aguasbonenses*). Don Francisco de Salas Torres served as its first captain, or mayor (from 1838 to 1841). In 1842, the first public school was established, and three years later, in 1845, the new parish was inaugurated. Its first parish priest was Father Ramón Quiñones. In 1850, efforts were undertaken to separate the barrios of Juan Asencio and Mula from the municipalities of Aguas Buenas and Sabana del Palmar (now Comerío), respectively, and to add Bayamoncito as well, so that these areas could be incorporated into the new municipality. (Municipality of Aguas Buenas, 2020)¹.

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The Municipality of Aguas Buenas can be classified as a predominantly rural municipality. It belongs to the island’s central mountainous region, the most extensive geomorphological region in Puerto Rico (Municipality of Aguas Buenas, 2020).

The Municipality of Aguas Buenas is situated in the central-eastern region of Puerto Rico. It shares municipal boundaries with Guaynabo and San Juan to the north, Caguas to the east, Comerío to the west, and Cidra to the south. Aguas Buenas encompasses a territorial area of 77,845,544.04 square meters, equivalent to

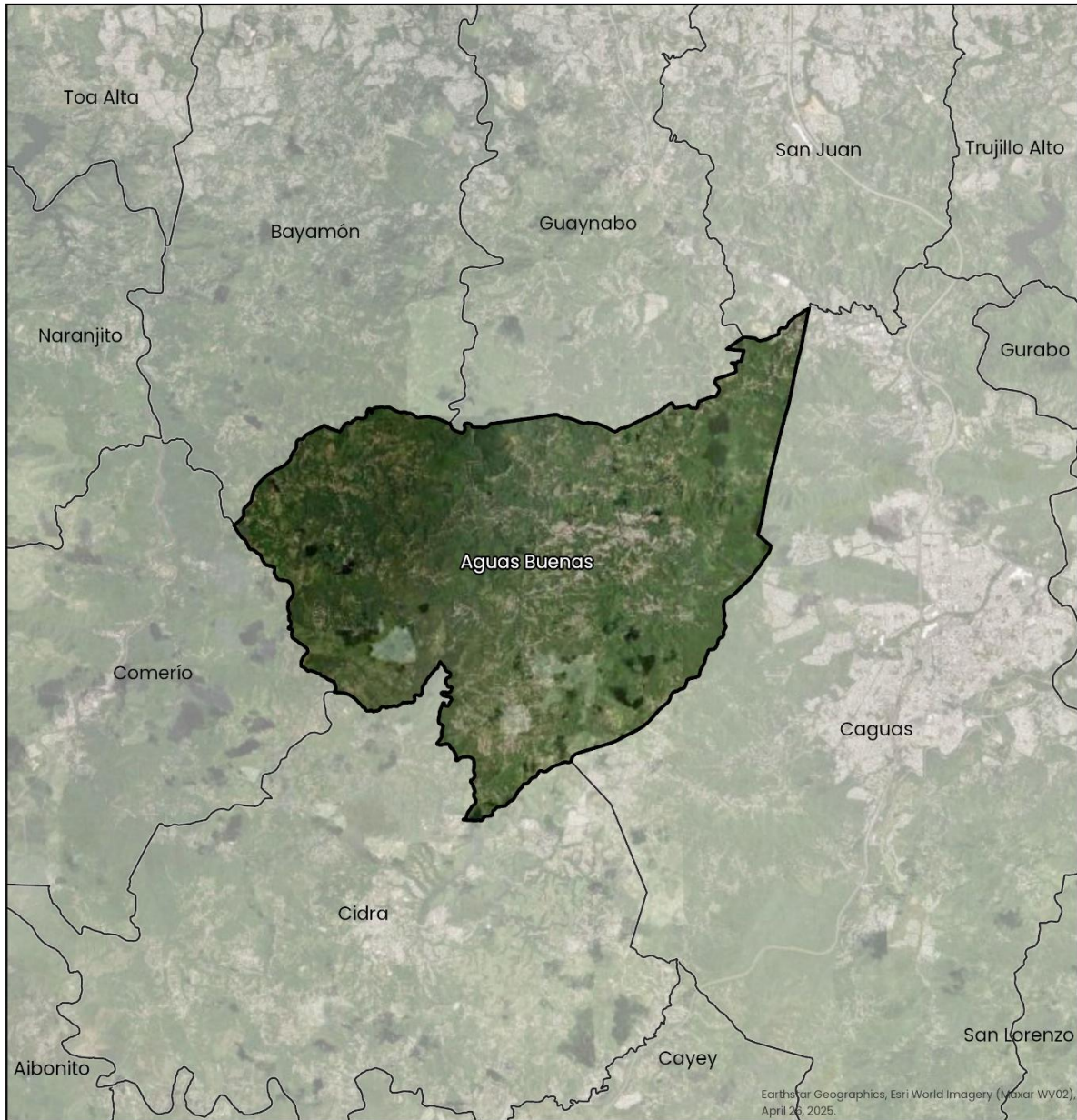
¹ Many of the resources used for the preparation of LHMP update are in Spanish. For uniformity the bibliographical entries and citations of the sources will be translated to English.

approximately 19,806 *cuerdas* or 30 square miles (Municipality of Aguas Buenas, 2011). The total territorial boundary of Aguas Buenas was modified pursuant to Law 391 of 2000, losing land in Barrio Jagüeyes and in the Municipality's overall boundary (Municipality of Aguas Buenas, 2011).

Map 1 illustrates the geographic location of Aguas Buenas within the central-eastern region of Puerto Rico. The municipality is located within the Island's mountainous interior and shares boundaries with the municipalities of San Juan, Guaynabo and Bayamón to the north, Caguas to the east, Cidra to the south, and Comerío to the west. The map provides regional context by showing Aguas Buenas' position within Puerto Rico's central mountain region and its relationship to adjacent municipalities and major transportation corridors.

Map 2 illustrates the municipal ward (*barrio*) boundaries within Aguas Buenas. The municipality is subdivided into ten wards: Aguas Buenas Pueblo, Bairoa, Bayamoncito, Cagüitas, Jagüeyes, Juan Asencio, Mula, Mulita, Sonadora, and Sumidero. The map depicts the spatial distribution and extent of these administrative divisions, which vary in topography, land use, and development patterns. While Aguas Buenas Pueblo serves as the municipality's administrative and urban center, the remaining barrios are primarily characterized by rural and mountainous landscapes, with elevations and slopes that influence settlement patterns, transportation access, and natural hazard exposure throughout the municipality.

GEOGRAPHIC AREA



Source: Puerto Rico Planning Board

SPCS PR & VI NAD83

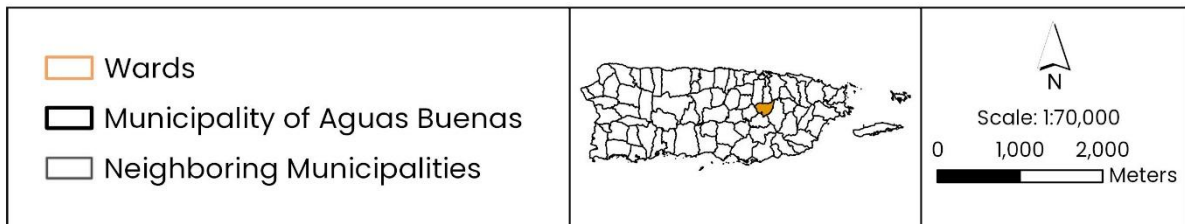


WARDS BOUNDARIES



Source: Puerto Rico Planning Board

SPCS PR & VI NAD83



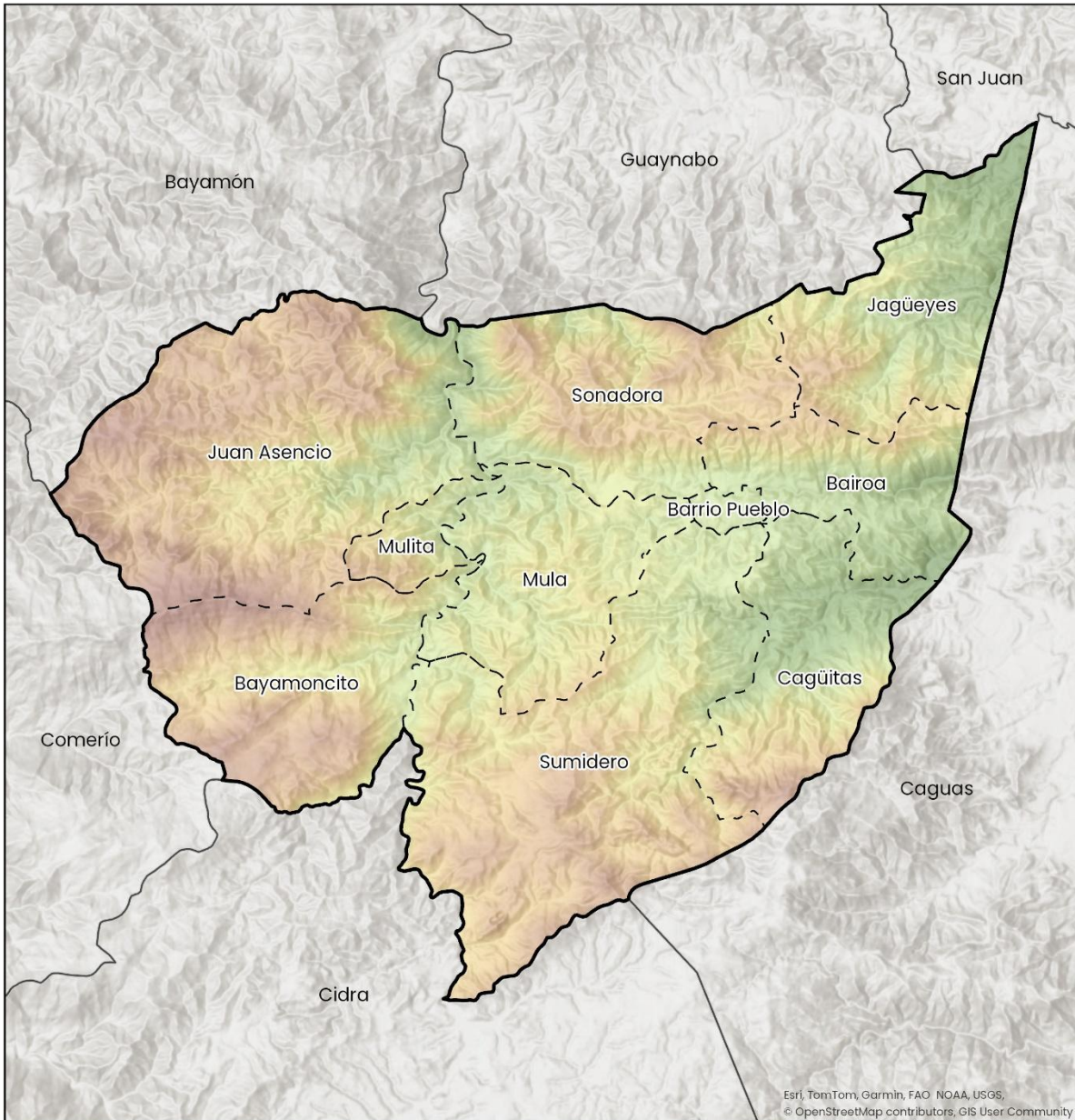
The Municipality of Aguas Buenas is situated at an approximate elevation of 300 meters above sea level. Its topography ranges from approximately 100 meters in the Río Cagüitas basin to 500 meters at some peaks within the municipal territory. Among the best-known peaks are Cerro Mula (481 meters) in Barrio Juan Asencio; Cerro Santa Bárbara (515 meters) in Barrio Bayamoncito; Cerro Chícharos (495 meters) in Barrio Sonadora; and Cerro Marquesa (510 meters), on the boundary between Barrio Sonadora in Aguas Buenas and Barrio Sonadora in Guaynabo. Moderate slopes (less than 25°) are found in the eastern part of the municipality, while the steepest slopes (greater than 25°) are located toward the west and northwest (Municipality of Aguas Buenas, 2020).

The Municipality of Aguas Buenas belongs to the Island's mountainous region; more than 50% of its lands are predominantly mountainous and rugged (Municipality of Aguas Buenas, 2011). These topographic conditions contribute to increased susceptibility to landslides, erosion, and runoff during intense rainfall events, particularly in areas characterized by steep slopes and unstable soils.

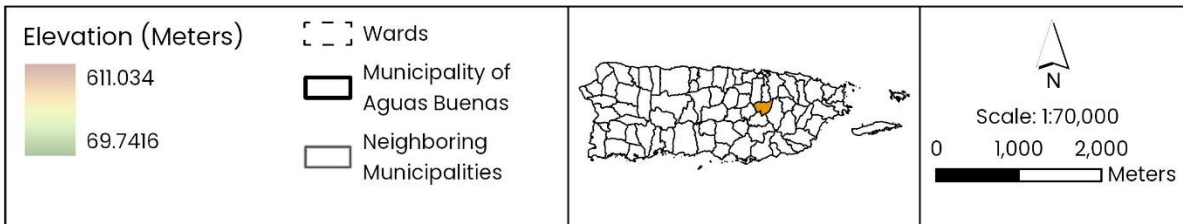
Map 3 illustrates the physiographic characteristics of Aguas Buenas and the distribution of elevation across the municipality. The map depicts a predominantly mountainous landscape with elevations ranging from approximately 70 meters to more than 600 meters above sea level. Higher elevations are concentrated in the western, southwestern, and southern portions of the municipality, while lower elevations are generally found in the eastern and northeastern sectors.

The highest terrain is primarily associated with portions of Juan Asencio, Bayamoncito, Mulita, and Sumidero, where steep slopes and rugged landforms are more prevalent. Lower elevations occur within portions of Bairoa, Cagüitas, Jagüeyes, Barrio Pueblo, and Sonadora. These physiographic characteristics influence drainage patterns, land development, transportation accessibility, and the municipality's susceptibility to hazards such as landslides, erosion, and flash flooding.

PHYSIOGRAPHY



Source: Puerto Rico Planning Board and United States Geological Survey SPCS PR & VI NAD83



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The five geologic formations in Aguas Buenas, according to the Hydrogeologic Map of Puerto Rico and Adjacent Islands, are KII, Kt, KI, TkP, and QI. Kt is the most extensive; it covers more than half of the northern part of the municipality. It consists of tuffaceous sandstone, shale, breccia, conglomerates, lava, and tuff. This formation dates to the Late Cretaceous, with an approximate age of millions of years. In the southern part of the municipality, the KI formation predominates, consisting of lava, lava breccia, and tuff breccia. Much of this formation was deposited in a marine environment, so it contains some limestone deposits, which are highly weathered, an example of this is the Caves of Aguas Buenas, to the southeast of the barrios Sumidero and Cagüitas, bordering Caguas (Municipality of Aguas Buenas, 2011).

The TkP and KII formations are smaller. TkP represents plutonic rocks, mainly granodiorite and quartz diorite, some diorite, porphyritic quartz, gabbro, and amphibolites, presumably intruded during the Late Cretaceous. It is also highly weathered. The KII formation represents deposits of lava, lava breccia, tuff, and tuff breccia, primarily in a marine environment, with some sandstones and shales. Like the previous formations, it shows high levels of weathering. The last geologic formation is QI, which represents Quaternary deposits and landslide deposits, commonly composed of rocks and residual boulders with approximate diameters of 10 feet (Municipality of Aguas Buenas, 2011).

In summary, the geology of the Aguas Buenas territory is reduced to volcanic material deposited under a predominantly marine environment during the Early and Late Cretaceous, with late plutonic intrusions and areas of recent landslides. All this surface is highly weathered or altered by the area's high rainfall precipitation. The municipality of Aguas Buenas contains several well-known caves that have developed within Cretaceous limestone formations (Municipality of Aguas Buenas, 2011).

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The Municipality of Aguas Buenas is fragmented by important systems of rivers and streams, some of which originate within the territory. The Río Aguas Buenas is the main system and runs from south to north. It is composed of several smaller river or stream systems that join it, such as Quebrada Grande, Quebrada San Vicente, Quebrada Pueblo Viejo, and Quebrada Jácana. It also has some intermittent (unnamed) streams that are tributary to the system. The Río Bairoa flows from west to east, passing through

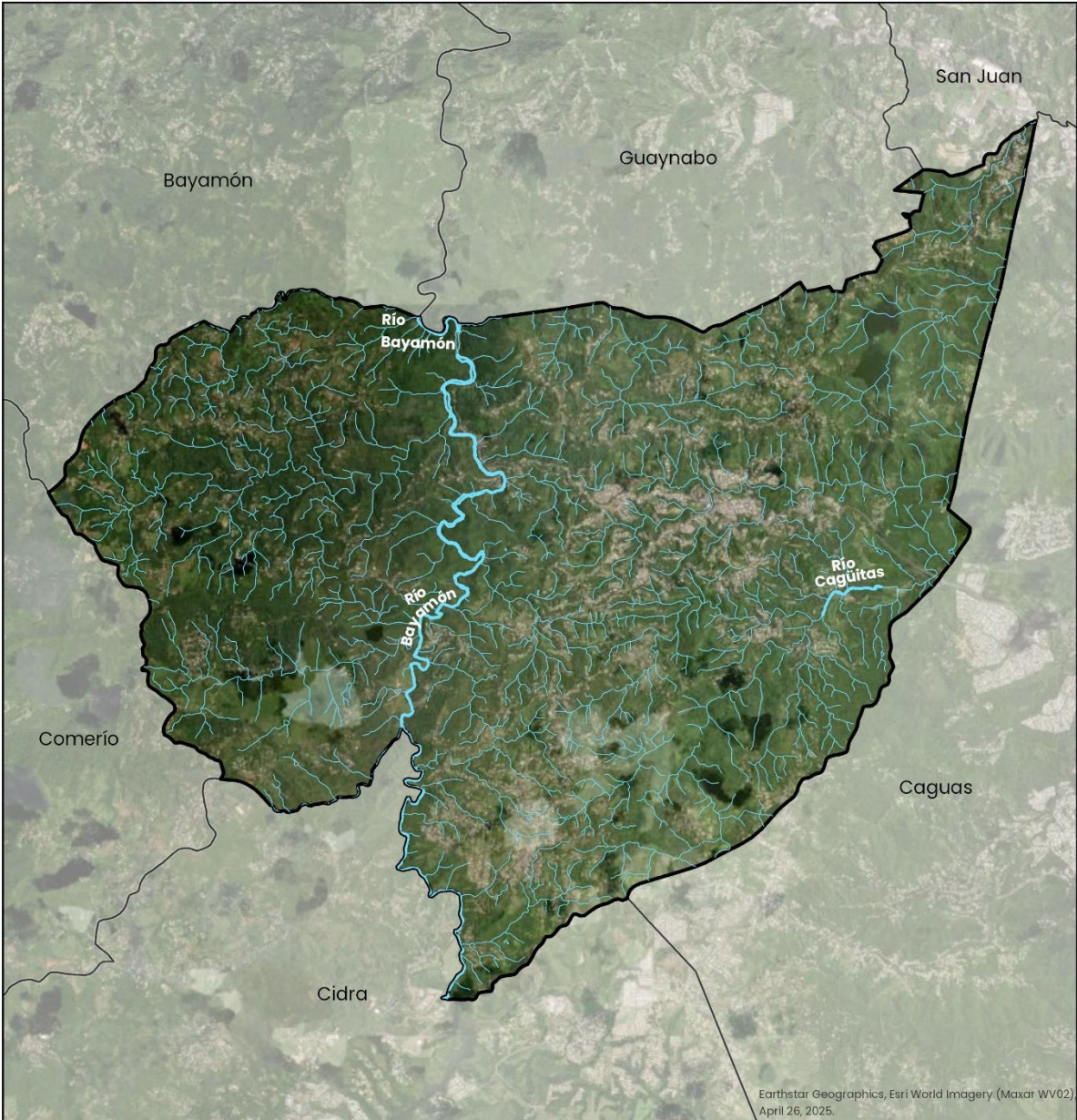
the town of Aguas Buenas. Although it has a narrow channel and floodplain, it is the most susceptible to flooding due to its proximity to the urban area. The Río Cagüitas, south of the town of Aguas Buenas, drains toward the east. It connects with Quebrada Sanjelo and Quebrada del Horno. In Barrio Sumidero it flows underground at the site known as the Caves of Aguas Buenas. To the north of the town of Aguas Buenas is Quebrada Sonadora, which begins draining toward the west and then varies its course northward, while Río Cañas, east of the town of Aguas Buenas, drains toward the northeast. (Municipality of Aguas Buenas, 2011).

The Municipality of Aguas Buenas is located within three major basins, which include Puerto Rico's most voluminous rivers: first, Río La Plata, the longest; Río Grande de Loíza, the most voluminous and the third longest; and Río Aguas Buenas or Río Hondo, which feed the Carraízo and La Plata Reservoirs, which together with Lago de Cidra, provide water to one third of the Island's population. (Municipality of Aguas Buenas, 2011).

In Aguas Buenas the total of lands with flood susceptibility is 221.49 "cuerdas"; this represents 1.11% of the municipality's total territorial extension. (Municipality of Aguas Buenas, 2011).

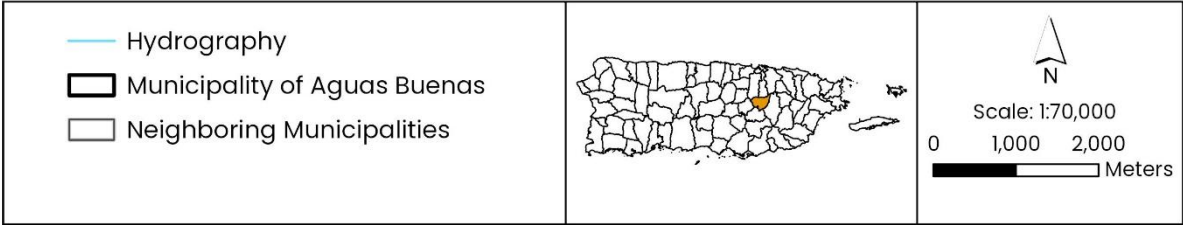
Map 4 illustrates the hydrography network of Aguas Buenas is composed of a dense system of rivers, streams, and tributaries distributed throughout the municipality. The principal watercourses shown on the map are Río Bayamón in the northern sector, Río Bayamón extending through the central-western portion, and Río Cagüitas in the eastern sector. Numerous smaller tributaries branch across the municipality, creating an extensive drainage network that covers both the central upland areas and peripheral sectors. The hydrographic features are present throughout the municipality, with tributaries converging toward the major river channels shown on the map.

HYDROGRAPHY



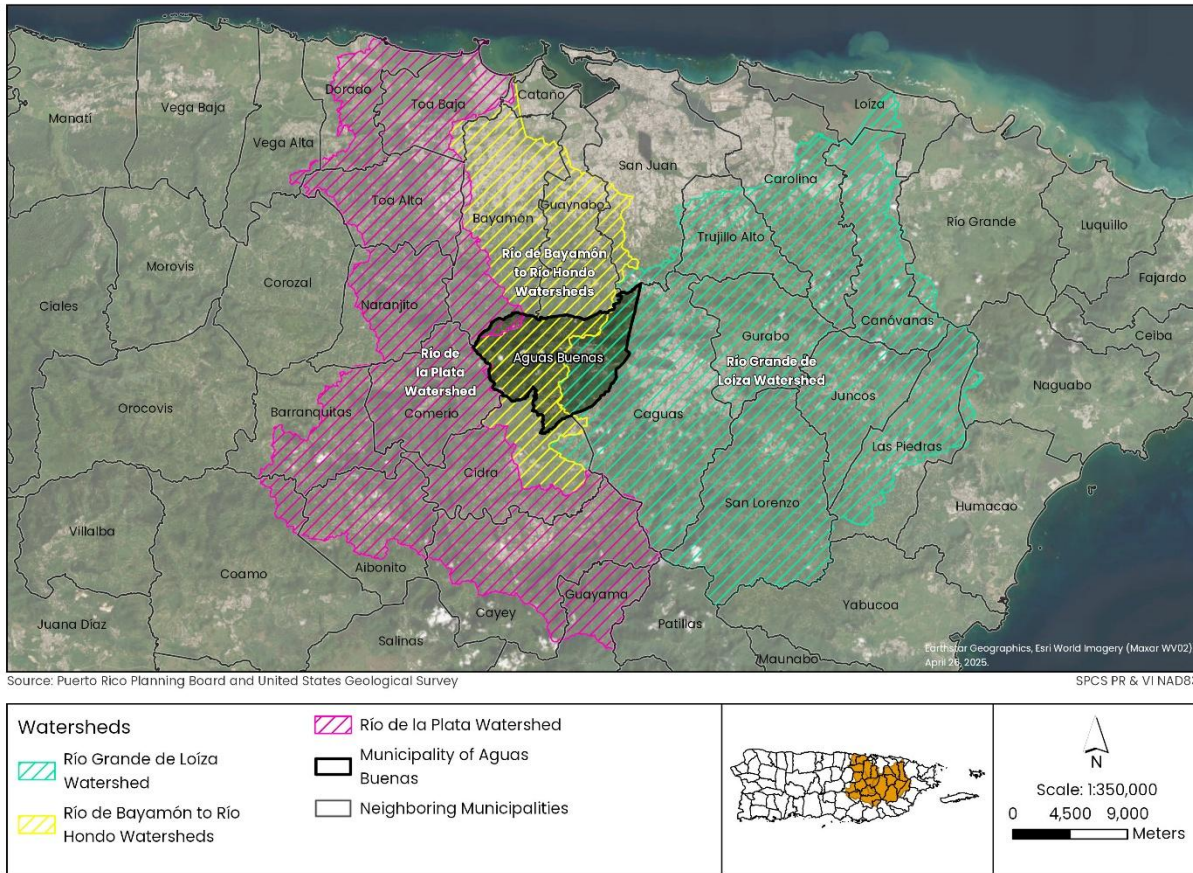
Source: Puerto Rico Planning Board and United States Geological Survey

SPCS PR & VI NAD83



Map 5: Hydrographic Watersheds

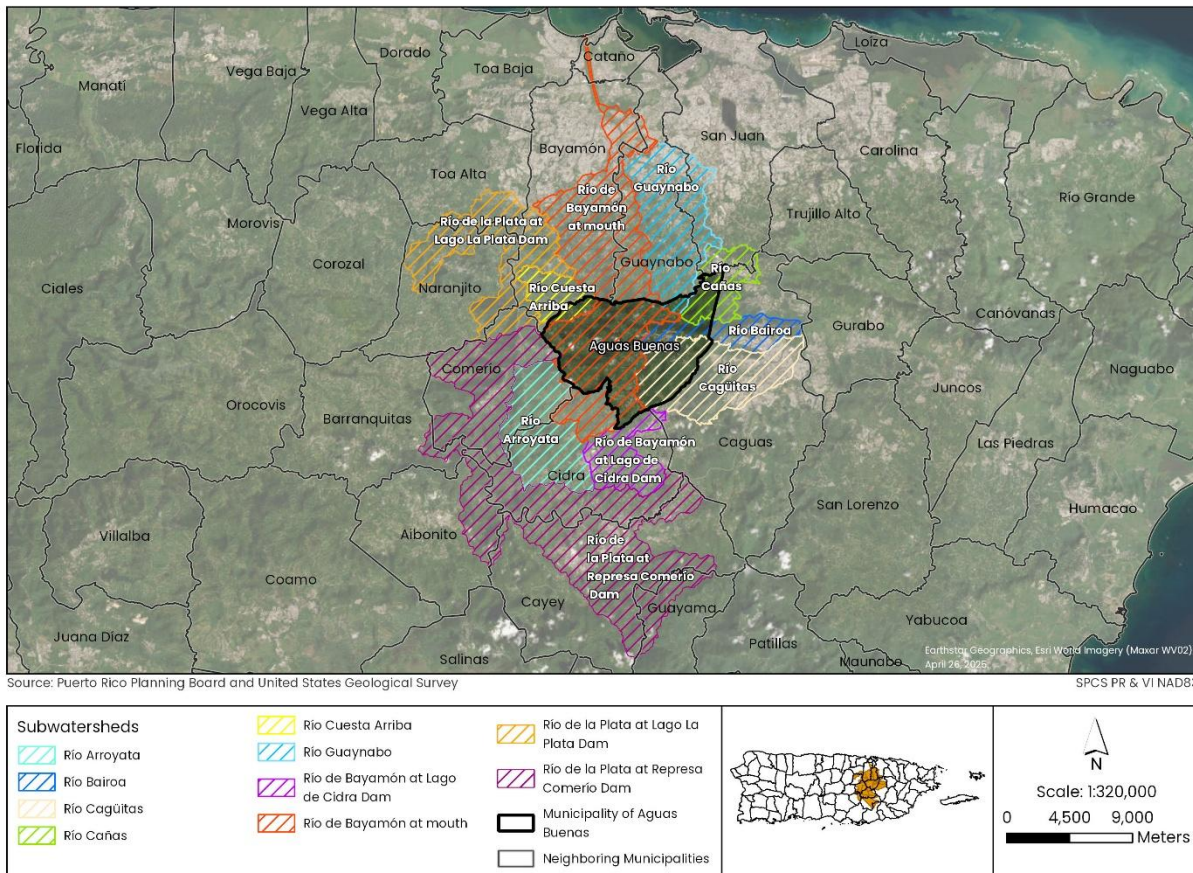
HYDROGRAPHIC WATERSHEDS



Map 5 illustrates the principal hydrologic watersheds that intersect the Municipality of Aguas Buenas. Most of the municipality lies within the Río Bayamón to Río Hondo Watersheds. Additional portions of the municipality are located within the Río Grande de Loíza Watershed, while the smallest area falls within the Río de la Plata Watershed. The map demonstrates how Aguas Buenas contributes to multiple watershed systems that play an important role in regional water resources management and drainage throughout Puerto Rico.

Map 6: Hydrographic Sub-watersheds

HYDROGRAPHIC SUBWATERSHEDS



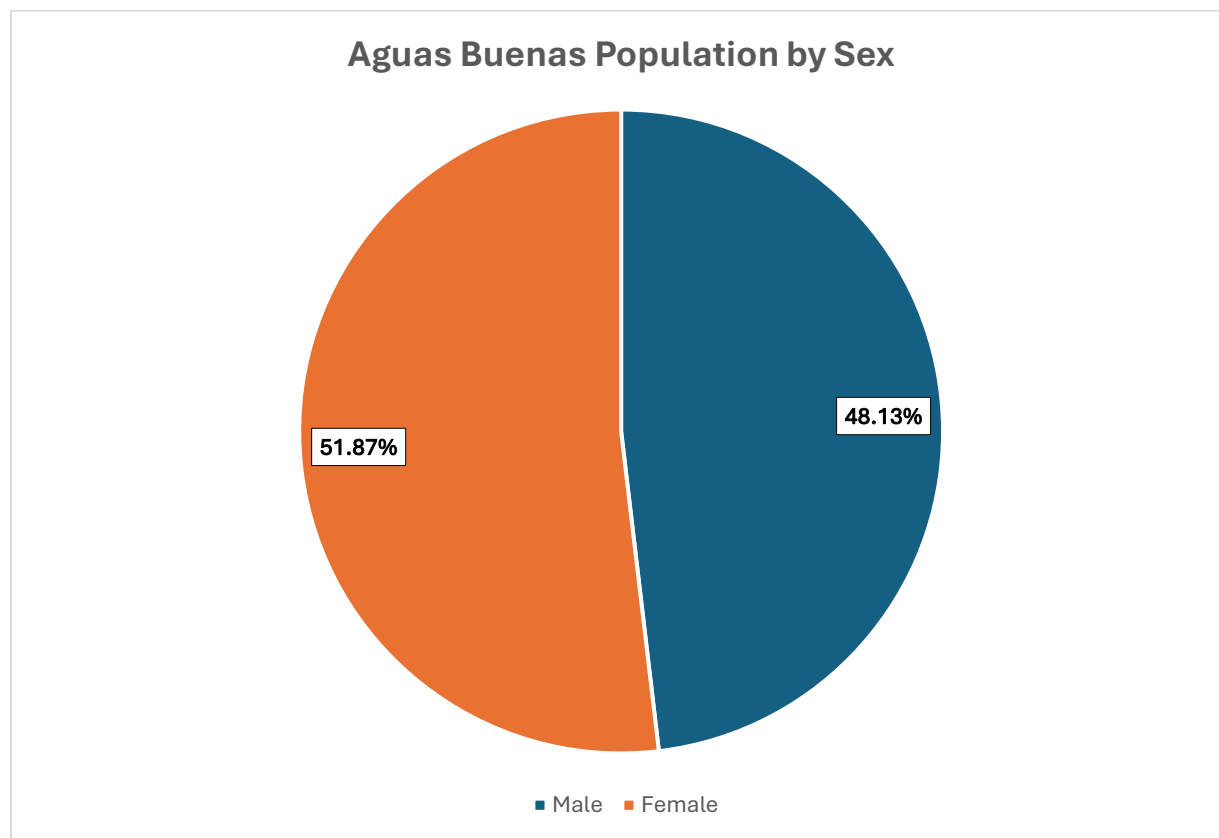
Map 6 illustrates that the municipality of Aguas Buenas is divided among multiple hydrologic subwatersheds. The largest portions of the municipality are located within the Río de Bayamón at mouth, Río Cagüitas, and Río de Bayamón at Lago de Cidra Dam subwatersheds. Smaller areas fall within the Río Cuesta Arriba, Río Arroyata, Río Cañas, and Río Guaynabo subwatersheds, as shown on the map.

1,2 B CK ME P _NF CAQ

1,2,/ AS PPCL R NMNS J _RCML

According to the 2020 - 2024 American Community Five-Year Survey (ACS 2024)² the total population of Aguas Buenas is 23,614. Of these, 11,365 persons are male and 12,249 are female. The percentage split is 48.13% male, 51.87% female. The sex ratio is of 92.78 males per 100 females (US Census Bureau, 2025).

Figure 9: Aguas Buenas Population by Sex (2024 ACS)



According to the 2024 ACS a total of 5,428 people in Aguas Buenas were 65 or older (22.99%). This constitutes almost a quarter of the total population of Aguas Buenas. While 2642 people (11.19%) or slightly more than $\frac{1}{10}$ of the population are 75 years old or older.

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

On the younger age groups, Aguas Buenas has 3,751 (15.88%) people that are younger than 18 years of age. Of those 1,642 (6.95%) are 9 years old or younger. This LHMP considers people younger than 18 and older than 64 as vulnerable. As such we find that 9,179 residents of Aguas Buenas (38.87% of the population) are especially vulnerable to the effects of a natural disaster.

The following table distributes the current population of Aguas Buenas by age groups in cohorts of four years and compares the rate of change between 2024 and 2019.

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

Age Cohort	Population 2024	Percentage 2024	Population 2019	Percentage 2019	Rate of Change %
Under 5 years	698	2.96%	1,013	3.93%	-31.10%
5 to 9 years	944	4.00%	1,274	4.95%	-25.90%
10 to 14 years	1,234	5.23%	1,749	6.79%	-29.45%
15 to 19 years	1,475	6.25%	1,765	6.85%	-16.43%
20 to 24 years	1,572	6.66%	1,738	6.75%	-9.55%
25 to 29 years	1,594	6.75%	1,694	6.58%	-5.90%
30 to 34 years	1,509	6.39%	1,504	5.84%	0.33%
35 to 39 years	1,099	4.65%	1,484	5.76%	-25.94%
40 to 44 years	1,790	7.58%	1,823	7.08%	-1.81%
45 to 49 years	1,531	6.48%	1,591	6.18%	-3.77%
50 to 54 years	1,481	6.27%	1,789	6.95%	-17.22%
55 to 59 years	1,521	6.44%	1,938	7.53%	-21.52%
60 to 64 years	1,738	7.36%	1,514	5.88%	14.80%
65 to 69 years	1,582	6.70%	1,555	6.04%	1.74%
70 to 74 years	1,204	5.10%	1,175	4.56%	2.47%
75 to 79 years	1,181	5.00%	961	3.73%	22.89%
80 to 84 years	645	2.73%	568	2.21%	13.56%
85 years and over	816	3.46%	613	2.38%	33.12%
Total	23,614		25,748		-8.29%

Source: US Census ACS 2020-2024

Findings show the population declined from 25,748 in 2019 to 23,614 in 2024, representing an overall 8.29% decrease. The most significant declines occurred among younger age groups, particularly children under 15, with decreases ranging from 25.9% to 31.1%, indicating a shrinking youth population. Most working-age cohorts also experienced declines, although the 30–34 age group remained stable (+0.3%). In contrast, older age groups showed growth, especially among residents 60 years

and older. Notable increases were observed in the 85+ population (+33.1%), 75–79 years (+22.9%), and 60–64 years (+14.8%). These trends suggest an aging population, characterized by fewer young residents and a growing proportion of seniors, which may have implications for future workforce availability, healthcare demand, and community services.

Figure 10 shows the same age group distribution in a bar chart form. Figure 11 shows the population pyramid for Aguas Buenas. As shown in Figure 11, the irregular population pyramid indicates a higher share of older residents than younger residents.

Figure 10: Aguas Buenas Population by Age Group (ACS 2024)

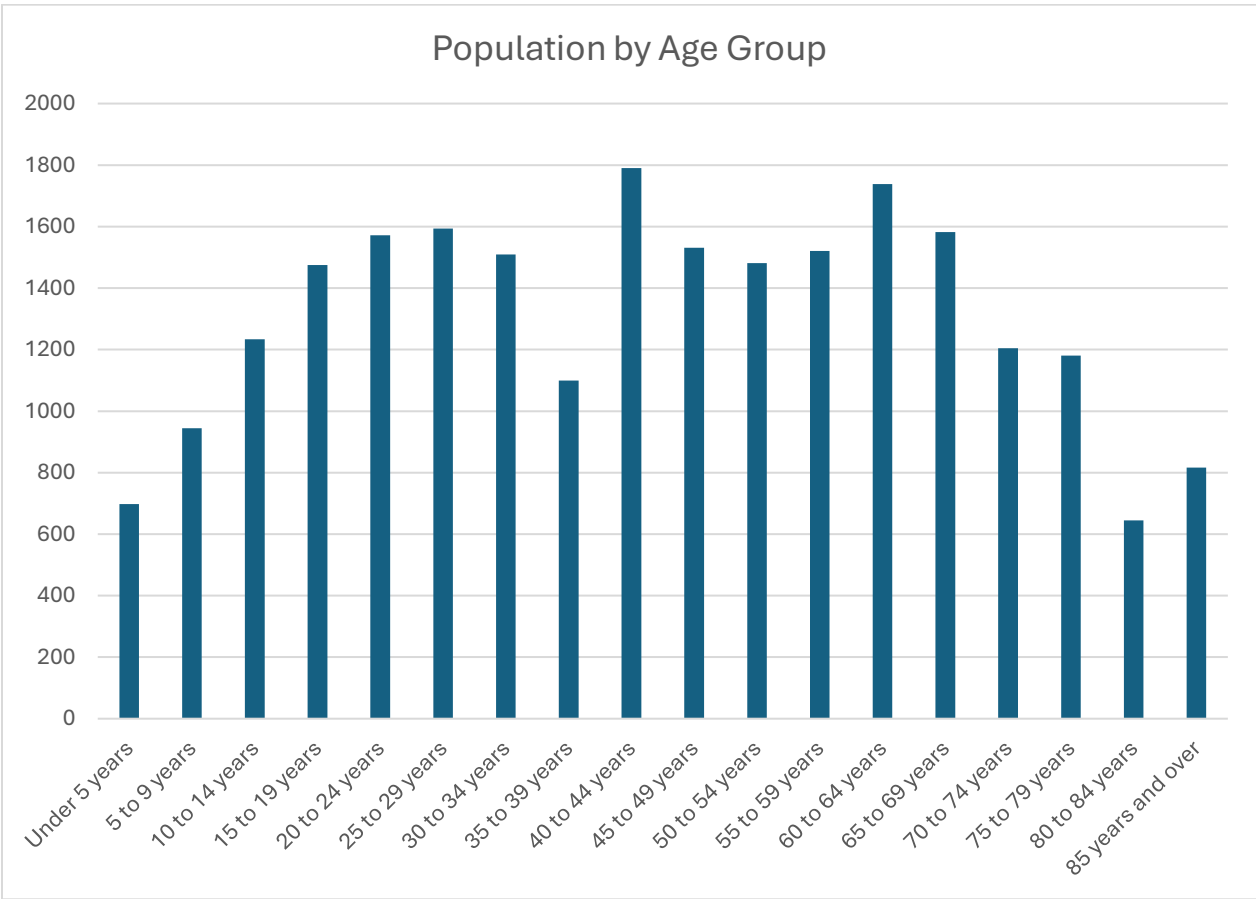
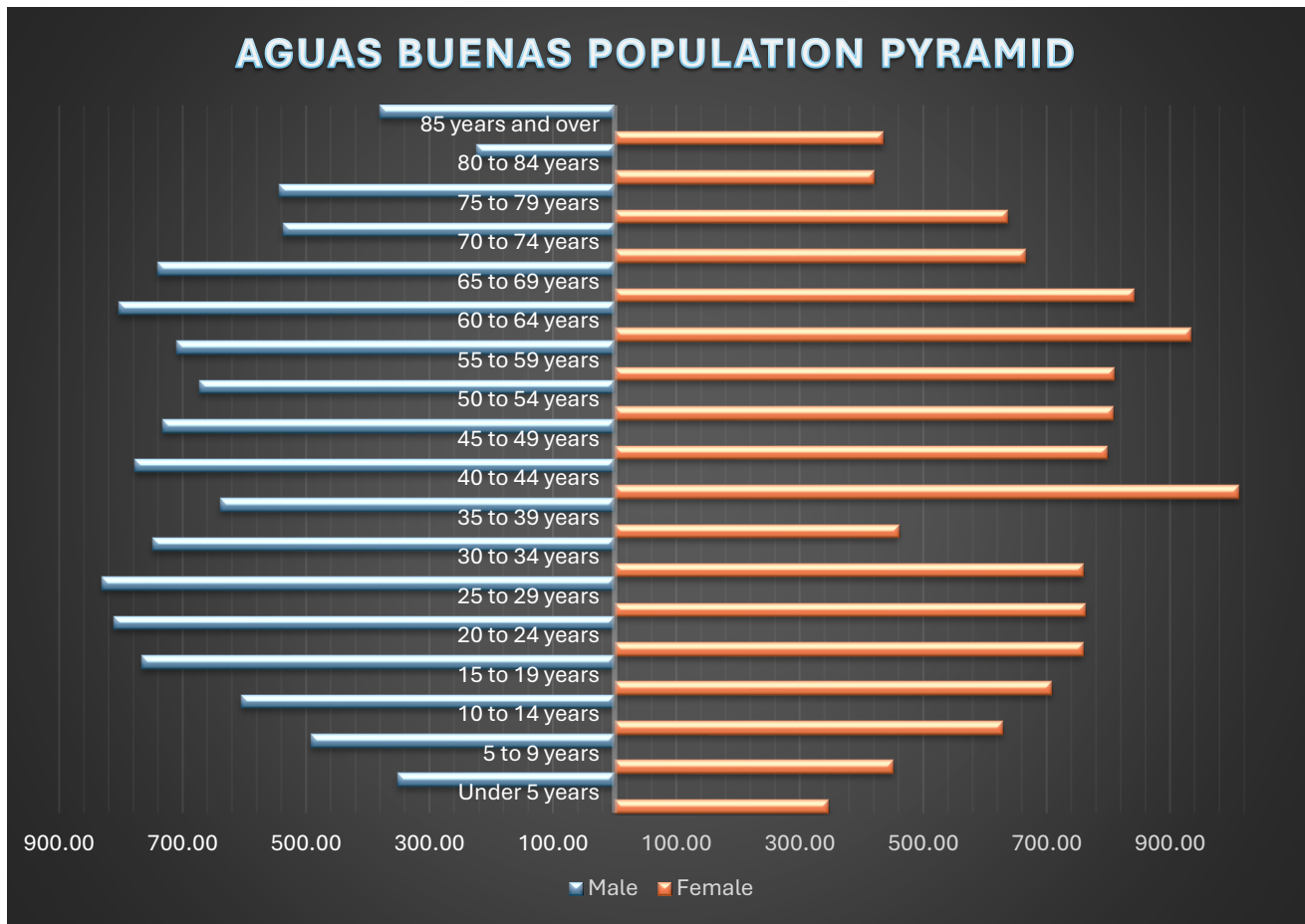
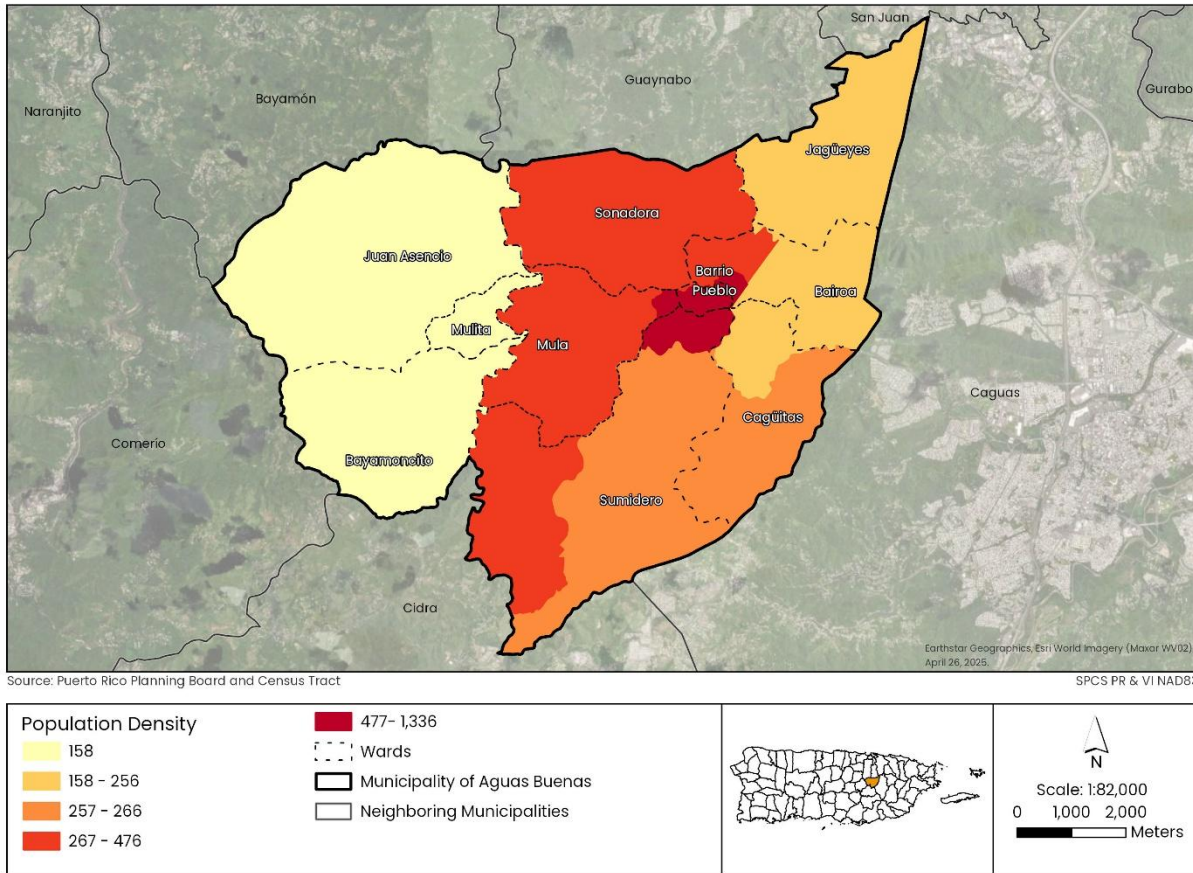


Figure 11: Aguas Buenas Population Pyramid (2024 ACS)



Map 7: Population Density

POPULATION DENSITY



1,2,0 QMAGMCAML MK CA AF _P_ARCPGGAQ
1,2,0,/ CK NJ MWK CL R

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

Table 6: Current Labor Force Statistics³

Variable	Estimate	Percentage
Population 16 years and over	20,425	
In Labor Force	9,085	44.48%

³ US Census Table DP03: Selected Economic Characteristics

Variable	Estimate	Percentage
Civilian Labor Force	9,085	44.48%
Employed	8,631	42.26%
Unemployed	454	2.22%
Armed Forces	0	0.00%
Not in Labor Force	11,340	55.52%
Unemployment rate		5.00%

Source: US Census ACS 2020-2024

The census data shows that the population in the labor force for Aguas Buenas is lower than population that is not in the labor force (44.48% in labor force vs 55.52% not in labor force). When comparing with the 2015-2019 Five-Year ACS the percentage of population in the labor force has stayed steady (44.48% in 2024 vs 42.42% in 2019). In comparison with the whole Commonwealth of Puerto Rico the municipal population in the labor force lower (42.26% for Aguas Buenas vs 46.40% for Puerto Rico).

The 2024 ACS showed an unemployment rate for the municipality of 5.00%. This represents a 60.79% decrease regarding the 2015-2019 Five-Year ACS unemployment rate which was 12.74%. In comparison to the whole Commonwealth of Puerto Rico the unemployment rate is lower (5.00% for Aguas Buenas vs 10.7% for Puerto Rico).

1,2,0,0 CKNJMWKCLR`WQBSQRPW

The following table presents employment by industry within the municipality, comparing data from the 2020-2024 Five-Year ACS with the 2015-2019 Five-Year ACS. 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	Rate of change (%) between 2024 and 2019 ⁴
Agriculture, Forestry, fishing and hunting and mining	150	1.74%	299	7.75%	-49.83%
Construction	727	8.42%	247	6.41%	194.33%
Manufacturing	674	7.81%	239	6.20%	182.01%
Wholesale Trade	288	3.34%	23	0.60%	1152.17%
Retail Trade	1360	15.76%	374	9.70%	263.64%
Transportation and warehousing, and utilities	121	1.40%	146	3.79%	-17.12%
Information	199	2.31%	16	0.41%	1143.75%
Finance and Insurance, and real estate and rental and leasing	388	4.50%	128	3.32%	203.13%
Professional, scientific, and management, and administrative and waste management services	797	9.23%	213	5.52%	274.18%
Educational services, health care and social assistance	1922	22.27%	1142	29.62%	68.30%
Arts, entertainment, recreation, and accommodation and food services	619	7.17%	305	7.91%	102.95%
Other services, except public administration	600	6.95%	182	4.72%	229.67%
Public administration	786	9.11%	542	14.06%	45.02%

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	Rate of change (%) between 2024 and 2019 ⁴
Total employee Population 16 years and over	8631	-	3856	-	123.83%

Source: US Census ACS 2020-2024

Table 7 shows the following employment characteristics for Aguas Buenas:

- The industry with the highest level of employment in Aguas Buenas in 2024 is the “Educational services, healthcare and social assistance” industry occupying 22.27% of Aguas Buenas workforce. This can be related to high population that is above 65 years old.
- In comparison with the 2019 survey, we find that “Educational services, health care and social assistance industry” was also the one with the highest level of employment percentage, based on the total workforce. This industry had a net increase of 1,922 individuals or a 68.30% rate of change. Although, the municipality of Aguas Buenas showed a negative -7.35% rate of change from this industry between 2024 ACS and 2019 ACS from the total industry distribution, this is due to a net increase of 4,775 individuals (or 123.83% rate of change) of the total workforce.
- The other two industries that occupy more than or close to 10% of the employee population are the Retail Trade industry (15.76%), the Public Administration industry (9.11%), and the Professional, scientific, and management, and administrative and waste management services (9.23%).
- The industries that had negative growth between the 2019 and the 2024 surveys are:
 - Transportation and warehousing, and utilities (-25 individuals or a -17.12% rate change).
 - Agriculture, Forestry, fishing and hunting and mining (-149 individuals or a -49.83% rate change).
- The two industries that had the highest net growth were Wholesale Trade, with a net increase of 265 individuals (this represents a percentage rate change of

1,152.17%) and the Information industry with a net increase of 183 individuals (this represents a percentage rate change of 1,143.75%).

- Other industries that had a positive percentage change rate are:
 - “Retail Trade” (1,360 individuals or 263.64% rate of change).
 - “Professional, scientific, and management, and administrative and waste management services” (797 individuals or 274.18% rate of change).
 - “Other services, except public administration” (600 individuals or 229.67% rate of change).
 - “Finance and Insurance, and real estate and rental and leasing” (380 individuals or 203.13% rate of change).
 - “Construction” (727 individuals or 194.33% rate of change).
 - “Manufacturing” (674 individuals or 182.01% rate of change).
 - “Arts, entertainment, recreation, and accommodation and food services” (619 individuals or 102.95% rate of change).
 - “Public administration” (789 individuals or 45.02% rate of change).

An interesting outlier is that, overall, the municipality of Aguas Buenas shows a significant increase of employment rate industry-wise.

1.2.0.1 *NMTCPRW/CTCJ*

According to the U.S. Census Bureau, 10,693 residents of Aguas Buenas (45.50%) live in poverty over the past 12 months, as determined by income thresholds that vary according to household size and composition. This information is used to evaluate the economic well-being of individuals and families. The next table is essential for understanding the economic conditions of different groups and for guiding the development and implementation of policies aimed at reducing poverty as well as the vulnerability of the population.

Table 8: 2024 ACS Poverty Level

Total Population	Number of Individual below the poverty level during the last 12 months	Percentage of the Population below the poverty level in the last twelve months
23,525	10,693	45.50%

Source: US Census ACS 2020-2024

1,2,0,2 *QAMKC*

According to the 2024 ACS the median household income for Aguas Buenas was \$21,317, while the mean household income was \$35,616. 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	2,028	22.70%
\$10,000 to \$14,999	872	9.76%
\$15,000 to \$24,999	1,822	20.40%
\$25,000 to \$34,999	1,365	15.28%
\$35,000 to \$49,999	1,113	12.46%
\$50,000 to \$74,999	741	8.30%
\$75,000 to \$99,999	475	5.32%
\$100,000 to \$149,999	331	3.71%
\$150,000 to \$199,999	44	0.49%
\$200,000 or more	141	1.58%
Total Households	8,932	100%

Source: US Census ACS 2020-2024

This table shows that slightly more than 1/5 of all households (22.70%) in Aguas Buenas earn less than \$10,000 per year. While 52.86% of households earn less than \$25,000 per year. In comparison for the 2015–2019 ACS 37.39% of households earn less than \$10,000 and 69.91% of households earn less than \$25,000.

1,2,0,3 *NMNSJ_RGML UCRF BQQ`QRCQQ*

Table 10 presents data on individuals in Aguas Buenas living with disabilities based on the 2020–2024 and 2015–2019 Five-Year American Community Survey datasets. Overall, the number of individuals living with a disability decreased from 8,132 in 2019 to 6,709 in 2024, representing a reduction of 17.50 percent. Most age groups experienced declines during the study period, with the largest decreases observed among residents under 18 years of age. The only age group showing a slight increase was the population aged 75 years and over, which increased by 0.17 percent. These findings are important for hazard mitigation planning because people with disabilities may face additional challenges during evacuation, sheltering, emergency response, and post-disaster recovery activities.

Table 10: Population Living with Disabilities

Age Group	2024	2019	Net change	Rate of change
Under 5 years	0	30	-30	-100.00%
5 to 17 years	338	763	-425	-55.70%
18 to 34 years	536	710	-174	-24.51%
35 to 64 years	2,696	3,322	-626	-18.84%
65 to 74 years	1,407	1,578	-171	-10.84%
75 years and over	1,732	1,729	3	0.17%
Total Population living with a disability	6,709	8,132	-1,423	-17.50%

Source: US Census ACS 2020-2024

1.2.0.4 NMNJ_RGL PCAGL E QNCKCL_RJ LSRP_RGL_J QNMPR

Table 11 provides information on households in Aguas Buenas 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	8,932	8,488	444	4.97%
Households receiving food assistance	5,684	3,974	1,710	30.08%
Percent of Households receiving food assistance	63.64%	46.82%	–	–
Households with children under 18	2,261	2,428	-167	-7.39%
Married Couple	3,544	3,525	19	0.54%
Male Householder, no spouse present	665	660	5	0.75%
Female Householder, no spouse present	2,046	2,021	25	1.22%
Households with one or more people 60 years and over	4,655	4,184	-471	11.25%

Source: US Census ACS 2020-2024

As shown in the table, the total number of households in Aguas Buenas increased by 4.97% since 2019 ACS; however, households receiving food assistance increased by 30.08%. This indicates that growth in food assistance participation outpaced overall household growth during the same period. Approximately 63.64% of households in the municipality reported receiving food assistance during the 2020–2024 ACS period. This

high level of participation may indicate socioeconomic conditions that could affect household resilience and recovery capacity following natural hazard events.

1,2,0,5 F C_JRF Q Q_P_LACAMTCP_EC

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	23,525	
With health insurance coverage	22,765	96.77%
With private health insurance	8,804	37.42%
With public coverage	16,783	71.34%
No health insurance coverage	760	3.23%

Source: US Census ACS 2020–2024

The data shows that in 760 people (3.23%) in Aguas Buenas do not have health insurance coverage. In contrast, approximately 71.34% of the population relies on public health insurance coverage. This data will be revisited when discussing the hazard of pandemic/epidemic.

1,2,1 F MS Q Q E Q RMAI _L B MRF CP P CJ _RCB B CR_ Q Q

According to the 2024 ACS Aguas Buenas had a total of 10,959 housing units of those a total of 2,027 were vacant. Vacant housing units account for approximately 18.5% 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

	Housing Units	Percentage
Built 2020 or later	0	0.00%
Built 2010 to 2019	501	4.60%
Built 2000 to 2009	1,411	12.90%
Built 1990 to 1999	1,911	17.40%
Built 1980 to 1989	1,763	16.10%
Built 1970 to 1979	2,574	23.50%
Built 1960 to 1969	1,743	15.90%
Built 1950 to 1959	472	4.30%
Built 1940 to 1949	99	0.90%
Built 1939 or earlier	485	4.40%
Total	10,959	100%

Source: US Census ACS 2020-2024

The 2024 ACS indicates that 57.00% of the housing stock in Aguas Buenas was built between 1970 and 1999. The current Puerto Rico Building Code was adopted in 2018, replacing the previous code adopted in 2011. Table 13 shows that at least 95.40% of the municipality's housing units were built before adoption of the 2011 Building Code. Because the ACS groups housing units built from 2010 through 2019 into a single category, the exact percentage constructed before the 2018 Building Code cannot be determined from the available data. Nevertheless, the data indicates that most of the municipality's housing stock predates both the current and immediately preceding building codes.

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

Table 14: 2024 ACS Vehicles per Occupied Housing Unit

Variable	Occupied Housing Units	Percentage
No vehicles available	1,211	13.56%
1 vehicle available	3,760	42.10%
2 vehicles available	2,637	29.52%
3 or more vehicles available	1,324	14.82%
Total	8,932	

Source: US Census ACS 2020-2024

The 2024 ACS shows that there are 1,211 (13.56%) occupied housing units that do not have available vehicles in Aguas Buenas. The lack of access to a private vehicle may increase transportation challenges during evacuations, emergency response operations, and post-disaster recovery activities, particularly given the municipality's predominantly rural and suburban development pattern.

1.3 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.

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.

1.3.7 J C C J C L C 8 Q D C R W _ L B C C A S P C R W

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 distribution of the Safety and Security Lifeline facilities in Aguas Buenas that includes the Municipal Emergency Management Office (OMME), the Puerto Rico Police Bureau station serving the municipality, and the local fire station located near the urban center. These facilities are concentrated within or adjacent to the traditional urban core, providing rapid access to the municipality's primary population centers and transportation corridors. The map shows that public safety facilities are strategically located along the PR-156 and PR-173 corridors, which serve as the principal routes for emergency response operations. No military installations or correctional facilities were identified within the municipal boundaries of Aguas Buenas. The concentration of police, fire, and emergency management facilities within the urban area strengthens response capabilities; however, the mountainous terrain and winding road network may increase response times to remote sectors of the municipality during major hazard events.

1.3.0 J C C J C L C 8 D M M B * F W B P _ R G M L _ L B Q E C J R C P



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 includes emergency shelters, food distribution facilities, potable water supply facilities, and other resources that support residents during and after disaster events. As shown on the map, most of these facilities are concentrated near the urban center of Aguas Buenas and along the PR-156 and PR-173 corridors, allowing efficient access from the municipality's principal residential areas. Additional facilities are in the western, eastern, and southern sectors of the municipality, providing geographic coverage to support emergency sheltering and resource distribution during disaster events. The map identifies several designated emergency shelters strategically distributed throughout the municipality to support evacuation and temporary housing needs during natural hazard events. Water-related infrastructure, including potable water facilities and storage components, is also represented and plays a critical role in maintaining essential services during emergencies. The concentration of these facilities near the urban core facilitates coordination and service delivery; however, residents in remote mountainous sectors may experience longer travel times to shelters and distribution centers following major disasters due to roadway closures, flooding, or landslides. Maintaining the operational capability of these facilities and ensuring reliable access routes is essential to supporting the municipality's disaster response and recovery efforts.

1.3.1 J C C J C L C 8 F C _ J R F _ L B K C B Q C L C

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.

The Health and Medicine Lifeline includes healthcare facilities, medical offices, pharmacies, and emergency medical services that provide essential medical care to the residents of Aguas Buenas. As shown on map 8, these facilities are primarily concentrated within and around the municipality's urban center, where accessibility is enhanced by the convergence of the PR-156 and PR-173 corridors. This concentration of health-related facilities allows residents to access primary care, emergency services, pharmacies, and other medical resources within a relatively small geographic area. The clustering of healthcare facilities near the urban core facilitates coordination between medical providers and emergency management personnel during hazard events. However, residents living in remote mountainous sectors may experience longer travel times to healthcare facilities when roads are obstructed by flooding, landslides, or fallen debris. Maintaining access to these facilities is critical, as they support emergency medical response, routine healthcare needs, medication distribution, and the continuity of care for vulnerable populations, including older adults and individuals with chronic medical conditions.

1.3.2 JACCAL C8CL CPEW



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 8 illustrates the distribution of gas stations within the

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

The Energy Lifeline is represented by energy-related facilities distributed throughout the Municipality of Aguas Buenas. As shown on map 8, these facilities are primarily concentrated within and around the urban center, with additional facilities located along the municipality's principal transportation corridors, including PR-156 and PR-173. The distribution pattern indicates that most energy-related assets are in areas that are readily accessible by the road network and in proximity to other critical infrastructure. This concentration enhances the municipality's ability to support essential services and emergency operations during hazard events, while also highlighting the importance of maintaining access to these facilities through the primary transportation routes. Based on the map, the highest concentration of Energy Lifeline assets is located within the urban core, where they are integrated with other critical community services.

1.3.3 J C C J C L C 8 A M K K S L G A _ R C M L Q

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.



equipment.

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

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 [Aguas Buenas](#). The primary transportation corridors within the municipality are described below.

North-South Corridors – The municipality is primarily traversed by the PR-173 corridor, which serves as the principal north-south route through Aguas Buenas. PR-173 enters the municipality from Cidra to the south, passes through the Aguas Buenas urban center, and continues north toward Guaynabo, providing a direct connection to the San Juan Metropolitan Area. The route is one of the municipality's most important transportation corridors, linking residential communities, commercial areas, and public facilities throughout the municipality.

A secondary north-south corridor is PR-174, which connects the urban center of Aguas Buenas with Bayamón to the north. This roadway provides an alternative connection between Aguas Buenas and the metropolitan region and serves several residential sectors located north of the urban center.

The north-south roadway network is characterized by mountainous terrain and winding alignments that follow the topography of the Central Mountain Range. As a result, travel speeds are generally lower than in the coastal municipalities, but these corridors remain essential for regional mobility and access to employment centers in the San Juan metropolitan area.

East-West Corridors – The principal east-west corridor is PR-156, which traverses the municipality and serves as the main transportation axis connecting Comerío to the west and Caguas to the east. PR-156 passes directly through the Aguas Buenas urban

center and functions as the municipality's primary commercial corridor. The route provides access to government services, retail establishments, educational facilities, and residential developments.

Connectivity and Development Patterns

The intersection of PR-156 and PR-173 in the urban center of Aguas Buenas forms the municipality's principal transportation hub. Commercial development is concentrated along these corridors, particularly within and adjacent to the downtown area, where businesses, public services, and community facilities are located.

Residential development has generally expanded along the PR-156, PR-173, and PR-174 corridors, reflecting the municipality's mountainous topography and the limited availability of developable land away from major roadways.

A continuing challenge to mobility within Aguas Buenas is the mountainous terrain, which limits the number of direct connections between communities and concentrates traffic onto a small number of arterial roadways. Consequently, most trips within and outside the municipality rely heavily on PR-156, PR-173, and PR-174 corridors.

1,3,5 J C C C F _ X _ P B M S Q K _ R C P G J Q

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 the identified hazardous materials site based on the most recent information provided by the Puerto Rico Planning Board (PRPB). As illustrated on the

map, the site is in the northern portion of the municipality, near the municipal boundary with Guaynabo and adjacent to a principal transportation corridor. Its location along a major roadway facilitates transportation access and emergency response operations. Because the facility is situated outside the urban center, a hazardous materials incident at this location would likely require coordination among municipal emergency responders, state agencies, and other regional stakeholders to ensure rapid containment and minimize potential impacts on nearby populations, transportation routes, and critical infrastructure.

The map indicates that hazardous materials facilities are limited in number within Aguas Buenas, suggesting that potential hazardous materials risks are concentrated in a relatively small area rather than being widely distributed throughout the municipality. Industrial and commercial activities within Aguas Buenas are primarily located along the municipality's principal transportation corridors and near the urban center. These areas contain commercial, warehousing, industrial, and service-related uses that support the local economy and transportation network.

1.3.6 JCCJ CL C8U _RCP QWCRCK Q



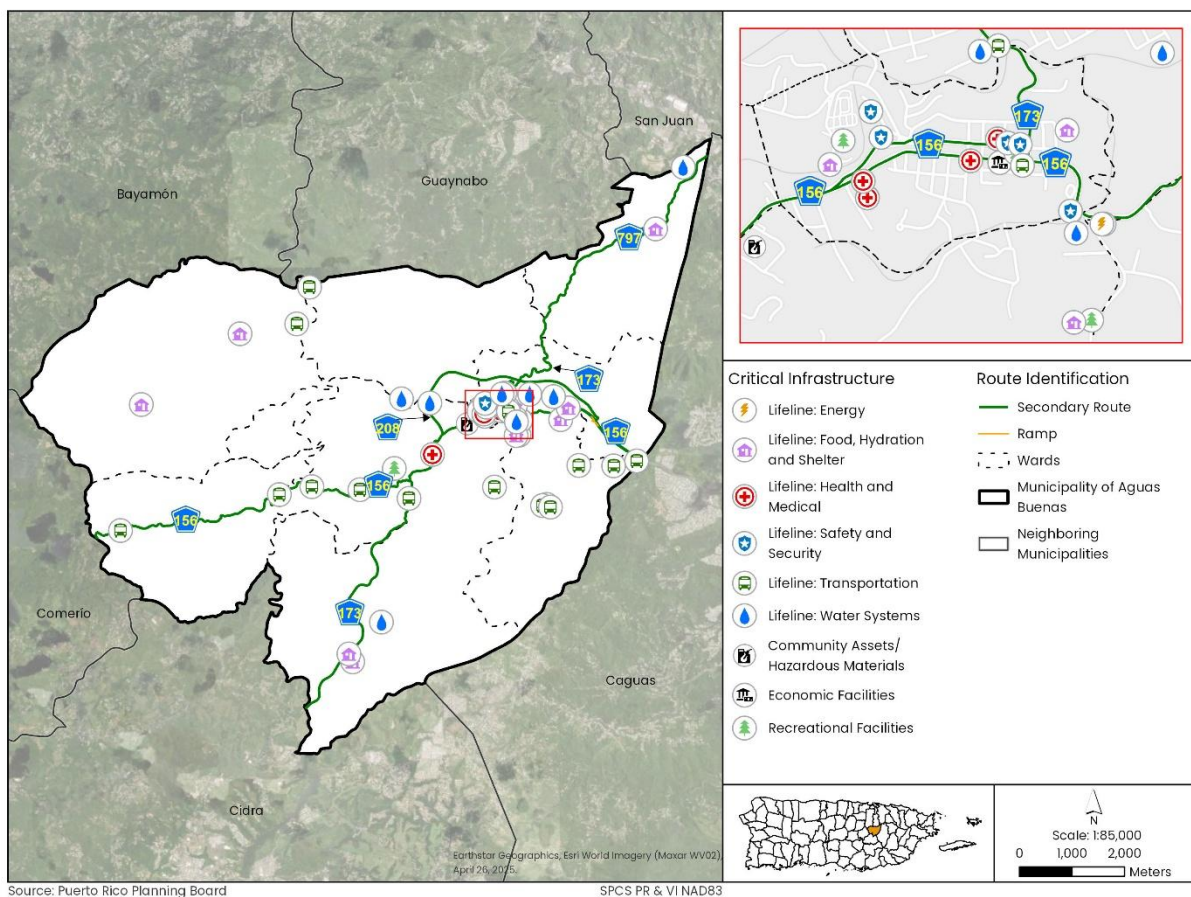
This lifeline highlights the critical role of water infrastructure in disaster response and recovery. Its primary objective is to ensure reliable access to and the timely restoration of drinking water and wastewater services, which are essential to public health, safety, and economic stability. The Water 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 identifies the Water Systems Lifeline facilities within the Municipality of Aguas Buenas. As shown on the map, water-system-related facilities are distributed throughout the municipality, with the greatest concentration located near the urban center and along the primary transportation corridors. Additional facilities are in the northern, eastern, and southern portions of the municipality, providing broad geographic coverage to support water service operations. The distribution of these facilities throughout the municipality enhances service redundancy and accessibility

while supporting residential, commercial, and public-service areas. Their location along major roadways facilitate maintenance operations, emergency access, and post-disaster response activities. Because water systems are essential to public health, emergency response, and daily municipal operations, maintaining the functionality and accessibility of these facilities is critical to community resilience during hazard events.

Map 8: Critical Infrastructure by Lifeline

CRITICAL INFRASTRUCTURE BY LIFELINE



ROADS



The data indicate a notable increase in construction activity during the COVID-19 pandemic period (2020–2023). This rise in permit approvals may be associated with the availability of federal stimulus funding provided during that time; however, additional analysis would be required to confirm any direct relationship. Based on the annual data for 2020–2026, the average number of occurrences was 29.9 per year, while the median value was 29. These statistics indicate that the typical annual

occurrence count during the period was approximately 30, despite fluctuations from a low of 13 in 2026 to a high of 47 in 2024.

Table 15 and Figure 12 present the number of construction 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 2023, and another showing permits issued from 2024 to 2026.

Table 15: Aguas Buenas-Approved Construction Permits, 2020-2026⁵

Approved Construction Permits 2020-2026	
Year	Permits Approved
2020	21
2021	36
2022	36
2023	27
2024	47
2025	29
2026	13

Source: Puerto Rico Planning Board

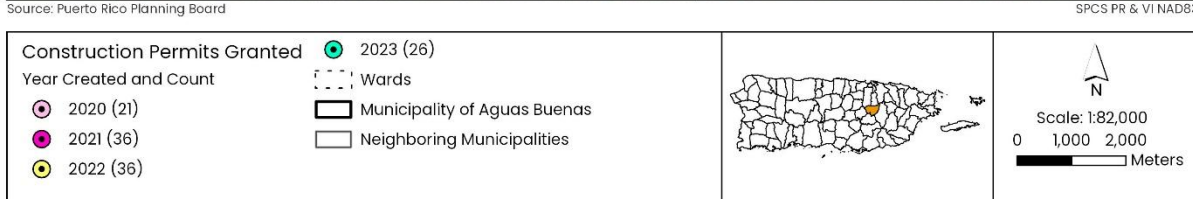
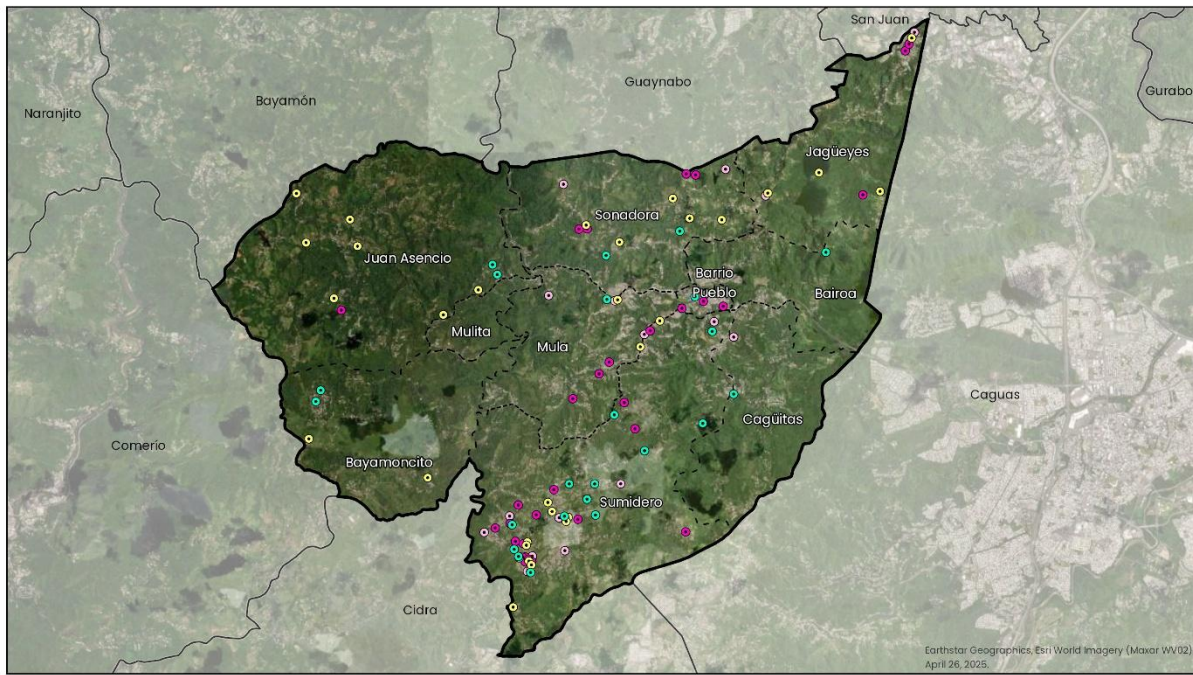
Figure 12: Aguas Buenas Approved Construction Permits 2020-2026⁶



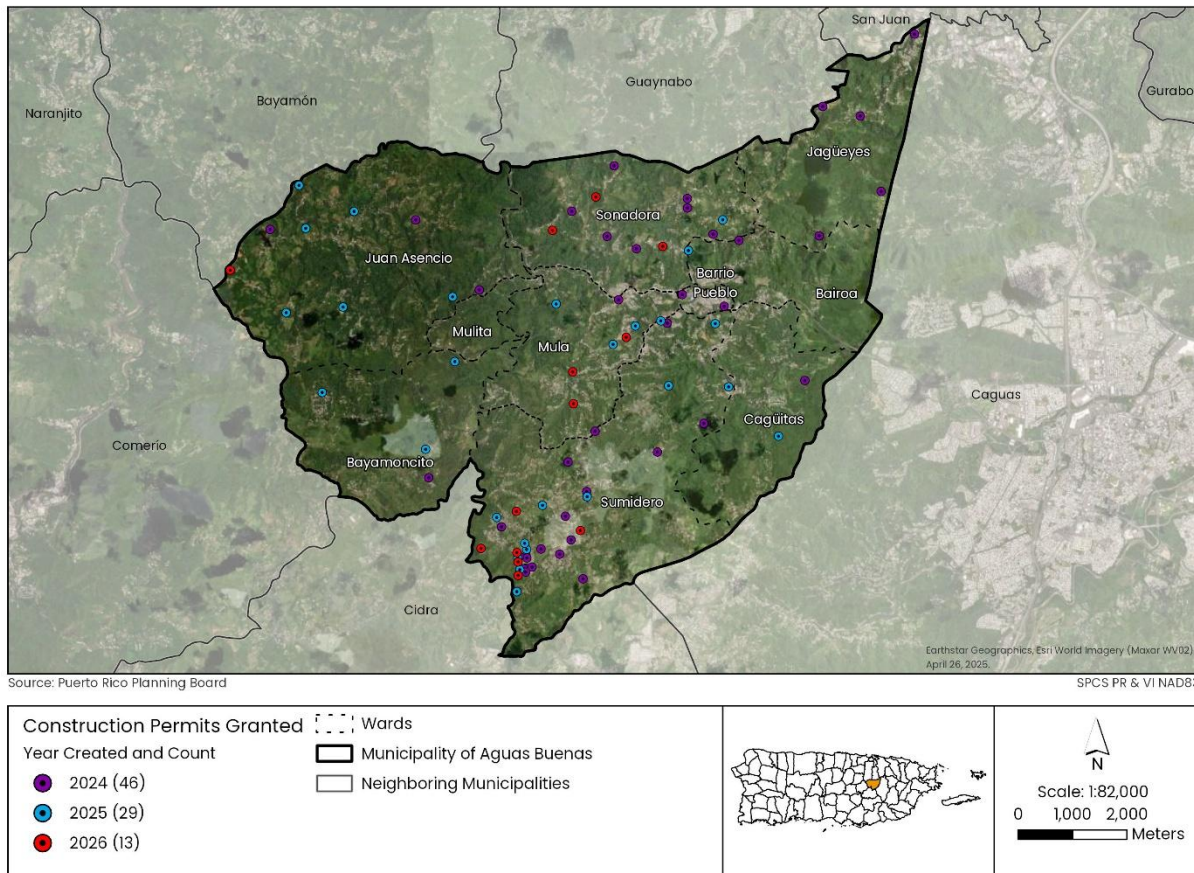
⁵ 2025 total only accounts for permits up to November 12, 2025

⁶ 2026 totals have not been finalized, and it could provide a false trend

RECENT DEVELOPMENT 2020 - 2023



RECENT DEVELOPMENT 2024 - 2026



2, F_X_PB QNP MDJ CQ_L B P CQ ? L_J W CQ

2,/ L MRC ML RF C B CQAS CQML MDF_X_PB Q

The 2020 LHMP divided the discussion of the considered hazards into two separate and non-continuous sections. This arrangement made the analysis of the hazard cumbersome since the reader had to go back and forth between two different sections of this large document. To improve this, this new LHMP discusses both the profile of the hazard and the risk associated in one single section.

2,0 PCE S J_RMPWP COS CCK CL RQ

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

2.1 F _X_ P B Q R F _R A_ L _ D D C A R R F C K S L G A G N _ J C R W

To determine the Hazards to be addressed in this LHMP, the Municipality reviewed and integrated information from the current 2021 Puerto Rico State Hazard Mitigation Plan, the 2020 Aguas Buenas LHMP and the current LHMP from the Municipalities that share a border with Aguas Buenas. The following table summarizes the hazards discussed in those HMPs. A check marks “✓” in the table means that a hazard was discussed in the corresponding hazard mitigation plan, X means indicates that it was not.

Table 16: Historical Hazard Inventories

Hazard	2021 PRSHMP	2020 Aguas Buenas LHMP	Neighboring Municipalities
Earthquake/Liquefaction	✓	✓	✓
Landslides	✓	✓	✓
Flooding	✓	✓	✓
Extreme Winds Hazard	✓	✓	✓
Extreme Heat	✗	✓	✓
Drought	✓	✓	✓
Wildfire	✗	✓	✓
Pandemic/Epidemic	✗	✗	✗
Epidemic Contagious Disease	✗	✗	✗
High Hazard Potential Dams	✗	✗	✓

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

Table 17: Hazards to be included in the Aguas Buenas 2026 LHMP

Hazard	Included in Aguas Buenas 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 Aguas Buenas 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.

Hazard	Included in Aguas Buenas 2026 LHMP?	Comments
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	x	The risk was not evaluated in this plan as the municipality has no direct risk exposure within its territory.
Long Term Coastal Modification	x	The risk was not evaluated in this plan as the municipality has 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	✓	Several of Aguas Buenas neighboring communities include this hazard.
Pandemic/Epidemic	✓	The municipality of Aguas Buenas included this in the previous LHMP. It will be considered by the LHMP update given the COVID -19 emergency declaration of 2020.

Hazard	Included in Aguas Buenas 2026 LHMP?	Comments
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 Aguas Buenas.

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
Biological Hazards	Pandemic/Epidemic
Anthropogenic Hazards	High Hazard Potential Dam

2.2 AF PML MJ ME WMDCTCL RQ

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.

2.3 PCL ? CCCCCL CL R K CRF MB MJ ME W

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.

4.5.1 F ?XS Q4, /

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

2,3,0 ? J RCP L _RGTC E QK MB CJ Q E

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

2,3,1 QRMAF _QRA P Q ? QQQQK CL R

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.

2.3.2 FCEFF_X_PBNMRCLRGJB_KQ

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

2.4 C_PRFOSS_IC

2.4.1 BCOAPNRCML &@/+_'

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 event 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
- The 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, and amplification. 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.

2,4,/,/ ?DDCARCB ?PC_ &@/+`

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

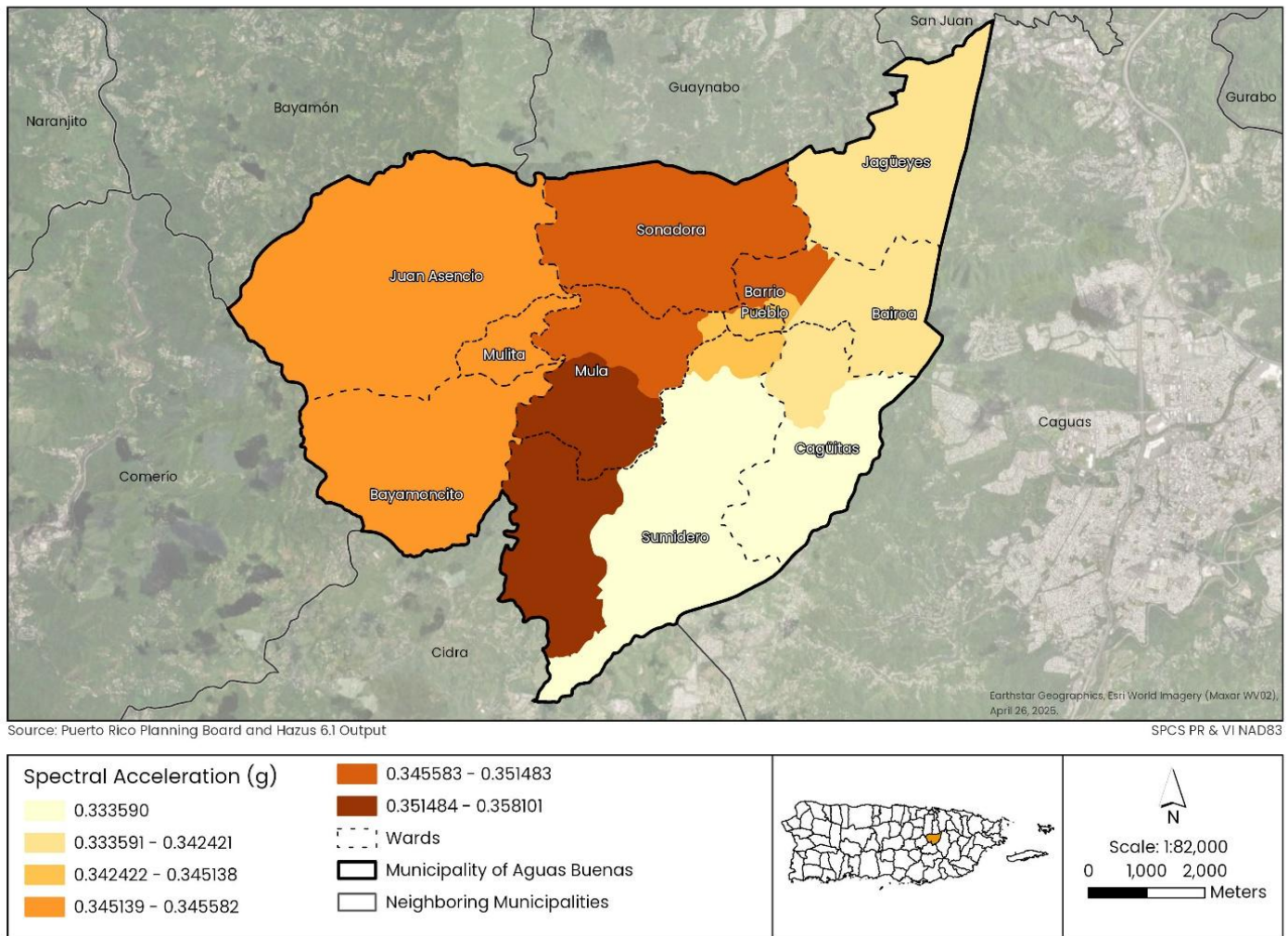
Spectral Displacement measures how far a structure is expected to move (deform) during an earthquake, based on its natural vibration period and damping in other words, it answers: “For a building with a given natural period, what is the maximum

displacement it would experience during earthquake shaking?” (National Institute of Building Sciences, 2020).

Furthermore, maps 12 and 13 show the Hazus scenario for .03 second and 1.0 second. The difference relates to how an earthquake impacts different types of structures based on the natural vibration period of 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)

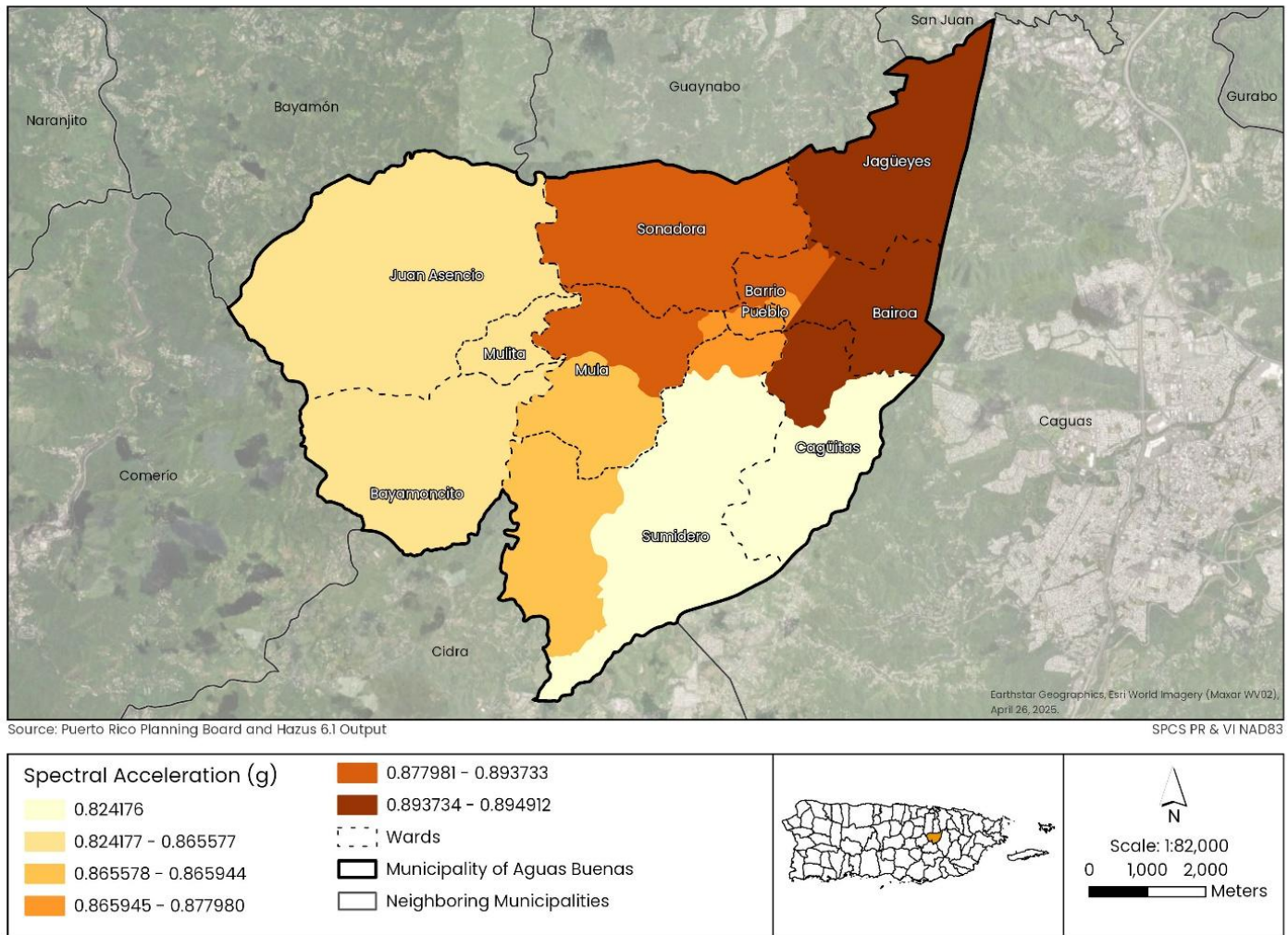
EARTHQUAKE: SPECTRAL ACCELERATION AT 1.0 SEC (G)



As shown on Map 12, the spatial distribution of spectral acceleration at a 1.0-second period across Aguas Buenas. The highest spectral acceleration values are concentrated in the central and southwestern portions of the municipality, particularly within Mula Ward and adjacent areas of Sumidero. Intermediate values are observed in Sonadora, Juan Asencio, Bayamoncito, and Mulita. The lowest spectral acceleration values occur primarily in Jagüeyes, Bairoa, Cagüitas, and portions of Barrio Pueblo located in the eastern and northeastern portions of the municipality.

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

EARTHQUAKE: SPECTRAL ACCELERATION AT 0.3 SEC (G)



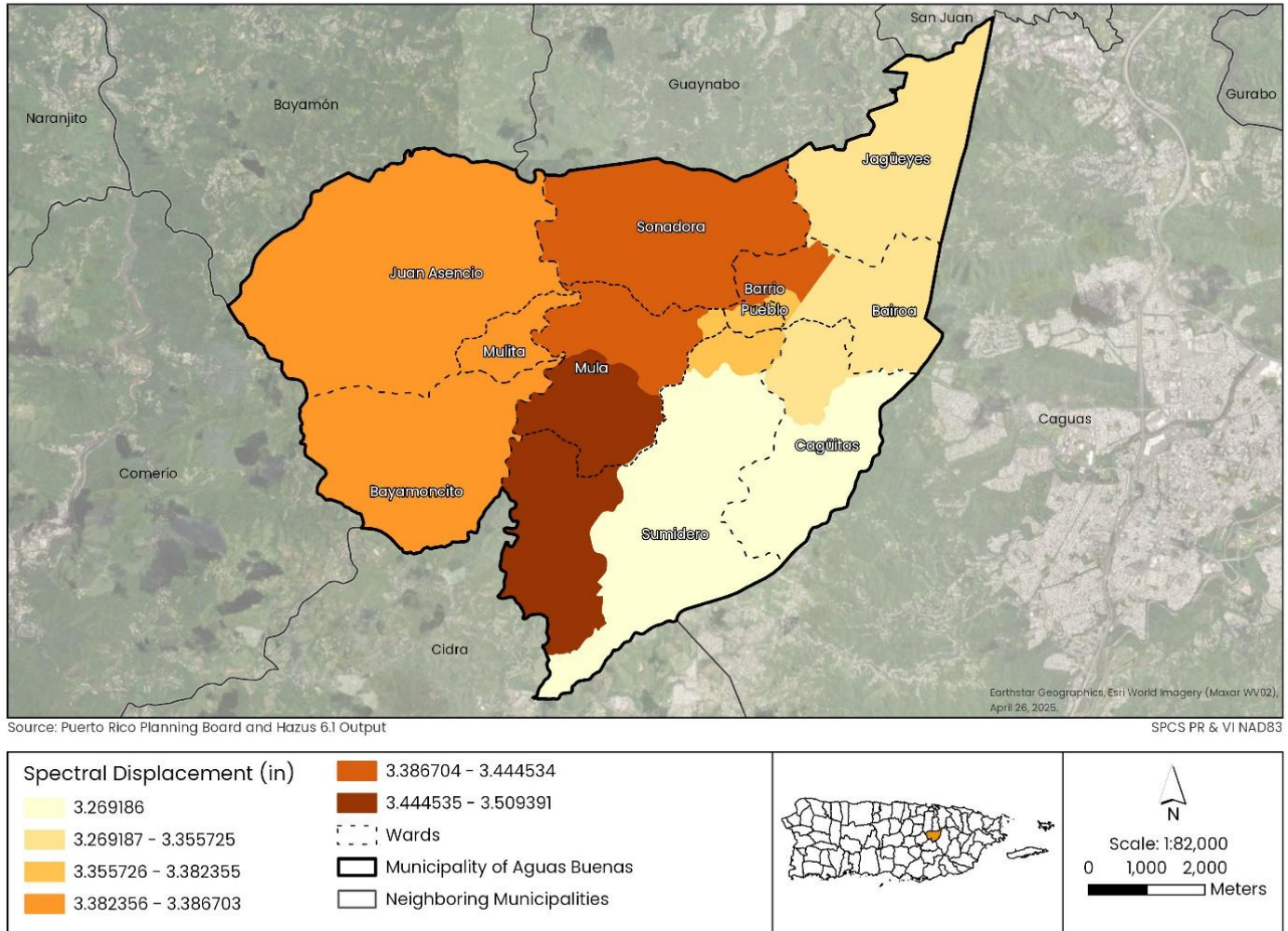
Map 13 illustrates an additional earthquake scenario based on the spatial distribution of spectral acceleration at a 0.3-second period across Aguas Buenas. The highest spectral acceleration values are concentrated in the eastern and northeastern portions of the municipality, particularly within Jagüeyes, Bairoa, and portions of Barrio Pueblo wards. Intermediate values occur in Sonadora and Mula. The lowest spectral acceleration values are observed in Juan Asencio, Bayamoncito, Mulita, Cagüitas, and Sumidero wards.

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)

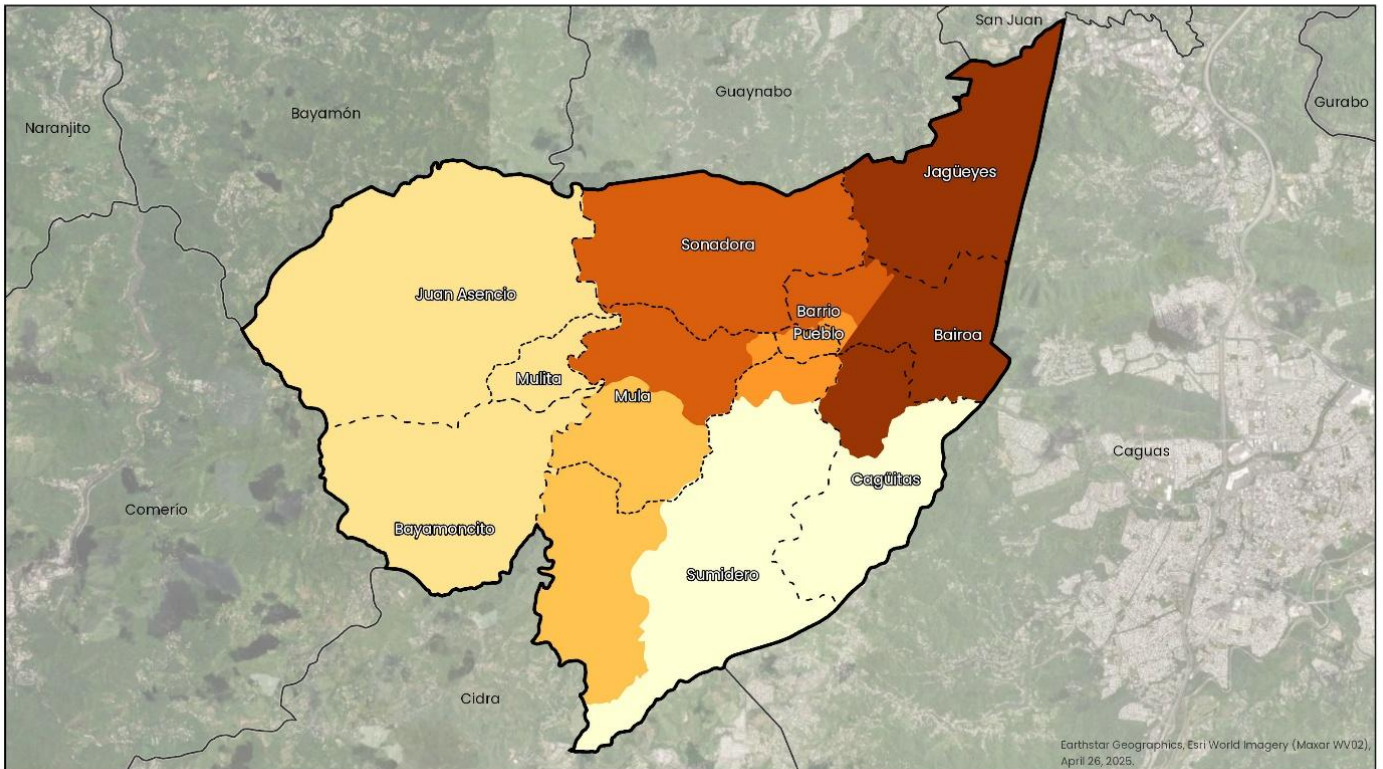
EARTHQUAKE: SPECTRAL DISPLACEMENT AT 1.0 SEC (IN)



Map 14 illustrates the spatial distribution of spectral displacement at a 1.0-second period across Aguas Buenas. The highest spectral displacement values are concentrated in the central portion of the municipality, particularly within Mula Ward, Sumidero and adjacent areas of Sonadora and Barrio Pueblo. Intermediate values are observed in Juan Asencio, Bayamoncito, Mulita, and portions of Sonadora. The lowest spectral displacement values occur predominantly in Jagüeyes, Bairoa, Cagüitas, and Sumidero wards, located in the eastern and southeastern portions of the municipality.

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

EARTHQUAKE: SPECTRAL DISPLACEMENT AT 0.3 SEC (IN)



Source: Puerto Rico Planning Board and Hazus 6.1 Output

SPCS PR & VI NAD83



This map illustrates the spatial distribution of spectral displacement at a 0.3-second period across Aguas Buenas. The highest spectral displacement values are concentrated in the eastern and northeastern portions of the municipality, particularly within Jagüeyes, Bairoa, and portions of Barrio Pueblo wards. Intermediate values occur in Sonadora, Mula, and portions of Sumidero. The lowest spectral displacement values are observed in Juan Asencio, Bayamoncito, Mulita, Caguaitas, and portions of Sumidero wards.

2,4,/,0 PQQ K_EL CRS BC&@/+A'

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 scale.

Table 19: Moment Magnitude Scale⁷

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.
Mw 6.0 – 6.9	Strong can cause significant damage in populated areas.
Mw 7.0–7.9	Major, serious damage over large areas.

⁷ Source: USGS, 2025

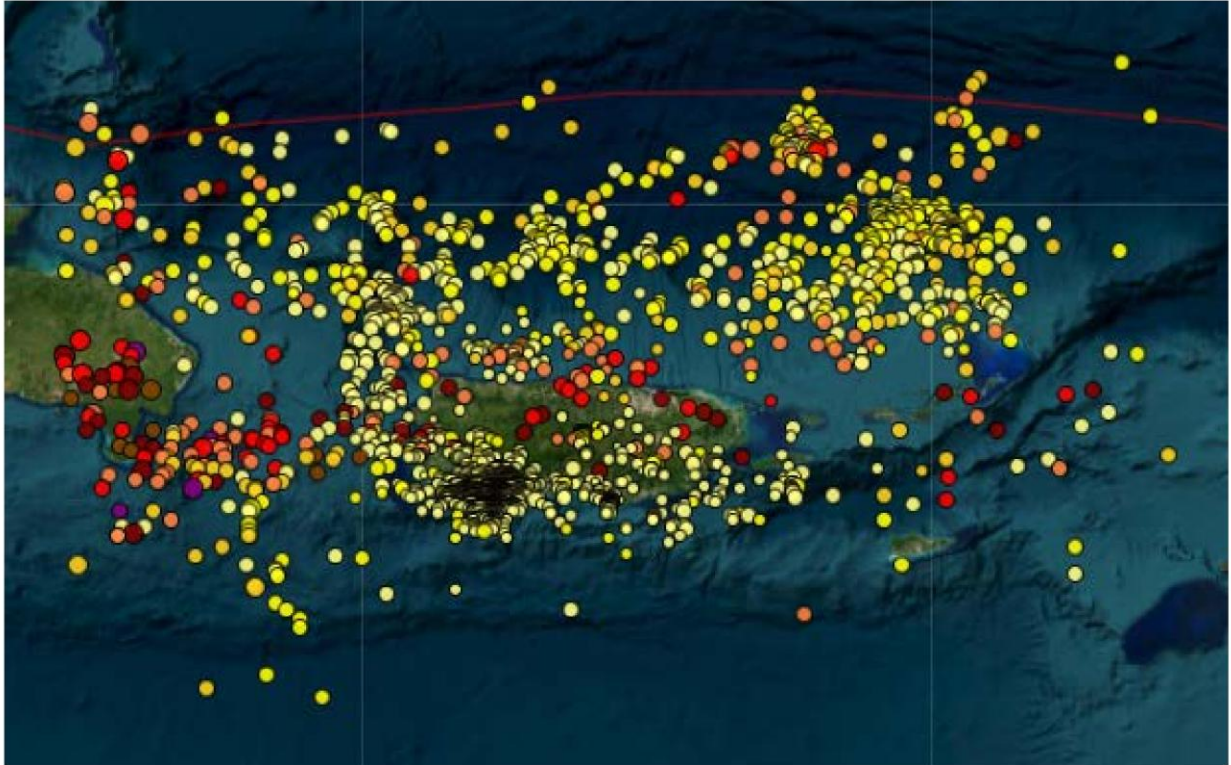
Mw ≥ 8.0	Great earthquakes, catastrophic damage over very large regions.
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2.4.1.1 *Normal Faulting*

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 Earthquake Epicenters (PRSN, 2025)



Earthquake Chronology

Table 20 below shows the chronological list of the seismic activity in Puerto Rico for the period of 2013 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

Year	Description of seismic events
	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 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.

Year	Description of seismic events
	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 Aguas Buenas 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 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.

Year	Description of seismic events
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. 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	Description of seismic events
	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 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

Year	Description of seismic events
	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 Aguas Buenas 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 damages, disrupted 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.

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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 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 Aguas Buenas 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.

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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 \$283,854,094,000.00. This includes \$2,867,294,000.00 exposure of building value and \$ \$280,986,800,000.00 population exposure.

Table 21: Exposure to Earthquake Hazard

Exposure - Impacted Area (sq mi)	Exposure - Building Value	Exposure - Population	Exposure - Population Equivalence	Exposure - Total
30.399675	\$2,867,294,000.00	24,223	\$280,986,800,000.00	\$283,854,094,000.00

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
\$1,851,049.10	0.1242	\$1,440,417.25	\$3,291,466.35

Source FEMA's NRI

The results indicate an average annual building-related loss of approximately \$1.9 million due to earthquake events. In addition, the estimated annual population loss is 0.1242 population equivalents, which FEMA converts to an annualized economic loss of approximately \$1.4 million using its population equivalence methodology. Combined, these values result in a total expected annual earthquake loss of approximately \$3.3 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.

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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

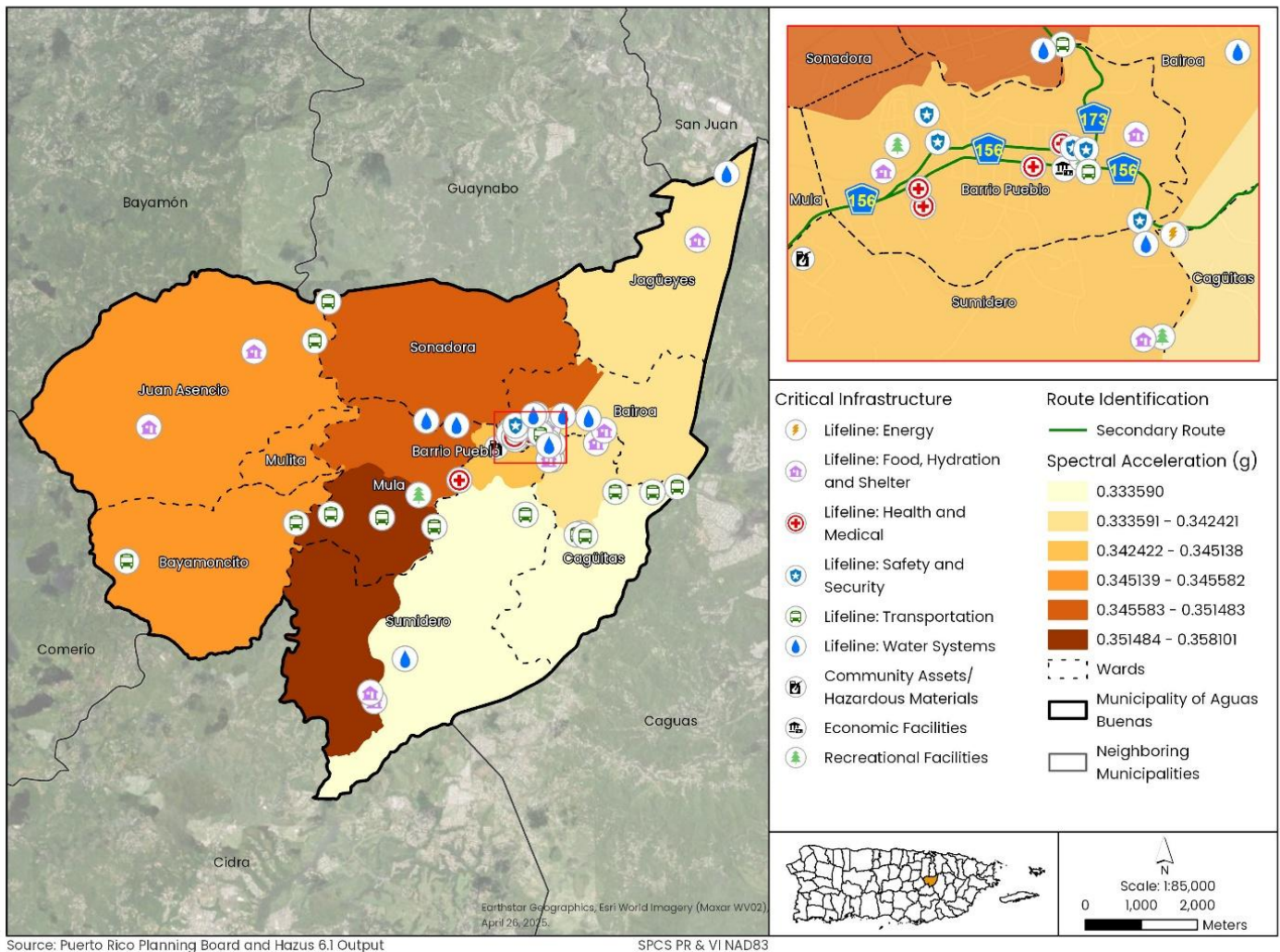
water. There could also be disruption of food supply chains due to damaged transportation routes and storage facilities. There can be increased need for temporary shelters because of widespread structural damage. Finally, loss of refrigeration capacity can lead to loss of perishable goods.

- 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)

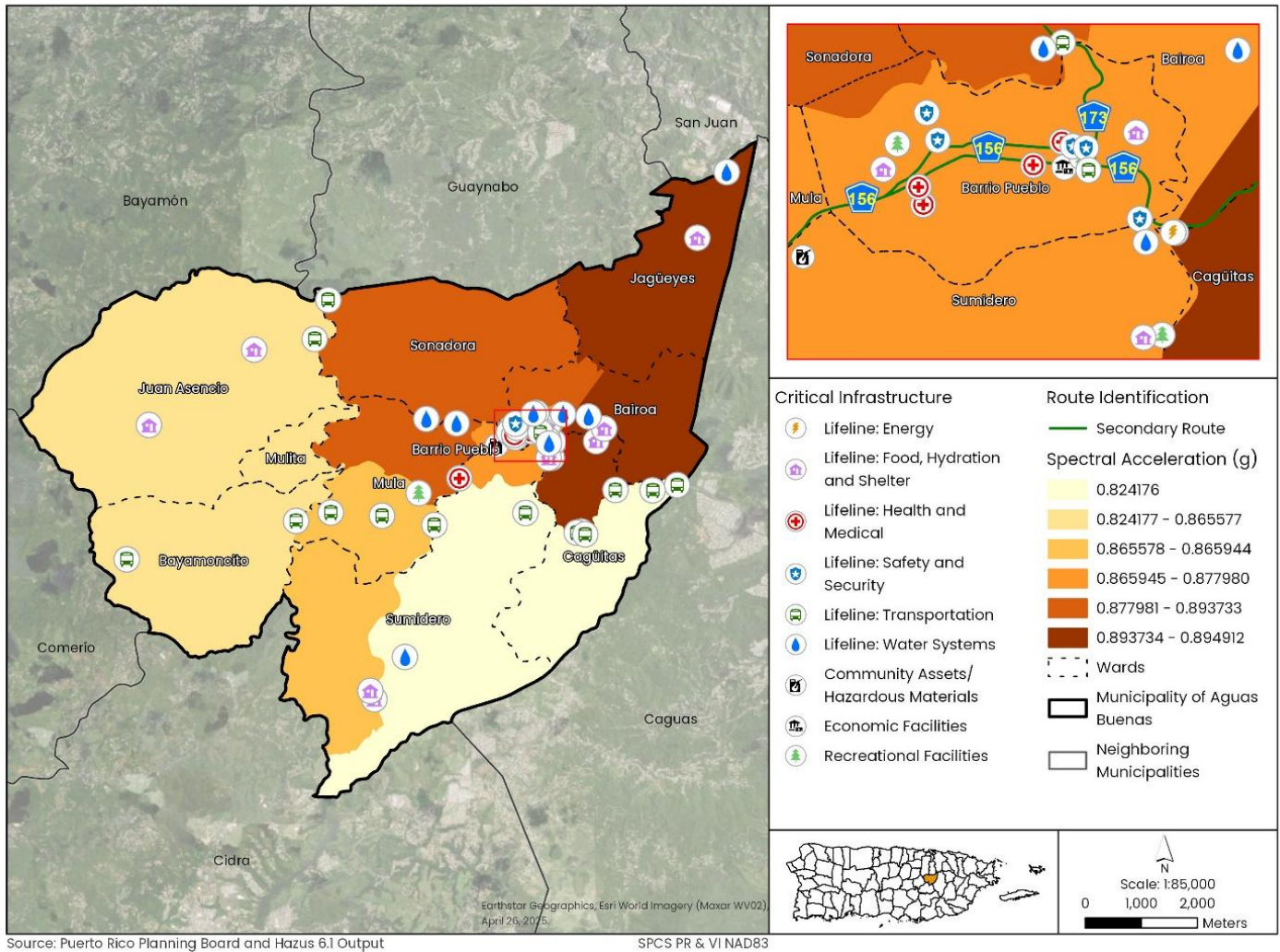
EARTHQUAKE: CRITICAL FACILITIES EXPOSURE TO SPECTRAL ACCELERATION AT 1.0 SEC (G)



Map 16 illustrates that critical facilities in the Municipality of Aguas Buenas are located across spectral acceleration values ranging from approximately (0.3336 g to 0.3580 g). The highest mapped spectral acceleration values (0.3515–0.3580 g) occur primarily in the southern portion of Sumidero Ward, while elevated values (0.3456–0.3515 g) extend through parts of Mula, Sonadora, and the central area near Barrio Pueblo. Lower spectral acceleration values are mapped in Jagüeyes, Cagüitas, and portions of the southeastern municipality. Critical facilities from multiple infrastructure sectors are distributed throughout the municipality, with a noticeable concentration near Barrio Pueblo, where several facilities are located within the moderate to high spectral acceleration zones shown on the map.

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)



Map 17 illustrates that critical facilities are concentrated primarily in the central and northeastern portions of Aguas Buenas, particularly within Barrio Pueblo, Bairoa, Sonadora, and portions of Cagüitas. Most of these facilities are located within areas mapped with Very High and Extreme spectral acceleration at 0.3 seconds, represented by the darker orange and brown shading.

Water system, transportation, health and medical, safety and security, and economic facilities are clustered around Barrio Pueblo and Bairoa, where the map depicts Very High to Extreme spectral acceleration values. Additional transportation and water system facilities are distributed across Cagüitas, Sonadora, Sumidero, and

Bayamoncito, while food, hydration, and shelter facilities are in Juan Asencio, Bairoa, Cagüitas, and Sumidero.

Overall, the map indicates that many critical facilities are situated within areas classified as Very High and Extreme spectral acceleration, with the highest concentration of exposed facilities occurring in the Barrio Pueblo-Bairoa corridor and surrounding portions of Sonadora and Cagüitas.

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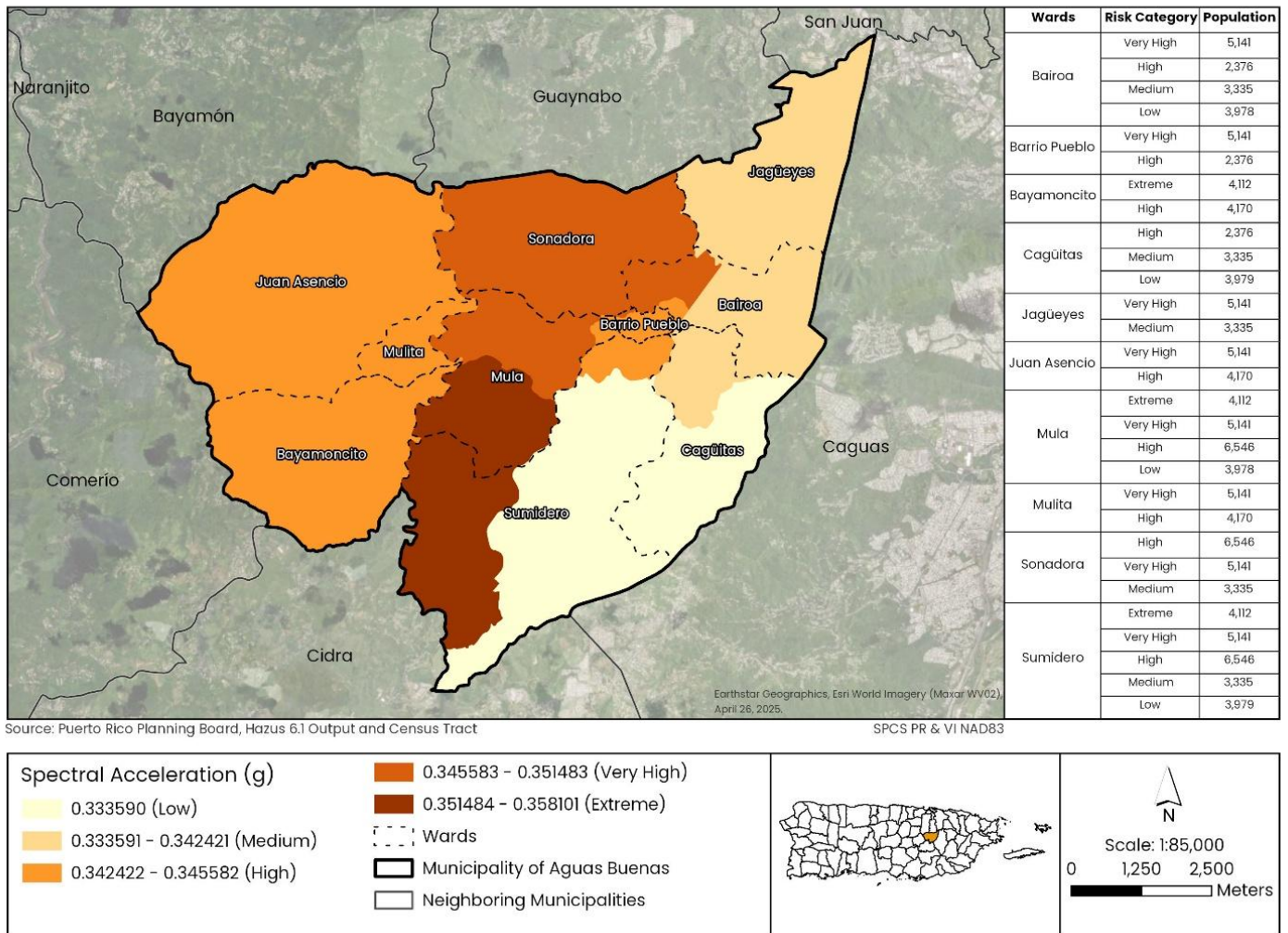
Social vulnerability to earthquakes in Puerto Rico is shaped by high levels of poverty, aging infrastructure, and limited access to essential resources, all of which disproportionately affect the ability of communities to withstand and recover from seismic events. Many residents face compounding disadvantages—such 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 Exposure to Spectral Acceleration at 1.0 sec (G)

EARTHQUAKE: POPULATION EXPOSURE TO SPECTRAL ACCELERATION AT 1.0 SEC (G)



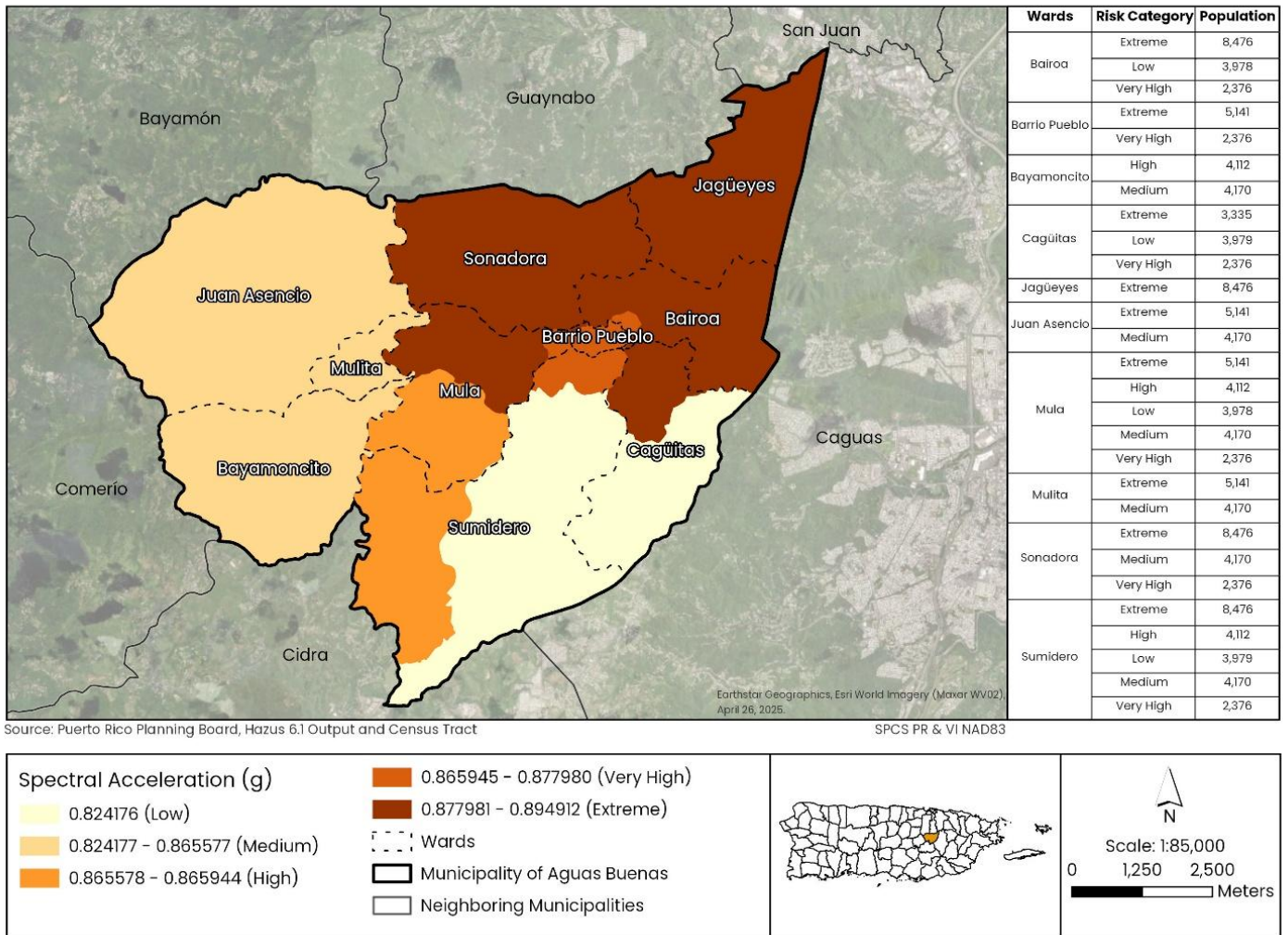
The map indicates that earthquake spectral acceleration at 1.0 second varies across Aguas Buenas, with the highest values (Very High to Extreme) concentrated in the central and southern portions of the municipality. The wards of Mula, Sonadora, and Sumidero show the greatest exposure, while Juan Asencio, Bayamoncito, and Mulita are primarily classified as High to Very High. The eastern wards of Bairoa, Cagüitas, and Jagüeyes exhibit lower spectral acceleration values, ranging from Low to Medium.

Population exposure follows a similar spatial pattern. The largest populations exposed to the Very High category are found in Bairoa, Barrio Pueblo, Jagüeyes, Mulita, Sonadora, and Sumidero (5,141 residents each), while Mula and Mulita have the highest

populations exposed to the High category (6,546 residents). Mula is the only ward with population exposure in the Extreme spectral acceleration category (4,112 residents), indicating the highest level of seismic ground-motion exposure shown on the map.

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

EARTHQUAKE: POPULATION EXPOSURE TO SPECTRAL ACCELERATION AT 0.3 SEC (G)



The map illustrates that spectral acceleration at 0.3 second is highest in the northern and northeastern portions of Aguas Buenas. The wards of Sonadora, Bairoa, Jagüeyes, and most of Barrio Pueblo are classified within the Extreme spectral acceleration category, while Mula is primarily classified as Very High. Juan Asencio, Bayamoncito, and Cagüitas show the lowest spectral acceleration values and are generally within the Low to Medium categories, with Sumidero displaying a mix of Medium and High values.

Population exposure is concentrated in the Extreme category in Bairoa, Jagüeyes, Mulita, and Sonadora, each with 8,476 residents exposed. Barrio Pueblo and Juan Asencio each have 5,141 residents exposed to the Extreme category, while Mula and Sumidero have populations distributed among the Low, Medium, High, and Very High exposure categories. Overall, the northern and northeastern wards exhibit the highest mapped spectral acceleration values, whereas the southern and western wards generally display lower exposure levels.

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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.

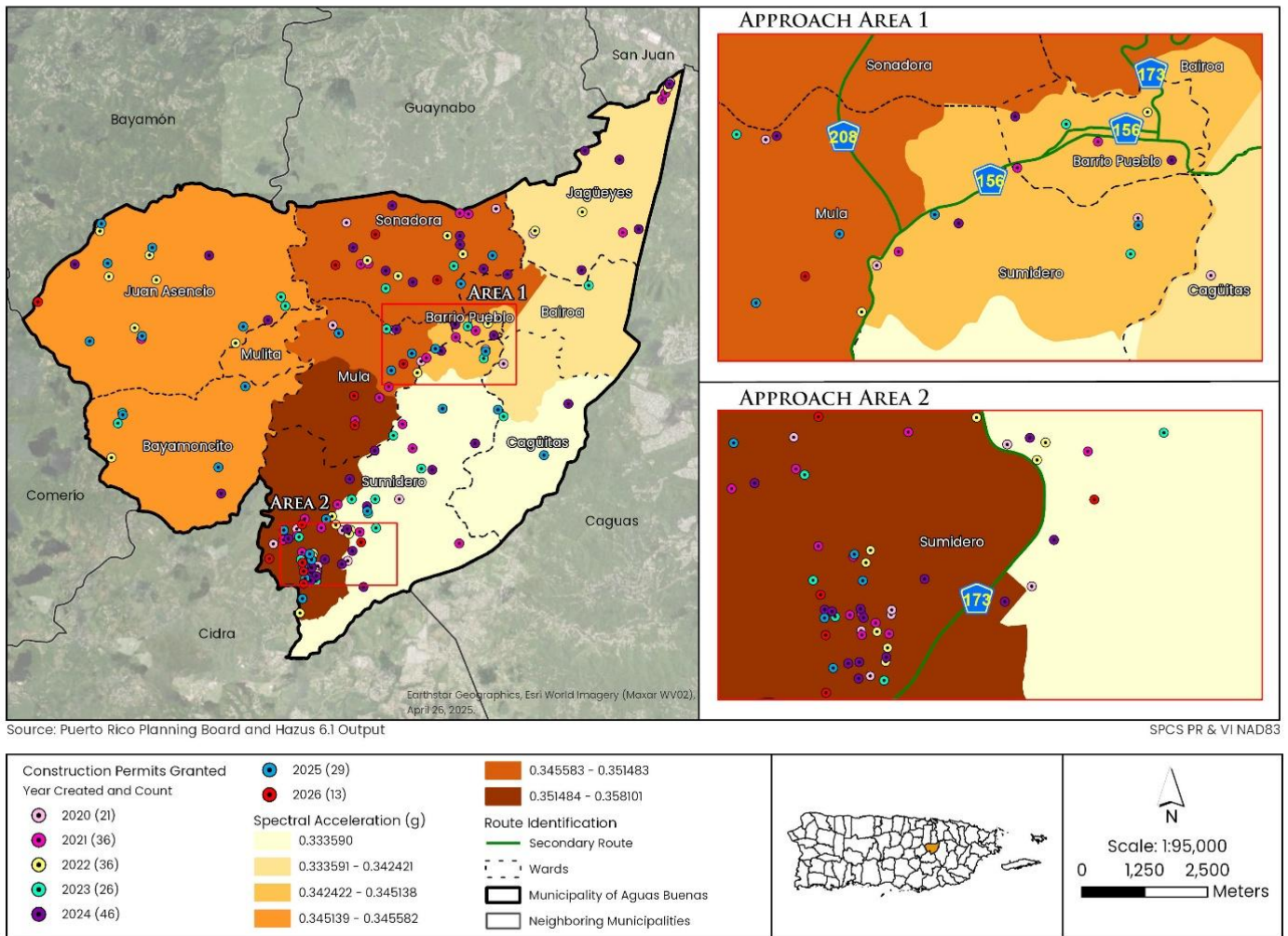
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As discussed in Section 3.6, the elevated number of construction permits issued by the Municipality reflects a sustained level of economic activity. To further support this analysis, Maps 20 and 21 highlight the areas with the highest spectral acceleration 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)

EARTHQUAKE: RECENT DEVELOPMENT EXPOSURE TO SPECTRAL ACCELERATION AT 1.0 SEC (G)



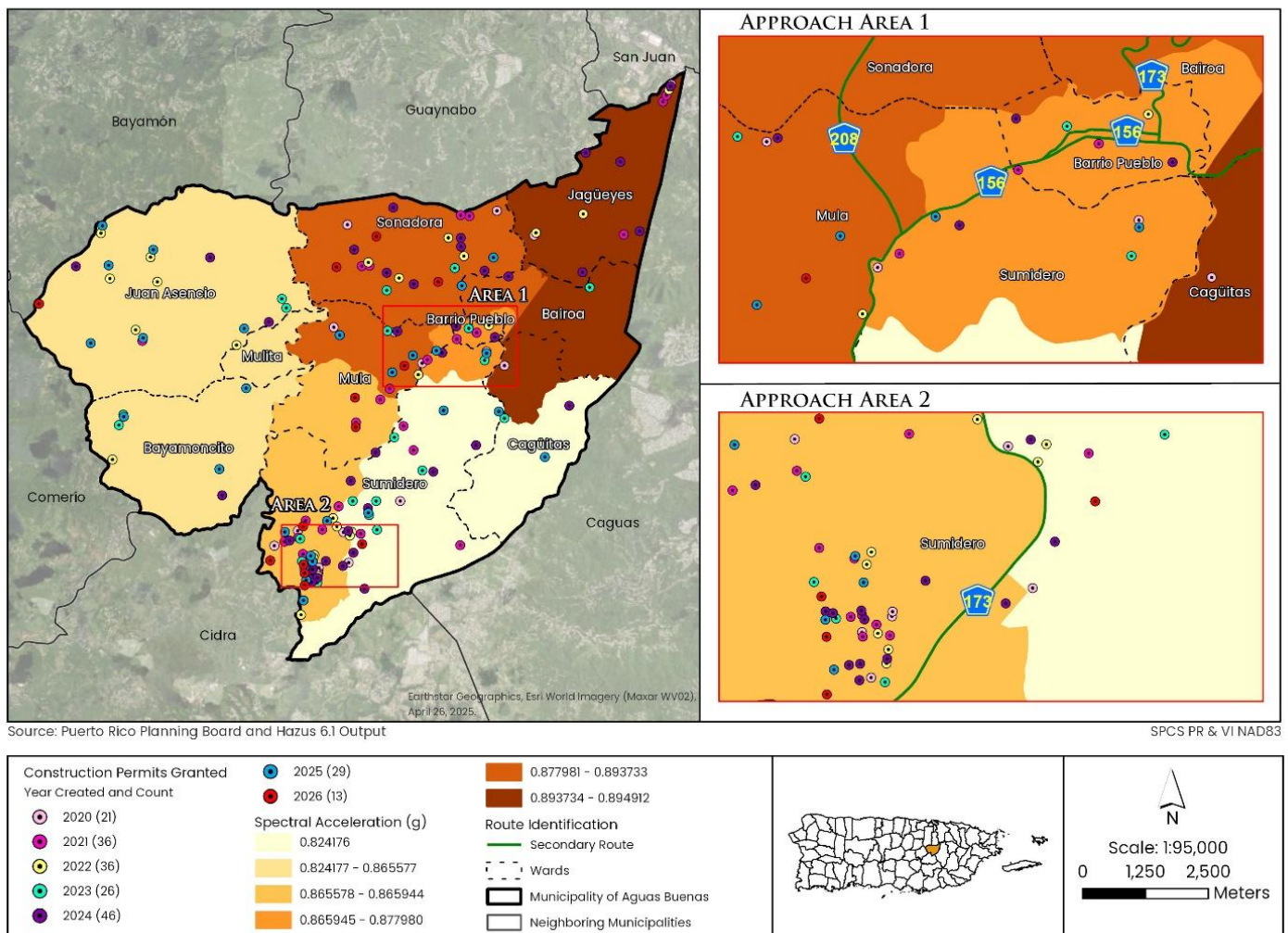
The map shows that recent development permits are distributed throughout Aguas Buenas, with notable concentrations in the central and southern portions of the municipality. The largest cluster of recent development is in Sumidero, particularly within the area characterized by the Extreme spectral acceleration category, as highlighted in Approach Area 2. Additional concentrations of recent development are present near the boundaries of Mula, Barrio Pueblo, and Sonadora, within areas

classified as High to Very High spectral acceleration.

Scattered recent development permits are also observed across Juan Asencio, Bayamoncito, Mulita, Bairoa, Cagüitas, and Jagüeyes, although at lower densities. Overall, the map indicates that many recent development locations are situated within areas mapped as High, Very High, and Extreme spectral acceleration at 1.0 second, with the highest concentration occurring in the southern portion of Sumidero and the central area near Mula and Barrio Pueblo.

Map 2f: Earthquake: Recent Development Exposure to Spectral Acceleration at 0.3 sec (G)

EARTHQUAKE: RECENT DEVELOPMENT EXPOSURE TO SPECTRAL ACCELERATION AT 0.3 SEC (G)



The map indicates that recent development permits are distributed across all wards

of Aguas Buenas, with the greatest concentration located in the southern portion of Sumidero. Most of the development clustered in Sumidero is situated within areas classified as High spectral acceleration, as shown in Approach Area 2. Additional concentrations of recent development are present in the central part of the municipality near Mula, Barrio Pueblo, Sonadora, and Bairoa, where spectral acceleration values range from High to Very High.

Scattered recent development permits are also observed throughout Juan Asencio, Bayamoncito, Mulita, Cagüitas, and Jagüeyes. The northeastern wards of Bairoa and Jagüeyes contain the areas mapped with the Extreme spectral acceleration category, while the western and southwestern wards are predominantly classified as Low to Medium. Overall, the map shows that many recent development locations are situated within areas mapped as High, Very High, and Extreme spectral acceleration at 0.3 seconds, particularly in the central and southern portions of the municipality.

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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).

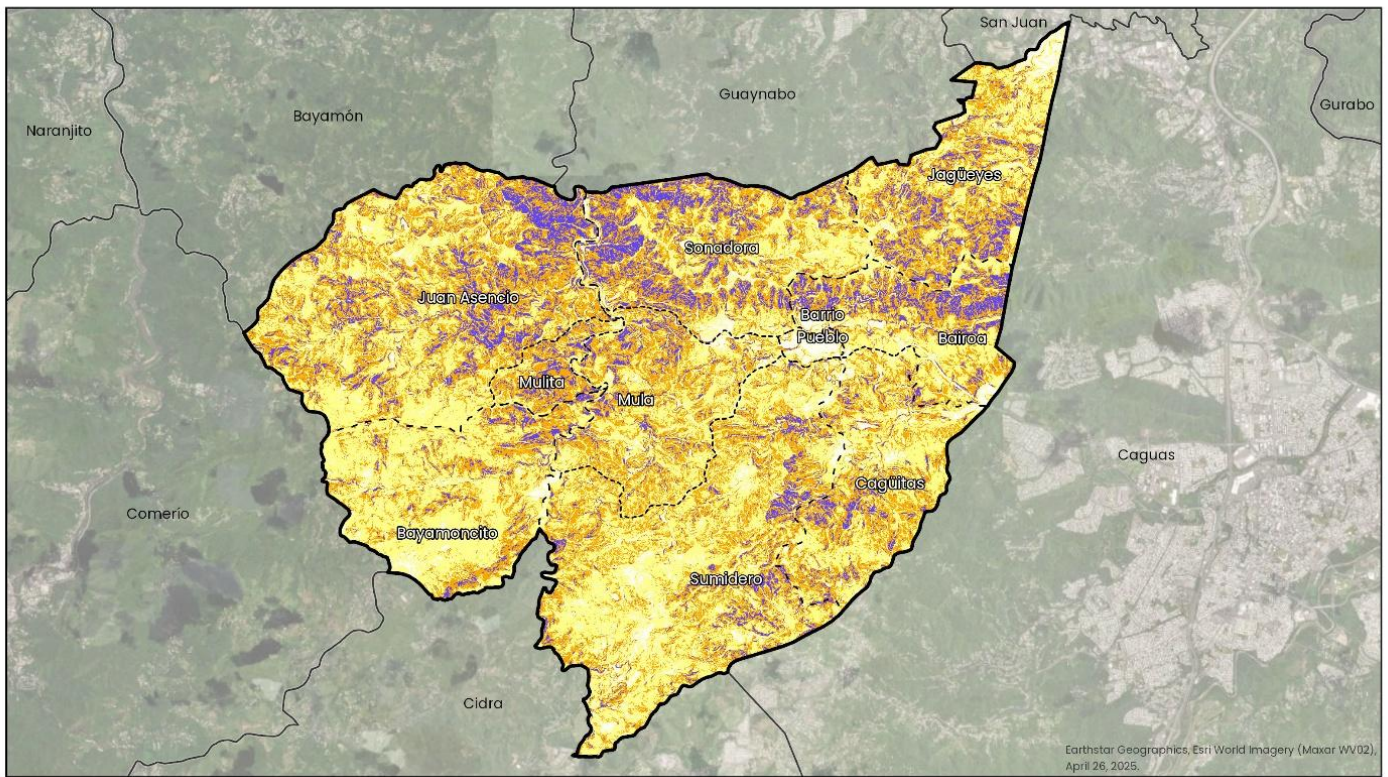
Many of the landslides that occur in Puerto Rico falls into a special category of landslides known as “debris flows.” The flow occurs in mountainous areas with significant slopes during intense rainfall. Rain saturates the soil and causes the flat subsurface to lose solidity and detach, usually where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

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As with all municipalities within Puerto Rico’s mountainous region, Aguas Buenas has experienced a high volume of landslides in recent years (Municipality of Aguas Buenas, 2020). Map 22 shows the areas considered as moderately and highly susceptible to landslides in Aguas Buenas. The following map identifies the areas with the highest susceptibility to landslide events.

LANDSLIDE SUSCEPTIBILITY



Source: Puerto Rico Planning Board and Hazus 6.1 Output

SPCS PR & VI NAD83



The areas that are more susceptible to landslide events are concentrated primarily in the wards of Jagüeyes, Sonadora, Bairoa, and Juan Asencio, where the greatest extent of Very High susceptibility (shown in purple) is mapped. Additional areas of Very High susceptibility are also present in Mulita, Mula, and Cagüitas, while Bayamoncito and Sumidero contain comparatively smaller concentrations of these areas.

Overall, the map indicates that landslide susceptibility is distributed throughout the municipality, but the highest concentrations of Very High susceptibility are in the northern and northeastern portions of the municipality, particularly within Jagüeyes, Sonadora, Juan Asencio and Bairoa.

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.

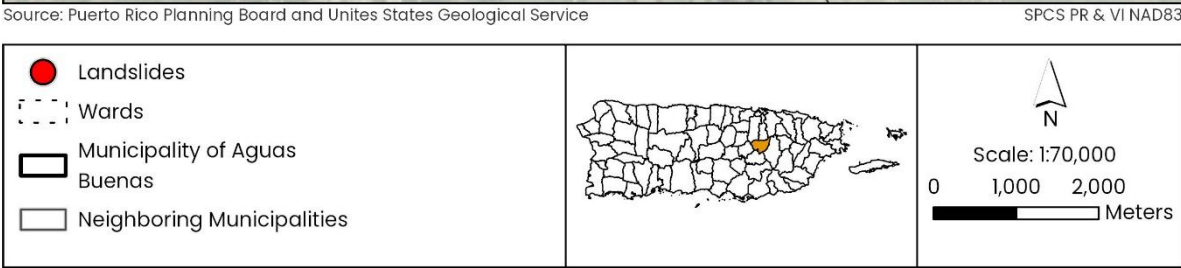
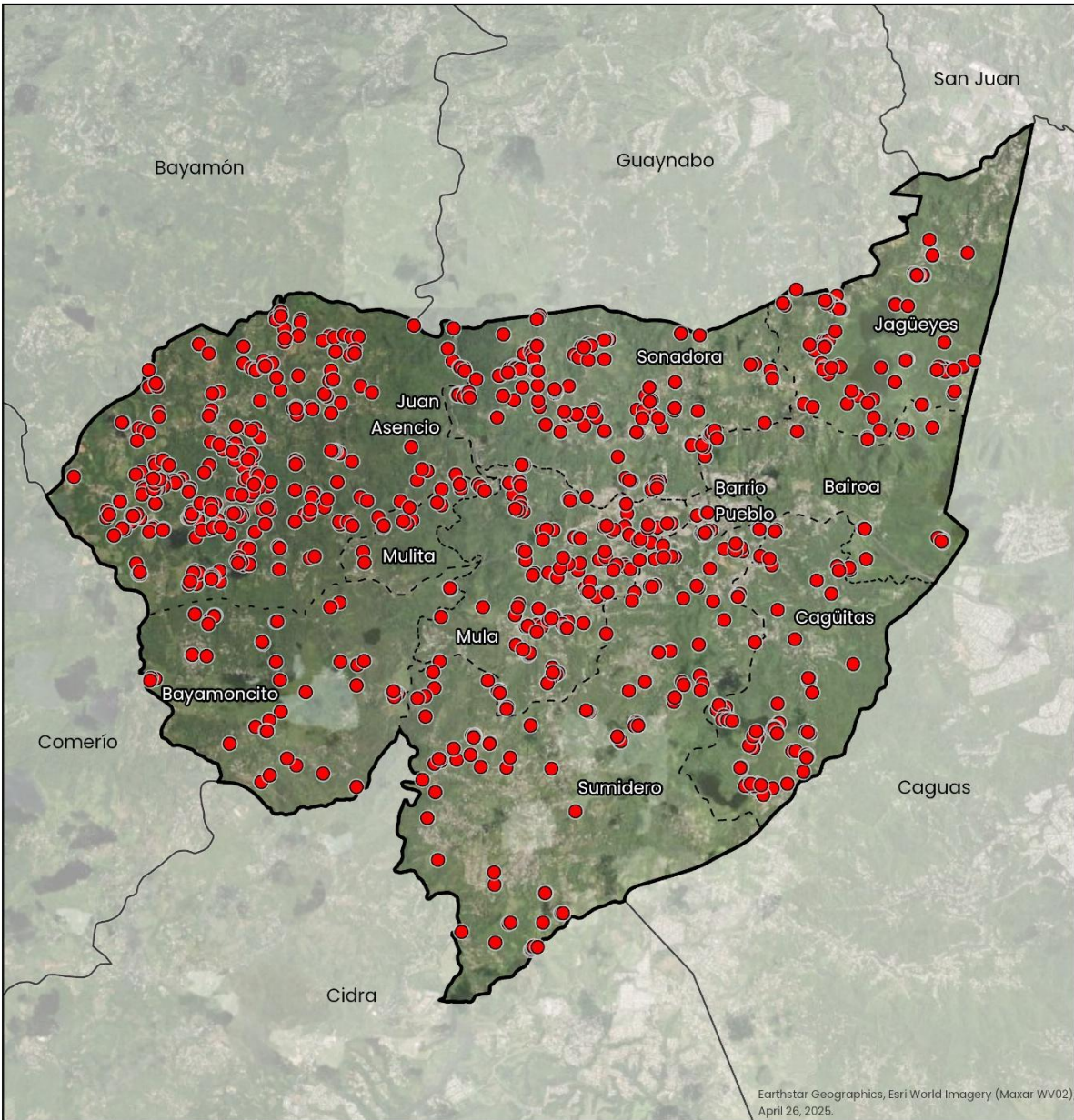
The municipality incorporates landslide prevention and mitigation measures as an integral component of its earthquake response protocol.

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As stated above, landslides are frequently associated with heavy rainfall events. Map 23 illustrates the landslides as reported by the USGS following Hurricane María in 2017, which align with the areas of greatest susceptibility shown in the map. The map shows that landslides reported after Hurricane María were distributed throughout the municipality, with occurrences recorded in all wards. The highest concentrations of reported landslides are visible in the northwestern and north-central portions of the municipality, particularly within Juan Asencio, Sonadora, and parts of Jagüeyes. Additional clusters are observed in Mula, Barrio Pueblo, Bairoa, and Cagüitas. Reported landslides are also present in Mulita, Bayamoncito, and Sumidero, although they appear more dispersed. Overall, the map indicates a municipality-wide distribution of reported landslides, with greater concentrations in the northern half of the municipality.

Map 23: Landslides Reported in the Aftermath of Hurricane María

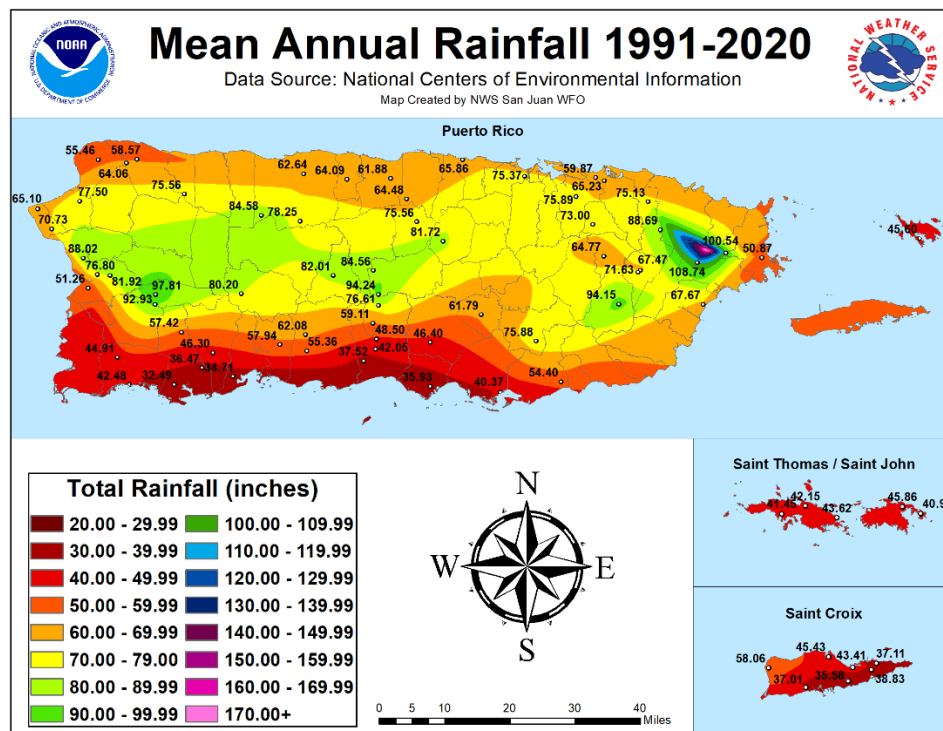
LANDSLIDES REPORTED IN THE AFTERMATH OF HURRICANE MARÍA



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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 14 shows the Mean Annual Rainfall for Puerto Rico and the US Virgin Islands from 1991 to 2020. The Municipality of Aguas Buenas lies entirely within an area where the mean annual rainfall ranges from 70.00 to 79.00 inches. Continued exposure to substantial rainfall and intense precipitation events can saturate slopes, destabilize soils, and contribute to the occurrence of landslides within the municipality.

Figure 14: Mean Annual Rainfall 1991-2020 (PR & USVI)⁸



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In the Municipality of Aguas Buenas, as in much of Puerto Rico, landslides typically occur during or after major storms with torrential rainfall. The occurrence of rainfall-

⁸ Obtained from https://www.weather.gov/sju/climo_pr_usvi_normals

induced landslides is closely associated with severe storms or sequential rain events that saturate vulnerable steep soils.

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 Aguas Buenas. 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.

2.5.0.0 JØJQ CQ LB A PRA J Q DP QRPSARS PC

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).

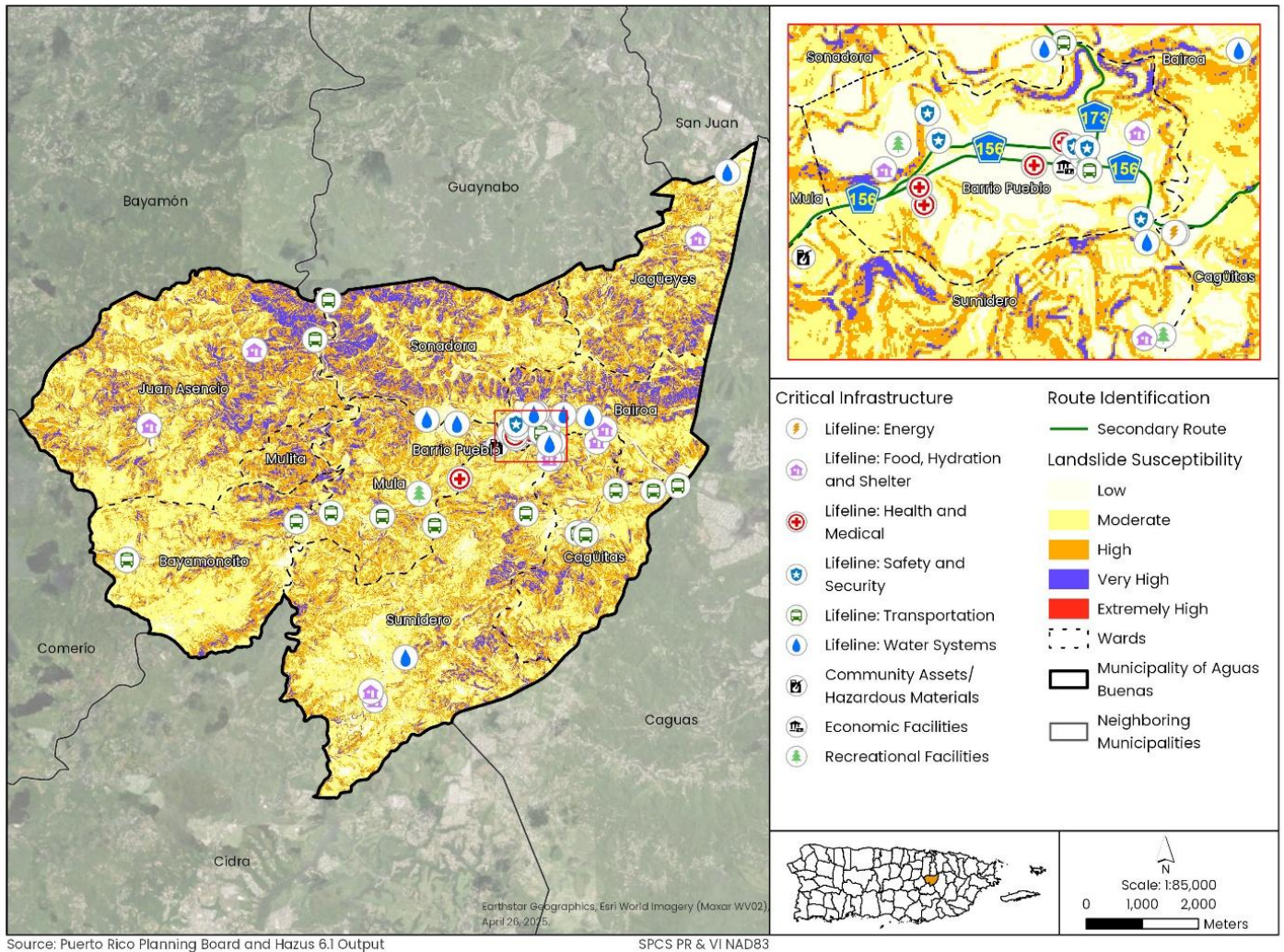
- Water Systems - Damage to water intake, treatment, distribution, sewage collection, and treatment facilities can result in contamination, reduced water pressure, and service interruption (IFRC, 2023).

Map 24 shows the identified critical infrastructure that could be affected by Landslides. The map illustrates that critical infrastructure is distributed throughout Aguas Buenas, with the greatest concentration located in and around Barrio Pueblo, extending into portions of Sonadora, Bairoa, Mula, and Sumidero. Several critical facilities are situated within areas mapped as High and Very High landslide susceptibility, particularly along the central corridor of the municipality.

Transportation facilities are dispersed across multiple wards, including Bayamoncito, Mula, Cagüitas, and Bairoa, while water system facilities are concentrated near Barrio Pueblo and scattered throughout Sumidero, Bairoa, and Jagüeyes. Health and medical facilities, safety and security facilities, and economic facilities are clustered primarily within Barrio Pueblo, where areas of Moderate to High and localized Very High landslide susceptibility are present.

Overall, the map indicates that numerous critical infrastructure assets are located within or adjacent to areas mapped as High and Very High landslide susceptibility, with the highest concentration of exposed facilities occurring in the central portion of the municipality around Barrio Pueblo and neighboring wards.

LANDSLIDE: CRITICAL INFRASTRUCTURE EXPOSURE



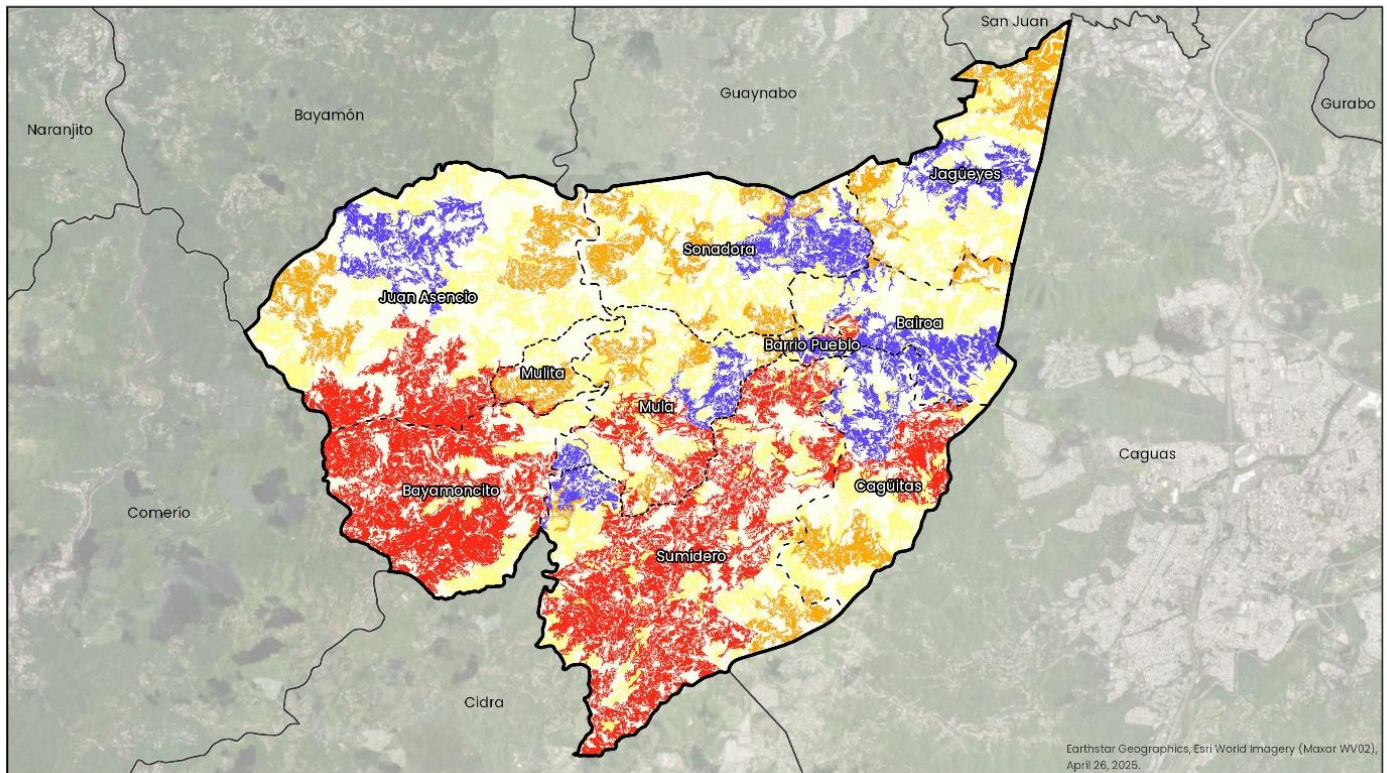
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Social vulnerability to landslides in Puerto Rico is the product of topography, poverty, aging populations, fragile infrastructure, and geographic isolation, all of which shape the severity of impacts after major storms or seismic events. Academic 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).

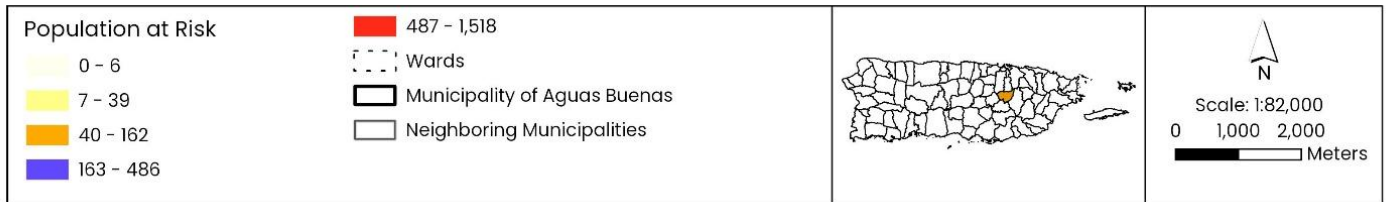
As discussed earlier, a significant portion of Aguas Buenas population is considered vulnerable (38.87%). Of particular concern, rural residents often depend on a single road that can be destroyed or blocked by slope failures, isolating entire communities. Focus groups on the municipality of Utuado highlighted 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 Aguas Buenas 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).

LANDSLIDE: POPULATION EXPOSURE



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

SPCS PR & VI NAD83



Map 25 shows that population exposure to landslide hazards is distributed throughout the municipality, with the highest concentrations of exposed population (shown in red) located primarily in Bayamoncito, Sumidero, and portions of Cagüitas. Additional areas of elevated population exposure are present in Mula and parts of Juan Asencio. Moderate to high population exposure (orange and purple) is observed across Barrio Pueblo, Sonadora, and Jagüeyes, while lower exposure levels are scattered throughout the municipality. Overall, the map indicates that the largest concentrations of population exposed to landslide hazards are in the western, southern, and southeastern portions of the municipality, particularly within Bayamoncito, Sumidero, and Cagüitas.

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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.

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As Map 26 shows, recent development permits are distributed throughout the municipality and occur within all landslide susceptibility categories. The largest concentration of recent development is in the southern portion of Sumidero, where numerous permits are clustered within areas mapped as Low to Moderate landslide susceptibility, with adjacent areas of High susceptibility. Additional concentrations of recent development are present in Barrio Pueblo, Mula, Sonadora, Bairoa, and Jagüeyes, where permits are interspersed with areas of High and Very High landslide susceptibility. Overall, the map indicates that recent development has occurred across the municipality, including in locations mapped with elevated landslide susceptibility.

LANDSLIDE: RECENT DEVELOPMENT EXPOSURE



- 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.

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Flood Hazard Insurance Map

Map 27 shows the areas affected by floods in Aguas Buenas. The map indicates that flood hazard areas within Aguas Buenas are concentrated along major river and stream corridors. The 1% annual chance flood hazard zone follows a north-south watercourse extending through portions of Sonadora, Mulita, Bayamoncito, Mula, and Sumidero, continuing toward the municipal boundary with Cidra. Additional flood hazard areas are mapped along a stream corridor crossing Barrio Pueblo and extending eastward into Bairoa.

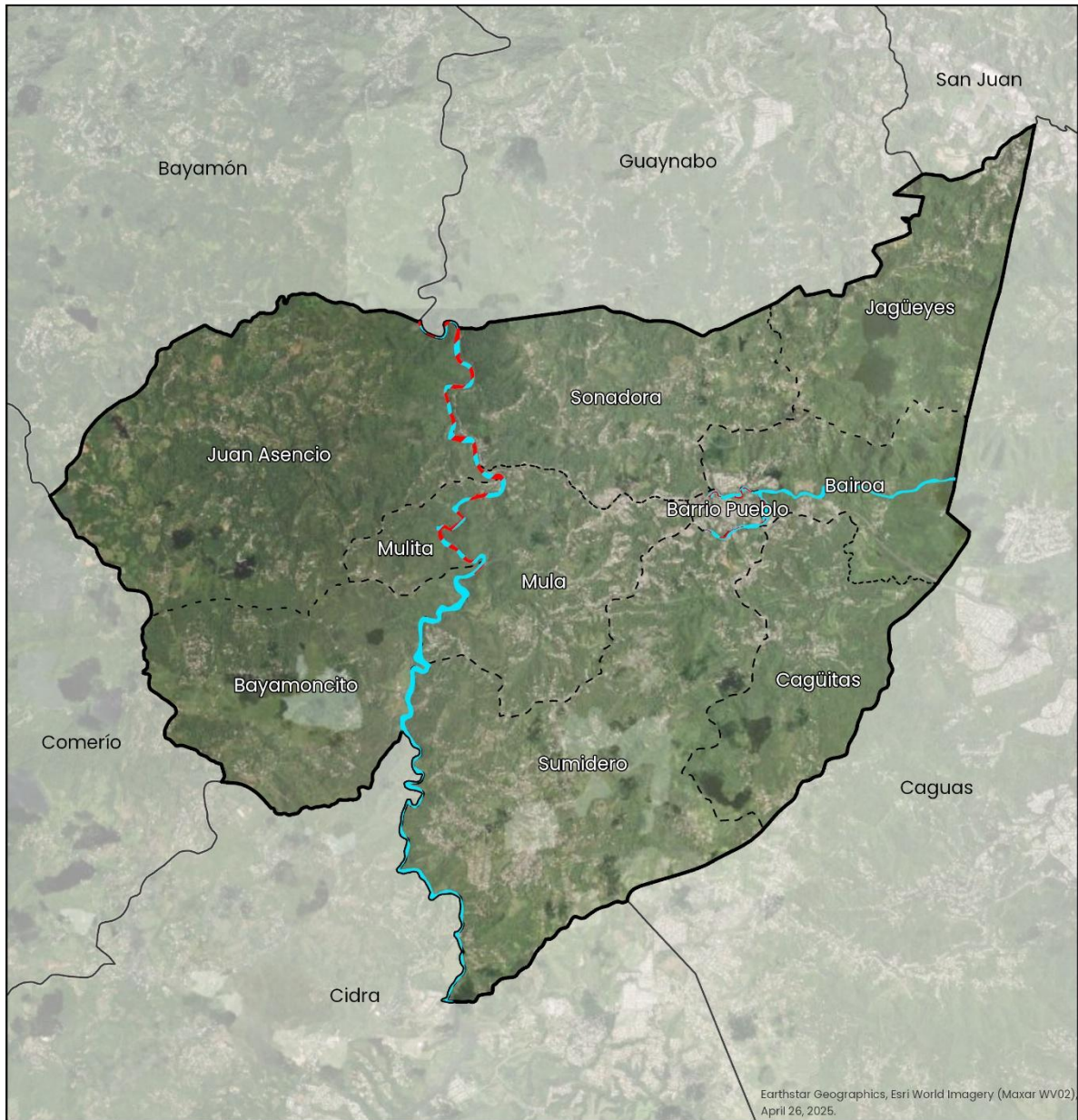
The regulatory floodway is mapped along a portion of the northern stream segment near the boundary between Sonadora and Mulita, indicating a more limited area within the broader flood hazard corridor. No other mapped flood hazard areas are

shown in Juan Asencio, Jagüeyes, or most of Cagüitas. Overall, the mapped flood hazard zones are confined to river and stream channels traversing the central, western, and northeastern portions of the municipality.

Figures 15 to 17 shows various FIRMette that shows specific areas of flooding in the Municipality.

- Figure 15 shows a study area that is composed of a mixed urban and wooded watershed located within the Municipality. A meandering stream runs from east to west through a densely vegetated valley, with residential neighborhoods, local streets, public facilities, and recreational fields situated near the watercourse. Much of the surrounding landscape is covered by tropical forest and steep hills typical of Puerto Rico's interior region.
- Figure 16 shows the study area located within the urban core of Aguas Buenas, Puerto Rico. Land use is primarily residential, commercial, and civic, surrounded by forested hillsides. A meandering stream flows around the town center, with FEMA-designated Zone AE floodplains and regulatory floodways extending along the channel. The area contains developed infrastructure, recreational facilities, local roadways, and residential communities that may be affected during significant flood events.
- Figure 17 shows the study area concentrated primarily along major stream and river corridors. The most extensive flood-prone area follows a north-south alignment through the central portion of the municipality, extending from the municipal boundary with Cidra through portions of Mula and Mulita and continuing north toward the municipal boundary with Guaynabo. This flood corridor includes both the 1-percent annual chance flood hazard area and the associated regulatory floodway. Additional flood-prone areas are located along watercourses in the Barrio Pueblo and Bairoa wards, where smaller flood hazard zones follow the natural drainage network toward the eastern portion of the municipality. The map demonstrates that flood risks in Aguas Buenas are closely associated with the municipality's river and stream systems rather than being widely distributed across the territory. As a result, development, transportation infrastructure, utilities, and other assets located adjacent to these waterways may be exposed to flood-related impacts during significant rainfall events.

FLOOD HAZARD ZONES



Source: Puerto Rico Planning Board and Federal Emergency Management Agency (FEMA)

SPCS PR & VI NAD83

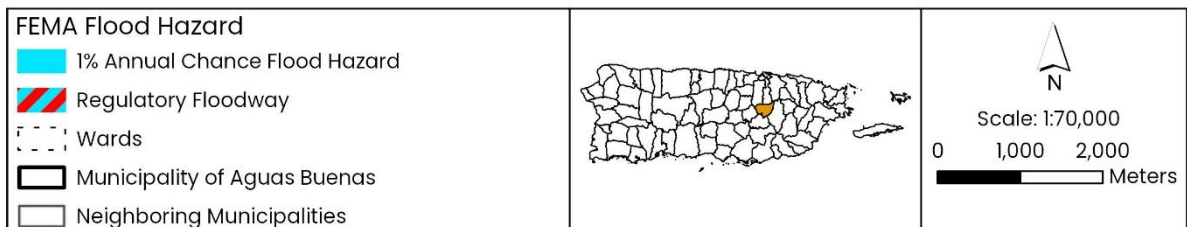


Figure 15: National Flood Hazard Layer FIRMette (Aguas Buenas)

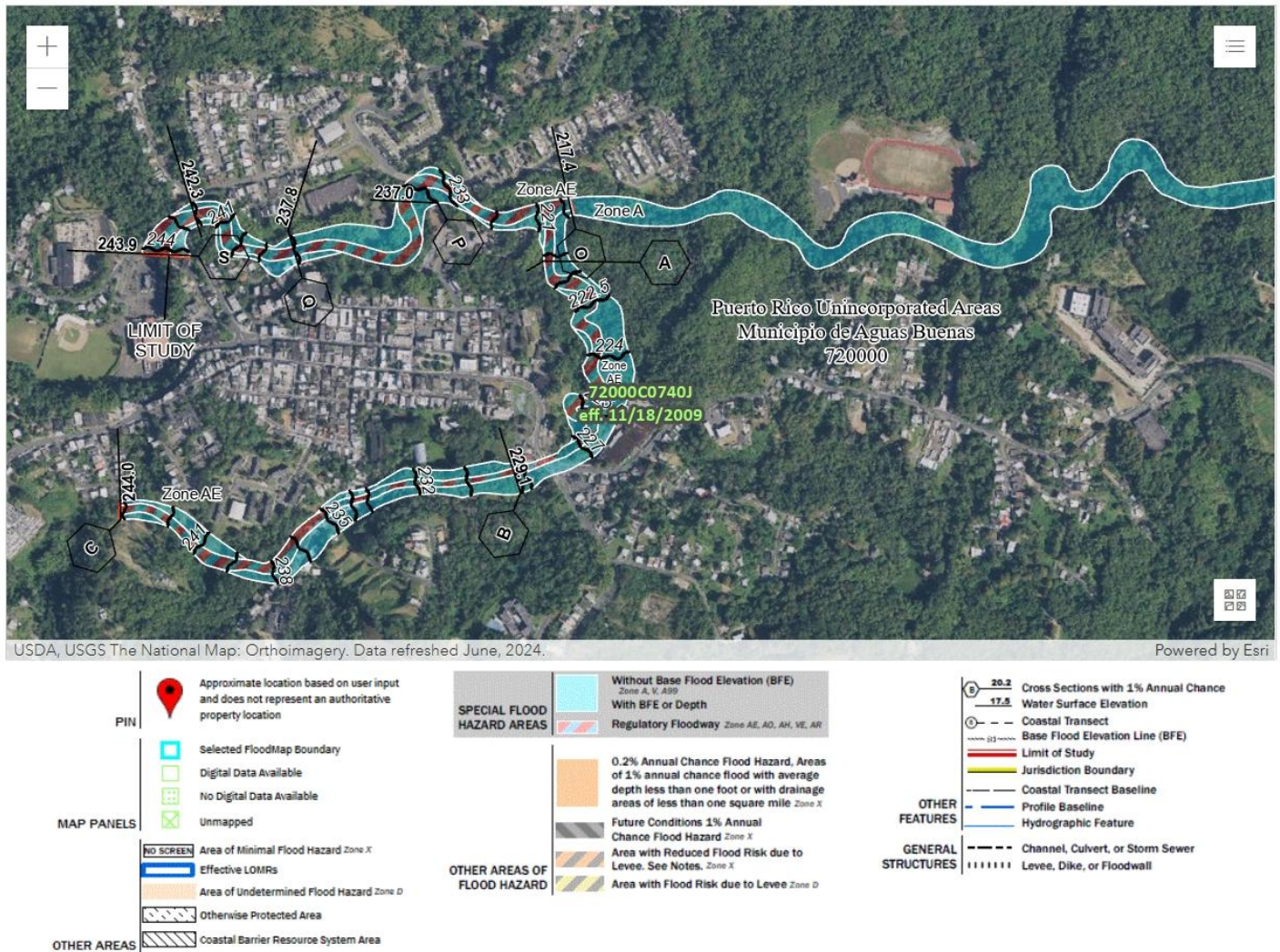


Figure 16: National Flood Hazard Layer FIRMette (Aguas Buenas Casco Urbano)

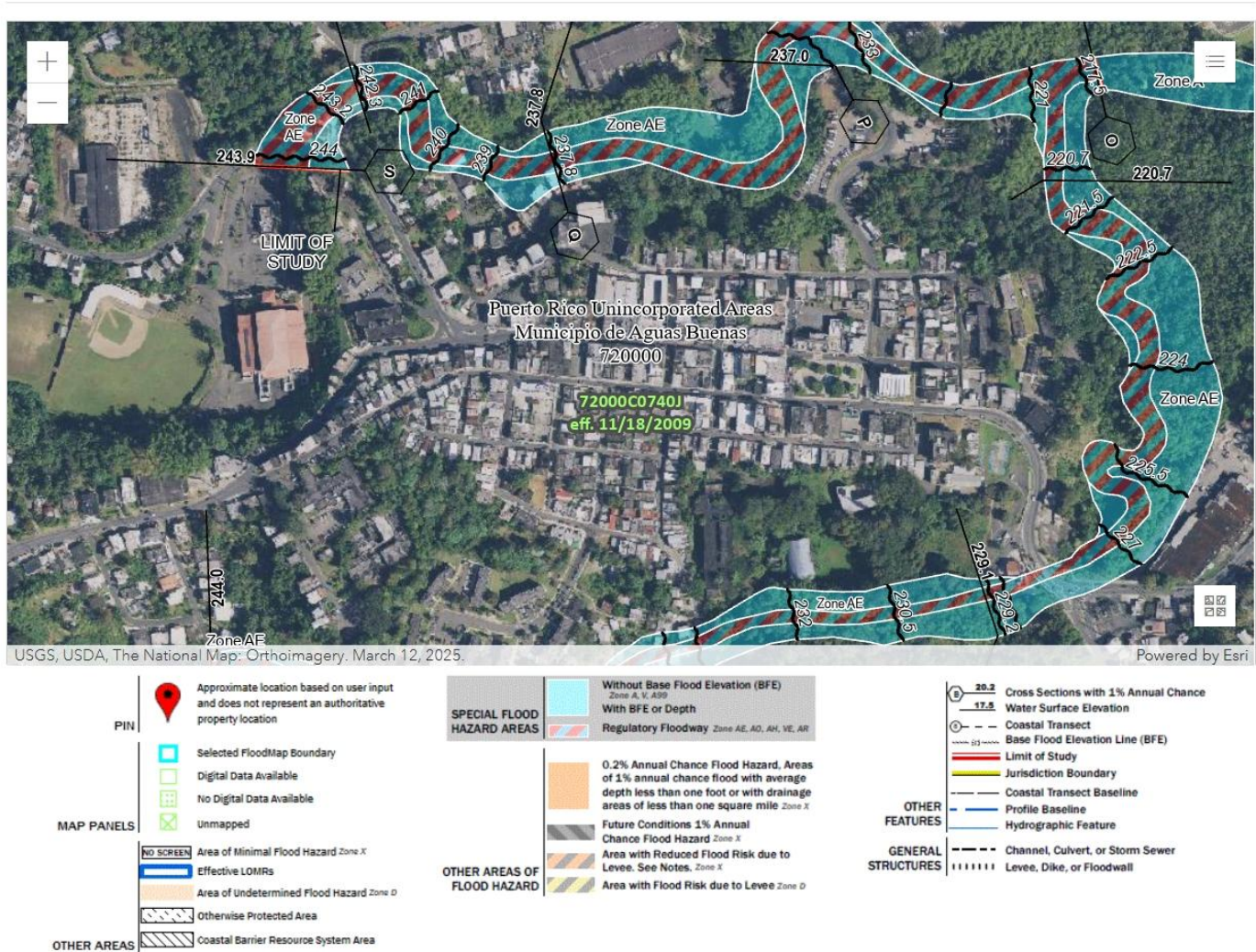
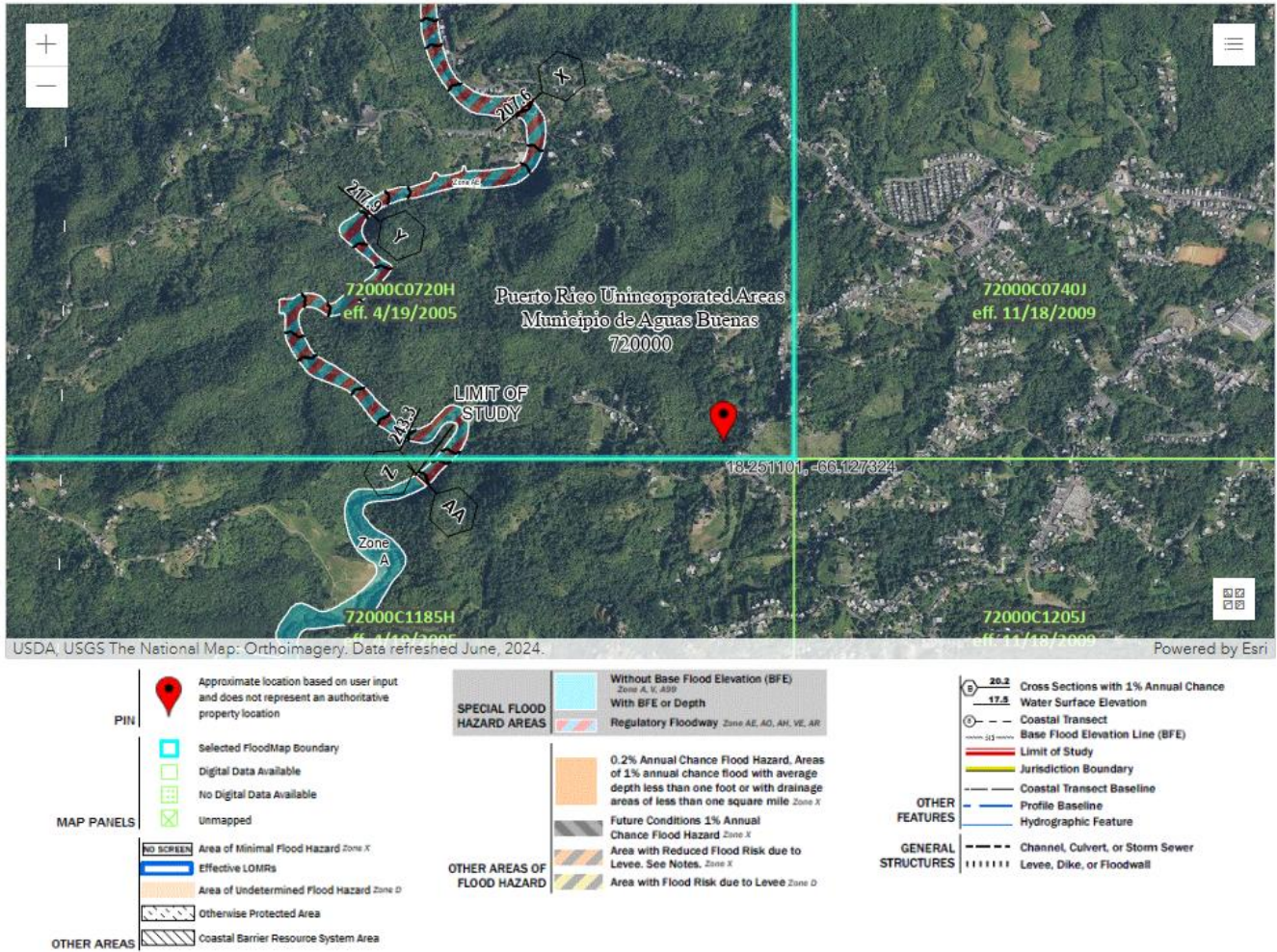


Figure 17: National Flood Hazard Layer FIRMette (Aguas Buenas)



Advisory Base Flood Elevation (ABFE)

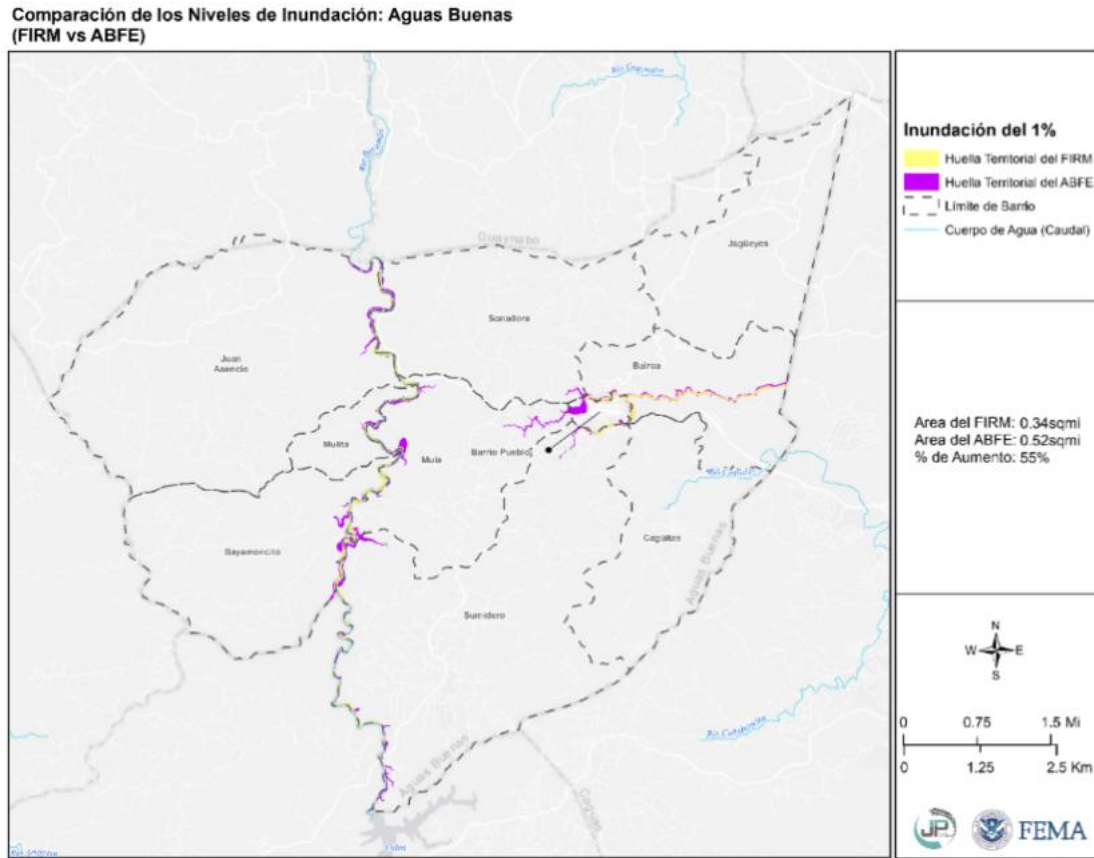
Likewise, FEMA uses another type of map for the purpose of developing regulations and construction permits known as the Advisory Base Flood Elevation Maps (ABFE). ABFEs are developed after the occurrence of a high-impact atmospheric event, and several factors related to the latest engineering analysis 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 Aguas Buenas. 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 18: 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.

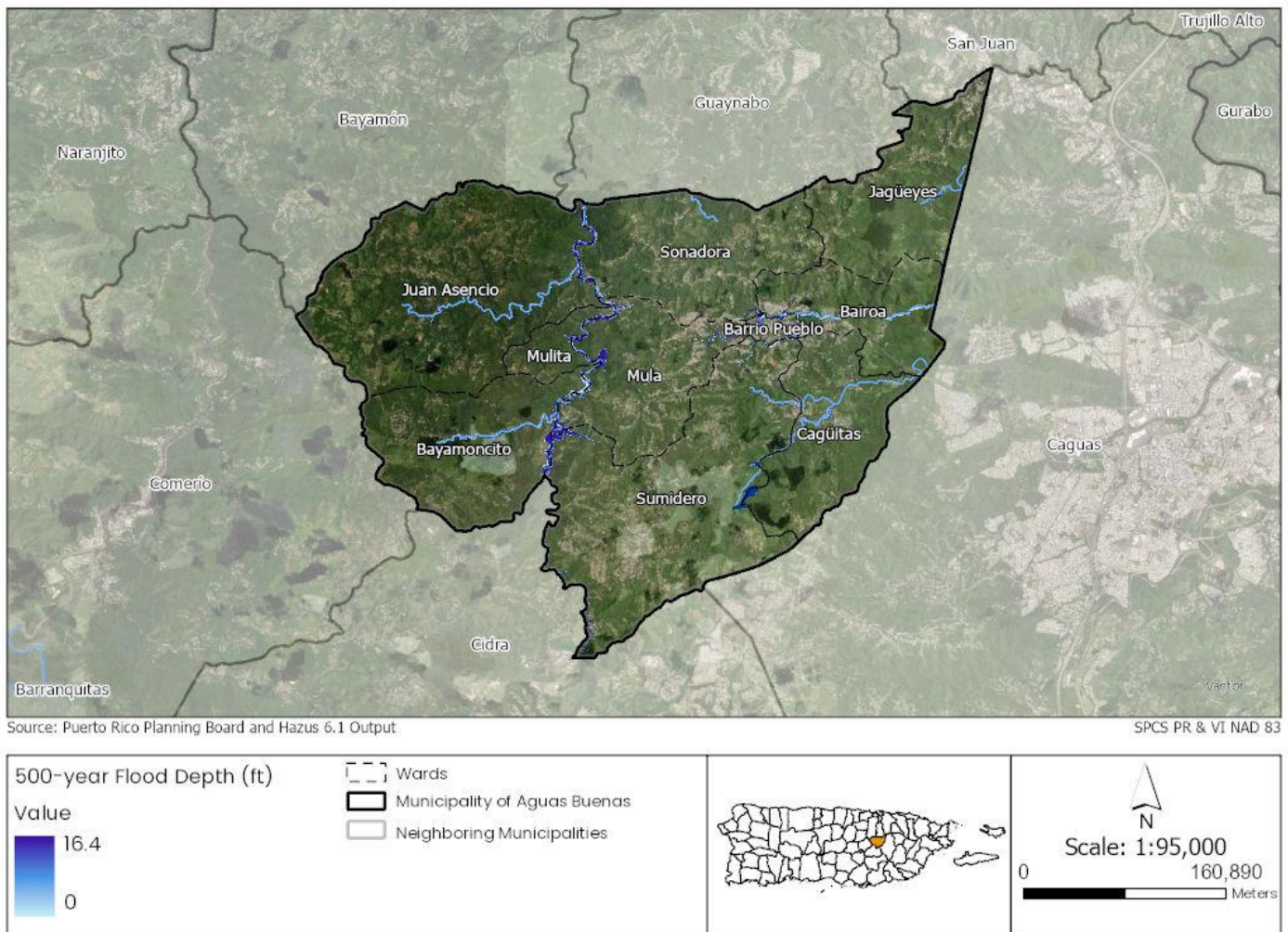
Topographic data used by Hazus for depth calculations and damage estimation was sourced from the USGS 3D Elevation Program (3DEP) seamless 1/3 arc-second Digital Elevation Model (DEM), at an approximate resolution of 10 feet. This dataset provides current coverage of Puerto Rico and its surrounding islands.

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.

HAZUS ANALYSIS FOR 500-YEAR FLOOD EVENT



The map depicts modeled flood depths for a 500-year flood event in Aguas Buenas. Areas with mapped flood depths are concentrated along river and stream corridors throughout the municipality, with the most extensive flood-prone areas occurring in the central, western, and southeastern portions of Aguas Buenas. The highest flood depths, shown in darker blue tones, are located along segments of the major watercourses, while lower flood depths extend outward along connected drainage channels. Flood depth areas are present within multiple wards, including Juan Asencio, Mulita, Mula, Bayamoncito, Barrio Pueblo, and Caguitas.

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).

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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	Aguas Buenas 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	Aguas Buenas 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	Aguas Buenas 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	Aguas Buenas 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	Aguas Buenas 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	Aguas Buenas Included?	Description
				in Culebra.
Tropical Storm María ⁹	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 - Yes	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

⁹ 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	Aguas Buenas 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 - 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

Event	Date	Disaster Declaration Number	Aguas Buenas Included?	Description
			Individual Assistance - No	exceeded 12 inches in some areas, 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 Aguas Buenas has been eligible for either public assistance or individual assistance in five instances.

2.6.1.2 QNAG J AML QB CP_RGML QI_PQR DMPK_RGML

The karst 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).

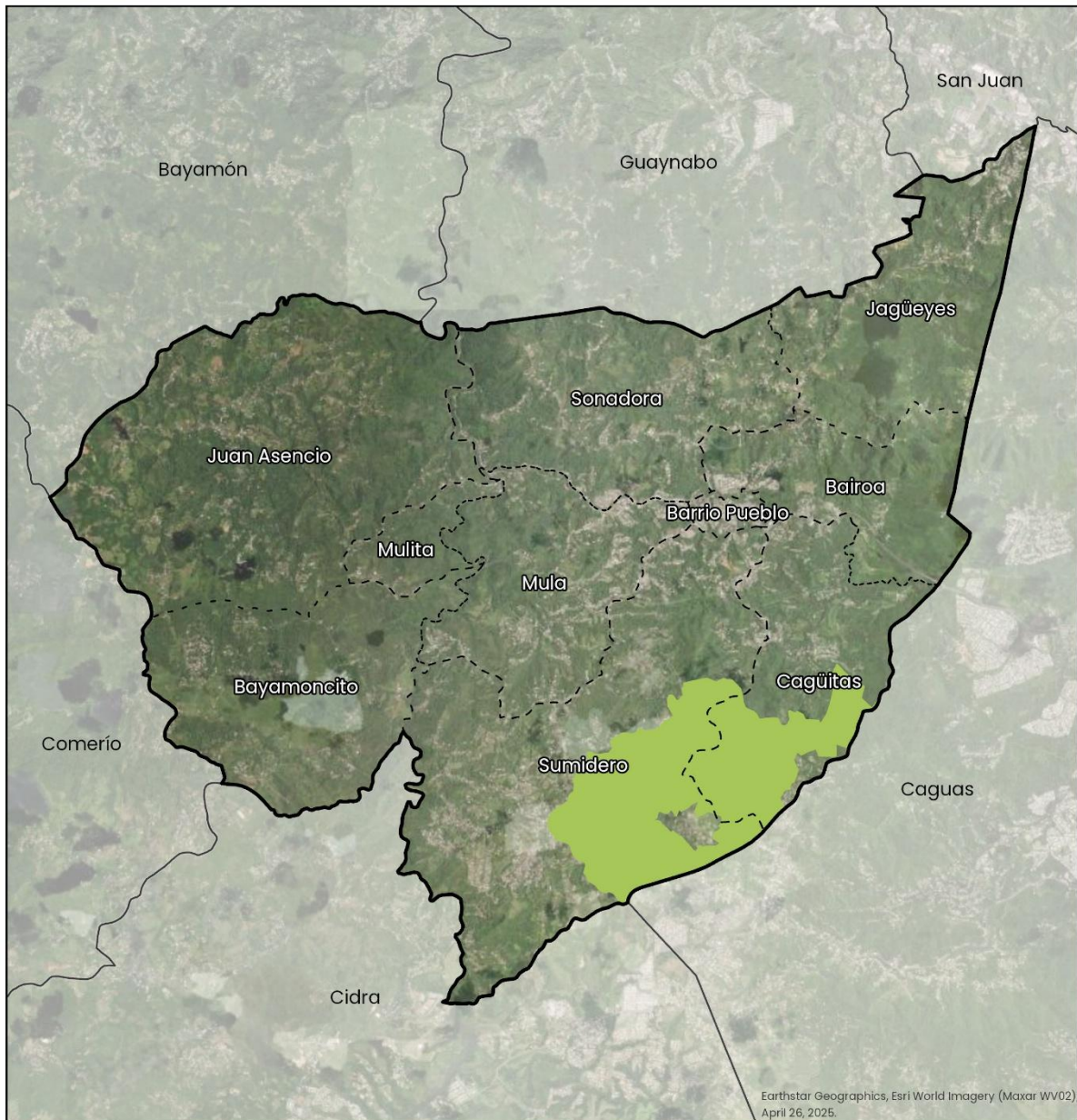
The karst belt is in northern Puerto Rico, of which part is in Aguas Buenas. is a unique limestone landscape shaped by tropical solution processes, featuring mogotes, sinkholes, caves, and underground aquifers. It provides the island's largest freshwater reserves, supports mature forests, wetlands, and 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 Aguas Buenas, restricted Special Planning Area of the Karst is in the southeastern portion of the municipality, encompassing much of Sumidero and extending into

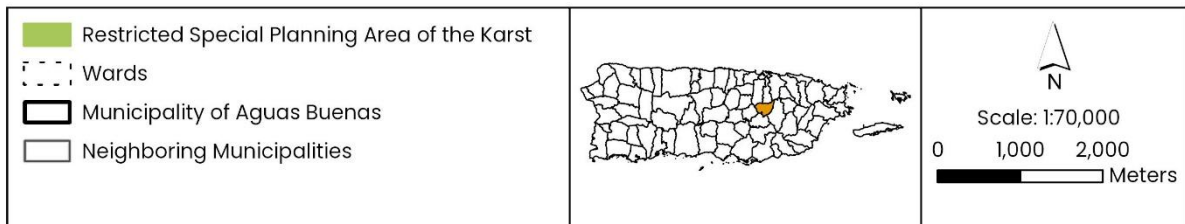
portions of Cagüitas.

KARST REGION



Source: Puerto Rico Planning Board

SPCS PR & VI NAD83



Urban drainage systems that are 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).

2.6.1.4 Disaster Prevention and Preparedness

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 Aguas Buenas 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 Aguas Buenas, the probability of future events is considered high.”

2.6.0 Policy and Planning

2.6.0.1 Comprehensive Risk Management

Map 30 shows the estimated building loss from a 500-year flood in Aguas Buenas, distributed by census tract. The highest projected losses are concentrated in zones of Barrio Pueblo and southeastern and southern portions of the municipality, particularly within Cagüitas and Sumidero wards. Additional areas of elevated projected losses are visible in portions of Bayamoncito and Juan Asencio. Areas near the southern municipal boundary also contain census tracts with relatively high estimated building losses.

Map 31 shows the estimated building loss from a 100-year flood in Aguas Buenas, distributed by census tract. The highest projected losses are concentrated in zones of Barrio Pueblo and the southeastern and southern portions of the municipality, particularly within Cagüitas and Sumidero wards. Additional areas of elevated projected losses are visible in portions of Bayamoncito and Juan Asencio. Areas near the southern municipal boundary also contain census tracts with relatively high estimated building losses.

As a reminder, this map does not measure extent of flooding, but rather the estimated economic losses resulting from flooding. In this northern section there are various rivers that can overtop bridges or affect nearby structures.

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
0.027021	\$18,975,306.23	113	\$1,307,937,319.83	\$1,326,912,626.06

Source FEMA's NRI

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

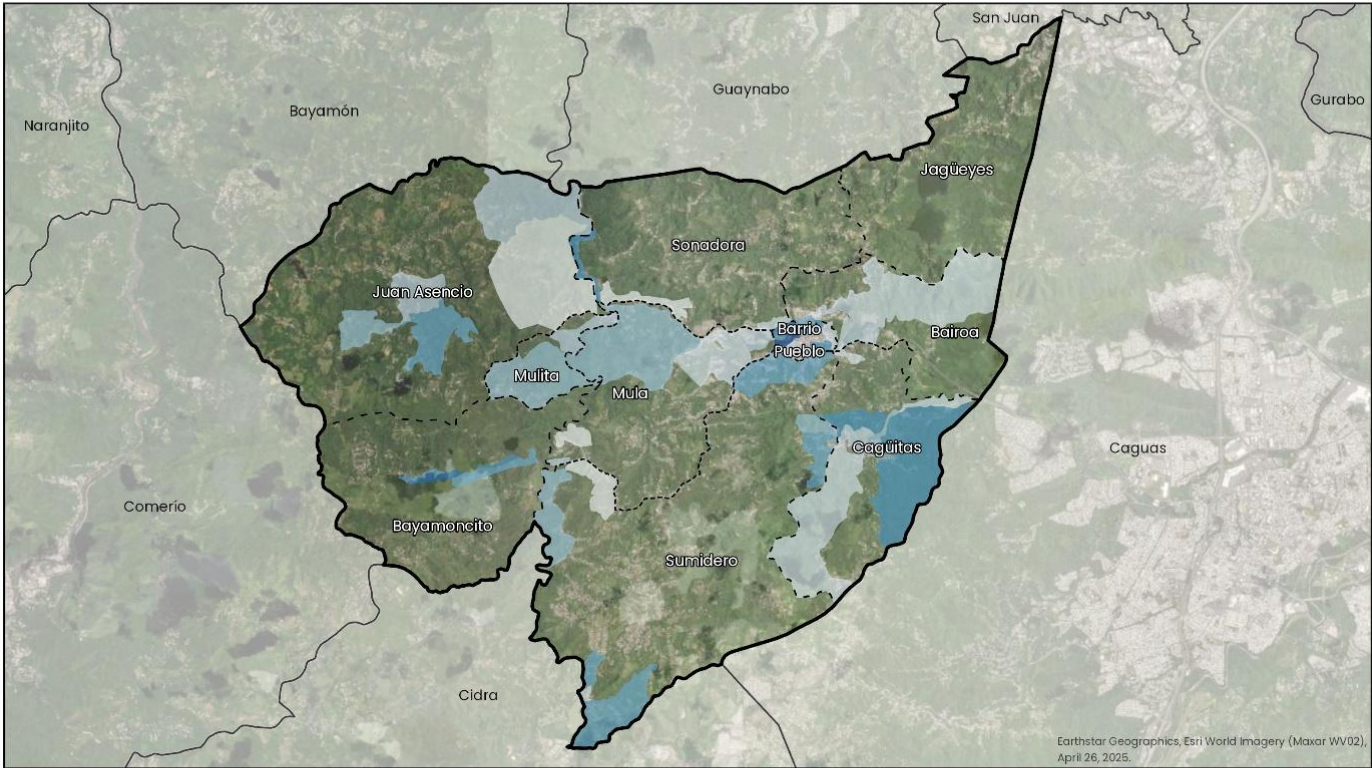
Table 27: Expected Annual Loss to Flood

Expected Annual Loss - Building Value	Expected Annual Loss - Population	Expected Annual Loss - Population Equivalence	Expected Annual Loss - Total
\$269,229.57	0.002	\$22,957.43	\$292,187.01

Source FEMA's NRI

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

BUILDING LOSS TO FLOOD EXPOSURE 500-YEAR FLOOD



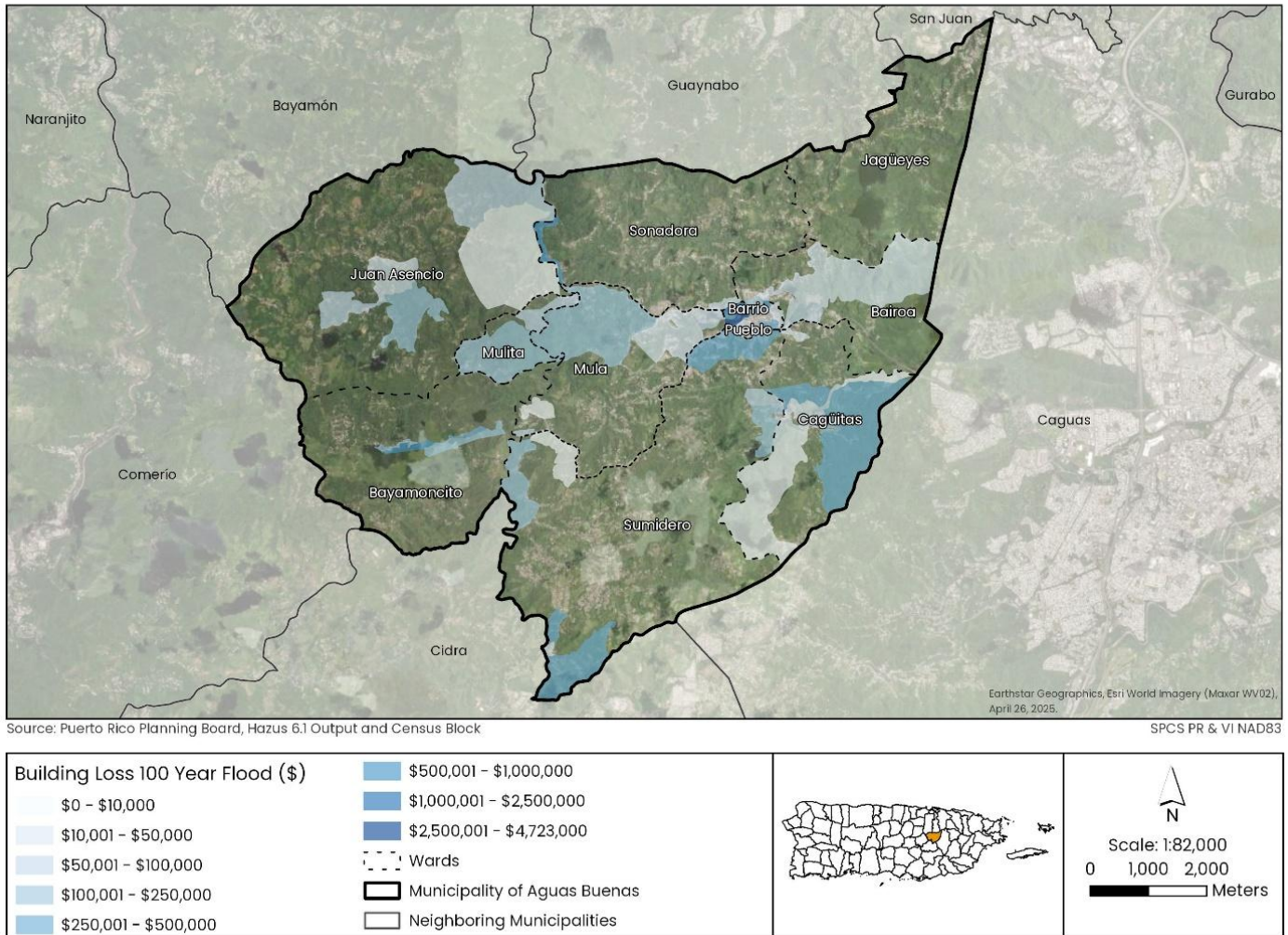
Source: Puerto Rico Planning Board, Hazus 6.1 Output and Census Block

Earthstar Geographics, Esri World Imagery (Maxar WV02), April 26, 2025.

SPCS PR & VI NAD83



BUILDING LOSS TO FLOOD EXPOSURE 100-YEAR FLOOD



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

- A total of 10,247 structures would experience losses (see Table 28).
- An estimated total of \$14,621,000.00 in losses is projected for a 100-year event (1%) and \$17,826,000.00 for a 500-year event (0.2%) (see Table 29).
- Specifically, for nonresidential structures, total losses are estimated at \$3,873,000.00 for 100-year events (1%) and \$4,505,000.00 for 500-year events (0.2%) (see Table 30).
- For residential uses, losses are estimated at \$10,748,000.00 for 100-year events

(1%) and \$13,321,000.00 for 500-year events (0.2%) (see Table 31).

Table 28: Total Structures at Risk

Structures	
Non-Residential	18
Residential	10,229
Total	10,247

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	\$3,873,000.00	\$4,505,000.00
Residential	\$10,748,000.00	\$13,321,000.00
Total	\$14,621,000.00	\$17,826,000.00

Table 30: Detailed Loss for Non-Residential Buildings

Occupancy	Losses in Dollars, 1% Event	Losses in Dollars, 0.2% Event
Commercial	\$412,000.00	\$412,000.00
Education	\$544,000.00	\$1,090,000.00
Government	\$2,917,000.00	\$3,003,000.00
Religious	\$0	\$0
Agriculture	\$0	\$0
Industrial	\$0	\$0
Total	\$3,873,000.00	\$4,505,000.00

Table 31: Detailed Loss for Residential Buildings

Residential, Detailed Losses	Losses in Dollars, 1% Event	Losses in Dollars, 0.2% Event
Structure	\$4,664,000.00	\$6,019,000.00
Contents	\$2,597,000.00	\$3,304,000.00
Relocation	\$1,972,000.00	\$2,333,000.00
Rental Income	\$1,515,000.00	\$1,665,000.00
Total	\$10,748,000.00	\$13,321,000.00

2,6,0,0 J A C Q L B A P C A J A D P Q R P S A R S P C

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.

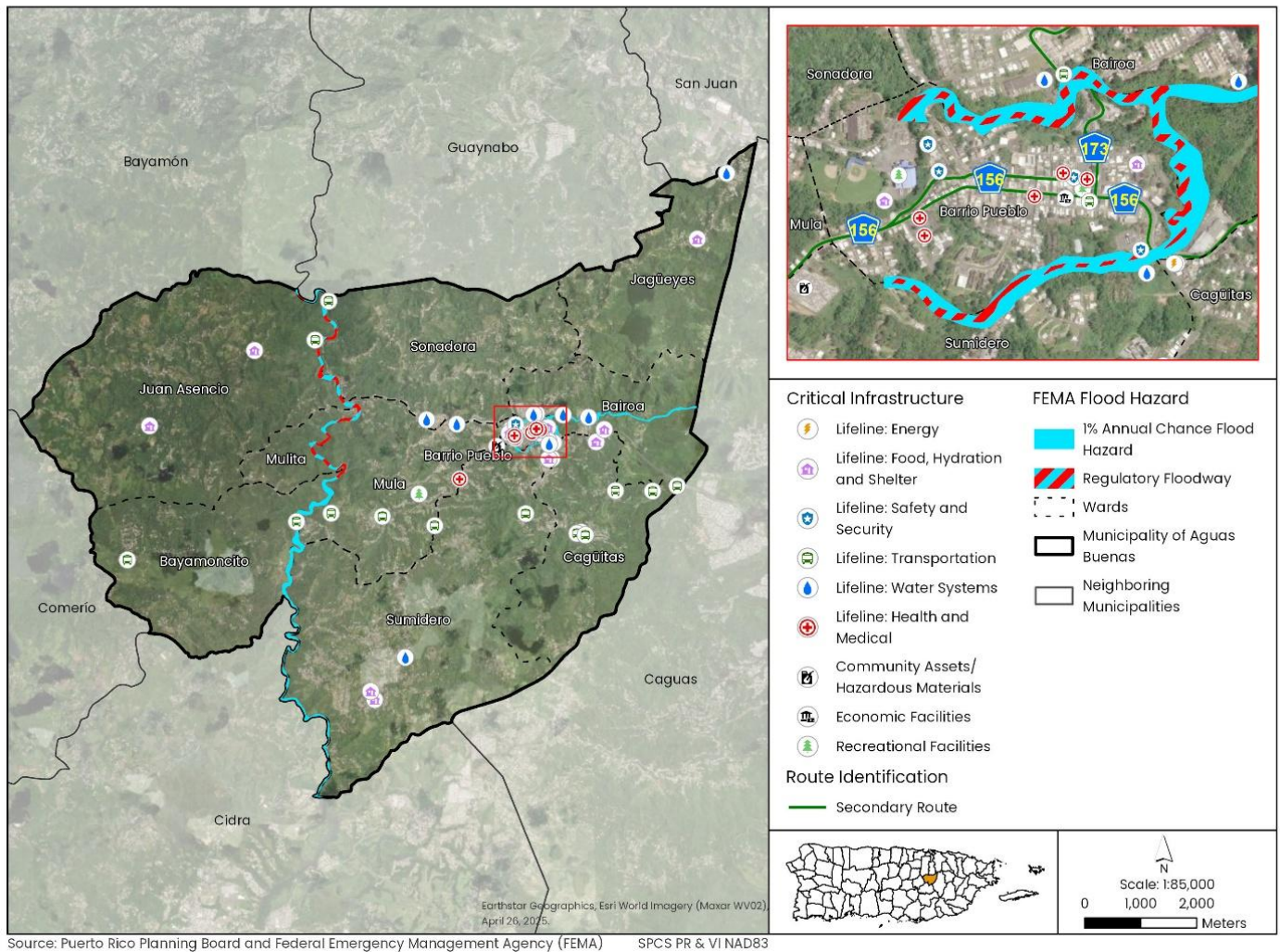
- Water Systems – Floodwaters often contaminate drinking water supplies and damage water treatment facilities. Excessive inflow from floodwaters overwhelms sewer systems, causing untreated sewage to backflow into streets and homes. Flooding exceeds the design capacity of storm drains and retention basins,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

Map 32 shows that critical infrastructure exposed to flood hazards is concentrated primarily in and around Barrio Pueblo, where the mapped 1% annual chance flood hazard area intersects a cluster of facilities. Facilities associated with health and medical services, safety and security, water systems, transportation, economic activities, food, hydration, and shelter services are located within or immediately adjacent to the flood hazard corridor.

Additional water systems and transportation facilities are located near flood-prone stream corridors extending through Sonadora, Mulita, Mula, Sumidero, and Bairoa. The mapped regulatory floodway is located along a portion of the northern stream corridor, while the broader flood hazard area follows stream channels through the central and northeastern parts of the municipality.

Overall, the map indicates that the greatest concentration of critical infrastructure exposed to mapped flood hazard areas is in Barrio Pueblo, with additional exposed facilities situated along the stream corridors traversing Sonadora, Mulita, Mula, Sumidero, and Bairoa.

FLOOD: CRITICAL INFRASTRUCTURE EXPOSURE



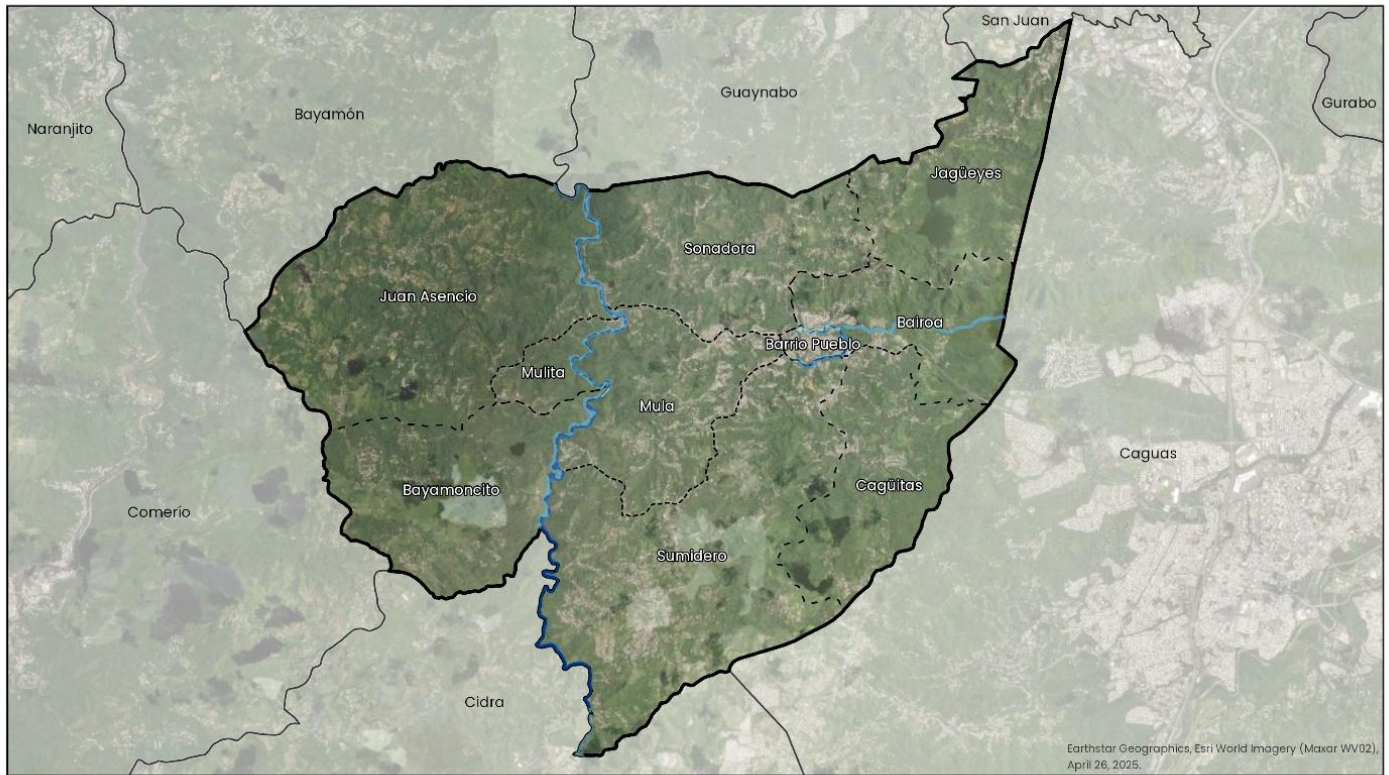
2.6.0.1 *QAGJ TsJL CP_`GRCCQ*

Map 33 depicts the population at risk of displacement under both 100-year and 500-year flood scenarios, organized by census tract. The census tracts where there is higher population exposed to flooding are around the municipality's central river corridor, which extends from the southern boundary northward through the central wards. The highest exposure category (58-100 people at risk) is in a limited area near the central-northern portion of the municipality. Moderate exposure levels (26-57 and 8-25 people at risk) occur in several census tracts adjacent to the river corridor, while

most of the municipality is characterized by low exposure categories (0–7 people at risk). Areas of population exposure are distributed across multiple wards, with the greatest concentration occurring near the main watercourses traversing the municipality.

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).

FLOOD: POPULATION EXPOSURE



Source: Puerto Rico Planning Board, Census Tract and Federal Emergency Management Agency (FEMA)

SPCS PR & VI NAD83



2,6,0,2 L_RS P_J _L B AS JRS P_J PCQMS PACQ

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.

2.6.0.3 *QNCAGJ AML QB CP_RML 8 PCNCRGTC JMQQQQ _LB QCTPC PCNCRGTC JMQQQQ*

In Aguas Buenas 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 May 2026, the information regarding NFIP coverage for the Municipality of Aguas Buenas is as follows:

Table 32: NFIP Policies in Force and Coverage

Policies in Force	Total Coverage
4	\$0

Source: Puerto Rico Planning Board

According to available NFIP data, the municipality does not contain any properties with a history of Repetitive Loss (RL) or Severe Repetitive Loss (SRL) within identified flood hazard areas.

Table 33: NFIP Repetitive Losses and Severe Repetitive Losses

Number of NFIP Policies	Structures with Repetitive Losses (RL)	Insured structures (RL)	Repetitive Losses (RL)	Structures with Severe Repetitive Losses (SRL)	Insured structures (SRL)	Severe Repetitive Losses (SRL)	Total disbursed for combined RL & SRL
0	0	0	0	0	0	0	0

Source: Puerto Rico Planning Board

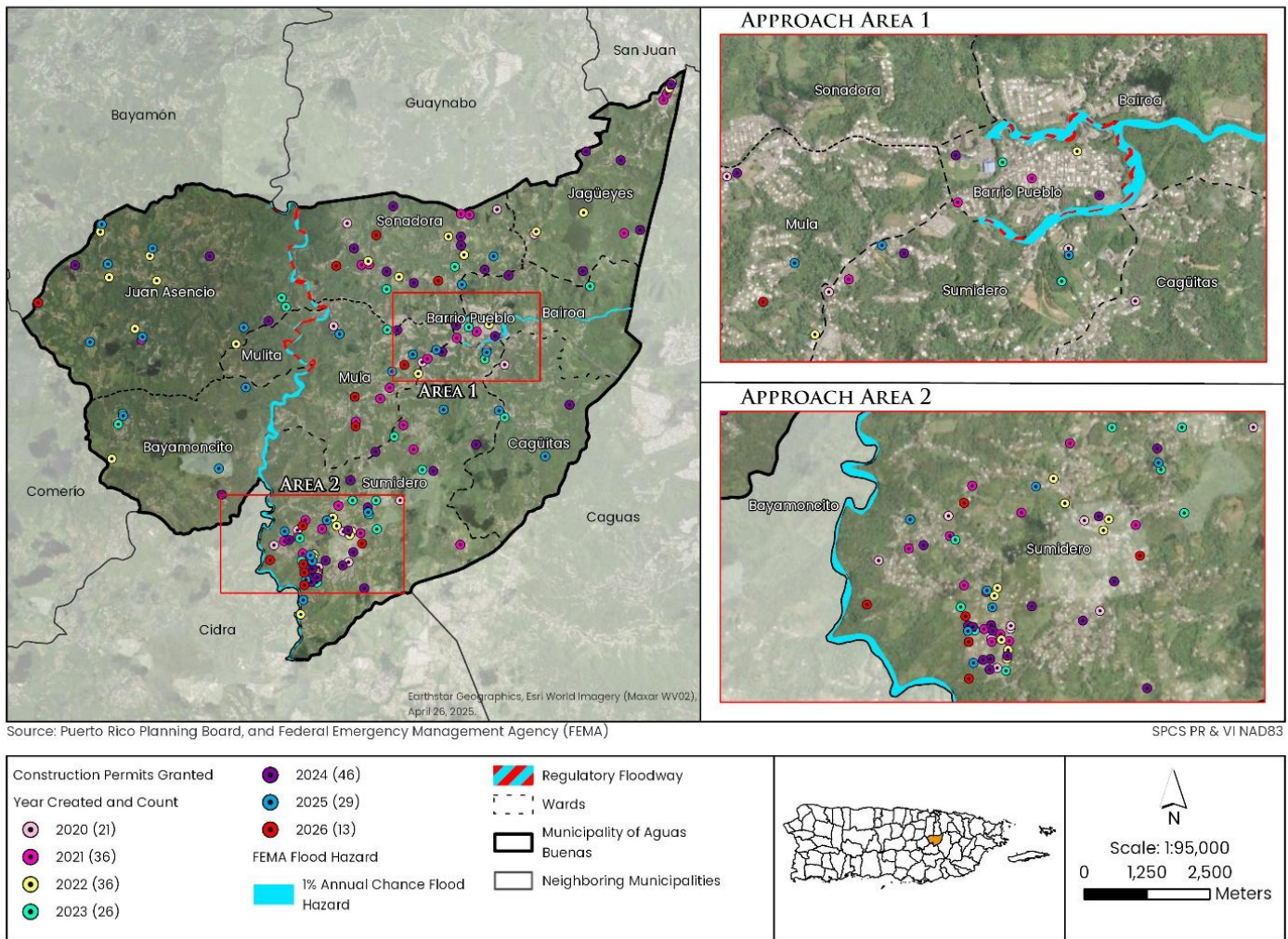
2,6,0,4 DS RS PCAML B RCML Q&C/+ '

The following map shows the locations of recent construction permits in Aguas Buenas in relation to known flood area. The map shows that recent development permits are distributed throughout Aguas Buenas, with the largest concentration located in the southern portion of Sumidero near the municipal boundary with Cidra. Additional clusters of recent development are present in Barrio Pueblo, Bairoa, Sonadora, Mula, and Cagüitas, while smaller numbers of permits are scattered across Juan Asencio, Bayamoncito, Mulita, and Jagueyes.

Several recent development permits are located within or immediately adjacent to the mapped 1% annual chance flood hazard areas, particularly in the Barrio Pueblo-Bairoa corridor shown in Approach Area 1. Additional development is located near the flood hazard corridor extending through Mulita, Mula, Bayamoncito, and Sumidero, as shown in Approach Area 2. Overall, the map indicates that recent development activity is concentrated in the central and southern portions of the municipality, with some permits occurring near mapped flood hazard areas and regulatory floodways.

Map 34: Flood: Recent Development Exposure

FLOOD: RECENT DEVELOPMENT EXPOSURE



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C T C L R Q

2,7,/ B C Q A P C N R G M L & @ / + _ '

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). However, since

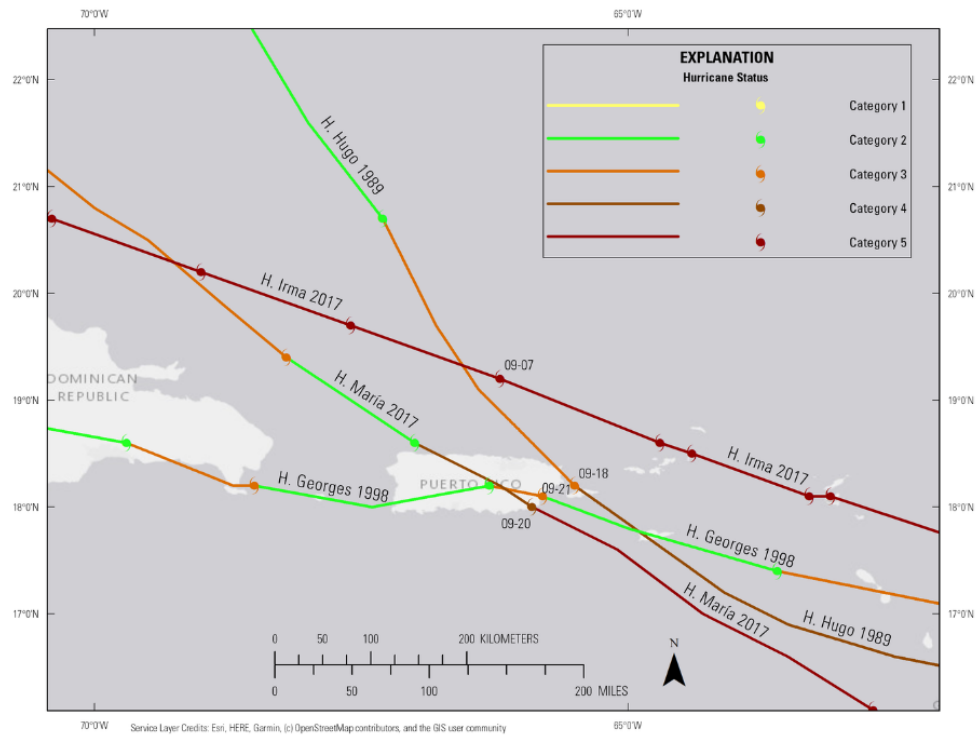
there was a confirmed tornado in Aguas Buenas in 2019, we will provide more information regarding this hazard in the past events section.

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 19 shows the path of hurricanes category 2 – 5 that have affected Puerto Rico since 1993.¹⁰

¹⁰ Hortense (1996) and Fiona (2022) are not shown since they were category 1 hurricanes when they hit Puerto Rico.

Figure 19: Hurricane Tracks 1989–2017 (Categories 2–5 Only) ¹¹



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Figure 1. Hurricane tracks for Hugo (1989), 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.

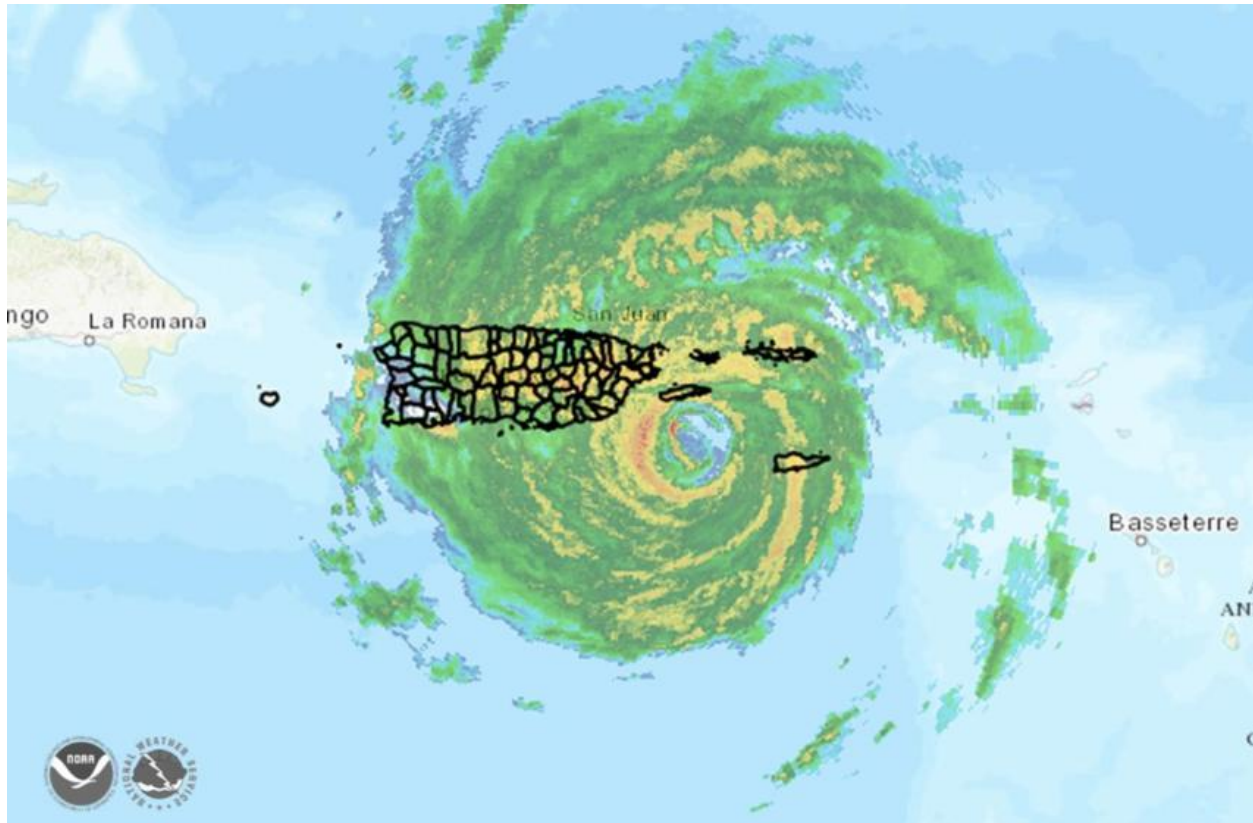
Figura 1: Trayectorias de los huracanes Hugo (1989), Georges (1998), Irma (2017) y María (2017). Datos provistos por la NOAA. La imagen de base es propiedad intelectual de Esri y se usa aquí bajo licencia. Los derechos de autor y reproducción son propiedad de Esri y sus licenciarios.

¹¹<http://www.usgs.gov/mission-areas/natural-hazards/science/Puerto-rico-natural-hazards-hurricanes-peligros-naturales-de>

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Tropical Cyclones are atmospheric systems that can affect the whole island. For example, Figure 20 shows the size of hurricane María (2017) as it approached Puerto Rico.

Figure 20: Hurricane María (2017) as it approaches Puerto Rico¹



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

Table 34: 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 ¹² (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)

¹² 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.

2.7.1.1 *Natural Risk Assessment*

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 Aguas Buenas was designated for Public Assistance (PA), Individual Assistance (IA), or both under each declaration. Table 35 shows a list of presidential disaster declarations since 1987.

Table 35: Tropical Cyclone Disaster Declarations

Event	Date	Disaster Declaration Number	Aguas Buenas 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	Aguas Buenas 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	Aguas Buenas 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 ¹³	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

¹³ 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	Aguas Buenas 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-1152-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	Aguas Buenas 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.

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

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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%.

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Table 36 presents the exposure to tropical cyclones, as registered in FEMA National Risk Index.

Table 36: Tropical Cyclone Exposure

Exposure Impacted Area (sq mi)	Exposure - Building Value	Exposure - Population	Exposure - Population Equivalence	Exposure - Total
30.399675	\$2,867,086,255.94	24,189	\$280,591,561,714.31	\$283,458,647,970.25

Source FEMA's NRI

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

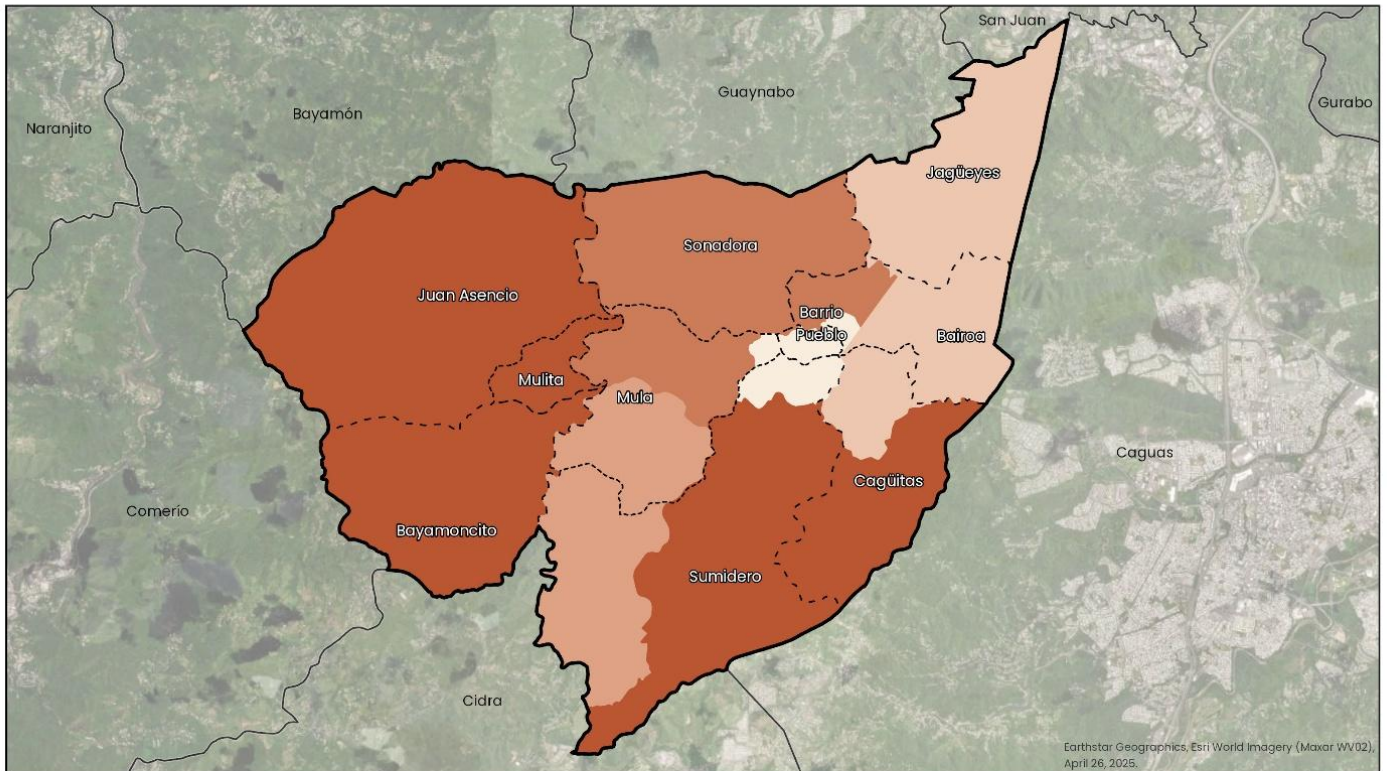
Table 37: Expected Annual Loss to Tropical Cyclones

Expected Loss - Building Value	Annual Loss - Population	Expected Loss - Population Equivalence	Annual Loss -Total
\$11,843,903.16	0.0402	\$466,355.26	\$12,310,258.43

Source FEMA's NRI

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

TROPICAL CYCLONE: TOTAL DAMAGED BUILDINGS 100-YEAR EVENT



Source: Puerto Rico Planning Board and Hazus 6.1 Output

SPCS PR & VI NAD83

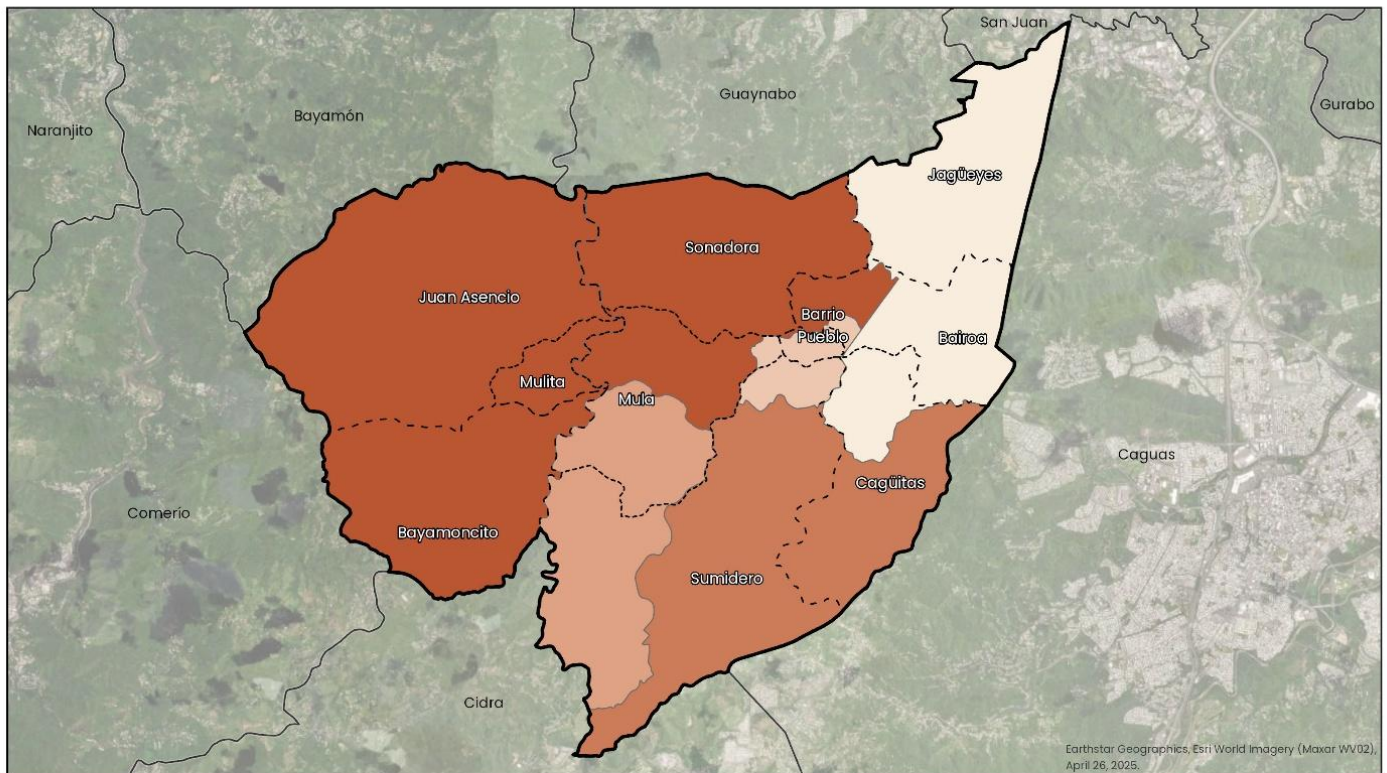


Map 35 shows the total damage to buildings resulting from a 100-year wind event. The map indicates that the highest concentration of building damage is projected to occur in the western, northern, and southeastern portions of the municipality, particularly within the wards of Juan Asencio, Bayamoncito, Mulita, Sumidero and Cagüitas, where the estimated number of damaged structures ranges from 367 to 479 buildings. Moderate levels of damage, ranging from 297 to 366 damaged buildings, are projected for Sonadora, and portions of Mula and Bairoa. Lower levels of damage, ranging from 251 to 296 buildings, are expected in Jagüeyes and portions of Bairoa and Barrio Pueblo, while the lowest projected building damage, approximately 250 structures, occurs within the central portion of Barrio Pueblo. Overall, the map suggests

that a significant tropical cyclone could result in widespread structural damage throughout Aguas Buenas, with the western and southeastern wards experiencing the greatest number of damaged buildings under the 100-year wind event scenario.

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

TROPICAL CYCLONE: TOTAL DAMAGED BUILDINGS 500-YEAR EVENT



Source: Puerto Rico Planning Board and Hazus 6.1 Output

SPCS PR & VI NAD83



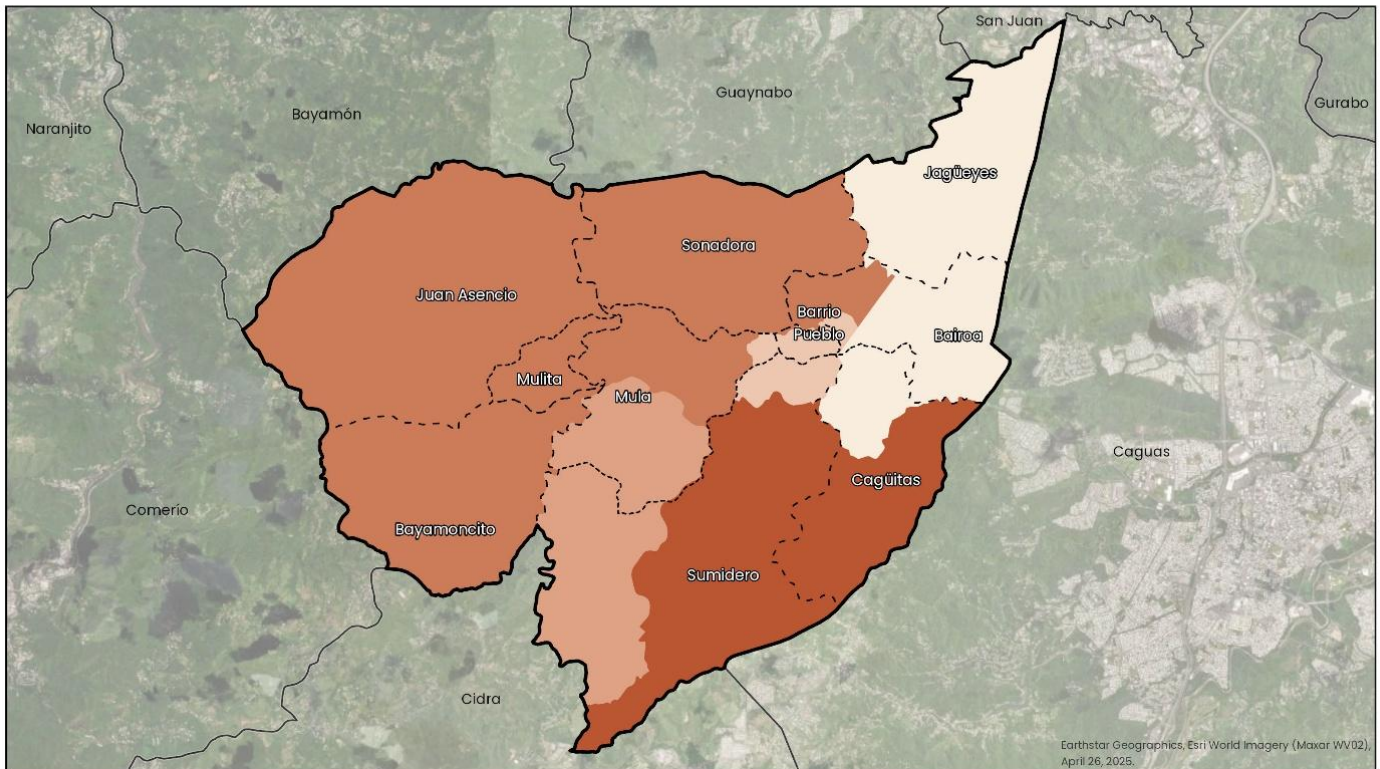
The 500-year event shows results like the 100-year event map. Map 36 shows that the greatest concentration of damaged buildings is projected to occur in the western and northern portions of the municipality, particularly within the wards of Juan Asencio, Bayamoncito, Sonadora, Mulita, and portions of Mula where the estimated number of damaged structures ranges from 358 to 468 buildings. Moderate levels of building damage, ranging from 294 to 355 structures, are projected for Cagüitas and Sumidero, while lower levels of damage are expected in Mula and portions of Barrio

Pueblo, where estimated losses range from 286 to 293 buildings. The lowest number of damaged buildings is projected in Jagüeyes and Bairoa, where approximately 285 structures are expected to be affected. Overall, the map indicates that a severe tropical cyclone could produce widespread building damage throughout Aguas Buenas, although the western and northern wards appear to be the most vulnerable under the 500-year wind event scenario.

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

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

TROPICAL CYCLONE: TOTAL ECONOMIC LOSS 100 YEAR-EVENT (\$K)



Source: Puerto Rico Planning Board and Hazus 6.1 Output

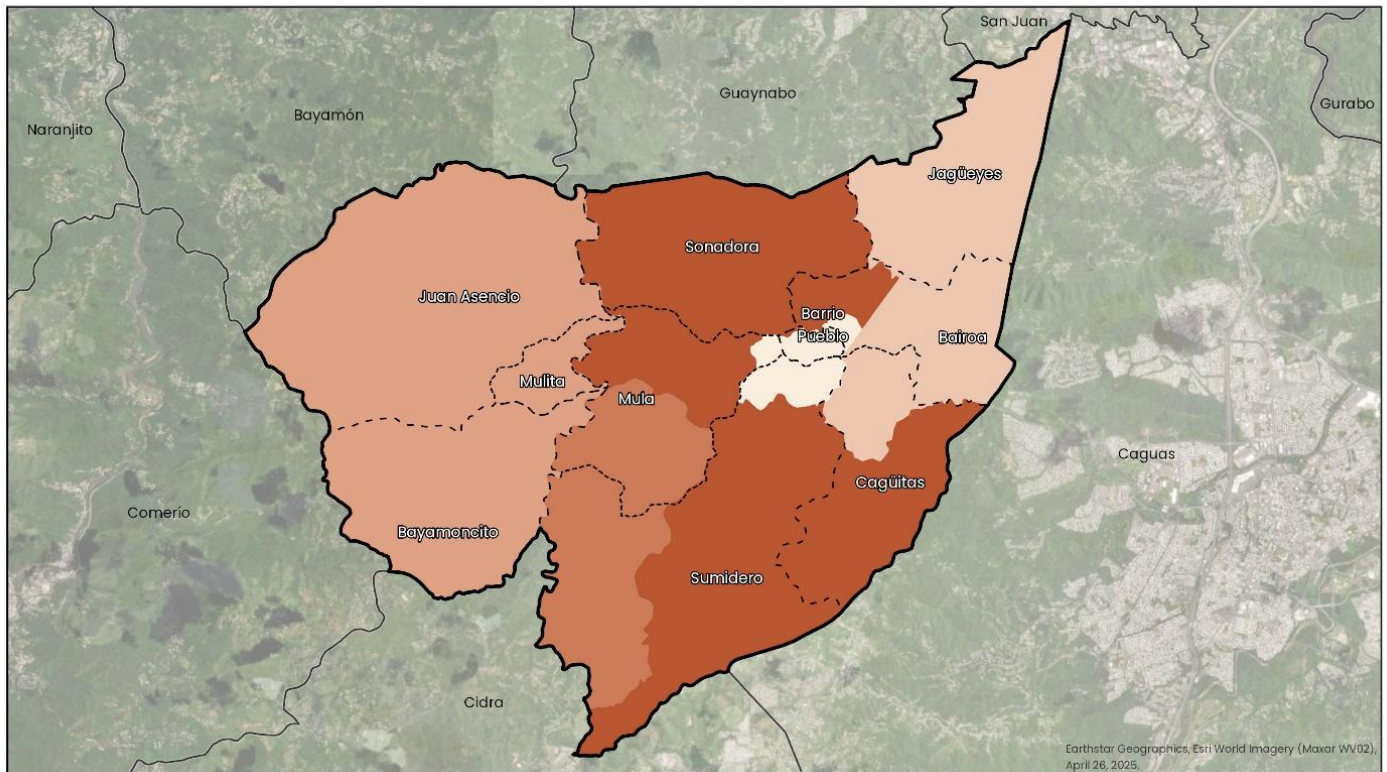
SPCS PR & VI NAD83



Map 37 shows the estimated total economic loss associated with a 100-year tropical cyclone event in Aguas Buenas. The highest projected losses are concentrated in the wards of Cagüitas and Sumidero, where estimated losses range from approximately \$138,710.82 to \$179,481.84. The next highest loss category, ranging from \$103,927.09 to \$138,710.81, includes Juan Asencio, Bayamoncito, Mulita, Sonadora, and portions of Barrio Pueblo and Mula. Lower projected losses are observed in portions of Mula and Sumidero, while the lowest loss values are concentrated in Jagüeyes, Bairoa, and portions of the urban center. Overall, the map indicates that projected economic losses from a 100-year tropical cyclone event vary throughout the municipality, with the greatest losses concentrated in the southeastern portion of Aguas Buenas.

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

TROPICAL CYCLONE: TOTAL ECONOMIC LOSS 500 YEAR-EVENT (\$K)



Map 38 shows the estimated total economic loss associated with a 500-year tropical cyclone event in Aguas Buenas. The highest projected losses, ranging from approximately \$264,138.40 to \$301,545.73, are concentrated in the wards of Sonadora, Cagüitas, and Sumidero. Losses ranging from \$187,987.85 to \$264,138.39 are projected for Mula and portions of Barrio Pueblo. Lower loss values, ranging from \$175,003.05 to \$187,987.84, are observed in Juan Asencio, Bayamoncito, and Mulita. The lowest projected losses, ranging from \$147,451.26 to \$175,003.04, occur in Jagüeyes, Bairoa, and portions of Barrio Pueblo. Overall, the map indicates that projected economic losses from a 500-year tropical cyclone event vary across the municipality, with the highest losses concentrated in the central, southeastern, and northern wards of Aguas Buenas.

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.

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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 Aguas Buenas is vulnerable to this hazard. For further details on the Municipality's social vulnerability see section 3.4.4.

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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.

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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.

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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 °F. 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.

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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 °F higher than temperatures in outlying areas; nighttime temperatures are about 2–5 °F 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).

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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.

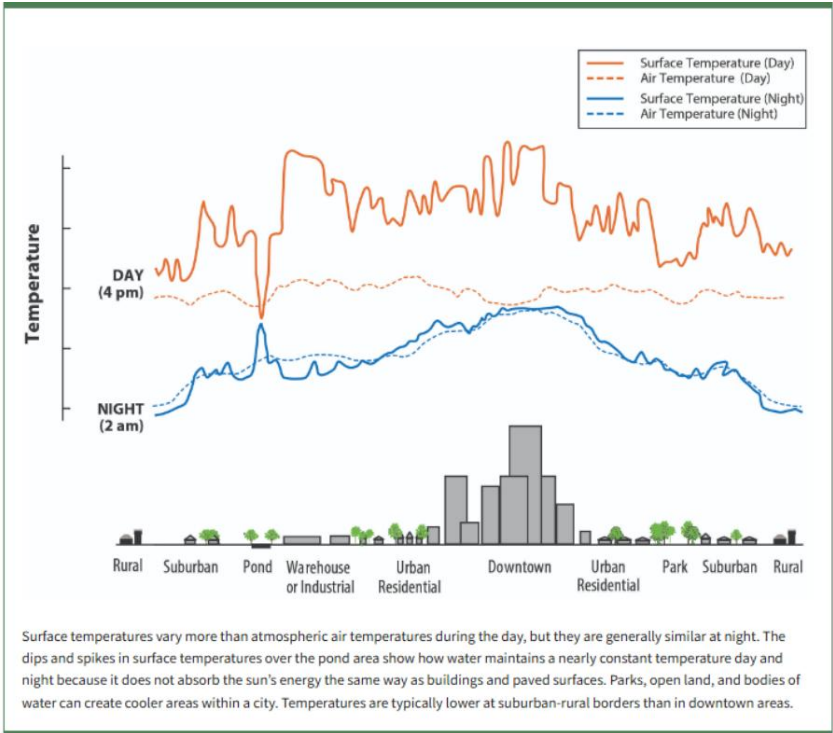
It must be emphasized that Urban Heat islands (UHI) phenomena can occur regardless of whether there is an extreme heat warning event. UHI is a relative temperature difference between urban and surrounding rural areas caused by factors like heat-absorbing surfaces, lack of vegetation, and human activities. 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 21: Heat Island Effect Diagram (EPA, 2025)



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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).

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Official NOAA assessments in the 2018 Puerto Rico and U.S. Virgin Islands State Climate Summary report an increase in both average temperature ($\approx 1.5^{\circ}\text{F}$ 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.).

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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.

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).

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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).

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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).

2.4.3 DISPERSED DEVELOPMENT

The approved construction permits map (Section 3.6) shows that the greatest concentration of recent development activity is in the southern portion of Aguas Buenas, primarily within Sumidero Ward near the municipal boundary with Cidra.

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 38: 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.

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Aguas Buenas 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 Aguas Buenas depends 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.

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 39: 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

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;

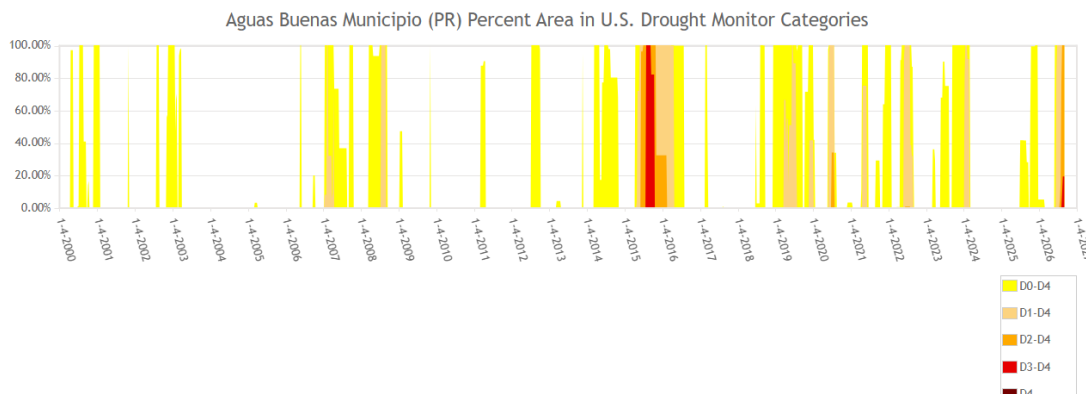
- Puerto Rico Extreme Drought Conditions (DR-170-PR) – Date of Declaration May 26, 1964.
- Puerto Rico Impact of Drought (EM-3002-PR) – Date of Declaration August 29, 1974.

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 22 shows the percentage of Aguas Buenas classified within the U.S. Drought Monitor categories (D0-D4) from 2000 to 2026. Most drought occurrences are represented by D0-D4 (abnormally dry or worse) and periodically reach 100% of the municipal area, indicating that the entire municipality was affected during several events.

The most prominent drought occurred during 2015–2016, when the municipality reached 100% coverage in the more severe categories, including D3-D4 and D4. Additional periods with widespread drought coverage are visible during 2007–2008, 2014–2015, 2018–2020, 2021–2024, and 2026, with several instances where a large percentage of the municipality was affected. Overall, the graph indicates recurring drought conditions of varying severity throughout the period of record, with the largest and most severe event occurring in 2015–2016.

Figure 22: Aguas Buenas Municipio (PR) Percent Area in U.S. Drought Monitor Categories



Source US Drought Monitor

2.3.2 Drought Risk Management

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 23 shows, moderate droughts periods have become more prevalent since 2018.

2.3.0 Potential Impacts

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.

2.3.0.1 Drought Risk Reduction

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 Aguas Buenas is 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 2015–2016 drought had a net cost of \$14,000,000.00 impact on the agricultural sector.

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.

The Municipality of Aguas Buenas is situated within several key watersheds, including those of the Bayamón, Guaynabo, and Bairoa rivers, and lies within three of Puerto Rico's most significant hydrologic basins: Río La Plata, the longest river; Río Grande de Loíza, the most voluminous and third longest; and Río Bayamón (also known as Río Hondo). These river systems feed the Carraízo and La Plata reservoirs which, together with Lake Cidra, supply water to approximately one-third of the island's population. As a result, Aguas Buenas plays a critical role in Puerto Rico's water resource management, and drought conditions in the municipality can have far-reaching impacts on the island-wide scale.

As mentioned in Section 3.4.2 the estimated vulnerable population of Aguas Buenas is 38.87%. If the pattern that began in 2019 continues, the vulnerable population 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 Aguas Buenas as exposed to this hazard.

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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.

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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 Aguas Buenas 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.

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.

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).

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).

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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 Administration, 2025).

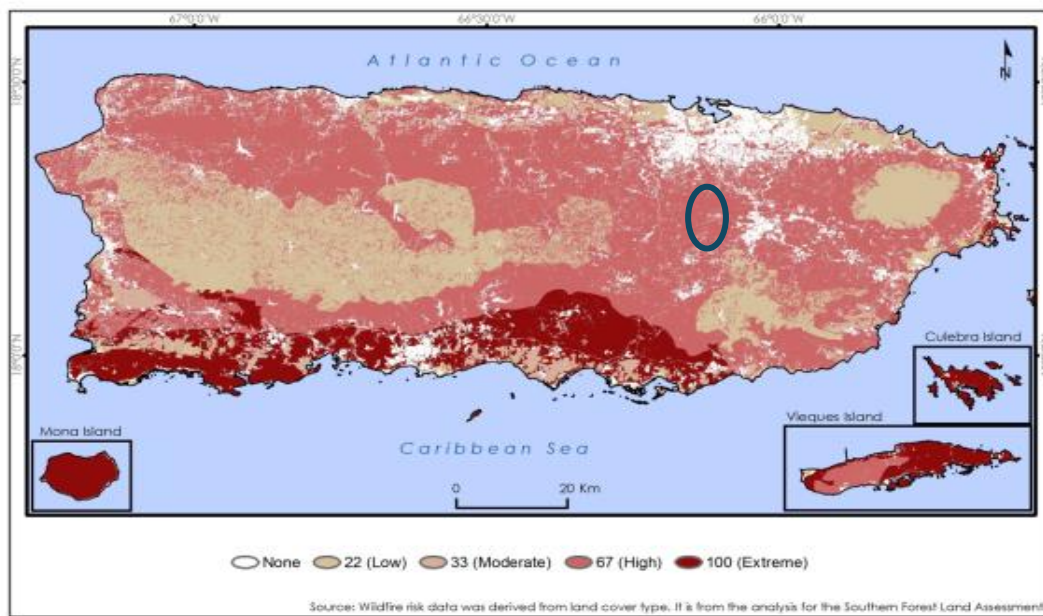
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Figure 23 (DNER, 2021) provides an overview of areas in Puerto Rico, Vieques, and Culebra under varying levels of wildfire incidence, as defined by Southern Federal Land Assessment (SFLA). This information provides the state of knowledge of what is 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.

Within the municipality of Aguas Buenas –generally corresponding to the location highlighted by the blue oval—the landscape is predominantly characterized by high wildfire incidence.

Wildfires tend to be associated with temperate 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

Figure 23: Overview of areas of Puerto Rico, Vieques, and Culebra under different levels of wildfire incidence according to SFLA



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.

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 40: Registered Wildfires

Case Number	Discovery Date	Containment Date	Incident Coordinates
BPR010724-462	2024-01-07 12:25:26.236000	2024-01-07 12:54:29.279000	-66.117, 18.4315
PR021124-424	2024-02-11 12:00:28.640000	2024-02-11 14:09:26.109000	0.0, 0.0
PR021724-429	2024-02-17 11:10:41.453000	2024-02-17 11:41:29.255000	-66.13206, 18.2577
BPR060824-597	2024-06-08 12:46:22.995000	2024-06-08 13:52:49.930000	-66.1283, 18.2462
PR071324-906	2024-07-13 19:54:26.630000	2024-07-13 21:18:20.022000	-66.16229, 18.2796

Source: Puerto Rico Fire Bureau

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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.

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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.

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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.

2.4.0.1 QMAGJ TSJL CP_`GRCEQ

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 Aguas Buenas population is considered vulnerable (38.87%), 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.

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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 (CO₂), methane (CH₄), 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.

2./0,0,3 D RS PC AML B CRML Q&/_ '

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.).

2./1 N L B CK GA- CNB CK GA

2./1,/ B CQAP CNRGL &@/+_ '

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.

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

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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).

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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 41: Pandemics and Epidemics 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

Disease	Date	Clasification	Description
			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)
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).

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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.).

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2./1,0,/ C Q R K _ R C B J M Q Q Q Q

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 Aguas Buenas, 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 Aguas Buenas -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.

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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 or 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.

2./1,0,1 QMAGJ TSJL CP_`QCRW

For this hazard, the whole population of Aguas Buenas is considered equally vulnerable. Nonetheless besides factors of age and poverty, the 2024 ACS shows that a total of 760 people in Aguas Buenas did not have health insurance coverage (US Census Bureau, 2025). This means that 3.23% of the total population of Aguas Buenas is uninsured.

Of those most of the uninsured group belonged to the 55-to-44-year cohort (3,252 persons) followed by the cohort of 6 to 18 years (3.219 persons). The results given by the ACS show that the young adult population is the most vulnerable in terms of uninsured in the face of a pandemic or epidemic.

Table 42 shows the breakdown of uninsured people in Aguas Buenas according to the 2020 – 2024 ACS.

Table 42: Number of People in Aguas Buenas without Healthcare Coverage

Age Cohort	Number of people uninsured
Under 6 years	0
6 to 18 years	78
19 to 25 years	78
26 to 34 years	222
35 to 44 years	165
45 to 54 years	77

Age Cohort	Number of people uninsured
55 to 64 years	119
65 to 74 years	21
75 years or older	0

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.

2./1,0,2 L_RS P_J _L B AS JRS P_J PCQMS PACQ

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}, PM₁₀, NO₂, SO₂, CO, and CO₂) 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).

2.1.0.3 DISPCAML BRCML Q&+ '

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.

2.2 FÆF F_X_PB NMRCL RG_J B_K Q

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 Regulations¹⁴ 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).

¹⁴ 44 CFR § 201.6

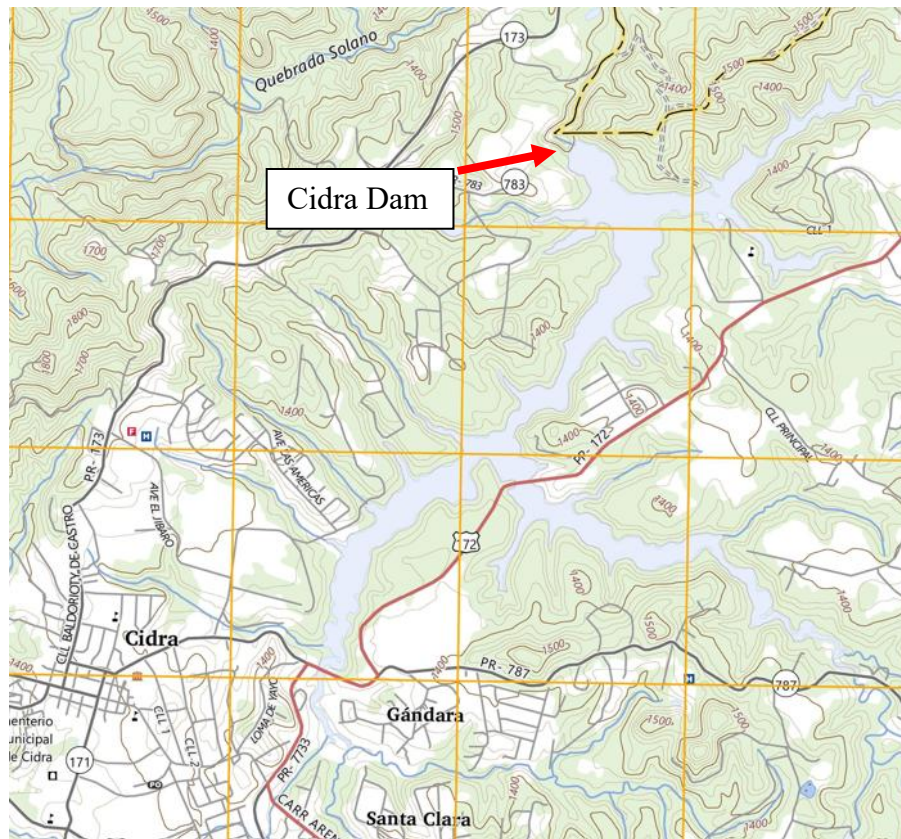
Cidra Reservoir Dam

Table 43: Cidra Dam NID Data

Cidra Dam	
Watershed	Aguas Buenas River Watershed
Purposes	Water Supply
Main Body of Water	Aguas Buenas River
Municipality	Cidra
Date of Completed Construction	1946
Dam Type	Gravity
Hazard Potential Classification	High
NID ID	PR00020
Coordinates as per NID	18.18583, -66.13472
Estimated Coordinates using Google Earth	18.197029, -66.140659
Height as per NID	115 ft
Storage as per NID	10,800 Acre Ft.
Emergency Action Plan	YES
Last Recorded NID Inspection	3/17/2022
Condition Assessment	Satisfactory
Operator	PRASA

Figure 24 shows the Cidra Reservoir as it appears in the latest USGS Topographic map.

Figure 24: Cidra Reservoir USGS¹⁶ Comerío 2024 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 the Cidra Dam (PR00020) located south of Aguas Buenas near the municipal boundary with Cidra. The mapped impact area extends northward from the dam along a narrow corridor that follows a drainage channel through the central-western portion of the municipality.

The impact area traverses portions of Sumidero, Mula, and Mulita, continues north through Sonadora, and reaches the northern municipal boundary. The mapped corridor is confined to the drainage pathway and occupies only a small portion of the municipality relative to the total land area. However, the affected corridor may contain residential areas, transportation routes, utilities, and other critical infrastructure that could experience significant impacts during a dam breach event. Overall, the impact area forms a continuous north-south corridor extending from the Cidra Dam to the northern boundary of Aguas Buenas.

¹⁶ Not to scale

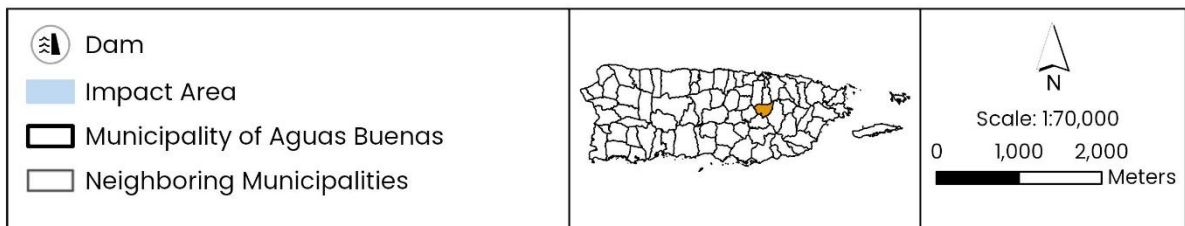
Map 39: High Hazard Potential Dam: Impact Area

HIGH HAZARD POTENTIAL DAM: IMPACT AREA



Source: Puerto Rico Planning Board and Hazus 6.1 Output

SPCS PR & VI NAD83



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

2./2./,1 N QR CTA RQ

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 (IRRM)
- 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 25: Social Media Post from NWS warning about the Guajataca Dam Breach¹

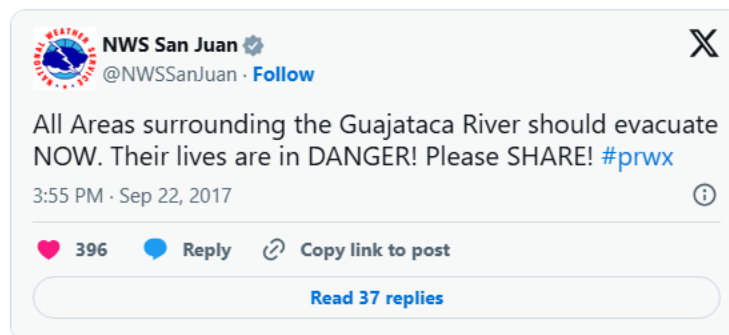


Figure 26: Guajataca Dam Breach 9/23/2017¹



2.2.2 Dams and Critical Infrastructure

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.

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The following section discusses an analysis of sunny day – scenario breach at the Cidra Dam. The risk analysis for this hazard differs from the other hazards because it is following a different recommended format developed for Puerto Rico.

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F F N B 0 + ` ,

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, DSS- 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.

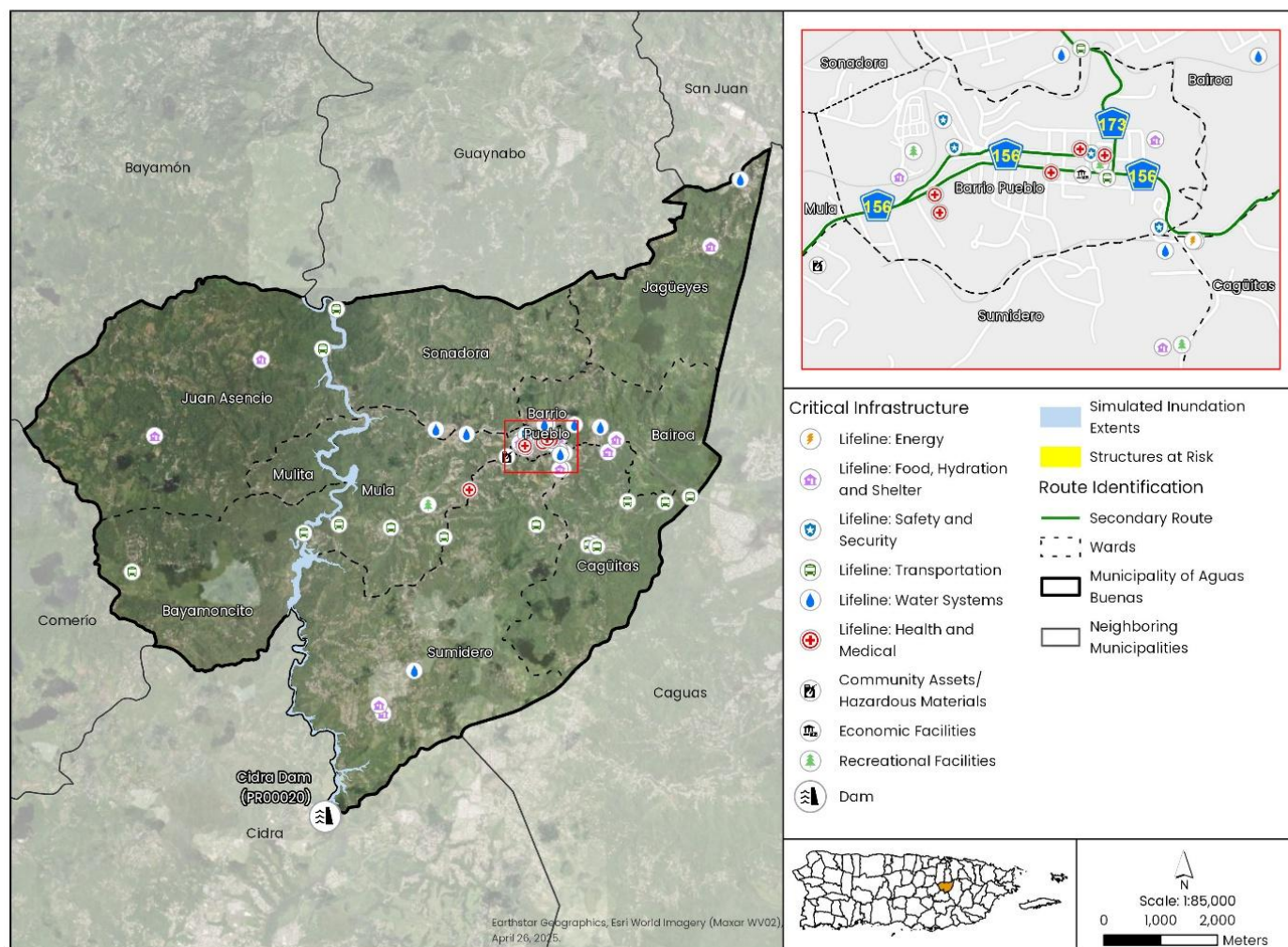
In the case of the 2017 modeling exercise, input data for the simulations was obtained from 2013 United States Geologic Survey (USGS) LIDAR for Puerto Rico, with a 10-meter cell spacing, and from the databases contained within DSS-WISE for dam sizes, bridge sizes, and terrain. There were occasional conflicts 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).

2,/2,0,0 CQCK_RCB JMQCQ&F F NB 0+_ '

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.

Map 40: High Hazard Potential Dam: Critical Infrastructure Exposure

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, the simulated inundation extent associated with the Cidra Dam (PR00020) follows a north-south corridor through the western-central portion of Aguas Buenas. The inundation area extends from the municipal boundary with Cidra northward through portions of Sumidero, Mula, Mulita, and Sonadora.

Most critical infrastructure facilities are located outside the mapped inundation extent. A small number of transportation facilities are positioned near the inundation corridor in Mula and Bayamoncito, while the largest concentration of critical facilities is in Barrio

Pueblo and adjacent areas outside the mapped inundation area. Overall, the map indicates that the simulated inundation extent is concentrated along a narrow drainage corridor, while critical infrastructure is primarily clustered in the central portion of the municipality.

2.2.2.2 QMAG J TS J L CP_`QCRW

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).

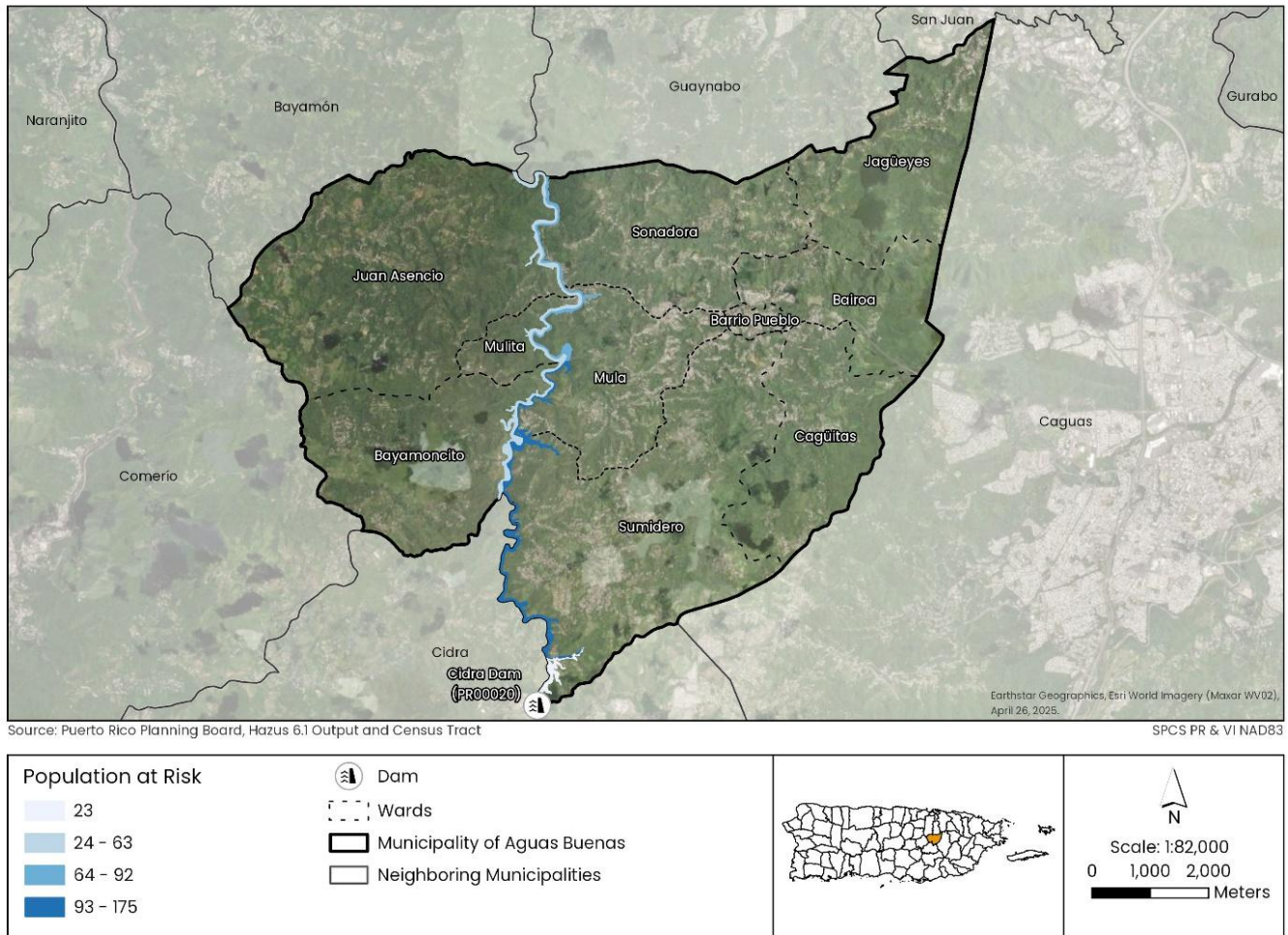
Map 41 shows the population density and the modeled impact area. The map shows that population exposure associated with the Cidra Dam (PR00020) impact area is

concentrated along a narrow north-south corridor extending from the municipal boundary with Cidra through portions of Bayamoncito, Mulita, Mula, and Sonadora. Population at risk is distributed in varying concentrations along this corridor, as indicated by the different shades of blue.

The highest population exposure category (93-175 persons) is concentrated near the southern portion of the impact area close to the municipal boundary with Cidra. Additional areas of moderate population exposure occur along the central portions of the corridor in Bayamoncito, Mulita, and Mula, while lower population exposure categories are distributed throughout the remainder of the mapped impact area. Overall, the population exposure is confined to the dam impact corridor and does not extend into the eastern wards of the municipality.

Map 4f: High Hazard Potential Dam: Population Exposure

HIGH HAZARD POTENTIAL DAM: POPULATION EXPOSURE



2, / 2, 0, 3 P C A C L R B C T Q M N K C L R

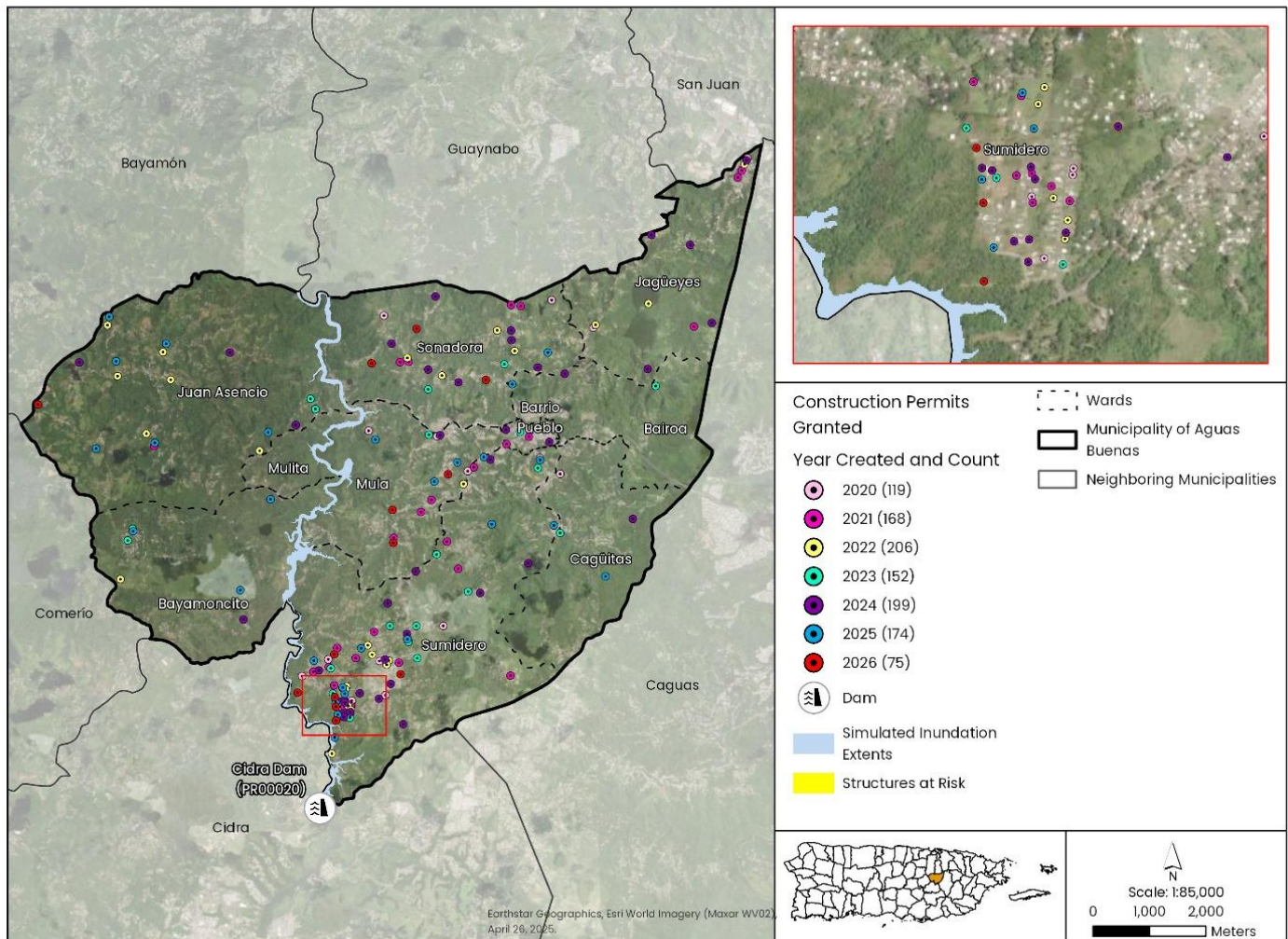
The following map shows the recent development exposure for a sunny day dam breach scenario. It shows that recent development permits are distributed throughout Aguas Buenas, with the highest concentration located in the southern portion of Sumidero near the Cidra Dam (PR00020) and the mapped simulated inundation extent. Additional recent development permits are scattered across Juan Asencio, Sonadora, Jagüeyes, Barrio Pueblo, Bairoa, Cagüitas, Mula, Mulita, and Bayamoncito.

The simulated inundation extent follows a north-south corridor through Sumidero, Mula, Mulita, and Sonadora. Several recent development permits are located within or adjacent to this corridor, particularly in the southern part of Sumidero, as highlighted

in the inset map. Overall, the map indicates that recent development activity occurs throughout the municipality, with a notable cluster of permits situated near the mapped dam inundation area in Sumidero.

Map 42: High Hazard Potential Dam: Recent Development Exposure

HIGH HAZARD POTENTIAL DAM: RECENT DEVELOPMENT EXPOSURE



2,/2,0,4 QNCAGJ AML QB CP_RGML Q AMMPB CL_RGML UCRF JMA_J B_K
MUL CPQ_L B QR RCB_K Q DCRW_E CL ACCQ& F NB /+ \$ F F NB /+ ^

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.

The Cidra dam is operated by the Puerto Rico Aqueduct and Sewer Authority (PRASA). This dam has a current Emergency Operation Plan.

2./3 F _X_P B NP GMP CRGX_RQML

After receiving feedback from the public and stakeholders (see Sections 2.5–2.6 and the Appendixes C and D) along with their own expertise the planning committee has determined that the following is the prioritization for the hazard discussed in this LHMP.

Table 44: Hazard Prioritization

Hazard	Priority
Earthquake	Low Priority
Landslide	High Priority
Flooding	High Priority
Tropical Cyclones and Extreme Winds	High Priority
Extreme Heat	Low Priority
Drought	Mid Priority
Wildfire	Low Priority
Pandemic/Epidemic	Mid Priority

2./4 NJ_L L Q E K CAF _ L QK

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.

2./4./ I _ PQR QNCAGJ NJ_L L Q E ? PC_ NJ _ L _ L B PCE S J _ RQML &NP? NCA*
`WCRQQL Q E ? A PML WK' ' 0. /2'

Figure 27: (PRAPEC, by its Spanish Acronym) Coversheet



In compliance with Act 292-1999, this plan and regulation establish two overlaid districts in the karst zones of Puerto Rico. The Restricted Karst Special Planning Area (APE-RC) overlaid 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) overlaid 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.

2./4,0 HML R PCE SJ_RGML DMP RF C CT_JS_RGML _L B GGS_L AC MD
 NCP K GRQ_P CJ _RCB RM B CTCJ MNK CL R* J _L B S Q* _L B @S QL CQQ
 MNCP _RGML Q&. 01'

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

Figure 28: Joint Regulation Cover



resources, and facilitate economic development under criteria of competitiveness and sustainability, integrating planning with permit management.

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. This zoning designation can serve as an important mitigation tool by discouraging future development in areas subject to repetitive flood losses, landslides, or other natural hazards. 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.

2./4,1 QNCAG J D MMB F _X_PB ? PC_QPCE S J _RCML &. 0/'

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.

2./4,2 NS CPRM P G A M @ S Q B Q E A M B C

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.

2./4,3 PCE S J_RGML DMP RF C B CQCE L * MNCP_RGML APGRCPG _L B
K _CL RCL _L AC MDQMP K U _RCP QWRCK QCL N\$ CPM P GAM

Figure 29: 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.

2./4,4 ? E S _Q@S CL _QRCP PGRMPG J NJ _L Q. //'

Figure 30: Aguas Buenas Land
Use Plan Cover Page



As per the Puerto Rico Municipal Code and the land use planning framework established by the Puerto Rico Planning Board (JP), the Municipality of Aguas Buenas 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 Aguas Buenas was approved in 2011. In 2024, Aguas Buenas approved a resolution to collaborate with the Planning Board on a review of that

Land Use Plan.

2./4,5 ? E S _ Q @ S C L _ Q C K C P E C L A W M N C P _ R G M L N J _ L

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 Aguas Buenas can respond to, withstand, and recover from a wide range of emergencies.

2./4,6 L _ R G M L _ J D J M M B C L Q S P _ L A C N P M E P _ K

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 Aguas Buenas 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.

2./4,7 L _RGML _J NMJJS R_L R B CAF _PE C Q CK CL _RGML QORCK & NB CQ

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.

2./4,/. MNCP _RGML _J E S GB C J CL CQ DMP B CRCP K CL CL E B _K _E CQ _L B Q ` Q R L RG J CK NP MTCK CL RQ CL N\$ CPRM P GAM &. 03'

Figure 30: Operational Guidelines



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.

2./4,// E PCCL CL DP _QRPS ARS PC _L B L _RS PC @ _QCB QMJ S RGML Q

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).

2.4.0 DMS P' WC_P G TCQRK CL R NP ME P_K

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 municipalities²⁰.

3, K S L G A G N J A _ N _ A C R C C Q

3,/ P C E S J _ R M P W _ L B N _ L L C L E K C A F _ L C C K Q & A / + _ '

These capabilities refer to the legal provisions that influence land use 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 4.16.

3,0 R C A F L G A _ J _ L B ? B K C L C C R P _ R G T C A _ N _ A C R C C Q & A / + _ '

The Municipality of Aguas Buenas is well staffed to implement this LHMP. Copy of this organigram can be found as part of Appendix E.

Table 45 shows the Municipality's Technical and Administrative Capacity.

Table 45: 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. ¹⁷		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 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		Currently the municipality does not have this staff.

¹⁷ Though the Municipality does have a functioning planning office, currently no member of that office has this experience.

Personnel Team / Resources	Yes	No	Future Positions	Department or Agency	Opportunities to Integrate into LHMP	Comments
				Seismic Network, other universities in Puerto Rico		If the need arises this position will be provided 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 provided 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

3.1 Disaster Preparedness and Mitigation

The Municipality has successful track record administrating federal funds from various funding streams and has a dedicated office to administer and supervise the use of federal funds, and when any finding has been identified by grant – providers it has been addressed and corrected.

3.1.1 Disaster Preparedness and Mitigation

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.

3.1.0 L ML +DCK ? DCB CP _J D L B Q E QPC_K Q

Non-FEMA federal Funding Streams can include:¹⁸

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, as long as the activities address identified risks.

CDBG-MIT

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,

¹⁸ Please note that the following list is not intended to be exhaustive.

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.

3.1.1 JMA_J D L B Q

Aguas Buenas, 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.

3.2 MS RPC_AF _L B AMK K S L GA_RGML Q&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 the Mayor 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 46 details the communication tools available to the municipality.

Table 46: 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

3.3 A_N_ACRWB CTQ MNK CL R &A/+`

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.

4. Mitigation Goals

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.

4.1 Mitigation Goal 1

4.1.1 Mitigation Goal 1.1

The Municipality of Aguas Buenas adopts the following goals and objectives as part of their mitigation efforts from the 2020 LHMP:

Goal 1: Protect Life and Property

Reduce the risk of injury, loss of life, and damage to public and private property from natural hazards.

Objectives:

- Improve the safety of residents, businesses, and visitors.
- Reduce exposure of existing and future development to natural hazards.
- Protect critical facilities and essential infrastructure.

Goal 2: Strengthen Municipal Planning and Regulation

Incorporate hazard mitigation into municipal planning, land use, and development decisions.

Objectives:

- Integrate mitigation principles into local plans, regulations, and permitting processes.
- Discourage development in hazard-prone areas.
- Promote hazard-resilient construction practices.

Goal 3: Protect Critical Infrastructure and Essential Services

Maintain and improve the resilience of infrastructure and public services before, during, and after disasters.

Objectives:

- Reduce vulnerabilities in transportation, utilities, communications, and public facilities.
- Improve continuity of government operations and emergency services.
- Prioritize mitigation investments for critical assets.

Goal 4: Protect Natural Resources and Environmental Systems

Preserve and enhance natural systems that reduce hazard impacts and support community resilience.

Objectives:

- Protect watersheds, floodplains, karst areas, and environmentally sensitive lands.
- Reducing environmental degradation contributes to increase exposure and vulnerability to natural hazard.
- Encourage sustainable land management practices.

Goal 5: Improve Emergency Preparedness and Response Capability

Increase the municipality's ability to prepare for, respond to, and recover from disasters.

Objectives:

- Strengthen emergency management capabilities.

- Improve coordination among agencies and stakeholders.
- Enhance disaster response planning and resource availability.

Goal 6: Increase Public Awareness and Education

Promote public understanding of hazards and mitigation measures.

Objectives:

- Expand community outreach and education programs.
- Encourage residents and businesses to take mitigation actions.
- Improve dissemination of hazard and preparedness information.

Source: Municipio de Aguas Buenas Plan de Mitigación contra Peligros Naturales 2020, Chapter 6, "Estrategia de Mitigación".

4./,0 L _RQML _J K GRCE _RQML G TCQK CL R QRP _RCE W

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.

4.0 KRCF_RGML QRP_RCE WQJ_CARGML AP_CRCPG

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 Aguas Buenas 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.

4.1 KRCF_RGML QRP_RCE WA_RCE MPCK_RGML

- 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

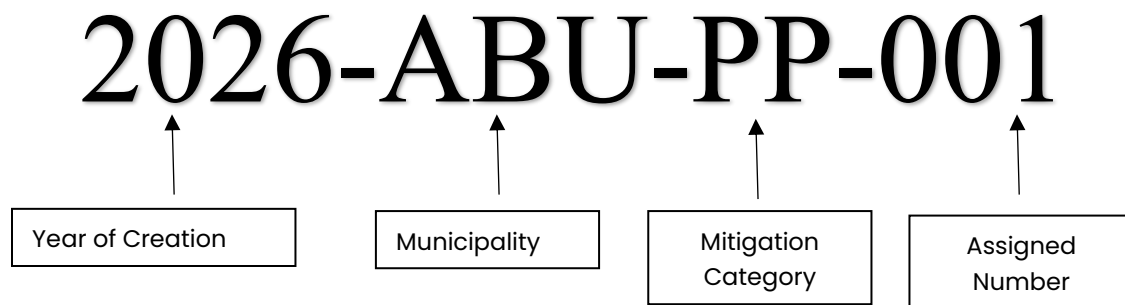
- Insurance policies
- Natural resource protection – activities reduce the impact of natural disasters by preserving or restoring natural areas that offer protective benefits. These areas include flood plains, wetlands, steep slopes, and sand dunes. Parks, recreational agencies, and conservation organizations 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

4.2 K RCE _RCML QRP _RCE CCQ&A2+_ * A2+_`\* A3+\_ \* A3+\_`* C0+_`'

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 2020 LHMP (if applicable)

Table 47: Mitigation Strategies – Prevention

New ID	Old ID	Description	Hazard	Priority	Lifeline	Leading Municipal Office	Possible Funding Source	Implementation Term	Current Status and Expected Benefits
2026-ABU-P-001	1	Area Plan for the Vistas de Jagüeyes sector - consists of the creation of an Area Plan that allows us to establish precisely the condition of each of the housing units in the sector, the treatment that will be given to each unit, and recommend the appropriate activity for them, whether it is rehabilitation, demolition, and/or relocation of owners, among others. The Plan must recommend the best use for the land, so that it is compatible with the vulnerability of the area. In	All	Moderate	Safety & Security	Office of Planning and Territorial Planning	Federal Proposals, Home Program	Long	Current Status: Completed. Slope stabilization work was carried out with FEMA-PW 03447 funds COST \$33,338.34.

New ID	Old ID	Description	Hazard	Priority	Lifeline	Leading Municipal Office	Possible Funding Source	Implementation Term	Current Status and Expected Benefits
		addition, the Plan will establish the costs of all the activities to be carried out, and the time of development of these, to make this community resilient to disasters.							
2026-ABU-P-002	2	Inventory of Homes Located in High-Risk Areas - will specifically identify which housing units are in high-risk areas, as well as their condition to resist the event that delimits and identifies the area as one of High or Very High vulnerability. The proposed action will identify and quantify them and will establish the socioeconomic and	Flooding, Landslide	Moderate	Safety & Security	Office of Planning and Territorial Planning	Ordinary budget	Long	Current Status: In design. This strategy proposes to identify areas where buildings are safe for housing development and developments. Expected Benefits: Use of rural land and developable land.

New ID	Old ID	Description	Hazard	Priority	Lifeline	Leading Municipal Office	Possible Funding Source	Implementation Term	Current Status and Expected Benefits
		demographic data of the residents. It will define the action to be taken with the properties, to safeguard the life and safety of the affected population in the face of the onslaught of a natural disaster, maintaining an inventory of safe homes in the municipality. The study will also establish what will be the best land use for the areas delimited as High and Very High Risk, which is compatible with their vulnerability, and will recommend the activities to be developed to reduce vulnerability in them.							

New ID	Old ID	Description	Hazard	Priority	Lifeline	Leading Municipal Office	Possible Funding Source	Implementation Term	Current Status and Expected Benefits
2026-ABU-P-003	4	Public Works Inventory, Phase 2 – will establish the exact location of each of the municipal works and properties that are not currently in the municipal property inventory. It will contain the coordinates (X,Y) in the same projection in which the maps of the Risk Mitigation Plan of the Autonomous Municipality of Aguas Buenas were created. It will create an information layer, with data on each work, such as name, location (road, sector, neighborhood), description, cost, current condition of	All	High	Transportation, Safety & Security	Office of Planning and Territorial Planning	Ordinary budget, Federal and/or Legislative Funds	Immediate	Current Status: Completed.

New ID	Old ID	Description	Hazard	Priority	Lifeline	Leading Municipal Office	Possible Funding Source	Implementation Term	Current Status and Expected Benefits
		the structure and vulnerability.							
2026-ABU-P-004	5	Elimination of Public Nuisances - make an inventory of structures considered as public nuisances, declare them as such in accordance with regulations and procedures, and remove them, to avoid further damage to life and property in the event of a disaster event, since this type of structures would not resist it and can become harmful elements, such as projectiles and debris that cause flooding, and damage to life and property, among others.	All	High	Safety & Security	Office of Planning and Territorial Planning	Ordinary budget, Non-profit Entities	Immediate	Current Status: Continuous action. Expected Benefits: Avoid major damage to life and property in the event of a disaster event.

New ID	Old ID	Description	Hazard	Priority	Lifeline	Leading Municipal Office	Possible Funding Source	Implementation Term	Current Status and Expected Benefits
2026-ABU-P-005	6	Community Rating System (CRS) Program - The project consists of participating in the Community Rating System Program, to exceed the standards of the National Flood Insurance Program (NFIP), for the management of floodplains, and to get the CRS to provide up to a 45% discount on flood insurance premiums to the residents of Aguas Buenas.	Flooding	High	Safety & Security	Office of Planning and Territorial Planning	Federal Funds/ Ordinary Budget	Long	Current Status: Carry out a census of properties in susceptible areas and their location on the municipal map through cadastral number. Funding. Expected Benefits: Getting CRS to provide up to 45% discount on flood insurance premiums to Aguas Buenas residents.
2026-ABU-P-006	7	The municipality and its agencies will actively participate in the effort to implement land use	Flooding	High	Safety & Security	Office of Planning and Territorial Planning	Municipality of Aguas Buenas (Operational Funds), Federal and State Funds	Long	Current Status: In execution. Works on updating the Municipality's POT with

New ID	Old ID	Description	Hazard	Priority	Lifeline	Leading Municipal Office	Possible Funding Source	Implementation Term	Current Status and Expected Benefits
		controls to prohibit the development of illegal structures in flood-prone areas under the Special Flood Risk Areas Regulation, better known as the Flood Risk Regulations. Planning #13, as amended and the feasibility of designating areas susceptible to high risk as Hazard Zones (ZRs).							the assistance of the Planning Board. Expected Benefits: Prohibit the development of illegal structures in flood-prone areas.
2026-ABU-P-007	16	Develop a continuous plan for preventive maintenance of public works.	All	Moderate	Transportation, Safety & Security	Office of Planning and Territorial Planning	Municipality of Aguas Buenas (Operational Funds)	Long	Current Status: Continuous execution. Weeding, debris removal, repair of municipal roads, construction of curbs, collection of solid waste, painting of infrastructure and cleaning are carried out.

New ID	Old ID	Description	Hazard	Priority	Lifeline	Leading Municipal Office	Possible Funding Source	Implementation Term	Current Status and Expected Benefits
									Expected Benefits: Improve the quality of life of citizens and better performance of infrastructure works.
2026-ABU-P-008	19	Keep the Committee that worked on the review of the Mitigation Plan active during the entire term of the Plan, to guarantee the implementation and Update of the Mitigation Plan.	All	Moderate	Safety & Security, Communications	Office of Planning and Territorial Planning	Municipality of Aguas Buenas (Operational Funds)	Immediate	Current Status: The Committee for the Mitigation Plan was established.

Table 48: 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-ABU-PP-001	8	Flood Control – La Charca Sector – Includes studies, design and development of the necessary works to provide safe road access to the residents of the Juan Asencio neighborhood and the Mulitas neighborhood and eliminates the flooding problem of the La Charca sector, including the existing recreational area. The construction of a bridge over the Bayamón River, and erosion and sedimentation control	Flooding	High	Transportation, Safety & Security	Office of Planning and Territorial Planning	Federal Funds	Medium	Current Status: In design. This strategy includes studies, design and development of the necessary works. Expected Benefits: To provide safe road access to the residents of the Juan Asencio neighbourhood and the Mulitas neighbourhood and eliminate the flooding problem of the La Charca sector, including the existing recreational area.

New ID	Old ID	Description	Hazard	Priority	Lifeline	Leading Municipal Office	Possible Funding Source	Implementation Term	Current Status and Expected Benefits
		works in the area are being considered. With the project we will be able to specify the works to be carried out for flood control, which in turn will allow us to recover approximately 4.96 acres of land from the flood zone where the La Charca Recreational Facilities are located, thus avoiding damage recurrent to the existing structures in the place.							
2026-ABU-PP-002	9	Improvements to the Aguas Buenas Sports Complex for its habilitation as a "Safe Room".	All	Low	Food, Hydration, Shelter,	Office of Planning and Territorial Planning	Ordinary budget, FEMA Funds	Immediate	Current Status: Completed. Repair work was carried out on the facilities of the coliseum, both inside and outside.

New ID	Old ID	Description	Hazard	Priority	Lifeline	Leading Municipal Office	Possible Funding Source	Implementation Term	Current Status and Expected Benefits
					Safety & Security				
2026-ABU-PP-003	11	Rehabilitation of Housing under CDBG-DR fund program.	Landslide, Flooding	Moderate	Safety & Security	Office of Planning and Territorial Planning	State and Federal Funds	Long	Current Status: Completed.

Table 49: 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-ABU-SP-01	3	Plan to carry out the Public Works that intervene with bodies of water and that are part of the road network of the Municipality- The Plan includes an inventory of all the rainwater works that are part of the road network of the municipality; determine their current condition, and bring these works into compliance with current building codes and regulations, so that they are structures resistant to those identified events that will always be occurring and	All	Moderate	Transportation, Safety & Security	Office of Planning and Territorial Planning	Ordinary budget, Federal Funds	Long	Current Status: In execution. Expected Benefits: That they are structures resistant to those identified events that will always be occurring and impacting them and to which they are vulnerable.

New ID	Old ID	Description	Hazard	Priority	Lifeline	Leading Municipal Office	Possible Funding Source	Implementation Term	Current Status and Expected Benefits
		impacting them and to which they are vulnerable. The Plan will establish the cost of developing the activities it recommends, establish the priorities and the execution time.							
2026-ABU-SP-02	10	Improvements to the Runoff Water Collection System- The project to improve the runoff water collection system in the Quebrada Prieta sector, Panchito Sierra Sector, La Vega Sector, Macho Gomas Sector and El Llano Sector consists of the construction of gutters and sewer	Flooding	High	Transportation, Safety & Security	Office of Planning and Territorial Planning	Federal Funds, Administration Budget	Long	Current Status: Completed.

New ID	Old ID	Description	Hazard	Priority	Lifeline	Leading Municipal Office	Possible Funding Source	Implementation Term	Current Status and Expected Benefits
		systems to manage the runoff water that currently runs through the road system reaching speeds that cause severe damage to the pavement and the various existing cuts at the different points where the road network crosses over the ravines of the Quebrada Prieta sector.							
2026-ABU-SP-03	12	Stabilization of slopes on state roads.	Landslide	High	Transportation, Safety & Security	Office of Planning and Territorial Planning	Ordinary budget, FEMA Funds	Short	Current Status: Continuous execution.
2026-ABU-SP-04	13		Flooding	High	Transportation	Office of Planning and	Ordinary budget	Short	Current Status: Clean-up work was carried out in

New ID	Old ID	Description	Hazard	Priority	Lifeline	Leading Municipal Office	Possible Funding Source	Implementation Term	Current Status and Expected Benefits
		Runoff Management and Control Plan- The Developed Areas will be identified as established in the Territorial Plan of the Autonomous Municipality of Aguas Buenas, and those existing bodies of water in the municipality that are affected by the urban activities that are developed in said areas. It will evaluate the condition of the rainwater works to manage the runoff water that corresponds to it, recommend the necessary works to be carried out for the management and control of runoff,			n, Safety & Security	Territorial Planning			several bodies of water through OMME DSR #5037 ABU 001, 002, 005, 007 and 008. A company was hired to update the runoff plan. Cost \$ 44,500.00

New ID	Old ID	Description	Hazard	Priority	Lifeline	Leading Municipal Office	Possible Funding Source	Implementation Term	Current Status and Expected Benefits
		establish the priority in them, execution time of the proposed projects and their costs.							
2026-ABU-SP-05	New	Reconstruction and improvements to infrastructure in municipal sectors. Construction of gabion walls, repair of road sections, construction of sidewalks and gutters, security fences and paving.	Landslide	High	Transportation, Safety & Security	Office of Planning and Territorial Planning	CDBG Funds and FEMA Funds	Long	Current Status: Continuous execution.

Table 50: 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-ABU-NRP-01	14	Inventory of Water Bodies not registered in the Hydrology Maps of the municipality.	Flooding	N/A	N/A	N/A	N/A	N/A	N/A
2026-ABU-NRP-02	15	Implement measures within the Territorial Plan of the municipality and grant inter-agency agreements aimed at protecting water supplies such as aquifers, watersheds, geological micro-basins, among others.	Drought, Wildfires	High	Food, Hydration, Shelter, Safety & Security	Office of Planning and Territorial Planning	Municipality of Aguas Buenas (Operational Funds)	Immediate	Current Status: Continuous execution. Expected Benefits: Reduce the adverse impact and detriment of the (promote the protection of) the municipality's natural resources and protection of the main watersheds and water sources, as well as prevent events of marked drought conditions from affecting the municipality. Promote the supply of water in a

New ID	Old ID	Description	Hazard	Priority	Lifeline	Leading Municipal Office	Possible Funding Source	Implementation Term	Current Status and Expected Benefits
									constant and preventive manner.
2026-ABU-NRP-03	New	Implement measures to address extreme heat.	Drought, Wildfires	High	Health & Medical, Food, Hydration & Shelter, Water Systems, Energy	Office of Planning and Territorial Planning	Ordinary Budget	Immediate	Current Status: Continuous execution. Installation of green roofs, planting trees, disseminating warnings through the network, heat alerts and identifying leaders in the communities who periodically check 2 or 3 vulnerable neighbors.

Table 51: 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-ABU-ES-01	20	Update of Emergency Management Plans.	All	High	Safety & Security, Communications	Office of Planning and Territorial Planning	Municipality of Aguas Buenas (Operational Funds)	Immediate	Current Status:
2026-ABU-ES-02	21	Protection of Critical Facilities- It is the intention of the municipality to have facilities of prolonged shelters for the service of its constituents at times when due to a natural disaster it is necessary, for which to begin they are identifying at least two housing units to be acquired and later	All	High	Food, Hydration, Shelter, Safety & Security	Office of Planning and Territorial Planning	Regular budget	Short	Current Status: Of the schools closed by the Department of Education, one was set up as a shelter and two were given to non-profit entities

New ID	Old ID	Description	Hazard	Priority	Lifeline	Leading Municipal Office	Possible Funding Source	Implementation Term	Current Status and Expected Benefits
		enabled as prolonged temporary shelters. Once these properties are acquired by the municipal administration, a project to convert them into Prolonged Temporary Shelters will be included in the Action Plan of the Risk Mitigation Plan.							
2026-ABU-ES-03	22	Acquisition of electricity generators for critical facilities in the municipality.	All	High	Energy, Safety & Security	Office of Planning and Territorial Planning	Ordinary budget, Federal Funds	Short	Current Status: The government center is in the process of acquiring an electric generator. OMME, POLICE STATION, CDT, GERIATRICS and MAYOR'S OFFICE HAVE AN ELECTRIC GENERATOR.
2026-ABU-ES-04	17	Update the existing Emergency Management operational plans in	All	Moderate	Safety & Security	Office of Planning and Territorial Planning	Municipality of Aguas Buenas (Operational Funds)	Immediate	Current Status: New vehicles and equipment were provided, and the

New ID	Old ID	Description	Hazard	Priority	Lifeline	Leading Municipal Office	Possible Funding Source	Implementation Term	Current Status and Expected Benefits
		the municipality so that they have risk assessments and response capacity.							operational plan is updated annually. Expected Benefits: It will enable the municipality to have the necessary personnel (trained) to identify the estimates of damage after any hazard event, allowing them to direct an immediate response, as well as the identification of possible sources of necessary funds and areas of need.
2026-ABU-ES-05	18	Have trained personnel to efficiently assess the damage caused by the impact of a natural event or train municipal staff in damage assessment processes caused by	All	Moderate	Safety & Security, Communications	Office of Planning and Territorial Planning	Municipality of Aguas Buenas (Operational Funds)	Immediate	Current Status: Employees of the municipality were trained by personnel from FEMA and the Prida Program to assess damages. Expected Benefits: It will facilitate the maintenance

New ID	Old ID	Description	Hazard	Priority	Lifeline	Leading Municipal Office	Possible Funding Source	Implementation Term	Current Status and Expected Benefits
		the impact of natural events, to quantify and document them in the shortest possible time.							and updating of the Mitigation Plan at the end of five (5) years and will minimize the need to delay the process during the next review. It will allow the mitigation strategies contained herein to be directed and compliance with it to be ensured.

Table 52: Mitigation Strategies – Community Awareness and Information

New ID	Old ID	Description	Hazard	Priority	Lifeline	Leading Municipal Office	Possible Funding Source	Implementation Term	Current Status and Expected Benefits
2026-ABU-CAI-01	23	Develop awareness and education program, through workshops, talks and/or publications aimed at merchants, stakeholders and the public about the importance of water conservation and alternatives for its storage and protection.	Drought	Moderate	Food, Hydration, Shelter, Communications	Office of Planning and Territorial Planning	Municipality of Aguas Buenas (Operational Funds), Federal and State Funds.	Immediate	Current Status: A brochure was created for educational purposes and orientation for citizens. Expected Benefits: Improve the public dissemination capacity of the municipality and train the community on the proper use and preservation of water to avoid the misuse of natural resources and prevent events of marked drought conditions from affecting the municipality. Promote the supply of water in a constant and preventive manner.
2026-ABU-CAI-02	24		All	Moderate	Safety & Security,	Office of Planning and	Municipality of Aguas Buenas	Medium	

New ID	Old ID	Description	Hazard	Priority	Lifeline	Leading Municipal Office	Possible Funding Source	Implementation Term	Current Status and Expected Benefits
		Train citizens in those regulations and/or requirements that are necessary for them to be eligible for claims for damage to their property caused by natural events.			Communications	Territorial Planning	(Operational Funds)		Current Status: It has not been implemented. Expected Benefits: Promote the municipality's public outreach capacity to foster community preparedness and response to a hazard event during all phases of the emergency cycle. Having an informed citizenry lightens the response and recovery process, in addition to allowing the funds allocated under Individual Assistance (IA) and/or Public Assistance (PA) to be well used and that citizens can benefit from them effectively. To his It will allow citizens to obtain and have with them, in advance, the necessary documentation and/or

New ID	Old ID	Description	Hazard	Priority	Lifeline	Leading Municipal Office	Possible Funding Source	Implementation Term	Current Status and Expected Benefits
									mobilize to comply, prior to a disaster event.

4.3 N _ P R O G R A M _ R G M L _ C L _ L D C N & A 0 + _ '

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.

5, N _ L K _ C R C L _ L A C

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.

5.0 MONITORING, REVISION AND UPDATE

The designated point of contact for the monitoring, revision and update of the Aguas Buenas LHMP is:

Table 53: Point of Contact Information

Name	Juan Ortiz Rivera
Position	Director
Office	Finance and Budget Office
Telephone Number	787-732-4700, ext.2412
Email	jortiz@aguasbuenaspr.net

5.0.1 PUBLIC PARTICIPATION

The Municipality of Aguas Buenas 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.

5.1 J F K N M T C P Q E F R & 0 + _ '

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.

5.2 J F K N C T _ J S _ R C M L _ L B K M L C R M P C L E

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 54: 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.
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	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.

Time Period	Participants	Purpose of the Meeting
	deemed necessary)	

5.3 J F K N S N B _ R C _ L B P C T C O M L & B 0 + A * B 1 + _ '

5.3./ P C T C O M L D M J J M U C L E _ K _ H M P B C Q Q R C P

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.

5.3.0 D G T C ' W C _ P A M K N P C F C L Q Q T C S N B _ R C

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.

5.4 J F K N C L R C E P _ R C M L U C R F M R F C P N J _ L L C L E
K C A F _ L C Q Q & B 1 + _ '

The following public policies and planning documents were considered in the development of this LHMP:

Commonwealth Level:

- Puerto Rico Land Use Plan (PUT-PR)

- Aguas Buenas 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
- Aguas Buenas 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.

6, ? B MNRGML _ L B ? NNP MT_J &D/+_* D/+`'
6,/ J F K N? B MNRGML

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)¹⁹.

This LHMP was adopted by the Municipality of Aguas Buenas on XXXXXX. A copy of Resolution, titled “To Adopt the 2026 Natural Hazard Mitigation Plan of the Municipality of Aguas Buenas and for Other Related Purposes,” is included as part of Appendix A.

6,0 J F K N? NNP MT_J

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,*” is included in **Appendix A**. FEMA’s approval of the Plan is valid for a period of **five (5) years**, through XXXXXX

¹⁹ 44 C.F.R. §201.6(c)(5)

- American Society of Civil Engineers. (2024, August 20). *Civil Engineering Source*. Retrieved December 17, 2025, from Rising heat is scorching Americans - and our infrastructure: <https://www.asce.org/publications-and-news/civil-engineering-source/article/2024/08/20/rising-heat-is-scorching-americans-and-our-infrastructure>
- Anderson, S., Barford, C., & Barford, P. (2020). *Five Alarms: Assessing the Vulnerabilities of US Cellular Communication Infrastructure to Wildfires*. Association for Computing Machinery.
- Aqilah, S., Karmilla, K., Tamanna, K., Ali, Z., & Mat, N. (2024). Assessing Socio-Economic and Environmental Losses of Dam Failure Flood Risk: A Review on Sustainable Framework. *Journal of Sustainability Science and Management*, 19(1), 171 - 195.
- ASDSO. (2022). *Dam Safety Performance Report 2022*. Lexington, KY. Retrieved January 4, 2026, from <https://damsafety-dev.s3.amazonaws.com/s3fs-public/files/Puerto%20Rico%20Dam%20Safety%20Performance%20Report%2022.pdf>
- ASPR. (n.d.). *ASPR Health Care Readiness State Highlights*. Retrieved January 5, 2026, from <https://aspr.hhs.gov/HealthCareReadiness/HealthCareReadinessNearYou/Pages/Puerto-Rico.aspx>
- AtkinsRéalis. (2024). *Hazard Mitigation Plan: Dam Annex Template for Puerto Rico*.
- Autonomous Municipality of Bayamón. (2018). *Plan de Mitigación Multi-Riesgos 2018 (All Hazard Local Mitigation Plan)*. Bayamón, PR: Oficina de Planificación y Ordenamiento Territorial.
- Autonomous Municipality of Bayamón. (2025). *Emergency Operation Plan*. Bayamón PR: Municipal Agency for Emergency Management and Disaster Administration.
- Baker, C., Cohen, S., Coulson, G., Durden, S., & Rossman, E. (n.d.). *Identification and Engagement of Socially Vulnerable Populations in the USACE Decision Making Process*. The Institute for Water Resources.
- Caricoos. (n.d.). *Marejada Ciclónica*. Retrieved Noviembre 18, 2025, from <http://www.caricoos.org/mao/storm-surge>
- Castro Rivera, A. (n.d.). *Proyecto 1867*. Retrieved December 27, 2025, from La triple condena de 1867: <https://www.proyecto1867.com/la-triple-condena-de-1867.html>
- Castro Rivera, A., & López Marrero, T. (2018). *Cartilla de los Ciclones*. Mayagüez, PR: Sea Grant - Universidad de Puerto Rico, Mayagüez.
- CBO. (2024). *Federal Spending for Flood Adaptations*. Retrieved from www.cbo.gov/publication/59971
- CCOF. (2026, March). *Caribbean Climate Outlook Newsletter - April to June 2026*. Caribbean Institute for Meteorology and Hydrology. Caribbean Climate Outlook Forum. Retrieved from <https://rcc.cimh.edu.bb/files/2026/03/caricofamjjas.pdf>
- CDC. (2012, May 18). *CDC Archive*. Retrieved December 29, 2025, from https://archive.cdc.gov/www_cdc_gov/csels/dsepd/ss1978/lesson1/section11.html

- CDC. (2014, December 5). *Morbidity and Mortality Weekly Report*. Retrieved December 29, 2025, from Chikungunya Cases Identified Through Passive Surveillance and Household Investigations - Puerto Rico, May 5 - August 12, 2014: <https://www.cdc.gov/mmwr/preview/mmwrhtml/mm6348a1.htm>
- CDC. (2024, Junio 25). *Heat Health*. Retrieved November 12, 2025, from Heat and Older Adults (Aged 65+): <https://www.cdc.gov/heat-health/risk-factors/heat-and-older-adults-aged-65.html>
- CEACC. (2024). *Borrador del plan de mitigación, adaptación y resiliencia al cambio climático en Puerto Rico*. San Juan, PR: Gobierno de Puerto Rico.
- Center for Disaster Resilient Communities. (n.d.). *The Health Effects of Landslides*. Retrieved December 28, 2025, from <https://edge.deohs.washington.edu/sites/edge/files/2025-07/Landslides%20Fact%20Sheet.pdf>
- Colón, J. A. (2009). *Climatología*. San Juan, PR: La Editorial Universidad de Puerto Rico.
- Colorado State University. (2026). *Tropical Cyclones, Radar, Atmospheric Modeling, and Software Team*. Retrieved April 28, 2026, from CSU Tropical Cyclone Impact Probabilities: https://tropical.colostate.edu/TC_impact.html
- Columbia University/Mailman School of Public Health. (2021, February 19). *Epidemic, Endemic, Pandemic: What are the Differences?* Retrieved from <https://www.publichealth.columbia.edu/news/epidemic-endemic-pandemic-what-are-differences>
- COR3. (n.d.). *Coronavirus (COVID-19)*. Retrieved January 4, 2026, from <https://recovery.pr.gov/en/coronavirus>
- Cutter, S., Boruff, B., & Shirley, W. (2003). Social Vulnerability to Environmental Hazards. *Social Science Quarterly*, 84(2), 244 - 261.
- Cutter, S., Emrich, C., Morath, D., & Dunning, C. (2013). Integrating Social Vulnerability into Federal Flood Risk Management Planning. *Journal of Flood Risk Management*, 6, 332 - 344.
- Dennin, L., Nock, D., Muller, N., Akindede, M., & Adams, P. (2025). Social Vulnerable Communities Face Disproportionate Exposure and Susceptibility to US wildfire and prescribed burn smoke. *Communications Earth & Environment*, 6(190). doi:<https://doi.org/10.1038/s43247-025-02100-y>
- DHS. (n.d.). *Ready.gov*. Retrieved enero 16, 2020, from <https://www.ready.gov/heat>
- Dirlikov, E., Ryff, K. R., Torres -Aponte, J., Thomas, D. L., Pérez - Padilla, J., Muñoz-Jordán, J., ... Rivera - García, B. (2016, May 6). Update: Ongoing Zika Virus Transmission - Puerto Rico, November 1, 2015 - April 14, 2016. *Morbidity and Mortality Weekly Report*, 65(17), 451-455. Retrieved December 29, 2025, from <https://www.cdc.gov/mmwr/volumes/65/wr/pdfs/mm6517.pdf>
- DNER. (2006, Marzo). Incendios Forestales en Puerto Rico. *Hojas de Nuestro Ambiente*, pp. 1 - 2.
- DNER. (2015). *Informe sobre la sequía de 2014-2016 en Puerto Rico*. San Juan, PR: Division de Monitoreo del Plan de Aguas.
- DNER. (2016). *Informe sobre la sequía 2014 - 16 en Puerto Rico*. San Juan, PR: Departamento de Recursos Naturales y Ambientales.

- DNER. (2021). *Puerto Rico Forest Action Plan*. <https://www.drna.pr.gov/documentos/planes-de-manejo/puerto-rico-forest-action-plan-2021/>; Puerto Rico Department of Natural and Environmental Resources . Retrieved from <https://www.drna.pr.gov/documentos/planes-de-manejo/puerto-rico-forest-action-plan-2021/>
- DNER. (2021). *Puerto Rico Forest Action Plan, 2021*. San Juan, PR: DNER.
- DNER. (2021). *The Puerto Rico Forest Action Plan*. The Puerto Rico Department of Natural and Environmental Resources. Retrieved from <https://www.drna.pr.gov/documentos/planes-de-manejo/puerto-rico-forest-action-plan-2021/>
- DOE. (2023, October 25). *Protecting our Electric Grid from Wildfire*. Retrieved December 16, 2025, from <https://www.energy.gov/gdo/articles/protecting-our-electric-grid-wildfire>
- Ecoexploratorio. (2000). *¿Qué son las inundaciones?*
- Eliot, J. W., Cloyd, T. E., & Philbin, M. (1994). Impacts of Landslides on an Ecosystem. *ASAE International Winter Meeting*. Atlanta, GA.
- EPA. (2012). Cool Pavements. In *Reducing Urban Heat Islands: Compendium of Strategies*.
- EPA. (2025, September 2). *Heat Island*. Retrieved December 17, 2025, from What are Heat Islands?: <https://www.epa.gov/heatislands/what-are-heat-islands>
- FBI & DHS. (2023). *Strategic Intelligences Assessment and Data on Domestic Terrorism*.
- FEMA. (1997). *Multi - Hazard Identification and Risk Assessment: A Cornerstone of the National Mitigation Strategy*. Federal Emergency Management Administration.
- FEMA. (1997). *Multi- Hazard Identification and Risk Assessment: A Cornerstone of the National Mitigation Strategy*.
- FEMA. (1997). *Multi-Hazard Identification and Risk Assessment: A Cornerstone of the National Mitigation Strategy*.
- FEMA. (2013). *Federal Guidelines for Inundation Mapping of Flood Risk Associated with Dam Incidents and Failures - FEMA P-946*.
- FEMA. (2018). *Threat and Hazard Identification and Risk Assessment (THIRA) and Stakeholder Preparedness Review (SPR) Guide*.
- FEMA. (2021). *National Incident Management System*.
- FEMA. (2023, July). *fema.gov*. Retrieved November 24, 2025, from Community Lifelines Implementation Toolkit: https://www.fema.gov/sites/default/files/documents/fema_lifelines-toolkit-v2.1_2023.pdf
- FEMA. (2024, February 20). *2.7 Community Lifelines: The HAZMAT Lifeline*. Retrieved December 28, 2025, from <https://www.fema.gov/oet-tools/chemical-incident-consequence-management/2/7>
- FEMA. (2024). *Federal Guidelines for Dam Safety*. DHS.
- FEMA. (2024). *Hazus Earthquake Model User Guidance*.
- FEMA. (2024). *Natural and Nature-based Solutions Job Aid for Stormwater Management in Puerto Rico*.
- FEMA. (2025). *Local Mitigation Planning Handbook*.
- FEMA. (2025). *Local Mitigation Planning Policy Guide*.

- FEMA. (2025, May 9). *National Dam Safety Program*. Retrieved April 20, 2026, from Resources for the General Public: <https://www.fema.gov/grants/mitigation/learn/dam-safety/resources-general-public>
- FEMA. (2025). *National Risk Index Data - Technical Documentation*.
- FEMA. (2025). *Reducing Damage from Localized Flooding*.
- FEMA. (n.d.). *Puerto Rico Earthquakes DR-4473-PR*. Retrieved December 15, 2025, from <https://www.fema.gov/disaster/4473>
- Fox, S., Agyemang, F., Hawker, L., & Neal, J. (2024). Integrating social vulnerability into high-resolution global flood risk mapping. *Nature Communication*, 15. doi:<https://doi.org/10.1038/s41467-024-47394-2>
- Gill, J. C., & Malamud, B. D. (2017). Anthropogenic processes, natural hazards, and interactions in a multi-hazard framework. *Earth-Science Reviews*, 246 - 269.
- Gould, W. (2008). Editorial. *AMBIO: A Journal of the Human Environment*, 37(7), 521,.
- Guibert, G., & Hyde, I. (2021). *Analysis: COVID-19's impact on Arts and Culture*. Argonne National Laboratory.
- Guo, Q., & Lee, D. C. (2021). The Ecology of COVID-19 and Related Environmental and Sustainability Issues. *Ambio*.
- Guzmán-Colon, B., Guido, Z., Amaya-Ardilla, C. P., Cabrera-Rivera, L. T., & Méndez-Lázaro, P. A. (2025). Heat Risk Perception and Vulnerability in Puerto Rico: Insights for Climate Adaptation in the Caribbean. *International Journal of Environmental Research and Public Health*, 22(1197). doi:<https://doi.org/10.3390/ijerph22081197>
- Hernández - Padilla, J. A., & Méndez-Piñero, M. I. (2020). Economic Impact of the COVID-19 Pandemic in Puerto Rico. *Proceedings of the 9th Annual World Conference of the Society for Industrial and Systems Engineering 2020 SISE Virtual Conference*, (pp. 90-95). Retrieved January 5, 2026, from <https://ieworldconference.org/content/SISE2020/Papers/Hernandez-Padilla.pdf>
- Hernández - Torres, R., Martínez - Lozano, M., Torres, I., Rosario - Hernández, E., Ramos - Pibernus, A., Soto, A., . . . Rivera - Segarra, E. (2023). The impact of the Covid-19 pandemic and previous natural disasters on the mental health of healthcare workers in Puerto Rico. *PLOS Global Public Health*, 3(5). Retrieved January 5, 2026, from file:///C:/Users/PITR4955/Downloads/journal.pgph.0001784.pdf
- Highland, L. M., & Bobrowsky, P. (2008). *The Landslide Handbook - A Guide to Understanding Landslides*. Reston, VA: USGS.
- Highways Industry. (n.d.). *Highways Industry.com*. Retrieved January 2, 2026, from <https://www.highwaysindustry.com/impact-extreme-heat-roads/>
- Hirsh, G. B., & Centeno - Marín, H. (2015). The Puerto Rico Emergency Preparedness Model. *Proceedings of the System Dynamics Society*. Retrieved January 4, 2026, from <https://proceedings.systemdynamics.org/2015/papers/P1186.pdf>
- IFRC. (2023, August 8). *Landslides*. Retrieved December 28, 2025, from <https://epidemics.ifrc.org/manager/disaster/landslides>
- Institute for Environmental Research and Education. (2025). *How Do Tsunamis Impact the Environment*. Retrieved December 28, 2025, from <https://iere.org/how-do-tsunamis-impact-the-environment/>

- Jessen, J. (2025, June 30). *Energy Digital*. Retrieved December 17, 2025, from <https://energydigital.com/news/climate-change-how-heatwaves-are-affecting-power-grids>
- Kerber, S., & Alkoins, D. (2024). *Lahaina Fire Incident Analysis Report*. Columbia, MD: Fire Safety Research Institute.
- Lander, J. F., Whiteside, L. S., & Lockridge, P. A. (2002). A Brief History of Tsunamis in the Caribbean Sea. *Science of Tsunami Hazards*, 20(1). Retrieved December 27, 2025, from https://www.proyecto1867.com/uploads/8/6/3/9/86396506/lander_et_al._2002_.pdf
- Larsen, M., & Torres-Sanchez, A. (1998). The frequency and distribution of recent landslides in three montane tropical regions of Puerto Rico. *Geomorphology*, 309-331.
- Larsen, M., & Park, J. (1997). How wide is a road? The association of roads and mass-wasting in a forested montane environment. *Earth Surface Processes and Landforms*, 835-848.
- Lugo, A. E., Miranda Castro, L., Abel, V., López, T., Hernández Prieto, E., García Martinó, A., . . . Helmer, E. (2021). *Puerto Rican Karst - A Vital Resource*. Forest Service, United States Department of Agriculture. USFS.
- Méndez - Lázaro, P. A., Di Napoli, C., Rivas - Tumanyan, S., Pérez Ríos, N., González Sepulveda, L., Rodríguez, E., . . . Milán, L. (2025). Too hot and too humid in the Caribbean: Impacts of extreme heat events and non-accidental mortality in the tropical island of Puerto Rico. *The Journal of CLimate and Healt*.
- Muche, M., Yemata, G., Molla, E., Muasya, A., & Tsegay, B. (2022). COVID-19 Lockdown and Natural Resources: A Global Assessment on the Cahllenges, Opportunities and the Way Forward. *Bulleting of the National Research Centre*, 46(20).
- Municipality of Aguas Buenas. (2011). *Plan Territorial: Adendum del Memorial (Datos Oficiales Censo 2010)*. Aguas Buenas: Municipio de Aguas Buenas.
- Municipality of Aguas Buenas. (2011). *Plan Territorial: Memorial de Plan Final*. Aguas Buenas: Municipio de Aguas Buenas.
- Municipality of Aguas Buenas. (2011). *Plan Territorial: Programa de Actuación*. Aguas Buenas: Municipality of Aguas Buenas.
- Municipality of Aguas Buenas. (2020). *Plan de Mitigacion contra Peligros Naturales*. Aguas Buenas: Municipio de Aguas Buenas.
- Municipality of Bayamón. (2018). *Plan de Mitigación Multi-Riesgos 2018 (All Hazard Local Mitigation Plan)*. Bayamón, PR: Oficina de Planificación y Ordenamiento Territorial.
- National Institute of Building Sciences. (2020). *2020 NEHRP Recommended Seismic Provisions: Design Examples, Training Materials; and Design Flow Chart*. FEMA. Retrieved April 28, 2026, from https://www.fema.gov/sites/default/files/documents/fema_nehrp_design-examples-training-materials_volume-1.pdf
- National Integrated Heat Health Information System. (n.d.). *Heat.gov*. Retrieved noviembre 12, 2025, from Urban Heat Islands: <https://heat.gov/urban-heat-islands/>
- NIST. (n.d.). Retrieved November 26, 2024, from Infrastructure: <https://www.nist.gov/infrastructure>

- NMEAD. (2021). *Plan Estatal de Mitigación de Peligros Naturales de Puerto Rico*. San Juan, PR: Negociado de Manejo de Emergencias y Administración de Desastres.
- NOAA. (2022). *Centers for Environmental Information*. Retrieved January 2, 2026, from State Climate Summaries: Puerto Rico and the US Virgin Islands: <https://statesummaries.ncics.org/chapter/pr/>
- NOAA. (2025). *National Centers for Environmental Information*. Retrieved December 28, 2025, from <https://www.ncei.noaa.gov/stormevents/choosedates.jsp?statefips=99%2CPUERTO+RICO>
- Okamura, K., Fujisawa, A., Kondo, Y., Fujimoto, Y., Uozu, T., Kaner, S., & Mizoguchi, K. (2013). The Great East Japan Earthquake and cultural heritage: towards an archeology of disaster. *Antiquity*, 87, 258-269.
- PRDH. (2022). *Resumen ejecutivo: Situación de la epidemia del COVID-19 en Puerto Rico año 2021*. Retrieved January 5, 2026, from <https://www.salud.pr.gov/CMS/DOWNLOAD/8708>
- PRDOH. (2025). *Puerto Rico Mitigation Action Plan, CDBG-MIT*. San Juan, PR: Puerto Rico Department of Housing.
- PREMB. (2021). *2021 Puerto Rico State Natural Hazards Mitigation Plan*.
- PRPB. (2014). *Plan de Manejo del Area de Planificación Especial del Carso*.
- PRPB. (2015). *Plan de Uso de Terrenos, Guías de Ordenación del Territorio*. San Juan, PR: Junta de Planificación.
- PRPB. (2021). *Special Flood Hazard Areas Regulation*.
- PRPB. (2023). *Reglamento para la evaluación y expedición de permisos relacionados al desarrollo, uso de terrenos y operación de permisos*. San Juan, PR: Junta de Planificación.
- PRSN. (n.d.). Retrieved December 27, 2025, from <http://www.prsn.uprm.edu/Spanish/tsunami/historia.php>
- PRSN. (2019). *Red Sísmica de Puerto Rico*. Retrieved enero 13, 2020, from <http://redsismica.uprm.edu/Spanish/educacion/terremotos/>
- PRSN. (2025). *Puerto Rico Seismic Network*. Retrieved December 15, 2025, from <https://redsismica.uprm.edu/english/education/prediction.php>
- PRSN. (2025). *Red Sísmica de Puerto Rico*. Retrieved December 15, 2025, from Resumen Preliminar de actividad sísmica anual para el 2024: https://redsismica.uprm.edu/spanish/sismicidad/reportes/anales/Informe_Anual_2024.pdf
- PRSN. (2025). *Seismic Information*. Retrieved December 26, 2025, from Earthquake of 1918: <http://www.prsn.uprm.edu/English/information/quake1918.php>
- PRSN. (n.d.). *Red Sísmica de Puerto Rico*. Retrieved December 15, 2025, from Reporte de Sismicidad: <https://redsismica.uprm.edu/spanish/sismicidad/reportes/>
- Public-Private Analytic Exchange Program. (2025). *Implications of Extreme Weather Events on U.S. Telecommunications Infrastructure*. DHS.
- Rigau-Pérez, J., & Vallejo - Calzada, E. D. (2020, march). Measles, Malnutrition and Mortality. *Puerto Rico Health Science Journal*, 39(1), 20 - 27. Retrieved December 29, 2025, from

- https://issuu.com/coleccionpuertorriquena/docs/rigau_vallejo_measles_in_pr_1917-1918_prhsj_2020
- Robbins, A. M., Eckelmann, C., & Quiñones, M. (2009). Forest Fires in the Insular Caribbean. *Ambio: A Journal of the Human Environment*, 37:528-534.
- Rodríguez, D. M., Madwell, Z. J., Torres, J. M., Rivera, A., Wong, J. M., Santiago, G. A., . . . Adams, L. E. (2024, December 12). Epidemiology of Dengue - Puerto Rico, 2010 - 2024. *Morbidity and Mortality Weekly Report*. Retrieved December 29, 2025, from <https://www.cdc.gov/mmwr/volumes/73/wr/pdfs/mm7349a1-H.pdf>
- Rosario Urrutia, M. (2021, February 12). *Puerto Rican Endowment for the Humanities - Encyclopedia of Puerto Rico*. Retrieved December 29, 2025, from From the forgotten Flu Pandemic in Puerto Rico, 1918-1919, to the beginning of Covid-19 in 2020: <https://en.encyclopediapr.org/content/from-flu-pandemic-1918-to-covid19-puerto-rico/>
- Sánchez - Plazas, L. C., García - De Jesús, R., Martínez - González, K. G., Amaya - Ardila, C. P., & Almodóvar - Rivera, I. A. (2024). The psychological impact of the COVID-19 pandemic on physicians in Puerto Rico: a cross-sectional study after the second wave in 2021. *Psychiatry*, 14. Retrieved January 5, 2026
- Sandia National Laboratories. (n.d.). *Wildfire Electric Grid Resilience*. Retrieved December 16, 2025, from <https://energy.sandia.gov/programs/electric-grid/wildfire-electric-grid-resilience/>
- Schumann, III, R., Emrich, C., Busic, V., Mockrin, M., Zhou, Y., Johnson - Gaither, C., . . . Aksha, S. (2024). The Geography of Social Vulnerability and Wildfire Occurrence (1984 - 2018) in the Conterminous USA. *Natural Hazards*, 120, 4297 - 4327. doi:<https://doi.org/10.1007/s11069-023-06367-2>
- Sharp, T. M., Roth, N. M., Torres, J., Ryff, K., Pérez Rodríguez, N., Mercado, C., . . . Rivera García, B. (2014, December 5). Chikungunya Cases Identified Through Passive Surveillance and Household. *Morbidity and Mortality Weekly Report*. Retrieved December 29, 2025, from <https://www.cdc.gov/mmwr/pdf/wk/mm6348.pdf>
- SNOFLO. (2026). *Carite Dam Report*. Retrieved January 4, 2026
- SNOFLO. (2026). *Cidra Dam Reservoir Report*. Retrieved January 2, 2026, from <https://snoflo.org/reservoir/puerto-rico/pr00020-cidra-dam>
- Soler - López, L. R. (2010). *Sedimentation Survey of Lago de Cidra, Puerto Rico*. Retrieved January 2, 2026, from <https://pubs.usgs.gov/sim/3118/>
- Stein, S. M., Comas, S. J., Menakis, J. P., Carr, M. A., Steward, S. I., Cleveland, H., . . . Radeloff, V. (2013). *Wildfire, Wildlands and People: Undertaking and preparing for Wildfire in the Wildland-Urban Interface - a Forest on the Edge Report*. Fort Collins, CO: US Department of Agriculture - Forest Service, Rocky Mountain Research Station.
- Thomas, D. L., Sharp, T. M., Torres, J., Armstrong, P. A., Muñoz-Jordán, J., Ryff, K. R., . . . Rivera - García, B. (2016, February 19). Local Transmission of Zika Virus — Puerto Rico,. *Morbidity and Mortality Weekly Report*, 65(6). Retrieved December 29, 2025, from <https://www.cdc.gov/mmwr/volumes/65/wr/pdfs/mm6506e2.pdf>
- Timothee, R. A., Morris, L., Filiberti, M., & Mainardi, L. E. (1963). Epidemic of Poliomyelitis in Puerto Rico, 1960. *Public Health Reports*, 78(1), 65 - 76.
- UNESCO. (2021). *World Heritage in the Face of COVID-19*.

US Census Bureau. (2024, September 26). *Resource Library*. Retrieved February 10, 2025, from Tools for Vulnerable Populations in Puerto Rico: <https://www.census.gov/library/stories/2024/09/cre-pr-tools.html>

US Census Bureau. (2025). *Census Data*. Retrieved November 21, 2025, from <https://data.census.gov/table/ACSST5Y2023.S1701?g=050XX00US72021>

US Census Bureau. (2025). *Census Data*. Retrieved November 21, 2025, from <https://data.census.gov/table/ACSST5Y2023.S0101?g=050XX00US72021>

US Census Bureau. (2025). *Census Data*. Retrieved November 30, 2025, from S1810 Disability Characteristics: <https://data.census.gov/table/ACSST5Y2023.S1810?g=050XX00US72021>

US Census Bureau. (2025). *Data Census*. Retrieved November 21, 2025, from <https://data.census.gov/table?g=050XX00US72021>

US Census Bureau. (2025). *Data Census*. Retrieved November 30, 2025, from S1810 Disability Characteristics: <https://data.census.gov/table/ACSST5Y2018.S1810?g=050XX00US72021>

US Census Bureau. (2025). *Data Census*. Retrieved November 30, 2025, from S2201: Food Stamps/Supplemental Nutrition Assistance Program: <https://data.census.gov/table/ACSST5Y2023.S2201?g=050XX00US72021>

US Drought Monitor. (2025). *Data*. Retrieved December 16, 2025, from Time Series: <https://droughtmonitor.unl.edu/DmData/TimeSeries.aspx>

US Fire Administration. (2025, December 16). *What is the WUI?* Retrieved from <https://www.usfa.fema.gov/wui/what-is-the-wui/>

USACE. (2019). *LifeSim: Flood life-loss estimation model - Technical reference manual*.

USACE. (2020). *Safety of Dams- Policy and Procedures*.

USACE. (2021). *HEC-RAS river analysis system user's manual*.

USACE. (2022, May 11). *National Inventory of Dams*. Retrieved January 4, 2026, from Cidra Dam: <https://nid.sec.usace.army.mil/nid/#/dams/system/PR00020/inspections>

USACE. (2022, May 11). *National Inventory of Dams*. Retrieved January 4, 2026, from Carite Dam: <https://nid.sec.usace.army.mil/nid/#/dams/system/PR00021/inspections>

USACE. (2022, May 11). *National Inventory of Dams*. Retrieved January 4, 2026, from <https://nid.sec.usace.army.mil/nid/#/dams/system/PR00018/inspections>

USACE. (2022, May 11). *National Inventory of Dams*. Retrieved January 4, 2026, from <https://nid.sec.usace.army.mil/nid/#/dams/system/PR00019/summary>

USACE. (2023, May). *Congresional Fact Sheets 2025*. Retrieved December 29, 2025, from Guajataca Dam Repairs: <https://www.saj.usace.army.mil/About/Congressional-Fact-Sheets-2025/Guajataca-Dam-Repairs-PR-C/>

USACE. (n.d.). *Publications*. Retrieved April 20, 2026, from Risk - Informed safety Program: https://www.publications.usace.army.mil/Portals/76/Publications/EngineerPamphlets/EP_360-1-31.pdf

USACE. (n.d.). *Value to the Nation*. Retrieved December 22, 2025, from Flood Risk Mgmt: Economic Impact: <https://www.iwr.usace.army.mil/Missions/Value-to-the-Nation/Flood-Risk-Mgmt/Flood-Risk-Economic-Impact/>

USDOT - FRA. (2013). *Track Buckling Prevention: Theory, Safety Concepts, and Applications*. Washington DC: Office of Research and Development.

- USFS. (n.d.). *Fire Effects Information System*. Retrieved December 16, 2025, from <https://www.fs.usda.gov/database/feis/glossary.html#SCATTER-HOARD>:
- USGS. (2014). *Puerto Rico's Rainfall Deficit Indicates Drought*. Retrieved December 23, 2025, from <https://www.usgs.gov/news/state-news-release/puerto-ricos-rainfall-deficit-indicates-drought>
- USGS. (2016). *Caribbean - Florida Water Science Center*. Retrieved December 23, 2025, from Drought Conditions in Puerto Rico: <https://www.usgs.gov/centers/caribbean-florida-water-science-center-%28cfwsc%29/science/drought-conditions-puerto-rico>
- USGS. (2019, August 6). *Earthquake Hazards 201 Technical Q&A*. Retrieved April 28, 2026, from <https://www.usgs.gov/programs/earthquake-hazards/science/earthquake-hazards-201-technical-qa>
- USGS. (2020). *La duración potencial de las réplicas del terremoto 2020 del suroeste de Puerto Rico*. Reston Virginia: Servicio Geológico de EE. UU.
- USGS. (2024, September 10). Retrieved December 15, 2025, from Moment magnitude, Richter scale- what are the different magnitudes scales, and why are there so many?: <https://www.usgs.gov/faqs/moment-magnitude-richter-scale-what-are-different-magnitude-scales-and-why-are-there-so-many>
- USGS. (n.d.). *Earthquake Hazard Program*. Retrieved December 15, 2025, from Earthquake Hazards Program M 6.4 - 4 km SSE of Indios, Puerto Rico: <https://earthquake.usgs.gov/earthquakes/eventpage/us70006vll/executive#d>
- USGS. (n.d.). *Topoview*. Retrieved Noviembre 12, 2025, from <http://ngmdb.usgs.gov/topoview/#13/18.3925/-661240>
- Vega Lugo, R. (2021, February 21). *Enciclopedia de Puerto Rico*. Retrieved December 29, 2025, from El cólera morno en Puerto Rico, 1855 a 1856: <https://enciclopediapr.org/content/el-colera-morbo-en-puerto-rico-1855-a-1856/>
- Ware-Gilmore, F., Rodríguez, D. M., Ryff, K., Torres, J. M., Pérez Vélez, M., Torres - Toro, C. T., . . . Marzán-Rodríguez, M. (2025, February 20). Dengue Outbreak and Response — Puerto Rico, 2024. *Morbidity and Mortality Weekly Report*, 74(5). Retrieved December 29, 2025, from <https://www.cdc.gov/mmwr/volumes/74/wr/pdfs/mm7405-H.pdf>
- Weilert, L., & Laó-Dávila, D. (2023, August). Fault structure and segmentation of the Punta Moltalva Fault in southwestern Puerto Rico using high-resolution digital elevation models. *Tectonophysics*.
- West, J., Rodríguez Cruz, L. A., & Hughes, K. (2023). Assessing Social Vulnerability to Landslides in Rural Puerto Rico. *Natural Hazards Center Public Health Disaster Research Report Series*. Retrieved February 10, 2025, from <https://hazards.colorado.edu/public-health-disaster-research/steep-risks>
- WHO. (2025). *Floods*. Retrieved December 22, 2025, from https://www.who.int/health-topics/floods/#tab=tab_1
- World Bank. (n.d.). *Climate Knowledge Portal*.
- World Bank. (n.d.). *Think Hazard*. Retrieved from <https://www.thinkhazard.org/en/report/200-puerto-rico-u-s/WF>
- Zhang, R., Ji, H., Pang, Y., & Suo, L. (2022). The Impact of COVID-19 on Cultural Industries: An Empirical Research Based on Stock Market Returns. *Frontiers in Public Health*.

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JUNTA DE

PLANIFICACIÓN

GOBIERNO DE PUERTO RICO

Carta de Compromiso sobre el Plan de Mitigación Municipal

El Municipio de Aguas Buenas, representado en este acto por su alcalde, Hon. Karina Nieves Serrano, 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.



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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.

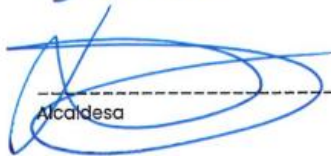
Se coordinará por parte del municipio la recopilación de información necesaria que sea requerida, incluyendo:

- 
- 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 a la alcaldesa, según corresponda.

Por lo que, de acuerdo con este compromiso, yo, Karina Nieves Serrano, lo firmo conforme a los mejores intereses del pueblo de Aguas Buenas.

En Aguas Buenas, Puerto Rico, hoy 17 de diciembre de 2025.



Alcaldesa

NOTIFICACIÓN DE DESIGNACIÓN
Comité de Planificación del Municipio de Aguas Buenas

Yo, Hon. Karina Nieves Serrano, alcaldesa del Municipio de Autónomo de Aguas Buenas, 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 Aguas Buenas*, 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.)
Gerardo Cárdena	Director /Planificación		787-732-4700 ext.2474
Melissa García	Secretaría/ Planificación	mgarcia@aguasbuenaspr.net	787-732-4700 ext.2131
Iliana Aponte	Directora/Programas Federales	iaponte@aguasbuenaspr.net	787-732-4700 ext.2101
Juan Ortiz Rivera	Director/Finanzas y Presupuesto	jortiz@aguasbuenaspr.net	787-732-4700 ext.2412

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, 20 de enero de 2026

Hon. Karina Nieves Serrano
Nombre


 Firma _____
 Alcaldesa Municipio de Aguas Buenas



JUNTA DE

PLANIFICACIÓN

GOBIERNO DE PUERTO RICO

FORMULARIO PARA DESIGNAR PERSONA(S) CONTACTO(S) PLAN DE MITIGACIÓN CONTRA PELIGROS NATURALES

Municipio: Aguas Buenas

	Nombre	Teléfono	Correo electrónico
Personal Designado	<u>Juan J. Rivera</u>	<u>787-381-3335</u>	<u>jrivera@aguasbuenas.pr.gov</u>
Personal Alterno			

Hon. Karina Nieves Serrano
Nombre (letra de molde)
Alcalde

Firma
Alcalde

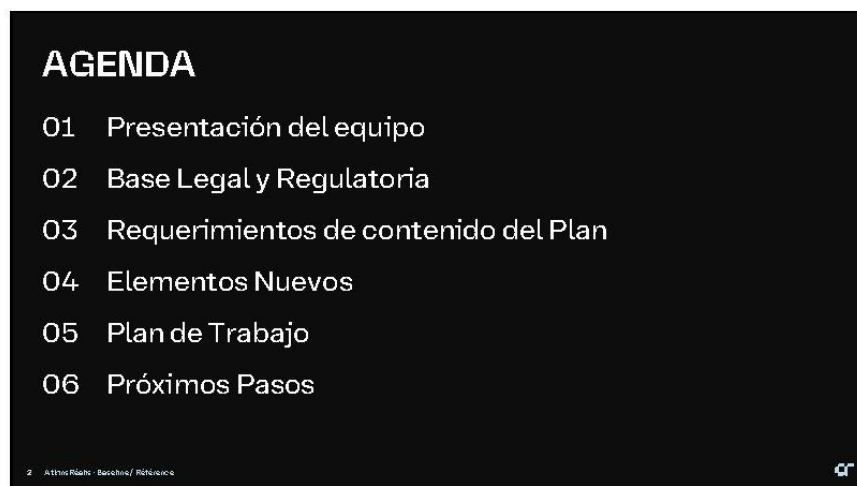
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1



2

1

Equipo de Trabajo



AtkinsRéalis - Baseline / Référence

3

Equipo de Trabajo

William Pitre, Senior Planner

Ivelisse Gorbea, Senior Planner

Celso Ruiz, Data Analyst

Marsha Caride, Administrative Assistant

4

2

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



Leonardo
Pérez

Barranquitas



Leonardo
Pérez

Comerio



Mario
González

Salinas



Armando
Rodríguez

Santa
Isabel



Armando
Rodríguez

Vieques



Mario
González

6

3

Base Regulatoria

7 Atina Rósis - Becerra / Rósis



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 Atina Rósis - Becerra / Rósis

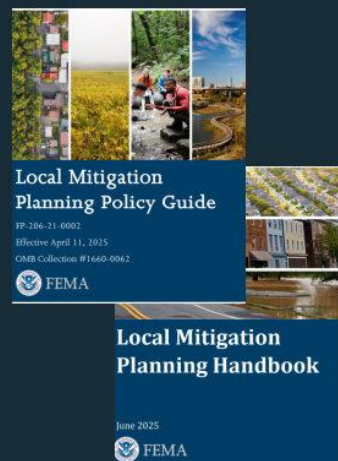


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4

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 Atina Rósis - Becerra / Rósis

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

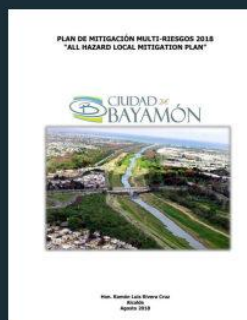


10 Atina Rósis - Becerra / Rósis

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.

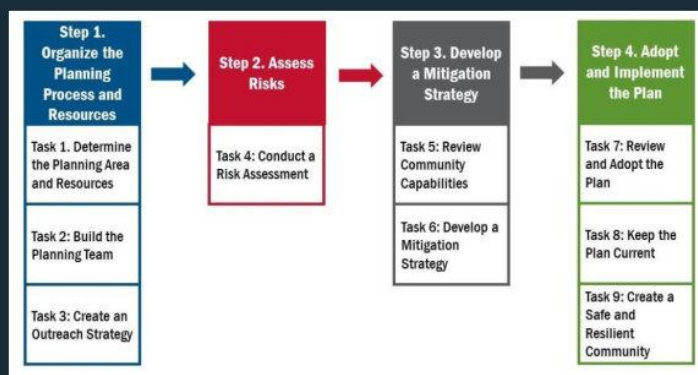


Element E: Plan Update		
Element E Requirements	Location in Plan (section and/or page number)	Met / Not Met
E1: Was the plan revised to reflect changes in development? (Requirement 44 CFR § 201.6(d)(2))		
E2: Does the plan describe the changes in development that have occurred in hazard-prone areas that have increased or decreased each community's vulnerability since the previous plan was approved?	Click or tap here to enter text.	Choose...

11 Attn: Rdah - Bache/ Rdah/ucw

11

Proceso del Plan de Mitigación



12 Attn: Rdah - Bache/ Rdah/ucw

[Local Mitigation Planning Handbook](#)

12

Riesgos a Evaluar

13 Atino Rósis - Becaria/ Rósis/roce



13

Peligros a considerar



Terremoto



Modificaciones
costeras



Marejada
Ciclónica



Fuego Forestal



Deslizamientos



Inundaciones



Calor Extremo



Pandemia/
Epidemia



Tsunami



Ciclones Tropicales



Sequías

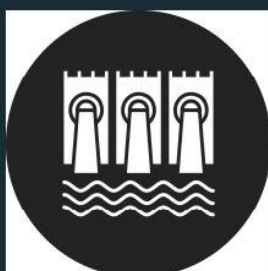
14 Atino Rósis - Becaria/ Rósis/roce



14

7

Represas



Aguas
Buenas



Comerío

16 Attns Río de la Plata / Referencia



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.



Actualización de capacidades

16 Attns Río de la Plata / Referencia



16

Evaluación de Capacidades

17. Ateneo Río de la Plata / Referencia



17

Capacidades

Planificación y
Reglamentación

Técnica

Financiera

Alcance
Comunitario

Desarrollo de
Capacidades

18. Ateneo Río de la Plata / Referencia



18

9

Participación Ciudadana

19 Atlix Róbal - Baobab/ RHN/roca



19

Participación Ciudadana

- Dos reuniones de participación ciudadana.
- Notificación será publicada por Junta de Planificación.
- Publicar 15 días antes de la reunión
- Se otorga 15 días para comentarios
- Para la Segunda reunión se discute el primer borrador.
- El primer borrador será comentado por el público, el municipio y la Junta de Planificación



20 Atlix Róbal - Baobab/ RHN/roca



20

Ventana para la primera actividad de participación ciudadana

2 de marzo al 13 de marzo

Debe informar su fecha de reunión 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 Attn: Róbal - Bacheval - Róbal



21

Comunicación

22 Attn: Róbal - Bacheval - Róbal



22

11



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

Atkins Réalis

23

Grupos de Trabajo

Atkins Réalis - Bahamas / República

24



25

13

MINUTA

PROYECTO:	PRPB 25 LHMP Update		
TITULO:	First Committee Meeting		
LUGAR DE LA REUNIÓN:	Junta de Planificación Salón B	# REUNIÓN:	1
FECHA Y HORA:	2/9/2026 @ 9:00am	MINUTA POR:	Leonardo Pérez García

Lista de Asistencia:

NOMBRE	INICIALES	COMPAÑÍA
Juan Ortiz	JO	Municipio de Aguas Buenas
Leonardo Pérez	LPG	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 con el municipio de Aguas Buenas - Luego de la presentación, se inició la mesa de trabajo con el municipio de Aguas Buenas. L. Pérez se presentó y ofreció un breve trasfondo de su experiencia como ingeniero.

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	ASUNTOS DISCUTIDOS
	▪ L. Pérez solicitó que el municipio confirmara el Punto de Contacto (POC). J. Ortiz indicó que fue designado como el POC. ▪ Se repasó parcialmente la lista del "Local Hazard Mitigation Plan" (LHMP) anterior para que el municipio identificara el estatus actual de las acciones incluidas en dicho plan. Se le indicó a J. Ortiz que las acciones deben modificarse para que tengan la codificación de identificación correcta dentro del plan. Dentro de las acciones, tenemos los siguientes estatus actuales: ○ Acción #3 – J. Ortiz indicó que la acción se está trabando dentro del Plan de Escorrentía. ○ Acción #7 – J. Ortiz indicó que el municipio le ha hecho el acercamiento a Departamento de Transportación y Obras Públicas (DTOP) y a la Oficina de Permisos (OPE) para atender y mitigar la acción. ○ Acción #8 – J. Ortiz indicó que se encuentra en fase de diseño para desarrollar un puente elevando bajo fondos de "Community Development Block Grant Mitigation Funds (CDBG-MIT). ○ Acción #9 – J. Ortiz indicó que la medida está actualmente en subasta y ya fue clasificada como "Safe Room". ○ Acción #11 – J. Ortiz indicó que el Plan Estatal de Rehabilitación de Viviendas se adaptó localmente. ▪ L. Pérez realizó una dinámica con el municipio donde tenían que poner acciones nuevas que les gustaría incluir dentro del Plan de Mitigación. J. Ortiz mencionó dos nuevas acciones: ○ Mitigar los hundimientos de las carreteras que conectan con el casco urbano de Aguas Buenas. ○ Limpieza de alcantarillados para evitar la acumulación de agua y mejorar el drenaje de escorrentías. ▪ L. Pérez realizó otra dinámica con el municipio llamada "Planning Poker". ▪ Se le preguntó al municipio que, si recibieran fondos ilimitados para realizar un solo proyecto de mitigación, cuál sería y por qué. J. Ortiz, como único participante, respondió que realizaría una evaluación de los puentes, atarjeas y vados del municipio que presentan peligro de deslizamiento o colapso por la fuerza hidráulica de los cuerpos de agua durante eventos de crecida. L. Pérez realizó una última dinámica con J. Ortiz donde establecía la prioridad de los peligros naturales del municipio, utilizando la escala uno (1 – baja) a tres (3 – alta): ○ Ciclones Tropicales – 3 ○ Deslizamientos – 3 ○ Pandemia – 2 ○ Inundaciones – 3 ○ Calor Extremo – 1 ○ Sequías – 2 ▪ L. Pérez dio por culminada la dinámica e indicó que el correo electrónico para enviar o solicitar información es prpb.lhmp@atkinsrealis.com. También informó que es importante que, cada vez que envíen un correo electrónico, el título comience con el nombre del municipio, en este caso -Aguas Buenas, seguido de una breve descripción del contenido, con el fin de archivar y atender las comunicaciones de manera más eficiente. ▪ L. Pérez otorgó su información de email leonardo.perez@atkinsrealis.com con el POC.

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	ASUNTOS DISCUTIDOS
	J. Ortiz indicó que tiene pendiente enviar la información de la reunión con la comunidad y estarán enviando un correo electrónico para confirmar la fecha, hora y lugar.
AD-5	Discusión de Acciones por Tomar Tabla Inferior
AD-6	Coordinación Próxima Reunión TBD

Acciones Por Tomar:

ID	ACCIONES POR TOMAR	FECHA LÍMITE	ENTIDAD RESPONSABLE
AT-1	Confirmación de Fecha, hora y lugar para reunión comunitaria.	2/9/2026	Mun. Aguas Buenas
AT-2	Envío de logo el municipio.	2/9/2026	Mun. Aguas Buenas
AT-3	Enviar lista de Comité de Planificación de Aguas Buenas.	TBD	Mun. Aguas Buenas
AT-4	Enviar lista de estrategias y/o acciones nuevas para el Plan de Mitigación.	TBD	Mun. Aguas Buenas
AT-5	Enviar lista de infraestructura crítica de Aguas Buenas con coordenadas.	TBD	Mun. Aguas Buenas

Acuerdos/Aclaraciones:

ID	DESCRIPCIÓN
AC-1	N/A

Anejos:

ID	DESCRIPCIÓN ANEJO	NÚMERO DE PÁGINAS
AN-1	N/A	

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.



PRÓXIMA REUNIÓN:	TBD		
MEDIO DE DISTRIBUCIÓN:	Email		
FECHA DISTRIBUCIÓN:	02/06/2026	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.



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? RRCL B _ L AC Q CCR



JUNTA DE
PLANIFICACIÓN
GOBIERNO DE PUERTO RICO

HOJA DE ASISTENCIA



Fecha: 9 de febrero de 2026

Hora: 9:00am

Asunto: 1era Reunión -Revisión Plan de Mitigación contra Peligros Naturales

Nombre y dos apellidos	Teléfono	Municipio	Firma	Correo Electrónico
Juan Ortiz Rivera	787-7322811	Aguas Buenas		juan.ortiz@juntae.aguasbuenas.pr.gov

QCAML B NJ_L L CL E AMK K QRRCC K CCRCL E
NPCCCL R_RGML

To be included in the next draft.

B MAS K CL R_RGML

To be included in the next draft.

? NNCL B CV A8N5 `J CA N PRCA N_RQML _L B MS RPC_AF
 DPQR N5 `J CA N PRCA N_RQML K CCRCL E
 N5 `J CA L MRCCA_RQML

PLANIFICACIÓN AVISO PÚBLICO

PRIMERA REUNIÓN DE PLANIFICACIÓN CON LA COMUNIDAD

La Junta de Planificación, junto al Municipio de Aguas Buenas, invita 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 Aguas Buenas 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: 6 DE MARZO DE 2026
 HORA: 6:00 PM
 LUGAR: CASA DE ARTE Y CULTURA
 CALLE SALAS TORRES #4, BO. PUEBLO
 AGUAS BUENAS, PR

AGUAS BUENAS

PARA MÁS INFORMACIÓN, ACCEDA: JP.PR.GOV

PLANIFICACIÓN AVISO PÚBLICO

PRIMERA REUNIÓN DE PLANIFICACIÓN CON LA COMUNIDAD

La Junta de Planificación, junto al Municipio de Hatillo, invita 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.

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FECHA: 10 DE MARZO DE 2026
 HORA: 2:30 PM
 LUGAR: TEATRO JOSÉ A. MONROUZEAU
 CALLE PEDRO P. VARGAS
 HATILLO, PR

HATILLO

PARA MÁS INFORMACIÓN, ACCEDA: JP.PR.GOV

DRNA AVISO AMBIENTAL

SOBRE INTENCION DE EMITIR PERMISOS DE INYECCION SUBTERRANEA

El peticionario, Puma Energy Caribe, LLC, ha solicitado a la oficina Regional de Arecibo del Departamento de Recursos Naturales y Ambientales (DRNA) la renovación del **Permisos de Operación UIC-13-52-0005-RA** para una facilidad de inyección subterránea (FIS) Clase VII, bajo las disposiciones del Reglamento para el Control de la Inyección Subterránea (RCIS) del Programa para el Control de la Inyección Subterránea (PCIS) y la Ley Federal de Agua Potable Segura, según enmendada 42 USC 300f, et seq. (LFAPS).

La FIS consiste de un (1) tanques de retención en forma rectangular de 7 pies 6 pulgadas de largo por 18 pies de ancho por 6 pies de profundidad líquida para una capacidad de 6,563 galones para la disposición de aguas de lavado de autos de la estación Puma #378 ubicada en la Carr 155 Km 35.5 Bo. Perchas en Morovis, Puerto Rico.

Luego de realizada la evaluación correspondiente de los documentos sometidos, el DRNA tiene la intención de otorgar la renovación del permiso de operación para la instalación en conformidad con el RCIS y de la LFAPS. Esta notificación se hace para informar que el DRNA, ha preparado el borrador del permiso de operación de forma tal que el público interesado pueda someter sus comentarios con relación al mismo. El borrador de permiso contienen las condiciones y prohibiciones necesarias para cumplir con los requisitos reglamentarios aplicables.

El público puede evaluar copia de la solicitud de permiso que sometieron el peticionario ante el DRNA, el borrador de permiso y otros documentos relevantes en la oficina Regional de Arecibo del DRNA ubicada en la Avenida San Patricio #44 Marginal Carr. #2 Km 80.6 en Arecibo, Puerto Rico. Copia de dichos documentos pueden adquirirse (\$0.50 por pliego) en el antes mencionado lugar entre 7:30am y 4:00pm de lunes a viernes o escribiendo a la siguiente dirección: Departamento de Recursos Naturales y Ambientales, San Jose Industrial Park, 1375 Avenida Ponce de León, San Juan, Puerto Rico 00926.

Las partes interesadas pueden enviar sus comentarios por escrito al Sr. Luis Reyes Vazquez, Director Regional, y al Ing. Waldemar Quiles Perez, Secretario del DRNA, a la dirección postal indicada anteriormente. Los comentarios por escrito o la solicitud de vista pública deberán ser sometidos al DRNA no más tarde de treinta (30) días a partir de la fecha de publicación de este aviso. La fecha límite para someter comentarios puede ser extendida si se estima necesario o apropiado para el interés público. La solicitud para una vista pública deberá señalar la razón o razones que en la opinión del solicitante ameritan la celebración de esta. De realizarse una vista pública los interesados o afectados tendrán una oportunidad razonable para presentar evidencia o testimonio sobre si se emiten o deniegan los permisos, si el Secretario determina que dicha vista es necesaria o apropiada.

En San Juan, Puerto Rico, hoy 3 de junio de 2024.

Waldemar Quiles Pérez
 Waldemar Quiles Pérez
 Secretario

Este anuncio se publica conforme a lo requerido por la Ley Sobre Política Pública Ambiental Núm. 416 del 22 de septiembre de 2004, según enmendada. El costo del Aviso Público es sufragado por la entidad peticionaria.

San José Industrial Park, 1375 Ave Ponce de León, San Juan, PR 00926
 1787.999.2200 1 -> www.drna.pr.gov

23 EL NUEVO DÍA, Martes, 16 de febrero de 2025



Municipio de Aguas Buenas



23 feb. · 🌐

Aviso Importante



JUNTA DE
PLANIFICACIÓN
GOBIERNO DE PUERTO RICO

AVISO PÚBLICO

PRIMERA REUNIÓN DE PLANIFICACIÓN CON LA COMUNIDAD



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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 Aguas Buenas 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: 8 DE MARZO DE 2026

HORA: 6:00 PM

LUGAR: CASA DE ARTE Y CULTURA

CALLE SALAS TORRES #4, BO. PUEBLO

AGUAS BUENAS, PR



**PLANES DE MITIGACIÓN
CONTRA PELIGROS NATURALES**
Planificar para proteger

AGUAS BUENAS

PARA MÁS INFORMACIÓN, ACCEDA: JP.PR.GOV



13



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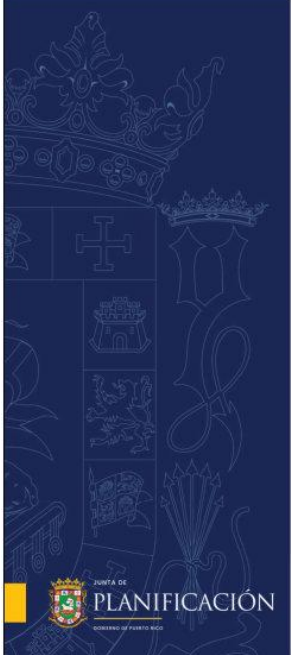


Municipio de Aguas Buenas



KCL S RCQ





AGENDA DE LA REUNIÓN

Trastondo 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



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.



OFICINA DE
PLANIFICACIÓN
GOBIERNO DEL ESTADO DE FLORIDA



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.



OFICINA DE
PLANIFICACIÓN
GOBIERNO DEL ESTADO DE FLORIDA



CICLO PARA EL MANEJO DE EMERGENCIAS



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



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.



EVALUACIÓN DE RIESGOS



Terremoto



Erosión costera/
modificaciones
costeras



Marejada
Ciclónica



Deslizamientos



Inundaciones



Calor Extremo



Tsunami



Ciclones Tropicales



Sequías



Fuego Forestal



Pandemia/
Epidemia



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:



RESULTADO DE EVALUACIÓN



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.



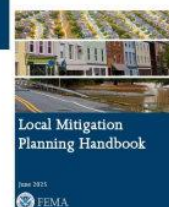
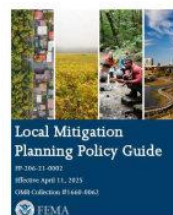
PROYECTO ACTUALIZACIÓN DE LOS PLANES DE MITIGACIÓN



ALCANCE DEL TRABAJO

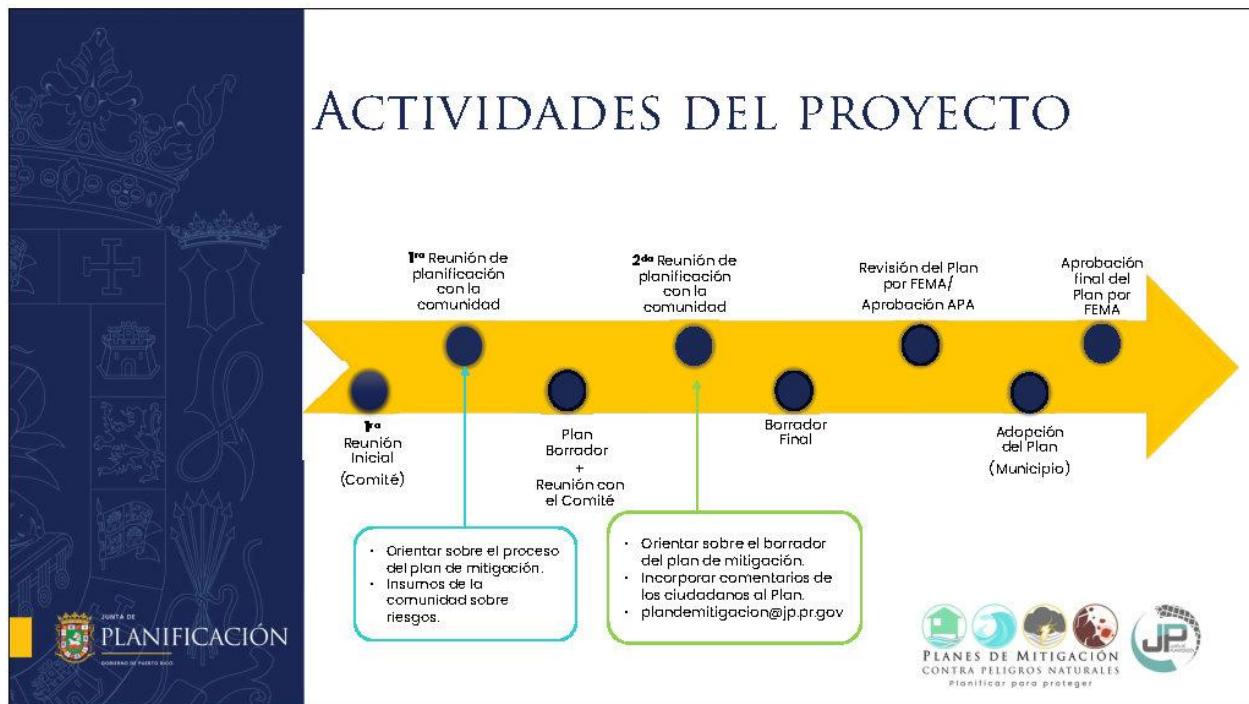
1. Revisar y actualizar los planes de mitigación contra peligros naturales de acuerdo con las nuevas guías y regulaciones.
2. Coordinar las actividades y trabajos en conjunto con el municipio y la Junta de Planificación.
3. Promover la participación ciudadana.

- Reuniones de planificación con la comunidad
- Página cibernética JP (www.jp.pr.gov)



 plandemitigación@jp.pr.gov





COMENTARIOS DE LA COMUNIDAD

Plan de Mitigación contra Peligros Naturales Agua Buena

Referencia relativa del lugar: _____

Comentario relacionado a temas de mitigación de peligros naturales:

(Describa inquietudes, riesgos identificados, sugerencias o situaciones que afecten su comunidad)

La alcantarilla que tapa el agua por
debajo de la casa. Los labores de DTOP se demoran y el
señero se está moviendo.

¿Cómo se afectó?

Fue reportado al municipio. Hasta que no llegue el
ingeniero de la zona no se puede atender por parte
del municipio.

Fecha: _____

Plan de Mitigación contra Peligros Naturales Agua BuenaReferencia relativa del lugar: Sede entrada comunidad Chacero

Comentario relacionado a temas de mitigación de peligros naturales:

(Describa inquietudes, riesgos identificados, sugerencias o situaciones que afecten su comunidad)

deslizamiento de terreno

¿Cómo se afectó?

deslizamiento

Fecha: 6/Marzo/2024

? RRCL B _ L AC Q CCRQ



HOJA DE ASISTENCIA

Asunto: 1^{ra} Reunión de Planificación con la Comunidad- Municipio de Aguas Buenas
Lugar: Casa de Arte y Cultura

Fecha: 6 de marzo de 2016
Hora: 6:00 p.m.

Nombre completo (en letra de molde)	Municipio/Barrio/ Comunidad
Juan Ortiz Rivera	Municipio Fajardo
Carlos T. Kerpner	Municipio San Juan
Melissa G. G. G.	Aguas Buenas
Leonia Araya Hernández	Aguas Buenas
Alex Gómez Rivera	Aguas Buenas
Luis A. Rodríguez	Aguas Buenas
Ilana Aponte Castellano	Mun. Aguas Buenas
Rafael Medina López	Aguas Buenas
Betzaida Rosa Ríos	Aguas Buenas
Alagna Soto Camacho	Aguas Buenas



HOJA DE ASISTENCIA

Asunto: 1^{ra} Reunión de Planificación con la Comunidad- Municipio de Aguas Buenas
Lugar: Casa de Arte y Cultura

Fecha: 6 de marzo de 2016
Hora: 6:00 p.m.

Nombre completo (en letra de molde)	Municipio/Barrio/ Comunidad
Norma L. P. P.	Aguas Buenas
Jeilyn Rivera	Aguas Buenas
Fredy Colon Melendez	Municipio San Juan

HOJA DE ASISTENCIA

Asunto: 1^{era} Reunión de Planificación con la Comunidad- Municipio de Aguas Buenas

Fecha: 4 de marzo de 2020

Lugar: Casa de Arte y Cultura

Hora: 6:00 p.m.

Nombre completo (en letra de molde)	Municipio/Barrio/ Comunidad
Aurea E. Rivera Llanos	Sector Las Drogas
Roberto Ortiz Salas	Sanidero
Dalwin Flores Rosendo	Aguas Buenas Mula
Carlos X. Cotto Román	A. B.
Maria V. Acosta Rivera	Aguas Buenas
Mayra Ocasio Pizarro	Sanidero
León Niles	Mula
Nestor L. Rivera Merced	Pueblo
Juan C. Díaz Comand	A. B.
David A. Ferrer Baez	Mun. Aguas Buenas









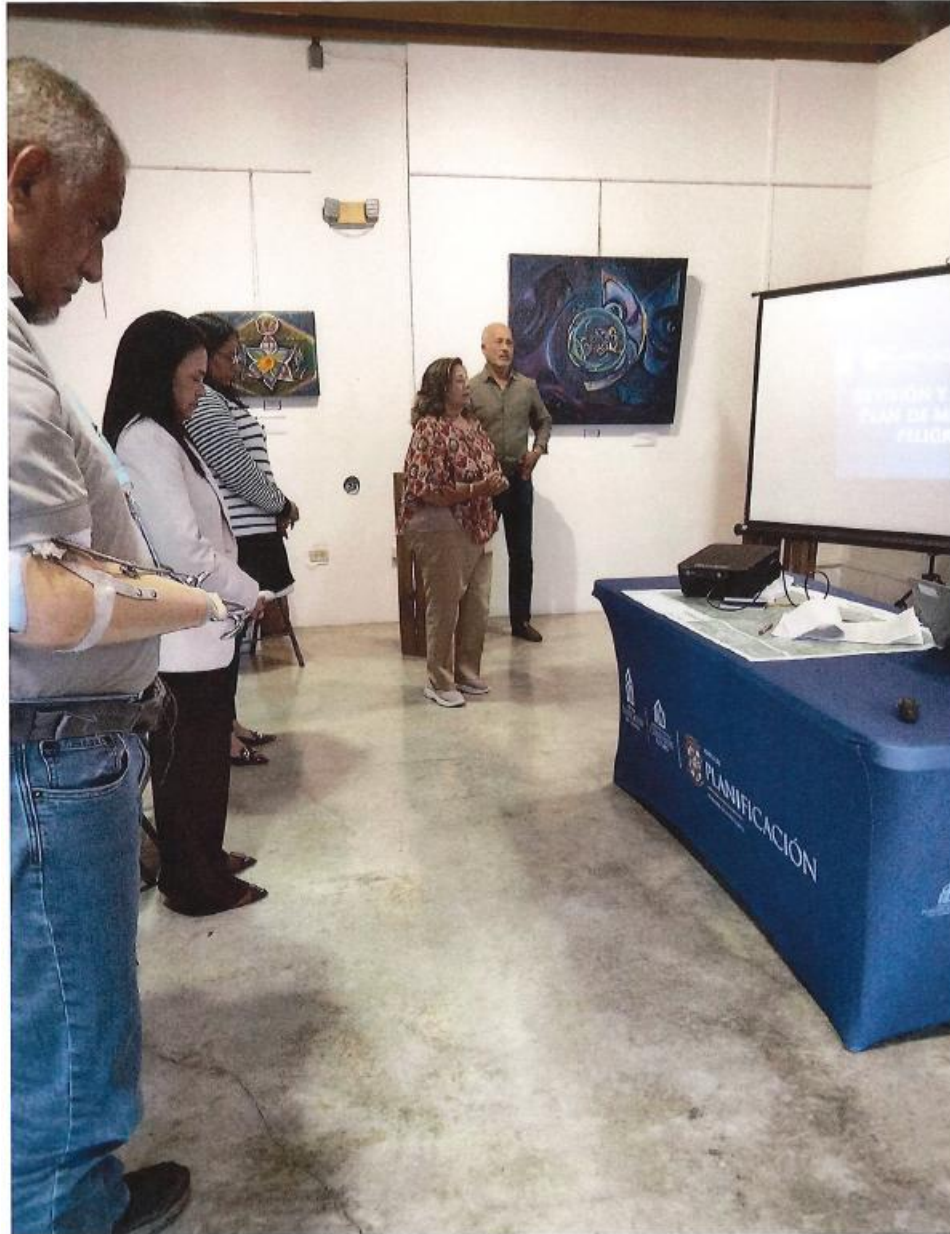














QCAML B N\$ `J GA N PRGAGN_RGML K CCRCL E

N\$ `J GA L MRCDGA_RGML

To be included in the next draft

K CL S RCQ

To be included in the next draft

NPCCQL R_RGML

To be included in the next draft

? RRCL B _L AC Q CCRQ

To be included in the next draft

NF MRME P _NF GA P CAMP B Q

To be included in the next draft

? NNCL B QV B 8QR I CF MJ B CP Q TMJ TCK CL R

? NNCL B QV C8MPE _L QX_RQML _J AF _PR



Gobierno de Puerto Rico
Municipio Autónomo de Aguas Buenas
Organigrama Organizacional
Año Fiscal 2025-2026

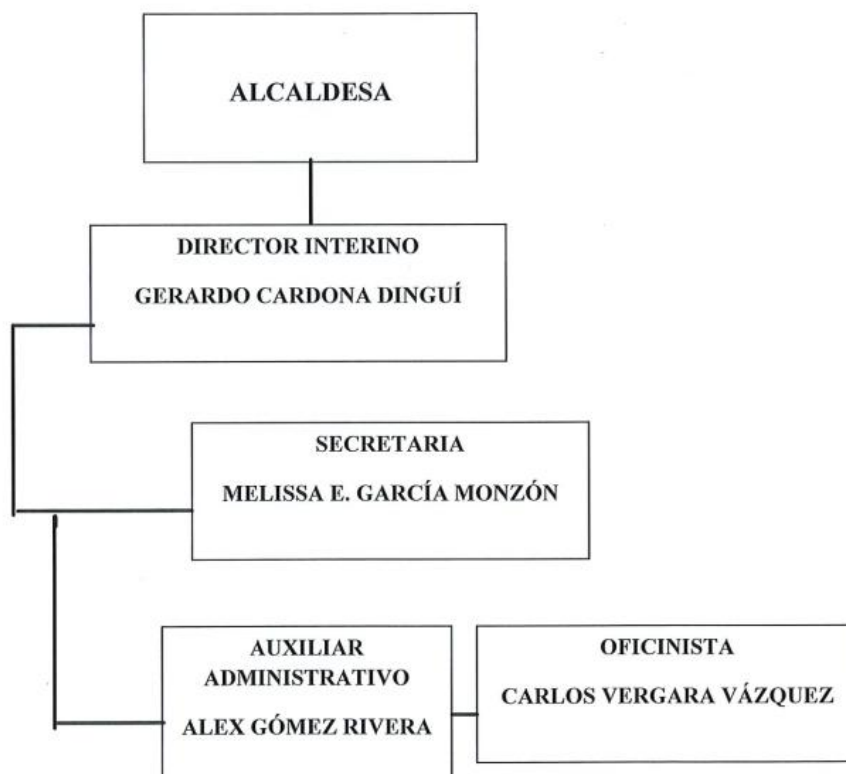


KARINA NIEVES SERRANO
ALCALDESA
09 DE SEPTIEMBRE DE 2025

Teléfono: (787) 732-4700
Apartado 128, Aguas Buenas, Puerto Rico, 00703



ORGANIGRAMA DEL DEPARTAMENTO DE PLANIFICACIÓN Y ORDENAMIENTO TERRITORIAL



? NNCL B CV D8B QQU CQCCK S J _RCML K CRF MB MJ ME WDMF
N5 CPRM P CAM F _X_P B K CRCE _RCML NJ _L S NB _RC



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 (PR00009)

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, Comerio, 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 identified 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 from 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.

QUALITY CONTROL TRACKING STAMP (3-STEP)	
QC DOCUMENT:	
QC REVIEW ACTIVITY	
1. READY FOR REVIEW	ORIG: Juan P. Rotger Date: 9/15/2026
2. QC REVIEW  (Red = correction)	REV: Rosa Lozano Date: 9/16/2026
3. CHANGES MADE AND VERIFIED   (Blue check next to comment = accept)   (Yellow highlight over red comment = change made to address comment)	ORIG: Juan P. Rotger Date: 9/17/2026
ORIG = Originator, REV = Independent Reviewer	
Atkins North America, Inc.	