Final Discovery Report (DRAFT)

Río Grande de Loíza Watershed, HUC10 2101000504

Municipalities of Aguas Buenas, Caguas, Canóvanas, Carolina[1], Gurabo, Juncos, Las Piedras, Loíza, San Lorenzo, and Trujillo Alto, Commonwealth of Puerto Rico

September 2017

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[1] Separate NFIP Community

FEMA

Table of Contents

Tables

Figures

Appendices

GLOSSARY OF TERMS

1-Percent-Annual-Chance Flood: The flood having a one percent chance of being equaled or exceeded in any given year. This is the regulatory standard also referred to, as the —100-year flood . The base flood is the national standard used by the National Flood Insurance Program (NFIP) and all Federal agencies for the purposes of requiring the purchase of flood insurance and regulating new development. The standard constitutes a reasonable compromise between the need for building restrictions to minimize potential loss of life and property and the economic benefits of floodplain development. (FEMA)

0.2-Percent Annual Chance Flood: A flood that has a 0.2 percent chance of being equaled or exceeded in any given year; also known as a 500-year flood. (FEMA)

Approximate Study: A flood hazard study that results in the delineations of floodplain boundaries for the 1-percent-annual-chance flood, but does not include the determination of base flood elevations or floodways. An approximate study is represented on a FIRM by a Zone A. (FEMA)

Base Flood Elevation (BFE): The computed elevation to which floodwater is anticipated to rise during the base flood. BFEs are shown on a community's FIRM and on the flood profiles in the Flood Insurance Study (FIS). The BFE is the regulatory requirement for the elevation or floodproofing of structures. The relationship between the BFE and a structure's elevation determines the flood insurance premium. (FEMA)

Declared Disaster: An emergency declaration triggers aid that protects property, public health, and safety, and lessens or averts the threat of an incident becoming a catastrophic event. A major disaster declaration, issued after catastrophes occur, constitutes broader authority for federal agencies to provide supplemental assistance to help state and local governments, families and individuals, and certain nonprofit organizations recover from the incident. (FEMA)

Detailed Study: A flood hazard mapping study done using hydrologic and hydraulic methods that produce base flood elevations, floodways, and other pertinent flood data. Detailed study areas are shown on the FIRM as Zones AE, AH, AO, AR, A99, A1-A30, and in coastal areas Zones V, VE, and V1-30. (FEMA)

Flood Insurance Study (FIS): A compilation and presentation of flood risk data for specific watercourses, lakes, and coastal flood hazard areas within a community. When a flood study is completed for the NFIP, the information and maps are assembled into an FIS. The FIS report contains detailed flood elevation data in flood profiles and data tables. (FEMA)

Geocode: Geocoding is the process of transforming a description of a location—such as a pair of coordinates, an address, or a name of a place—to a location on the earth's surface. You can

geocode by entering one location description at a time or by providing many of them at once in a table. The resulting locations are output as geographic features with attributes, which can be used for mapping or spatial analysis. (ArcGIS Resource Center)

Multi-Hazard Risk Assessment and Loss Estimation Program (HAZUS): A nationally applicable standardized methodology that contains models for estimating potential losses from earthquakes, floods, and hurricanes. Hazus uses Geographic Information Systems (GIS) technology to estimate physical, economic, and social impacts of disasters. It graphically illustrates the limits of identified high-risk locations due to earthquake, hurricane, and floods. (FEMA)

Hydrology: The science that encompasses the occurrence, distribution, movement and properties of the waters of the earth and their relationship with the environment within each phase of the hydrologic cycle. The water cycle, or hydrologic cycle, is a continuous process by which water is purified by evaporation and transported from the earth's surface (including the oceans) to the atmosphere and back to the land and oceans. (USGS)

Light Detection and Ranging (LiDAR): LiDAR is an active remote sensing technique similar to radar, but uses light pulses instead of radio waves. LiDAR is typically —flown or collected from planes and produces a rapid collection of points (more than 70,000 per second) over a large collection area. Collection of elevation data using LiDAR has several advantages over most other techniques. Chief among them are higher resolutions, centimeter accuracies, and penetration in forested terrain. (NOAA)

Limited Detailed Study: A flood hazard study that is assigned to certain areas previously designated as approximate Zone A flood zones where communities have requested upgraded flood hazard analyses, but due to the low level of projected development or budget limitations, a detailed study is not performed. It is also applied to lakes that do not have level gauge data.

The term “limited survey” refers to the survey of man-made hydraulic obstructions, such as dams, bridges and culverts, and to the survey of the outlet channels of lakes with natural outlet controls. The purpose of collecting “limited survey” is to enhance the accuracy of the hydraulic model thus allowing the development of Advisory BFEs at selected cross sections. (FEMA)

Letter of Map Amendment (LOMA): An official revision to a FEMA FIRM done by describing the property affected and amending the FIRM by letter, rather than by physically changing the map. LOMAs are generally issued when properties have been inadvertently included in the floodplain. (FEMA)

Letter of Map Revision Based on Fill (LOMR-F): Is used to determine the flood risk to a structure or property in situations where fill material (in most cases fill-dirt) has been placed after the first floodplain (FBHM or FIRM) map of the area was established. Like the LOMA process, the LOMR-F uses elevations of the finished property or structure to the elevation of the base flood to determine if the subject of the LOMR-F is at risk of inundation. (FEMA)

Mitigation: —Any sustained action taken to eliminate or reduce the long-term risk to life and property from natural and technological hazards, including, but not limited to flooding. Acceptable flood mitigation measures include but are not limited to structural projects such as elevation, floodproofing, relocation, or demolition, planning mechanisms such as modifications to zoning codes, ordinances or community plans, education and outreach actions, and natural resource protection. (FEMA)

Special Flood Hazard Area (SFHA): SFHAs are high-risk areas subject to inundation by the base (1-percent-annual-chance) flood; they are also referred to as 1-percent-annual-chance floodplains, base floodplains, or 100-year floodplains. (FEMA)

Stakeholder: An individual or group that has an interest in a decision or proposed action. A stakeholder may have none, one, or more of the following roles: Has authority or decision-making power over some aspect of the project; is affected by the outcome of the project; will be involved in the implementation of the project; and/or can stop or delay the project (through litigation or other means). A project may have multiple stakeholders, and these stakeholders often have conflicting interests and want competing outcomes. (US Department of the Interior)

Vertical Datum: A vertical datum is a base measurement point (or set of point) from which all elevations of points on the Earth's surface are determined. Without a common datum, surveyors would calculate different elevation values for the same location. Vertical datums are either tidal, that is, based on sea levels, or geodetic, based on the same ellipsoid models of the earth used for computing horizontal datums (FEMA). Common vertical datums used on FIRMs are NGVD29 and NAVD88.

Watershed: A watershed is a basin-like landform defined by highpoints and ridgelines that descend into lower elevations and stream valleys. A watershed carries water from the land after rain falls and snow melts. Drop by drop, water is channeled into soils, ground waters, creeks, and streams, making its way to larger rivers and eventually the sea. (Watershed Atlas). In other words, a watershed is the area of land where all of the water that is under it or drains off of it goes into the same place. (EPA)

List of Acronyms

AAL	Average Annualized Loss
AEMEAD	Agencia Estatal para el Manejo de Emergencias y Administración de Desastre (State Emergency Management and Disaster Administration)
CAC	Community Assistance Contact
CAV	Community Assistance Visit
CBRS	Coastal Barrier Resources System
cms	cubic meters per second
CNMS	Coordinated Needs Management Strategy
CRS	Community Rating System
CTP	Cooperating Technical Partner
EAP	Emergency Action Plan
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
FIS	Flood Insurance Study
GAR	Governor's Authorized Representative
GIS	Geographic Information System
Hazus-MH	Hazards U.S. Multi-Hazard Risk Assessment and Loss Estimation software
HUC	Hydrologic Unit Code
HWM	High Water Mark
LiDAR	Light Detection and Ranging
LOMA	Letter of Map Amendment
LOMC	Letter of Map Change
LOMR	Letter of Map Revision
LOMR-F	Letter of Map Revision based on fill
LOMR-FW	Letter of Map Revision-Floodway
MIP	Mapping Information Platform
MSC	Map Service Center
NED	National Elevation Dataset
NFHL	National Flood Hazard Layer
NFIP	National Flood Insurance Program

NHD	National Hydrography Dataset
NID	National Inventory of Dams
NOAA	National Oceanic and Atmospheric Administration
NVUE	New, Valid and Updated Engineering
PA	Public Assistance
PRPB	Puerto Rico Planning Board
Risk MAP	Risk Mapping, Assessment, and Planning
RL	Repetitive loss
SFHA	Special Flood Hazard Area
SREP	Specially Protected Rustic Land
SREP-A	Specially Protected Rustic Land with Agricultural Value
SREP-E	Specially Protected Rustic Land with Ecological Value
SRL	Severe repetitive loss
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Survey
WBD	Watershed Boundary Dataset

Executive Summary

In the fall of 2016, the Puerto Rico Planning Board (PRPB), a Federal Emergency Management Agency (FEMA) Cooperating Technical Partner (CTP), initiated a Risk Mapping, Assessment, and Planning (Risk MAP) project for Discovery for the Río Grande de Loíza Watershed in the Commonwealth of Puerto Rico. The watershed covers ten municipalities: Aguas Buenas, Caguas, Canóvanas, Carolina, Gurabo, Juncos, Las Piedras, Loíza, San Lorenzo, and Trujillo Alto.

Discovery is the first step in achieving the goals of the Risk MAP Program, which are building hazard resilient communities, assessing risk, and mitigation planning. The primary objectives of Discovery include engaging watershed stakeholders, understanding the needs of the municipalities in the watershed, introducing and enhancing flood risk discussions, and balancing local needs with FEMA resources to develop the scope for a possible flood risk project. The Discovery process includes watershed stakeholder coordination, data collection and analysis, holding watershed Discovery Meetings, and scope refinement of Risk MAP projects in the watershed.

During the Río Grande de Loíza Watershed Discovery process, extensive data was collected from Federal, Commonwealth, and local sources for all municipalities in the watershed. Discussions with watershed stakeholders are imperative to obtain a more comprehensive and holistic understanding of flood risk within the Río Grande de Loíza Watershed. Information, knowledge, and input from local stakeholders were shared in-person at the Discovery Kickoff Meeting and Discovery Meetings, as well as through stakeholder responses to the Discovery Data Questionnaire.

The collected data and information was used to develop the Discovery Maps and Discovery Report. The identified mapping needs will be assessed using stakeholder input and the Coordinated Needs Management Strategy (CNMS) criteria, and Risk MAP scope recommendations for the watershed will be determined from this data. The PRPB and FEMA Region II will continue to work with representatives of the municipalities within Río Grande de Loíza Watershed throughout the Risk MAP process.

Within the Río Grande de Loíza watershed the streams with a CNMS status of Unverified and those currently modeled Zone A should all be restudied. There are a few streams that should be upgraded to detailed studies, and those under effective Zone AE and Valid CNMS status should be redelineated. There is new island-wide LiDAR data, expected to be completed in January 2018 that should be the new topographic foundation for these proposed re-studies and redelineations. Section 6.3 in the report elaborates in greater depth these scope recommendations. Since the creation of this report Puerto Rico and its residents were affected by Hurricane Irma and Maria, in September 2017. The damage of these disasters and their corresponding aftermath has been extremely strenuous for the island. The data collected and conclusions arrived to in this report are pre-disaster. For future Risk MAP products created, post-hurricane should be taken into consideration along with this report, in order to create representative products.

1. Discovery Overview

The Federal Emergency Management Agency (FEMA) is currently implementing the Risk Mapping, Assessment, and Planning (Risk MAP) Program across the Nation. The Risk MAP Program represents FEMA's continued efforts to improve implementation of the National Flood Insurance Program (NFIP), which FEMA has administered for nearly 40 years. Important goals of the Risk MAP Program include the promotion of increased national awareness and understanding of flood risk and the support of Federal, Commonwealth, and local mitigation actions to reduce risk. Risk MAP provides high quality flood maps and information, tools to better assess flood risks, and planning and outreach support to assist communities to take action to reduce and mitigate flood risk.

The vision and intent of the Risk MAP Program is, through collaboration with commonwealth and local entities, to deliver quality data that increases public awareness of flood risks and lead to mitigation actions that reduce risk to life and property. To achieve this vision, FEMA has transformed its traditional flood identification and mapping efforts into an integrated process of more accurately identifying, assessing, communicating, planning, and mitigating flood risks (see Figure 1). Risk MAP assists in addressing gaps in flood hazard data and forming a solid foundation for risk assessment and floodplain management.

Figure Reference: FEMA's Risk Mapping, Assessment and Planning website (FEMA, 2017a)

Figure 1: FEMA's Risk MAP Vision

The Risk MAP Program starts with Project Planning to identify which watersheds to select for Discovery based on evaluations of risk, need, availability of elevation data, regional knowledge of issues, and input from the Commonwealth and Cooperating Technical Partners (CTPs). The following stages proceeding from Project Planning are: Discovery, Data and Product Development, Risk Awareness, preliminary NFIP Map Release, Planning for Mitigation Action, Due Process, and FIS and FIRM Delivery (see Figure 2). Although each step has a unique purpose, the end goal of the Risk MAP Program is to select and appropriate watershed, collect any flood and mitigation related data, assess the risk within the watershed, and create the appropriate regulatory products to depict the risk. The Risk MAP Program does not have a defined timeframe and varies for every watershed, but typically takes 3-5 years from Project Planning to delivery of the final Flood Insurance Study (FIS) and Flood Insurance Rate Maps (FIRMs). As a result of the Project Planning process, the Río Grande de Loíza Watershed was selected for Discovery.

1.1 Discovery Objectives

The goal of Discovery is to work closely with communities to better understand local flood risk, mitigation efforts, and other topics and spark watershed-wide discussions about increasing resilience to flooding. Discovery assists communities within a watershed to come together to develop partnership, share flood risk information with the Puerto Rico Planning Board (PRPB) and FEMA, and identify opportunities for mitigation action within the communities.

FEMA defines the primary objectives of the Discovery process as the following (FEMA, 2016a):

- Engage watershed stakeholders
- Understand the needs of the communities in a watershed
- Introduce or enhance flood risk discussions
- Balance local needs with FEMA resources and inform the scope for a possible flood risk project

1.2 Discovery Process

The Discovery process allows the PRPB, FEMA, and watershed stakeholders to obtain a more holistic understanding of the flood risk within a watershed. The Discovery process for watersheds typically takes a year to be completed, and Discovery projects with coastal or levee considerations may longer timelines.

As shown in Figure 2, the Discovery process involves the following steps:

- Watershed Stakeholder Coordination
- Data Collection and Analysis
- Discovery Meeting and Follow-up
- Scope Refinement

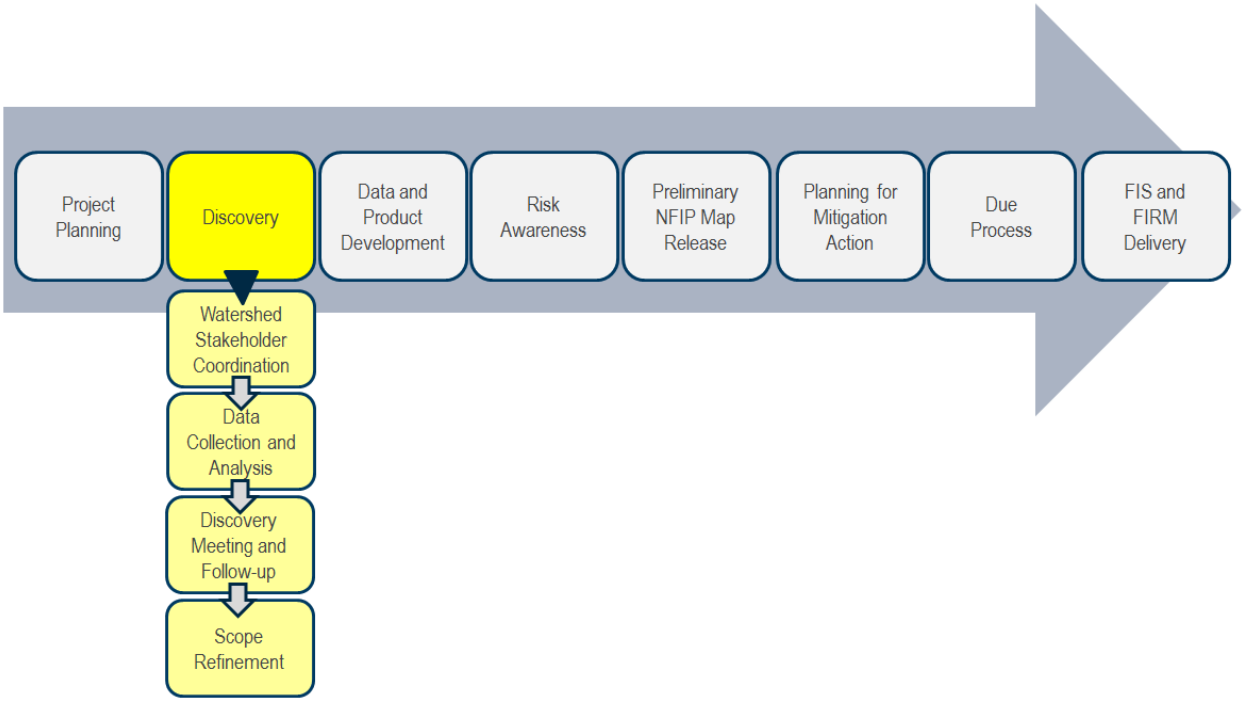


Figure 2: Risk MAP Program and Discovery Process Steps

1.3 Discovery Outputs

The information and data collected through outreach efforts are used to develop the Discovery Products, which are the Discovery Maps and this Discovery Report. The Discovery Products are resources that can be used by the PRPB, FEMA, and the watershed municipalities in numerous ways, including planning new studies, identifying and providing relevant trainings, working with selected municipalities to join the NFIP and consequently the Community Rating System (CRS), and/or supporting municipalities with advancing mitigation actions.

The Discovery results and products are used to refine a scope of work for future Risk MAP flood risk projects in the watershed. Through Discovery, the PRPB and FEMA can determine which areas of the Río Grande de Loíza Watershed should be studied or restudied for further flood risk identification and assessment in a collaborative manner, taking into consideration the information collected from local communities during the process.

The Discovery process also helps to the future determination whether regulatory or non-regulatory products will be useful to the municipalities. Regulatory products would include new FIRMs and FISs while non regulatory products would be flood risk databases, flood risk reports and watershed risk maps. Both regulatory and non-regulatory products contain really useful information in terms of risk assessment and mitigation; however Risk MAP products that are non-regulatory are not subject to statutory due-process requirements and can thus not be used

for insurance purposes. The type of product determined optimal for a watershed, at the end of the Risk MAP Program, depends on a variety of data, some of it being information available at a local level, at a national level, along with funding available.

2. Watershed Overview

Risk MAP is typically performed on a watershed-wide basis to provide communities with a more holistic picture of flood risk for the entire watershed, rather than only within the single boundary of a municipality.

2.1 Geography

The Río Grande de Loíza Watershed is located in the northeastern Atlantic coast of Puerto Rico, within the municipalities of Aguas Buenas, Caguas, Canóvanas, Carolina, Gurabo, Juncos, Las Piedras, Loíza, San Lorenzo, and Trujillo Alto (See Figure 3). The Río Grande de Loíza Watershed boundary is established according to the U.S. Geological Survey's (USGS's) Watershed Boundary Dataset (WBD), that defines the areal extent of surface water drainage to a point, for all land and surface areas (USGS, 2016). The Río Grande de Loíza Watershed is part of the Hydrologic Unit Code 10 (HUC10) 210100504 of the WBD.

The Río Grande de Loíza Watershed has a drainage area of approximately 290 square miles or approximately 750 square kilometers. The river with the higher volumetric water, which is also the second longest river in Puerto Rico, is Río Grande de Loíza, also known by its indigenous name of "Cayrabó". Other Major streams in the watershed include Río Gurabo, Río Turabo, Río Caguitas, Río Bairoa, Río Canóvanas, Río Cayaguas, and Río Valenciano. Two large creeks within the watershed are the Grande and the Morocudo. Additionally, the Blasina creek drains to Torecilla lagoon. The Carraízo Dam within the Municipality of Trujillo Alto also creates the Loíza reservoir, known as the Carraízo reservoir, and supplies water to the municipalities of Caguas, Carolina, Trujillo Alto, and parts of San Juan, Canóvanas, and Loíza. In Juncos, there is a subterranean aquifer that occupies an area of 35.1 square miles or 90.9 square kilometers.

The region consists of three major physiographic areas: the nearly level to sloping coastal plain, the haystacks or limestone hills with karst topography, and the extensive igneous upland (FEMA, 2009). The watershed includes both open space and metropolitan areas.

Figure 3: Río Grande de Loíza Watershed Map

2.2 Land Use: Classification and Zoning

The Land Use Plan of Puerto Rico, in force since 2015, establishes the land use classification in the territory of Puerto Rico. The document divides the island into categories, which are identified by the values of the territory. Within the Río Grande de Loíza watershed, three main classifications are identified:

- 35.98% of the lands that comprise the watershed are classified as Specially Protected Rustic Land (SREP). This land classification has the highest percentage. SREP is defined as land not contemplated for urban or future urban use and, due to its special location, topography, aesthetic, archaeological, ecological, agricultural, unique natural resources, risks to health and public safety, among other attributes, is identified as a land that should never be used as urban land. The SREP classification has two subcategories, Specially Protected Rustic Land with agricultural value (SREP-A) and Specially Protected Rustic Land with ecological value (SREP-E). The 15.43% of the land that is part of the watershed is classified as SREP-A, while 20.55% of the land is classified as SREP-E.
- 35.80% of the land in the study area is classified as Common Rustic Land (SRC). SRC is defined as the land not contemplated for urban or future urban use.
- 17.13% of the land in the study area is classified as Urban Land (SU). These lands have road access, water supply, electric power supply, and other necessary infrastructure to carry out the administrative, economic, and social activities that take place out in these lands and included in consolidated areas.

Figure 4 shows the land classification map for the Río Grande de Loíza Watershed. In recent years, the lower Río Grande de Loíza Basin has changed from agricultural use to residential, commercial, and industrial use (FEMA, 2009). Vegetative cover in the basin consists primarily of improved pasture, such as pangola-grass, star grass, and merker grass. Most of the pastureland is used for beef and dairy cattle. The principal agricultural crops in the basin are plantains, tanniers, yams, and tobacco (FEMA, 2009).

Weather in this watershed can be categorized as sub-tropical humid and very humid. The rain season is from August to December, although regional changes in temperature and wind also contribute to frequent precipitation in May, June, and July. Average annual precipitation is that of 77 inches (range from 57-108 inches) (DRNA, 2017).

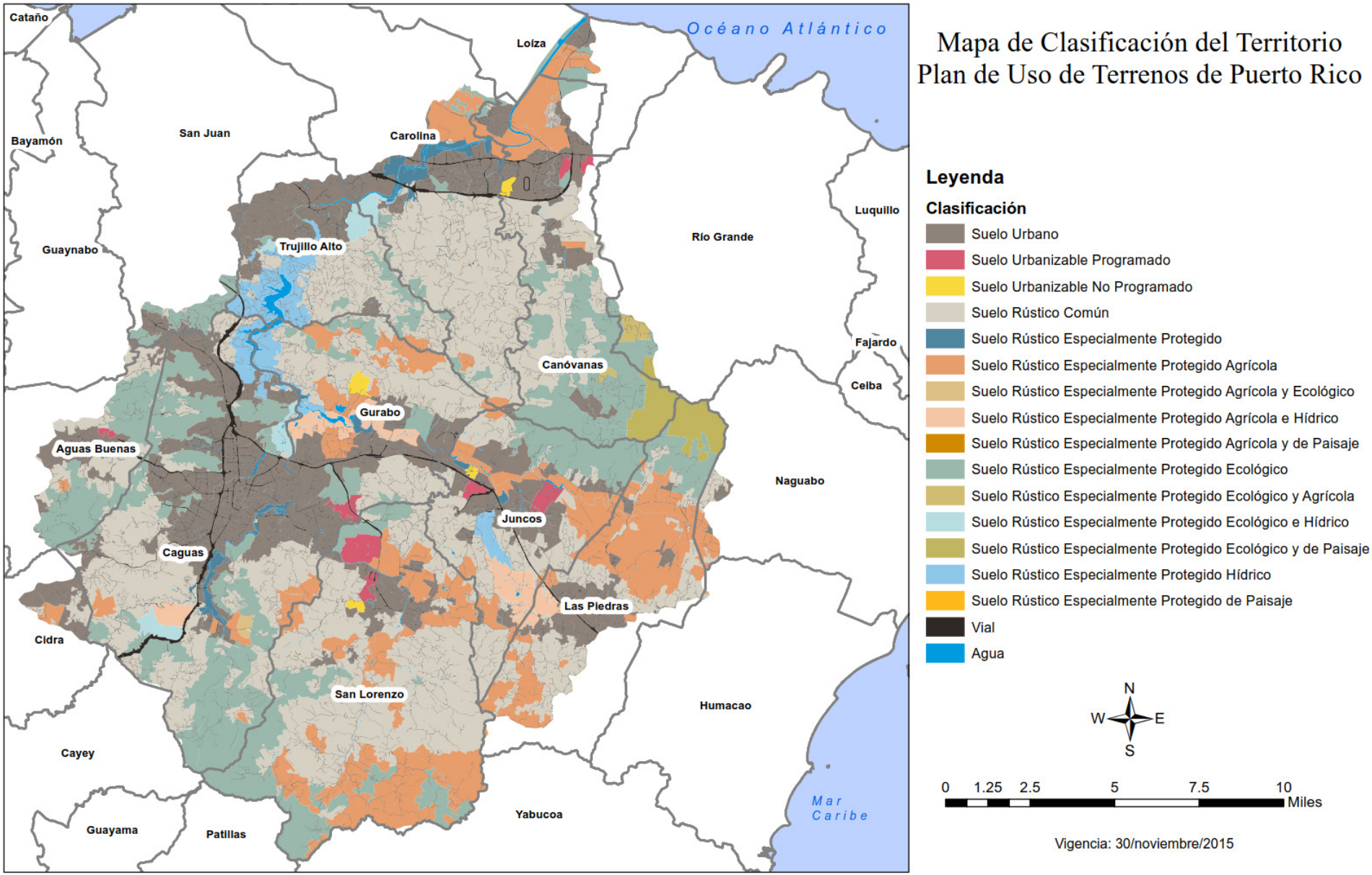
Zoning

According to the Joint Regulations for Construction Permits and Land Uses, which has been in force since 2010, land use zoning is the main instrument for regulation of land uses and development in Puerto Rico. According to available information in the PRPB database, the predominant zoning districts within the Río Grande de Loíza Watershed are:

- 31.71% of the lands in the watershed are zoned as Resource Conservation (CR) or Forest (B). These lands are mostly identified to maintain or improve areas of high natural value such as lagoons and other water bodies, coastal areas and dune areas among others.

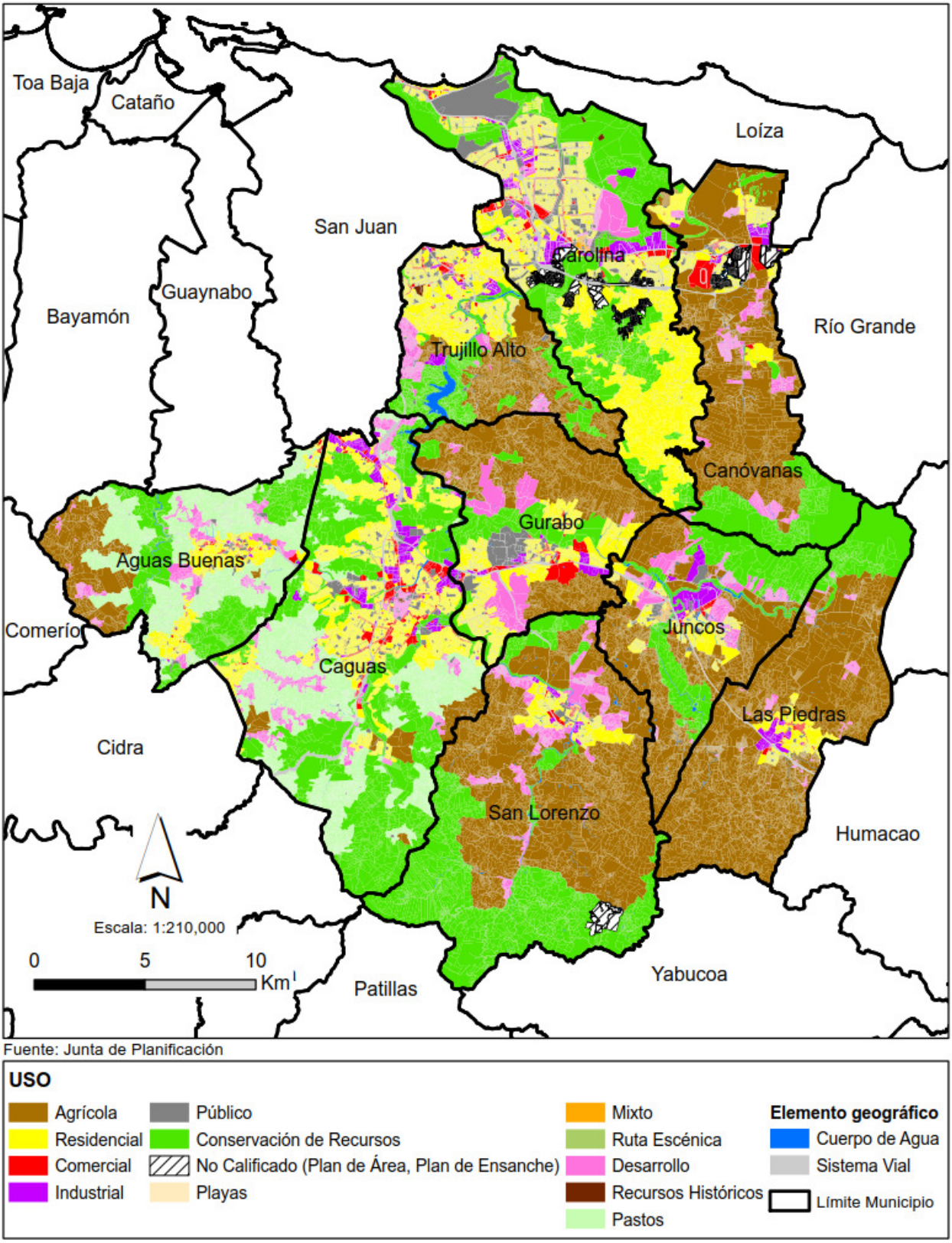
The lands zoned as Forest (B) are suitable for wood production, soil, and water quality protection. Lands zoned as Forest (B) also include mangroves or urban forests.

- 23.25% of the lands in the study area have some agricultural zoning district. Permitted uses for these lands include those related to the agricultural industry. These lands are suitable or have the potential for agricultural activities. These lands were zoned according to the analysis performed by the Federal Natural Resources Conservation Service (NRCS).
- 16.88% of the Río Grande de Loíza Watershed lands are zoned as General Rural Lands (RG). These lands are mainly agricultural but with certain limitations. In addition, other uses such as artisanal uses, specialized lodges, inns, among others are allowed. In fourth place 13.73% of the Río Grande de Loíza Watershed lands are occupied by the Residential Zoning District, which includes several densities.



Reference: Figure was provided by the Puerto Rico Planning Board

Figure 4: Land Classification Map for Río Grande de Loíza Watershed



Reference: Figure was provided by the Puerto Rico Planning Board

Figure 5: Land Zoning in Río Grande de Loíza Watershed

2.3 Demographics

2.3.1 Population

In 2010, Puerto Rico was home to approximately 3,725,789 residents throughout its 78 municipalities. For the ten municipalities within the Río Grande de Loíza Watershed, there is a combined population of 666,256 inhabitants. The population of each municipality of the watershed based on the 2010 U.S. Census (U.S. Census Bureau, 2010) is shown in Table 1. It is important to note that the figures on the table below are based on the 2010 Census, and do not take into consideration a recent population decline that Puerto Rico as a nation has been experiencing (U.S. Census Bureau 2017).

Table 1: Population of Municipalities in the Watershed

Municipality	Population (2010 Census)	Population Estimate (as of July 1)[1]						
		2010	2011	2012	2013	2014	2015	2016
Aguas Buenas	28,659	28,653	28,334	28,053	27,797	27,367	26,929	26,471
Caguas	142,893	142,863	141,490	140,101	138,674	136,567	134,354	132,164
Canóvanas	47,648	47,696	47,671	47,658	47,552	47,291	46,893	46,477
Carolina	176,762	176,421	173,841	171,119	168,491	165,283	161,851	158,457
Gurabo	45,369	45,563	46,070	46,484	46,906	47,076	47,213	47,269
Juncos	40,290	40,349	40,296	40,243	40,261	39,967	39,761	39,477
Las Piedras	38,675	38,714	38,768	38,728	38,711	38,549	38,295	38,049
Loíza	30,060	30,017	29,525	29,009	28,541	27,925	27,226	26,583
San Lorenzo	41,058	41,023	40,640	40,263	39,917	39,322	38,737	38,174
Trujillo Alto	74,842	74,760	73,888	73,011	72,091	70,799	69,542	68,242

[1] The estimates are based on the 2010 Census and reflect changes to the April 1, 2010 population due to the County Question Resolution program and geographic program revisions. See Geographic Terms and Definitions at http://www.census.gov/programs-surveys/popest/guidance-geographies/terms-and-definitions.html for a list of the states that are included in each region and division. For population estimate methodology statements, see http://www.census.gov/programs-surveys/popest/technical-documentation/methodology.html.

2.3.2 Government/Representatives

The Government of Puerto Rico joined the NFIP in August 1978, and the PRPB was appointed as the state agency responsible for coordinating the activities related to this program and as the state floodplain administrator in Puerto Rico and the Island municipalities of Vieques and Culebra. The PRPB has the responsibility of ensuring that regulations and maps comply with the regulations of the NFIP (AEMEAD, 2016). The PRPB coordinates outreach activities focused on raising awareness among municipalities and the public on mitigating and minimizing flood risks.

Puerto Rico's Government Representatives, as of March 2017, are as shown in Table 2. On a municipal level, the representative figures specifically for municipalities within the Río Grande de Loíza Watershed participating in this study are shown in Table 3. The representative figures for the municipalities, shown in Table 3, play a key role, as they establish a point of contact between the residents and the PRPB. The success of most Risk MAP products is directly related

to the level of involvement at a local level. Municipal representatives need to convey current information and needs from the PRPB to the residents they represent and vice versa, to ensure the securement and production of programs and data that will contribute to the mitigation of risks such residents may face.

Table 2: Government Representatives of Puerto Rico (as of March 2017)

Position	Representative
President	Donald J. Trump
Vice President	Mike Pence
Governor	Ricardo Rosselló
Resident Commissioner	Jennifer González
President of the Senate	Thomas Rivera Schatz
Speaker of the House Representative	Carlos Johnny Méndez

Table 3: Municipality Representatives of Puerto Rico (as of March 2017)

Municipality	Representative
Aguas Buenas	Mayor Luis Arroyo Chiqués
Caguas	Mayor William Miranda Torres
Canóvanas	Mayor Lorna Soto Villanueva
Carolina	Mayor José C. Aponte Dalmau
Gurabo	Mayor Rosachely Rivera Santana
Juncos	Mayor Alfredo Alejandro Carrión
Las Piedras	Mayor Miguel A. López Rivera
Loíza	Mayor Julia M. Nazario
San Lorenzo	Mayor José R. Román Abreu
Trujillo Alto	Mayor José Luis Cruz

2.4 Economy

According to the Economic Report for the Governor, which was prepared by the PRPB in 2016, the main economic activity of the Commonwealth of Puerto Rico was manufacturing, which consists mainly of chemical products and their derivatives (pharmaceuticals). The second main industry was the real estate sector, rent and lease, and the third main industry was retail sales. Agriculture and mining comprised the smallest sectors. With respect to risk assessment, it is crucial understanding the main sources of revenue as it is beneficial to understand and factor in how these may be when affected by a flood event, or determined disaster. Understanding such industries from a geographic stand point helps in assigning importance to the level of detail that each stream within a watershed should be studied with.

Table 4 shows the industry by occupation for employed population aged 16 or over within the Río Grande de Loíza Watershed. According to the 2011-2015 American Community Survey, the three main industries by employed population within the Watershed were: 1) education, health care and social care, 2) retail trade, and 3) professional, scientific, management, and waste

management. The three industries with the least employed population in the Watershed were: 1) agriculture, forestry, hunting, fishing, and mining, 2) information, and 3) wholesale trade.

Table 4: Industry by Occupation for Employed Population Aged 16 or Over

Industry	Puerto Rico	Aguas Buenas	Caguas	Canóvanas	Carolina	Gurabo	Juncos	Las Piedras	Loíza	San Lorenzo	Trujillo Alto
Agriculture, forestry, hunting, fishing and mining	14,489	50	175	139	129	199	66	60	0	165	106
Construction	59,003	653	2,402	878	2,873	755	485	753	528	918	1,434
Manufacture	96,303	751	4,191	1,133	2,995	2,200	1,721	2,161	457	1,324	1,344
Wholesale trade	29,562	193	1,412	424	2,475	392	280	168	110	322	1,054
Retail Trade	143,674	875	6,527	2,299	8,946	2,569	1,631	1,475	908	1,657	3,357
Transportation, ware-housing and public services	39,313	223	1,929	1,087	3,271	452	255	263	336	282	1,111
Information	21,251	116	1,171	365	1,476	331	180	70	159	138	672
Finance and insurance, real estate, rent and lease	58,154	300	2,979	749	5,444	922	447	422	374	494	2,376
Professional, scientific, management, and waste management	102,630	523	5,070	1,496	6,368	1,708	1,059	824	893	782	3,453
Education, health care and social care	251,139	1,561	11,802	3,015	13,680	4,252	2,817	1,910	2,173	2,670	6,951
Arts, entertainment, recreation, lodging, and food services	93,899	396	4,321	1,319	7,007	917	912	647	880	957	2,433
Other services, except public administration	58,579	489	2,277	597	3,614	1,338	548	592	385	608	1,614
Public administration	95,354	329	3,827	1,296	5,701	1,490	1,158	757	1,240	1,010	2,154
Total:	**1,063,350**	**6,459**	**48,083**	**14,797**	**63,979**	**17,525**	**11,559**	**10,102**	**8,443**	**11,327**	**28,059**

According to the 2011-2015 American Community Survey, the agriculture, forestry, hunting, fishing and mining industries had the lowest number of employed persons within the Watershed. The municipalities with the largest population employed in this industry were Gurabo (199) and Caguas (175). The municipalities with the lowest population employed in this industry were Loíza (0), Aguas Buenas (50), and Las Piedras (60).

In the construction industry, the municipalities with the highest employed population were Carolina (2,873), Caguas (2,402), and Trujillo Alto (1,434). The municipalities with the lowest number of employees were Juncos (485) and Loíza (528).

In the manufacturing industry, the municipalities with the highest employed population were Caguas (4,191), Carolina (2,995), and Gurabo (2,200). In contrast, the municipalities with the lowest population in the manufacturing industry were Loíza (457) and Aguas Buenas (751).

In the wholesale trade industry, the municipalities with the highest employed population were Carolina (2,475) and Caguas (1,412). The municipalities with the lowest population in this industry were Loíza (110) and Las Piedras (168).

In the retail sales industry, which is the second largest industry by occupation in the Watershed, the municipalities with the highest employment were Carolina (8,946), Caguas (6,527), and Trujillo Alto (3,357). The municipalities with the lowest number of jobs in this industry were Aguas Buenas (875) and Loíza (908).

In the transportation, warehousing and public services industries, the municipalities with the highest number of employed persons were Carolina (3271), Caguas (1929), and Trujillo Alto (1,111). The municipalities with the lowest employability in this industry were Aguas Buenas (223), Juncos (255), and San Lorenzo (282).

In the information industry, the municipalities that reflect the most jobs were Carolina (1,476) and Caguas (1,171), while the municipalities with the least jobs in this industry were Las Piedras (70), Aguas Buenas (116), and San Lorenzo (138).

In the finance, insurance, real estate, rent and lease industries, the municipalities with the highest number of jobs were Carolina (5,444), Caguas (2,979), and Trujillo Alto (2,376). The municipalities with the least amount of jobs in this industry were Aguas Buenas (300) and Loíza (374).

In the professional, scientific, management, administrative and waste management industry, which was the third largest industry by Occupation in the Watershed, the Municipalities of Carolina (13,680), Caguas (11,802), and Trujillo Alto (6,951) had the most employed persons. The municipalities with the least amount of employment in this industry were Aguas Buenas (1,561) and Las Piedras (1,910).

The education, health care and social care industry was the primary industry by occupation in the Río Grande de Loíza Watershed. The Municipalities of Carolina (13,680) and Caguas (11,802) had the most employed persons in this industry. The municipalities with the lowest employed persons in this industry were Aguas Buenas (1,561) and Las Piedras (1,910).

In the art, entertainment, recreation and lodging and food services industry, the municipalities with the highest number of jobs were Carolina (7,007), Caguas (4,321), and Trujillo Alto (2,433). The municipalities with the least amount of employment in these industries were Aguas Buenas (396) and Las Piedras (647).

In the other services industry, except for public administration, the municipalities with the highest number of jobs were Carolina (3,614), Caguas (2,277), and Trujillo Alto (1,614). The municipalities with the least amount of employment were Loíza (385) and Aguas Buenas (489).

In the public administration industry, the municipalities with the highest number of jobs were Carolina (5,701), Caguas (3,827), and Trujillo Alto with (2,154). The municipalities that represented the fewest jobs were Aguas Buenas (329) and Las Piedras (757).

2.5 Historic Flooding Problems

Puerto Rico is located between the Atlantic Ocean and the Caribbean Sea, making it prone to tropical storms. The rainy season in Puerto Rico is from April to November, but floods can occur in Puerto Rico any time during the year. The main factor contributing to loss of life and property because of floods is associated with rain events. Information regarding historic flooding and natural disasters has been collected for the Río Grande de Loíza Watershed.

2.5.1 Types of Flooding

The Puerto Rico Hazard Mitigation Plan (AEMEAD, 2016) describes the four types of flooding in Puerto Rico as follows:

- Flash Floods: This is the most life-threatening to humans and is the cause of the most deaths from natural disasters in the world. It happens quickly and sometimes without warnings from the National Weather Service. Flash floods are the most difficult to predict and those requiring immediate action of people who are in danger of being affected. Several factors contribute to the occurrence of flash floods, but the two key elements are rainfall intensity and duration.
- Riverine Floods: Once the rain has caused flooding of a river, it may come out of its banks for several hours or even days. If the rain event continues for several hours and the intensity of the rainfall decreases but remains constant, it will be very difficult for the stream current to return to normal. The flooding of rivers and streams is common in Puerto Rico. The plains lack of absorption capacity is the major cause of flooding damage.
- Coastal Floods: In Puerto Rico, coastal flooding is very common and is associated with low pressure weather systems, including tropical storms and hurricanes. The winds can bring high tides causing serious flooding and surf on the coast. This occurs most frequently in the months of November to February where strong low pressure systems north of Puerto Rico are stationed for several days, thus generating high and dangerous waves that reach from the Mona Passage to the Anegada Passage. When a hurricane approaches, the combination of strong winds, its low pressure center and the shape of the coast, allow sea level rise and development of storm surge. Coastal flooding also

may be the result of tidal waves or tsunamis, which are the result of seismic or volcanic activity in the sea.

- Urban Floods: In urban areas, lack of capacity in drainage systems combined with lack of proper maintenance and floating debris swept away by the rains, prevent the water to flow into existing storm drains, streets, and highways. Water accumulates and causes serious flooding threatening residential and commercial properties. Another element that contributes to this type of flooding is that the land loses its ability to absorb rainfall as a result of urban development, such as roads, housing, and parking garages.

2.5.2 Historic Flood Events

The Effective FIS for the Commonwealth of Puerto Rico (FEMA, 2009) describes several historic flood events in the watershed:

- Río Grande de Loíza: The largest known flood to occur on the Río Grande de Loíza was on August 4, 1945 with a discharge of 2,410 cubic meters per second (cms) (based on stream gage near PR Highway 189 at Caguas). Other notable floods for the river occurred on September 6, 1960; August 4, 1961; and October 9, 1970.
- Río Gurabo: The largest flood on the Río Gurabo occurred on September 6, 1960 with a discharge of 2,110 cms, and another notable flood for the river occurred on October 9, 1970.
- Hurricane Donna in September 1960 produced record high discharges on Río Valenciano and Río Turabo, and a peak outflow of 4,760 cms was recorded at Loíza Dam.
- A tropical depression in October 1970 caused extensive flooding over most of Puerto Rico, and a discharge of 4,160 cms was recorded at Loíza Dam.

The Puerto Rico Hazard Mitigation Plan (AEMEAD, 2016) mentions several historical flood events affecting municipalities in the watershed, including the following:

- Severe storms led to flooding, mudslides, and landslides during the period of May 20, 2011 to June 8, 2011. The most affected municipalities included Caguas, Las Piedras, and San Lorenzo.
- Hurricane Irene in June 2011 caused severe rain, flooding, and landslides, and had an impact on infrastructure, housing, personal property, and vehicles in 22 municipalities, including Aguas Buenas, Caguas, Canóvanas, Carolina, Gurabo, Juncos, Loíza, and San Lorenzo. The Presidential Disaster Declaration included individual assistance for seven municipalities, including Caguas, Canóvanas, Carolina, and Loíza. The total individual assistance cost estimate was $30,346,741, and the total public assistance cost estimate was $4,905,003, where the primary impact was on roads and bridges.

Landslides caused by heavy rains are also a hazard present throughout the Commonwealth. The Puerto Rico Hazard Mitigation Plan (AEMEAD, 2016) lists the following historical landslide events that affected municipalities in the watershed:

- Rains in March 2012 activated a landslide in Cañaboncito Ward in the municipality of Caguas. About 25 residences were identified to be at risk. On 2013, various properties were declared open space.
- Tropical Storm Jeanne in 2004 caused multiple landslide events on nearly the entire Island.

2.5.3 Disaster Declarations

FEMA's disaster declaration history for Puerto Rico is available on FEMA's "*Disaster Declarations for Puerto Rico*" website (FEMA, 2017b). Table 5 lists all disaster declarations that have occurred within Puerto Rico since 1956, as well as the corresponding incident description. Within the Commonwealth, 32 flood-related disasters have been declared during that time period, with the most recent declaration occurring in 2011.

Table 5: Disaster Declarations in the Commonwealth of Puerto Rico

Disaster Number	Declaration Date	Type	Incident Description
DR-4040	10/18/2011	Major Disaster Declaration	Tropical Storm Maria
DR-4017	8/27/2011	Major Disaster Declaration	Hurricane Irene
DR-3326	8/22/2011	Emergency Declaration	Hurricane Irene
DR-4004	7/14/2011	Major Disaster Declaration	Severe Storms, Flooding, Mudslides, and Landslides
DR-1946	10/26/2010	Major Disaster Declaration	Severe Storms, Flooding, Mudslides, and Landslides associated with Tropical Storm Otto
DR-1919	6/24/2010	Major Disaster Declaration	Severe Storms and Flooding
DR-3306	10/24/2009	Emergency Declaration	Explosions and Fire
DR-1798	10/1/2008	Major Disaster Declaration	Severe Storms and Flooding
DR-1613	11/10/2005	Major Disaster Declaration	Severe Storms, Flooding, Landslides, Mudslides
DR-1552	9/17/2004	Major Disaster Declaration	Tropical Storm Jeanne and resulting Landslides and Mudslides
DR-1501	11/21/2003	Major Disaster Declaration	Severe Storms, Flooding, Mudslides, and Landslides
DR-1396	11/28/2001	Major Disaster Declaration	Severe Storms and Flooding
DR-1372	5/16/2001	Major Disaster Declaration	Flooding

Disaster Number	Declaration Date	Type	Incident Description
DR-3151	11/17/1999	Emergency Declaration	Hurricane Lenny
DR-1247	9/24/1998	Major Disaster Declaration	Hurricane Georges
DR-3130	9/21/1998	Emergency Declaration	Hurricane Georges
DR-3124	11/21/1996	Emergency Declaration	Gas Leak Explosion
DR-1136	9/11/1996	Major Disaster Declaration	Hurricane Hortense
DR-1068	9/16/1995	Major Disaster Declaration	Hurricane Marilyn
DR-931	1/22/1992	Major Disaster Declaration	Flooding, Severe Storm
DR-842	9/21/1989	Major Disaster Declaration	Hurricane Hugo
DR-805	12/17/1987	Major Disaster Declaration	Severe Storms and Flooding
DR-768	7/10/1986	Major Disaster Declaration	Heavy Rains, Flooding, Mudslides
DR-746	10/10/1985	Major Disaster Declaration	Severe Storms, Flooding, Mudslides
DR-736	5/31/1985	Major Disaster Declaration	Storms, Mudslides, Landslides, Flooding
DR-597	9/2/1979	Major Disaster Declaration	Hurricane David
DR-483	9/19/1975	Major Disaster Declaration	Tropical Storm Eloise
DR-455	11/30/1974	Major Disaster Declaration	Flooding
DR-3002	8/29/1974	Emergency Declaration	Impact Of Drought
DR-296	10/12/1970	Major Disaster Declaration	Heavy Rains, Flooding
DR-170	5/26/1964	Major Disaster Declaration	Extreme Drought Conditions
DR-62	8/18/1956	Major Disaster Declaration	Hurricane

2.5.4 High Water Marks

High Water Mark (HWM) data were available from the USGS for Hurricane Hugo, which hit Puerto Rico in September 1989 (USGS, 1996). Immediately after the storm, USGS surveyed the maximum water-surface elevations caused by the storm tide. Table 6 shows the HWMs from Hurricane Hugo for the municipalities of Carolina and Río Grande.

Table 6: USGS High Water Marks for Hurricane Hugo 1989

Municipality	HWM ID	Area	Latitude	Longitude	Elevation (feet, above MSL)
Carolina	21	Balneario Isla Verde	18°27'32"	65°59'42"	7.4
Carolina	22	Punta Cangrejos	18°27'58"	65° 59'17"	12.9
Carolina	23	Punta Maldonado	18°27'54"	65° 58'41"	12.3
Carolina	24	La Torre	18°27'40"	65° 58'19"	8.6
Carolina	25	Playa de las Tres Palmitas	18°27'18"	65 55'58"	11.6
Carolina	26	Arenas	18°27'32"	65°53'53"	10.2
Carolina	27	Arenas	18°27'11"	65 °53'20"	10.1
Río Grande	28	Punta Iglesia	18°26'10"	65 ° 51'29"	8
Río Grande	29	Las Carreras	18°25'52"	65 ° 50'20"	7.6
Río Grande	30	Boca Herrera	18°26'26"	65° 49'44"	6.3
Río Grande	31	Punta San Agustin	18°24'43"	65° 49'01"	9.8
Río Grande	32	Punta Miquillo	18°25'12"	65° 47'42"	6.4
Río Grande	33	Punta Picua	18°24'36"	65° 46'16"	3.7

2.5.5 Flood Protection Measures

The Effective FIS for the Commonwealth of Puerto Rico (FEMA, 2009) describes the following flood protection measures that have been implemented in the watershed and notes that the mentioned measures have little effect on the 1- and 0.2-percent-annual chance floods:

- Río Grande de Loíza: The river has been channelized for drainage and flood control from the Atlantic Ocean to a point just upstream from the confluence of Río Canóvanas.
- Loíza Dam: The embankment, located on the Río Grande de Loíza, was built in 1956 for water supply and hydroelectric generation, not as a flood protection measure. The reducing effect of the reservoir on flood flows through the dam is relatively small and there are approximately 1,360 hectare-meters available for storage.

- Río Caguitas Tributary 1: A concrete-lined channel extending from the PR Highway 156 bridge to approximately 0.6 km upstream was completed in 1972 as a flood control project at Caguas.

There are three proposed storm water projects for the Municipality of Carolina, as specified in their response to the Discovery Data Questionnaire via SurveyMonkey; these are explained in detail in section 4.2.9 and provided in Appendix D.

3. Discovery Outreach and Engagement Strategy

3.1 Stakeholder Identification

Communication to all municipalities and potential stakeholders is a critical aspect of the Discovery process. To communicate effectively throughout the life of this Risk MAP project, the use of e-mail, telephone, and letters is essential. FEMA's *"Guidance for Stakeholder Engagement, Discovery"* (FEMA, 2014a) provides strategies for stakeholder outreach during Discovery. The PRPB contacted each municipality in the watershed to identify the best point of contacts for each municipality. Once these contacts were determined, the PRPB established a master list of key stakeholders and sent invitations to the Discovery Kick-off Meeting and the Discovery Meeting to everyone on that list. The list of the Río Grande de Loíza Watershed stakeholder contacts is included as Appendix E.

The PRPB and FEMA Region II consider the local government representatives of the 10 municipalities within the Río Grande de Loíza Watershed to be essential stakeholders in the Discovery process, as they represent the interests of the watershed's residents, businesses, and visitors. Additionally, elected officials representing the municipalities within the Río Grande de Loíza Watershed were invited to participate in the Discovery Meetings. These county officials often have a breadth of knowledge on local issues, GIS, and other technical capabilities, as well as the planning authority to assist FEMA with FIRM revisions and other information, such as mitigation plan status.

Also attending the Discovery Meetings were representatives of:

- Department of Housing
- Department of Natural and Environmental Resources
- Governor's Authorized Representative
- Lilly del Caribe
- Office of Special Communities
- Puerto Rico Emergency Management Agency
- Puerto Rico Highways and Transportation Authority
- Puerto Rico Water and Sewer Authority
- United States Geological Survey
- University of Puerto Rico

3.1.1 Key Stakeholder Groups and Influences

The majority of the identified stakeholders are representatives for the municipalities holding Planning Director positions. These are key influences since a Planning Director knows the different types of projects ongoing in their respective municipality. Understanding the different projects, the areas of growth, and the current and future needs a community will be facing is

crucial for the Discovery process. Only by understanding the current and future changes that may arise due to development and growth can the corresponding needs for flooding and its associated mitigation planning to reduce loss of life and property be truly addressed.

3.2 Pre-Discovery Meeting Engagement and Information Exchange

3.2.1 Discovery Kickoff Meeting

On February 22, 2017, the PRPB invited communities in the watershed to a Discovery Kickoff Meeting. During that meeting, community officials were presented with the Risk MAP Discovery concept and encouraged to participate in the Discovery process in the months to come. The PowerPoint presentation, meeting notes, and sign-in sheet are included in Appendix B.

3.2.2 Discovery Data Questionnaire

During the Discovery process, a database of available flood hazard and flood risk assessment information was created to inventory and identify gaps. Federal, Commonwealth, and Municipality government GIS websites were used to start the data search. However, local knowledge of flooding and mitigation projects is critical to accurately determine flood risks and mapping needs. Therefore, locally and regionally developed data were gathered where possible.

To assist in identifying potential information, an online survey questionnaire was created to collect data from municipalities and communities. This online survey was created through the website SurveyMonkey.com. Responses were received from the following municipalities:

- Aguas Buenas
- Caguas
- Canóvanas
- Carolina
- Gurabo

Responses to the Discovery Data Questionnaire were also received from the following organizations:

- Department of Transportation and Public Works
- Governor's Authorized Representative - Mitigation
- Lilly Del Caribe, Inc.
- Puerto Rico Highways and Transportation Authority
- Puerto Rico Solid Waste Authority
- Puerto Rico Electric Power Authority
- Puerto Rico Planning Board

The questionnaire and responses received are included in Appendix D. The questionnaire responses were further discussed at the in-person Discovery Meetings.

3.2.3 Draft Discovery Report and Maps

Prior to the Discovery Meetings, the draft Discovery Report and Maps were shared with the watershed stakeholders via email.
This was purposefully done with the intent to give the municipalities time to review the report and maps and provide feedback and more data, if available, to be included in the final products. The collaboration and data provided at a local level is crucial in the creation of Risk MAP products. It is the intent of the entire Risk MAP process to create products with data representative at a local level. Allowing the municipalities to thoroughly review the drafts created helps to achieve more representative final Discovery products, and helps ensure the accuracy for future Risk MAP regulatory products, that local residents agree with.

4. Summary of Watershed-Wide Data

The discussion of the Summary of Watershed-Wide Data is divided into three sections: NFIP data, other data useful for flood risk assessment, and hazard mitigation planning and activities. A list of the types of data collected during the Discovery process, the Discovery product where the data is included, and the sources of the data are shown in Table 7.

GIS data was collected according to FEMA's "*State Geospatial Data Coordination Procedure*" for Puerto Rico (FEMA, 2014b) and "*National Discovery Data Coordination Procedure*" (FEMA, 2015). The documents outline sources of GIS data and contact information, preferences for base map data and geospatial participation in flood insurance studies, and information for the project Discovery stage. The GIS clearinghouse for Puerto Rico is maintained by the PRPB at www.jp.pr.gov

Information from stakeholders is an important part of the data analysis because it provides local knowledge about the Watershed. Discovery outreach and stakeholder engagement are discussed in Section 3.

The data analysis assists FEMA Region II and the PRPB to better understand the characteristics of Río Grande de Loíza Watershed.

Table 7: Data Collection for Río Grande de Loíza Watershed

Data Types	Deliverable/Product	Source(s)
Average Annualized Loss Data	Discovery Map and Geodatabase	FEMA, PRPB
Boundaries: Barrios	Discovery Map and Geodatabase	FEMA, PRPB
Boundaries: Municipalities and Commonwealth	Discovery Map and Geodatabase	FEMA
Boundaries: Watersheds	Discovery Map and Geodatabase	USGS National Hydrography Dataset
Census Blocks	Discovery Map and Geodatabase	U.S. Census Bureau
Contacts	Discovery Report	PRPB, Watershed Stakeholders
Community Assistance Visits	Discovery Report	PRPB
Community Rating System	Discovery Report	FEMA's "Community Rating System Communities and Their Classes"
Dams and Levees	Discovery Map and Geodatabase	USACE
Declared Disasters	Discovery Report	FEMA's "Disaster Declarations Summary"
Demographics	Discovery Report and Map	PRPB, U.S. Census Bureau
Effective Special Flood Hazard Areas	Discovery Map and Geodatabase	FEMA
Hazards Mitigation Plans and Status	Discovery Report	PRPB
Flood Insurance Claims	Discovery Report and Map	FEMA, PRPB
Letters of Map Change (LOMCs)	Discovery Report and Map	FEMA's Mapping Information Platform
Mitigation Projects: Past, Ongoing, Planned, Desired FEMA/Other Federal Agency/Local Projects	Discovery Report	PRPB, Watershed Stakeholders
Repetitive Loss	Discovery Report and Map	FEMA, PRPB
Stream Centerlines	Discovery Map and Geodatabase	FEMA, USGS National Hydrography Dataset
Stream Gages	Discovery Report, Map, and Geodatabase	USGS
Study Needs: FEMA	Discovery Report, Map, and Geodatabase	FEMA's Coordinated Needs Management Strategy (CNMS)
Study Requests: Municipalities	Discovery Report and Map	Watershed Stakeholders
Transportation: Major Roads	Discovery Map and Geodatabase	Department of Transportation and Public Works, FEMA

FEMA = Federal Emergency Management
PRPB = Puerto Rico Planning Board
USACE = U.S. Army Corps of Engineers
USGS = U.S. Geological Survey

4.1 NFIP Data

The National Flood Insurance Program is a Federal program; it was created by Congress with the purpose of mitigating future flood losses. It achieves this through the implementation of community-enforced building and zoning ordinances and provides affordable insurance to property owners, renter and businesses. Participation in the NFIP is based on an agreement between local communities and the Federal Government. If the communities enforce floodplain management ordinances, the Government makes flood insurance available within the community.

Within the Río Grande de Loíza Watershed, the municipality of Carolina is a separate NFIP community. A community, as defined for the NFIP's purposes, is any state, area, or political subdivision; any Indian tribe, authorized tribal organization, or Alaska native village; or authorized native organization that has the authority to adopt and enforce floodplain management ordinances for the area under its jurisdiction.

A prevalent issue particular to Puerto Rico, is that less than 4% of households have flood insurance. Furthermore, 90% of residential flood insurance is private rather than through the NFIP (Wharton 2018).

4.1.1 Effective FIRMs

The Effective Commonwealth-wide FIS for Puerto Rico, dated November 18, 2009, is a revised study to the initial Commonwealth-wide FIS, which was issued on April 19, 2005. Prior to 2005, the FISs in Puerto Rico were primarily on a basin or community-basis. The development of a Commonwealth-wide or countywide FIS does not necessarily mean that the underlying hydrologic and hydraulic engineering analyses and mapping were updated, but that previous basin and community-based FISs were combined into a comprehensive Commonwealth-wide FIS.

Table 8 lists the flooding sources in the watershed that were studied by detailed methods, which primarily correspond to Zone AE Special Flood Hazard Areas (SFHAs).

Table 8: Flooding Sources in the Watershed Studied by Detailed Methods

Flooding Source
Río Grande de Loíza Reaches 1 and 2
Río Canóvanas
Río Canovanillas
Quebrada Cambute
Río Gurabo
Río Valenciano
Río Bairoa
Quebrada Muertos
Quebrada Algarrobo
Río Caguitas
Río Caguitas Tributary 1
Río Caguitas Tributary 2
Río Turabo
Río Herrera
Río Canaboncito

The 2009 FIS revision (FEMA, 2009) was the most recent study for the Río Grande de Loíza Watershed and the following streams were studied or restudied by detailed methods:

- Río Grande de Loíza Reach 1, from approximately 176 meters upstream of confluence with Atlantic Ocean to approximately 3,557 meters upstream of PR Highway 181
- Río Grande de Loíza Reach 2, from approximately 3,640 meters downstream of PR Highway 30 to approximately 2,703 meters upstream of Carretera 183
- Río Gurabo, from the confluence with Río Grande de Loíza Reach 2 to approximately 1,790 meters upstream of Carretera 31
- Río Valenciano, from the confluence with Río Gurabo to approximately 1,030 meters upstream of Carretera 31
- Río Bairoa, from the confluence with Río Grande de Loíza Reach 2 to approximately 288 meters upstream of Calle Gardenia
- Río Caguitas, from the confluence with Río Grande de Loíza Reach 2 to approximately 1,814 meters upstream of Calle Canaboncito
- Río Turabo, from the confluence with Río Grande de Loíza Reach 2 to approximately 7,489 meters upstream of Calle Georgetti
- Quebrada Cambute, from the confluence with Río Canovanillas to approximately 786 meters upstream of confluence with Río Canovanillas

The Effective SFHA information is presented in overview format on the Flood Risk Discovery Map. The Discovery Map is not meant to replicate the Effective FIRM information for the Río Grande de Loíza Watershed, but to provide a general picture of Effective SFHAs within the

watershed. The Effective SFHA mapping has been reviewed by the Discovery team to assist in assessing the flood hazard mapping needs in the watershed.

The PRPB completed an analysis of the population in each municipality affected by the hazard of flooding, and the result of the analysis for the municipalities in the watershed is shown in Table 9. In order to estimate the population affected by flooding in the Río Grande de Loíza Watershed, the PRPB used the following methodology to estimate only areas affected by flooding and not for the entire municipality.

- Data from the 2015 American Community Survey were obtained from the American Fact Finder (https://factfinder.census.gov). Data are from the estimates for the years 2011-2015. In addition, the spatial data corresponding to the groups of blocks for the ten municipalities evaluated in the Río Grande de Loíza Watershed were downloaded. The information in tables was linked to spatial information. Once this new geodata was created, the area of the block groups in square meters (original area) was calculated.
- Urban soil identified by the Puerto Rico Land Use Plan was used to increase the population location pressure in each block group. With the data of the Puerto Rico Land Use Plan, an intersection and the census data were performed. Once the intersection is performed, the area (new area) of the resulting polygons for each block group is recalculated. In order to calculate the total population in the areas identified as urban, a ratio was calculated between the new area of the block group and the original area of the block group resulting in the percent of the area. The product of the percent of the area with the original population of the block group results in the new population in the block group.
- In order to calculate the population affected by flood zones, the intersection with the new population was carried out in the block group and the flood zones identified by FEMA (FEMA, 2009), excluding zone X. The area of the resulting new polygons was computed in square meters, resulting in the flood area. The ratio between the flooded area and the new block group area was then calculated again resulting in the percent of the floodable area. The product of the percent of the floodable area with the new population of the block group results in the population affected by the flood zone in the Río Grande de Loíza basin. The information obtained by block group was grouped and counted by municipality. [It is important to note Puerto Rico has been recently experiencing a population decline trend, and that the conclusions arrived above may not be inclusive of such trend (U.S. Census Bureau 2017)].

Table 9: Population Affected by the Hazard of Flooding

Municipality	Total Population	Population at Risk	Percent of Population at Risk
Aguas Buenas	27,693	250	0.90
Caguas	138,262	9,403	6.80

Municipality	Total Population	Population at Risk	Percent of Population at Risk
Canóvanas	47,432	1,908	4.02
Carolina	168,114	27,130	16.14
Gurabo	46,765	4,109	8.79
Juncos	40,104	639	1.59
Las Piedras	38,605	178	0.46
Loíza	28,454	5,107	17.95
San Lorenzo	39,778	981	2.47
Trujillo Alto	71,886	2,754	3.83

[1] Population from the American Community Survey (2015)

The Puerto Rico Hazard Mitigation Plan (AEMEAD, 2016) also includes an analysis of the population in each municipality affected by the hazard of flooding. The map and graph from the Puerto Rico Hazard Mitigation Plan showing the hazard assessment for flooding are provided in Appendix F.

4.1.2 LOMCs

Table 10 lists the completed Letters of Map Change (LOMCs) in Río Grande de Loíza Watershed, as of March 2017. LOMCs in the Río Grande de Loíza Watershed were identified through the FEMA Map Service Center (MSC) and Mapping Information Platform (MIP) (FEMA, 2017d and FEMA, 2017c). LOMCs are categorized by determination type and outcome. The different LOMC types referenced in Table 10 include: Letter of Map Amendment (LOMA); Letter of Map Revision Based on Fill (LOMR-F); and Letter of Map Revision Floodway (LOMR-FW). LOMR-Fs result from the same comparisons; however, the placement of fill on the property is the basis of the request. LOMR-FWs are LOMAs for which the subject property is shown inside a regulatory floodway on the FIRM.

For LOMA requests, FEMA compares the natural ground elevation data at a specific property to the base flood elevation at the property. In some cases, FEMA can determine that a property is outside the SFHA by comparing its location on a certified map, such as a plat or tax assessor's map, to the FIRM. LOMAs, LOMR-Fs, and LOMR-FWs do not result in a physical change to the FIRM. Each LOMC application results in a determination that a structure or lot has either been removed or not removed from the SFHA. In a removal, the SFHA designation was removed from the property in question. In a non-removal, FEMA determined the property to be correctly shown within an SFHA.

During a FIS project, FEMA evaluates previous LOMC determinations, and LOMCs that remain valid are officially revalidated once a new FIRM becomes Effective.

Table 10: LOMCs within the Río Grande de Loíza Watershed

Municipality	Community Name	Case Number	LOMC Type	LOMC Date	Flooding Source

Municipality	Community Name	Case Number	LOMC Type	LOMC Date	Flooding Source
Caguas	Calle Violeta 68A	11-02-0855A	LOMA	4/22/2011	Río Bairoa
Caguas	Reparto Caguax	11-02-2204A	LOMA	8/2/2011	Río Grande de Loíza Reach 2
Caguas	Santa Cecillia	11-02-2218A	LOMA	10/20/2011	Río Grande de Loíza Reach 2
Caguas	Santa Elvira	11-02-2550A	LOMA	11/22/2011	Río Grande de Loíza Reach 2
Caguas	Santa Elvira	11-02-2577A	LOMA	12/6/2011	Río Grande de Loíza Reach 2
Caguas	Santa Elvira	12-02-0269A	LOMA	2/16/2012	Río Grande de Loíza Reach 2
Caguas	PR 769, Rio Cañas Ward	12-02-0341A	LOMA	4/5/2012	Río Grande de Loíza Reach 2
Caguas	PR-796, Rio Cañas Ward	13-02-0245A	LOMA	12/13/2012	Río Grande de Loíza Reach 2
Caguas	Santa Cecilia	13-02-1794A	LOMA	9/24/2013	Río Grande de Loíza
Caguas	Santa Juana	14-02-0518A	LOMA	1/21/2014	Río Caguitas
Canóvanas	Forest Plantation	11-02-2454A	LOMR-F	9/22/2011	Río Canóvanas
Canóvanas	River Gardens Development	12-02-0847A	LOMR-F	5/1/2012	Río Canóvanas
Canóvanas	Monterrey Estates	12-02-1625A	LOMR-F	11/6/2012	Río Canóvanas
Canóvanas	River Gardens Development	13-02-0430A	LOMR-F	6/6/2013	Río Canóvanas
Canóvanas	River Gardens Development	13-02-0431A	LOMR-FW	3/6/2013	Río Canóvanas
Canóvanas	Quintas de Altamira	15-02-1950A	LOMA	1/27/2016	Río Canóvanas Tributary
Carolina	Edificio 1 Chales de la Fuente	11-02-2184A	LOMA	9/15/2011	Río Grande de Loíza
Carolina	Federico Cordero	13-02-0433A	LOMR-F	1/17/2013	Río Grande de Loíza Reach 1
Carolina	Chalets de la Fuente	15-02-1425A	LOMA	8/31/2015	Río Grande de Loíza
Gurabo	Paseo de Santa Barbara	10-02-0620A	LOMR-F	2/8/2010	Río Grande de Loíza; Río Gurabo Reach 1
Gurabo	Los Flamboyanes Development	10-02-1770A	LOMR-F	9/23/2010	Río Gurabo Reach 1
San Lorenzo	Bosque Llano	10-02-1361A	LOMR-F	8/12/2010	Unnamed Tributary to Río Grande de Loíza
San Lorenzo	Monterey	13-02-0117A	LOMA	12/18/2012	Río Grande de Loíza Reach 2 Tributary

Municipality	Community Name	Case Number	LOMC Type	LOMC Date	Flooding Source
San Lorenzo	Alejandra Valley	16-02-1181A	LOMA	6/17/2016	Río Grande de Loíza Reach 2
San Lorenzo	Alejandra Valley	16-02-1692A	LOMA	8/24/2016	Río Grande de Loíza Reach 2

Conditional LOMCs are not included in Table 10 because conditional determinations are based on proposed projects rather than actual as-built conditions. Letters of Map Revision (LOMRs) are also not included because they result in a physical change to the FIRM and will either be incorporated into the new FIRM or superseded by new flood hazard data when FIS updates are made.

The presence or absence of completed LOMCs within a specified location may contribute to the analysis of whether that area needs to be restudied. Knowing the type of LOMC and its respective outcome can provide an additional layer of detail. For example, a high number of LOMA removals in an area may mean that the area may need to be restudied with updated topography, while a high number of LOMA non-removals may indicate that the flood hazard delineation within the area agrees with ground elevations. A high number of LOMR-Fs may not necessarily indicate that an area should be reexamined, but that property owners have cooperated with the local municipality to mitigate flood risks in accordance with local regulations.

For the data collected for the Río Grande de Loíza Watershed, portrayed above in Table 10, it can be seen how there are several LOMAs processed in Caguas, Carolina, and San Lorenzo. Almost all of these are associated with the Río Grande de Loíza Reach 2 flooding source. This correlation would be an indicator in the future Risk MAP stage of Data and Product development, to look into the available topographic data for this stream and determine whether it is representative or not of the actual physical conditions.

Areas with clusters of four or more LOMCs are shown on the Flood Risks Discovery Map.

4.1.3 CNMS

FEMA's Coordinated Needs Management Strategy (CNMS) was initiated as part of FEMA's Risk MAP program in 2009. The CNMS inventory provides an overview of the status and attributes of existing studies within FEMA's floodplain inventory. FEMA's CNMS inventory is accessible through the CNMS Viewer on FEMA's MSC website (https://msc.fema.gov/cnms/). CNMS helps FEMA, the PRPB, and community members and officials manage their flood hazard mapping inventory through the following ways (FEMA, 2016b):

- Informs mapping project planning and standardizes how new and updated flood data is collected for flood map production
- Enhances data driven planning activities for map update prioritization
- Validates SFHAs and flood hazard data on FIRMs
- Allows authorized account users to submit, review, track, and evaluate mapping need requests

- Facilitates greater control of review and evaluation of mapping needs requests to Regional officials

FEMA applies four validation status types to FISs shown within the CNMS: Valid, Unverified, Unknown, and Assessed. During the validation review, FEMA checks physiological, climatological, and environmental factors against the stream studies to determine if the studies are still valid. FEMA (FEMA, 2016b) defines the validation status types as:

- Valid: A New, Valid and Updated Engineering (NVUE) compliant study that has been completed using up-to-date engineering methodology and/or conducted in areas that have not seen significant climatological or physiological changes since the effective date of the study.
- Unverified: A study that has not passed the critical and secondary element checks part of FEMA's validation standards and is eligible to receive resources for a re-study in the future or is currently being restudied.
- Unknown: A study that is either being currently evaluated, is planned to be evaluated, or lacks enough information to be able to determine a validation status.
- Assessed: A study in an unmapped area that has been identified for a new study in the current or future fiscal year or is a deferment of a new study request. Streams not part of FEMA's SFHA inventory that have been or are being considered for a new study also fall under this validation status category.

Additionally, while streams without identified flood risk can be featured in the CNMS database, most are not. Streams without flood hazard information cannot go through element evaluation because the validation elements rely on study data, which these streams lack.

The CNMS database information was used during the initial Río Grande de Loíza Watershed Discovery effort and served as an important discussion point. Through the Discovery process, the PRPB and FEMA Region II learned of new flood risks and study needs and incorporated that information into the CNMS at the end of Discovery.

Table 11 and Figure 6 summarize the results of the validation analysis obtained from the CNMS. The table lists the flooding source, municipality or municipalities affected by the flooding source, and the validation status category by study type. CNMS lists approximately 113.24 miles in the Río Grande de Loíza Watershed, with 18.92 miles as Unverified, 36.47 miles as Unknown, and 57.85 miles as Valid. Of the detailed studies in the watershed, all of the streams have a Valid status, except the Río Grande de Loíza Reach 1 and Reach 2, which have an Unverified status. All of the approximate study streams in the watershed have an Unknown status. Of the redelineated study streams in the watershed, the Río Canóvanas (6.81 miles) has an Unverified status, and Quebrada Muertos (0.9 miles), Río Caguitas and Tributaries (3.57), and Río Canovanillas (1.62 miles) have a Valid status.

Part of the proposed scope of study for Río Grande de Loíza Watershed will be to update the study for any Unverified stream miles, which would include the following flooding sources:

- Río Grande de Loíza Reach 1 and 2 (Effective detailed study)

- Río Canóvanas (Effective redelineation)

Additional proposed scope of study based on municipality feedback and flood hazard concerns through this Discovery process have been added to the CNMS inventory as requests to be considered by FEMA Region II and the PRPB.

It is important to note that CNMS has not yet captured streams in Río Grande de Loíza Watershed that have been identified using sources such as the National Hydrography Dataset (NHD). Many of these stream miles are not associated with existing SFHAs; however they do have the potential to flood. The flowlines from the NHD that do not have a corresponding FEMA FIS are shown on Figure 6.

Table 11: CNMS Mileage for Río Grande de Loíza Watershed

Flooding Source	Municipalities	Detailed Study Stream Mileage			Approximate Study Stream Mileage			Redelineated Study Stream Mileage		
		Unverified	Unknown	Valid	Unverified	Unknown	Valid	Unverified	Unknown	Valid
Lago Loíza	Gurabo, Trujillo Alto	0	0	0	0	4.91	0	0	0	0
Quebrada Algarrobo	Caguas	0	0	0.18	0	0.28	0	0	0	0
Quebrada Arenas	Juncos	0	0	0	0	0.89	0	0	0	0
Quebrada Cambute	Carolina	0	0	0.49	0	0.20	0	0	0	0
Quebrada Ceiba	Juncos	0	0	0	0	1.55	0	0	0	0
Quebrada Grande	Trujillo Alto	0	0	0	0	1.77	0	0	0	0
Quebrada Maracuto	Carolina	0	0	0	0	0.89	0	0	0	0
Quebrada Muertos	Aguas Buenas	0	0	0	0	0	0	0	0	0.90
Quebrada Naranjito	Caguas	0	0	0	0	0.79	0	0	0	0
Quebrada Pastrana	Carolina	0	0	0	0	1.56	0	0	0	0
Quebrada Rohena	Trujillo Alto	0	0	0	0	0.48	0	0	0	0
Río Bairoa	Aguas Buenas, Caguas	0	0	6.47	0	2.58	0	0	0	0
Río Caguitas and Tributaries	Caguas	0	0	6.33	0	0.42	0	0	0	3.57
Río Canaboncito	Caguas	0	0	0.11	0	0.38	0	0	0	0
Río Canas	Caguas	0	0	0	0	1.79	0	0	0	0
Río Canóvanas	Canóvanas	0	0	0	0	1.38	0	6.81	0	0
Río Canovanillas	Carolina, Canóvanas	0	0	0	0	0.72	0	0	0	1.62
Río Cayaguas	San Lorenzo	0	0	0	0	1.81	0	0	0	0
Río Grande de Loíza Reach 1 and 2	Caguas, Canóvanas, Carolina, Gurabo, Loiza, San Lorenzo, Trujillo Alto	28.75	0	0	0	3.10	0	0	0	0
Río Gurabo	Las Piedras, Juncos, Gurabo	0	0	13.58	0	2.08	0	0	0	0
Río Turabo	Caguas	0	0	5.79	0	1.25	0	0	0	0
Río Valenciano	Juncos	0	0	2.17	0	0.37	0	0	0	0
Unnamed	Caguas, San Lorenzo	0	0	0	0	7.27	0	0	0	0
TOTAL		**28.75**	**0**	**35.12**	**0**	**36.47**	**0**	**6.81**	**0**	**6.09**

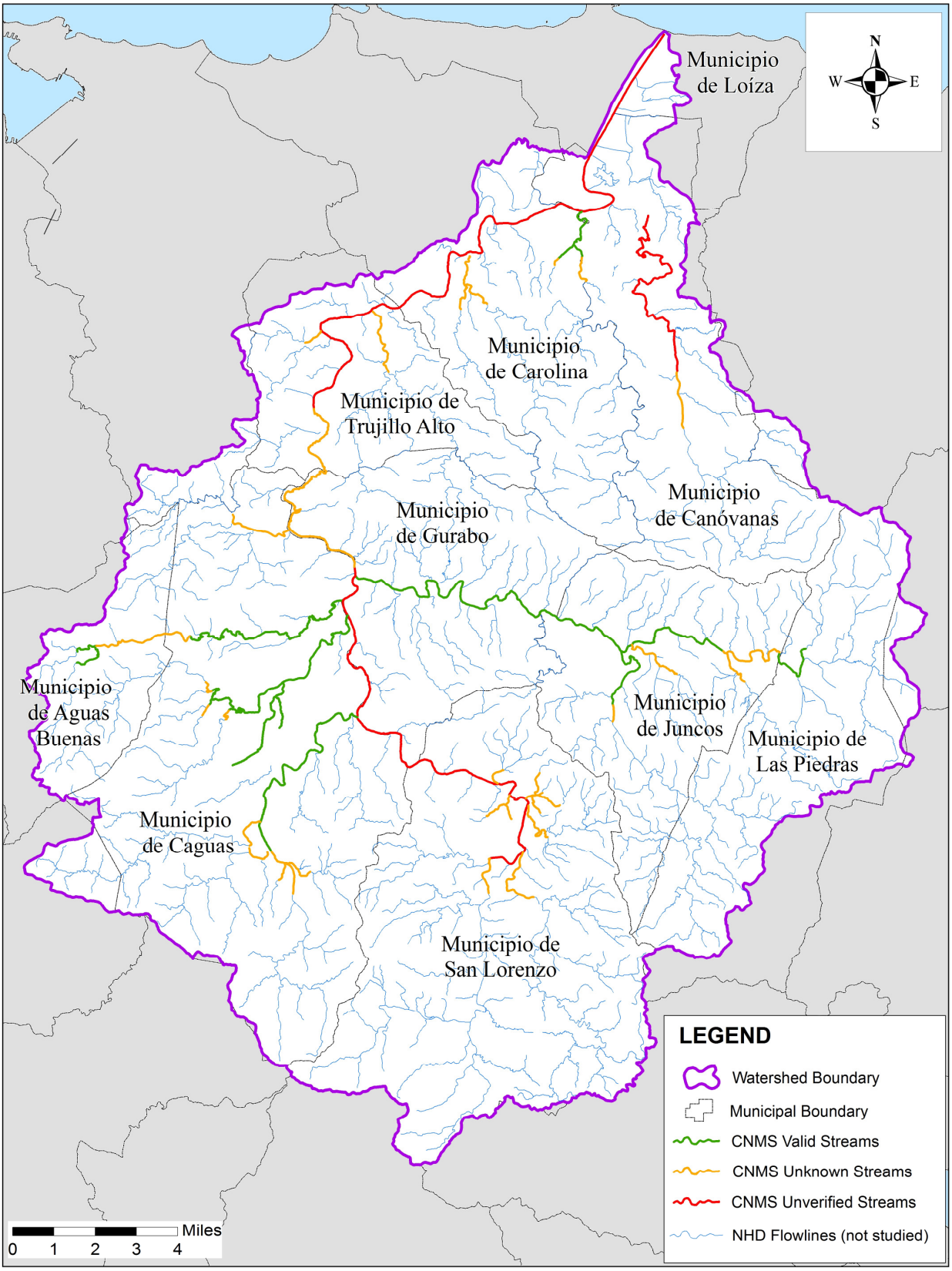


Figure 6: CNMS Validation Status in the Río Grande de Loíza Watershed

4.1.4 Flood Insurance Policies

General flood insurance policy information was obtained through the PRPB and is used to determine if the identified flood risk mapped for each area matches the flood magnitudes and frequencies that have actually occurred. This is crucial to assess whether there are any discrepancies between what has been identified versus what is being experienced. If there are any areas for which these two fields do not match, then those areas need to be carefully assessed to determine the source of the discrepancy.

For the entire Commonwealth of Puerto Rico, there are 4,982 NFIP flood insurance policies (as of May 2017) and 46,709 non-NFIP flood insurance policies (as of May 2017). Within the ten municipalities for the Río Grande de Loíza Watershed there are a total of 1,187 NFIP policies, as shown on the Potential Loss Discovery Map and in Table 12. The number of private (non-NFIP) policies within the watershed is unknown since this data is not publicly available. The PRPB is currently working with the Insurance Commissioner's Office to have access to this valuable information for risk planning.

Table 12: NFIP Flood Insurance Policies for Municipalities in the Río Grande de Loíza Watershed (as of May 2017)

Municipality	NFIP Flood Insurance Policies
Aguas Buenas	1
Caguas	258
Canóvanas	66
Carolina	685
Gurabo	66
Juncos	16
Las Piedras	3
Loíza	34
San Lorenzo	25
Trujillo Alto	33

4.1.5 NFIP Claims

The Discovery process also involved gathering data on flood insurance claims in the county through the NFIP. Within Puerto Rico, 24,489 flood insurance claims have been filed since 1974, as of October 31, 2016. For the entire Commonwealth a magnitude of $124,925,526 has been approved for such claims. For Discovery, it is important to take into consideration the claims filed due to flood losses, because these can support or contradict the accuracy of current maps and studies delineating the probability of floods for its respective territory.

4.1.6 Repetitive Losses

For the claims filed, particular attention is placed to areas where repetitive loss structures have been identified. A repetitive loss (RL) structure is defined as an NFIP-insured structure that has had at least two paid flood claims of more than $1,000 each in any 10-year period since 1978. A severe repetitive loss (SRL) structure has had either two separate claims that exceed market value of the building or have had four claims over $5,000 each and the cumulative amount of such claims exceeds $20,000.

The Municipalities within the Río Grande de Loíza Watershed with considerate amounts of claim are Caguas, Canóvanas, Loíza, and Carolina. FEMA Region II has identified 167 RL structures for Municipalities within the Río Grande de Loíza Watershed of which five have been identified as being SRL structures.

When FEMA determines whether an area's flood hazards should be restudied, it may consider areas where RL/SRL structures have been identified. However, it is important to note that NFIP claims may be made after events that do not meet or exceed the 1-percent-annual-chance, or 100-year flood. Therefore, previous claims data only represents a single factor to consider when determining mapping needs.

The Potential Loss Discovery Map shows areas where RL/SRL structures exist and areas where NFIP claims have been made. Table 13 shows the number of repetitive losses by municipality, as of October 31, 2016. Because of guidelines set forth by the Privacy Act of 1974, FEMA Region II will not include detailed repetitive loss data as part of the Discovery deliverables.

Table 13: Repetitive Losses for Municipalities in the Río Grande de Loíza Watershed

Municipality	Number of Repetitive Losses (as of 10/31/2016)
Aguas Buenas	0
Caguas	22
Canóvanas	53
Carolina	33
Gurabo	10
Juncos	5
Las Piedras	3
Loíza	41
San Lorenzo	0
Trujillo Alto	0

4.1.7 CAVs

Statewide Community Assistance Visits (CAVs) are part of the evaluation and review process that occurs between FEMA and local officials. CAV visits are intended to ensure that each community adequately enforces local floodplain management regulations in compliance with NFIP requirements. CAVs are also a way for FEMA to provide technical assistance to communities.

Table 14 lists CAVs that have occurred within Puerto Rico in the last five years, as provided by the PRPB. Representatives of Region II performed some of the CAVs on behalf of FEMA.

Table 14: Community Assistance Visits in Puerto Rico since 2012

Municipality	Community	Community ID	Year Performed	Agency
Guánica	Commonwealth of Puerto Rico	720000	2014	PRPB and FEMA Caribbean Division
Bayamón	Separate NFIP Community	720100	2013	PRPB and FEMA Caribbean Division
Humacao	Commonwealth of Puerto Rico	720000	2012	PRPB and FEMA Caribbean Division
Arecibo	Commonwealth of Puerto Rico	720000	2012	FEMA Caribbean Division and EPA

4.1.8 CACs

Community Assistance Contacts (CACs) are important in order to provide a link between the communities and FEMA. Furthermore, CACs can enhance the working relationship between the State or FEMA and NFIP communities, and creates a greater awareness of the NFIP and its requirements. As stated in FEMA's *Guidance for Conducting Community Assistance Contacts and Community Assistance Visits* (FEMA, 2011) can be conducted by either a telephone call or a brief visit to the community itself. Its purpose is to be less comprehensive and less time-consuming than a CAV. A CAC should not take place in a community that is experiencing more serious floodplain management problems or in communities with high potential for damage to existing development. In such cases, a comprehensive visit in coordination with the applicably agencies should be completed.

4.1.9 CRS

The CRS is a voluntary program that provides flood insurance premium discounts to NFIP participating communities that take measures to manage floodplains more rigorously than Federal minimum requirements. A point system is used to determine a CRS rating. As a community takes measures to minimize or eliminate exposure to floods, CRS points are awarded and higher discounts on flood insurance premiums are offered. The discount each community receives (45 percent – 5 percent) is determined by its class rating (1 – 9, respectively).

None of the municipalities in the Río Grande de Loíza Watershed participate in the CRS. In Puerto Rico, only the separate NFIP communities can join this system (Bayamón, Carolina, Guaynabo, and Ponce), and currently the Municipality of Ponce is the only one that has implemented the CRS Program.

A full list of communities participating in the CRS is available on FEMA's website "*CRS Communities and their Classes*" (FEMA, 2016c). During the last years, the PRPB has conducted several workshops to motivate separate NFIP communities to join the CRS and get the benefits this system offers.

4.2 Other Data Useful for Flood Risk Assessment and Mitigation

4.2.1 LiDAR/Topographic Coverage

The PRPB and USGS are currently working on developing high-resolution topographic and bathymetric Light Detection and Ranging (LiDAR) data for the entire Commonwealth of Puerto Rico and its surrounding islands for a total of approximately 3,424 square miles. The topography dataset is expected to be completed in January 2018.

USGS currently has topographic data available for all areas within the Río Grande de Loíza Watershed. The USGS National Elevation Datasets (NEDs) as 10-meter and 30-meter grids are available to view and download through The National Map (https://viewer.nationalmap.gov/). The most recent available topographic data from USGS was published in 2016. Additionally, LiDAR for the coastal areas of Puerto Rico was collected and processed in 2004 by National Oceanic and Atmospheric Administration (NOAA).

4.2.2 Dams

The National Inventory of Dams (NID) maintained by the U.S. Army Corp of Engineers (USACE) shows 33 dams within Puerto Rico, out of which 29 are classified as High Hazard Potential, 3 are classified as Significant Hazard Potential, and 1 is classified as Low Hazard Potential. The dams are classified according to *FEMA 333: Federal Guidelines for Dam Safety: Hazard Potential Classification System for Dams* (2005), which defines the classifications as follows:

- Class 1-Low Hazard Potential: Dam failure results in no probable loss of human life and insignificant economic and/or environmental losses.
- Class 2-Significant Hazard Potential: Dam failure results in no probable loss of human life but can cause economic loss, environmental damage, disruption of lifeline facilities, or can impact other concerns.
- Class 3-High Hazard Potential: Failure or mis-operation will likely cause loss of human life.
- Unclassified Hazard Potential: Hazard potential undetermined.

There is only one dam listed in the NID that is located in the Río Grande de Loíza Watershed, which is the Loíza Dam, also known as the Carraízo Reservoir, located in Trujillo Alto. The dam, completed in 1954, is owned by the Puerto Rico Aqueduct and Sewer Authority. This reservoir was constructed with a capacity of 23,500 acre-feet and meant to provide domestic water use to San Juan's metropolitan area. It stores water from the Río Grande de Loíza and its tributaries

as supply for the Sergio Cuevas Filtration Plant (Puerto Rico Aqueduct and Sewer Authority, 2016). The Loíza Dam is classified as High Hazard Potential in the NID. The location of the dam is shown on Figure 7 and on the Flood Risk Discovery Map.

As stated in the Emergency Action Plan (EAP) for the Carraízo Reservoir (Puerto Rico Aqueduct and Sewer Authority, 2016), "The Reservoir Carraízo is in good conditions, from a structural point of view, and under no ordinary circumstances exist the risk of mechanical or dam failure. Nevertheless there can be extraordinary circumstances that can be threatening to the usual operation and stability of the reservoir." For such extraordinary circumstances there are a series of guidance and steps to take as specified in the EAP. The inundation maps showing different dam breach scenarios for the Carraízo Dam were collected during the Discovery process. The dam breach scenarios included the 100-year, maximum historic flood, maximum probable flood, maximum probable precipitation, and sunny day.

4.2.3 Levees

The National Levee Database (http://nld.usace.army.mil/) is maintained by the USACE and includes comprehensive information about levee structures nationwide. Authorized by Congress in 2007, the National Levee Database contains information to facilitate and link activities, such as flood risk communication, levee system evaluation for the NFIP, levee system inspections, floodplain management, and risk assessments.

The National Levee Database includes levees in Puerto Rico. In the Río Grande de Loíza Watershed, there are no certified or accredited levees in the National Levee Database. There are also no coastal flood control structures localized in the Puerto Rico Department of Environmental Protection area.

4.2.4 Coastal Barrier Resources System

The Coastal Barrier Resources Act (CBRA) of 1982 (16 U.S.C. 3501 et seq.) was enacted by Congress to minimize the loss of human life, reduce wasteful Federal expenditures, and minimize damage to the natural resources associated with coastal barriers.

Coastal barriers are unique land forms that provide protection for distinct aquatic habitats and serve as the mainland's first line of defense against damage from coastal storms and erosion.

The CBRA established the Coastal Barrier Resource System (CBRS), and defines a coastal barrier as a land form composed of unconsolidated shifting sand or other sedimentary material which is generally long and narrow and entirely or almost entirely surrounded by water. They are sufficiently elevated above normal tides so that they usually have dunes and terrestrial vegetation. To varying degrees, they enclose and thereby protect other features, such as estuaries, salt marshes, and the mainland from direct wave influence by the open ocean. This defined set of geographic units is located along the Atlantic, Gulf of Mexico, Great Lakes, U.S. Virgin Islands, and Puerto Rico coasts.

The units are delineated on a set of maps maintained by the U.S. Fish and Wildlife Service. Most new Federal expenditures and financial assistance that have the effect of encouraging development, including Federal flood insurance, are prohibited within the CBRS. CBRA does not

prohibit development, and it imposes no restrictions on development conducted with non-Federal funds.

U.S. Fish and Wildlife Service adopted in 2016 final revised maps for all of the John H. Chafee CBRS units in Alabama, Georgia, Louisiana, Michigan, Minnesota, Mississippi, Ohio, Puerto Rico, Wisconsin, the U.S. Virgin Islands, the Great Lakes region of New York, and 125 units in Florida. These maps were prepared by the Service in partnership with FEMA.

The effective CBRS maps show that there are no units of the coastal barrier system present within the Río Grande de Loíza Watershed. However, Puerto Rico has designated units of the coastal barriers present along the coastline with the North Atlantic Ocean and Caribbean Sea. All CBRS lands are currently classified as Specially Protected Rustic Land and no development is permitted.

4.2.5 Stream Gages

The USGS National Water Information System Web Interface (USGS, 2017a) provides real-time data for any given USGS sponsored stream gage location. Table 15 shows the gage identification number, location, drainage area, status, and municipality for all USGS gages relevant to Río Grande de Loíza Watershed with a historical period of record greater than 10 years. Gage locations are also illustrated in Figure 7 and on the Flood Risk Discovery Map.

FEMA Region II will employ historical stream flow information from the USGS gages listed in Table 15 for use in hydrological analyses where applicable. Locally owned and operated rainfall gages may be present throughout the watershed as well.

Table 15: USGS Stream Gages in Río Grande de Loíza Watershed

Gage Identification Number	USGS Gage Name	Drainage Area[1] (Square Miles)	Gage Status
50058350	Río Canas at Río Canas, PR	7.5	Active
50055380	Río Bairoa above Bairoa, Caguas, PR	4.9	Active
50053025	Río Turabo above Borinquen, PR	7.2	Active
50054500	Río Turabo at Caguas, PR	29	Inactive
50055225	Río Caguitas at Villa Blanca at Caguas, PR	16.6	Active
50055250	Río Caguitas at Highway 30 at Caguas, PR	14.1	Active
50055410	Río Bairoa at mouth, PR	7.51	Inactive
50055000	Río Grande de Loíza at Caguas, PR	89.7	Active
50059050	Río Grande de Loíza below Loíza damsite, PR	208.7	Active
50059100	Río Grande de Loíza below Trujillo Alto, PR	213	Inactive
50057025	Río Gurabo near Gurabo, PR	62.8	Inactive
50057000	Río Gurabo at Gurabo, PR	60.0	Active
50051500	Río Cayaguas near San Lorenzo, PR	Not provided	Inactive
50051800	Río Grande de Loíza at Highway 183 San	41.1	Active

Gage Identification Number	USGS Gage Name	Drainage Area[1] (Square Miles)	Gage Status
	Lorenzo, PR		
50051310	Río Cayaguas at Cerro Gordo, PR	10.1	Active
50056400	Río Valenciano near Juncos, PR	16.4	Active
50056500	Río Valenciano at Juncos, PR	Not provided	Inactive
50061800	Río Canóvanas near Campo Rico, PR	10.2	Active

[1]Drainage areas are from the USGS website. "Not provided" indicates that no drainage area was listed for the gage.

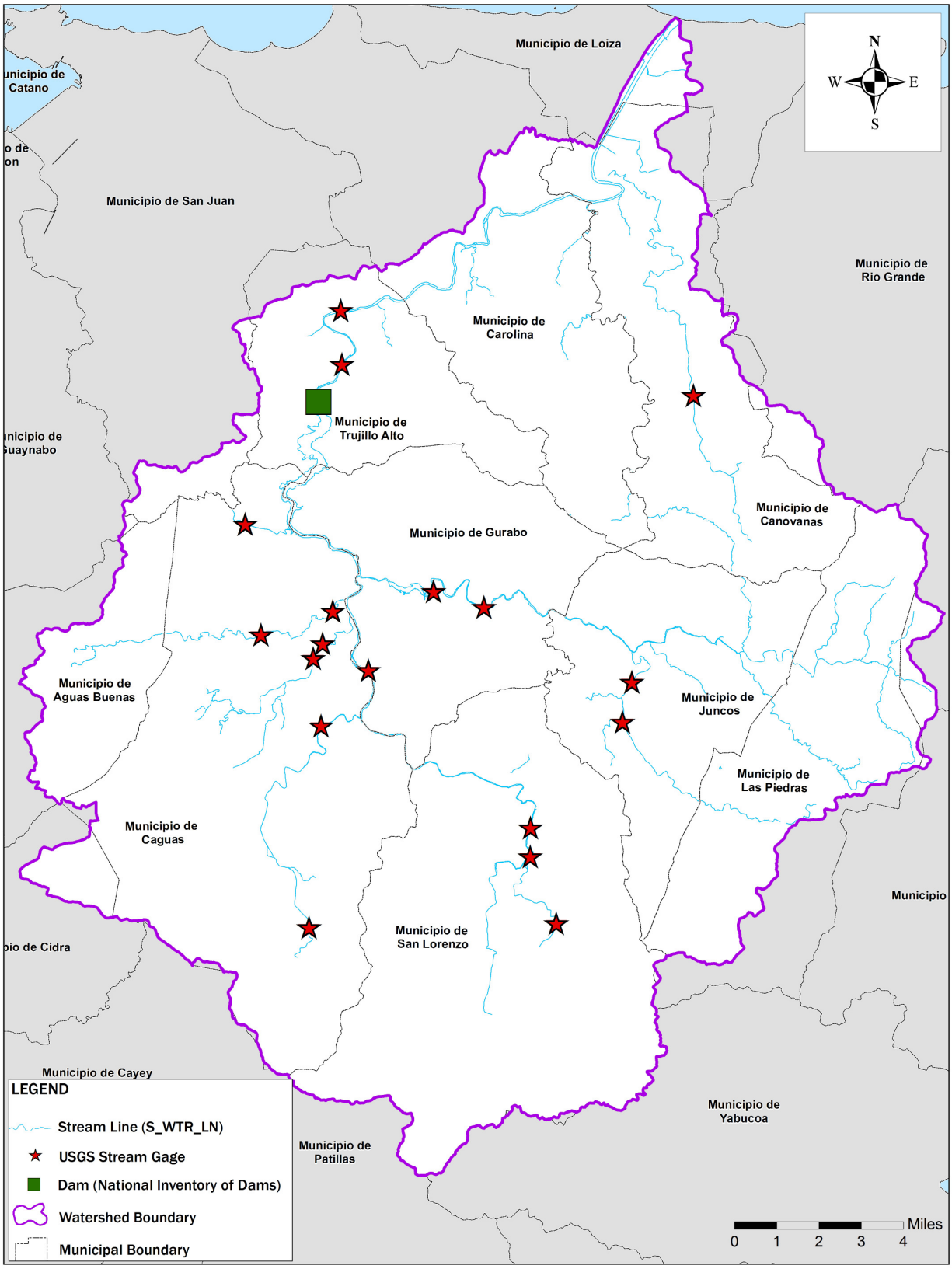


Figure 7: Locations of USGS Stream Gages in Río Grande de Loíza Watershed

4.2.6 USGS Streamflows and Watershed Characteristics

The Río Grande de Loíza Watershed is located in the North-Central Region of Puerto Rico. The two major streams within this watershed are the Río Grande de Loíza and the Río Gurabo. The USGS has stream gages throughout the watershed; all of the stream gages within the watershed are located in Table 15 above. Below is a brief hydrographic summary for each municipality.

Within Caguas, there are several tributaries to the Río Grande de Loíza: Cañas, Turabo, Caguitas and Bairoa Rivers.

Within Loíza, the main hydrographic features are comprised of the Río Grande de Loíza, Herrera Rivers, and the Río Grande; as well as Piñones, and La Torecilla lagoons.

Within Juncos, the hydrography is composed of Valenciano and Gurabo Rivers. Ravine Ceiba and Valenciano River are both tributaries to the Rio Grande de Loíza, and the Ravines La Santa, Don Victor, Montones, and De los Muertos are tributaries to Valenciano River.

In Aguas Buenas, the Bayamón River is the main stream with tributaries such as Ravine Quebrada, San Vicente, Pueblo Viejo, and Jácana. Furthermore the upstream-most end of the Rivers Baiora, Caguitas, and Cañas are here. The Bairoa River flows from West to East and is the most dangerous for this Municipality because of its proximity to the developed areas. The Caguitas River is connected to Ravines Sangelo and Horno.

Within the Las Piedras, the hydrography consists of Gurabo River, Valenciano and Humacao, and the ravines Honda, Rábanos, Arenas and Montones.

In Gurabo, the Río Grande Loíza, and Gurabo Rivers, along with Ravines Grande, Infierno, and Maracuta comprise the hydrography of this Municipality.

In Trujillo Alto, the main hydrographic feature is the Río Grande de Loíza, however several creeks are also present: Rohena, Colorada, Infierno, Grande, Limones, Naranjo, Pastrana, Hoyo Frio, Maracuto, and Variante (or Los Guanos). Furthermore, this municipality includes springs being utilized for commercial extraction of water, among them: springs La Roca and La Montaña; the Carraízo Reservoir is also located within Trujillo Alto.

In Canóvanas, the main river is the Río Grande de Loíza with tributaries Canóvanas, Canovanillas, Herrera and Cubuy. Within this Municipality the most impacted area is that of the central zone along the perimeter of the PR-3 transportation feature and the Canóvanas town.

The main hydrographic feature for the Carolina Municipality is the Río Grande de Loíza with tributaries Canovanillas and ravines Maracuta, Pastrana, and Hoya Fría. Other features worth mentioning are the ravine Blasina that flows into the sea, and the lagoons Piñones, San José, Los Corozos, and La Torecilla (Enciclopedia de Puerto Rico, 2017).

4.2.7 Average Annualized Loss Data

The PRPB recently completed an island-wide Hazus analysis, which provides average annualized loss (AAL). AAL is defined as the average dollar loss that an individual, or individuals, will experience during a given year from exposure to flooding. This AAL dollar value is calculated by using flood hazard data in combination with U.S. Census data. Flood hazard areas are determined for storm events of a given probability of occurrence and are then overlaid on U.S.

Census block data. The losses for a given Census block are then calculated for structures and their contents based on the area that has flooded. Total losses for both the structures and their contents are added together to determine the AAL for a given Census block. The AAL for a community can then be determined by adding the AAL together for all its Census blocks. AAL data is most commonly organized by Census block and displayed with color intervals based on severity of losses.

The AAL dataset provided with this Discovery Report and shown on the Discovery Map was created using FEMA's Hazus software and included Census data from 2000. The Hazus analysis used data sources with only limited detail shown for flood hazard areas. This type of low-detail Hazus analysis is conducted primarily to correlate the location of residents and infrastructure to the floodplain within a given community, and is not intended to provide a thorough and accurate estimation of yearly losses from flooding.

4.2.8 Land Use Management Plans

Land use planning is a very important tool for reducing risks from natural hazards. Through this, a balance between economic development, safety, and resource protection can be achieved. The integration of risks into planning helps communities to become resilient by allowing certain compatible land uses and putting restrictions to areas were loss of life and property is in the equation.

Land Use Plans for Piñones (Loíza), San Lorenzo, and Carolina have as a vision and goal to regulate and classify the land within their jurisdictional territory in order to guide the development within their municipalities.

As stated in the Land Use Plan for Carolina, their vision is to “attain integral development and maintain a continuous and self-sustained socio-economic development, addressed so that each citizen maximizes his/her quality of life without sacrificing valuable customs and resources” (Municipality of Carolina, 2007). In this manner and through such a well-defined and carefully constructed document, communities can ensure that they will grow and develop in the fashion that they intend, fostering the values and resources most important to them.

The Piñones Land Use Plan states that “it is one of the most important natural and cultural systems in Puerto Rico”. This area offers a variety of value and resources- in ecologic and recreational terms. It contains the largest mangrove swamp in Puerto Rico. Through the study of these plans, and of the land classification, one can pinpoint areas where future development will take place. For such areas, it is crucial to determine whether or not they will need some sort of risk assessment, in order to safeguard the security of the future inhabitants.Stormwater Projects

The Municipality of Carolina identified two proposed storm water projects in their response to the Discovery Data Questionnaire:

1. Vistamar Urbanization Project: Improvements to the current storm water network, replacement of storm water basin, construction of storm water pipe network, mechanized mobilizing of runoff and catchment area. Geographic location: Alicante Street (East of Pelota Park) Ur. Vistamar, Bo. Sabana Abajo.
2. Los Angeles Urbanization Project: Two proposed structures to control the water surface elevation in the Flamboyan channel, composed by: sluice gates, two

pumping stations operated through several screw pumps with an approximate capacity of 40,000 GPM each. A barrier to control flood to the west limits of the urbanization. The clean up within the channel and of existing ponds also being considered. Geographic location: Estrella del Norte Street, Urb. Los Angeles, Bo. Cangrejo Arriba.

3. Villamar: A reinforced concrete wall with a height of 1.45 meters above sea level. The wall will have an approximate length of 1,077 linear meters. The project proposes the elimination of three pumping stations to be substituted by two pumping stations with a combined capacity of 39,000 GPM. The project will furthermore collect runoff through a network of pipes proposed, with an approximate length of 526 linear meters. Geographic location: El Palmar Sur Final Street, Bo. Sabana Abajo.

4.2.9 Transportation

Transportation data for the Watershed were obtained from FEMA's National Flood Hazard Layer (NFHL) on the MSC (FEMA, 2017d). The delineation of the main road system within the Río Grande de Loíza Watershed can be observed in all three maps. The roads portrayed include: PR-187, PR-951, PR-874, PR-3, PR-188, PR-66, PR-857, PR-185, PR-853, PR-945, PR-181, PR-852, PR-175, PR-798, PR-52, PR-30, PRI-1, PR-183, PR-172, PR-763, and PR-765. The portrayal of the road system is not only meant to illustrate when these intersect or run parallel a flooding source, and thus may be compromised in a flooding event, they are also meant to illustrate the settlement of local residents, as the development of a municipality is related to the transportation routes, and the evacuation routes available when facing a disaster

4.2.10 Jurisdictional Boundaries

The jurisdictional boundaries for the surrounding municipalities were published by the U.S. Census Bureau and downloaded from the NFHL on FEMA's MSC (FEMA, 2017d). The boundaries were updated based on information provided by the municipalities.

In the Río Grande de Loíza Watershed, El Yunque National Forest and El Toro Wilderness are the only federally owned lands. El Yunque National Forest is a tropical rain forest covering nearly 29,000 acres across several municipalities, including Carolina, Canóvanas, Juncos, and Las Piedras. El Tori Wilderness is located within El Yunque and covers 10,154 acres across several municipalities, including Canóvanas and Las Piedras. The federally owned lands GIS boundaries were obtained from the USGS National Map (USGS, 2017b).

There are no federally recognized tribes located within the Río Grande de Loíza Watershed.

4.3 Hazard Mitigation Planning and Activities

4.3.1 Summary of Hazard Mitigation Plans

Table 16 shows the status of current hazard mitigation plans for the municipalities within the Río Grande de Loíza Watershed. The Municipalities of Aguas Buenas, Caguas, Canóvanas, Carolina, Gurabo, Loíza, and Trujillo Alto currently have an approved mitigation plan. The Municipalities of Juncos and Las Piedras have previously approved mitigation plans that have lapsed past the expiration date. Table 16 shows municipalities and their corresponding barrios within the Río Grande de Loíza Watershed that participate in the plan and when the municipalities adopted the plan.

Table 16: Existing Hazard Mitigation Plans within Río Grande de Loíza Watershed

Municipality	Wards Participating	Mitigation Plan Approval Date	Mitigation Plan Expiration Date	Status (as of June 2017)
Aguas Buenas	Aguas Buenas barrio-pueblo, Bairoa, Bayamoncito, Caguitas, Jagüeyes, Juan Ascencio, Mula, Mulita, Sonadora, Sumidero	8/14/2013	8/14/2018	Approved
Caguas	Bairoa, Beatriz, Borinquen, Caguas barrio-pueblo, Cañabón, Cañaboncito, Río Cañas, San Antonio, San Salvador, Tomás de Castro, Turabo	8/4/2016	8/3/2021	Approved
Canóvanas	Canóvanas, Canóvanas barrio-pueblo, Cubuy, Hato Puerco, Lomas, Torecilla Alta	9/29/2014	9/28/2019	Approved
Carolina	Barrazas, Buena Vista, Cacao, Cangrejo Arriba, Canovanillas, Carolina Barrio-Pueblo, Carruzos, Cedro, Martin González, Sabana Abajo, San Antón, Santa Cruz, Trujillo Bajo	7/15/2013	7/15/2018	Approved
Gurabo	Celada, Gurabo barrio-pueblo, Hato Nuevo, Jaguar, Jaguas, Mamey, Masa, Navarro, Quebrada Infierno, Rincón	7/21/2016	7/21/2021	Approved
Juncos	Caimito, Ceiba Norte, Ceiba Sur, Gurabo Abajo, Gurabo Arriba, Juncos barrio-pueblo, Lirios, Mamey, Valenciano Abajo	2/16/2012	2/16/2017	Lapsed
Las Piedras	Boquerón, Ceiba, Collorones, El Río, Las Piedras barrio-pueblo, Montones, Quebradas Arenas, Tejas	1/5/2012	1/5/2017	Lapsed
Loíza	Canóvanas, Loíza barrio-pueblo Medianía Alta, Medianía Baja, Torecilla Alta, Torecilla Baja	7/21/2016	7/21/2016	Approved
San Lorenzo	Pueblo, Cayaguas, Cerro Gordo, Espino, Florida, Hato, Jagual, Quebrada, Quebrada Arenas, Quebrada Honda, Quemados	8/20/2014	8/19/2019	Approved
Trujillo Alto	Carraízo, Cuevas, Dos Bocas, La Gloria, Quebrada Grande, Quebrada Negrito, St. Just, Trujillo Alto barrio-pueblo	9/12/2014	9/11/2019	Approved

Puerto Rico also maintains a Commonwealth-level Hazard Mitigation Plan, which was revised in 2016 (AEMEAD, 2016), and was developed as the main instrument to guide mitigation efforts that could potentially affect the island. As part of the development of the Puerto Rico Hazard Mitigation Plan, the municipal mitigation plans were reviewed.

4.3.2 Critical Facilities and Other Important Properties in SFHA

Critical infrastructure within the Río Grande de Loíza Watershed has been evaluated by the PRPB. The recompilation of these data has been provided as a GIS layer. The main structures included are: police stations, firefighter stations, areas designated for shelter, reservoirs, airports, schools, and hospitals, among others. Selected critical facilities, such as schools, airports, hospitals, fire stations, and police stations were included on the Flood Risk Discovery Map for assistance in understanding the risk mapping needs within each municipality

Table 17: Critical Infrastructures within Río Grande de Loíza Watershed

	Police Stations	Fire Stations	Schools	Hospitals
Aguas Buenas	2	1	8	-
Caguas	14	3	50	5
Canóvanas	2	2	11	-
Carolina	6	1	12	-
Gurabo	2	-	12	-
Juncos	2	1	13	-
Las Piedras	2	-	8	-
Loíza	-	-	2	-
San Lorenzo	2	3	14	-
Trujillo Alto	4	-	14	3

4.3.3 Hazard Mitigation Grants

According to the data for the Public Assistance (PA) Grant Program as of November 2016, there have been 696 projects funded with this Grant since 2009 for all the municipalities within the Río Grande de Loíza Watershed. These grants were provided for disasters due to hurricanes and severe storms. The total amount of funds provided amounted to $20,207,883. There were also 23 Hazard Mitigation Grant Program projects for municipalities within the watershed as of November 2016, totaling $12,191,483.

Property acquisition and relocation for the purpose of open space is a mitigation action that falls under FEMA's Hazard Mitigation Grant Program. Generally, FEMA-funded property acquisition projects consist of a community purchasing flood-prone structures from willing sellers and either demolishing the structures or relocating the structures to a new site outside of the floodplain. The purchased property is then maintained for open space purposes in order

to restore and/or conserve the natural floodplain functions. This data was currently available for the municipality of Caguas, as of July 2017, and these properties are listed in Table 18.

4.3.4 Mitigation Projects Completed or Underway

There have been different projects funded through federal assistance regarding mitigation, such as road and bridge repair, debris removal, and emergency protection measures, among others. Approximately 7,549 of these types of projects have received PA Funds for all ten municipalities within the watershed. The magnitude of federal money dedicated for all these different projects funded was $19,372,567, while the total cost was $25,756,738, as of November 2016.

Several mitigation projects or hydro-modification projects were identified through the USACE Joint Permit Application or Coastal Zone Certification. These projects are shown in Table 19. It should be noted that these are proposed projects, and it is currently unknown if they have been constructed or finished. For the projects located in the Effective FEMA floodway, project 1508 for Río Grande de Loíza at Ingenio Ward completed a no-rise certificate; however, it is unknown at this time if a no-rise certificate was completed for the other projects.

Table 18: FEMA Open Space Properties in Caguas

Address	Latitude	Longitude	HMGP-Project Number	Ward	Disaster Number or Grant
S-19 Buckingham St Villa del Rey I	18.20858	-66.0439	PR-0014	Villas del Rey	1501
S-20 Buckingham St Villa del Rey I	18.20854	-66.04405	PR-0014	Villas del Rey	1501
S-21 Buckingham St Villa del Rey I	18.20866	-66.04415	PR-0014	Villas del Rey	1501
S-22 Buckingham St Villa del Rey I	18.20877	-66.04427	PR-0014	Villas del Rey	1501
S-23 Buckingham St Villa del Rey I	18.20878	-66.04436	PR-0014	Villas del Rey	1501
T-1 Buckingham St Villa del Rey I	18.20895	-66.04457	PR-0014	Villas del Rey	1501
T-2 Buchkingham St,Villa del Rey I, Turabo Ward	18.20895	-66.0447	PR-0013	Villas del Rey	1552
Lot 102 C, Street 3	18.211164	-66.07273	PDM-2013-0005	Cañaboncito	PDM-2013
Lot 101 A, Street 3	18.211003	-66.073175	PDM-2013-0005	Cañaboncito	PDM-2013
Lot 208 A, Street 3	18.211217	-66.073411	PDM-2013-0005	Cañaboncito	PDM-2013
Lot 178, Street 1	18.210697	-66.072453	PDM-2013-0005	Cañaboncito	PDM-2013
Lot 164, Street 4	18.212461	-66.073958	PDM-2013-0005	Cañaboncito	PDM-2013
Lot 214 B, Street 5	18.211867	-66.073111	PDM-2013-0005	Cañaboncito	PDM-2013
Lot 205-A, Street 3	18.21123	-66.072997	PDM-2013-0005	Cañaboncito	PDM-2013
Lot 182, Street 1	18.211456	-66.07245	PDM-2013-0005	Cañaboncito	PDM-2013
Lot 213, Street 4	18.212064	-66.073756	PDM-2013-0005	Cañaboncito	PDM-2013
Lot 183, Street 1	18.211647	-66.072519	PDM-2013-0005	Cañaboncito	PDM-2013

Table 19: USACE Joint Permit Application or Coastal Zone Certification Proposed Projects

Municipality	Project[1]	Location	Latitude	Longitude	CZ/JPA	Permit Application Date	FEMA SFHA Zone
Caguas	River bank stabilization	Turabo River (HIMA Hospital south bound)	18.216496°	-66.031309°	0519-059	May 2009	Floodway
Caguas	Channelization segment	Río Bairoa, PR-1, Km 36.5	18.255776°	-66.035657°	0914-018	Sept. 2012	Floodway
Caguas	River bank restoration	Turabo River, PR 183, Km. 1.2	18.22476	-66.0178	1011-025	Oct. 2010	Floodway
Caguas	Los Muertos Creek banks protection at Villa del Rey	Street 4 to 10, Cañaboncito Ward	18.215362°	-66.055410°	0905-014	Sept. 2012	Floodway
Caguas	New bridge	Turabo River (PR-183 int. PR 789)	18.218895°	-66.028881°	0910-027	Sept. 2014	Floodway
Carolina	Bridge reconstruction	Maracuto Creek	No data	No data	1010-035	Oct. 2014	AE
Carolina	Seawall rehabilitation	Isla verde (Galaxy Condominum)	No data	No data	No data	Nov. 2011	VE
Carolina	Storm drainage system improvements and flood control works	Los Angeles Housing, Cangrejo Arriba	18.427162°	-66.008663°	0209-068	Feb. 2015	AE
Carolina	River slope restoration at Ingenio Street	Rio Grande de Loiza, Ingenio Ward	18.385125°	-65.946715°	1508	Sept. 2016	Floodway
Juncos	Bank stabilization	Gurabo River, PR-31, Km. 24.6	18.238054°	-65.909077°	0326-053	March 2009	Floodway
Juncos	New channel for flood mitigation	Urb. Ceiba Norte (Ceiba Creek)	18.226100°	-65.909199°	0829-020	Aug. 2011	A

[1]These are proposed projects. It is unknown if they were constructed and/or finished. Project 1508 has a no-rise certificate. For others in the floodway, it is unknown if they have a no-rise certificate.

CZ = Coastal Zone Certification

JPA = Joint Permit Application

The municipality of Caguas provided a shapefile with mitigation plan points for the municipality that included information about mitigation projects and recommendations from their Approved Projects Plan 2016 and Projects Maintenance Plan 2021. This data is included in Appendix H as a figure and supplemental table. The municipality of Caguas also noted the channelization of the Quebrada de Los Muertos on the segment between the urbanization of Turabo Gardens and Villa del Rey. This section suffered from severe erosion, which put the houses located along it at risk.

The municipality of Canóvanas noted the three following mitigation measures to reduce risk associated with floods that are underway or completed:

- For the flooding of the Río Grande de Loíza, Canóvanas ditch and channel – the Department of Natural Resources developed a plan and projects to mitigate the effects associated with the flooding of the Río Grande de Loíza of Carolina, Loíza, and Canóvanas. Several projects have been finalized and others are in process.
- Retention basin at Plaza Canóvanas was constructed by the developer.
- Retention basin at Outlet 66 was constructed by the developer.

4.4 Other Data Received from Stakeholders

In addition to data received from stakeholders through the Discovery Data Questionnaire, Discovery Kick-off Meeting, and Discovery Meeting, the following items were provided by watershed stakeholders:

- The Department of Housing provided a map and geodatabase showing their projects in the Watershed. The map shows projects based on the following categories: Law 173, special communities, properties available for sale, project based, and residential. A copy of the map is included in Appendix G.
- FEMA Caribbean Area Division provided open space data within the watershed
- USGS provided historic high water mark reports

5. Discovery Meetings

The main goals of the Discovery Meeting is to review and validate the gathered flood risk data; discuss the municipality's flood history, development plans, flood mapping needs, and flood risk concerns; and discuss the importance of mitigation planning and community outreach.

Four in-person Discovery Meetings throughout the Río Grande de Loíza Watershed were held from May 10-12, 2017. An additional meeting for the Municipality Carolina was held on May 31, 2017. Table 20includes the meeting dates and locations for the Discovery Meetings.

Table20: Discovery Meetings

Meeting Date and Time	Municipalities	Meeting Location
May 10, 2017 9:00 AM	Carolina	Carolina
May 10, 2017 2:00 PM	Caguas	Caguas
May 11, 2017 9:00 AM	Aguas Buenas Gurabo San Lorenzo Trujillo Alto	Gurabo
May 12, 2017 9:00 AM	Canóvanas Juncos Las Piedras Loíza	Canóvanas
May 31, 2017 1:30 PM	Carolina	Carolina

The Discovery Maps were displayed at the meetings to facilitate the discussions. Attendees, including affected municipalities and other watershed stakeholders, were asked to cooperatively identify areas of flood hazard concern within the Río Grande de Loíza watershed. Input received from watershed stakeholders, as well as findings from the Discovery process, is discussed in Section 6.

Following the Discovery Meetings, meeting invitees received a copy of the PowerPoint presentation and meeting minutes.

Appendix C includes the following Discovery Meeting materials:

- Discovery Meeting presentations
- Discovery Meeting minutes
- Discovery Meeting sign-in sheet

6. Discovery Process Findings

The necessity of any future Risk MAP projects in the watershed is determined through the review of watershed-wide data (see Section 4), Discovery Maps, and watershed stakeholder input.

6.1 Discovery Maps

The Discovery Maps are a resource used to display and share the data and information collecting during the Discovery process. The Río Grande de Loíza Project Team created a set of four Discovery Maps, following FEMA's Discovery guidelines (FEMA, 2016a):

- Flood Risk Discovery Map
  The Flood Risk Discovery Map includes FEMA's Effective SFHAs, the location of dams, LOMC clusters (of four or more), and USGS stream gages. The map also shows several critical facility types, including schools, airports, hospitals, fire stations, and police stations. This map provides a holistic view of flooding in the watershed, as currently recognized by FEMA's Effective FIRMs, and provides an idea of critical facilities currently impacted.
- Mapping Needs Discovery Map
  The Mapping Needs Discovery Map includes the CNMS validation status for streams in the watershed. This map provides a comprehensive view of mapping needs based on FEMA's CNMS database.
- Potential Loss Discovery Map
  The Potential Loss Discovery Map includes the AAL per census block, the number of repetitive losses, and the number of NFIP flood insurance policies. This map can be used to determine areas with high AALs.
- Community Comments Discovery Map
  The Community Comments Discovery Map summarizes comments related to flood risks received from watershed stakeholders at the Discovery Meetings. The comments are represented by numbers that correspond to numbers on a supplemental table included with this map.

All the maps include the Río Grande de Loíza Watershed HUC-8 boundary, municipal boundaries, streamlines from FEMA's Effective National Flood Hazard Layer database, and major roads and highways. To comply with FEMA's Discovery guidelines (FEMA, 2016a) and ensure privacy, sensitive data, such as data that may name a unique address or person, was aggregated and/or generalized at the centroid of a census block and represented as a point or generalized area.

The draft Discovery Maps, along with the draft Discovery Report, were provided to the watershed stakeholders for feedback prior to the Discovery Meetings. The draft Discovery Maps were presented at the Discovery Meeting as a facilitation and communication tool.

The Discovery Maps were finalized following the Discovery Meetings and incorporated stakeholder comments and feedback.

6.2 Summary of Stakeholder Comments about Flood Study Needs

Stakeholder input received through discussions at the Discovery Meetings and through the Discovery Data Questionnaires indicated the need for updated studies, as well as new areas that should be studied. Input about flood risks related to specific municipalities is summarized below.

The Municipality of Aguas Buenas filled out the Discovery Data Questionnaire and municipal officials attended the Discovery Meetings. Input from the Municipality of Aguas Buenas about flood study needs included the following:

- SFHAs currently shown on the FIRMs should be revised for knowledge
- During the Discovery Meetings, the following two areas were pointed out (see Community Comments Discovery Map for geographical locations):
    - Bridge inundation area along Río Bairoa, which is currently correctly shown as being in an Effective SFHA
    - Recurring flood area at the Holy Spirit Church

The Municipality of Caguas filled out the Discovery Data Questionnaire and municipal officials attended the Discovery Meetings. Input from the Municipality of Caguas about flood study needs included the following:

- There are areas that get flooded that are not currently included on the FIRMs
- There are areas that are currently included on the FIRMS that do not get flooded
- Changes to flood risks are expected related to the completion of channelization of the Quebrada Muertos between Turabo Gardens and Villa del Rey
- During the Discovery Meeting, municipal officials provided a map and corresponding shapefile that show the locations of municipal flood risks. These have been included on the Community Comments Discovery Map and supplemental table. Many of the provided areas are currently not in an Effective SFHA. These areas were considered by for the recommended future Risk MAP project scope. Based on discussions with the Municipality, numerous recurring flood areas are caused by local drainage issues that are not related to riverine flooding.

The Municipality of Canóvanas filled out the Discovery Data Questionnaire and municipal officials attended the Discovery Meetings. Input from the Municipality of Canóvanas about flood study needs included the following:

- It is very important for the maps to be revised because there are areas that do not flood that are included in the Effective FIS and areas that do flood, which should be included
- Flooding is not accurately represented on the FIRMs for Jardines de Canóvanas, San Isidro, Quintas de Canóvanas, Campo Rico, and La Central
- H&H study performed or in-process for:
    - Río Grande de Loíza by Pueblo Indio and La Central, study by Caribe Environmental Services in 2015
    - Río Canóvanas by Quebrada Prieta, study by private developers
    - Río Canóvanas by River Hills Development (now River Valley and River Valley Park), study by LEMA Developers

    - Río Canóvanas by Señorio de Gonzaga Residential Development, study by CMA Architects and Engineers in 2005
    - Río Canóvanas by Las Haciendas, study by Roberto Lopez and Associates
    - Quebrada Calderón by Ocean Hills Estate and River Hills, study by Osvaldo Rivera and Associates in 2006
- Changes to flood risks are expected as a result of the construction of the retention pond at Plaza Canóvanas; it has helped avoid inundation in Jardines de Canóvanas
- Worried there is beginning to be construction for development with stormwater runoff that affects several communities, including Villa Tiro in San Isidro, Las Delicias in San Isidro, Campo Rico in PR-185, and Loíza Valley

- During the Discovery Meetings, the following areas were pointed out (see Community Comments Discovery Map for geographical locations):
    - Recurring flood area in San Isidro, which is currently correctly shown as being in an Effective SFHA
    - Recurring flood area in San Isidro Villo Hugo 1 and 2, which is currently correctly shown as being in an Effective SFHA
    - Recurring flood area in Jardines de Canóvanas, which is currently correctly shown as being in an Effective SFHA
    - Recurring flood areas in Loiza Valley and other locations near Río Grande de Loíza Reach 1, which are currently not in an Effective SFHA
    - Recurring flood area near Río Canóvanas, which is currently not in an Effective SFHA
    - Bridge inundation area along Río Canóvanas, which is currently correctly shown as being in an Effective SFHA

The Municipality of Carolina filled out the Discovery Data Questionnaire and municipal officials attended the Discovery Meetings. Input from the Municipality of Carolina about flood study needs included the following:

- During the Discovery Meetings, the following areas were pointed out (see Community Comments Discovery Map for geographical locations):
    - Future LOMC location that will be submitted in 2017 along Río Grande de Loíza Reach 1
    - Area that has not seen flooding in years and is above the inundation zone located in an Effective Zone A SFHA
    - Location of two retention ponds in the area

Lilly del Caribe, located in the Municipality of Carolina, also filled out the Discovery Data Questionnaire and attended the Discovery Meetings. Input from Lilly del Caribe about flood study needs included the following:

- Lilly del Caribe performed modeling using TUFLOW with Atkins; this modeling reflected some changes in BFEs with respect to the Effective 2009 FEMA maps. This information was submitted to FEMA. Lilly del Caribe noted that the modeling needs to be taken in consideration for new development and construction.

The Municipality of Gurabo filled out the Discovery Data Questionnaire and municipal officials attended the Discovery Meetings. Input from the Municipality of Gurabo about flood study needs included the following:

- The following areas should be restudied: the area of Celada and Hato Nuevo, area of urbanization the Robles and the Flamboyanes in Rincon Valle of Santa Barbara.
- Permits should be provided for the cleaning in the area of rivers or ravines that flow into the watershed of the Gurabo River. The excess trash and sediment at the bottom of the lake is one of the biggest contributors for erosion problems.

The Municipality of Loíza attended the Discovery Meetings. Input from the Municipality of Loíza about flood study needs included the following:

- During the Discovery Meetings, the following areas were pointed out (see Community Comments Discovery Map for geographical locations):
    - Area (Calle Espíritu Santo and San Patricio) floods when dam is open due to being at sea level; this area is currently a coastal SFHA on the Effective FIRM.
    - Several recurring flood areas along Río Grande de Loíza Reach 1 are currently correctly shown as being in an Effective SFHA. One of these locations has an accumulation of 3-4 feet of water from Caño Gallando and Río Grande de Loíza.

Additionally, general input about flood risks in the watershed was received, including the following:

- The Department of Transportation and Public Works responded that all Effective flooding should be revised because they are incorrectly delineated with obsolete information and methodology and inadequate representation.
- The GAR noted that they are aware of areas with frequency flooding and that it is important for these areas to be identified on the maps so that there can be an increase in fund allocation for these.
- The Puerto Rico Electric Power Authority noted that an H&H study for the Reservoir Patillas has been completed. This reservoir is outside of the watershed of study.

6.3 Recommendations for Future Risk MAP Project Scope

Recommendations for future Risk MAP project scope in the Río Grande de Loíza Watershed are shown in Table 20and Figure 8. A copy of figure is also included in Appendix I as a PDF. The study locations were determined based on current CNMS status, stakeholder input, assessment of watershed data, and FEMA's Discovery guidelines (FEMA, 2016a).

New island-wide LiDAR is expected to be completed in January 2018, and this new dataset will serve as the topographic foundation for future Risk MAP studies in the Watershed and across the island. It is recommended that older studies be updated or redelineated using the newer terrain data because it will more accurately delineate the floodplain and flood risks.

There are currently three streams (Río Canóvanas, Río Grande de Loíza Reach 1, and Río Grande de Loíza Reach 2) with an Unverified status in CNMS. These studies should be restudied to provide more accurate representation of flood risks to the affected municipalities. Additionally, the Lilly del Caribe flood study should be considered during the restudy of Río Grande de Loíza Reach 1.

Within the Watershed, the entire Zone A studies currently has an Unknown status in CNMS. These studies should be restudied in order to provide model-backed water surface elevations to the municipalities. Having model-backed water surface elevations assists municipal planning and improves the identification and understanding of flood risks. There are a few streams (Quebrada Cambute, Río Grande de Loíza Reach 1, Río Grande de Loíza Reach 2 (in Gurabo), and Unnamed Stream (in San Lorenzo)) that should be upgraded to detailed studies due to development in the area.

Other streams to study were identified based on municipality comments, assessment of the current Effective data or lack of Effective study, and development in the area.

The Effective Zone AE streams that currently have a Valid CNMS status should be redelineated using the new LiDAR-based topographic data. Ideally, these streams would be restudied, however, as the studies are relatively recent and there were no major community concerns about them, redelineation is a viable option to help allocate funding to studying other identified flood risks.

Table 21: Proposed Scope of Study

Stream Name	CNMS REACH ID	Municipalities Impacted	Miles	Effective Study Type	Proposed Study Type	Reason(s) for Study
All Effective Zone AE Studies with an Unverified CNMS Status	-	**Canóvanas, Carolina, Gurabo, Loíza, San Lorenzo, Trujillo Alto**	**35.56**	**Detailed**	**Detailed**	**CNMS status is Unverified**
Río Canóvanas	720000100223	Canóvanas	6.81	Detailed	Detailed	• Municipality request • Effective engineering study from 1979 using HEC-1 & HEC-2 and older topographic data
Río Grande de Loíza Reach 1	720000100355	Loíza, Canóvanas, Carolina, Trujillo Alto	16.64	Detailed 2D	Detailed 2D or 1D/2D	• Municipality request • Consider Lilly del Caribe 2D study during updated analysis
Río Grande de Loíza Reach 2	720000100126	Caguas, Gurabo, San Lorenzo	12.11	Detailed	Detailed	• Municipality comments
All Effective Zone A Studies	-	**Aguas Buenas, Caguas, Canóvanas, Carolina, Gurabo, Juncos, Las Piedras, San Lorenzo, Trujillo Alto**	**36.47**	**Approximate**	**Varies**	**CNMS status is Unknown for all Zone A streams in the watershed, and the Effective studies are not model backed**
Lago Loíza	720000100009	Caguas, Gurabo, Trujillo Alto	4.91	Approximate	Approximate	
Quebrada Algarrobo	720000100008	Caguas	0.28	Approximate	Approximate	
Quebrada Arenas	720000100086	Juncos	0.89	Approximate	Approximate	
Quebrada Cambute	720000100238	Carolina	0.20	Approximate	**Detailed**	• Area is medium to high flood risk • Effective study shows streamline cutting through house and survey would be beneficial for accurate channel representation
Quebrada Ceiba	720000100301	Juncos	1.55	Approximate	Approximate	
Quebrada Grande	720000100164	Trujillo Alto	1.77	Approximate	Approximate	
Quebrada Maracuto	720000100067	Carolina	0.89	Approximate	Approximate	

Stream Name	CNMS REACH ID	Municipalities Impacted	Miles	Effective Study Type	Proposed Study Type	Reason(s) for Study
Quebrada Naranjito	720000100105	Caguas	0.79	Approximate	Approximate	
Quebrada Pastrana	720000100012	Carolina	1.56	Approximate	Approximate	
Quebrada Rohena	720000100133	Trujillo Alto	0.48	Approximate	Approximate	
Río Bairoa	720000100149	Aguas Buenas, Caguas	1.81	Approximate	Approximate	
Río Bairoa	720000100275	Aguas Buenas, Caguas	0.78	Approximate	Approximate	
Río Caguitas	720000100107	Caguas	0.42	Approximate	Approximate	
Río Canaboncito	720000100198	Caguas	0.38	Approximate	Approximate	
Río Canas	720000100168	Caguas	1.79	Approximate	Approximate	
Río Canóvanas	720000100111	Canóvanas	1.38	Approximate	Approximate	
Río Canovanillas	720000100252	Carolina, Canóvanas	0.72	Approximate	Approximate	
Río Cayaguas	720000100264	San Lorenzo	1.81	Approximate	Approximate	
Río Grande de Loiza Reach 1	720000100141	Trujillo Alto	0.04	Approximate	**Detailed**	• Include this reach in the updated detailed study for Río Grande de Loíza Reach 1
Río Grande de Loiza Reach 2	720000100125	Caguas, Gurabo	1.00	Approximate	Approximate	
Río Grande de Loiza Reach 2	720000100192	Gurabo	2.01	Approximate	**Detailed**	• Include this reach in the updated detailed study for the Río Grande de Loíza Reach 2 • Area is medium to high flood risk
Río Gurabo	720000100227	Las Piedras, Juncos, Gurabo	2.08	Approximate	Approximate	
Río Turabo	720000100040	Caguas	1.25	Approximate	Approximate	
Río Valenciano	720000100057	Juncos	0.37	Approximate	Approximate	
Unnamed Stream	720000100336	San Lorenzo	0.12	Approximate	Approximate	
Unnamed Stream	720000100337	San Lorenzo	0.51	Approximate	Approximate	
Unnamed Stream	720000100338	San Lorenzo	1.36	Approximate	**Detailed**	• Area is medium to high flood risk
Unnamed Stream	720000100334	San Lorenzo	0.62	Approximate	Approximate	
Unnamed Stream	720000100335	San Lorenzo	0.93	Approximate	Approximate	
Unnamed Stream	720000100340	San Lorenzo	0.36	Approximate	Approximate	
Unnamed Stream	720000100339	San Lorenzo	0.83	Approximate	Approximate	

Stream Name	CNMS REACH ID	Municipalities Impacted	Miles	Effective Study Type	Proposed Study Type	Reason(s) for Study
Unnamed Stream	720000100333	San Lorenzo	0.52	Approximate	Approximate	
Unnamed Stream	720000100347	Caguas	0.44	Approximate	Approximate	
Unnamed Stream	720000100348	Caguas	0.90	Approximate	Approximate	
Unnamed Stream	720000100349	Caguas	0.70	Approximate	Approximate	
Other Streams to Study	**-**	**Aguas Buenas, Caguas, Canóvanas, Carolina**	**22.97**	**Varies**	**Varies**	**Varies**
Quebrada Muertos	720000100167	Aguas Buenas	0.90	Detailed	Detailed	• Municipality comments; changes to flood risks expected related to channelization of Quebrada Muertos • Effective engineering study from 1979 using HEC-1 & HEC-2 and older topographic data
Río Caguitas Tributary 1	720000100080	Caguas	2.74	Detailed	Detailed	• Effective engineering study from 1979 using HEC-1 & HEC-2 and older topographic data
Río Caguitas Tributary 2	720000100283	Caguas	0.83	Detailed	Detailed	• Effective engineering study from 1979 using HEC-1 & HEC-2 and older topographic data
Rio Canovanillas	720000100041	Canóvanas, Carolina	1.62	Detailed	Detailed	• Effective engineering study from 1979 using HEC-1 & HEC-2 and older topographic data
Caño San Isidro	N/A	Canóvanas	4.60	N/A	Detailed	• No Effective study • Recent development at upstream end • Municipality comments
Quebrada Cambute	N/A	Carolina	0.77	N/A	Detailed	• Extend Effective study upstream through developed area
Río Turabo	N/A	Caguas	1.79	N/A	Approximate	• Extend Effective study upstream through developed area • Municipality comments

Stream Name	CNMS REACH ID	Municipalities Impacted	Miles	Effective Study Type	Proposed Study Type	Reason(s) for Study
Río Canaboncito	N/A	Caguas	3.01	N/A	Approximate	• Extend Effective study upstream through developed area • Municipality comments
Río Cañas Tributary	N/A	Caguas	1.62	N/A	Approximate	• No Effective study • Add new study through developed area • Municipality comments
Unnamed Stream	N/A	Caguas	0.96	N/A	Detailed	• No Effective study • Add new study through developed area
Unnamed Stream	N/A	Juncos	1.81	N/A	Detailed	• No Effective study • Add new study through developed area
Quebrada Ceiba	N/A	Juncos	0.77	N/A	Detailed	• No Effective study • Add new study through developed area
Unnamed Stream	N/A	Juncos	0.94	N/A	Detailed	• No Effective study • Add new study through developed area
Unnamed Stream	N/A	Juncos	0.61	N/A	Detailed	• No Effective study • Add new study through developed area
Effective Zone AE Streams for Redelineation	-	**Aguas Buenas, Caguas, Carolina, Gurabo, Juncos, Las Piedras**	**35.12**	**Detailed**	**Redelineation**	**New LiDAR-based topographic data will be available in January 2018**
Quebrada Algarrobo	720000100017	Caguas	0.18	Detailed	Redelineation	
Quebrada Cambute	720000100062	Carolina	0.49	Detailed	Redelineation	
Rio Bairoa	720000100092	Aguas Buenas, Caguas	5.85	Detailed	Redelineation	
Rio Bairoa	720000100208	Aguas Buenas, Caguas	0.62	Detailed	Redelineation	

Stream Name	CNMS REACH ID	Municipalities Impacted	Miles	Effective Study Type	Proposed Study Type	Reason(s) for Study
Rio Caguitas	720000100170	Caguas	6.33	Detailed	Redelineation	
Rio Canaboncito	720000100352	Caguas	0.11	Detailed	Redelineation	
Rio Gurabo	720000100128	Las Piedras, Juncos, Gurabo	12.02	Detailed	Redelineation	
Rio Gurabo	720000100245	Las Piedras, Juncos, Gurabo	1.56	Detailed	Redelineation	
Rio Turabo	720000100177	Caguas	5.79	Detailed	Redelineation	
Rio Valenciano	720000100212	Juncos	2.17	Detailed	Redelineation	

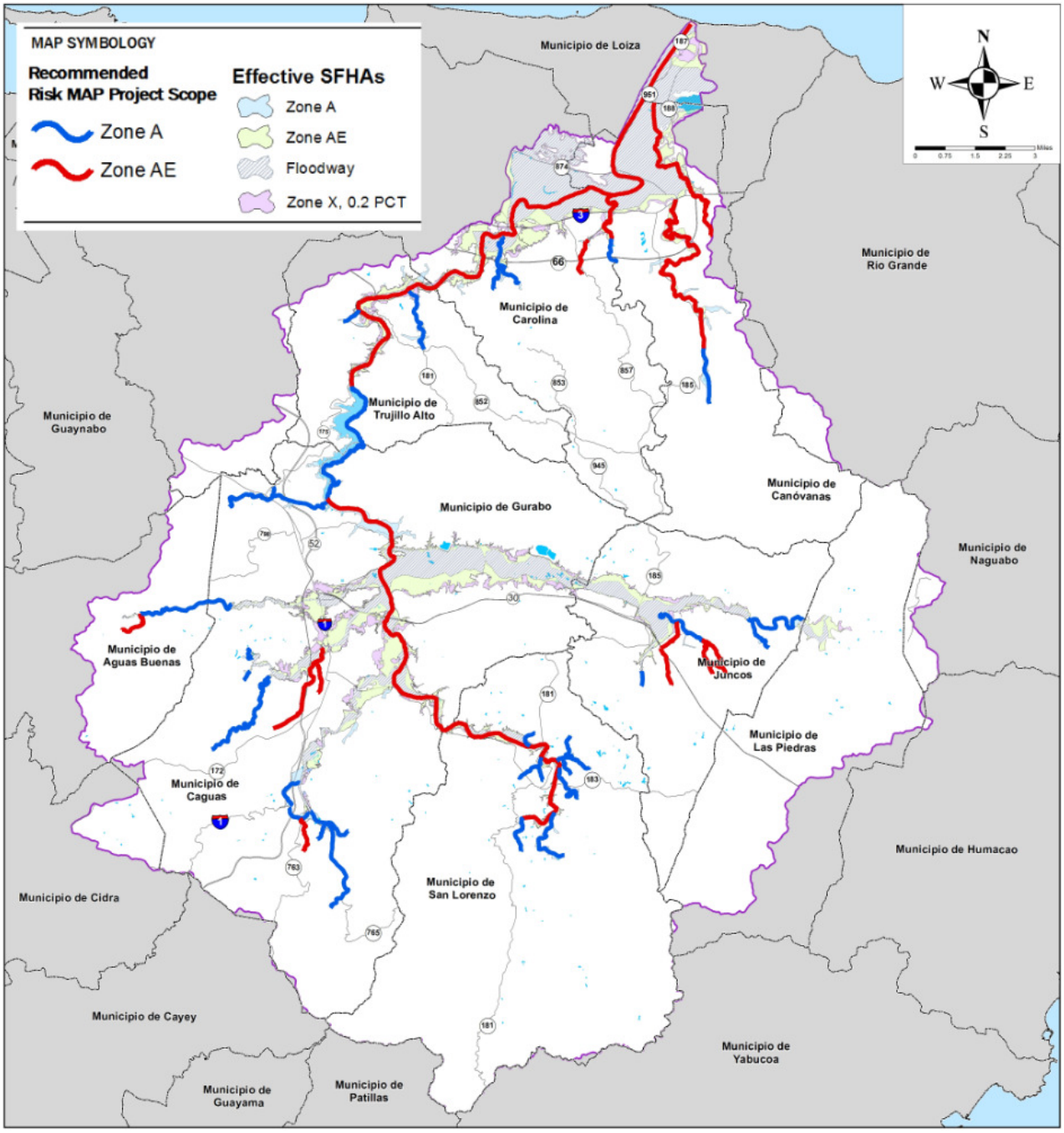


Figure 8: Recommended Risk MAP Scope of Work

6.3.1 Study Types

Table 21provides a summary of proposed study type and stream miles to be studied in the Río Grande de Loíza Watershed followed by explanations of study types.

Table 2: Overview of Proposed Scope of Study (as of August 2017)

Study Type	Miles
Approximate	39.26
Detailed	55.72
Redelineation	35.12

The study types were determined based on the current Effective study, urbanization along the stream, input from watershed stakeholders, and consideration of using the study method that is appropriate based on the level of risk. The study types reflect the type of hydrologic and hydraulic analyses that will be used to determine water surface elevations and floodplain boundary extents. The study type also defines which SFHA (e.g., Zone A, Zone AE) the flooding source and corresponding floodplain will be mapped as.

Approximate (Zone A): Hydrologic and hydraulic analyses are performed using FEMA-approved methods and software for approximate studies. Analyses and floodplain mapping are performed using recent topographic data meeting FEMA quality standards. Approximate study streams are mapped as Zone A SFHAs on FEMA flood maps, and because detailed hydraulic analyses have not been performed, no Base Flood Elevations or flood depths are shown; however, an updated approximate study provides model-backed water surface elevations.

Detailed (Zone AE): Hydrologic and hydraulic analyses are performed using FEMA-approved methods and software for detailed studies. Analyses and floodplain mapping are performed using recent topographic data meeting FEMA quality standards. Structures impacting the inundation area are typically surveyed and included in the modeling. Detailed study streams are mapped as Zone AE SFHAs on FEMA flood maps and will often also include a floodway. Base Flood Elevations are provided, as well as detailed stream profiles.

Redelineation: The current Effective floodplains and associated detailed flood elevations are updated utilizing newer topographic data, such as the LiDAR-based terrain data. LiDAR is an advanced technology that uses light, and in some instances lasers, to measure ground elevations or topography.

6.3.2 Future Risk MAP Products

The FEMA Project Officer will make decisions regarding the types of products (regulatory products and/or Flood Risk Products) to scope as part of the flood risk project in discussions with the other Project Team members, taking into consideration requirements mandated by the Flood Risk Analysis and Mapping standards, and while navigating the Key Decision Point process.

6.3.3 Finalizing Discovery

The final outputs of Discovery are the Final Discovery Map and Final Discovery Report. Additionally, as part of the activities, a Project Charter is sent to watershed municipalities. The Project Charter provides documentation of FEMA and the PRPB's commitment to the watershed and the commitments of the municipalities for a flood risk project. The Project Charter identifies and clarifies roles and responsibilities for the Project Team, municipalities, and other stakeholders; provide a projected timeline and an explanation of what would be expected from FEMA and the PRPB and municipalities at each major milestone; and document the desired study areas. The Project Charter is not a binding agreement, but rather a tool to convey a clear understanding of the scope and its impact in a community. While it is not required, municipalities are encouraged to sign and return the final Project Charter.

At the close of Discovery, the following will take place by September 2018:

- CNMS will be updated and/or populated
- Community-requested project or flooding areas will be added to CNMS
- The final Discovery Products will be uploaded to FEMA's MIP

Following the review of recommendations for a scope of work and discussions with the affected municipalities, FEMA and the PRPB will work towards formally initiating the analysis and mapping work portion of subsequent flood risk projects.

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