Aguadilla Multi Hazard Mitigation Plan 2011

Jardín del Atlántico

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SECTION ONE

This section provides a general introduction to the Municipality of Aguadilla Multi Hazard Mitigation Plan Revision and Update for 2011. This introduction is presented in the following four subsections:

- Background
- Purpose
- Authority
- Organization of the Plan

1.1 BACKGROUND

Natural hazards, such as hurricanes, floods, fires, mudslides, coastal floods, earthquakes and tsunamis are a part of the world around us. Their occurrence is natural and inevitable, and there is little we can do to control their force and intensity. It is when these naturally occurring events intersect with our built environment — where we live, work and play — that these hazards have the potential to become disasters.

The Municipality of Aguadilla is a coastal municipality located in northwest Puerto Rico (Figure 1.1). The Municipality is bordered to the east by the municipalities of Isabela and Moca and to the south by Aguada. The geographic coverage of Aguadilla is approximately 36.3 square miles (94 square kilometers) and has a population of 60,949 as per US Census Bureau[1]. Aguadilla was founded in 1775 by Luis de Cordova and its name is derived from the Indian word "Aguadilla" for garden. In addition to a number of manufacturing facilities, tourist attractions, lodging and its international airport (Rafael Hernandez International Airport" the second most important airport in Puerto Rico), Aguadilla is also a processing and distribution center for agricultural products. The Municipality of Aguadilla is located in an area of the Caribbean that is vulnerable to a wide range of natural hazards, including flooding, fires, earthquakes, tsunamis, and hurricanes, among others.

This is a Mitigation Plan Update for 2011 of the city of Aguadilla. This plan is presented to proper authorities for their revision and approval to establish mitigation projects that will help the citizens and government of Aguadilla mitigate or eliminate any hazard that may cause loss of life and property. This plan updates the prior 2004 plan and will analyze the current changes or progress within the mitigation projects that were presented previously and update them to actual risks, vulnerabilities and consequences.

These hazards threaten the life and safety of the residents of Aguadilla, and have the potential to damage or destroy both public and private property. While the threat from hazard events may not ever become fully eliminated, there is much we can do to lessen their potential impact. The concept and practice of reducing

[1] Based on US Census data "estimate" for 2005 - 2009

risks to people and property from known hazards is generally referred to as *hazard mitigation*.

Mitigation techniques include both structural measures, such as strengthening or protecting buildings and infrastructure from the forces of hazards, and non-structural measures, such as the adoption of land use policies or the creation of public awareness programs. A comprehensive mitigation approach addresses hazard vulnerabilities that exist today and in the foreseeable future. Because of the development pressures facing Aguadilla, it is critical that projected patterns of future development are evaluated relative to how that growth will increase or decrease its overall vulnerability to hazards.

One of the best ways a community can implement a comprehensive approach to hazard mitigation is to develop, adopt and update as needed, a local hazard mitigation plan. A mitigation plan both establishes broad guiding principles and specific actions that can be implemented to reduce identified risks. The Municipality of Aguadilla Hazard Mitigation Plan (referred to throughout the document as "Hazard Mitigation Plan" or "Plan") is a logical first step toward incorporating hazard mitigation practices into the municipality's daily activities, thereby lessening the vulnerability of the Municipality.

Figure1.1
Location of the Municipality of Aguadilla in Puerto Rico

1.2 PURPOSE

As the costs of disasters continue to rise, governments and ordinary citizens must find ways to reduce hazard risks to their communities and themselves. Efforts made to reduce hazard risks are easily made compatible with other community goals; safer communities are more attractive to employers as well as residents. As communities plan for new development and improvements to existing infrastructure, mitigation can and should be an important component of the planning effort. The United States Congress made the development of a hazard mitigation plan a specific eligibility requirement for any local government applying for federal mitigation grant funding through the Disaster Mitigation Act of 2000 (DMA 2000). Communities with an adopted and federally approved hazard mitigation plan will therefore become pre-positioned and more apt to receive available mitigation funds in both the pre- and post-disaster environments.

This Plan is designed to meet both the requirements of DMA 2000 and the applicable rules of the Puerto Rico State Emergency Management Agency (PRSEMA). The planning process followed for the Municipality of Aguadilla was intended to:

- Protect life, safety and property by reducing the potential for future damages and economic losses that result from natural hazards.
- Speed recovery and redevelopment following future disaster events.
- Demonstrate a firm local commitment to hazard mitigation principles; and
- Comply with both central government and federal legislative requirements for local hazard mitigation plans.

A key element of the Plan is to ensure that proposed mitigation actions are coordinated at the local level, and supported by appropriate central government agencies.

1.3 AUTHORITY

This Plan has been adopted and certified by the Municipality of Aguadilla under the authority defined under Law 81, August 30, 1991(Ley Núm. 81 del 30 de Agosto de 1991). The law was enacted to empower local municipalities. It established a framework for a more democratic and participatory form of government. This Plan was adopted and certified by the Mayor and the Municipal Assembly, a local representative group of residences, which according to the Law 81, is given broad legislative powers to approve ordinances, resolutions and regulations on matters of municipal jurisdiction.

To adopt the Plan, the Mayor, Carlos Méndez Martínez, called an extraordinary session of the Municipal Assembly. This special session, called to order and

held in accordance with procedures outlined in Law 81, "certified" the municipality's Hazard Mitigation Plan on October 26, 2004. A copy of the adoption is included at the beginning of the Plan.

This Plan has been prepared in accordance with all current guidance from the Federal Emergency Management Agency (FEMA) relating to local hazard mitigation plans. The Plan shall be routinely monitored and updated to remain in compliance with the following enabling legislation and regulatory guidance:

- The Robert T. Stafford Disaster Relief and Emergency Assistance Act, as amended by the Disaster Mitigation Act of 2000 (Public Law 106-390 – October 30, 2000).
- The Interim Final Rule to implement DMA 2000 was published in the Federal Register on February 26, 2002 (see 44 CFR Parts 201 and 206).

1.4 ORGANIZATION OF THE PLAN

The following sections of the Plan present detailed information to support the purposes of the Plan, they are:

- Section one, introduces the Plan.
- Section Two provides a background of the municipality.
- Section Three describes the development of a Hazard Mitigation Committee and local community planning activities that were conducted for the development of this Plan.
- Section Four summarizes the results of the hazard identification and risk assessment, which estimates potential losses associated with identified hazards.
- Section Five describes goals and objectives of the Plan, along with a broad range of mitigation actions.
- Section Six presents the strategy for implementing the prioritized mitigations presented in Section Five. It outlines requirements for monitoring and updating the Plan following its adoption.
- Section 7, a bibliography

SECTION TWO

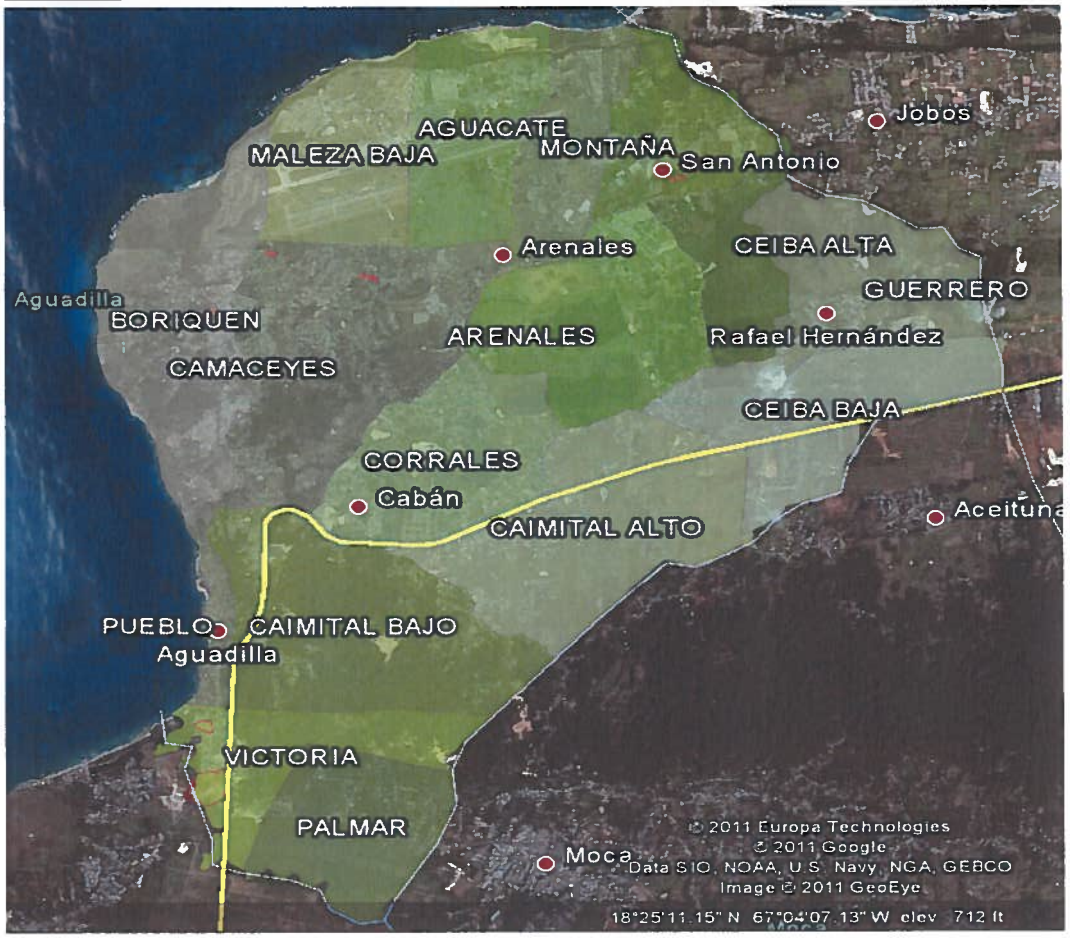
This section provides a brief overview of the Municipality of Aguadilla presented in the following five subsections:

- 2.1 Administrative Divisions
- 2.2 Environment
- 2.3 Population and Demographics
- 2.4 Economy, Employment and Industry
- 2.5 Housing

2.1 ADMINISTRATIVE DIVISIONS

Like other cities throughout Puerto Rico, Aguadilla recognizes "barrios" as territorial or district "areas" divisions within the city of Aguadilla. Each municipality identified as a barrio, the area that represented the seat of the government at the time Puerto Rico formalized the municipality and barrio boundaries in the late 1940s. Figure 2.1 depicts the municipality's sixteen (16) barrios.

FIGURE 2.1 *Administrative Boundaries, Municipality of Aguadilla (18.50N 67.13W).*



2.2 ENVIRONMENT[1]

2.2.1 GEOLOGY AND SOILS

Aguadilla is located within the Karst Region of Puerto Rico. Although the Municipality lacks the notable landforms of haystack hills (mogotes) and massive cave systems found further to the east, the rock formations throughout Aguadilla are limestone. The limestone rock formations have been exposed to a long process of chemical weathering. The lack of significant slope constraints and the nature of the limestone bedrock limit the susceptibility of the Municipality to landslide and flood hazards. Road cuts in limestone are often made close to vertical with high probability of triggering landslide events.

The soil types found in Aguadilla falls into the broad physiographic classification of Humid Costal Plains. Alluvial soils are found along the major rivers, such as Rio Culebrinas, and smaller streams throughout the Municipality.

2.2.2 TOPOGRAPHY AND HYDROLOGY

Aguadilla is located in the Coastal plain and has limited topographical relief. Jimenez Peak is the highest point in the Municipality at 728 feet (222 meters). Aguadilla consists generally of gently rolling hills and valleys that gradually gain in elevation towards the southeast. The majority of the Municipality falls within 50 to 150 meters in elevation. The Municipality has few areas of steeply sloped terrain, except along some portions of the coastline. The coastal areas also contain some low-lying terrain including lagoons, remnant cut-off channels, and mangrove swamps within the floodplain of the Rio Culebrinas. Figure 2.2 shows the topography and hydrology of the Municipality.

The mayor river system within the Municipality is Rio Culebrinas. The Rio Culebrinas basin has a drainage area of 103 square miles (267 square kilometers). The river flows in a westerly direction from the central mountain range, through the towns of San Sebastian and Moca, before entering in the Municipality of Aguadilla. The lower portion of the Rio Culebrinas delineates the boundaries between Aguadilla and Aguada. Other smaller perennial and intermittent streams drain directly to the Mona Channel.

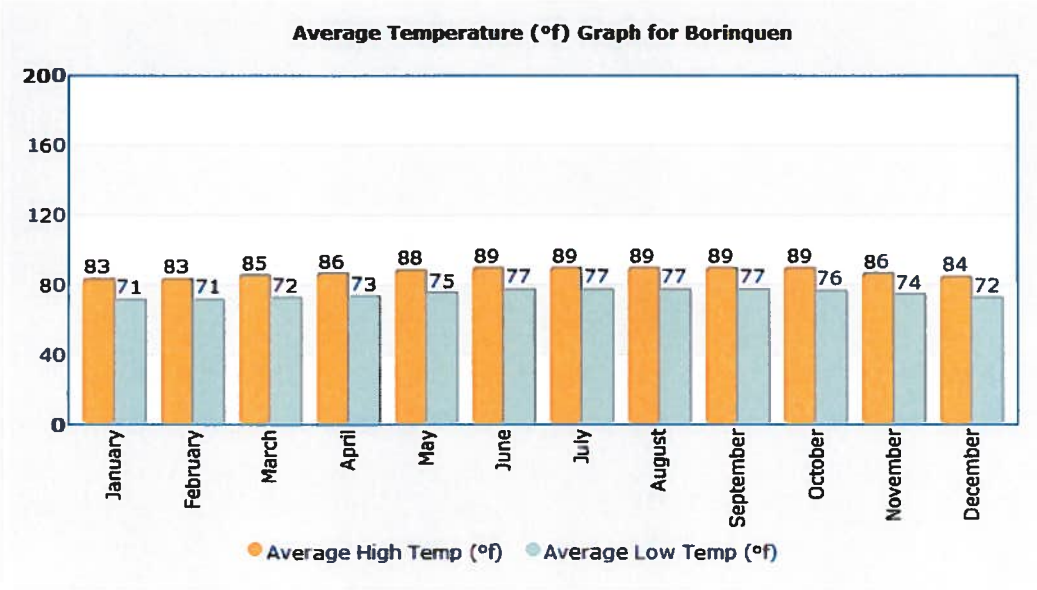
2.2.3 ECOLOGICAL ZONES

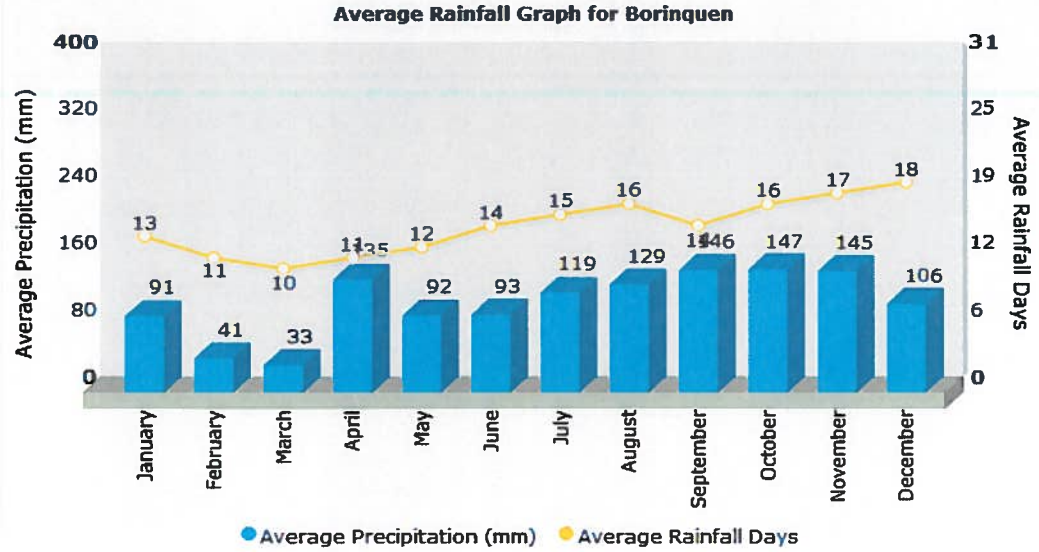
The entire Municipality of Aguadilla falls within the Subtropical Moist Forest zone. This zone receives an average annualized rainfall between 39—87 inches and is optimal for agricultural activities. The vast majority of the original forests have been lost to past agricultural practices and land development. Historically much of the original forest was cut to fuel the sugarcane industry and provide lumber for ships and home construction. Remnants of forested land can be found along stream valleys and undeveloped tracts of land throughout the Municipality.

[1] The Environment Section remains the same as prior 2004 mitigation plan. No major changes were made.

2.2.4 CLIMATE

The climate of Aguadilla is characterized as warm and humid (tropical-marine), with frequent showers occurring throughout the year. Throughout the entire year, for tropical areas like Puerto Rico, more or less the same quantity of energy is lost during the night as is received during the day. The result is more or less uniform temperatures throughout the year. One of the 55 weather stations (Borinquen AP) in Puerto Rico is located within the Municipality. Data from the Borinquen AP station 2011 show the average monthly temperatures (72 to 89 degrees Fahrenheit).





An average of approximately 67 inches of rain falls annually, although there may be considerable variations from year to year. [2]

2.3 POPULATION AND DEMOGRAPHICS

In terms of population size, Aguadilla is the eleventh largest Municipality in Puerto Rico (94.8km) represents 6.4% of the region and 1.1% of Puerto Rico. Over the past three decades, Aguadilla has experienced steadily increasing population growth. The U.S. Census reported that approximately 51,400 persons resided in Aguadilla in 1970 and 54,600 in 1980, representing a 6.2 percent increase. By 1990, this number had increased to 59,300, which represented an 8.6 percent increase in total population. In 2000, the U.S. Census reported a 9.1 percent increase in the population of Aguadilla to 67,187. Nevertheless, the US Census preliminary estimated report from 2005-2009 reported a 5.8% decrease in the population of Aguadilla with a total of 60,949. There are 3,736 less people living is Aguadilla than 2000 census. This trend reflects non favorable conditions for business, industry and employment in the Municipality. Table 2.2 shows the latest demographic data for Aguadilla.

TABLE 2.2 ***Municipality of Aguadilla, Population Data*** **(2010)** [3]

Subject	Number	Percent	Subject	Number	Percent
TOTAL	60,949	100.0	45 to 54 years	7,976	12.5
Male	30,293	49.2	55 to 59 years	3,290	5.2
Female	30,656	50.8	60 to 64 years	2,916	4.5
Under 5 years	4,690	7.3	65 to 74 years	4,426	6.8
5 to 9 years	4,841	7.5	75 to 84 years	2,297	3.6
10 to 14 years	4,723	7.4	85 years and over	811	1.3
15 to 19 years	5,544	8.6	18 years and over	46,926	72.5
20 to 24 years	5,144	7.9	21 years and over	43,619	67.4
25 to 34 years	9,001	14.0	62 years and over	9,216	14.2
35 to 44 years	8,612	13.3	65 years and over	7,534	11.6

[3] Even when the official 2010 Census is not updated on-line we calculated an even decrease of 5.8% to all columns The official 2010 US Census information, tables only show an "estimate" from 2005-2009 of the final data but nothing official yet. These data were published in the near future according to information from US Census website.

2.4 ECONOMY, EMPLOYMENT AND INDUSTRY

Economically, the Municipality of Aguadilla is comparable to other municipalities in the region and slightly better well off than Puerto Rico overall. It should be noted that economic statistics for Puerto Rico are heavily biased towards the San Juan Metropolitan Area. The median family income for Aguadilla was $13,814.00.

TABLE 2.3 ***Municipality of Aguadilla, Comparative Household Income Levels****

Income in 2005 -2009	Aguadilla	%
Households 2005 - 2009	19,629	100.0
Less than $10,000	7,889	40.2
$10,000 to $14,999	2,499	12.7
$15,000 to $24,999	3,615	18.4
$25,000 to $34,999	1,695	8.6
$35,000 to $49,999	1,680	8.6
$50,000 to $74,999	1,377	7.0
$75,000 to $99,999	636	3.2
$100,000 to $149,999	159	0.8
$150,000 to $199,999	6	0.0
$200,000 or more	73	0.4
Median HH Income	13,814	
Per Capita Income	7,705	

TABLE 2.4 ***Municipality of Aguadilla, Workforce by Industry (2005 - 2009)*** *

Employed civilian population 16 years and over	#	%
Agriculture, forestry, fishing and hunting, and mining	137	0.8
Construction	1,305	7.9
Manufacturing	2,205	13.3
Wholesale trade	283	1.7
Retail trade	2,319	14.0
Transportation and warehousing, and utilities	619	3.7
Information	168	1.0
Finance, insurance, real estate, and rental and leasing	641	3.9
Professional, scientific, administrative, and management services	1,295	7.8
Educational, health and social services	3,474	20.9
Arts, entertainment, recreation, accommodation and food services	1,724	10.4
Other services (except public administration)	711	4.3
Public administration	1,733	10.4
Total Civilian Employed Population over 16	16,614	

* Based on US Census data "estimate" for 2005 - 2009

2.5 HOUSING

The U.S. Census 2005 – 2009 estimate indicates that there are 23,993 housing units in the Municipality of Aguadilla. Of the total housing units, 19,629 are classified as occupied. Table 2.5 illustrates housing trends in Aguadilla, as compared to Puerto Rico. These figures indicate that new housing construction in Aguadilla over the past decade is comparable to statistics for all of Puerto Rico

TABLE 2.5 ***Municipality of Aguadilla, Number of Housing Units (2005 – 2009)****

Number of Housing Units			
Location	**2000**	**2005-2009**	**Percent Change**
Aguadilla	24,882	23,993	-0.4%
Puerto Rico	1,418,476	1,434,711	1.0%

The predominant housing type is a single-family detached dwelling. It accounts for the majority of housing types throughout the Municipality (Table 2.6).

TABLE 2.6 ***Types of Housing Units, Municipality of Aguadilla****

Units in Housing Structure		
Housing Type	Number	Percent
1-unit, detached	16,988	70.8
1-unit, attached	3,534	14.7
2 units	296	1.2
3 or 4 units	481	2.0
5 to 9 units	1,180	4.9
10 to 19 units	838	3.5
20 or more units	605	2.5
Mobile home	71	0.3
Total Housing Units	23,993	100

Table 2.7 indicates that 69.8 percent of the municipality's housing stock is owner-occupied, while renters occupy approximately 33.2 percent of households. A number of factors influence tenure patterns including age and household income.

TABLE 2.7 ***Tenure of Housing, Municipality of Aguadilla****

Tenure	2005-2009	%
Owner-occupied housing units	13,692	69.8
Renter-occupied housing units	5,937	30.2
Total	19,629	100.0

* Based on US Census data "estimate" for 2005 - 2009

SECTION THREE

SECTION THREE PLANNING PROCESS

This section includes a description of the hazard mitigation planning approach utilized for the development of the 2011 Aguadilla Mitigation Plan. It also describes the organization of community resources (i.e., formation of the Hazard Mitigation Planning Committee), outcomes of public informational meetings, comparisons from prior 2004 mitigation plan presented previously with the submitted projects with the corresponding status, and important documents/legislation reviewed during the development of the Plan. As part of the continuous Hazard Mitigation Planning that the Municipality of Aguadilla must undertake, the scope of the Data Base currently being established must be extended in terms of the inventory and the potential damage of each hazard event. Additional data that must be collected must include: structure size, structure value, contents value, occupancy or capacity, and/or any other special consideration. The section is presented in the following seven subsections:

- 3.1 IFR Requirements for Planning Process
- 3.2 Description of the Hazard Mitigation Planning Process
- 3.3 Formation of a Hazard Mitigation Committee
- 3.4 Public Involvement and Outreach
- 3.5 Public Participation and Community Workshops
- 3.6 Public Review of the Draft Plan
- 3.7 Review of Existing Legislation, Plans and Reports

3.1 IFR REQUIREMENTS FOR PLANNING PROCESS

IFR Requirement **§201.6(b)**: states that "[I]n order to develop a more comprehensive approach to reducing the effects of natural disasters, the planning process shall include:

1) An opportunity for the public to comment on the plan during the drafting stage and prior to plan approval.

2) An opportunity for neighboring communities, local and regional agencies involved in hazard mitigation activities, and agencies that have the authority to regulate development, as well as businesses, academic and other private and non-profit interests to be involved in the planning process.

3) Review and incorporation, if appropriate, of existing plans, studies, reports and technical information.

- Plan Documentation as per Requirement §201.6(c) (1): [The plan shall document] the planning process used to develop the plan, including how it was prepared, who was involved in the process, and how the public was involved.

3.2 DESCRIPTION OF THE HAZARD MITIGATION PLANNING PROCESS

The planning process began with a Project Initiation Meeting held on December 3, 2010. Municipality of Aguadilla, Urbanism and Land-Use Office and ISP Inc., the consulting firm selected to support Plan preparation, facilitated this initial planning meeting. Key Departments represented at the initial meeting included: Emergency Management, Federal Programs, and Planning. The Hazard Mitigation Committee, introduced later in this Section, along with project consultant ISP led the development of the Plan over a six month timeframe that included the steps listed below:

- Background research and field assessment;
- Community-based planning process;
- Hazard identification and risk assessment;
- Previous plan status and outcomes;
- Community-based mitigation strategy; and
- Strategy for plan implementation and maintenance.

The findings of the background research conducted by the study contractor are found in Section Two, titled *Community Profile (this information did not changed because there are no major changes in community profile since 2004).* Section Two describes the makeup of the community, including the prevalent environmental, demographic and economic characteristics. During this phase, an analysis of the community's built environment and critical facilities was conducted. This baseline information, which provides a snapshot of the community's exposure (i.e., economic assets), is located in the *Hazard Identification and Risk Assessment* (Section Four) and is essential to the vulnerability analysis conducted for the municipality.

The hazard mitigation planning process, which is highlighted in this Section, was initiated by the creation of a Hazard Mitigation Planning Committee. This committee provided oversight to the plan development process and worked to engage the public through multiple public informational workshops. A fundamental component of this planning process involves public participation and input. Also, in this phase of the planning process, the study contractor conducted a review of applicable plans, legislation, regulations, policies, and reports relevant to Aguadilla and the topic of hazard mitigation.

The next important phase of the planning process involved the *Hazard Identification and Risk Assessment* (Section Four) An analysis was conducted to identify and describe the type of hazards that can affect the Municipality and evaluate which risks had been mitigated or which projects are currently in progress since the last mitigation plan on 2004. This analysis included a hazard profile that presents a description of the location and extent of each identified hazard (delineate areas at risk), describes previous occurrences of hazard events (history), and provides an understanding of the frequency (probability) of

each hazard event. To be consistent with DMA 2000, further analysis was conducted that assesses vulnerability to hazards by providing a summary of the overall impact to community assets (types and numbers of buildings, infrastructure and critical facilities), and projects future vulnerability (potential losses) in Aguadilla so that mitigation options can be reasonably assessed.

Based on citizen input gathered from community workshops, an assessment of the baseline information and the findings of the *Hazard Identification and Risk Assessment*, the community formulated a comprehensive *Mitigation Strategy* (Section Five). This involved the development of broad mitigation goals and objectives and the identification and prioritization of mitigation measures or actions. Following the completion of its *Mitigation Strategy*, the Municipality concentrated on designing measures to ensure the Plan's ultimate implementation, presented in *Plan Implementation* (Section Six). In this section, an implementation framework is provided to ensure that mitigation actions, outlined in the Plan, are implemented, evaluated and routinely updated.

3.3 FORMATION OF A HAZARD MITIGATION COMMITTEE

The planning process was initiated with an executive-level meeting on December 3, 2010 consisting of the Directors of Office of Emergency Management, Federal Programs, Urbanism and Land Use, and the project consultant, ISP. The purpose of this initial planning meeting was to provide the Directors an overview of the planning process, identify general concerns of all participants, and to discuss the creation of the Hazard Mitigation Planning Committee. At this time it was agreed that the Municipality of Aguadilla's Municipal Urbanism and Land-Use Office, Director, The Urban Planner Mr. Manuel Hidalgo, would lead the development of the Plan at the staff level.

The major outcomes from the Project Initiation meeting included:

- A general concern was raised by participants that public involvement may prove difficult, as the Municipality of Aguadilla because participation is often limited.
- Identification of special interest and organizations, and businesses that should be involved in the hazard mitigation planning process might not participate in the process.
- A decision was made to focus the plan development process on natural hazards.
- Determine which projects will be presented on this plan and which will be re submitted since they are still on hold since 2004 and the risks still in place.
- Plan adoption would occur through a resolution signed by the Mayor of Aguadilla.

This meeting led to the creation of a small select Hazard Mitigation Planning Committee. The Municipality focused on identifying persons that would be committed to being part of the planning process.

Ultimate responsibility for Committee Assignments resides with the Director of the Urbanism and Land-Use Office, Director, The Urban Planner Mr. Manuel Hidalgo. The Hazard Mitigation Planning Committee is comprised of individuals from relevant municipal departments, the private sector, and community organizations. The persons listed in Table 3.1 all made a firm commitment to be part of the Aguadilla Hazard Mitigation Planning Committee.

TABLE 3.1 *Hazard Mitigation Planning Committee*

Hon. Carlos Méndez Martínez, Mayor

Oficina de Urbanismo y Ordenamiento Territorial (Urbanism and Land-Use Office)

Plan. Manuel A.G. Hidalgo, PPL - Director, Urban Planner

Mrs. Isabel Nieves, Technician

Oficina Municipal para el Manejo de Emergencias (Municipal Emergency Management Office)

Mr. Frank Hernández, Director

Oficina de Programas Federales (Federal Programs Office)

Mrs. Emily Masters, Director

Mrs. Annette González, Technician

Oficina de Planificación y Adm.de Proyectos (Planning and Project Management Office)

Mrs. Jessica Acevedo, Director

Secretaría de Obras PÚBLICAS (Public Works)

Mr. José L. Castro, Director

Policía Municipal (Municipal Police)

Mr. Luis Irizarry, Police Commissioner

Community Board Members

Mr. Benjamín García Pérez

Mrs. Isabel Ortiz Hernández

Mrs. Nayda Hernández Lorenzo

Mr. Mariano Rodríguez Cortés

Mr. Pablo A. Hernández Román

Mr. Luis López Vale

Mr. Héctor I. Nieves Pérez

Mr. Kenneth Vargas Crespo

Mrs. Ivette Mejías Maldonado

Mr. Wilfredo Segarra Linares

3.4 PUBLIC INVOLVEMENT AND OUTREACH

As citizens become more involved in decisions that affect their safety, they are more likely to gain a greater appreciation of the natural hazards present in their community and take personal steps to reduce their potential impact. Public awareness is the "key" to making a home, neighborhood, school, business or city safer from the potential effects of natural hazards.

Two Community Workshops were held on January 25 and March 25, 2011. Community Leaders from each sector were invited to these meetings but only a few of the community leaders participated in the workshops and visited the vulnerable areas. The Appendix section includes a list of invitees, attendance sheets, and minutes for each meeting in the development of the Plan:

Communities Representatives:

- Mrs. Mayra Guzman- Urb. Victoria- Aguadilla. Long term resident for 30 years
- Mr. Wilfredo Segarra- Residente Caimital Bajo, Aguadilla
- Mr. Pablo Hernandez- Poblado San Antonio, Aguadilla- Long term resident for 40 years.
- Mrs. Ivette Mejias- Ave. Los Corazones, Aguadilla. Resident since 2005
- Mr. Luis Lopez- Bo. Ceiba Baja, Carr#110, Aguadilla.
- Mr. Mariano Rodriguez- Bo Guerrero, Aguadilla. Long term resident for 42 years

Neighborhood Groups:
The following Community members were invited to be part of the Hazard Mitigation Committee and/or participate in the Community Meetings:

- Community Leaders from each barrio
- Municipal Legislature,
- Community Board Members, and
- Representatives from each Municipal Agency were invited to all community meetings.

Local Businesses:
Local Business leaders were invited to all Community Meetings. Additionally, offsite- meetings were held with:

- Mariano Rodriguez

Some other stakeholders were invited but they didn't responded.

Minutes of these meetings are found in the Appendix section.

3.5 PUBLIC PARTICIPATION: COMMUNITY WORKSHOPS

This subsection explains how the public was involved during the development of the plan. Public participation in the Plan development has been encouraged through a series of Community Workshops.

3.5.1 HAZARD MITIGATION PLANNING COMMITTEE AND FIRST COMMUNITY WORKSHOP

The first Community Workshop was held on January 25, 2011 at 6:00 p.m. at the City Hall of Aguadilla. The Urbanism and Land-Use Office sent out approximately 20 letters inviting representatives from a wide range of community associations and organizations. As referenced above, a copy of the invitation to the first Community Meeting and mailing is provided in the Appendix section.

The project consultant used a PowerPoint presentation to outline the proposed hazard mitigation planning process, explain federal requirements, and discuss the timeframe and schedule for project completion. Unfortunately, there were only six participants at the First Community Workshop. Given the low turnout of the general public, the ISP workshop facilitator emphasized the importance of engaging the public, private and non-profit sectors in the Plan development. Following the formal presentation, discussions centered on how to expand public involvement in mitigation planning process.

The outcomes from the First Community Workshop included:

- Additional efforts by the Hazard Mitigation Committee would be needed to target specific stakeholders and personally invite them to subsequent public informational meetings. This targeted approach proved much more successful.

As referenced above, the minutes from the First Community Workshop are provided in the appendix section.

3.5.2 SECOND COMMUNITY WORKSHOP

The Second Community Workshop and community visits were held on March 25, 2011 at the City Hall at 9:00am and later during the day both committees visited the prospect communities and vulnerable areas of the city of Aguadilla (field inspection). Some areas were revisited from prior mitigation plan submittal on 2004 to re evaluate if these communities still with the same problems as before and how, if any, project was submitted or approved to attend such hazards.

Emergency Management and municipal personnel escorted the planning and community leaders during the process of inspection. The workshop facilitator outlined the proposed hazard mitigation planning process, explain requirements, and discuss the survey and risk assessment process.

The Municipality identified a preliminary list of hazards of concern specifically for the Municipality of Aguadilla. Table 3.2 summarizes this hazard identification and selection process. First column indicates the initial hazards identified. Second Column shows hazards of interest carried forward for further study based on group discussion.

TABLE 3.2 ***Identification of Hazards***

Identified	Hazard
☑	Riverine Flooding
☑	Coastal Flooding
	Drought
☑	Wildfire
☑	Earthquake (Ground Shaking)
☑	Earthquake (Liquefaction)
☑	Earthquake-Induced Landslide
☑	Tsunami
☑	Urban Fire
☑	Rainfall-Induced Landslide
☑	High Wind (includes hurricane and tropical storm)

From the list of eleven (11) hazards, ten (10) were selected as hazards of interest for the Municipality for the Hazard Mitigation Plan. These ten hazards include *earthquake (ground shaking, liquefaction, earthquake-induced landslide and tsunami), flooding (riverine and coastal, rainfall-induced landslide), and high wind (includes hurricanes and tropical storms) Fire (wildfire and urban fire)*

Once hazards were identified, a descriptive and historical event discussion technique was used to identify citizen concerns about natural hazards. The summarized minutes and results of this strategic planning exercise, including output from both the first and second community workshops, are summarized below:

Flooding

General concerns noted about flooding hazards throughout the Municipality include:

- Debris removal and cleaning—Debris disrupts natural flow of rivers and streams. This is due to increased run-off and sedimentation. Also, garbage discarded in stream beds is a problem.
- Bridge and culvert maintenance—Related to the above, debris blockages beneath bridges and culverts cause problems at river, stream and some road intersections.

Specific concerns and locations of flooding hazards:

- Low-lying areas of residential, commercial and industrial land uses in the Nuevo San Antonio area receive shallow flooding from nearby streams, storm channels and ditches. The volume of stormwater flooding surrounding roads and nearby homes frequently overwhelms several area Storm Water Management (SWM) facilities. Repetitive flooding along the portion of road from Calero Bridge to the entrance of San Antonio Village near the intersection of Carr. 459 and 110 often obstructs traffic. Barrio Camaseyes and Poblado San Antonio are also affected.
- Landslides and periodic floods cause the obstruction of the local street Toño Colon Tunnel. The situation of this issue is that this tunnel is the official evacuation route in the Tsunami Ready Plan. The obstruction of this tunnel impedes the evacuation of the communities around it in case of a Tsunami.
- Periodic flooding of the El Culebrina River in Aguadilla can affect residential, commercial and infrastructure in Urbanization Victoria and García, along Avenue Victoria, at the intersection of Carr. 111 and Carr. 115, and along Carr. 115 towards the Municipality of Aguada. The most vulnerable area is Barrio Victoria along Carr. 111, from the Aponte Residential Area to the entrance of the Coloso Sugarcane Central. Over 400 families that reside in La Victoria, Urbanization García, Victoria Gardens and the Aponte Public Housing area are affected during major storm events.
- Los Corazones Ave. Caimital Alto y Bajo, Cambija and Los Corazones Ave. (declared CR- Resource Conservation) due to the sump (drain) condition of the terrain. Constant landslide due to illegal terrain removal in the area.
- Road 465 esq. Sector Muñiz. Road 466 Hm 2. First street from Jardines de Guerrero are subject to many floods during heavy rain weeks. There are no pump system that may help mitigate this problem.

High Wind
The major concerns identified by the community about the high wind hazard include:

- General concern about poorly constructed homes and/or abandoned buildings.
- Concerns about potential high wind damages to existing and future homes perched upon the steep, hilly terrain surrounding the urban center (Centro Urbano) and Calle la Victoria area.

Earthquake–Related Hazards
The major concerns identified by the community about earthquake hazards include:

- General community concerns are latent about this matter because they just had seen the lately experience from Haiti, Chile and Japan which suffered major earthquakes in 2010 and 2011.
- There are general concerns about the earthquake hazard/risk, especially the identification of earthquake hazard areas to determine suitable areas for development.
- There is a general awareness of the potential for a tsunami event along the coast. Two Tsunami warning systems are installed along the Aguadilla shore. The area of concern runs from the cemetery to Parque Colón and includes a number of public and private facilities and infrastructure (Carmen Gómez Tejera School, San Carlos Private College, the public library, the local Police Department, Eladio J. Vega School, Unitec Technical College, a major electrical substation, Rafael de Valle School, José de Diego Middle School, Agustín Stahl Middle School and Luis T. Díaz Coliseum).

Landslides
The major concerns identified by the community about landslide hazard include:

- There are general concerns about the potential for landslides associated with the seismic risk.
- Given the limited topographic relief and limestone bedrock present in the Municipality, there were few concerns mentioned about the likelihood of landslides associated with rainfall events.

Infrastructure
The major concerns identified by the community include:

Transportation Systems

- Several community representatives commented that many publicly maintained roads did not have adequate storm drainage parallel to the road and undersized culverts at key road intersections.

Electrical and Telecommunications

- There are general concerns about power and telephone poles breaking during high wind events. It was mentioned that lines are often inadequately secured and there can be long restoration periods following high wind events.

Emergency Management
The major concerns identified by the community include:

- Proper and actual rescue equipment available for responders during a major incident.

Environment
The major environmental concerns identified by the community include:

- Uncontrolled development—increased development in coastal areas has adversely affected littoral environments and may locally aggravate flooding conditions.
- Private development on beaches and sea cliffs has limited access to beaches and the coast line.

Wildfire [1]
The major concerns identified by the community about wildfires are:

- Dry conditions at various times of the year and in various parts of Aguadilla greatly increase the potential for wildfires specially near besides road #2. This type of fire cause major damage to infrastructure and weaken the side hills stability.
- Expansion of development into forested areas has created a situation where wildfires can adversely affect lives and property, as can the flooding and landslides that occur in the aftermath of the fires.
- Post-fire landslide hazards include fast-moving, highly destructive debris flows that can occur in the years immediately after wildfires in response to

[1] This hazard was included in this plan update it wasn't on 2004 plan.

high intensity rainfall events, and those flows that are generated over longer time periods accompanied by root decay and loss of soil strength.

- Post-fire debris flows are particularly hazardous because they can occur with little warning, can exert great impulsive loads on objects in their paths, can strip vegetation, block drainage ways, damage structures, and endanger human life.
- Wildfires could potentially result in the destabilization of pre-existing deep-seated landslides over long time periods.

Urban Fire[2]

The main concerns of urban fires in Aguadilla are:

- Urban Fires in Aguadilla may involve buildings, residences, warehouses and industries with potential for spread to adjoining structures.
- Although the statistics show a decline in fire casualty rates in recent years as acknowledged by the Puerto Rico Fire Department.
- The urban fire hazard in Aguadilla may involve areas where single family homes, multi-family occupancies and/or business facilities are clustered close together, increasing the possibility of rapid spread to another structure.
- Other areas are characterized by adjoining buildings. Adjoining buildings are found in the downtown region of the city or include other closely spaced wood frame structures. The cause of fires in urban areas could happen by the following:

    - Residential accidents (improper use of electrical appliances, faulty connections, grease fires, smoking, heating appliances or improper disposal of wood ashes).
    - Industrial accidents (hazardous material incidents, explosions, transportation accidents)
    - Acts of nature (lightening strikes, earthquake byproduct)
    - Criminal acts (arson, illegal explosive devices, acts of terrorism)

Government Coordination

The major government concerns identified by the community include:

- Municipal officials are aware of the need to improve coordination between municipal government and the central government, specifically with the Department of Natural Resources (i.e., stream cleaning programs) and OGPE (development planning enforcement).

[2] This hazard was included in this plan update it wasn't on 2004 plan.

Education
The major education concerns identified by the community include:

- Community members pointed out that hazard mitigation should be part of everyday life for the people who live and work on an island.
- The Municipality was encouraged to pursue outreach programs through community institutions such as churches, libraries, and government offices.

3.5.3 HAZARD MITIGATION PLANNING COMMITTEE: DEVELOPING MITIGATION STRATEGY

The Hazard Mitigation Planning Committee explained the strategies that are intended to support, correspond and define a path to attain the desired timeframe goals. Also, in the plan it should include the following goals and objectives to comply with requirements and needs:

Goal #1 **Reduce the impact of natural disasters on residents and property**

- Objective 1.1 Protect existing development from future disaster events
- Objective 1.2 Reduce the vulnerability of future development

Goal #2 **Strengthen the capabilities of municipal agencies to implement and maintain hazard mitigation programs and evaluate prior plans**

- Objective 2.1 Identify and develop policies, regulations, and specialized training necessary to support an effective hazard mitigation program in the Municipality.

Goal #3 **Increase the awareness and understanding of those living and working in Aguadilla to natural hazards and to the principles of hazard mitigation**

- Objective 3.1 Develop outreach programs focused on increasing public awareness of hazards and their associated risks
- Objective 3.2 Support local businesses and industries in becoming more disaster resistant

Goal #4 **Improve local ability to restore critical facilities, essential infrastructure, and ensure the continuity of municipal operations following natural disasters**

- Objective 4.1 Enhance municipal capabilities to support emergency response and recovery operations
- Objective 4.2 Undertake planning to maximize governmental coordination and communication between municipality, central government and federal agencies
- Objective 4.3 Reduce the vulnerability of critical facilities, infrastructure and essential municipal facilities

3.5.4 MEETING: HAZARD MITIGATION PLANNING COMMITTEE PREPARING AN IMPLEMENTATION STRATEGY

The study contractor led a strategic planning process at the planning committee meeting to identify, evaluate and prioritize a series of mitigation actions designed to achieve the aforementioned goals and objectives. The outcome of this meeting was a prioritized list of 16 mitigation actions.

For each action, specific implementation requirements were defined. These requirements included the identification of the lead department/agency designated for action implementation, an estimation of project costs (approximation until actual final dollar amounts can be determined), determination of funding method, determination of a project implementation timeframe; and a prioritization of each action.

3.6 PUBLIC PARTICIPATION IN PLAN DEVELOPMENT, REVIEW AND COMMENTS OF THE PLAN

The subsection below clearly indicates how the public was involved in the development of the Plan, contributed to its development by providing specific content, and was given the opportunity to provide comments prior to Plan finalization. The Municipality harvested public input throughout the entire planning process. Specifically, these efforts included:

- Engaging public stakeholders through community meetings and site visits. Public concerns were documented and incorporated into draft and final version.
- Public input was obtained through workshops.
- Public input was obtained through personal interviews about hazards and associated impacts
- The Aguadilla Hazard Mitigation Committee was formed on December 10, 2010 and meetings were held on January 25, March 25 (field inspection) and April 4, 2011.

- Public input was sought during the Second community meeting, held March, 2011. The public, along with the Hazard Mitigation Committee, prioritized series of Mitigation Strategies and actions for incorporation into the Plan.

Supporting documentation is provided in the above mentioned appendix section. Furthermore, discussion related to the implementation of mitigation activities outlined in the plan is provided in the appendix section.

3.6.1 Plan Availability, Public Review of the Draft Plan

Plan availability would be given through a public announcement

A Draft Plan was made available to the public May 25, 2011 through October 10, 2011. The Municipality of Aguadilla chose to place copies of the document at the following locations for Public review and comment:

- Municipal Legislature
- The Mayor's Office
- The Emergency Management Office
- The Urbanism and Land-Use Office

The Plan was made available to representatives of nearby municipalities. A promise about comments and/or suggestions to the Plan was included. Letters by the Urbanism and Land-Use Office. There were no comments or suggestions by the public to the Mitigation Plan.

3.7 Review of Existing Legislation, Plans and Reports

The review of existing plans, studies, reports, and ordinances was an important aspect of the planning process. The review focused on important studies and legislation that would have an impact on the Municipality's ability to implement and manage a hazard mitigation initiative. The subsection below provides a summary of major documents/legislation that were reviewed during the development of the Plan. Several key issues from the following legislation and plan were incorporated into the Plan document.

3.7.1 LEGISLATION

A review of several central government regulations provided an understanding of the established norms and procedures for land use and development in Puerto Rico. An understanding of each of these is useful for future planning focused on reducing the impacts of natural hazards.

- **Commonwealth of Puerto Rico Regulation No. 7** adopted building standards to regulate building construction on the island. It was updated after Hurricane Georges by the adoption of the "Emergency Regulation to Repeal Building Regulation." Since December 2010, the Government of Puerto Rico through an Executive Order adopted the International Building Codes (IBC) as PR new construction/building standards, thus substituting the former Unified Building Codes (UBC 1997 edition.)
- **Commonwealth of Puerto Rico Regulation No. 12** established the "certification process" in OGPE. This process was implemented to streamline development review procedures. It allows the engineering and architectural community to certify that a construction or development project is in conformance with all regulations.
- **Commonwealth of Puerto Rico Regulation No. 13 - Flood Zone Regulations** *(Reglamento Sobre Zonas Susceptibles a Inundaciones)* Adopted in 1971 to restrict development in flood zones, this regulation was adopted under the protection of Law No. 3 of September 27, 1961, which is known as the (Law to Control Construction in Flood Zones). *Ley para el Control de Edificaciones en Zonas Susceptibles a Inundaciones* Regulation No. 13 was amended in 1978, when the Central Government joined the National Flood Insurance Program (NFIP). These amendments were necessary to conform to federal legislation regulating construction in the Special Flood Hazard Areas (SFHAs) as identified in the Flood Insurance Rate Maps (FIRMs). FEMA published the FIRMs for Puerto Rico in August 1978 and subsequently amended over time by more thorough and updated flood studies have been completed, primarily in the metropolitan San Juan region.

3.7.2 COMPREHENSIVE PLAN: LAND USE AND ZONING

The Municipality of Aguadilla is currently reviewing the land use plan; (Plan Territorial) the Plan including the adoption of zoning maps, was approved by the Puerto Rico Planning Board (JPPR) in November 2000. The new land-use plan is expected to be approved by the end of 2011. Actually, this plan is in its final approval phase from the JPPR (Junta de Planificacion de Puerto Rico). The Plan provides critical baseline information (history, demographic profile, etc.), in addition to an understanding of the Municipality's development objectives. It is also the main instrument for strategic and integrated land use planning for the municipal territory.

This document outlined goals and strategies based on a complete analysis of the Municipality's population, its potential for growth, and the general needs that may arise from this growth. It also described the public policies that would guide the implementation of recommendations outlined in the Plan.

3.7.3 Capability Assessment and Incorporation of Plans and Technical Information

While a capability assessment is not required part of the DMA 2000 planning requirements, the Project Consultant team reviewed current plans and legislation mentioned above. These plans provided important background information on the demographic profile of the municipality, proposed capital improvement projects and land use, as well as the administrative capabilities. This information was used to assess the municipality's capability to the implementation of hazard mitigation policies and programs.

This analysis provided invaluable information for developing an effective and practical Hazard Mitigation Strategy. Specifically, it allowed the project consultant team to determine what actions are practical, or is likely to be implemented over time given the administrative, technical, fiscal, legal and political makeup of the municipality.

An additional part of the evaluation involves the assessment of existing policies, programs and projects currently in place that impact the Municipality's vulnerability to natural hazards. For example, future vulnerability may be reduced as hazard maps are used to in the permit and development review process, now being implemented in the Municipal Permit Office. Hazard maps can be used to make decisions on where to place public infrastructure.

The assessment of local plans and legislation policies is reflected throughout this document, more specifically, in Section 5, which outlines hazard mitigation actions that reflect local realities, and therefore, are more likely to be implemented.

SECTION FOUR

This section presents the results of the risk assessment conducted in the Municipality of Aguadilla through a thorough inspection an evaluation of the different communities that the residents had experienced during their life span. The risk assessment was prepared to comply with the federal requirements of DMA 2000, FEMA Region II, and to meet the Puerto Rico State Emergency Management Agency (PRSEMA) guidance for the development of local hazard mitigation plans. More importantly, it provides a foundation for the community's decision makers to evaluate mitigation measures that can help reduce the impacts of natural hazard events.

This section is organized around the risk assessment process shown in Figure 4.1 and includes the following eight subsections:

- 4.1 CFR Requirements for Risk Assessment Title 44 Part 201
- 4.2 Introduction and Methodology
- 4.3 Identification of Hazards
- 4.4 Profile of Hazards
- 4.5 Inventory of Assets
- 4.6 Assessing Vulnerability
- 4.7 Loss Estimates
- 4.8 Understanding Future Losses In Aguadilla

4.1 CFR Requirements for Risk Assessment

Code of Federal Regulations CFR §201.6(c)(2):states that "[t]he plan shall include a risk assessment that provides the factual basis for activities proposed in the strategy to reduce losses from identified hazards. Local risk assessments must provide sufficient information to enable the jurisdiction to identify and prioritize appropriate mitigation actions to reduce losses from identified hazards."

The CFR goes on to include six specific requirements for the process of developing Local Hazard Mitigation Plan:

- **Identifying Hazards** per **Requirement §201.6(c)(2)(i):** [The risk assessment shall include] a description of the type … of all natural hazards that can affect the jurisdiction.

- **Profiling Hazards** per **Requirement §201.6(c)(2)(i):** [The risk assessment shall include] a description of the … location and extent of all natural hazards that can affect the jurisdiction. The plan shall include information on previous occurrences of hazard events and on the probability of future hazard events.

- **Assessing Vulnerability: Overview** per **Requirement §201.6(c)(2)(ii):** [The risk assessment **shall** include] description of the jurisdiction's vulnerability to the hazards described in paragraph (c)(2)(i) of this section.

This description **shall** include an overall summary of each hazard and its impact on the community.

- **Assessing Vulnerability: Identifying Structures** per **Requirement §201.6(c)(2)(ii)(A):** The plan **should** describe vulnerability in terms of the types and numbers of existing and future buildings, infrastructure, and critical facilities located in the identified hazard area

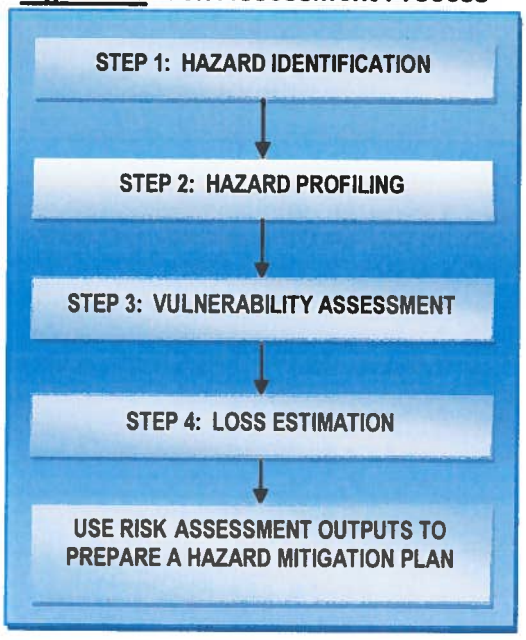
- **Assessing Vulnerability: Estimating Potential Losses** per **Requirement §201.6(c)(2)(ii)(B):** [The plan **should** describe vulnerability in terms of an] estimate of the potential dollar losses to vulnerable structures identified in paragraph (c)(2)(i)(A) of this section and a description of the methodology used to prepare the estimate.

- **Assessing Vulnerability: Analyzing Development Trends** per **Requirement §201.6(c)(2)(ii)(C):** [The plan **should** describe vulnerability in terms of] providing a general description of land uses and development trends within the community so that mitigation options can be considered in future land use decisions.

4.2 Introduction and Methodology

The risk assessment process used for this project is consistent with the process and steps presented in FEMA Local Multi-Hazard Mitigation Planning Guidance of July 1, 2008 and the FEMA Publication 386-2, "State and Local Mitigation Planning How-To Guide, Understanding Your Risks—Identifying Hazards and Estimating Losses" (FEMA 2001). Figure 4.0 shows the four major steps that comprise the risk assessment process: Hazard Identification, Hazard Profiling, Vulnerability Assessment, and Loss Estimation.

Figure 4.0 ***Risk Assessment Process***



Step 1 – Hazard Identification

The hazard identification was compiled by investigating the various natural hazard occurrences within the municipality.

Because it is assumed that hazards that occurred in the Municipality in the past may be experienced in the future, the hazard identification process included a series of interviews with municipal staff to identify various hazards and their occurrences. Information of past hazards was obtained from historical hazard assessment documents, and hazard specific plans and reports developed by experts over the past two decades.

Step 2 – Hazard Profiling as per 2004 to 2010

This step involved determining the frequency or probability of future events, their severity, and factors that may affect their severity. Each hazard type has unique characteristics that can impact the municipality in different ways. For example, no two hurricanes affect the municipality in the same manner based on the hurricane track, highest wind gusts, forward motion, and amounts of precipitation upon land fall. At the hazard identification phase, all natural hazards that could affect the Municipality were considered. The following natural hazards have been documented for the Municipality and have been assessed as risks for the purpose of this study. They are not listed in any particular order:

- Earthquake - Ground Shaking
- Earthquake - Liquefaction
- Earthquake - Induced Landslide
- Tsunami
- High Wind – Hurricane and Tropical Storm
- Riverine flood
- Coastal Flooding
- Fire – Wildfire and Urban Fire
- Rainfall - Landslide

The results of the hazard identification reveal that the hazards listed above warrant a vulnerability assessment due to their frequency of occurrence or due to the magnitude of their historical impacts. Please note that only natural hazards were identified. This follows the guidelines set forth in DMA 2000, which mandates that a natural hazard assessment be performed (i.e. hazards that occurs naturally, such as flood, wind, and earthquake. Man-made or man caused hazards, hazards caused by humans (for example, a terrorist act or a hazardous material spill), were not considered.

Step 3 – Inventory of Assets [1]

The inventory of assets quantifies what can be lost when a hazard occurs. Specifically, the people, places, and property that could be injured, damaged, or destroyed are quantified. To be consistent with the methodology outlined in the "*State and Local Mitigation Planning: How–to Guide: Understanding Your Risk*", the Consultant Project Team collected the following data and made calculations to:

- Estimate or count the total number of buildings, value of buildings, and population in the Municipality.
- Determine the proportion of buildings, the value of buildings, and the population in located in hazard prone areas.
- Calculate the proportion of assets located in hazard areas.

[1] General Building Stock Inventory is based upon 2004 plan. No major changes are observed.

In order to understand that vulnerability of people, buildings and infrastructure to natural hazards, a comprehensive inventory of assets was conducted. Inventory data was categorized into a number of asset categories, including population, general building stock, and infrastructure.

Population.
This was broken down to identify the number of people less than 18 years of age and the number of people over 65 years of age. These two demographic subgroups help define the municipality's social vulnerability as these two population groups are the most likely to need assistance during and/or after a hazard event.

General Building Stock. [2]
The field assessment was used to classify the general building stock into two general occupancy categories: commercial and residential. Detailed below are the procedures used to identify the number of buildings and to estimate the exposure values of the general building stock (replacement and content values Table 4.12 and 4.13).

1. The numbers of housing units were identified from the US Census data (2005 - 2009)[3]. This allowed the project team to identify the number of buildings per occupancy class, per census block. Since there were no commercial units listed in the US Census data a field assessment was deemed necessary.

2. An assessment matrix was used to relate the number of building to specific occupancy classes. Field surveys were used to identify how many buildings in an area were residential vs. commercial. This survey was conducted for several land use categories identified. Then the number of building identified as being residential and commercial were related to specific building types, showing the distribution of model building types through out the municipality. Distribution information was compiled to determine the number of building types per specific occupancy class. Collected data was aggregated at the census block level for each island.

3. An average replacement cost was developed for each building type. Replacement costs were based on the insurance policies for the municipality for 2011-2012 periods.

[2] General Building Stock inventory is based upon 2004 plan. No major changes are observed.
[3] Based on US Census data "estimate" for 2005 - 2009

Critical Facilities and Infrastructure[4]

A detailed list of critical facilities and infrastructure was developed by the Hazard Mitigation Committee. This list was then provided to the Consultant Project Team. Detailed procedures used to identify and estimate exposure values of critical facilities (replacement and content values) are provided below:

1. Facilities/structures were categorized by structural characteristics relevant to the prominent hazards addressed in the vulnerability assessment. The field investigation also allowed the Consultant Project Team to determine the vulnerabilities and risks of the structures for each possible hazard.

2. Replacement and content values were estimated based on field inspections which indicated that approximate building area.

The final step of the inventory process is a vulnerability assessment, which facilitates an understanding of the proportion of buildings, the value of buildings, and the population that is located in hazard areas. The results of the hazard identification and profile were used to understand characteristics of hazards (i.e. wind speed, flood depth, etc.) in order to assess the vulnerability parameters (specific damage and loss characteristics) of each asset identified. For instance, a wood frame building will have different damage and loss characteristics for a hurricane than a reinforced concrete structure. A hazard vulnerability assessment level (very low, low, medium, high, and very high) was assigned to each building type or facility to express the vulnerability for the general building stock (model building types) and critical facilities and infrastructure in qualitative terms.

Based on the vulnerability assessment for the general building stock, damage functions were developed to translate the hazard intensity data (given in terms of wind speed, ground shaking, depth of flooding, etc.) into its respective economic loss potential. In its simplest form, a damage function estimates the potential economic damage (e.g., cost to repair/replace the damaged components) of a building or group of buildings to a specified level of hazard intensity.

Step 4—Loss Estimation

The last step of the risk assessment is loss estimation. Hazard identification and profiling results are used together with the findings of the vulnerability assessment to understand potential losses for general building stock and critical facilities. Below are procedures for a prototypical census block in the municipality:

[4] This section did not changed because the information is not available and the methodology it is the same as 2004

1. Hazard maps (location) and hazard profile information (intensity) were used to identify the natural hazard affecting a particular area. Based on the intersection of hazard areas, each particular hazard intensity level (i.e. high winds, earthquakes).

2. Exposure to a specific hazard (i.e. number of buildings, % of total buildings, and value) was determined for identified buildings (general building stock and critical facilities).

3. A qualitative vulnerability level was assigned to each model building type to understand the vulnerability of buildings.

4. Qualitative vulnerability levels were related to specific loss estimation tables to determine possible damage to a structure (i.e. replacement and content value).

4.2.1 Uncertainties and Limitations

For this risk assessment, the loss estimates and exposure calculations rely on the best available data and methodologies. Uncertainties are inherent in any loss estimation methodology and arise in part from incomplete scientific knowledge concerning natural hazards and their effects on the built environment. Uncertainties also result from (1) approximations and simplifications that are necessary to conduct such a study, (2) incomplete or outdated data on inventory, demographic, or economic parameters, (3) the unique nature and severity of each hazard when it occurs, and (4) the amount of advance notice that the residents have to prepare for the event. These factors result in a range of uncertainty in loss estimates, possibly by a factor of two or more. As a result, potential exposure and loss estimates are approximate. These results do not predict precise results and should only be used to understand relative risk.

Data Sources, Hazard Model Assumptions, and Limitations

Data Sources, Hazard Model Assumptions, and Limitations are included below.

Ground Shaking Hazard Assessment: Data Sources, Ground Shaking Hazard Model Assumptions, and Limitations for Aguadilla[5]

The hazard assessment was developed using the Seismic Hazard Maps from the U.S. Geological Service (2003), which provides ground shaking intensity (expressed in terms of Peak Ground Acceleration (PGA) for 50-, 100-, 250-, 1,000-year return periods).

For this study is based on the probabilistic hazard methodology developed by the U.S. Geological Survey (USGS) as described by Frankel and others (1996, 2002), and present maps of probabilistic ground motions: peak ground acceleration (pga), 1.0-second spectral response, and 0.2-second spectral response, with 2% and 10% probability of exceedance in 50 years, corresponding to return times of approximately 2500 and 500 years, respectively. Like others in the USGS seismic hazard series, these maps will be used in earthquake mitigation and response planning, and derived engineering-design-motion maps will be considered for adopting in future updates of building codes and other structural design standards (Leyendecker and others, 2000). The USGS methodology is based primarily on 1) gridded and smoothed historical seismicity generalized using exponential magnitude distributions with regionally determined *b* values, and 2) specific fault sources with published slip-rate or recurrence information. Where there is reason to suspect that the seismicity or fault components of the model are incomplete, they can be supplemented with sources based on geodetic or other deformation data. Earthquakes are assumed to occur randomly in time; the probabilistic ground motions represent time-independent seismic hazard.

The Mona Passage between Puerto Rico and Hispaniola coincides with a broad zone of active crustal extension. Bathymetry, subsea seismic imaging, and focal-mechanism data are all suggestive of normal faulting on generally north-south trending structures and east-west-directed extension. One of the largest bathymetric features in the Passage, the north-south-trending Mona Canyon, is thought to be normal-fault controlled, and was probably the site (Mercado and McCann, 1998) of a magnitude~7.5, tsunami genic earthquake in 1918 that damaged northwestern Puerto Rico with large losses of life and property (Lafarge and McCann, 2003). We assign a rate of east-west extension of 5 mm/yr based on recent GPS geodesy results (Jansma and others, 2000), assume a *b* value of 1.0, and prorate faulting uniformly into each grid cell in the zone, using the method described by Frankel and others (1996) for computing hazard from areal zones.

[5] This information still the same as per 2004 plan. Nevertheless updated list of events is included accordingly on section 4.4.1 Earthquake Ground Shaking: Hazard Frequency and Magnitude

Figure 1 – PGA Hazard Curve

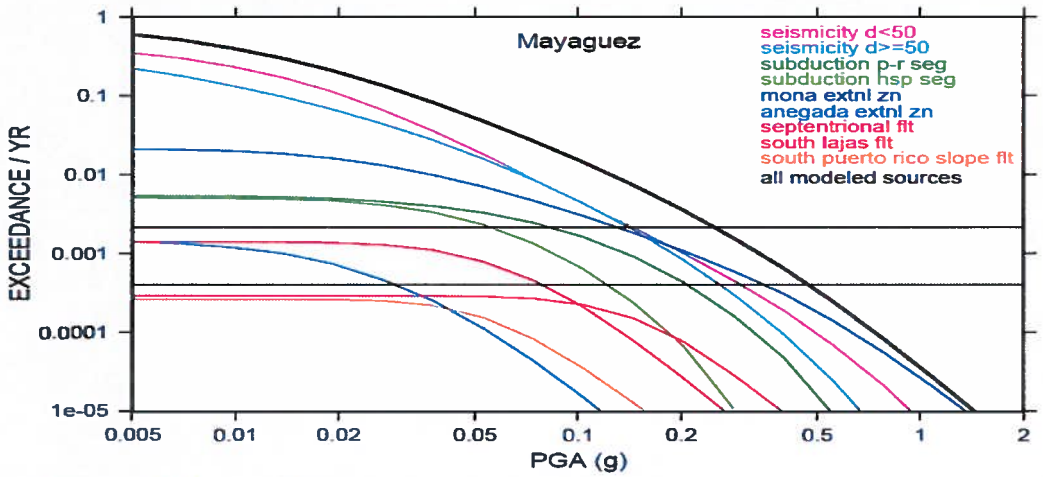
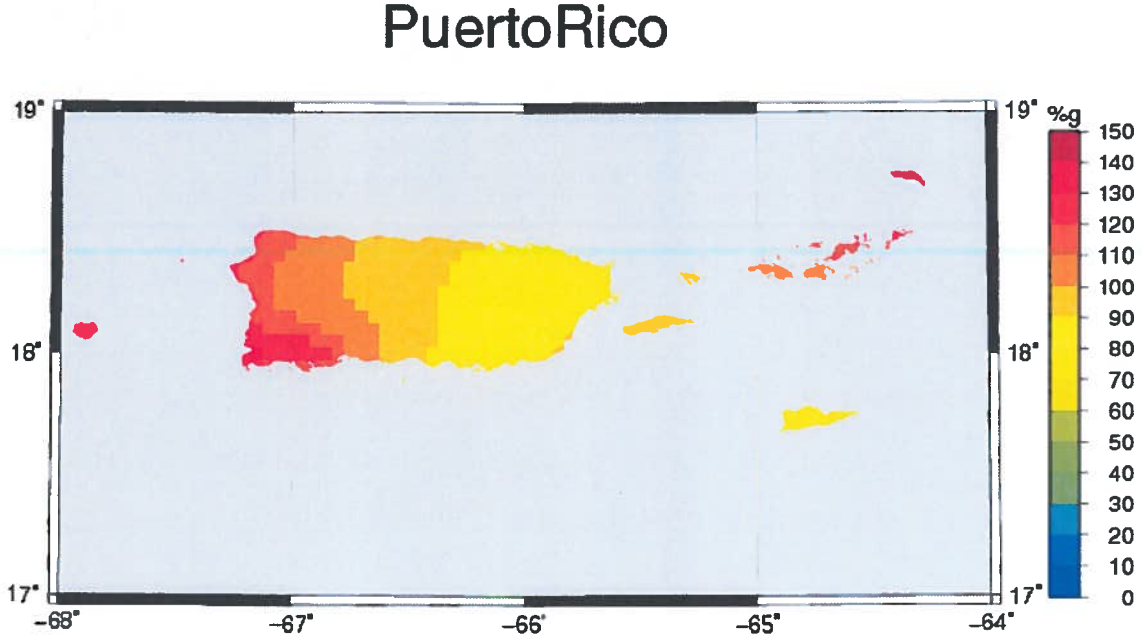


Fig.13b: PGA hazard curves for Mayaguez.

Figure 2 - Hazard curve for West Area

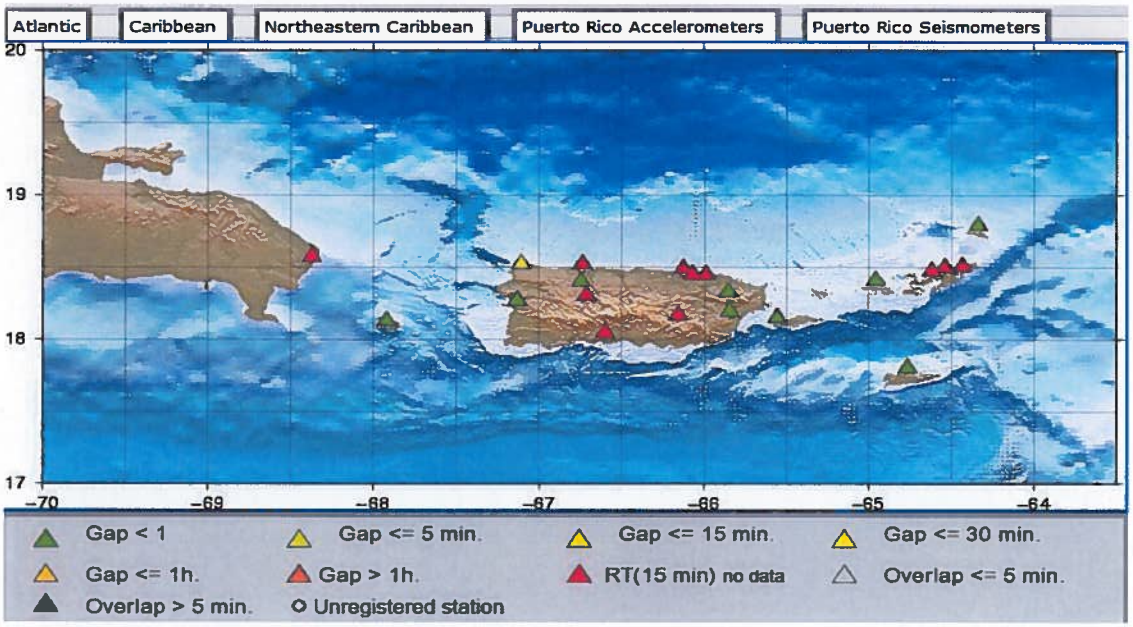


0.2 seconds SA, 2% in 50 years

- Seismicity near PRVI is primarily related to: 1) highly oblique subduction of the North American plate beneath the terrines of the plate boundary zone along the main plate interface south of the Puerto Rico Trench, and 2) the interactions of several probable micro plates within the complex boundary zone. Geodesy and seismicity data suggest the existence of a Puerto Rico - northern Virgin Islands micro plate that is relatively rigid and seismically quiescent internally (Masson and Scanlon, 1991; Jansma and others, 2000). Most of the major seismogenic sources are concentrated offshore; thus, estimates of activity rates on specific structures can be highly uncertain, often based on indirect evidence such as seismicity patterns and focal mechanisms, bathymetry and shallow seafloor seismic imagery, regional geodesy, kinematic reasoning, and tectonic analogs. The Great Northern and Great Southern Puerto Rico faults, major left-lateral strike-slip systems active on Puerto Rico from the early Cretaceous to the early Miocene are now considered largely quiescent, although they seem to be associated with very small earthquakes, and may represent inherited zones of weakness (McCann, 1985). Prentice and others (2000) have determined a recurrence rate for one fault onshore southwestern Puerto Rico that they consider to be currently active; several other candidate faults have been identified in western Puerto Rico, but not yet evaluated pale seismically.

- Seismic sources related to deformation along the main plate boundary include: mega thrust faulting along the plate interface, southward-deepening intraslab faulting within the sub ducting North American plate, and strike-slip faulting along several structures that strike sub parallel to the Puerto Rico trench north and northwest of Puerto Rico (Figure 9). These include the Septentrional fault, the major plate boundary structure in central Hispaniola, which extends eastward across the northern Mona Passage toward Puerto Rico, and the so-called North and South Puerto Rico Slope fault zones and related structures. Sources related to micro plate interactions include two broad zones of roughly east-west tectonic extension, one west of Puerto Rico roughly coincident with the Mona Passage, and one southeast of Puerto Rico roughly coincident with the Anegada Passage. Extension within these zones is thought to be related to differences in rates of eastward motion (relative to North America) of crustal blocks south of the main plate boundary (e.g., McCann and others, 1987; Jansma and others, 2000): the Caribbean plate moves eastward relatively unrestricted, while blocks within the boundary zone are restricted by relatively high-standing tectonic features like the Bahama Bank and Main Ridge (Figure 9). As discussed above, we include one terrestrial fault, the South Lajas fault onshore southwestern Puerto Rico (Prentice and others, 2000), in the hazard model.

Figure 3



Liquefaction Hazard Assessment: Data Sources, Hazard Model Assumptions, and Limitations for Aguadilla

The potential damage from liquefaction is conditional on the ground shaking amplitude (i.e., PGA), ground shaking duration, and groundwater depth.

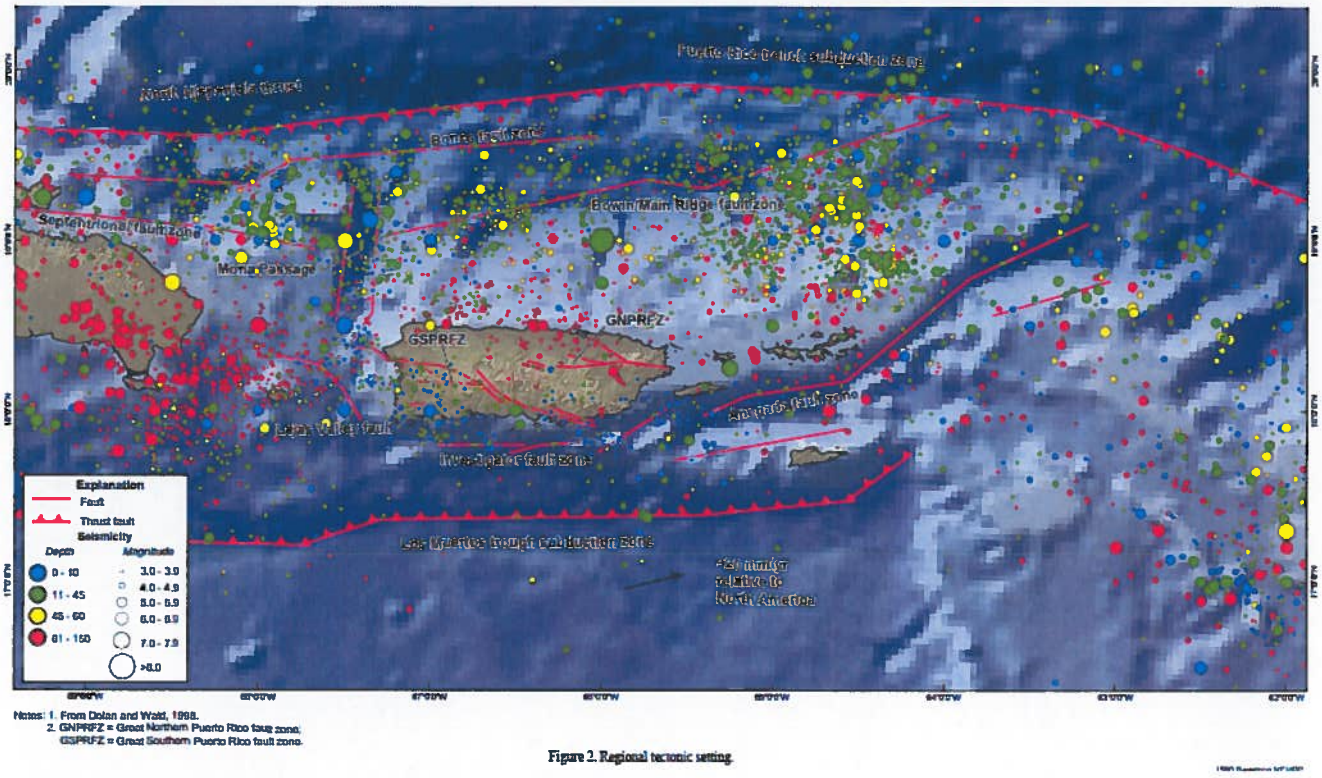
- The relative liquefaction susceptibility of a region was characterized by evaluating its soil/geologic conditions and groundwater depth. Susceptibility rating ranging from very low to very high was assigned using the Youd and Perkins (1978) classification system.
- To compute the damage potential (estimate losses), the baseline hazard frequency, intensity and susceptibility values (PGA) were computed against damage functions developed for a series of building types identified during field surveys.

- Puerto Rico is located in a seismically active region characterized by the convergence and lateral translation of the North America and Caribbean plates. Large earthquakes in 1670, 1787, 1867, and 1918 caused significant damage to major parts of the island, including the Aguadilla area. Pale liquefaction features, possibly caused by at least three different earthquakes since A.D. 1300, have been found in Holocene floodplain sediments at several sites in western Puerto Rico (Tuttle et al., this volume). The historic earthquakes and pale liquefaction features demonstrate that the opportunity exists for future liquefaction events to occur in Puerto Rico.

Figure 4 - Liquefaction Hazard

Geologic Unit	Description	Estimated Percent Liquefiable Texture	Estimated Liquefaction Triggering Acc.		Typical Groundwater Depth (m)	Liquefaction Hazard *
			M_w 6.5	M_w 8.0		
Qs	Holocene swamp deposits	50%	0.1g	0.05g	<1.5'	VERY HIGH
Qaf\Qs **	Artificial fill over swamps	<50%	0.1-0.2g	0.05-0.15g	<3.0'	VERY HIGH (See Note 2)
Qac	Late Holocene alluvial channels	<75%	0.15g	0.1g	<1.5'	High
Qb	Holocene beach deposits	80%	0.15-0.2g	0.1-0.15g	<1.5'	MEDIUM-HIGH
Qt	Late Pleistocene to Holocene terrace	35%	0.2g	0.15g	<3.0'	MEDIUM
Qaf	Artificial fill	<50%	0.2g	0.15g	1.5-6.0	MEDIUM
Qafe	Artificial road embankment fill	<50%	0.25g	0.15-0.2g	1.5-6.0	MEDIUM
Qay	Holocene alluvium	40%	0.2g	0.15g	<3.0'	MEDIUM
Qaf/Qay	Artificial fill over alluvium	<50%	0.2g	0.15g	1.5-6.0	MEDIUM
Qss	Late Pleistocene(?) dune sands	80%	>0.3g	>0.2g	3.0-10	LOW-MEDIUM
Qvf	Late Pleistocene to Holocene valley fill	<30%	>0.3g	>0.25g	1.5-6.0	LOW
Qf	Late Pleistocene to early Holocene fan	<10%	>0.3g	>0.25g	1.5-6.0	LOW
Qfo	Mid Pleistocene to Pliocene fan deposits	<10%	>0.3g	>0.3g	1.5-6.0	LOW
Qao	Late Pleistocene-Pliocene alluvium	<30%	>0.3g	>0.25g	1.5-6.0	LOW
Qtb	Late Pleistocene to Holocene blanket	<10%	>0.3g	>0.25g	1.5-6.0	LOW
QTt	Pleistocene alluvium	<10%	>0.3g	>0.3g	3.0-10	LOW-VERY LOW
Bx	Bedrock	0%	NA	NA	3.0-10	NEGLIGIBLE

Figure 5 - Regional Tectonic Plates Map



Notes: 1. From Dolan and Wald, 1998.
2. GNPRFZ = Great Northern Puerto Rico fault zone.
GSPRFZ = Great Southern Puerto Rico fault zone.

Figure 2. Regional tectonic setting.

Earthquake-Induced Landslide Hazard Assessment: Data Sources, Hazard Model Assumptions, and Limitations for Aguadilla[6]

The potential damage from an earthquake-induced landslide is significantly influenced by ground shaking amplitude (i.e., PGA) and the landslide susceptibility category.

- Conditional probability of earthquake-induced landslides is a function of Peak Ground Acceleration (PGA).
- The relative earthquake-induced landslide susceptibility was classified using a soil association map developed by the National Cooperative Soil Survey that distributed a broad-based inventory of soils and non-soil areas into five distinct physiographic regimes.
- For each physiographic regime, susceptibility categories were assigned as a function of geologic group and slope angle.
- To compute the damage potential (estimate losses), the baseline hazard intensity—permanent ground deformation values (PGD)—was computed against damage functions developed for a series of building types identified during field surveys.

Tsunami Hazard Assessment: Data Sources, Hazard Model Assumptions, and Limitations for Aguadilla

The danger of a tsunami in Puerto Rico is real. Since 1867, two tsunamis have affected their coastal region, causing death and destruction in 1867 and 1918. Although the source of the historical tsunamis have been local earthquakes, could also be generated by regional and distant earthquakes, landslide and much less likely (in the case of Puerto Rico) by a volcanic eruption or the impact of an object from sky. There is the tsunami threat in other parts of the Caribbean according to the *National Geophysical Data Center (NGDC)*. In Puerto Rico, efforts have been coordinated under the Tsunami Warning and Mitigation Program at the University of Puerto Rico Mayagüez (UPRM), while region efforts have been coordinated by IOCARIBE (Intergovernmental Oceanographic Commission, from UNESCO).

- There are 340 potential faults identified. A simulation was made of each one of them using the Japanese non-linear shallow water tsunami TIME model.
- Three nested grids were used, starting with the outer grid with a cell size of 27 arc seconds, followed by the intermediate grid with cell size of 9 arc seconds, and the inner grid with a resolution of 3 arc seconds.
- The induced sea bottom deformation was determined for each one of the potential faults using the Mansinha and Smylie (1971) method.
- Recently acquired SHOALS bathymetry was used to determine near shore ocean elevations. To determine the depth of deeper waters, NOS data and Sandwell and Smith (ETOPO-2) bathymetry were utilized.
- The USGS Digital Elevation Model was utilized to determine land elevations.
- The tsunami model and the data have been shown to provide good estimates of the observed runup due to the 1918 Puerto Rico tsunami (Mercado and McCann, 1998).
- The tsunami map was developed using a deterministic approach and is irrespective of the time of occurrence. Therefore, the inland flood extent for a 100-year recurrence timeframe cannot be determined.

[6] This information still the same as per 2004 plan.

High Wind Hazard Assessment: Data Sources, Hazard Model Assumptions, and Limitations for Aguadilla

The development of the high wind hazard map included two distinct sets of data: one derived from a simulation model and the other from a wind hazard model.

- The wind hazard methodology was based on numerical modeling of hurricane motion and procedures developed by the American Society of Civil Engineers (ASCE, 2000) for calculating wind loads. It takes into account basic wind speeds, surface roughness and topography.
- Hurricane wind speeds are based on the hurricane simulation model described in Vickery et al. (2000). The simulation uses the hurricane database HURDAT7 to generate synthetic storms and predicts 100-year peak gust wind speed in a flat terrain model from 120 mph to 130 mph (Applied Research Associates, Raleigh, North Carolina (2001)).
- Wind speeds are affected by surface roughness due to vegetation, terrain features, and buildings (Vickery, 2001). The roughness effect is taken into account for "Exposure B" according to ASCE 2000 and is assumed for the entire island.
- Automated GIS procedures were used to develop a map that depicts ASCE topographic speed-up effects in which local terrain features were taken into consideration. These factors account for the slow down experienced as the hurricane moves inland and for when it speeds up as the wind runs up hill slopes.

Riverine Flooding Hazard Assessment: Data Sources, Hazard Model Assumptions, and Limitations for Aguadilla

The magnitude of riverine flood damages is increasing in Aguadilla. Flood events continue to have an impact on greater numbers of buildings. The assessment of damages was limited to the FEMA 100-year floodplain data.

- The assessment utilizes the FEMA 100-year flood as an indicator of the overall hazard.
- Flood elevations for the 100-year floodplain were derived from FEMA Q3 Flood Data.
- Because of significant inconsistencies between the digital Base Flood Elevations (BFEs) and the terrain model, the 100-year floodplain polygons were used to infer flood elevations.
- The resulting GIS layer was used to generate an estimate of flood surface elevations to understand damages and losses.

Coastal Flooding Hazard Assessment: Data Sources, Hazard Model Assumptions, and Limitations for Aguadilla

The coastal flood damages are increasing in Aguadilla, particularly as development increases in coastal areas. The risk assessment in this study was limited to the VE zones from the FEMA Q3 maps.

- A 100-year flood probability was assumed for these areas.

[7] HURDAT is the National Hurricane Center's (NHC's) North Atlantic hurricane database. The original database of six-hourly positions and intensities was put together in the 1960s in support of the Apollo space program to help provide statistical track forecast guidance for tropical storms and hurricanes (Jarvinen et al., 1984).

- Flood elevations for the coastal high hazard areas were derived from an interpretation of both FEMA Q3 maps and digital USGS 1:20,000 topographic data.
- GIS overlay techniques were used to determine the flood depth of the Coastal High Hazard Area.8
- Flood damage functions were developed using various published reports, expert opinion, and FEMA Flood Insurance Administration (FIA) damage curves. Flood damage functions relate depth of flooding (in meters) to the damage ratio.
- The risk assessment allowed the project team to estimate the amount of property in the VE zones, as well as the type and value of structures present.

Infrastructure and Critical Facilities: Data Sources, Hazard Model Assumptions, and Limitations for Aguadilla

The loss estimation methodology for critical facilities is undertaken in a similar fashion to the loss estimation procedure for entire building inventory for Aguadilla, adjusted to reflect limitations in the available data and to account for differences in the resolution level of the data. The limitations include the following:

- Use of standardized exposure values, as specific information for each facility type was not available.
- Limited attribute information for detailed structure classification.
- Use of a methodology sensitive to exposure values.
- The methodology is adequate for determining approximate expected losses for use in comparison between structures, and not for structural evaluation of individual structures.
- No data was readily available to conduct an analysis on lifelines (i.e., transportation, water and electric networks).

It should be noted that the use of damage curves does not evaluate the structural integrity of critical facilities, but only determines expected losses from several hazards for comparison purposes for the infrastructure in a given region. The evaluation and expected behavior of a particular structure to any hazard should be undertaken with the services of a licensed and experienced structural engineer retained to provide facility specific assessments.

4.2.2 Maps

All maps referenced within this section are 11-inch x 17-inch map inserts. These maps are available electronically in PDF (Portable Document Format) viewable with Adobe Acrobat Reader. (Aguadilla Maps Folder)

[8] The error inherent in the terrain model suggests that flooding depths do not have great accuracy; however, they are suitable to distinguish between flooding depths of 1m, 2m, and 3m or greater.

4.3 IDENTIFICATION OF HAZARDS

This subsection includes describes the process used to identify those hazards that would be addressed in detail in this risk assessment. It also provides a description of the type of hazards that are particularly relevant to the Municipality. This information is presented in the following format:

- Hazard Selection and Prioritization
- Hazard Description

4.3.1 HAZARD SELECTION AND PRIORITIZATION

This process included identifying an initial list of hazards and then selecting hazards of interest specifically relevant to the study area. During community workshops held on March 25, 2011, the Municipality of Aguadilla identified a preliminary list of hazards of concern. Table 4.1 summarizes the hazard identification and selection process. Hazards of interest carried forward for further study based on group discussion.

TABLE 4.1 ***Identification of Hazards of Interest***

Identified	Hazard
☑	Riverine Flooding
☑	Coastal Flooding
	Drought
☑	Wildfire
☑	Earthquake (Ground Shaking)
☑	Earthquake (Liquefaction)
☑	Earthquake-Induced Landslide
☑	Tsunami
☑	Urban Fire
☑	Rainfall-Induced Landslide
☑	High Wind (including Hurricane and Tropical Storm)

From the list of 11 hazards, ten (10) were selected as hazards of interest for the Municipality. These eight hazards include (in the order in which they are discussed in this section) *earthquake (ground shaking, earthquake-induced, landslide) and tsunami, high wind (including hurricane and tropical storm,) urban fire, wildfire, and flooding (riverine and coastal).* Table 4.2 summarizes the hazards of interest selected for further analysis. It also shows historical event data and sources identified and used for the project.

TABLE 4.2 ***Summary of Hazards of Interest for Municipality of Aguadilla***

Hazard	Years	No. Of Events	Potential /Significant Impacts	Available Data Sources and Maps
Earthquake (including Ground Shaking, Liquefaction,- Induced Landslide, and Tsunami)	1918 to Present	11 major	Light to significant damages reported with these events. Note that in 2002, 967 earthquakes were reported in the Puerto Rico zone.	University of Puerto Rico Seismic Network, Integrated Hazard Assessment for Puerto Rico
High Wind (including Hurricanes and Tropical Storms)	1981 to 2010	24	Hurricane Hugo, Marilyn, Hortense and Georges. Hortense caused approx. 350,000 in damage to public infrastructure, while Georges caused the biggest impact on the Municipality. Reports provided by municipal staff indicated that there were over 2000 individual assistance applicants. Other storms was Debby, Jeanne, Noel, Olga and Fay.	National Weather Service (www.srh.noaa.gov/), Municipality of Aguadilla
Riverine Flooding	1972-1999	8 major	1972 Rio Culebrinas (exceeded 30,000 cubic feet per second) 1975 Flooding associated with Tropical Storm Eloise was estimated to exceed a 50 year flood event. 1999 Rio Culebrinas went out of its banks flooding Palmar and Corrales sector in Aguadilla	National Climate Data Center, USACE, Municipality of Aguadilla
Coastal Flooding	1999 to 2000	3	History of coastal flood events in Aguadilla has not been documented. The National Climate Data Center reported only three events between 1999 and 2000. Local interviews indicated that coastal flooding is common during heavy seas associated with low pressure systems or Atlantic winter storms.	National Climate Data Center, Municipality of Aguadilla

Notes: Modified from FEMA 386-2, Worksheet No. 1 (FEMA 2001).

4.3.2 HAZARD DESCRIPTION[9]

Earthquake Ground Shaking: Hazard Description

Puerto Rico is located in the limit between the plates of North America and the Caribbean, an area of oblique subduction and lateral displacement between these two plates. The seismic activity is concentrated in eight zones:

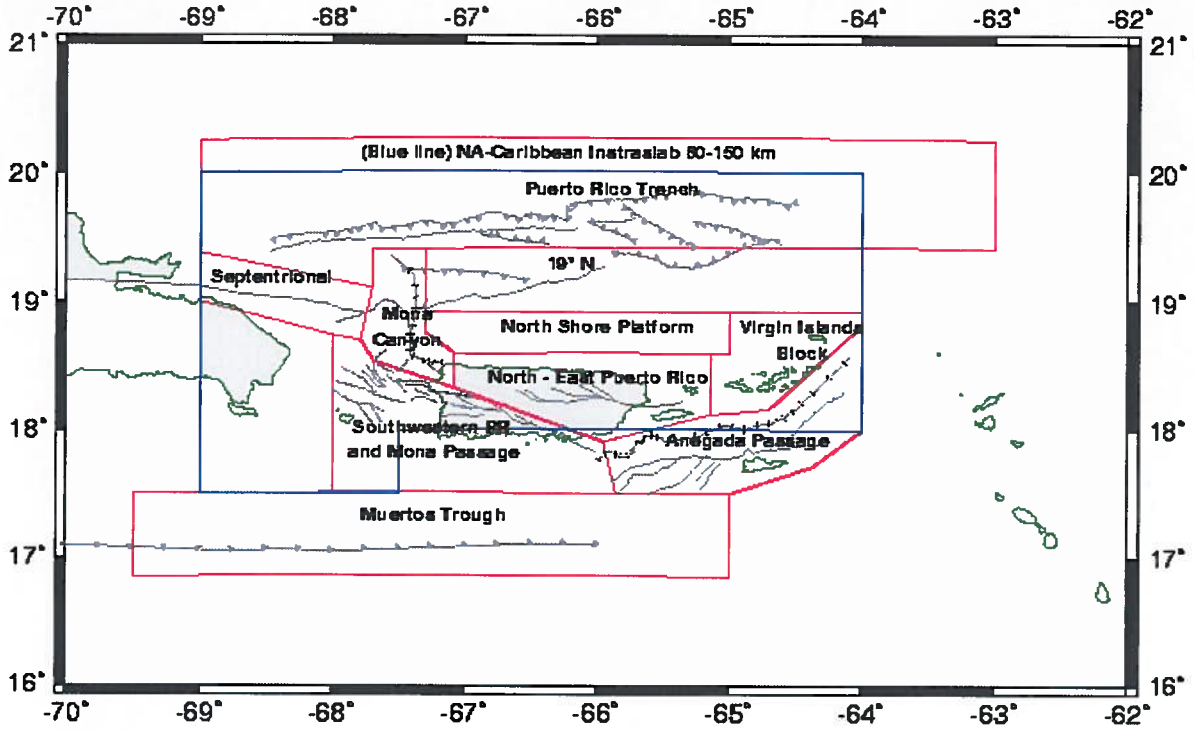
1. Puerto Rico Trench
2. Slope faults at north and south of Puerto Rico
3. Northeast of "Zona del Sombrero"
4. To the west, at the Mona Canyon
5. Mona Passage
6. To the east, in the depressions of Virgin Islands and Anegada
7. Muertos Depression to the south
8. Southeast of Puerto Rico

Aguadilla is located near the Mona Canyon Zone, an area of relatively frequent seismic activity. (See figure 6 on the following page.)

Earthquakes represent a particularly severe threat because of the irregular time intervals between events, the lack of adequate forecasting, and the catastrophic damage that can occur from a major event. An earthquake is caused by the release of energy accumulated within or along the edge of the earth's tectonic plates. It is characterized by sudden ground shaking. The severity of an earthquake depends on the location of the seismic event (its epicenter) and the amount of energy released. As it occurs, the seismic waves radiate away from the earthquake location causing the ground to shake. The severity of the shaking increases with the amount of energy released and decreases with distance from the location of the earthquake. The ground shaking from the earthquake may be felt hundreds of miles from where it occurred. The intensity of the ground shaking is the result of several factors including the magnitude and type of earthquake, distance from the earthquake, soil conditions of the area, and the orientation of the site relative to the earthquake occurrence.

[9] This information still the same as per 2004 plan.

Figure 6 - GROUND SHAKING HAZARDS MAP



Earthquake Liquefaction: Hazard Description

Liquefaction is a phenomenon that causes areas of unconsolidated soils and high water tables to lose strength and act like viscous fluid when subjected to earthquake ground shaking. The frequency and intensity of liquefaction that can occur during an earthquake is based on several factors, including the geologic conditions of the area, groundwater depth, ground shaking intensity, and the magnitude of the earthquake.

Earthquake-Induced Landslide: Hazard Description

Landslides are abrupt movements of materials that become detached from slopes or cliffs; they move by free-fall, sliding, or slumping. Earthquake-induced landslides can occur in natural slopes, cut slopes in soil or weathered rock, or fill slopes. They are common where steep cut slopes are present in relatively shallow soils over unweathered or fractured rock. The frequency and intensity of landslides that can occur during an earthquake is the result of several factors, including the geologic materials of the area, the slope, the water content of the slide material, the earthquake ground shaking, and the magnitude of the earthquake.

Tsunami: Hazard Description[10]

Earthquakes can generate tsunamis—large waves generated in the ocean by a sudden displacement of a large volume of water. After a major offshore earthquake, a tsunami can reach the shore in just minutes. Tsunamis can also travel over great distances and with longer advance warning, and can still have enough energy to cause significant damages on a distant coast. The earthquake that hit Puerto Rico in 1918 caused a tsunami with wave heights over 19 feet, killing more than 40 people and causing significant damage along the northwest coast of the island.

High Wind: Hazard Description

Hurricanes and tropical storms are the most frequently experienced high wind hazard in Puerto Rico, resulting in widespread damage and numerous casualties. Hurricanes are intense tropical weather systems with maximum sustained winds greater than 74 mph. They develop over warm water and are caused by the atmospheric instability created by the collision of warm and cool air masses. Hurricanes are particularly dangerous because of their destructive potential, large zone of influence, spontaneous generation, and erratic movement. Damage to buildings and infrastructure can be caused either by the force of high winds or from wind-borne debris that acts as wind-driven projectiles. Hurricanes are often accompanied by high tides, storm surges, and heavy rainfall that can cause rain-induced landslides and riverine flooding. The official Atlantic hurricane season extends from June 1 through November 30, with August and September as the peak months for hurricanes in Puerto Rico.

The magnitude of hurricanes is measured on the Saffir-Simpson scale, shown in Table 4.3, which categorizes hurricane magnitude by wind speeds and storm surge above normal sea levels. However, hurricanes are often associated with torrential rains that can lead to extensive inland flooding.

TABLE 4.3 ***Saffir-Simpson Hurricane Scale Definition***

Category	Wind Speed	Storm Surge (feet above normal sea level)	Expected Damage
1	74–95 mph	4–5 feet	**Minimal**: Damage is done primarily to shrubbery and trees, unanchored mobile homes are damaged, some signs are damaged, no real damage is done to structures.
2	96–110 mph	6–8 feet	**Moderate**: Some trees are toppled, some roof coverings are damaged, and major damage is done to mobile homes.
3	111–130 mph	9–12 feet	**Extensive**: Large trees are toppled, some structural damage is done to roofs, mobile homes are destroyed, and structural damage is done to small homes and utility buildings.

[10] This information still the same as per 2004 plan.

Category	Wind Speed	Storm Surge (feet above normal sea level)	Expected Damage
4	131–155 mph	13–18 feet	**Extreme**: Extensive damage is done to roofs, windows, and doors, roof systems on small buildings completely fail, some curtain walls fail.
5	> 155 mph	> 18 feet	**Catastrophic**: Roof damage is considerable and widespread, window and door damage is severe, there are extensive glass failures and entire buildings could fail.

Source: Understanding Your Risks: Identifying Hazards and Estimating Losses. FEMA. 2001.

Riverine Flooding: Hazard Description

Flooding is defined as the accumulation of water within a water body and the overflow of excess water onto adjacent floodplain lands. Riverine flooding occurs when the volume of water exceeds that capacity of stream channel. Water overflows banks and causes flooding.

Flooding events have had substantial impacts on residents and property in Aguadilla. The most serious flooding problems are associated with the Rio Culebrinas and its tributaries. Flooding has caused extensive property damage, blocked roads, disrupted economic activities by shutting down critical facilities, and has caused repetitive damages to residential areas.

The Rio Culebrinas basin has a drainage area of 103 square miles (267 square kilometers). The river flows in a westerly direction from the central mountain range, through the towns of San Sebastian and Moca, before entering in the Municipality of Aguadilla. There have been 38 major floods on this river system since 1900 (US Army Corps of Engineers, 2002). The alluvial flood plain of Rio Culebrinas encompasses approximately 1,500 acres of land in the Municipalities of Aguadilla and Aguada. The USACE estimates that during a 100-year flood on the Rio Culebrinas, over 560 structures would be subject to flooding (USACE 2002).

Coastal Flooding: Hazard Description

Coastal flooding is strongly associated with the term storm surge, which is the rising of the sea level due to the low pressure, high winds, and high waves associated with a hurricane or tropical storm as it makes landfall. Storm surge can cause significant flooding and loss of life if residents are caught unexpected.

Coastal flooding in Puerto Rico is common and associated with low-pressure systems, including tropical storms and hurricanes. The coastal plain also is vulnerable to flooding by large coastal sea swells generated by winter storms over the Atlantic Ocean. Storm surges occur with a rise in sea water level associated with intense low-pressure cells and ocean storms. Rising flood or water levels is a function of wind, atmospheric pressure, tide, waves, and/or swell. Coastal topography and immediate offshore bathymetry directly affects the extent of coastal flooding.

FIGURE 7 - AGUADILLA COASTAL FLOODING MAP

WILDFIRE: HAZARD DESCRIPTION

Wildfire caused intentionally, accidentally or incidentally, by the fire that occurs in vegetated areas, trees and busters.

Dry conditions at various times of the year and in various parts of Aguadilla greatly increase the potential for wildfires specially near besides road #2. This type of fire cause major damage to infrastructure and weaken the side hills stability. Post-fire debris flows are particularly hazardous because they can occur with little warning, can exert great impulsive loads on objects in their paths, can strip vegetation, block drainage ways, damage structures, and endanger human life. Wildfires could potentially result in the destabilization of pre-existing deep-seated landslides over long time periods

URBAN FIRE: HAZARD DESCRIPTION

Fire is any fire that occurs in a unwanted manner. The fire is the result of oxidation reactions of contact of a fuel with some heat. Urban Fires in Aguadilla may involve buildings, residences, warehouses and industries with potential for spread to adjoining structures. The urban fire hazard may involve areas where single family homes, multi-family occupancies and/or business facilities are clustered close together, increasing the possibility of rapid spread to another structure:

- Residential accidents (improper use of electrical appliances, faulty connections, grease fires, smoking, heating appliances or improper disposal of wood ashes).
- Industrial accidents (hazardous material incidents, explosions, transportation accidents)
- Acts of nature (lightening strikes, earthquake byproduct)
- Criminal acts (arson, illegal explosive devices, acts of terrorism)

RAINFALL- INDUCED LANDSLIDE

Rainfall-induced landslides are common in Puerto Rico (PR). The presence of steep slopes in mountainous terrain, coupled with weathered soils and intense rainfall, leads to severe slope-stability problems throughout the island. Episodic triggering events such as hurricanes and earthquakes further exacerbate these problems. All physiographic provinces of the island have experienced landslides. The stability of natural and man-made slopes is a serious concern for government authorities and the civil engineering community in Puerto Rico. In this plan we will present an overview of the rainfall induced landslide problem in Aguadilla, a summary of existing literature published on this subject, and proposes a rainfall intensity landslide threshold based on landslide events data from 1959 to 2003. This threshold can be used as a potential landslide warning criterion.

4.4 PROFILE OF HAZARDS

This subsection includes data and information used to profile priority hazards in the Municipality of Aguadilla. This information is presented in the following format:

- hazard location, extent and distribution;
- known history of hazard occurrences[11];
- frequency and magnitude as it relates to the risk assessment analysis and for determining the probability of future events; and

Please note that the information to compile a comprehensive history of hazards was very limited. Municipal staff, along with the consultant project team, worked diligently to gather information from a variety of sources including national data warehouses, local and regional emergency management offices, community workshops, and interviews with residents. The sources are listed in the following tables. Data provided by the municipality and records of interviews are provided in Appendix.

4.4.1 HAZARD PROFILE: EARTHQUAKE GROUND SHAKING

Earthquake Ground Shaking: Hazard Location, Extent and Distribution [12]

The ground shaking hazard is most severe in areas of deep, unconsolidated alluvial sediments. These areas are susceptible to amplification of peak ground acceleration (PGA) during an earthquake. Figure 4 illustrates the varying susceptibility of geological materials in Aguadilla to ground shaking. This map ranks ground shaking in five hazard intensity levels.

- The extent and distribution of the ground shaking hazard in Aguadilla is varied because:
- The high and very high ground shaking hazard areas are well distributed throughout the Municipality.
- Main areas affected by earthquake ground shaking include high density urban areas and the transportation corridors along PR 2, PR 110, and PR 111.
- A major earthquake will lead to significant loss of life and the disruption of critical facilities, infrastructure and lifelines, especially in urban center. Resulting damages will severely impair emergency response and recovery functions.
- Residential and commercial losses are expected to be concentrated among buildings that are not designed to current International Building

[11] The description of history of hazards was based on research, interviews with municipal emergency management staff, and comments received from the public during workshops. A thorough review of hazard documents and interviews revealed that data was not readily available. Where data was not available, the project consultant team relied on hazard history data for the whole of Puerto Rico.

[12] This information stills the same as per 2004 plan.

Code (IBC) standards (i.e. multi-story concrete buildings and older un-reinforced masonry structures, many of which are located in the urban center).

Earthquake Ground Shaking: Hazard History

As depicted above, Aguadilla falls into a relatively active seismic zone. During 2003 the PRSN located 947 earthquakes, this represents a decrease of 2.07% compared with the previous year (2002, 967 earthquakes).

The last major earthquake to strike in Puerto Rico was on **October 11, 1918**. The epicenter was located northwest of Aguadilla in the Mona Canyon (between Puerto Rico and the Dominican Republic). This earthquake had an approximate magnitude of 7.5 on the Richter scale and was accompanied by a tsunami ("tidal" wave) which got up to 6 meters (19.5 feet) high. Damage was concentrated in the western area of the Island because this was the closest zone to the earthquake. The earthquake and tsunami killed about 116 people and caused more than 4 million dollars of damage. Numerous houses, factories, public buildings, chimneys, bridges and other structures suffered severe damage13

Hazard	Date	Area Affected	Severity/Hazard Intensity	Damages/Economic Impact
Earthquake/Tsunami	October 18,1918	Western Puerto Rico, Including Aguadilla	M= 7.5	Damage severe on western side of island. 4 million, 116 people dead
Aftershock of an earthquake of the 10/11/1918.	October 24, 1918	Western Puerto Rico, Including Aguadilla	Maximum intensity in the island was VII (RF).	Unknown
Aftershock of an earthquake of the 10/11/1918.	November, 12, 1918	Western Puerto Rico, Including Aguadilla	Maximum intensity in the island was VI (RF, RT).	Unknown
Earthquake	February 10, 1920,.	Earthquake felt in all Puerto Rico	Maximum intensity was VI (DH), M=6.5.	Unknown
Earthquake	December 18, 1922	Earthquake felt in all Puerto Rico	Maximum intensity in the island was VI (DH), M=6.3	Unknown
Earthquake	June 12, 1939	Earthquake felt in all Puerto Rico	Earthquake felt in the entire island. Maximum intensity of VI (DH).	Unknown
Earthquake	July 28, 1943	Earthquake occurred to the northwest of Puerto Rico.	Its magnitude was of 7.5 (PS)	Many people around Puerto Rico felt the event but it did not cause damages

[13] *M* is the magnitude that reflects the energy released by the earthquake. If it is not specified that the intensity is RF (Rossi Forell), it is MM (Modified Mercalli). Data compiled by **University of Puerto Rico, Puerto Rico Seismic Network**.

Hazard	Date	Area Affected	Severity/Hazard Intensity	Damages/Economic Impact
Earthquake/Tsunami	August 4, 1946	Intensity of up to VI in the Mona Island and the western coast of Puerto Rico. In the rest of the island an intensity of V was reported. A tsunami of 2 feet was observed in the western and north coast of the island.	This earthquake of magnitude 7.8 (PS)	Smaller damages in all Puerto Rico were reported (DH).
. Earthquake/Tsunami	August 8, 1946	Earthquake in Dominican Republic (M=7.4, PS). Small tsunami in Mayagüez and Aguadilla		Unknown
Earthquake	March 23, 1979	Strong earthquake felt throughout the Caribbean; in Puerto Rico	M=6.1, it was felt with an intensity of VI	Unknown
Earthquake	May 30, 1987,	Strong earthquake felt in the southwest of the island, M=4.6, intensity VI. Epicenter near Boquerón.	There were light damages (USGS).	Unknown

Source: **University of Puerto Rico, Puerto Rico Seismic Network**, USGS

Earthquake Ground Shaking: Hazard Frequency and Magnitude

The frequency of the ground shaking hazard event is based on a 100-year return period—the municipality has a 1 percent annual probability of observing the losses shown in the loss estimates subsection of this risk assessment. Statistical analysis was used to PGA values range from .10 to .50 and was broken into five hazard level determinations ranging from very low to very high. This is the best available information to determination the probability and magnitude of future hazard events.

The following is a summary of annual earthquakes in the region of P.R. This report summarizes the frequency and magnitude as per reported by the Seismic Network of P.R.

2010

During 2010 the Seismic Network of P.R (SNPR) localized 1,681 earthquakes between latitude 17.00-20.00 N and longitude 63.5-69 W. 68 of these earthquakes were reported as "felt" and 66 were in our region. These movements were reported and varied from a 1.01 to 5.70 magnitude. The depth of these earthquakes varied from 0.3 km to 200.7 km. The majority of these earthquakes were felt in all the island of P.R.

2009

During 2009 the Seismic Network of P.R (SNPR) localized 2,739 earthquakes between latitude 17.00-20.00 N and longitude 63.5-69 W. 45 of these earthquakes were reported as "felt" and 43 were in our region. These movements were reported and varied from a .5 to 5.2 magnitude. The depth of these earthquakes varied from 3.1 km to 115 km. The majority of these earthquakes were felt in all the island of P.R.

2008

During 2008 the Seismic Network of P.R (SNPR) localized 2,574 earthquakes between latitude 17.00-20.00 N and longitude 63.5-69 W. 53 of these earthquakes were reported as "felt" and 51 were in our region. These movements were reported and varied from a 1.01 to 5.70 magnitude. The depth of these earthquakes varied from 3.44km to 119 km. The majority f these earthquakes were felt in all the island of P.R.

2007

During 2007 the Seismic Network of P.R (SNPR) localized 2,349 earthquakes between latitude 17.00-20.00 N and longitude 63.5-69 W. 49 of these earthquakes were reported as "felt" all in our region. These movements were reported and varied from a 0.3 to 4.9 magnitude. The majority of these earthquakes were felt in all the island of P.R.

2006

During 2006 the Seismic Network of P.R (SNPR) localized 2,253 earthquakes between latitude 17.00-20.00 N and longitude 63.5-69 W. 25 of these earthquakes were reported as "felt" all in our region. The majority of these earthquakes were felt in all the island of P.R.

2005

During 2005 the Seismic Network of P.R (SNPR) localized 1,086 earthquakes between latitude 17.00-20.00 N and longitude 63.5-69 W. 18 of these earthquakes were reported as "felt" all in our region. The majority of these earthquakes were felt in all the island of P.R.

2004

During 2004 the Seismic Network of P.R (SNPR) localized 1,047 earthquakes between latitude 17.00-20.00 N and longitude 63.5-69 W. 16 of these earthquakes were reported as "felt" all in our region. The majority of these earthquakes were felt in all the island of P.R.

Tectonic and seismic map of Puerto Rico Trench area. Arrows show direction of plate movements. USGS (2011).

Figure 8 - Tectonic and Seismic Frequency Map of Puerto Rico (2011)

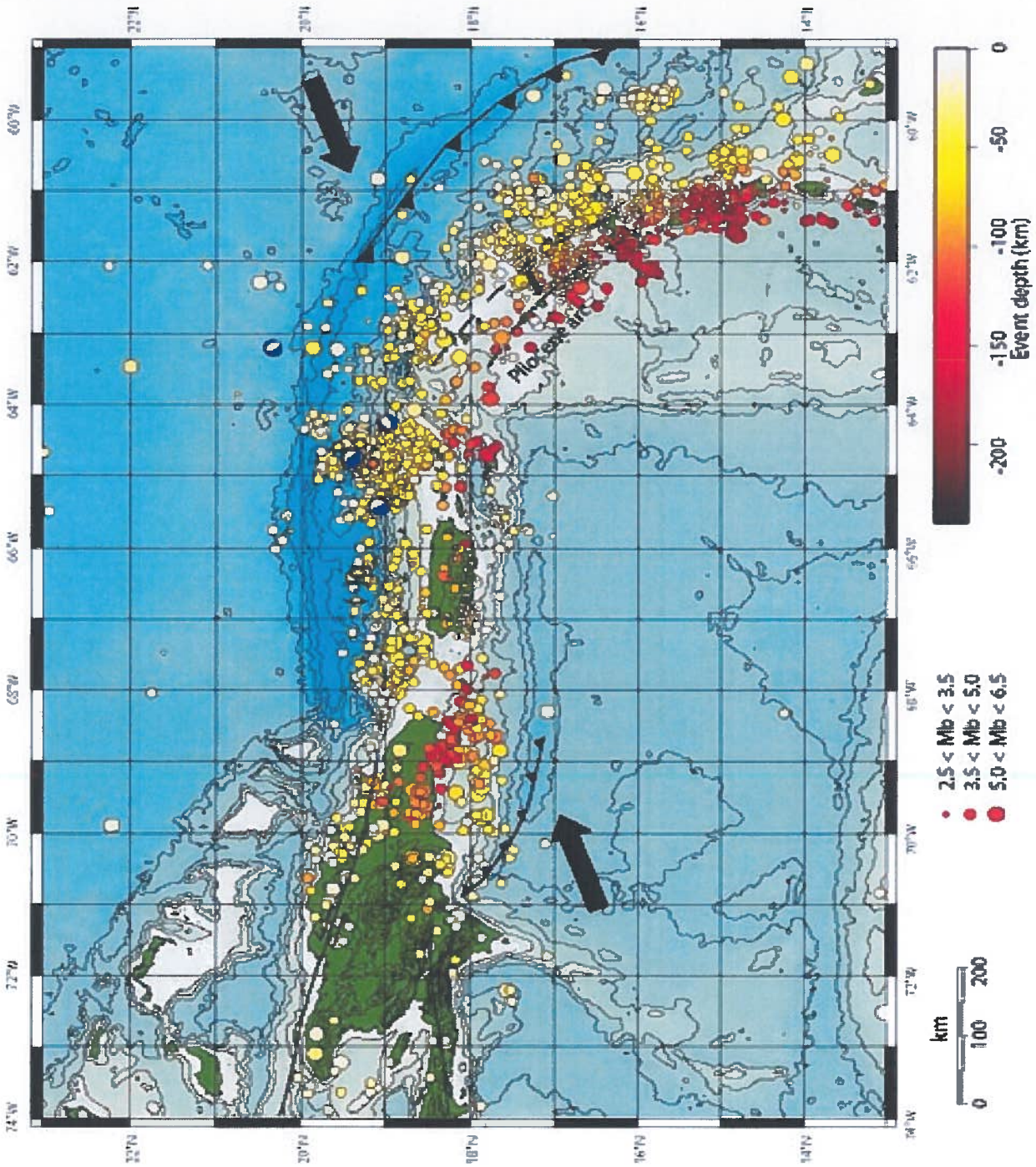
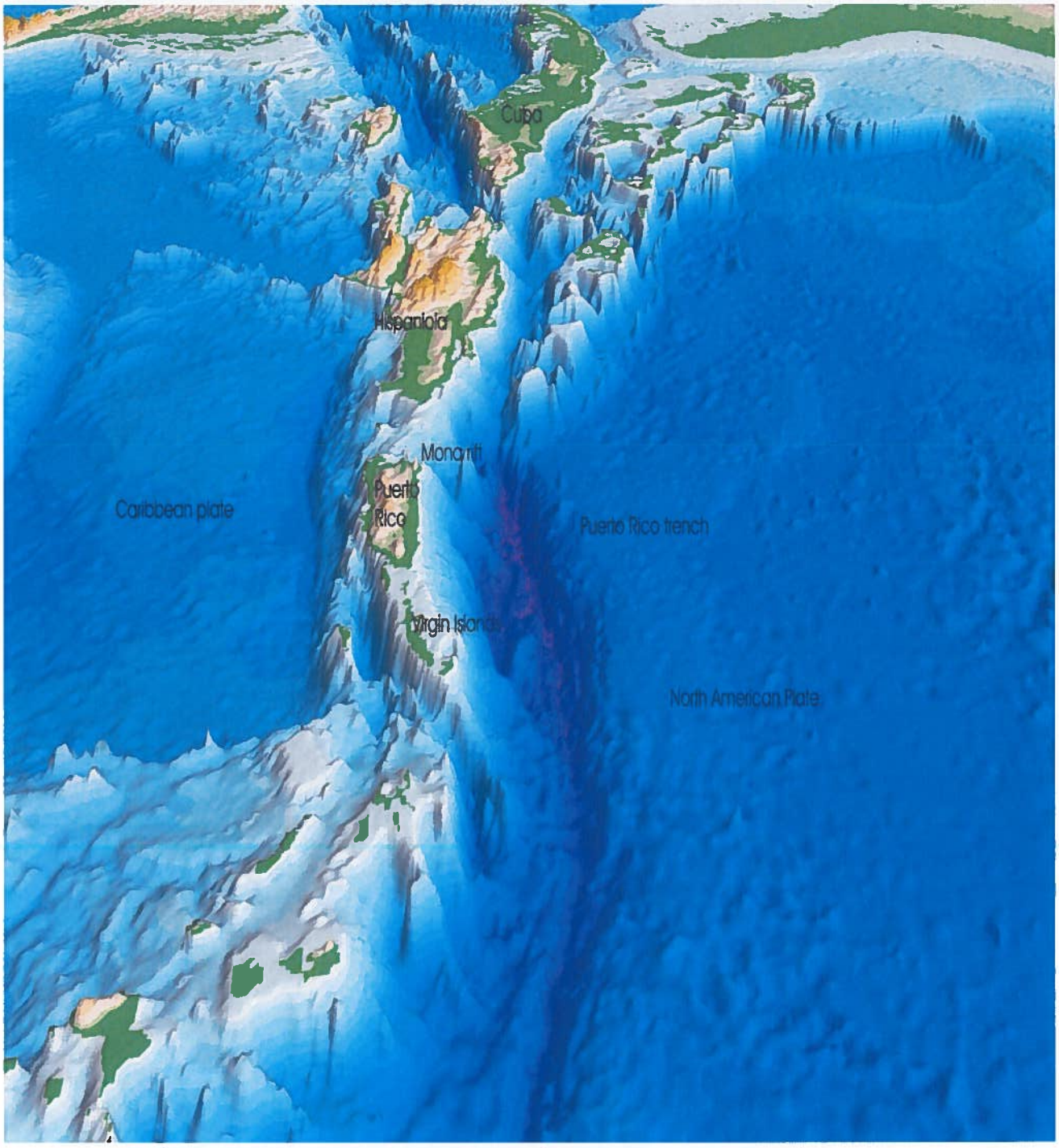


Figure 9 -DEEP SEA PERSPECTIVE, Puerto Rico Trench



Perspective view of the sea floor of the Atlantic Ocean and the Caribbean Sea. The Lesser Antilles are on the lower left side of the view and Florida is on the upper right. The purple sea floor at the center of the view is the Puerto Rico trench, the deepest part of the Atlantic Ocean and the Caribbean Sea.

4.4.2 HAZARD PROFILE: LIQUEFACTION

Liquefaction: Hazard Location, Extent and Distribution

The liquefaction hazard generally occurs in areas of deep, unconsolidated alluvial sediments. These areas are usually found in areas with high water tables. In Aguadilla, these are confined mostly to coastal areas. Unfortunately, the urban center of Aguadilla is located in this area of unconsolidated alluvial sediments and many of the older historic buildings were constructed using un-reinforced masonry construction practices. Figure 4 illustrates the varying susceptibility of geological materials in Aguadilla to liquefaction. This map ranks liquefaction into five hazard intensity levels.

The extent and distribution of the liquefaction hazard in Aguadilla is varied because:

- Liquefaction hazard incrementally increases the damage (in addition to the ground shaking damage) to buildings due to the ground deformation.
- Areas of particular concern are the urban center due to unconsolidated alluvial coastal deposits that contain high water levels and the presence of multi-story structures (i.e. commercial buildings) in the downtown area.
- Low to moderate hazard level distribution throughout the remainder of municipality is not of great concern due to low densities of vulnerable structures (i.e. multi-story buildings)

Liquefaction: Hazard History

As discussed earlier in this section, hazard history data specific to Aguadilla does not exist for some hazards identified in this section, including the liquefaction hazard. Information on previous occurrences is not available.

Liquefaction: Hazard Frequency and Magnitude

The frequency of the liquefaction hazard event is based on a 100-year return period—the municipality has a 1 percent annual probability of observing the losses shown in the loss estimates subsection of this risk assessment. PGA values range from .10 to .50. The likelihood of a liquefaction event is conditional based on the abovementioned PGA values. Conditional probability was based on hazard levels on ground shaking map. At a PGA value of .50, areas with a very high-low ground shaking hazard level, the conditional probability for liquefaction was assumed to be 1%; for Very High 25%. Statistical analysis was used to break the range of conditional probability percentages into five hazard level determinations ranging from very low to very high.

4.4.3 Hazard Profile: Earthquake-Induced Landslide

Earthquake-Induced Landslide: Hazard Location, Extent and Distribution

In Aguadilla, moderate to high earthquake-induced landslide hazard intensity areas coincide with ground shaking and liquefaction hazard areas. This is due to the predominance of soft soils in relatively flat coastal areas. However, potential damages related to this hazard are more likely to occur in mountainous areas that coincide with moderate ground shaking hazard levels. Figure 4 illustrates the varying susceptibility of geological materials in Aguadilla to earthquake-induced landslides. This map ranks earthquake-induced landslides into five hazard intensity levels.

The extent and distribution of earthquake-induced landslides is varied because:

- Damages from Earthquake-Induced Landslide hazard are expected to be significantly lower than earthquake ground shaking.
- The areas most prone to earthquake-induced landslides are steeply sloping land and land with unconsolidated consolidated sediments.
- Earthquake-induced landslides can threaten residential structures and infrastructure lifelines, particularly development along PR 2, PR 110, and the entrance of the urban center.

Earthquake-Induced Landslide: Hazard History

As discussed earlier in this section, hazard history data specific to Aguadilla does not exist for some hazards identified in this section, including the earthquake-induced landslide hazard. Information on previous occurrences is not available. Nevertheless, in the past years (2009-2011) some minor earthquakes had occurred causing some damages.

Earthquake-Induced Landslide: Hazard Frequency

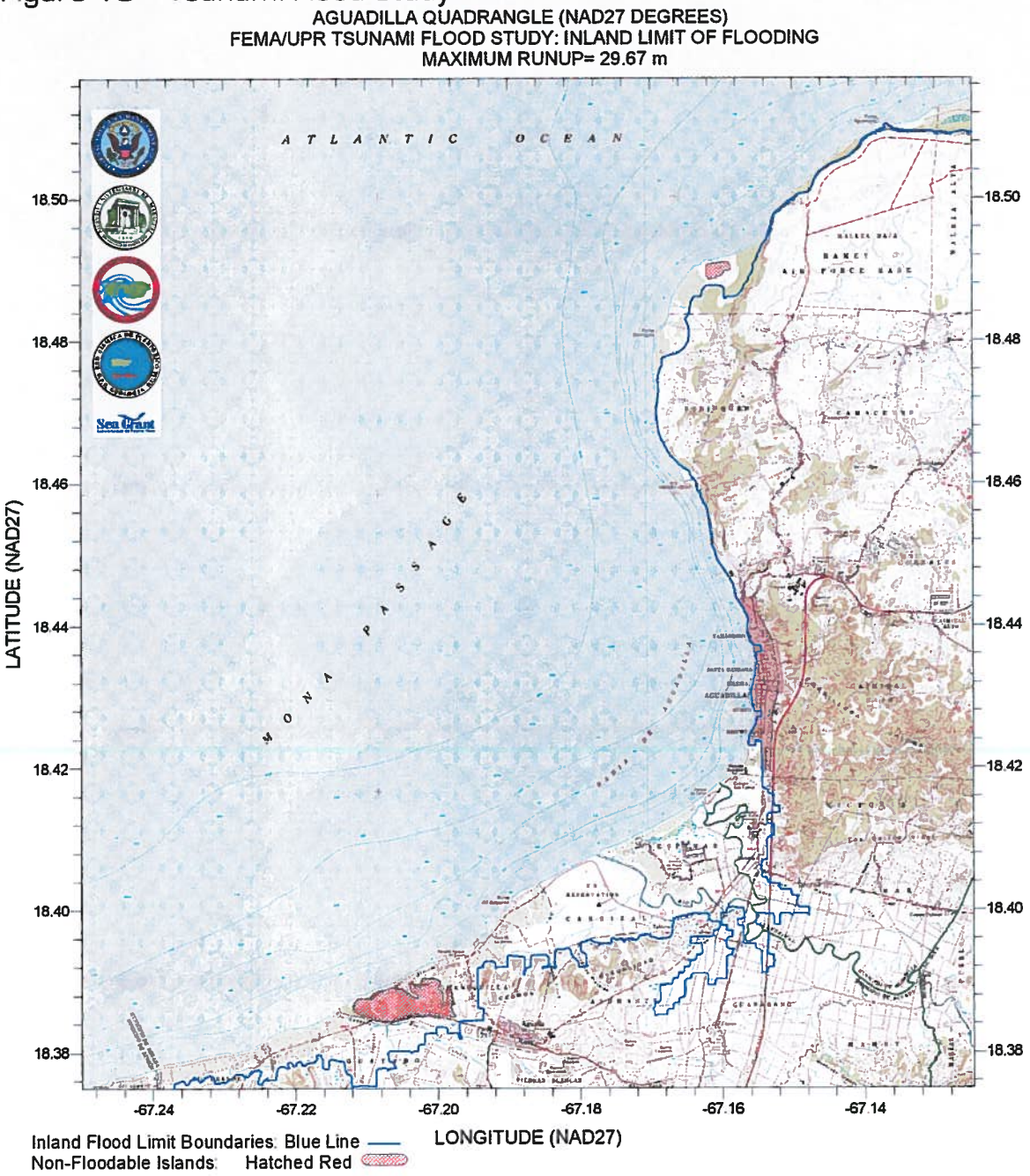
The frequency of the earthquake-induced landslide hazard event is based on a 100-year return period—the municipality has a 1 percent annual probability of observing the losses shown in the loss estimates subsection of this risk assessment. PGA values range from .10 to .50. The likelihood of an earthquake induced landslide is conditional based on the abovementioned PGA values. Conditional probability was based on hazard levels. At a PGA value of .50 areas with a very high low ground shaking hazard level, the conditional probability for liquefaction was assumed to be 1%; for Very High 30%. The PGA values and soil and geology were used to break the PGA values into five hazard level determinations ranging from very low to very high.

4.4.4 HAZARD PROFILE: TSUNAMI

Tsunami: Hazard Location, Extent and Distribution

Tsunami hazard areas are all low lying, relatively flat coastal areas. Inland flood areas in Aguadilla are depicted in the following figure:

Figure 10 - Tsunami Flood Study Limit



The last major earthquake and Tsunami to strike in Puerto Rico was on October 11, 1918. The epicenter was located northwest of Aguadilla in the Mona Canyon (between Puerto Rico and the Dominican Republic). This earthquake had an approximate magnitude of 7.5 on the Richter scale and was accompanied by a tsunami ("tidal" wave) which got up to 6 meters (19.5 feet) high. Damage was concentrated in the western area of the Island because this was the closest zone to the earthquake. The earthquake killed about 116 people and caused more than 4 million dollars of damage. Numerous houses, factories, public buildings, chimneys, bridges and other structures suffered severe damage14.
The extent and distribution of the tsunami hazard is confined to coastal areas:

- The presence of these large, active fault zones located just off shore of the island creates a substantial tsunami threat for the northwest coast of Puerto Rico.
- Although a tsunami advances much slower as it approaches land, its momentum is powerful enough to flatten houses, buildings and trees, and carry ships far inland.
- Parts of the communities of Victoria, Borinquen, Maleza Baja, Maleza Alta, Aguacate and Montaña fall within the tsunami inland flood area.
- Tsunamis cause extensive environmental damage as they may strip beaches of sand that may have taken years to accumulate, uproot trees and other coastal vegetation, and cause large-scale flooding.
- Tsunamis can devastate development along coastlines, causing widespread property damage and loss of life.
- Tsunamis can devastate infrastructure lifelines such as water, power, telecommunication, and transportation networks.

Tsunami: Hazard History

As discussed earlier in this section, hazard history data specific to Aguadilla does not exist for some hazards identified in this section, including the tsunami hazard. However, seven (7) significant tsunami events that have affected Puerto Rico have been documented from the historical record. The list below, extracted from "Disaster and Disruption in 1867: Earthquake, Hurricane and Tsunami in Danish West Indies (1997), indicates that the following tsunami events affected Puerto Rico.

14 *M* is the magnitude that reflects the energy released by the earthquake. If it is not specified that the intensity is RF (Rossi Forell), it is MM (Modified Mercalli). Data compiled by **University of Puerto Rico, Puerto Rico Seismic Network.**

Hazard	Date	Area Affected	Severity/Hazard Intensity	Damages/Economic Impact
Tsunami	1867 (November 18)	Western Puerto Rico		Unknown
Tsunami	1918 (October 11).	Western Puerto Rico, Mayagüez	19 feet	Most recent severe tsunami event in Puerto Rico affecting the northwest coast with a wave crest estimated to be over 19 feet and causing 40 fatalities.
Tsunami	1918 (October 25)	Western Puerto Rico		Unknown
Tsunami	1946 (August 4)	Western Puerto Rico,	2 feet	Unknown
Tsunami	1946 (August 8)	Western Puerto Rico, Aguadilla	2 feet	Unknown
Tsunami	1989 (November 1)	Western Puerto Rico		Unknown

Source: Eastern Caribbean Center, UVI, 1997. Disaster and Disruption in 1867: Earthquake, Hurricane and Tsunami in Danish West Indies. ;University of Southern California, Tsunami Research Group, http://www.usc.edu/dept/tsunamis/index.html

Tsunami: Hazard Frequency and Magnitude

The frequency of the tsunami hazard event cannot be determined from readily available information. The tsunami map was developed using a deterministic approach and is irrespective of the time of occurrence. Therefore, the inland flood extent for a 100-year recurrence timeframe cannot be determined nor can the probability of future events be calculated. In crude terms, based on the observed record of approximately 100 tsunamis in the Caribbean over the last 500 years, on average, a tsunami should be expected somewhere in the basin every 5 years. Conversely, there is a 20% chance that a tsunami will strike somewhere in the Caribbean in a particular year. The historical record for tsunami's indicates that the magnitude of these events have varied from 2 -19 ft.

4.4.5 Hazard Profile: High Wind

High Wind: Hazard Location, Extent and Distribution

The moderate to very high wind hazard intensity levels occurs in mountainous regions of the municipality due to a wind speed up factor as elevation increases. The high wind model also accounts for wind speed decay as a storm moves inland from the coast. Table 4.3 illustrates the varying susceptibility of high winds. This map ranks high wind hazard intensity in five hazard intensity levels.

The extent and distribution of the high wind hazard is varied because:

- Hazard levels range from very low to moderate with the highest hazard intensity levels along the coast. The wind speed up factor is relatively small in Aguadilla due to the limited range of elevation throughout the Municipality.
- During bad weather strong winds have the potential to cause extensive property damage throughout the Municipality.
- Intense winds associated with hurricanes and tropical storms are likely to cause damage to wooden frame structures found in historical districts and rural communities, known as "*parcelas*".
- Waterspouts are intense high wind gusts that come from the sea capable of damaging infrastructures without notice.
- Infrastructure, particularly power and telecommunication are susceptible to hurricane force winds.
- Riverine and coastal flooding are associated hazards.

HIGH WIND: HAZARD HISTORY

The list below highlights the tropical storms and hurricanes that passed within two degrees of latitude of Puerto Rico and the Virgin Islands from 1990 to present. Specific hazard history for river flooding was gathered by municipal staff. Personal interviews and comments gathered during public workshops were integrated into this report.

Table 4.4 Major High Wind Events

Hazard	Date	Area Affected	Severity/Hazard Intensity	Damages/Economic Impact
Hurricane Marilyn	September, 15-16, 1995	Passed over St. Thomas, USVI and Northeast Puerto Rico. Affected the entire Island, including Aguadilla	Category 2	Unknown
Hurricane Hortense	September, 9-10-16, 1995	Passed over the southwest corner of Puerto Rico. Affected the entire Island, including Aguadilla	Category 2	Unknown
Hurricane Georges	September 21, 1998	Passed over St Croix in the U.S. Virgin Islands and then entered Puerto Rico near Humacao and traveled through the interior of the island exiting just south of Mayagüez in Cabo Rojo. The hurricane traveled mainly in an E to W direction. Affected entire Island, including Aguadilla	Category 3	350,000 in direct damages to public facilities (i.e. parks, public buildings, roads, etc.)
Hurricane Lenny	November 16-18,1999	Passed within 1º latitude to the south of Puerto Rico and the U.S. Virgin Islands, Storm surge affected western Puerto Rico, including Aguadilla	Category 4	Unknown
Tropical Storm Jeanne	September 21, 2004	Passed over Puerto Rico, Affected the entire island, including Aguadilla	Tropical Storm	Limited damages, have not been quantified

Source: Public Workshops, Municipal Staff: Emergency Management and Public Works
*Waterspouts on April 13, 2011 this phenomenon affected the Aguadilla Region causing $200,000 in damages to local infrastructure (Luis T Diaz Coliseum and Parque Colon).

High Wind: Hazard Frequency and Magnitude

The frequency of the high wind hazard event is based on a 100-year return period—the municipality has a 1 percent annual probability of observing the losses shown in the loss estimates subsection of this risk assessment. For this return period, wind speeds ranged from 90-122 mph for Aguadilla. This is the best available information to determination the probability and magnitude of future wind hazard events. Statistical analysis was used to break down the range of wind speeds into five hazard level determinations ranging from very low to very high.

4.4.6 HAZARD PROFILE: RIVERINE FLOODING

Riverine Flooding: Hazard Location, Extent and Distribution

Riverine flooding generally occurs along the Rio Culebrinas and in several low-lying areas (often areas not mapped by FEMA as part of the 100-year floodplain) throughout the Municipality, notably in the Nuevo San Antonio Sector. Smaller tributaries are also susceptible to flooding from large meteorological systems, especially tropical storms. The storm waters in upstream tributaries drops quickly to lower elevations creating conditions that are ideal for flash flooding events. Figure 7 illustrates the varying susceptibility to riverine flooding throughout the Municipality.

The extent and distribution of riverine flooding hazard is varied because:

- Riverine flood hazard areas are confined to the flood plain associated with -the Rio Culebrinas.
- Barrio Victoria, Urbanization Garcia is particularly prone recurrent flooding. Residential, commercial and institutional buildings (i.e. low-income housing) are prone to flooding.
- Infrastructure, especially a major electrical sub-station is prone to flooding.

Riverine Flooding: Hazard History

As shown in Table 4.5, there have been 10 major flood events in Aguadilla between 1972 and 1999. The events highlight a seasonal pattern to flooding that follows a distinct rainy season that occurs usually between June and November. Specific hazard history for river flooding was gathered by municipal staff. Personal interviews and comments gathered during public workshops were integrated into this report. In addition, the study contractor was able, with the assistance of the Municipality, to identify a number of specific riverine flooding events that have led to property damages in Aguadilla. These local flooding events include:

TABLE 4.5 ***Chronology of Major Floods in Aguadilla, 1972 to Present***

Hazard	Date	Area Affected	Severity/Hazard Intensity	Damages/Economic Impact
Flood	1972 (October).	Rio Culebrinas.	Flood flow exceeded 30,000 cubic feet per second (cfs)	Unknown
Flood	1975 (September 16). 1980 (May).	Río Culebrinas. Tropical Storm Eloise. Largest flood of record with an estimated recurrence interval of 50 years.	50 Year Return Period	50 Years
Flood	1981 (October).	Rio Culebrinas. Flood flow exceeded 30,000 cfs	Flood flow exceeded 30,000 cubic feet per second (cfs)	Unknown

Hazard	Date	Area Affected	Severity/Hazard Intensity	Damages/Economic Impact
Flood	1985 (May).	Rio Culebrinas. Flood flow exceeded 30,000 cfs	Flood flow exceeded 30,000 cubic feet per second (cfs)	Unknown
Flood	1986 (May).	Rio Culebrinas.	Flood flow exceeded 30,000 cubic feet per second (cfs)	Unknown
Flood	1988 (August).	Rio Culebrinas.	Flood flow exceeded 30,000 cubic feet per second (cfs)	Unknown
Flood	September 21, 1996	Hurricane Hortense, Rio Culebrinas overflowed and caused residential flooding, infrastructure damaged.	Estimated to be equivalent to 100-year event.	
Flood	September 21, 1998	Hurricane Georges, Rio Culebrinas overflowed and caused residential flooding, infrastructure damaged.	Unknown	Unknown
Flood	May 26 – 28, 1999	Civil Defense indicated that river Culebrinas went out of its banks flooding Palmar sector in Aguadilla	Unknown	Unknown
Flood	Nov 7, 1999	Heavy rains induced small streams to overflow their banks flooding nearby roads. At Corrales sector a center for the elderly had to be evacuated, and a few cars were swept away by the waters. Elsewhere, a church was reported flooded.	Unknown	Unknown

Major Recorded Annual Floods at Rio Culebrinas

Date	Flow (ft^3/s)
September 16, 1975	41,200
September 22, 1998	36,900
May 17, 2003	31,800
September 26, 2004	33,100
November 17, 1968	30,00
October 4, 1993	28,400

Source: United States Geological Survey (http://water.usgs.gov/pubs/FS/FS-051-96/#HDR05) and data compiled from the National Climatic Data Center (http://www.ncdc.noaa.gov/oa/ncdc.html). Localized information on riverine flooding was not available for the entire municipality. Information included in the table above reflects information documented in USACE study on flooding in the Rio Culebrinas. Specific hazard

Hazard	Date	Area Affected	Severity/Hazard Intensity	Damages/Economic Impact

history for river flooding was gathered by municipal staff. Personal interviews and comments gathered during public workshops were integrated into this report.

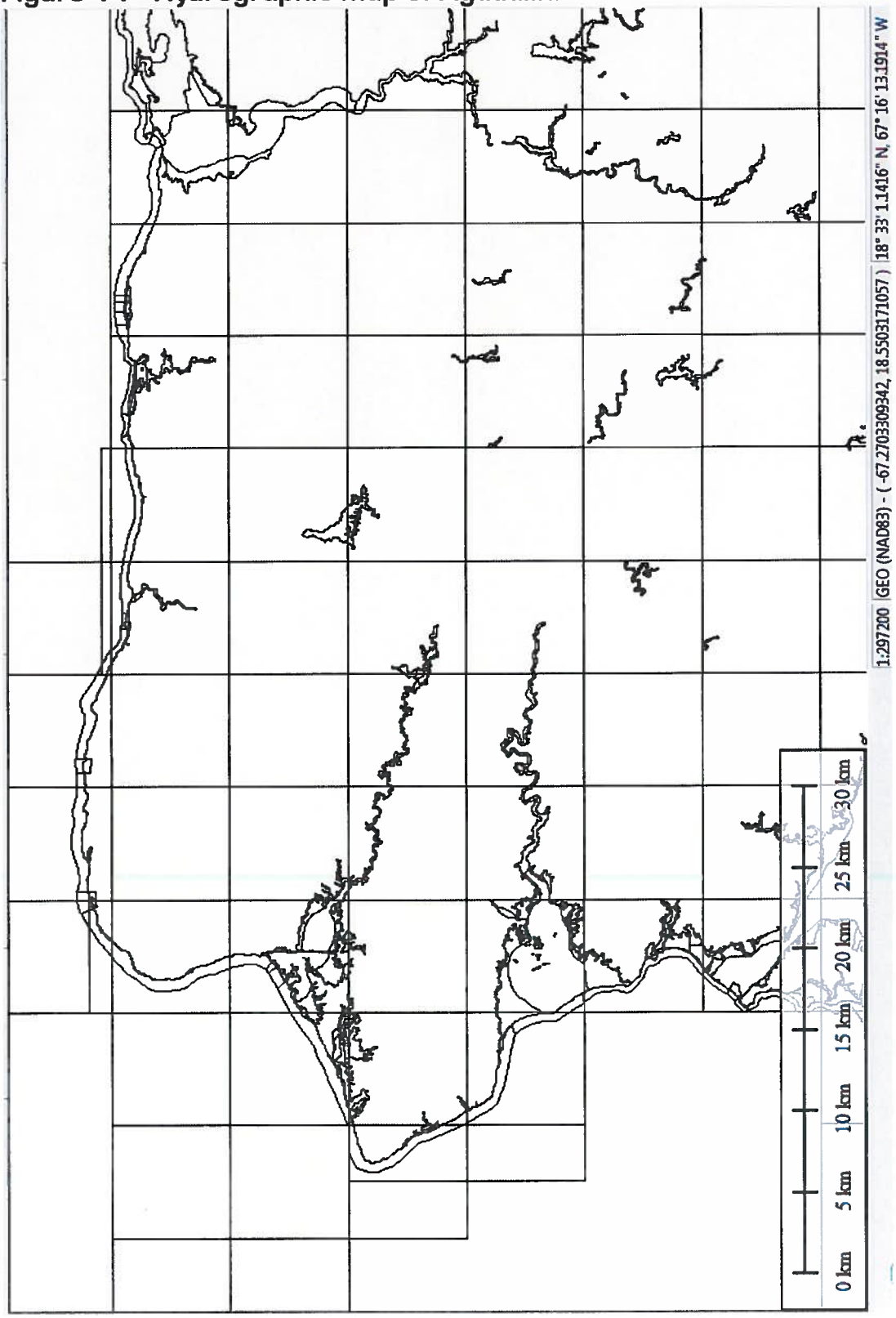
Riverine Flooding: Hazard Frequency and Magnitude

The frequency of the riverine flooding hazard event is based on a 100-year return period—the municipality has a 1 percent annual probability of observing the losses shown in the loss estimates subsection of this risk assessment. Based on the flood mapping and hazard analysis, flood depths ranged from 0-3.9 meters. Statistical analysis was used to break the range of flood depths into five hazard level determinations ranging from very low to very high. At the time, this should be considered the best available information to determine magnitude, impact and probability of future hazard events.

Table 4.6 Table of computed median runoff, by water-year, for Puerto Rico (USGS) Water Watch

State	Year	No. Streamgages	Run off (MM)	Run off (IN)	Rank
PR	2004	66	1304.39	52.18	6
PR	2005	3	1485.10	59.40	2
PR	2006	68	1078.71	43.15	12
PR	2007	18	735.31	29.41	39
PR	2008	74	998.96	39.96	20

Figure 11 - Hydrographic map of Aguadilla



4.4.7 HAZARD PROFILE: COASTAL FLOODING

Coastal Flooding: Hazard Location, Extent and Distribution

The distribution of coastal hazard intensity levels is confined to coastal areas with gradually sloping lands. In the past, there have been several areas that have been affected by coastal storm surges. Figure 7 illustrates the varying susceptibility to coastal flooding. This map ranks flooding hazard intensity in five hazard intensity levels.

The extent and distribution of the coastal flooding hazard is varied because:

- Relatively small area of Municipality is susceptible to coastal flooding associated with hurricanes, tropical storms and strong depressions.
- Significant coastal flooding events also have potential to threaten human life and safety, especially in low-lying coastal communities and settlements
- High waves frequently disrupt infrastructure, particularly roads and have the potential to cause damages to critical facilities (i.e. schools, police station, municipality offices), and residential structures. Many schools both public and private are located along the coast in the urban center of Aguadilla.

Coastal Flooding: Hazard History

The National Climatic Data Center (NCDC) Storm Event Database reported 6 coastal flood events for the Municipality of Aguadilla from 1999 to Present. As explained earlier in this section, hazard history data specific to Aguadilla is very limited. Localized information on riverine flooding was gathered by through interviews with concerns citizens and from various municipal departments. One of these 26 coastal flood events occurred in February 1999, when a strong low-pressure system north of the island caused large northwest swells across the north coasts of Puerto Rico and the U.S, Virgin Islands. In Aguadilla, several fishing boats suffered some damages. Through local interviews, it was confirmed that coastal flooding affects low-lying coastal roads and various coastal facilities. Table 4.7 details the dates and approximate damages of past flood events recorded by NCDC.

TABLE 4.7 *Chronology of Coastal Floods in Puerto Rico, 1999 to Present*

Hazard	Date	Area Affected	Severity/Hazard Intensity	Damages/Economic Impact
Hurricane Hortense	September 10, 1996	Coastal Areas, Calle Comercio until Colon Park	Estimated to be equivalent to 100-year event	Unknown
Hurricane Georges	September 21, 1998	Coastal Areas, Calle Comercio until Colon Park	Unknown	$4,900.00, Colón Park, Paseo Tablado
Coastal Flooding	Feb 1999	Coastal Areas	Unknown	Unknown
Coastal Flooding	Jan 2000	Coastal Areas	Unknown	Unknown
Rip Currents	April 2000	Coastal Areas	Unknown	
Coastal Flooding	September 8, 2001	Coastal Areas, Calle Comercio until Colon Park	Unknown	$90,000.00
Coastal Flooding	September 21, 2004	Coastal Areas, Calle Comercio until Colon Park	Unknown	Undetermined

Source: United States Geological Survey (http://water.usgs.gov/pubs/FS/FS-051-96/#HDR05) and data compiled from the National Climatic Data Center (http://www.ncdc.noaa.gov/oa/ncdc.html). Localized information on riverine flooding was gathered by the municipality.

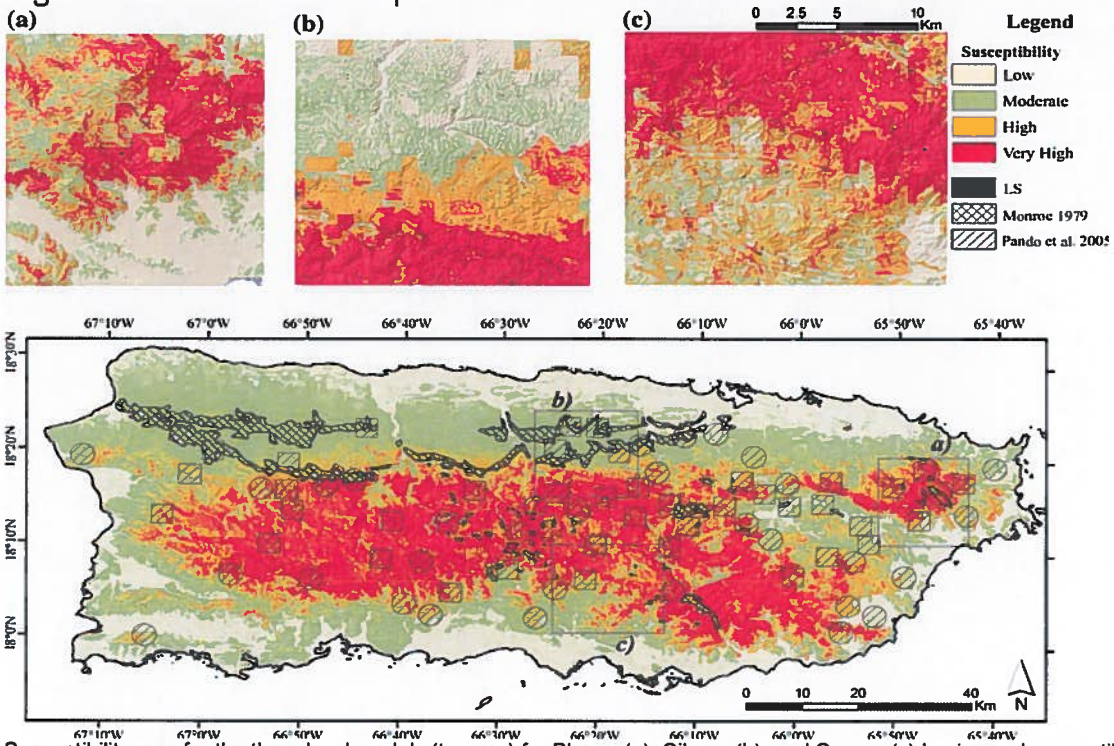
Coastal Flooding: Hazard Frequency and Magnitude

The frequency of the coastal flooding hazard event is based on a 100-year return period—the Municipality has a 1 percent annual probability of observing the losses shown in the loss estimates subsection of this risk assessment. Based on the flood mapping and hazard analysis, flood depths ranged from 0-2.5 meters. Statistical analysis was used to break the range of flood depths into five hazard level determinations ranging from very low to very high. This is the best available determination with regard to the probability of future hazard events.

4.4.8 Rainfall-Induced Landslide

Rainfall-Induced Landslides are a major geologic hazard with estimated tens of million dollars in economic losses per year in Puerto Rico. The island of Puerto Rico experiences one or two large events per year, often triggered in steeply sloped areas by prolonged and heavy rainfall. Identifying areas susceptible to landslides thus has great potential value for Aguadilla and would allow better management of its territory. Rainfall-Induced Landslide includes shallow soil slips, debris flow, debris slides, debris avalanches, and slumps (Larsen and Simon 1993). The factors contributing to the high landslide activity in Aguadilla are the steep slopes and the relatively moist condition of soils due to abundant rainfall, especially in the western part of the island.

Figure 12- Landslide Maps



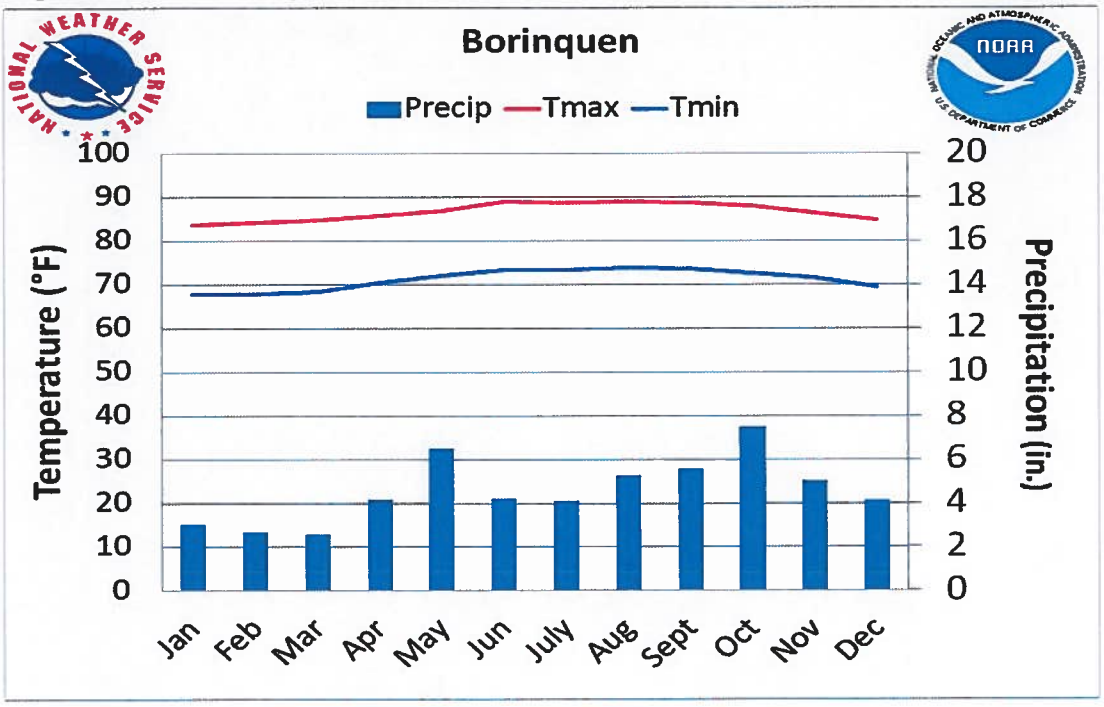
Susceptibility map for the three local models (top row) for Blanco (a), Cibuco (b), and Coamo (c) basins and susceptibility map for the whole island of Puerto Rico (bottom row). The hatched squares and circles are adapted from Pando et al. (2005); the irregular cross-hatched areas represent high susceptibility areas as identified by Monroe (1979)

Landslides are triggered by factors such as heavy rainfall, seismic activity, and construction on hill-slopes. The leading cause of landslides in Aguadilla is intense and/or prolonged rainfall. A rainfall threshold for rainfall-triggered land sliding is delimited by 256 storms that occurred between 1959 and 1991 in the central mountains of Puerto Rico, where mean annual rainfall is close to or in excess of 2,000 mm. Forty one of the 256 storms produced intense and/or prolonged rainfall that resulted in tens to hundreds of landslides. A threshold fitted to the lower boundary of the field defined by landslide-triggering storms is expressed as I = 91.46 D-0.82 where I is rainfall intensity in millimeters per hour, and D is duration in hours. Landslide-producing storms occurred at an average rate of 1.2 per year. In general the landslides triggered by short-duration, high-intensity rainfall events were mainly shallow soil slips and debris flows, while the long-duration, low-intensity rainfall produced larger, deeper debris avalanches and slumps. For storms that had durations of up to 10 h, land sliding did not occur until rainfall intensity was as much as three times as high as the rainfall intensity reported as sufficient to trigger land sliding in temperate regions. As storm durations approach 100 h, the rainfall conditions necessary to initiate land sliding in Aguadilla converge with those defined for temperate regions.

Table 4.8 Date and Characteristics of 41 Rainfalls-Induced Landslides in Puerto Rico between 1959 and 1991 (Larsen y Simon 1993).

Número	Fecha	Año	Duración [h]	Precipitación acumulada [mm]	Intensidad [mm/h]
1	14-Oct	1976	2	142	71.12
2	27-Sep	1980	2	221	110.5
3	10-Dec	1975	3	203	67.73
4	15-Nov	1977	3	127	42.33
5	30-Oct	1976	4	102	25.48
6	18-Sep	1989	6	225	37.5
7	9-May	1982	6	203	33.87
8	9-Nov	1969	6	178	29.66
9	26-Jan	1969	6	127	21.16
10	27-Aug	1970	9	225	25
11	13-Jan	1965	9	544	60.44
12	3-Nov	1984	24	192	8
13	6-Dec	1987	24	493	20.54
14	6-Oct	1985	24	625	26.04
15	12-Sep	1982	48	330	6.88
16	6-Sep	1960	48	477	9.94
17	27-May	1980	48	288	6
18	23-Aug	1971	48	232	4.83
19	12-May	1986	48	279	5.81
20	9-Nov	1970	48	254	5.29
21	29-Aug	1979	72	502	6.97
22	9-Dec	1965	72	474	6.58
23	8-May	1970	72	254	3.53
24	4-Sep	1979	72	459	6.38
25	8-Dec	1970	96	419	4.36
26	26-Nov	1968	96	329	3.43
27	22-Apr	1969	96	268	2.79
28	15-May	1985	96	635	6.62
29	11-Dec	1981	96	740	7.71
30	18-May	1987	120	453	3.78
31	22-Oct	1978	120	459	3.83
32	24-Nov	1987	120	583	4.86
33	29-Nov	1960	144	438	3.04
34	4-Oct	1970	144	976	6.78
35	20-May	1981	144	254	1.76
36	5-Oct	1990	312	303	0.97
37	27-Aug	1961	24	456	19
38	4-May	1965	24	144	6
39	14-Oct	1962	24	216	9
40	23-Aug	1988	24	312	13
41	16-Apr	1988	12	168	14

Figure 13 - Average Precipitation.



AVERAGE TEMPERATURES AND RAINFALL FOR AGUADILLA AIRPORT (BORINQUEN) FROM 1981-2010

NCDC 1981-2010	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average High (F)	83.6	84.1	84.7	85.7	86.7	88.8	88.5	88.9	88.6	87.8	86.3	84.6	86.5
Average Low (F)	67.9	67.8	68.4	70.4	71.9	73.3	73.2	73.9	73.6	72.6	71.6	69.4	71.2
Average Rain (in.)	3.06	2.66	2.57	4.14	6.50	4.22	4.08	5.28	5.80	7.50	5.02	4.09	54.72

Whenever a stationary cold front is present at the north region of the Island, the Municipality of Aguadilla is most likely to be affected by heavy rainfall causing flooding in many sectors and areas.

Repetitive loss in the Municipality has occurred since unmemorable times. Nonetheless, for this plan we are using as base the repetitive loss due to flooding. The municipality of Aguadilla has participation in the NFIP. Currently has 140 Flood Insurance Policy. There are three (3) areas that has repetitive looses with 25 claims. This represent, $305,859.33 in losses, see table 4.9

Table 4.9 Flood Repetitive Losses in Aguadilla

Code	Number	Address
000-55	1555400862403	Urb Victoria Carr 2 Aguadilla 00603-1250
000-56	1555400862404	Urb Victoria B22, Aguadilla 00603-1250
000-57	1555400862405	Urb Victoria 30 Calle Violeta, Aguadilla 00603-1250
000-58	1555400862643	Sect Campo Alegre Carr 111 Km M1 Aguadilla 00603-1250
000-59	1555400862813	Bo Palma Carr 684 Km5 Aguadilla 00603-1250
000-60	1555400862625	Sect Campo Alegre Carr 111 Aguadilla 00603-1250

4.4.9 Fire Hazard Description

Wildfire Hazard Location, Extent and Distribution

Accident caused intentionally, accidentally or incidentally, by the fire that occurs in vegetated areas, trees and busters. Dry conditions at various times of the year and in various parts of Aguadilla greatly increase the potential for wildfires. Post-fire debris flows are particularly hazardous because they can occur with little warning, can exert great impulsive loads on objects in the vegetation, block drainage ways, damage structures, and endanger human life.

The extent and distribution of the Wildfire hazard is varied because:

- Wildfire levels range is very low to moderate with the highest intensity levels along the green areas in the woods and in the dump area.
- Infrastructure like power poles and telecommunication are susceptible to wildfire because there are along the wooded parts of the municipality.
- Wildfires could potentially result in the destabilization of pre-existing deep-seated landslides over long time periods.

Wildfire: Hazard History

The Wildfire are being spontaneous, they are hard to predict when they will occur. In the landfill occur relatively frequently because there are chemical reactions of gases and waste. This is considering wildfire. In forested areas the fire arises because people throw garbage. The heat of the sun acts like catalytic and cause a Wildfire.

Wildfire: Frequency and Magnitude

The Wildfire occurs several times a year, especially in times of high temperature. This occurs many times by a combination of high temperature, garbage in the green areas and dry grass areas. The frequency of the Wildfire is showing in the table below.

Table 4.10 Five year Wildfire Frequency

Year	2006	2007	2008	2009	2010
Wildfire	8	21	22	27	5
Landfill / Debris	0	5	4	2	4

Urban Fire: Hazard Location, Extent and Distribution

Urban Fires in Aguadilla may involve buildings, residences, warehouses and industries with potential for spread to adjoining structures. The urban fire hazard may involve areas where single family homes, multi-family occupancies and/or business facilities are clustered close together, increasing the possibility of rapid spread to another structure:

The extent and distribution of the Urbanfire hazard is varied because:

- Residential accidents (improper use of electrical appliances, faulty connections, grease fires, smoking, heating appliances or improper disposal of wood ashes).
- Industrial accidents (hazardous material incidents, explosions, transportation accidents)
- Acts of nature (lightening strikes, earthquake byproduct)

Urban Fire: Hazard History

Urban Fires are one of the most devastating hazards with a direct impact to the citizens of Aguadilla. As presented on the Urban Fires Frequency Table 4.11 it is notable an increase of incidents of residential urban fires since 2006.

Urban Fire: Frequency and Magnitude

Urban Fire mostly occurs through careless of people. No matter is happened in homes or commercial buildings, inadvertently, poorly electrical connections, or intentional. Few fires arise spontaneously in urban areas. Many occur in the power lines, electrical transformers or when trees contact the power lines. Fire Hazards is a risk that will only be decreased through adequate response to an event and the proper handling of fire-induced material. The mitigation measures require control of waste sites, effective staff training, and equipment that allow for proper response and adequate access to susceptible areas, in addition to hydrant installation. It is clear that the measures are far more cost effective than assuming the dollar loss.

Table 4.11 Urban Fires Frequency in Aguadilla

Year	2006	2007	2008	2009	2010
Residential	5	16	18	17	19
Power Facilities	9	3	3	10	3
Commercials	2	1	4	3	0
Automobile	6	3	9	4	2
Chemical	1	0	0	0	0

4.5 INVENTORY OF ASSETS

To be consistent with the methodology of the FEMA Publication 386-2, "State and Local Mitigation Planning How-To Guide, Understanding Your Risks—Identifying Hazards and Estimating Losses" (FEMA 2001):

- Estimate or count the total number of buildings and value of buildings.

Please note that Section 2, entitled Community Profile, provides a demographic profile of Aguadilla. The following subsections are presented:

- General Building Stock
- Critical Facilities and Infrastructure

An important component of this Hazard Mitigation Plan is the identification of the general built environment. An understanding of the built environment provides an idea of the municipality's exposure (type of buildings and estimated value) the distribution of housing units.

Based on U.S. Census data[15], a building inventory profile was developed to estimate the distribution of commercial buildings. A rapid field survey was used to categorize number and types of buildings for select land use districts on the island. The following land use designations. They are:

- Urban Center (CU)
- Urban Peripheral (UP)
- Urbanization (UB)
- Rural Communities (RC)
- Rural Linear (RL)
- Manufacturing/Industrial (MA)

The **Urban Center (CU)** classification is comprised of areas of intensive use. This category refers to the traditional urban center, which is comprised mostly of commercial structures. Structure types vary from older historic un-reinforced concrete buildings to modern steel-frame buildings.

Emanating from traditional urban center, along main business thoroughfares, is the **Urban Peripheral (UP)** land use classification. This classification is mixed-use and consists of residential, retail establishments, businesses, financial, professional and repair services. Structure types vary from one and two story concrete structures to large steel frame concrete structures.

[15] Based on US Census data "estimate" for 2005 - 2009

Suburban developments are found near to the urban periphery. **Urbanization (UB)** or suburban residential subdivisions tend to consist of homogeneous house types, predominately single story concrete residential homes.

The **Rural Community (RC)** is the most predominant land use classification found in the Municipality. Over the years, rural lands have been developed as a result of Law 26 (Ley 26)[16], that sought to use unproductive agricultural lands for residential development. These lands, known as "parcelas," usually occur in areas that are adjacent to rural roads. They are rural in character and typically consist of single and two family dwellings. Structure types vary from simple wood frame dwellings to one and two story concrete structures.

The **Rural Linear (RL)** land use classification has occurred in recently developed mountainous areas. It consists of a disorganized pattern of land use. Structure types vary from informal wooden frame structures to multi-family concrete structures.

The **Manufacturing/Industrial Areas (MA)** land use classification refers to portions of the municipality where the predominant structural types are single-story masonry, concrete or steel frame structures used for light industrial and manufacturing purposes.

The field investigation identified ten (10) representative building types in the municipality. For each land use classification, a "structural distribution ratio" was assigned to identify the percentage of different building types and uses (i.e., occupancy classes—residential and commercial). The basic structural systems were grouped into 10 model building types with the following general construction characteristics:

- Wood, Steel,
- Reinforced Concrete,
- Steel-Frame,
- Un-reinforced Masonry, and
- Un-reinforced Masonry.

The analysis generated a distribution of particular building types for each census block based on land use categorization. It allowed Consultant Project Team members to understand the distribution of model building types for a specific occupancy class, at the census block level. This provided the basis to estimate the total number of buildings and to aggregate replacement and content values for model building types.

[16] Program developed under a Department of Housing (Vivienda), Administration of Social Programs.

Critical Facilities and Infrastructure

Facilities such as schools, police and fire stations, and hospitals, are known as "critical facilities." Infrastructure is separated into two distinct classes that have substantially different damage and loss characteristics: (1) transportation systems (key roads, ports, airports) and (2) utility infrastructure (electric power stations, potable water treatment plants, wastewater treatment plants, water pumps). For purposes of this plan, the following three-part definition of critical facilities and infrastructure shall apply:

Critical Facilities

Critical facilities are those facilities that provide services to the community and should be functional after a hazard event. They include:

- Government buildings necessary for continuity of operations
- Hospitals
- Police stations
- Fire stations
- Emergency Response
- Schools
- Shelters

Transportation Infrastructure

Transportation Infrastructure are those facilities that enable the movement of goods, particularly emergency relief supplies. They include:

- Airports

Utilities and Infrastructure

Utilities and Infrastructure are facilities that, if damaged, could have far-reaching consequences for the environment. They include:

- Electrical Power Substations
- Water Treatment Plants, and
- Wastewater Treatment Plants
- Main Road System

A detailed list of critical facilities and infrastructure was developed by the Hazard Mitigation Committee and Director of Emergency Management. This list was then provided to the Consultant Project Team. It was identified that detailed attribute information needed to conduct a vulnerability and risk assessment was missing. Therefore, site visits were undertaken with municipal staff to obtain information on structural characteristics and general conditions. Facilities and infrastructure were categorized by their structural characteristics relevant to vulnerability to the prominent hazards identified in the study.

General Building Stock

Building distribution and occupancy information collected during field surveys was integrated into a database to determine the number of representative building types across the municipality. The compilation of this data provided project planners with the ability to differentiate between building types with substantially different damage and loss characteristics. It also provided critical information to assess the values of the general building stock across the municipality. Table 4.12 below lists the estimated value for general occupancy classes used for this risk assessment. Exposure estimates are based on aggregated building replacement costs by insurance coverage policy for the 2011-2012 periods. Table 4.13 Municipality Critical Facilities.

TABLE 4.12 Estimated Values for General Occupancy Classes, Municipality of Aguadilla

Property Type	# of Buildings	Estimated Replacement Cost	Estimated Content Cost	Total Value
Private Property[17]	23,993	$2,399,300,000	$599,825,000	$2,999,125,000
Commercial	8,470	$945,104,860	$298,625,172	$1,243,730,032
Manufacturing	235	$105,413,400	$128,838,600	$234,252,000
Government / Public	180	$81,410,875	$3,838,600	$85,249,475
Total	32,878	$2,558,210,875	$630,013,600	$3,188,224,475

TABLE 4.13 Municipality of Aguadilla, Critical Facilities by class

Facility Type	# of Facilities	Exposure		
		Building	Content	Total
Critical Facilities				
Police Stations	3	$700,000	$175,000	$2,625,000
Fire Stations	2	$660,000	$291,000	$1,902,000
Emergency Response	3	$500,000	$75,000	$1,725,000
Hospital/Medical Clinic	2	$6,200,000	$7,750,000	$27,900,000
Government Buildings	5	$10,500,000	$1,500,000	$12,000,000
Schools	24	$300,000	$30,000	$7,920,000
Refuges	2	$750,000	$460,000	$2,420,000
Transportation Infrastructure				
Airport	1	$7,000,000	$1,050,000	$8,050,000
Utilities				

[17] This information is up to date based on the US Census estimate from 2005-2009 periods and the total insured municipally owned properties as per 2012 period.

Water Filtration Plants	4	$700,000	$1,400,000	$8,400,000
Pump Stations	2	$700,000	$0	$1,400,000
Power Station	1	$2,000,000	$0	$2,000,000
	Totals =	**$30,010,000**	**$12,731,000**	**$76,342,000**

Notes: Modified from FEMA 386-2, Worksheet No. 3a (FEMA 2001).

4.6 ASSESSING VULNERABILITY

Vulnerable subgroups of the population for each island were determined using the Census data[18]. This analysis identified the number of people less than 18 years of age and the number of people over 65 years of age. These two demographic subgroups help define the municipality's social vulnerability as they are the most likely to need assistance during and/or after a hazard event. A series of GIS hazard overlay queries were performed to indicate where the people reside within the municipality relative to hazards.

- Determine the proportion of buildings, the value of buildings, and the population the Municipality of Aguadilla that are located in hazard areas, and
- Calculates the proportion of assets located in hazard areas.

Following, the vulnerability assessment was used to estimate of losses to each hazard. The estimation of hazard related damage to buildings is based on the characteristics of the model building types and an estimate of the hazard intensity (wind speed, flood level, etc.). The extent and severity of damage to structural and nonstructural components of a building is described by one of five damage states:

- Very Low, (no, or negligible damage)
- Low, (easily repairable damage mainly to part of nonstructural components and/or contents)
- Moderate, (considerable, yet repairable damage to mainly non-structural components)
- High (considerable damage to both structural and non-structural components), and
- Very high (that the extent of damage is too much to be repaired; the facility has to be demolished and replaced).

The qualitative vulnerability ratings relate to a percentage of damage for each model building type. The damage estimation methods for critical facilities and infrastructure are identical to those utilized to estimate damage with general building stock, except that classification or grouping of facilities was not needed.

[18] Based on US Census data "estimate" for 2005 – 2009

TABLE 4.14 MUNICIPALITY FACILITIES AT HIGH RISK IDENTIFIED AREAS

Municipality Property	Physical Address	Potential Hazard	Potential Looses
Edif Casa Alcaldia	Ave San Carlos	CF,EG, EL,TS,UF,RL,HW	$2,670,000
Biblioteca Electronica	Ave San Carlos	CF,EG,EL,TS,UF,RL, HW	$2,500,000
Edif Plaza Mercado	Calle Progreso	CF,EG,EL,TS,UF,RL, HW	$10,340,000
Edif Obras Publicas	Carr Cuesta Vieja	CF,EG,EL,TS,UF,RL, HW	$2,000,000
Dispensario Camaseyes	Carr 467 Interior	RF,EG,EQ,EL,UF,HW	$840,000
Centro Geriatrico Juan Garcia Ducos	Carr 467 Km 2.0 Interior	RF,EG,EQ,EL,UF,HW	$400,000
Centro de actividades Multiples, Higuey	Calle Progreso #75	RF,EG,EQ,EL,UF,HW	$1,580,000
Centro Geriatrico Caimital Alto	Carr #2 Bo Caimital Alto	RF,EG,EQ,EL,UF,HW	$600,000
Centro Geriatrico San Antonio	Calle Barbosa #275	EG,EL,UF,HW	$450,000
Centro Geriatrico El Palmar	Carr #111 Bo Palmar	RF,CF,WF,EG,EQ,TS HW	$1,140,000
Coliseo Municipal Luis T Diaz	Paseo La Real Marina (PR-4442)	UF,EG,EQ,EL,RL,HW	$3,380,000
Parque Colon	Ave Fernando Yumet	CF,EG, EL,TS,UF,RL,HW	$585,000
Estadio Municipal Luis A Canela Marquez	Carr #2 Frente Villa Alegria	UF,EG,EQ,EL,RL,HW	$4,780,000
Parque Acuaticos Las Cascadas	Carr #2 Frente Villa Alegria	UF,EG,EQ,EL,RL,HW	$1,440,000
Terminal Carros Publicos	Ave San Carlos	EG,EL,UF,RL,HW	$2,000,000
Edif Plaza Marina Policia Municipal	Calle Stahl	CF,EG, EL,TS,UF,RL,HW	$1,530,000
Edif Los Bohios	Sector Tamarindo	EG, EL,TS,UF,RL,HW	$740,000
Centro Gubernamental Municipal 1	Paseo Garcia Mendez	CF,EG, EL,TS,UF,RL,HW	$1,700,000
Anexo Casa Alcaldia	Paseo Garcia Mendez	CF,EG, EL,TS,UF,RL,HW	$3,290,000
Complejo Deportivo Pupo Jimenez	Carr # 2 Caimital Alto	EG,EL,UF,RL,HW	$850,000
Skate Park Plaza	Calle Fernando Yumet	CF,EG, EL,TS,UF,RL,HW	$480,000
Plaza Placido Acevedo	Calle Fernando Yumet	CF,EG, EL,TS,UF,RL,HW	$1,540.000
Parque Nacional El Parterre	Calle Munoz Rivera	CF,EG, EL,TS,UF,RL,HW	$2,000,000
Plaza Rafael Hernandez	Ave San Carlos	CF,EG, EL,TS,UF,RL,HW	$1,000,000
Complejo Deportivo Camaseyes	Carr 456 Bo Camaseyes	EG,EL,UF,RLHW	$400,000
Complejo deportivo Ceiba Abajo	Bo Ceiba Abajo	EG,EL,UF,RLHW	$1,580,000
Parque Fuente de la Juventud	Calle Munoz Rivera frente al Partere	CF,EG, EL,TS,UF,RL,HW	$2,300,000
Pista Patinaje sobre Hielo	Paseo La Real Marina (PR-4442)	CF,EG, EL,TS,UF,RL,HW	$6,000,000

Dept de la Vivienda	Carr 107 Interior Bo Caimital abajo	EG,EL,UF,RLHW	$1,500,000
Paseo Garcia Mendez	Antigua Calle Ruiz Belvis	CF,EG, EL,TS,UF,RL,HW	$700,000
Estacionamiento Plaza del Mercado	Calle Progreso	CF,EG, EL,TS,UF,RL,HW	$2,100,000
Skate Board and Splash Park	Carr 107 Ave Borinquen	EG,EL,UF,RL,HW	$2,200,000
Museo Antropologico	Ave San Carlos	EG,EL,UF,RL,HW	$630,000

Earthquake Ground Shaking = EG, Earthquake Landslide = EL, Earthquake Liquefaction = EQ, Riverine Flooding = RF, Coastal Flooding = CF, Tsunami = TS, Urba fire = UF, Wildfire = WF, Rainfall Landslide = RL, High Wind = HW

4.7 Loss Estimates

This section of the risk assessment presents the "estimate of losses," including: exposure, damage, and loss estimates analyzed on a hazard-by-hazard basis. The findings support local and regional planners' understanding of the potential impacts of each hazard and enable a comparison of hazards by quantifying potential exposures impacts.

The loss estimates provided in this section were developed using available data, and the methodologies applied have resulted in an approximation of risk. These estimates should be used to understand relative risk from hazards and potential losses. However, it is important to understand that uncertainties are inherent in any loss estimation methodology, arising in part from incomplete scientific knowledge concerning natural hazards and their effects on the built environment. Uncertainties also result from approximations and simplifications that are necessary for a comprehensive analysis.

As outlined in previous sections, the risk assessment methodology utilized for this study was parametric. The risk analyses are based on a comprehensive methodology that incorporates approaches for:

- Characterizing Hazards, understanding the nature of the hazards (i.e. level of ground shaking, wind speed, depth of flooding);
- Categorization of the built environment, understanding number, distribution, and value of assets (i.e. general buildings & critical facilities),
- Vulnerability Analysis, understanding the damage and loss characteristics of identified buildings, and
- Estimating damage and losses to buildings and critical facilities.
- Regular meetings were held by the Community Advisory Board with representatives of various State and Federal Agencies where valuable information was gathered and analyzed

- An examination and analysis of existing reports per hazard has been researched. Information has been found through various State and Federal agencies. The detail on each source of information is presented on the Exhibit Section of the Plan
- As part of the Hazard Risk Assessment, Hazard Profile Description (pages 24-47) of Aguadilla were prepared. Risks were classified to which reference is made throughout the Plan.

TABLE 4.15 HAZARD IMPACT AND POTENTIAL LOSSES

Hazard Event	Population Impacted by risk	Percentage Of Affected Population	Number of buildings Residential and Commercial at Risk	Potential Losses
Earthquake-Ground Shaking	47,055	77.2%	15,685	$1,373,100,000
Earthquake-Liquefaction	3,660	6.0%	1,220	$9,932,500
Earthquake-Landslide	2,880	4.7%	960	$42,115,500
Tsunami	3,300	5.4%	1,100	$24,270,000
High Wind	55,650	91.3%	18,550	$153,408,678
Riverine Flooding	6,540	10.7%	2,180	$15,980,000
Coastal Flooding	720	1.1%	240	$3,730,000
Wildfire	30	0.04%	10	$1,000,000
Urban Fire	5,400	8.8%	1,800	$18,250,000
Rainfall - Landslide	390	0.06%	130	$5,000,000

Family composition was taken as three (3) members to get the average of people affected by each hazard event. It took the total population of 60,949 and was divided into the total number of houses according with the US census estimate of 2005-2009 periods.

Repetitive loss in the Municipality has occurred since unmemorable times. Nonetheless, for this plan we are using as base the repetitive loss due to flooding. The municipality of Aguadilla has participation in the NFIP. Currently has 140 Flood Insurance Policy. There are three (3) areas that has repetitive losses, this represents $305,859.33 in losses. The Urb Victoria, Sector Campo Alegre and the Barrio Palmar are the areas with continuing repetitive losses.

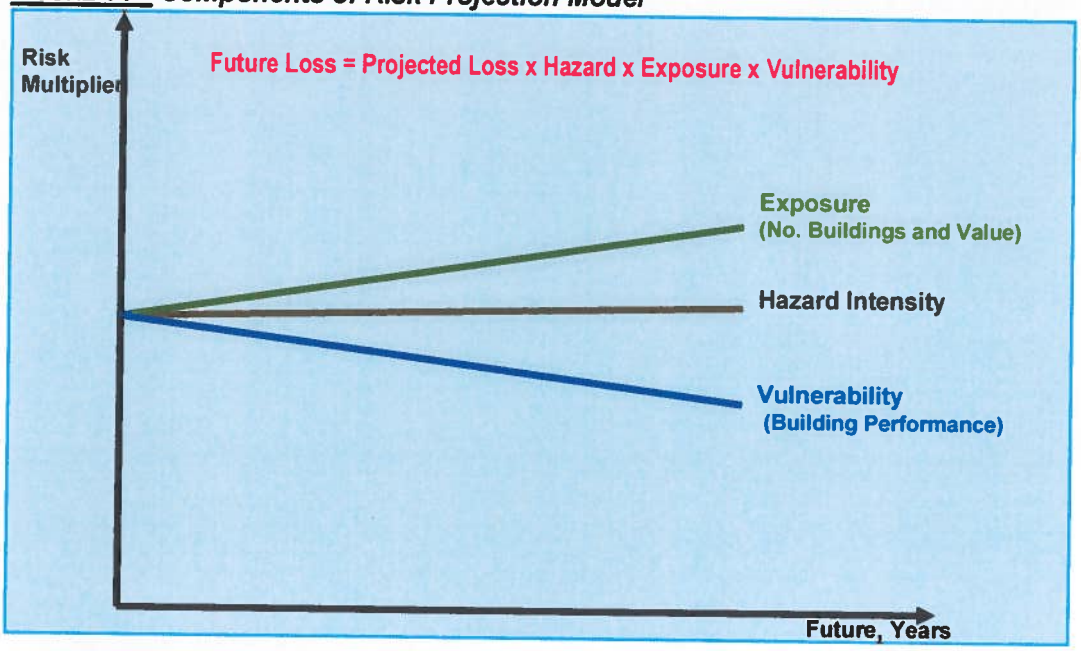
4.8 UNDERSTANDING FUTURE LOSSES IN AGUADILLA

In order to understand the future vulnerability (potential losses) in Aguadilla so that mitigation options can be reasonably assessed, it is necessary to compare expected future losses throughout the municipality. A comparative assessment of future risk may provide a basis to understand how future development may increase vulnerability to each hazard. This subsection presents a brief methodology that was used to compare future risk, projects losses for 10, 20 and 30-years from today, and proposes a land use map (The new land-use plan is expected to be approved by the end of 2011. Actually, this plan is in its final approval phase from the JPPR. The Plan provides critical baseline information (history, demographic profile, etc.), in addition to an understanding of the Municipality's development objectives. It is also the main instrument for strategic and integrated land use planning for the territory) that provides the basis for policy makers to assess ways to reduce vulnerability in years to come. The municipality of Aguadilla is fortunate to be able to gather this developmental information

The final hazard mitigation plan discusses and provides an analysis of the frequency of mayor development projects, current public sector projects, pending mayor development projects, per barrio.

The risk projection model presented in Figure 14 consists of three different components:
(1) hazard intensity that is defined for a 100-year return period for each identified hazard,
(2) exposure which is defined as the number of buildings (inventory) and value, and
(3) the vulnerability or damageability of the building stock over time.

FIGURE 14 - *Components of Risk Projection Model*



These components were systematically combined in a risk projection model to understand the potential future losses for each hazard. This methodology facilitates an understanding of how the following components of the risk assessment changed over time. A description of these components is provided below:

Hazard—the hazard intensity/frequency relationship was assumed to remain constant throughout the 10, 20, and 30 year periods. This means that the hazard intensity, which is based on 100-year return period, is not expected to change dramatically over time (i.e., the timeframe window chosen for the analysis).

Vulnerability—the general characteristics of the built environment are expected to change over time due to: a) regular code improvements and updates, b) degree and level of code enforcement, and c) improvements in the construction material and practices. A vulnerability multiplier was used to update/modify the building performance from the present to that of years 2010, 2020, and 2030.

- **Building Code**—Puerto Rico's building codes have recently been updated. Since December 2010, the Government of Puerto Rico through an Executive Order adopted the International Building Codes (IBC) as PR new construction/building standards, thus substituting the former Unified Building Codes (UBC 1997 edition).

- **Code Enforcement**—although formal building codes have been adopted by the central government in Puerto Rico, code enforcement continues to be poorly implemented in rural municipalities. The lack of regulatory control in rural municipalities is directly related to the comprehensive planning process in which municipalities must first complete and adopt a Plan Territorial in order to obtain regulatory responsibilities. Once adopted, it is expected that code enforcement will gradually improve throughout the municipality. A code enforcement multiplier was used to approximate improvements in the built environment.

- **Construction Practices**—it is assumed that construction practices, in terms of workmanship and materials, will improve over time. A construction multiplier was used to approximate improvements in the built environment.

Therefore, the risk projection model holds that vulnerability in the municipality will decrease over time (i.e., building performance for a given hazard type and intensity will improve over time).

Exposure—U.S. Census data is used to predict future exposure (number of buildings and value) across the municipality. The US Census preliminary estimated report from 2005-2009[19] reported a 5.8% decrease in the population of Aguadilla with a total of 60,949. There are 3,736 less people living is Aguadilla than 2000 census. This trend reflects non favorable conditions for business, industry and employment in the Municipality. The values were estimated based on a linear regression analysis for each land use classification defined during the field assessment. Therefore, the model assumes that exposure values will increase proportional to population growth and will be uniform across different land use categories in the municipality.

[19] Based on US Census data "estimate" for 2005 – 2009

TABLE 4.16 *Estimated Future Losses, Municipality of Aguadilla*

Hazard	10-year		20-year		30-year	
	No. Buildings	Potential Future Loss	No. Buildings	Potential Future Loss	No. Buildings	Potential Future Loss
Earthquake Ground Shaking	15685	$ 1,373,100,000	18394	$ 1,317,071,470	19919	$ 1,289,931,384
Earthquake Liquefaction	1220	$ 9,932,500	1988	$ 10,969,058	2153	$ 11,527,264
Earthquake Landslide	960	$ 42,115,500	10508	$ 44,680,178	11380	$ 46,020,468
Tsunami	1100	$24,270,000	1404	$ 24,342,415	1520	$ 24,342,415
High Wind	18550	$153,408,678	25423	$ 139,895,149	27532	$ 133,591,559
Riverine Flood	2180	$15,980,000	2558	$ 14,662,117	2770	$ 14,505,695
Coastal Flood	240	$3,730,000	215	$ 778,914	232	$ 653,594
Urban Fire	1800	$18,250,000	1776	$14,350,000	1735	$9,125,000
Wldfire	10	$1,000,000	15	$875,000	23	$783,640
Rainfall -Landslide	130	$5,000,000	215	$4,758,250	245	$3,845,500

4.8.1 AGUADILLA DEVELOPMENT TRENDS

The Municipality of Aguadilla has experienced substantial residential, commercial and industrial development over the past decade. The past trend in housing and economic development can be expected to continue, however, it is not expected to be as strong as during the decade of the 1990s. Nevertheless, the US Census preliminary estimated report from 2005-2009 reported a 5.8% decrease in the population of Aguadilla with a total of 60,949. There are 3,736 less people living is Aguadilla than 2000 census. This trend reflects non favorable conditions for business, industry and employment in the Municipality. A more conservative projection in new housing starts was used in estimating loss estimates for future development.

Table 4.17 List of current major projects being managed by the Planning and Project Management and Federal Program Office.

Núm.	Project	Description	Status
1	Housing Complex Old CDT Building (Atlantic Sun View)	Project Fifty-six (56) residential apartments spread over seven (7) plants. You will have about one hundred twenty (120) parking and ability to accommodate commercial local no more than 1,500 square feet	In the process of obtaining of the permits necessary for construction by the designer.
2	Housing Complex Old Villamar Building (Real Marina Suite)	Project Fifty-six (56) residential apartments spread over four floors. Have the capacity to one hundred twenty (120) parking and ability to accommodate commercial local no more than 1,500 square feet.	In the process of obtaining of the permits necessary for construction by the designer
3	Housing Complex Old Aneses Morell School (Ocean Dreams)	It is proposed forty (10) units housing and eighty (80) spaces parking lots, apartments are spread over four floors and covered several business premises rent of no more than 750 square feet	In the process of obtaining of the permits necessary for construction by the designer
4	Improvement of Colon Baseballpark	Ball park design, public restrooms, dressing room for players, food sales area, walking track, relocation of traffic, construction of gazebo.	In the process of obtaining of the permits necessary for construction by the designer
5	Las Cascadas Hotel	Around 79 rooms, restaurant, lobby, shops, swimming pool, gym and conference room	In the process of obtaining of the permits necessary for construction
6	Administrative offices in the Plaza del Mercado facilities	Commercial space over 18,000 for rental offices.	Identifying funds.
7	Municipality Gym.	Two-story structure with parking area and gym equipment.	Transferred to AFI.
8	Recreational Park Complex Tres Palmas at Borinquen Urbanization	Recreation park with ball park, walking area, rock climbing and community center.	Under construction
9	Municipality Cemetery	Located on State Road 110, Mountain neighborhood. Have around 15.000 pits sealed chapel building, administration area and parking lot.	In the process of obtaining of the permits necessary for construction
10	Road Conector Cuesta Vieja and Cuesta Nueva	Construction road between cuesta vieja and cuesta nueva ward, to shorten the trip and reduce the traffic between the urban areas. .	In the process of obtaining of the permits necessary for construction
11	Residential/ Single Family Caimital Alto	358 Single family residential units with 450-900 SQ meter lots.	Not Completed. The official reason is unknown but is presumed by the actual economy and the current Real Estate market.
12	Commercial in Camaseyes	38,900 SQ FT Commercial projects located on Farmland	Not Completed. The official reason is unknown but is presumed by the actual economy and the current Real Estate market.
13	Recreational Park Camaseyes	Jose de Diego Fountain Institutional Projects	Legal issue, problems with the expropriation.
14	Commercial Caimital Alto	Three (3) 450 SQ Meter lots for professional office use.	Not Completed. The official reason is unknown but is presumed by the actual economy and the current Real Estate market.
15	Business Center at Corraes ward	Consulting on site selections for 325,000 SQ. FT. commercial. Project on Farmland	Not Completed. The official reason is unknown but is presumed by the actual economy and the current Real Estate market.

16	Residential/ Single Family Camaseyes ward	60 Single family residential units with 185 SQ meter lots, located in farmland.	Not Completed. The official reason is unknown but is presumed by the actual economy and the current Real Estate market.
17	Tourism Montana ward	40 Unit Villa Tourism Condo Hotel Property	Not Completed. The official reason is unknown but is presumed by the actual economy and the current Real Estate market.
18	Commercial at Corrales ward	30,000 SQ FT Commercial projects located on farmland.	Not Completed. The official reason is unknown but is presumed by the actual economy and the current Real Estate market.
19	Industrial Park, Ceiba Baja	Industrial projects on farmland	Not Completed. The official reason is unknown but is presumed by the actual economy and the current Real Estate market.
20	Residential/ Single Family - Palmar	98 Single family residential units with 450 SQ meter lots, located on farmland.	Not Completed. The official reason is unknown but is presumed by the actual economy and the current Real Estate market.
21	Residential/ Single Family-Caimital Alto	50 Lot residential project with 300 SQ meter	Not Completed. The official reason is unknown but is presumed by the actual economy and the current Real Estate market.
22	Residential/ Single Family –Caimital Alto	35 Single family residential units with 485 SQ meter lots	Only 5 units were built as per 2011. Project is suspended for unknown reasons.
23	Residential/ Single Family – Caimital Bajo	280 Single family residential units with 300 SQ meter lots, located on farmland	Not Completed. The official reason is unknown but is presumed by the actual economy and the current Real Estate market.

Most relevant milestones for projects development in the Municipality of Aguadilla

The Aguadilla Pueblo is subject to high to very high vulnerability to earthquake, liquefaction, tsunami, coastal storm surge, flooding and urban fire. Limited staff resources for development review and building permitting/inspection are an issue for all municipalities in Puerto Rico, including Aguadilla. The Municipal Permit Office should focus careful attention by planners and building permit officials on evaluating compliance with the NFIP Program, development review and strict compliance with the building code on new development projects. As part of the continuous Hazard Mitigation, the Municipality of Aguadilla must undertake the scope of the database currently being established must be extended in terms of the inventory and the potential damage of each hazard event. Additional data that must be collected, must include: structure size, structure value, contents value, occupancy or capacity, and/or any other special consideration

As described in the introduction to Section Five, a gradual elimination of the most vulnerable masonry structures within the Aguadilla Pueblo that do have historical significance should be implemented over the long term. New development in the Barrio Pueblo will certainly continue in the future, however, hazard mitigation concerns in the development review process are critical to ensure that new development incorporates disaster resistant construction practices.

The most extensive floodplain within the Municipality of Aguadilla is associated with the Rio Culebrinas. Existing urbanizations within the Aguadilla Pueblo and Barrio Victoria are at extreme risk of flooding from the Rio Culebrinas. The Army Corps of Engineers has completed the final feasibility study for a flood control project in early 2004 (Final Detailed Project Report and Environmental Assessment, USACE 20004). If Federal and local funding becomes available, this project can move into engineering design and construction within five to ten years. Until then, the low-lying urbanized area in the southern portion of Aguadilla Pueblo and Barrio Victoria remain at risk.

The Municipality should pay careful attention to ensuring that any additional in-fill development within the urbanized floodplain area and especially any new residential or commercial development proposed within the upper portion of the Rio Culebrinas floodplain (in the barrios Victoria and Palmar) be consistent with all NFIP regulations. The Municipality should consider more restrictive zoning designations (open space or agricultural land use zoning districts) in the upper floodplain area that would be outside of the protection afforded by the proposed flood control project.

The Barrio of Camaceyes is expected to receive moderate development pressure over the next decade. Camaseyes is subject to high to very high ground shaking vulnerability and low to moderate earthquake landslide effects. Liquefaction hazard intensity is very low to moderate throughout the Barrio. Building permit reviews in this Barrio should concentrate on ensuring that seismic building standards are complied with for commercial, industrial and residential development projects.

Barrios Caimital Bajo and Camital Alto are expected to receive moderate development pressure in the future. These two barrios exhibit moderate to high earthquake hazard intensity levels and low to very low wind hazard intensity levels. Development review and building permit inspections in these two barrios should concentrate on ensuring that earthquake and high wind concerns are addressed in future developments.

The most cost effective means of implementing hazard mitigation and leading the Municipality to a more sustainable future is to reduce the vulnerability of future development to the key natural hazards that threaten Aguadilla. Eliminating development in severely hazard prone areas or reducing the intensity of development in areas of moderate to high hazard intensity levels will go a long way to ensuring a more sustainable future for Aguadilla

The data base it is very important, Aguadilla must currently being established a good data base with a good inventory of all their facilities. To handle all the future projects with reliable data. This allows making better decision regarding any future planning. In addition, it is most important to increase the capabilities of planners and building permit officials in Aguadilla through training and seminars so that they can better integrate hazard mitigation concerns in the development review and building permit approval/inspection processes. A number of the prioritized mitigation actions described in Section Five address the critical need to reduce the vulnerabilities associated with future development.

4.8.2 Assessing Vulnerability of Future Development

To assess the future vulnerability, a Composite Hazard Map was used to a) delineate areas at risk and define possible consequences, b) target development in areas less susceptible to natural hazards, and c) provide a basis to support planning decisions that will reduce the impact of natural hazards on people and property.

It combines the hazard levels for each hazard to simultaneously show the intensity or levels of composite hazard throughout the municipality. The hazard can then be used to inform the general public about natural hazard potential and support general mitigation and land use planning activities.

An overall policy goal of this plan is to help the municipality make wiser planning decisions related to constraints imposed by natural hazards. Municipal planners should encourage development in areas of lower composite hazard. The composite maps was used to identify assess the vulnerability of proposed development (i.e. future development). Although this information was not readily available in a spatial format, meaning it was not map able, an assessment was performed using the composite hazard map to determine the vulnerability thresholds based on the hazard intensity levels of each barrio. This provided a general idea of which areas of the municipality have the greatest potential for damages.

Though the intention of the composite hazard map is to be a tool for implementing sustainable development, its use should not preclude site-specific evaluations prior to new construction or the upgrading of buildings and other facilities.

As the municipality develops its plan review and permitting capabilities, the composite hazard map can be used to identify critical hazard areas. It should be made to determine areas within the municipality where development should be restricted because of the presence of natural hazards, and areas where development should be encouraged because of the lower hazard potential. Where land is already developed, these techniques may be used to justify the imposition of requirements on existing development where such controls are necessary in high hazard zones, and to assess the benefits and costs of mitigating hazards.

SECTION FIVE

This section of the Hazard Mitigation Plan for the Municipality of Aguadilla describes the strategy for reducing the island's vulnerability to the effects of natural hazards. The mitigation strategy is built upon a framework of goals, objectives and actions. These mitigation strategies are based on community input, the risk assessment, and an assessment of technical and administrative capabilities. Section Five is divided into the following eight subsections:

- 5.1 IFR Requirements for Mitigation Strategies
- 5.2 Mitigation Strategy
- 5.3 Mitigation Action Plan
- 5.4 Administration of Actions
- 5.5 Assessing Cost Effectiveness of Mitigation Actions
- 5.6 Mitigation Actions that Address Future Development
- 5.7 Prioritized List of Mitigation Actions
- 5.8 Broad Recommendations and Actions for Plan Update

5.1 IFR REQUIREMENTS FOR MITIGATION STRATEGIES[1]

§201.6(c)(3): of the IFR states that "[t]he plan shall include a mitigation strategy that provides the jurisdiction's blueprint for reducing the potential losses identified in the risk assessment, based on existing authorities, policies, programs and resources, and its ability to expand on and improve these existing tools"

- **Local Hazard Mitigation Goals** per **Requirement** §201.6(c)(3)(i): [The hazard mitigation strategy shall include a] description of mitigation goals to reduce or avoid long-term vulnerabilities to the identified hazards.

- **Identification and Analysis of Mitigation Actions** per **Requirement** §201.6(c)(3)(ii): [The mitigation strategy shall include a] section that identifies and analyzes a comprehensive range of specific mitigation actions and projects being considered to reduce the effects of each hazard, with particular emphasis on new and existing buildings and infrastructure.

- **Implementation of Mitigation Actions** per **Requirement:** §201.6(c)(3)(iii): [The mitigation strategy section shall include] an action plan describing how the actions identified in section (c)(3)(ii) will be prioritized, implemented, and administered by the local jurisdiction. Prioritization shall include a special emphasis on the extent to which benefits are maximized according to a cost benefit review of the proposed projects and their associated costs.

[1] This is a descriptive sub-section. No major updates were necessary.

5.2 MITIGATION STRATEGY

The mitigation strategy is intended to provide a clearly defined set of policies and projects based on a rational hierarchal framework for action. This framework consists of the following:

Goals: Goals represent broad statements that are achieved through the implementation of a range of more specific objectives. Goals are usually expressed as broad policy statements and provide the framework for achieving the desired results over the long-term planning horizon.

Objectives: Objectives describe more specific steps that would lead to implementation of the identified goals. They are intended to support, correspond and define a path on how to attain the desired goals.

Mitigation Techniques: A range of mitigation techniques was identified to reduce hazard vulnerability and achieve established community goals and objectives. Mitigation techniques include prevention, property protection, natural resource protection, structural projects, emergency services, and public information and awareness activities.

Mitigation Action Plan: The Mitigation Action Plan presents the short-term, specific actions to be undertaken in order to achieve identified objectives. For each action, the Mitigation Action Plan identifies the objective(s) it is intended to achieve, provides general background information to justify the proposed action, and provides measures to ensure successful and timely implementation, including task assignments and appropriate funding sources, if applicable. A simple voting technique was used by the Hazard Mitigation Committee to rank all of the proposed mitigation actions.

5.2.1 GOALS AND OBJECTIVES

The following goals and objectives represent a comprehensive approach taken by the Municipality of Aguadilla to reduce the impacts of natural hazards. Each goal and objective was approved by the Hazard Mitigation Committee and was based on public input gathered during a series of public information meetings. The goals and objectives are intended to guide both the day-to-day operations and the long-term approach taken by the Municipality of Aguadilla to reduce potential losses from future hazard events.

The Hazard Mitigation Plan for Aguadilla contains four (4) broad based goals and eight (8) objectives.

GOAL #1 REDUCE THE IMPACT OF NATURAL DISASTERS ON RESIDENTS AND PROPERTY

- **Objective 1.1 Protect existing development from future disaster events**
- **Objective 1.2 Reduce the vulnerability of future development**

GOAL #2 STRENGTHENS THE CAPABILITIES OF MUNICIPAL AGENCIES TO IMPLEMENT AND MAINTAINS HAZARD MITIGATION PROGRAMS

- **Objective 2.1 Identify and develop policies, regulations, and training necessary to support an effective hazard mitigation program in the Municipality**

GOAL #3 INCREASE THE AWARENESS AND UNDERSTANDING OF THOSE LIVING AND WORKING IN AGUADILLA TO NATURAL HAZARDS AND TO THE PRINCIPLES OF HAZARD MITIGATION

- **Objective 3.1 Develop outreach programs focused on increasing public awareness of hazards and their associated risks**
- **Objective 3.2 Support local businesses and industries in becoming more disaster resistant**

GOAL #4 IMPROVE LOCAL ABILITY TO RESTORE CRITICAL FACILITIES, ESSENTIAL INFRASTRUCTURE, AND ENSURE THE CONTINUITY OF MUNICIPAL OPERATIONS FOLLOWING NATURAL DISASTERS

- **Objective 4.1 Enhance municipal capabilities to support emergency response and recovery operations**
- **Objective 4.2 Undertake planning to maximize governmental coordination and communication between municipality, central government and federal agencies**
- **Objective 4.3 Reduce the vulnerability of critical facilities, infrastructure and essential municipal facilities**

5.2.2 MITIGATION TECHNIQUES

A range of mitigation techniques were presented to the Hazard Mitigation Committee and at the third Community Workshop (field inspections) for consideration in implementing the goals and objectives. The Techniques may be added or subtracted as this Plan evolves, taking into account the effectiveness of chosen actions, their completion, or in response to the changing vulnerabilities found in Aguadilla.

Range of Available Mitigation Techniques

Prevention

Preventative activities are intended to keep hazard-related problems from getting worse. They are particularly effective in reducing a community's vulnerability, especially in areas where development has not occurred or capital improvements have not been substantial. Examples of preventative activities include:

- Planning and zoning
- Open space preservation
- Stormwater management
- Drainage system maintenance
- Capital improvements programming
- Coastal and riverine setbacks

Property Protection

Property protection measures "harden" existing structures to better withstand hazard events, remove them from hazard prone areas, or provide insurance to cover potential losses. Examples include:

- Acquisition
- Relocation
- Building elevation
- Critical facilities protection or "hardening"
- Retrofitting (i.e., wind proofing, flood proofing, seismic retrofits)
- Insurance
- Safe room construction (room protected from hurricane strength winds)

Natural Resource Protection

Natural resource protection activities reduce the impact of hazards by preserving or restoring the function of environmental systems such as floodplains and wetlands. In many cases, environmentally sensitive areas are also high hazard areas. Thus, natural resource protection measures can serve the dual purpose of protecting lives and property while enhancing environmental goals such as improved water quality or enhancing recreational opportunities. Parks, recreation or conservation agencies and organizations often implement these measures. Examples include:

- Floodplain protection
- Riparian buffers (establishing no disturbance, no development zoning setbacks along streams, rivers or coastline)
- Fire resistant landscaping
- Erosion and sediment controls
- Wetland preservation and restoration
- Habitat preservation and restoration
- Slope stabilization

Structural Projects

Structural mitigation projects are intended to lessen the impact of a hazard by physically modifying the environment. They are usually designed by engineers and managed or maintained by public works staff. Examples include:

- Flood control reservoirs
- Levees/dikes/floodwalls
- Storm water management ponds
- Channel modification
- Storm drains and culverts

Emergency Services

Although not typically considered a "mitigation technique," emergency services minimize the impact of a hazard event on people and property. These actions are typically taken immediately prior to, during, or in response to a hazard event. Examples include:

- Search and rescue
- Evacuation planning and management
- Flood "fighting" methods (i.e., sandbagging, use of temporary flood walls, etc.)
- Warning systems
- Emergency Operation Center (EOC)
- Retrofitting critical facilities to better withstand disaster events

Public Information and Awareness

Public information and awareness activities are used to advise residents, business owners, potential property buyers and visitors about hazards, hazardous areas and mitigation techniques they can use to protect themselves and their property. Examples of measures to educate and inform the public include:

- Outreach
- Speaker series/demonstration events
- Hazard map information
- Real estate disclosure
- Education
- Training

Mitigation Techniques Applicable to the Municipality of Aguadilla

In considering the appropriate mitigation techniques for the Municipality of Aguadilla, the Hazard Mitigation Committee reviewed the findings of the *Hazard Identification and Risk Assessment*. The following natural hazards evaluated in the risk assessment are presented in descending order of estimated disaster damages (highest loss estimate to the lowest).

- Earthquake Ground Shaking
- Hurricane (high wind damage)
- Earthquake Landslide
- Urban Fire
- Wildfire
- Rainfall-Landslide
- Tsunami (tidal wave)
- Riverine Flooding
- Earthquake liquefaction
- Coastal Flooding

The northwest portion of Puerto Rico is most at risk to a major earthquake and fact is reflected in the loss estimates for the Municipality of Aguadilla. The loss estimates for a major earthquake are approximately 10 times greater than those for hurricane and flood losses combined. Several specific mitigation actions included in this Plan address the need for seismic retrofits for critical and essential public facilities. However, the cost of extensive seismic retrofits to residential and commercial structures would be prohibitively expensive and potential funding sources quite limited. The most cost effective way to address the Municipality's vulnerability to earthquakes is to reduce the vulnerability of future development by training the building community and through stricter compliance with the building codes. A number of the mitigation actions proposed address the need to reduce the vulnerability of future development (listed as earthquake or all hazards).

The lack of potential funding sources to implement seismic retrofits for a large number of highly vulnerable structures in the Urban Center, should not be interpreted as a lack of concern for the seismic risk by the study contractors or the Municipality of Aguadilla. Many of older, two to four-story masonry structures in the Urban Center were constructed prior to the advent of the building code and are extremely prone to collapse, even in an earthquake of moderate intensity. The destructive 1918 earthquake occurred just off the coast of Aguadilla in the Mona Passage and it is not a question of whether such an earthquake will occur but when. Although a number of these structures are commercial, many are residential, especially on the upper floors. A moderate intensity earthquake in the near future could result in a substantial loss of life for residents in these vulnerable structures.

The Urbanism and Land-Use Office should consider these highly vulnerable structures when reviewing any building permit requests for adaptive reuse. For some of the older structures that do have historic designation potential, demolition and reconstruction should be considered. A gradual phase out of residential use of some of the most vulnerable structures should be considered, with relocation to areas outside of the Urban Center that are not as susceptible to ground shaking and liquefaction attenuation. New residential construction in the Urban Center needs careful scrutiny to ensure that design and construction meets all seismic standards in the building code.

A number of the mitigation actions proposed address repetitive flooding events (riverine and coastal) that may or not be associated with a Hurricane event. Although these mitigation actions address natural hazards that do not have the highest loss estimates (calculated for the 100-year occurrence interval), they are regarded by Aguadilla residents as deserving serious attention because of the disruption and property damages that occur repeatedly (several times a year for minor flooding events and on the order of one or twice every five to ten years for major flood events).

The following matrix summarizes the mitigation techniques considered:

Mitigation Technique	Ground Shaking	Liquefaction	Earthquake Landslide	Riverine Flooding	Coastal Flooding	Rainfall Landslide	High Wind Hurricane	Wildfire	Urban Fire	Tsunami
Prevention	◆	◆	◆	◆	◆	◆				◆
Property Protection	◆			◆	◆		◆			◆
Natural Resource Protection	◆	◆		◆	◆	◆				
Structural Projects				◆	◆		◆			
Emergency Services				◆	◆		◆			◆
Public Information & Awareness	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆

5.3 MITIGATION ACTION PLAN

The mitigation actions listed on the pages that follow have been designed to achieve the goals and objectives identified in the Hazard Mitigation Plan. A series of draft mitigation actions was presented to the Hazard Mitigation Committee for their consideration. Each mitigation action was evaluated and, where necessary, modified, deleted from consideration, and several new mitigation actions were proposed by the Committee. A simple voting technique was used to prioritize each mitigation action.

Each proposed mitigation action includes:

- The categorization of the mitigation technique;
- The hazard it is designed to mitigate;
- The objective(s) it is intended to achieve;
- General background information;
- Priority Ranking (Low, Medium, High)
- Funding sources, if applicable;
- The department or person assigned responsibility for carrying out the action; and
- A target completion date.

The mitigation actions are short-term, specific measures to be undertaken by the Municipality of Aguadilla and will be used as the primary measure of the Plan's progress over time. This approach is intended to facilitate the quick review and update of the Plan as described in Section Six, *Plan Implementation*.

5.4 ADMINISTRATION OF ACTIONS

To implement and administer actions, the Municipality formed a Hazard Mitigation Monitoring and Evaluation Committee. Unlike the Hazard Mitigation Committee, which was responsible for the development of the Plan, this Committee will be in charge and responsible for the administration and implementation of the actions defined in the subsection above. Specific actions are assigned to specific individuals, municipal departments, and/or organizations.

The initial leadership of the Committee, which will be elected every year, would come from the Director of Urbanism and Land-Use Office. The Hazard Mitigation Monitoring and Evaluation Committee will be responsible for overseeing the progress made on the implementation of action items and updating the Plan, as needed, to reflect changing conditions. It will also be responsible for identifying opportunities to integrate findings of the Hazard Mitigation Plan into existing municipal plans and programs.

Not all mitigation actions require that the municipality request additional funds to implement them. At the moment, the implementations of these actions are under way by local agencies such as: Municipality's Emergency Management Office, Municipal Police Force, Public Works Office, Planning and Project Management and others. The evaluation of the mitigation actions that require additional funds, plus the request of funds is in charge of the Federal Programs Office.

5.5 ASSESSING COST EFFECTIVENESS OF MITIGATION ACTIONS

The Municipality and the Hazard Mitigation Committee considered cost effectiveness during the development and prioritization of the mitigation actions presented in this section. A formal Benefit-Cost Analysis was performed for each mitigation action for the submission of this Plan. A qualitative review, weighting the cost effectiveness of the actions was conducted by the municipality; actions were identified based on administrative, technical and financial capabilities of the municipality.

Actions identified in this Plan are pragmatic in that they are consistent with the administrative, technical and financial capabilities of the municipality. For example, actions such as the flooding problem in the Nuevo San Antonio Sector represent the first stage of a flood control project. Therefore, it was agreed upon that a detailed Benefit-Cost Analysis would be performed at a future date for any projects sent forward for funding consideration under state and federal programs such as the Hazard Mitigation Grant Program (HMGP) or the Pre-Disaster Mitigation (PDM) program.

Many of 16 prioritized mitigation actions presented in Section 5.7 concern programmatic actions that the Municipality of Aguadilla can take to reduce the impact of future development (i.e. new structures).

One other category of the 16 mitigation actions presented in Section 5.7 involve mitigation actions that provide solutions to existing hazards, primarily flooding, but also address the significant seismic risk posed by some sectors of the existing development, and in particular critical public facilities. For the majority of these actions, particularly those that address flooding issues, FEMA has developed specific

5.6 MITIGATION ACTIONS AND STRATEGIES FOR FUTURE DEVELOPMENT

The municipality of Aguadilla has participation in the NFIP. Currently has 140 Flood Insurance Policy. There are three (3) that has repetitive looses. This data can change every quarter. The municipality is part of the NFIP under the community # 7200000 with other 75 Municipalities.

Reducing the damages associated with new buildings, structures, and infrastructure, both public and private, is the most cost effective way to implement hazard mitigation. Dealing with the mistakes of the past is often prohibitively expensive. Given this key hazard mitigation concept, it is important to describe how this Plan addresses the need to implement hazard risk reduction measures for new structure and/or infrastructure. The mitigation actions that address future development include the following strategies:

- Integrate hazard mitigation into development review functions with the Urbanism and Land-Use Office, and Municipality Permits Office. This action is by far the most important Plan action dealing with new structures or infrastructure. (The new land-use plan is expected to be approved by the end of 2011. Actually, this plan is in its final approval phase from the JPPR. The Plan provides critical baseline information to an understanding of the Municipality's development objectives. It is also the main instrument for strategic and integrated land use planning for the municipal territory) Hazard mitigation must be an integral component when reviewing building permit applications, conducting building inspections, reviewing subdivision proposals and conducting long-range land use studies for the Municipality.

- Public Outreach. The municipality of Aguadilla to continue to comply with the National Flood Insurance Program (NFIP) will create brochures and facts sheets which are placed in the public expression areas, municipality web page and will be given to the community leaders to continue transmitting the information.

- Implement a coastal and floodplain protection along undeveloped coastal areas to limit construction, preserve wetlands and riparian buffers. Strengthening the existing flood prevention ordinance and amending subdivision and zoning regulations to restrict the amount and intensity of development within Special Flood Hazard Areas (SFHAs), environmentally sensitive areas, and providing adequate regulatory buffers to these hazard prone areas will substantially reduce future disaster damages.

- Prepare and adopt a municipal-wide storm water management plan. Although it would be better if adopted for all future development throughout Puerto Rico, this mitigation action proposes the adoption of storm water management regulations to reduce the impacts of future development, in addition to protecting existing development from increased flooding.

- These mitigation strategies collectively address the need for improving linkages between the Municipality and State and Federal emergency agencies for technical assistance, training, and grants management. Improving the technical capabilities of municipal staff for implementing hazard mitigation actions, and maintaining networks to obtain knowledge and guidance for nature grant opportunities can lead to substantial reductions in future disaster damages.

- These actions collectively address the need to increase public outreach within the Municipality on hazard mitigation techniques applicable to the general public, architects, engineers, contractors, planners and media. Providing hazard mitigation information directly to architects, engineers, planners and the contractors conducting business in the Municipality is clearly a cost effective technique for reducing damages associated with new structures or infrastructure.

5.7 PRIORITIZED LIST OF MITIGATION

The following pages describe a prioritized list of mitigation actions for the Municipality of Aguadilla. Starting with the 2004 mitigations that were not made in the last plan. (Yellow color) The municipality wishes and requests to include them to reapply for funds to make the works.

Mitigation Action	**Flood Control Project for the Rio Culebrinas in the Vicinity of Aguadilla and Aguada**
Goal and Objective Addressed:	*Goal #1* Reduce the impact of natural disasters on residents and property Objective 1.1 and 1.2 Protect existing development from future disaster events, reduce the vulnerability of future development.
Category:	Structural Projects
Hazard:	Flood
Background:	The USACE estimates annual damages from Rio Culebrinas flooding at $1.16 million. The 100-year flood would affect approx. 700 residential structures, commercial and public facilities in both municipalities. The USACE has recommended a series of two flood-control levees to protect the southwest portion of Aguadilla and the community of Espinal in Aguada. This mitigation it is included in the 2011 plan because for this projects the municipality endorsement a private project (Discovery bay) which proposed a canal to the Culebrinas river. At that time the municipality has not the funds for the construction the project. Currently applying for the permits. If the project is not completed the municipality requested funds to realize the projects.
Priority:	High
Potential Funding Sources:	External through USACE Section 205 funding with non/federal cost-sharing requirements. Under current program guidance and at 2002 dollars, Federal contribution is $2.4 million and non-Federal cost share is $2.14 million. Total estimated cost $5.0 million dollars
Hazard Mitigation Committee Action Lead:	Mrs. Emily Masters
Department Responsibility:	Federal Program Offices
Estimated Timeframe:	5 years

Rio Culebrinas Aguadilla and Aguada Lat. 18,23.57 N Long.67,09.26

NO PHOTO AVAILABLE

Mitigation Action	**Conduct structural engineering feasibility study for seismic retrofit and flood proofing of the Municipal Police Station**
Goal and Objective Addressed:	*Goal #4* Improve local ability to restore critical facilities, essential infrastructure, and ensure the continuity of municipal operations following natural disasters. Objective 4.3 Reduce the vulnerability of critical facilities, infrastructure and essential municipal facilities
Category:	Property Protection
Hazard:	Earthquake and Flood
Background:	The vulnerability assessment of critical facilities has revealed that the Municipal Police Station is at severe risk to an earthquake and coastal flooding damages. There is an immediate need to determine the economic feasibility of hardening the facility to withstand earthquake and flooding damages. The only alternative for this critical facility would be to relocate the Police Department. In 2004 proposal was submitted but was not approved. We are seeking funding for the relocation of the facilities.
Priority:	High
Potential Funding Sources:	Relocate and build this facilities. Estimated cost are $1,000,000. External (FEMA PDM, PRSEMA)
Hazard Mitigation Committee Action Lead:	Mr. Luis Irizarry
Department Responsibilities:	Municipal Police and Federal Programs
Estimated Timeframe:	12 months

NO PHOTO AVAILABLE

Mitigation Action	**Identify "special needs" citizens and develop rescue and evacuation procedures for this group**
Goal and Objective Addressed:	*Goal #2* Strengthen the capabilities of municipal agencies to implement and maintain hazard mitigation programs and evaluate prior plans Objective 2.1 Identify and develop policies, regulations, and specialized training necessary to support an effective hazard mitigation program in the Municipality
Category:	Emergency Services
Hazard:	All Hazards
Background:	A database can be developed on populations with special needs (age, disability, illness) and kept on file in the emergency management office. The compilation of this information is an important step in facilitating evacuation for special needs population. Currently the emergency Management Office is conducting this mitigation. Please include the 2011 plan.
Priority:	Low
Potential Funding Sources:	External $150,000
Hazard Mitigation Committee Action Lead:	Mr. Frank Hernandez
Department Responsibilities:	Municipal Office of Emergency Management
Estimated Timeframe:	12 months

NO PHOTO AVAILABLE

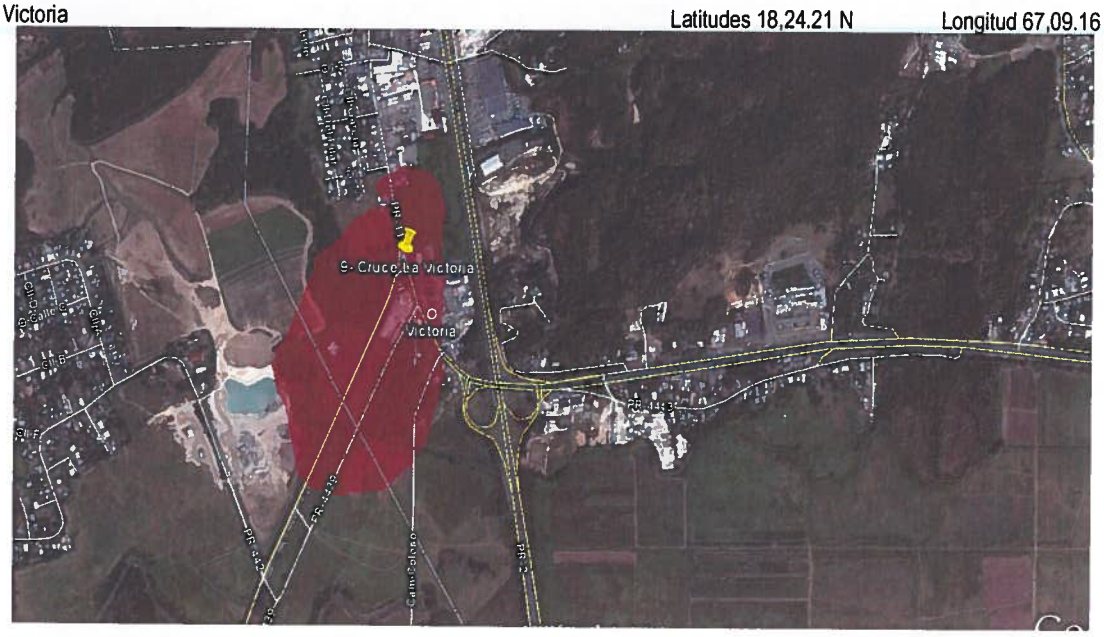
Mitigation Action	**Prepare and adopt a municipality-wide storm water management plan**
Goal and Objective Addressed:	*Goal #1* Reduce the impact of natural disasters on residents and property. Objective 1.2 Reduce the vulnerability of future development.
Category:	Prevention
Hazard:	Flood
Background:	Storm water management is an important tool to address flood problems throughout the municipality. New development, especially roads and bridges, can affect drainage patterns and have an impact on storm water run-off and flooding in surrounding areas. Currently the Municipality is working with the development of this plan
Priority:	Medium
Potential Funding Sources:	Is currently under budgeting. External (grant)
Hazard Mitigation Committee Action Lead:	Mrs. Emily Masters
Department Responsibilities:	Federal Grants Department (grant writing); Department of Public Works (lead department for plan development) Federal Programs Offices (Federal Proposal Division)
Estimated Timeframe:	30 months

Mitigation Action	**Storm water management improvements to eliminate localized flooding at the intersections of Carr. 459 and 461 near the Inter American University**
Objectives Addressed:	*Goal #1* Reduce the impact of natural disasters on residents and property Objective 1.1 Protect existing development from future disaster events.
Category:	Structural Projects
Hazard:	Flood
Background:	In developed areas, storm water, management improvements (ponds, new or larger culverts, and increased drainage channel capacity) is often necessary. This strategy represents an action that will reduce flooding impacts in surrounding neighborhoods in addition to eliminating repetitive flooding at the intersection of Carr 459 and 461. This project was not realized with the 2004 plan because lack of funds for the initial designed.
Priority:	High
Potential Funding Sources:	External (Estatal) Estimated cost $1,300,000.
Hazard Mitigation Committee Action Lead:	Mrs. Emily Masters
Department Responsibilities:	Federal Program Office and Planning and Project Management Office
Estimated Timeframe:	18 months

Int.Carr 459 con Carr 461 W Lat. 18.27.49 N Long 67.7.31

Mitigation Action	**Flood control project in Cruce La Victoria, (Cruce los Indios) Collect rain in main road 111 provide access to other towns.**
Goal and Objective Addressed:	*Goal #1* Reduce the impact of natural disasters on residents and property Objective 1.1 Protect existing development from future disaster events.
Category:	Structural Projects
Hazard:	Flood
Background:	Poor drainage, buildings and the proximity of two small rivers cause the rain to flood the entire area. Rivers must be cleaned to expand the ability to collect rain. Access on this road is closed sometimes because of the flood level (two feet) and the commercial activity is affected. Considering that this street is one of the main that provide access
Priority:	High
Potential Funding Sources:	Grants $3,265,000
Hazard Mitigation Committee Action Lead:	Mrs. Emily Master
Department Responsibility:	Federal Programs Office
Estimated Timeframe:	1 year for design and securing funding, 2 years construction

La Victoria Latitudes 18,24.21 N Longitud 67,09.16 W



Poor drainage, buildings and the proximity of two small rivers cause the rain to flood the entire area. Access on this road is closed sometimes because of the flood level.

111 Road View

111 Road view

Small river, at 50 meters of the flooding area, road 111

Flood area

Mitigation Action	**Flood Control Project in Nuevo San Antonio Sector at the 68-acre HP manufacturing facility and the surrounding residential, institutional, industrial drainage area along PR-459 and PR-110**
Goal and Objective Addressed:	*Goal #1* Reduce the impact of natural disasters on residents and property. Objective 1.1 Protect existing development from future disaster events.
Category:	Structural Projects
Hazard:	Flood
Background:	Historically, roads, residential areas and industrial sites in the Nuevo San Antonio area have had repetitive flooding problems. HP has provided up to 25-year controls on-site and desires a public/private initiative to provide 100-year controls for HP and surrounding residential areas. HP flood studies are evaluating off-site options, including new SWM facilities at a 9-acre PRIDCO site and at the nearby UPR Montana Research Station; in addition, to drainage channel capacity improvements and connection to a recently completed retention pond/injection wells just east of HP along PR-459. This mitigation was not made in 2004 plan. For this project, proposal was submitted, was approved but was not realized completed for breach of the agreement with the UPR university. This project is necessary and we are interested in reapplying for funds.
Priority:	High
Potential Funding Sources:	Federal Sources. Estimated project cost $3.0 million dollars.
Hazard Mitigation Committee Action Lead:	Mrs. Emily Masters
Department Responsibility:	Federal Programs Office
Estimated Timeframe:	1 year for design and securing funding, 2 years construction

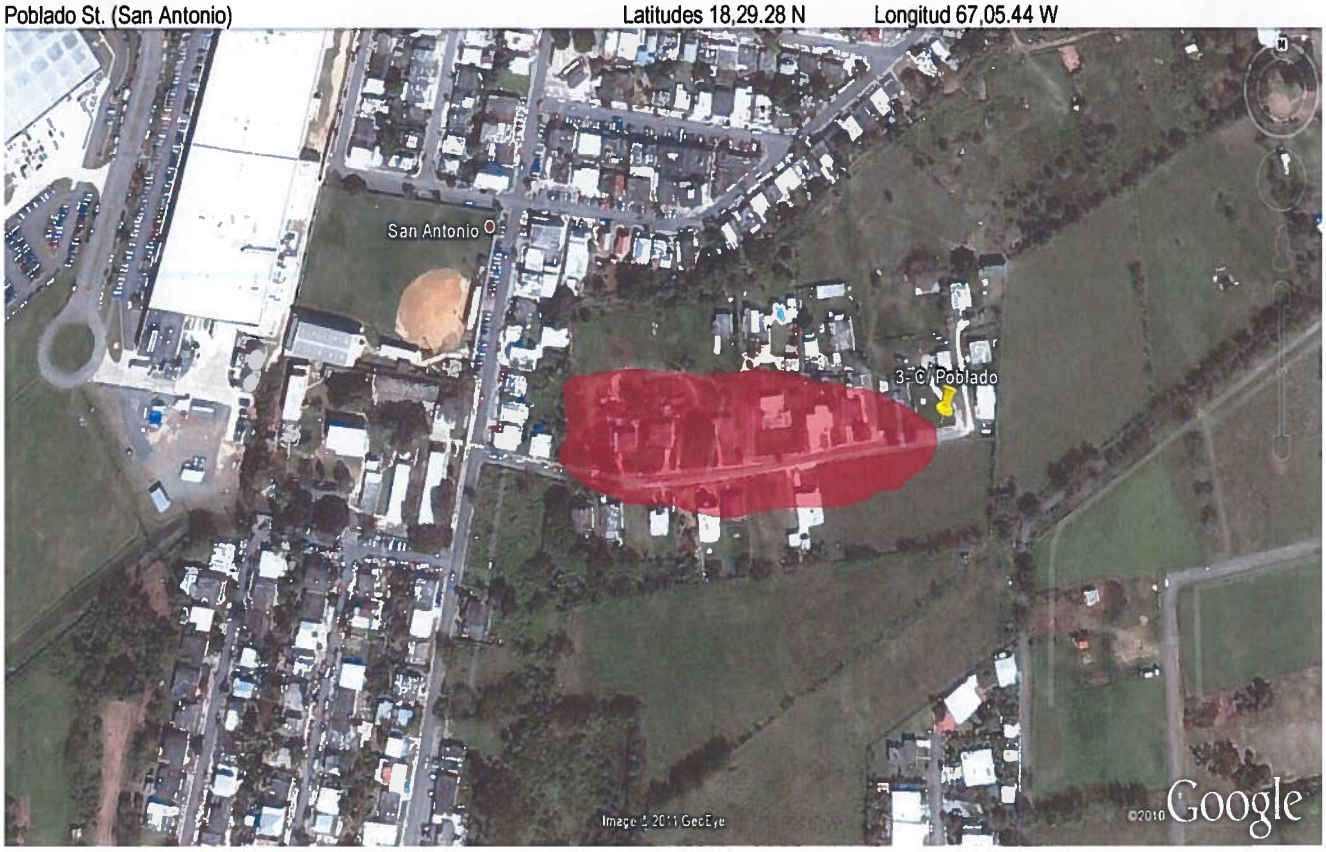
Puente San Antonio

Latitude 18,28.53 NLongitude 67,06.30 W

This area is poor drainage. With heavy rains flooded the area reaching almost four feet of water.

Mitigation Action	**Flood Control Poblado St San Antonio, Reparto Los Pinos**
Objectives Addressed:	*Goal #1* Reduce the impact of natural disasters on residents and property Objective 1.1 Protect existing development from future disaster events
Category:	Structural Projects
Hazard:	Flood
Background:	Sewer and drainage system does not have the capacity to manage the quantities of water during heavy rains causing repetitive floods in the area.
Priority:	Medium
Potential Funding Sources:	External (Estatal) $150,000
Hazard Mitigation Committee Action Lead:	Mr. Jose L. Castro
Department Responsibilities:	Dept. of Public Works and Dept. of Transportation (Estatal)
Estimated Timeframe:	18 months

Poblado St. (San Antonio) Latitudes 18,29.28 N Longitud 67,05.44 W



The area has poor drainage. In the middle of the street there is a culvert, which is blocked it doesn't have the capacity to manage the floods. The neighbors take the water with a tube using a pump and dump the water in a vacant lot near their homes.

Mitigation Action	**Flood control project in Calle Macetazo, Sector Los Cobos**
Objectives Addressed:	*Goal #1* Reduce the impact of natural disasters on residents and property Objective 1.1 Protect existing development from future disaster events
Category:	Structural Projects
Hazard:	Flood
Background:	This area have flood problems, because the drain is completely block by the soil
Priority:	Medium
Potential Funding Sources:	External (Estatal) $108,500
Hazard Mitigation Committee Action Lead:	Mr. Jose L. Castro
Department Responsibilities:	Municipal Emergency Management Office
Estimated Timeframe:	18 months

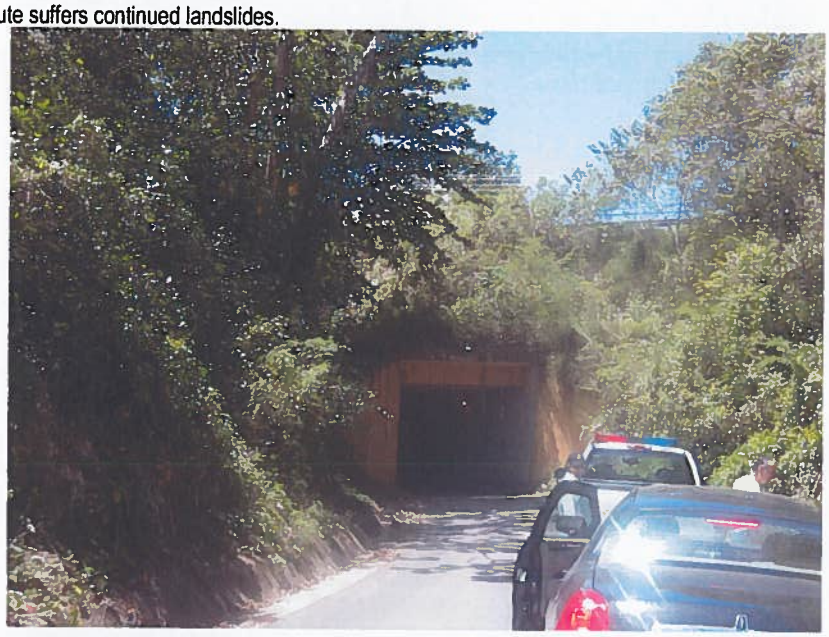
Macetazo St. (Sector Los Cobos) Latitudes 18, 28.20 N Longitud 67, 09.18

A vacant lot had a fence and have blocks in the bottom blocking a drain.

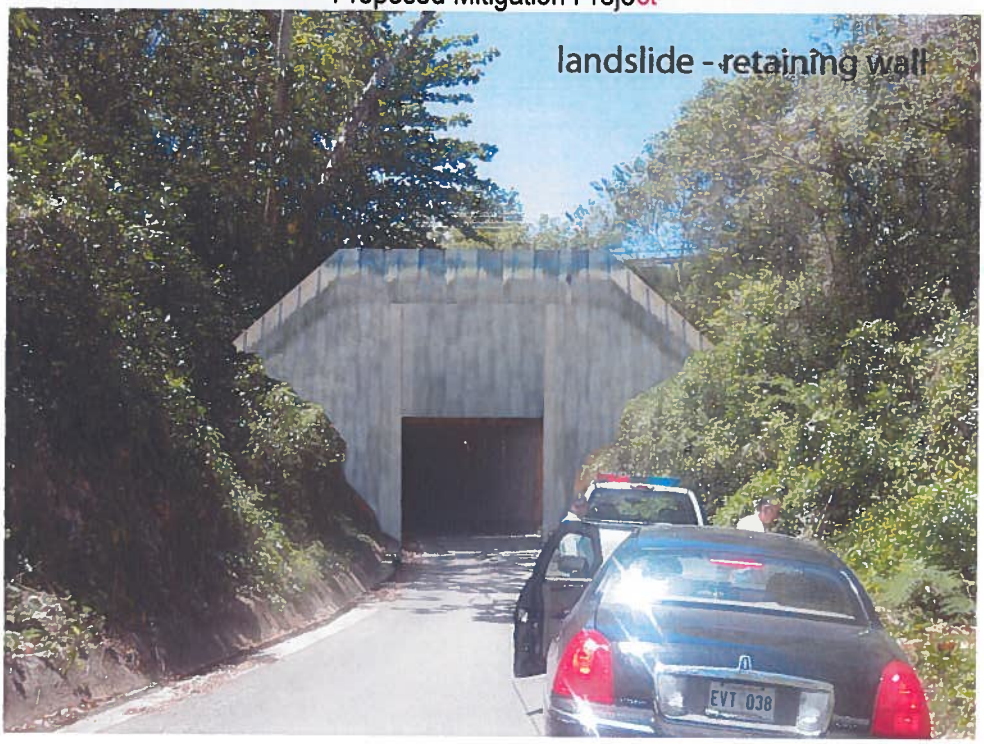
Mitigation Action	**Concrete wall in the evacuation route, multiple lateral landslide Carr # 2**
Objectives Addressed:	*Goal #1* Reduce the impact of natural disasters on residents and property Objective 1.1 Protect existing development from future disaster event.
Category:	Structural Projects
Hazard:	Earthquakes
Background:	This "tunnel" is essential part of an evacuation plan, and has loose soil at the top causing continuous landslides.
Priority:	Medium
Potential Funding Sources:	Federal Sources $280,000
Hazard Mitigation Committee Action Lead:	Mr. Frank Hernandez
Department Responsibilities:	Municipal Emergency Management Office and Planning and Projects Management Office.
Estimated Timeframe:	18 months

Evacuation route Carr #2 Latitude 18, 24.57 N Longitude 67, 09.06 W

The evacuation route suffers continued landslides.

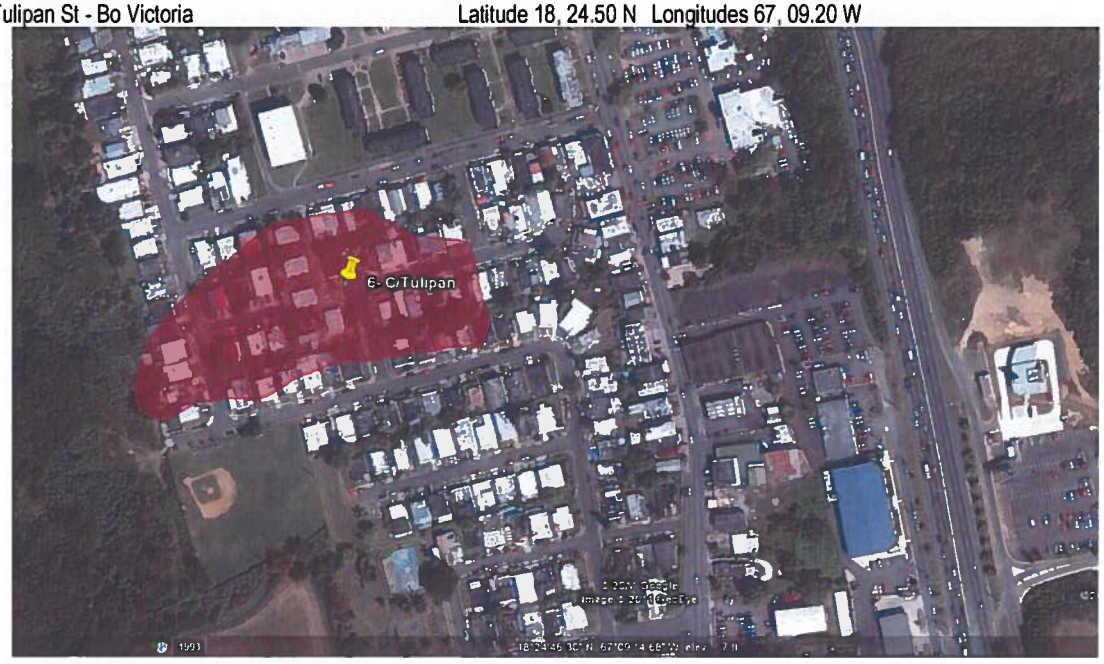


Proposed Mitigation Project



Mitigation Action	**Flood control projects in Bo. Victoria - Tulipan Street with C Street.**
Objectives Addressed:	*Goal #1* Reduce the impact of natural disasters on residents and property Objective 1.1 Protect existing development from future disaster events.
Category:	Structural Projects
Hazard:	Flood
Background:	In developed areas, storm water management improvements (ponds, new or larger culverts, increased drainage channel capacity) are often necessary. This strategy represents an action that will reduce flooding impacts in surrounding neighborhoods in addition to eliminating repetitive flooding.
Priority:	Medium
Potential Funding Sources:	External (Estatal) $59,000
Hazard Mitigation Committee Action Lead:	Mrs. Emily Masters
Department Responsibilities:	Federal Program Office
Estimated Timeframe:	18 months

Tulipan St - Bo Victoria Latitude 18, 24.50 N Longitudes 67, 09.20 W

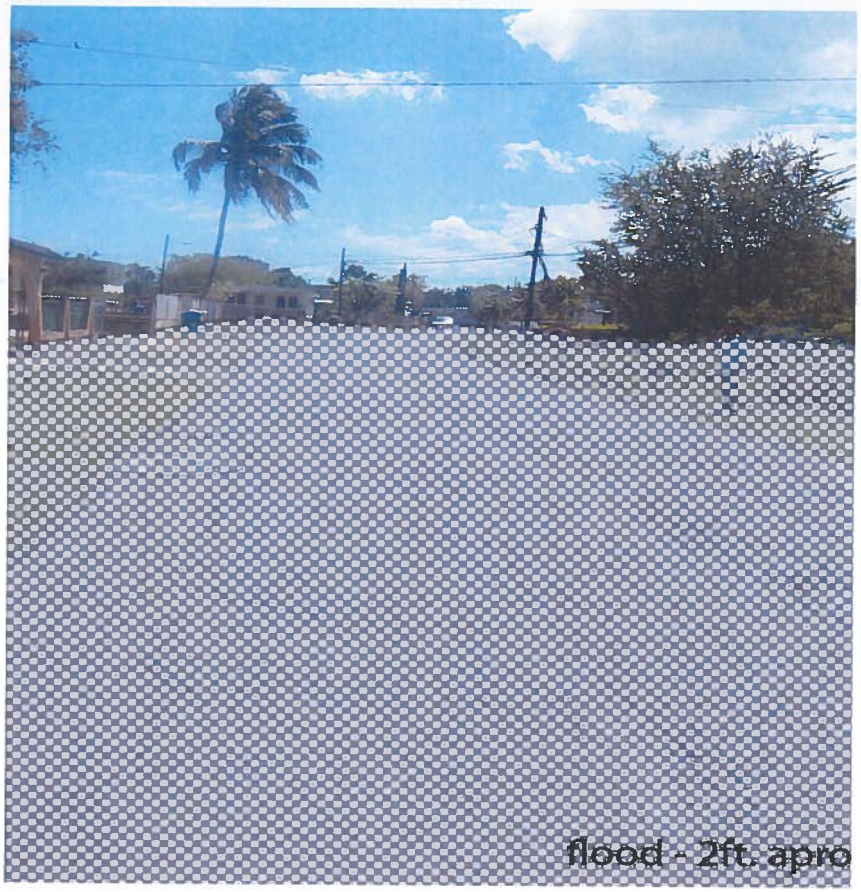


This area is the lowest area of the complex. All water flow into a single drain, which is capped at 80%. When saturated with rain and flooded the area.

Mitigation Action	**Bo. Camaseyes – Carr 467 Calle Malezas Flood control project**
Objectives Addressed:	*Goal #1* Reduce the impact of natural disasters on residents and property Objective 1.1 Protect existing development from future disaster events
Category:	Structural Projects
Hazard:	Flood
Background:	This street have no drainage causing floods all over the area
Priority:	Medium
Potential Funding Sources:	External (Estatal) $1,500,000
Hazard Mitigation Committee Action Lead:	Mrs. Emily Masters
Department Responsibilities:	Federal Program Offices
Estimated Timeframe:	18 months

Bo. Camaseyes - Malesa St Latitude 18, 28.38 N Longitudes 67, 08.06 W

Is flooded with heavy rain because there is no sewer system in all 467 road.



Mitigation Action	**Bo. Boriquen Camino 459 Flood control**
Objectives Addressed:	*Goal #1* Reduce the impact of natural disasters on residents and property Objective 1.1 Protect existing development from future disaster events.
Category:	Structural Projects
Hazard:	Flood
Background:	This street have no drainage causing floods all over the area. Someone built a house in a disused irrigation system.
Priority:	Low
Potential Funding Sources:	External (Estatal) $3,000,000
Hazard Mitigation Committee Action Lead:	Mrs. Emily Masters
Department Responsibilities:	Federal Program Offices
Estimated Timeframe:	18 months

Bo. BorinquenCamino 459 Latitude 18, 28.50 N Longitude 67, 08.51 W

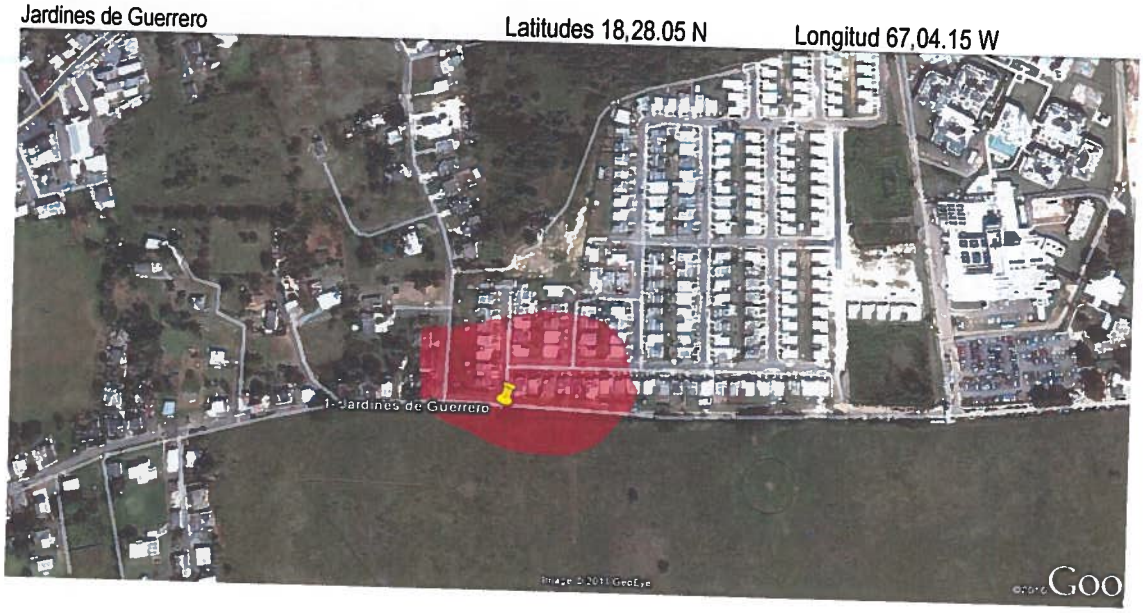

flood - 6ft. aprox

NO PHOTO AVAILABLE

Mitigation Action	**Integrate hazard mitigation into development review functions within Urbanism and Land-Use Office**
Goal and Objective Addressed:	*Goal #2* Strengthen the capabilities of municipal agencies to implement and maintain hazard mitigation programs and evaluate prior plans. Objective 2.1 Identify and develop policies, regulations, and specialized training necessary to support an effective hazard mitigation program in the Municipality.
Category:	Prevention
Hazard:	All Hazards
Background:	The Municipality, in implementing Geographic Information Systems (GIS) within the Urbanism and Land-Use Office, should assess how hazard mitigation can be incorporated into building permit, subdivision, major project review, and long-range comprehensive planning functions. A careful strategy should be implemented to determine how best to proceed. This project would include acquisition of hardware, software, and training.
Priority:	Low
Potential Funding Sources:	External and local funds in process (grant)$60,000
Hazard Mitigation Committee Action Lead:	Mr. Manuel Hidalgo
Department Responsibility:	Urbanism and Land-Use Office

Mitigation Action	**Flood Control Project: Jardines de Guerrero, Aguadilla,**
Goal and Objective Addressed:	*Goal #1* Reduce the impact of natural disasters on residents and property Objective 1.1Protect existing development from future disaster events.
Category:	Structural Projects
Hazard:	Flood
Background:	Historically, residential houses in Jardines de Guerrero area have had repetitive flooding problems. In the area is a pump (to pumped water out of the area) but is useless, causing flood in the area.
Priority:	Medium
Potential Funding Sources:	FEMA Competitive PDM Grant; PRIDCO, Municipal funds, potentially other State (Estatal) funding $175,000
Hazard Mitigation Committee Action Lead:	Mrs. Emily Master
Department Responsibility:	Federal Grants Office
Estimated Timeframe:	1 year for design and securing funding, 2 years construction

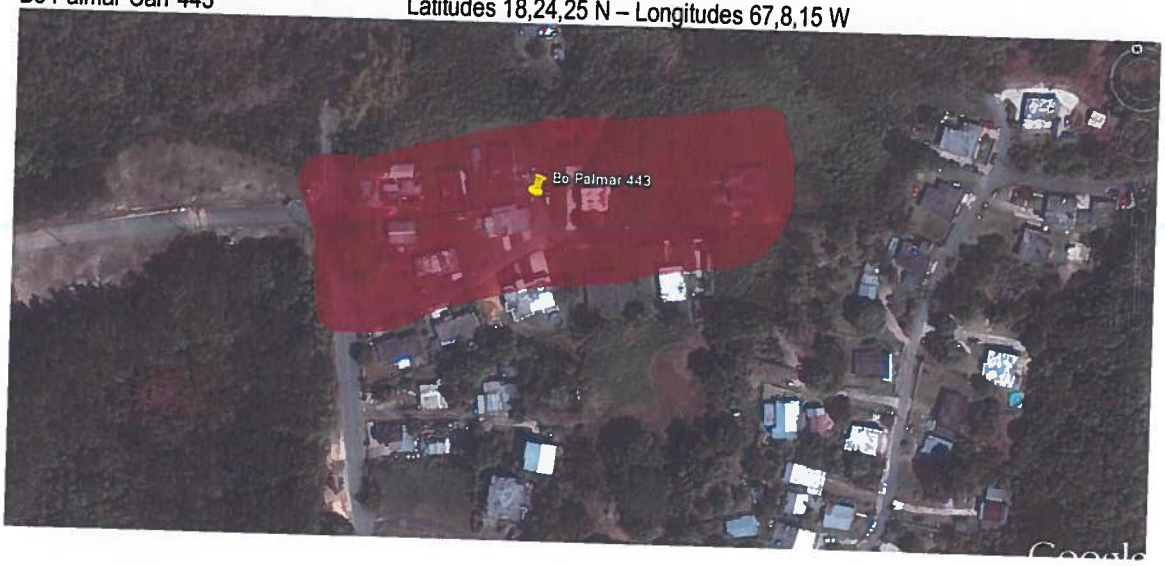
Jardines de Guerrero Latitudes 18,28.05 N Longitud 67,04.15 W



There was a water pump that prevented the area was flooded. Currently, the pump is not working and causes floods the entire area. The affected area is about 200 square meters.

Mitigation Action	**Bo. Palmar Carr 443, Flood control**
Objectives Addressed:	*Goal #1* Reduce the impact of natural disasters on residents and property Objective 1.1 Protect existing development from future disaster events.
Category:	Structural Projects
Hazard:	Flood
Background:	This street has no drainage causing floods all over the area. This situation occurs every time with heavy rain.
Priority:	Medium
Potential Funding Sources:	External (Estatal) $400,000
Hazard Mitigation Committee Action Lead:	Mrs. Emily Masters
Department Responsibilities:	Federal Program Offices
Estimated Timeframe:	12 months

Bo Palmar Carr 443 Latitudes 18,24,25 N – Longitudes 67,8,15 W



5.8 BROAD RECOMMENDATIONS AND ACTIONS FOR PLAN UPDATE

It is necessary to note that during the development of the plan several data limitations were identified. The recommendations below seek to improve the data quality of future Plan updates:

Hazard Profile

- Historical Hazard data. Data compiled for hazard history was limited. Data that included date of hazard event, damages, and magnitude were not readily available. Attempts should be made to catalog of all hazard events that occur within or in areas surrounding the municipality.

Assessing Vulnerability

- Collect data on exposure values of critical facilities (replacement costs and content values)
- Collect specific information to classify all structures in the municipality, including parcel base map that contains detailed structure classification.

Loss Estimation

- Collect data on lifelines (i.e., transportation, water and electric networks) in order to conduct a comprehensive loss estimation analysis.
- Collect data on general building stock, exposure estimates are based on aggregated building replacement costs by insurance coverage policy for the 2011-2012 periods
- Municipality of Aguadilla must undertake the scope of the Database currently being established must be extended in terms of the inventory and the potential damage of each hazard event. Additional data that must be collected must include: structure size, structure value, contents value, occupancy or capacity, and/or any other special consideration

Future Vulnerability

- Collect data that keeps track of future development projects in GIS format to assess risk to these projects by using hazard maps developed in this Plan.

SECTION SIX

SECTION SIX PLAN IMPLEMENTATION

This section of the Plan provides a framework for implementation, monitoring, evaluation, and updating of the Plan in accordance with the requirements of the Disaster Mitigation Act of 2000. It provides a framework based on the same level of participation of all involved in the development of the Plan, but with specific roles and responsibilities clearly defined for action implementation. Section Six consists of the following eight subsections:

- 6.1 IFR Requirements for Plan Maintenance
- 6.2 Responsibilities
- 6.3 Monitoring
- 6.4 Plan Evaluation and Reporting
- 6.5 Plan Review
- 6.6 Revisions and Updates
- 6.7 Public Involvement
- 6.8 Implementation Through Existing Planning Mechanisms

6.1 IFR REQUIREMENTS FOR PLAN MAINTENANCE

§201.6(c)(4)(i): of the Plan Interim Final Rule (IFR) requires the Municipality to include a section that describes the Plan Maintenance Process. Specific language in the IFR states that the Local Mitigation Plan must include:

- **Monitoring, Evaluating, and Updating the Plan** per **Requirement §201.6(c)(4)(i):** [The plan maintenance process shall include a] section describing the method and schedule of monitoring, evaluating, and updating the mitigation plan within a five-year cycle.

- **Incorporation into Existing Planning Mechanisms** per **Requirement §201.6(c)(4)(ii):** [The plan shall include a] process by which local governments incorporate the requirements of the mitigation plan into other planning mechanisms such as comprehensive or capital improvement plans, when appropriate.

- **Continued Public Involvement** per **Requirement §201.6(c)(4)(iii):** [The plan maintenance process shall include a] discussion on how the community will continue public participation in the plan maintenance process.

6.2 RESPONSIBILITIES

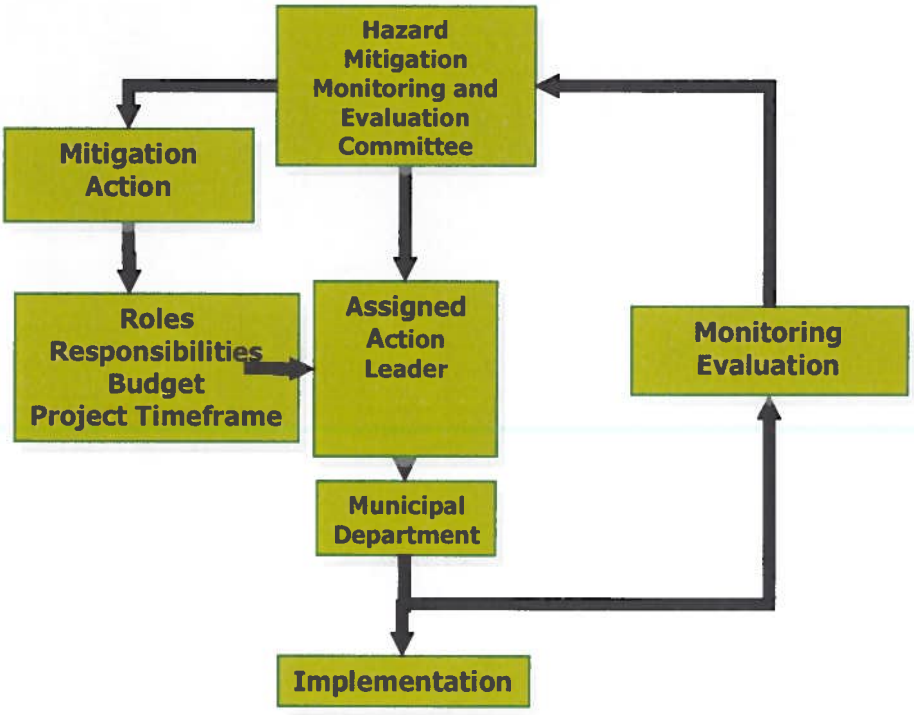
The Municipality of Aguadilla has developed a Hazard Mitigation Monitoring and Evaluation Committee. This committee will be responsible for the implementation of actions identified in the Plan. The Urbanism and Land-Use Office Mr. Manuel Hidalgo, will be in charge of the Hazard Mitigation Monitoring and Evaluation Committee. Mrs. Mercado has asked the following persons to work with him on implementing the actions defined in this Plan, they are:

TABLE 6.1 *Hazard Mitigation Monitoring and Evaluation Committee*

Name	Department
Mr. Manuel Hidalgo	Director Urbanism and Land-Use Office
Mrs. Isabel Nieves	Urbanism and Land-Use Office
Mrs. Jessica Acevedo	Director Planning Office
Mrs. Emily Masters	Director of Federal Programs Office
Mrs. Annette Gonzalez	Administrative Assistant Federal Programs Office
Mr. Frank Hernandez	Director, Office of Emergency Management
Mr. Jose L Castro	Director, Office of Public Works
Mr. Luis Irizarry	Commissioner Municipal Police

The Hazard Mitigation Monitoring and Evaluation Committee will be in charge and responsible for the implementation of the actions defined in Section Five. The Committee has assigned specific actions to individuals, municipal departments, and/or organizations. Figure 6.1 provides a conceptual framework for the administration and implementation of mitigation actions.

FIGURE 6.1 Implementation Frameworks



The Hazard Mitigation Monitoring and Evaluation Committee will be in charge of assigning action/project responsibilities to different members or municipal staff. Once actions/projects have been assigned, the Hazard Mitigation Monitoring and Evaluation Committee will be responsible for monitoring progress and ensuring that goals and objectives of the Hazard Mitigation Plan are obtained.

Mitigation Committee Action Leaders
The Hazard Mitigation Monitoring and Evaluation Committee will therefore need to have capable officers—called Action Leaders—to undertake the following responsibilities. Action Leaders will:

- Facilitate the formulation of actions/projects; and
- Provide reports to the Hazard Mitigation Monitoring and Evaluation Committee on success or shortfalls of project/action implementation.

An Action Leader will be in charge of working with each respective municipal department or organization that has been identified for implementation of the different actions.

6.3 MONITORING

As indicated above, the Urbanism and Land-Use Office Director, the Planner will have the task of monitoring the implementation through a designated Action Leader. Successful implementation of the Hazard Mitigation Plan requires continuous monitoring of all defined actions:

- Ensure that appropriate resources (technical, financial, political and legal) are assigned to the action/project;
- Monitor the implementation of each action item; and
- Conduct status meetings, site visits and phone calls with implementing municipal department.

The Committee will request that the Action Leader, along with the implementing department, submit an **annual** report that provides adequate information to assess the status of each action.

6.4 PLAN EVALUATION AND REPORTING

As part of the formal project/action evaluation, the Hazard Mitigation Monitoring and Evaluation Committee, and specifically the Urbanism and Land-Use Office Director, will task members of the Committee with a specific action or project. Each person that is assigned a project will have to submit a written progress report. Formal action/project status report is required at the annual meeting. Evaluation of each action should include:

- Description of the project;
- Percentage complete (per project task);
- Problems encountered during implementation; and
- Estimated completion date.

Based on this report, the Hazard Mitigation Monitoring and Evaluation Committee will assess the degree of effectiveness and relevancy of each action's progress against the Plan's stated goals and objectives.

6.5 PLAN REVIEW

The Hazard Mitigation Monitoring and Evaluation Committee shall review the Hazard Mitigation Plan on an annual basis. All meetings should be recorded and all recommendations noted. The Hazard Mitigation Monitoring and Evaluation Committee should also evaluate if actions need to be discontinued, modified and/or if additional actions should be added to the Plan. Based on the results of the review, the Hazard Mitigation Monitoring and Evaluation Committee shall develop a formal progress report and submit it to the Mayor, Municipal Legislature, and the Puerto Rico State Emergency Management Agency.

6.6 REVISIONS AND UPDATES

Periodic revisions and updates of the Plan are strongly suggested in order to ensure that the goals and objectives for the municipality are kept current. Updates should reflect increased construction and development, the development of new technical and administrative capabilities in the municipality, and changes in federal or state legislation. The Plan will be updated every five years, as required by DMA 2000, or within twelve (12) months following a Presidential Declaration in Puerto Rico where the Municipality of Aguadilla has been declared for both Public Assistance and Individual Assistance. The method utilized to revise or update the plan will include public notices, public announcements and/or any other form of public information dissemination deemed necessary by the Committee to reach all residents at the communities, collecting the data and editing the information to be added to the Plan. This process will take and average of six (6) to twelve (12) months. The updated Plan will account for all new developments and recommendations by the Communities and The Hazard Mitigation Monitoring and Evaluation Committee.

6.7 PUBLIC INVOLVEMENT

The Hazard Mitigation Monitoring and Evaluation Committee shall notify the public and involve the public during the annual evaluation and periodic updates of the Plan. This may be done through several mechanisms including: public education projects, public workshops, and public informational meetings. The public would also have access to information via newsletters, mailings, and through the different municipal departments delegated with implementation responsibilities.

6.8 IMPLEMENTATION THROUGH EXISTING PLANNING MECHANISMS

It will also be the responsibility of the Committee to facilitate the integration of the recommended actions of the Hazard Mitigation Plan into other local planning documents, processes or mechanisms as opportunities may arise. Such opportunities to integrate the requirements of this Plan into other local planning mechanisms will be identified through future meetings of the Hazard Mitigation Monitoring and Evaluation Committee and through the review process described herein. Several specific mitigation actions address the objective of implementation of hazard mitigation through day-to-day and long-term planning responsibilities of the Permit and Planning Offices.

This Plan highlights several key planning principles that offer a foundation that may guide public policies and avoid a cycle of disaster-reconstruction-disaster:

- The Municipality of Aguadilla should limit intensive development in hazard-prone areas;
- The Municipality of Aguadilla should initiate a long-term transformational process to reduce the vulnerability of older two- to four-story masonry commercial and residential structures in the Urban Center, through demolition, adaptive reuse, seismic retrofits where technically feasible, urban park planning, and more stringent compliance with the building code for new construction;
- The Municipality of Aguadilla should promote information about hazards and sustainable ways of coping with them;
- The Municipality of Aguadilla must develop the political will and capacity to effectively manage the land development process and encourage sustainable development practices;
- The Municipality of Aguadilla should foster innovation and change in land use development practices;
- The Municipality of Aguadilla should integrate findings into the Land Use Plan by modifying its Program, Memorial and Land Use Regulations (Reglamentación) when these documents are scheduled for updating.

The implementation framework outlined in the sections above provide a vehicle for the Hazard Mitigation Monitoring and Evaluation Committee to develop a "voice" within the community and work directly with policymakers and planners to help them understand the costs of risk reduction, assumption or elimination.

The Municipality of Aguadilla views the development and maintenance of this stand-alone Plan as an effective tool to incorporate hazard mitigation into larger development processes. The Municipality also understands that its implementation will require some fundamental changes in the way the Municipality plans for and regulates new development.

SECTION SEVEN

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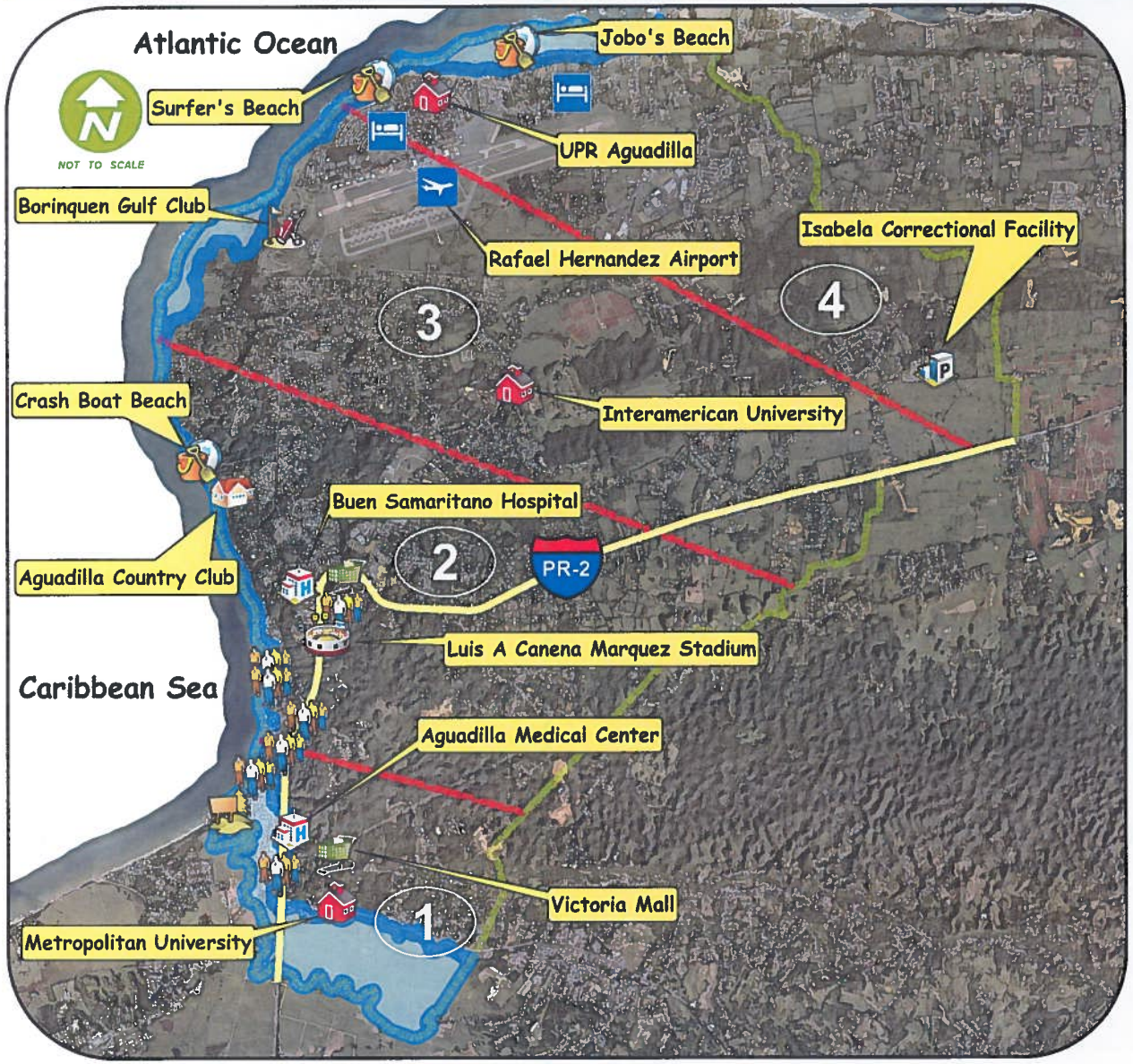
SECTION EIGHT

APPENDIX, DOCUMENTATION AND REFERENCES

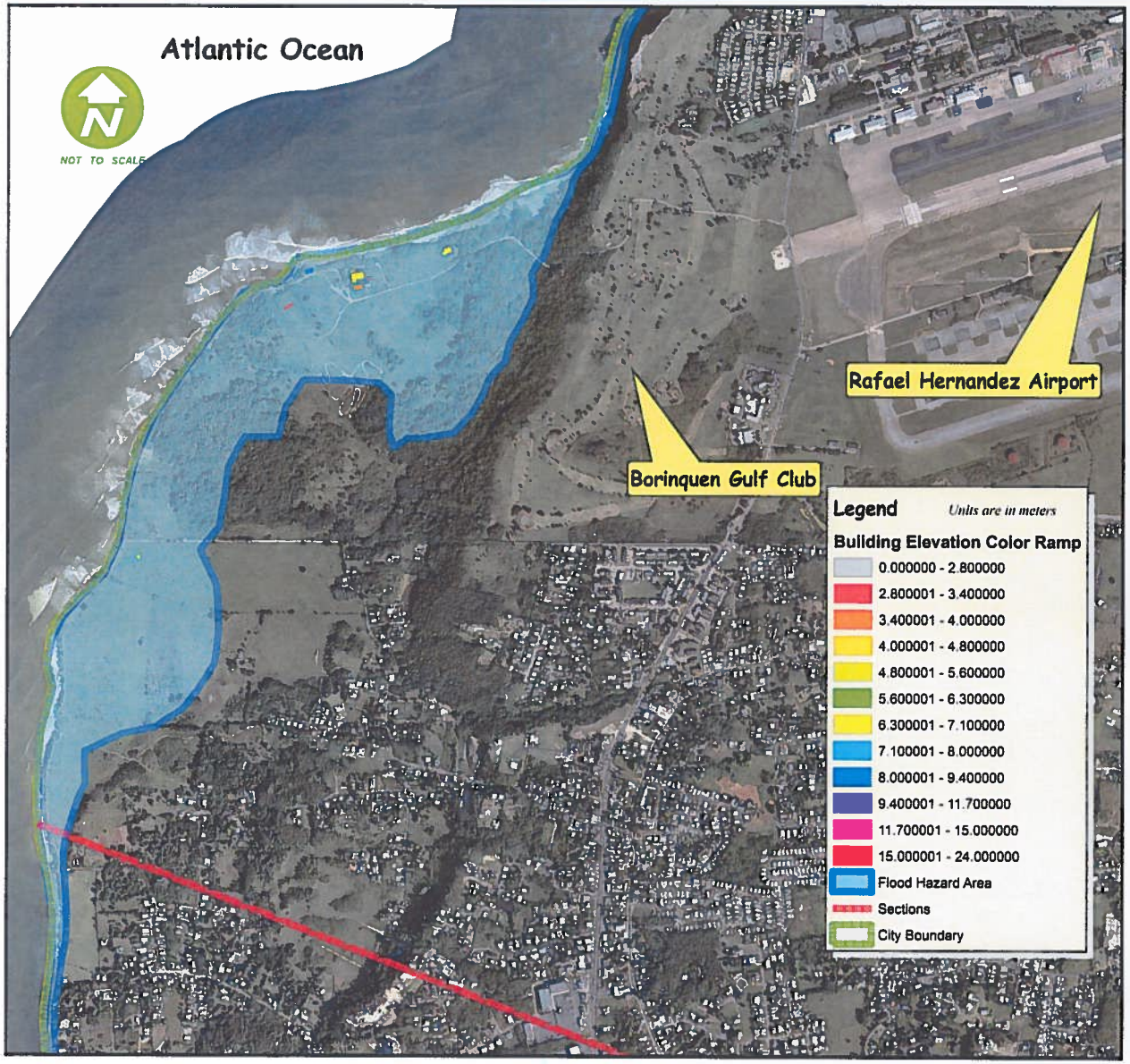
Aguadilla City: Affected Flood Hazard Area



Representation of the affected flood hazard areas in Aguadilla City. Some representation were made and edited for better cartographic representation and visualization using layers of information provided by ISP Company. Some areas of interest were pointed out in the map for faster localization.

Juan M. Rodriguez Rebollo

Aguadilla City: Affected Flood Hazard Area "North West Section"

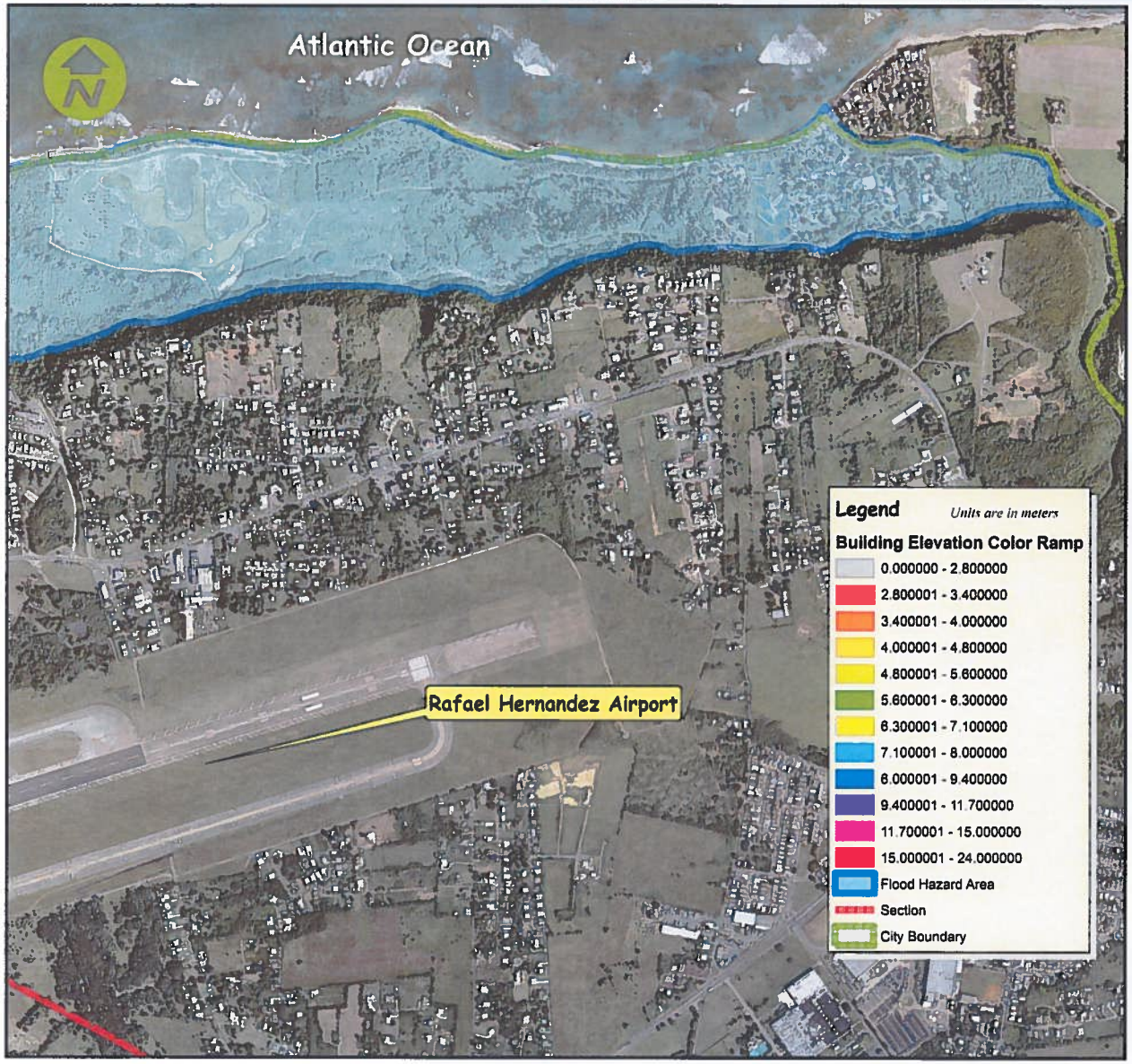


Representation of the affected flood hazard areas in Aguadilla City. Some representation were made and edited for better cartographic representation and visualization using layers of information provided by ISP Company. Some areas of interest were pointed out in the map for faster localization.

Geologic Map

Section Map

Aguadilla City: Affected Flood Hazard Area "North Section"

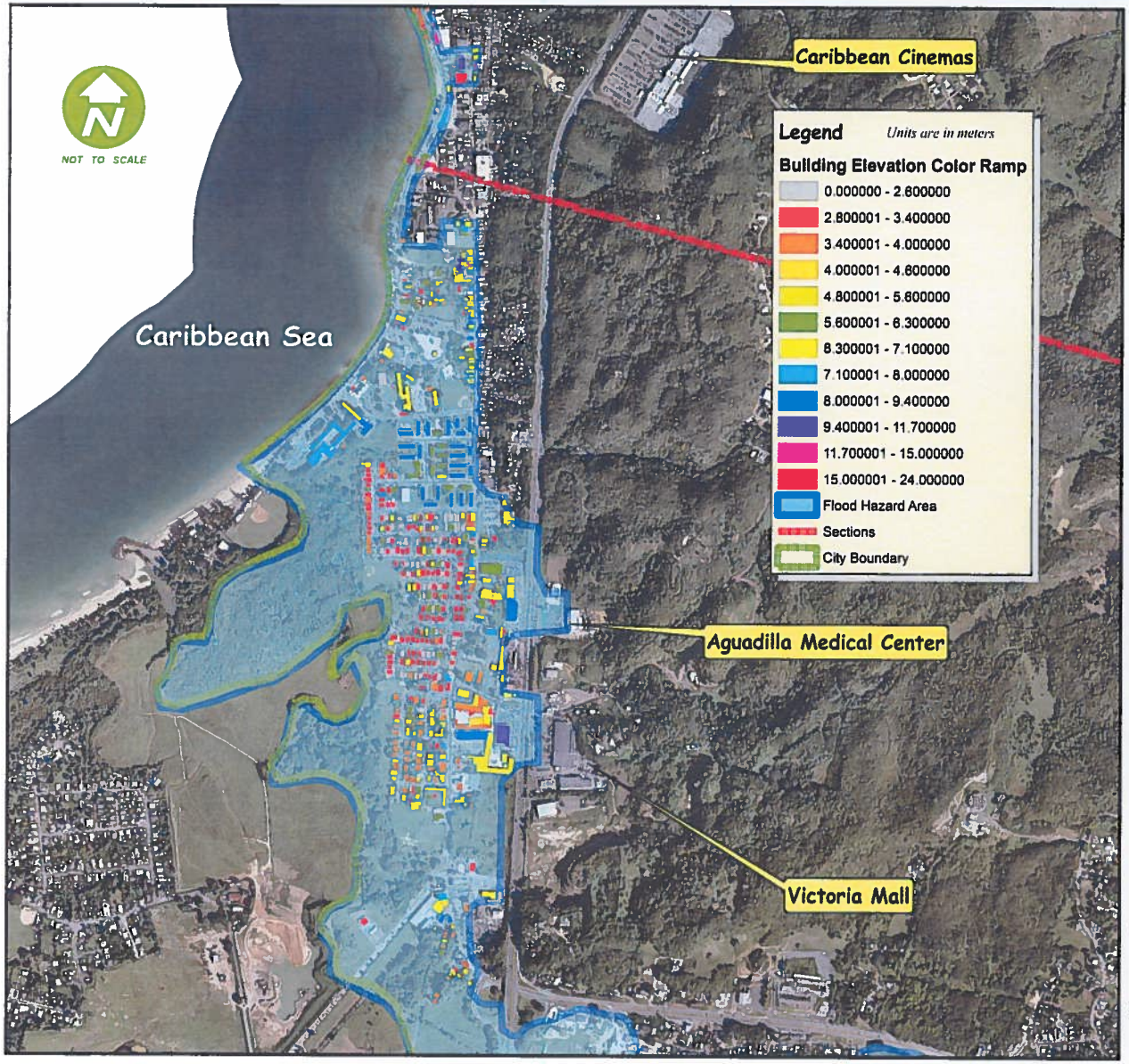


Representation of the affected flood hazard areas in Aguadilla City. Some representation were made and edited for better cartographic representation and visualization using layers of information provided by ISP Company. Some areas of interest were pointed out in the map for faster localization.

Geologic Map

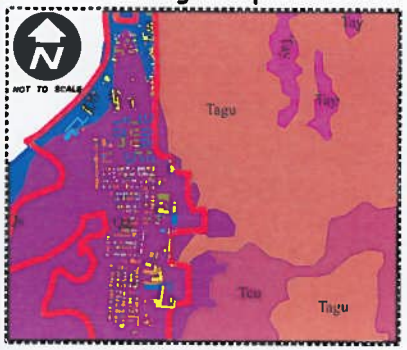
Section Map

Aguadilla City: Affected Flood Hazard Area "South West Section"



Representation of the affected flood hazard areas in Aguadilla City. Some representation were made and edited for better cartographic representation and visualization using layers of information provided by ISP Company. Some areas of interest were pointed out in the map for faster localization.

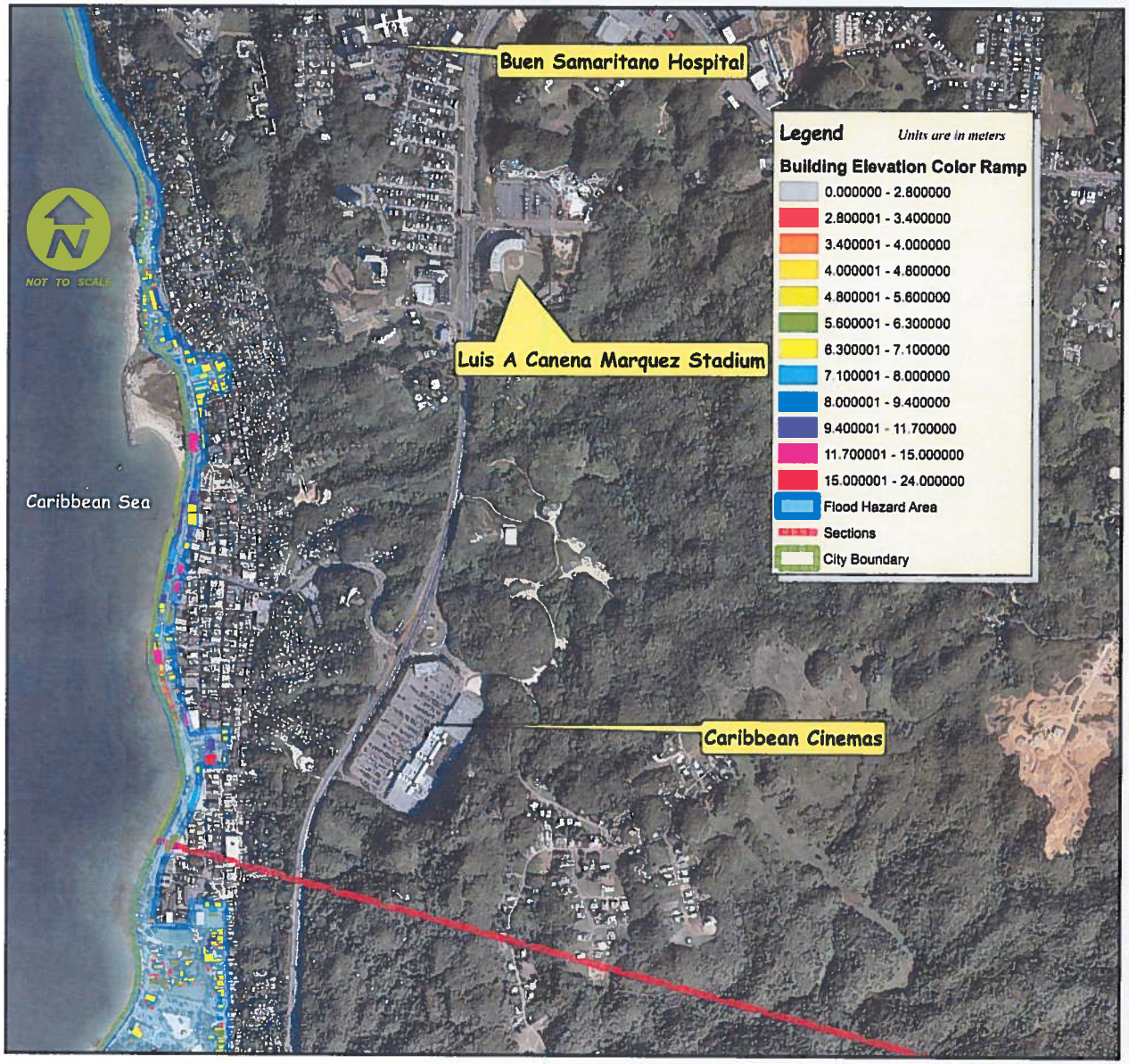
Geologic Map



Section Map

Juan M. Rodríguez Rebollo

Aguadilla City: Affected Flood Hazard Area "West Section"



Representation of the affected flood hazard areas in Aguadilla City. Some representation were made and edited for better cartographic representation and visualization using layers of information provided by ISP Company. Some areas of interest were pointed out in the map for faster localization.

Geologic Map

Section Map