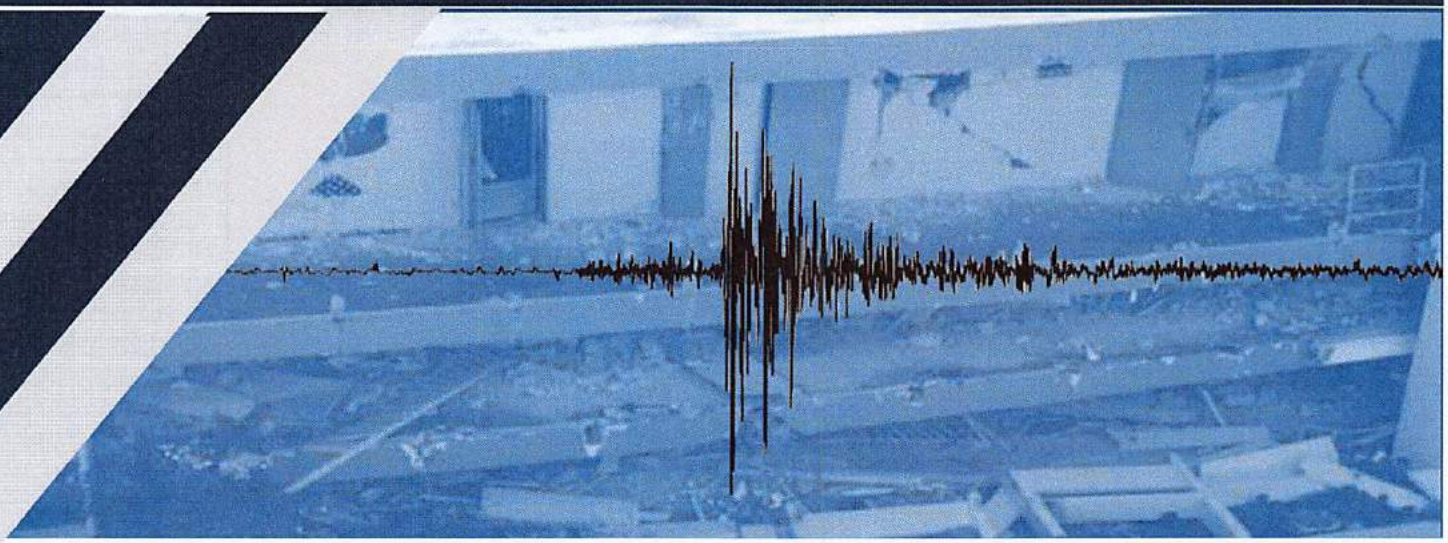
Operational Earthquake Plan of Puerto Rico



ANNEX H:

To Puerto Rico All Hazards Plan of Puerto Rico Emergency Management Bureau (PREMB)

January 2021

For Official Use Only

Protected Critical Infrastructure Information

V 1.6

Document Protection and Management

The following document is privileged content and should be handled as a document for official use only. This document also contains Security Sensitive Information and Protected Critical Infrastructure Information. This document is called the Operational Earthquake Plan of Puerto Rico.

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This Operational Earthquake Plan of Puerto Rico is a draft for strict evaluation and feedback use by the Government of Puerto Rico, its agencies, and FEMA. Until final approval, any changes, suggestions, or comments should be directly referred to the Commissioner of the Puerto Rico Emergency Management and Disaster Management Bureau (PREMB)

This document is for official use only and should not be distributed without the written permission of the PREMB Commissioner until it has been fully approved. Any comment or suggestion should be referenced with page number, objective, section, task, limitation or contingency.

This plan is designed as a living and interactive document subject to ongoing revisions and changes that will depend not only on lessons learned at previous events in Puerto Rico but also on incidents or events that occur anywhere in the world and that offer considerations that we need to integrate into this plan.

Introduction

Of all types of natural events, earthquakes and their secondary consequences have resulted in the largest numbers of casualties in the last century. Puerto Rico has a population of 3.2 million people. This represents one of the densest populations in the United States of America. Puerto Rico is divided into 78 municipalities, two of them are municipality islands. The island of Puerto Rico measures 100 miles from east to west and 35 miles from north to south approximately. [1]

The main island of Puerto Rico, also known as La Isla Grande, is surrounded by geological faults by the four cardinal points, and some of these cross the island. The Puerto Rico Seismic Network, an agency responsible for monitoring earthquakes in the Region of Puerto Rico and the Virgin Islands, has divided the region into 28 seismic zones. Among the most active areas are the Trench of Puerto Rico, Seismic Zone of the Hat, Mona Canyon, Depression of the Virgin Islands Pasaje de Anegada, Trinchera de Los Muertos, the northern region of Puerto Rico, and the southwestern region of the Island where between the end of 2019 and the beginning of 2020 countless seismic movements were registered and felt by thousands of people around the island. In the southwest of the island is sierra Bermeja with its extension of Montalva. Previous studies have indicated that significant seismic incidents (M>7.0) have occurred in the Puerto Rico region in the years 1740,1844,1860,1867, and 1918, some of which have caused tsunamis. These historic earthquakes have caused severe damage to the island's infrastructure. The last significant seismic event that caused extensive damage to the Puerto Rico region occurred in 1918, in Mona Canyon west of the island. This earthquake had a magnitude of 7.3 on the Richter scale, an intensity of IX on the Mercalli scale, and claimed the lives of 116 people, including 40 for the tsunami. The tsunami generated by

[1] USCB (2019) *Annual Estimates of the Resident Population: April 1, 2010 to July 1, 2018.* United States Census Bureau. Extraído de https://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=PEP_2018_PEPANNRES&prodType=table

the earthquake produced waves of up to 20 feet in the Municipality of Aguadilla that arrived inland in a few minutes.[23]

Scientific studies have detected several seismic faults within the island that have the possibility to generate earthquakes greater than 7.0 magnitude. For example, in 2000, as part of scientific studies, a seismic fault was identified near the bay of Boquerón and extends through the municipalities of Lajas and Guánica. This fault is capable of generating earthquakes of a magnitude of 7.0. In fact, the study revealed that in the past there have been earthquakes in this fault, where there have just been countless earthquakes between the magnitudes of 3 [45]to 6 on the Richter scale during January 2020. The earthquake sequence of January 2020 caused major damages to thousands of houses and infrastructures causing millions of dollars in losses.

Geological maps of the U.S. National Geology Service (USGS) indicate that Puerto Rico's seismic risks are similar to the western United States of America regions and that the large island is assigned to Seismic Zone 3 in the Puerto Rico building code. Studies also indicate that thousands of structures that have been improperly constructed or do not comply with building codes established since 1987 could be severely affected or collapse in case of a major earthquake. This is the case of the Agrippina Seda School of Guánica that collapsed during the earthquake in January 2020. Efficient emergency response to a major earthquake will be crucial to minimize the loss of life and disruption of essential services for Puerto Rico's citizens.

Earthquakes of high seismic intensity have occurred in the region where Puerto Rico is located approximately every hundred years. 103 years ago, an earthquake of

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[2] Puerto Rico Seismic Network (n.a.). *1918 earthquake*. Department of Geology. University of Puerto Rico Mayaguez Campus. http://redsismica.uprm.edu/Spanish/educacion/terremotospr/terremoto18.php
[3] RSPR (n.d.). *Tsunami Brochure*. Department of Geology. University of Puerto Rico Mayaguez Campus. http://redsismica.uprm.edu/Spanish/tsunami/media/Publication--sismonotas-tsunamis.pdf
[4] Martínez J., López R., González Y. (2013) *Seismic Rehabilitation of Houses in Zancos*. Puerto Rico Strong Movement Program. Department of Civil Engineering and Agrimensura. University of Puerto Rico in Mayaguez. Page 1. ISBN: 978-1-934325-99-5, 1-934325-96-6
[5] Prentice and Mann (2005). "*Paleoseismic Study of the South Lajas Fault*"

magnitude 7 occurred on October 11, 1918. 3 [6] on the Richter scale that caused a tsunami and caused 116 deaths. On January 7, 2020, an earthquake of magnitude of 6.4 occurred that caused significant damage to the southern part of the island, including the collapse of houses and a school. Experts understand that the island is very close to experiencing the next major Caribbean earthquake. In Puerto Rico, a population of approximately 250,000 people lives in a tsunami-prone area[7][8]. Due to a series of frequent earthquakes that were felt in almost the entire island during 2020 many people have become more seismically conscious.

As part of the government's response, immediately after an earthquake emergency manager must implement coordinated plans and make decisions quickly using minimal information that may be available at the time. The Government of Puerto Rico is developing the Operational Earthquake Plan of Puerto Rico, a Plan that considers the worst-case scenarios and has a detailed operational response section that includes Operational Objectives, specific Tasks, ESF, Responsible Agency, Limitations, and Contingencies in case a major earthquake happens. This plan aims to establish an adequate and educated response for this type of catastrophic event that cannot be predicted. Although an earthquake is a different event than an atmospheric event, this Plan considers the lessons learned and best practices used during the emergency of the most severe event that has impacted Puerto Rico over the past 92 years, category 4 Hurricane Maria that made landfall on September 20, 2017. This historic event exceeded the expectations of the population and the local, state, and federal governments. This new plan includes the initiatives, resources, and strategies needed to respond to a catastrophic event, and is an integral part of the Joint Operational Catastrophic Incident Plan (JOCIP), developed after Hurricane Maria (category 4).

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[6] RSPR (2020) Seismic Information. 1918 earthquake. Puerto Rico Seismic Network. Department of Geology. University Campus of Mayaguez. Extracted from http://redsismica.uprm.edu/Spanish/informacion/terr1918.php

[7] Martínez J., López R., González Y. (2013) *Seismic Rehabilitation of Houses in Zancos*. Puerto Rico Strong Movement Program. Department of Civil Engineering and Agrimensura. University of Puerto Rico in Mayaguez. Page 2. ISBN: 978-1-934325-99-5, 1-934325-96-6

[8] RSPR (2019) Puerto Rico Seismic Network. Guide for Tsunami Warning Focal Point Operators for Puerto Rico. 1st ed. Mayaguez, PR.

The Operational Earthquake Plan of Puerto Rico considers and adopts the term "Catastrophic Incident" as defined by the National Response Framework (NRF): "any natural incident, including hurricanes, earthquakes, floods, landslides, tsunamis, or man-made such as; chemical explosions, air crashes, and terrorist attacks, resulting in extraordinary levels of mass deaths, damage or disruptions that severely affect the population, infrastructure, environment, economy, national morals and/or government functions. A catastrophic incident can cause damage at the national level for a very long period time, exceeding the available resources of federal, state, local, and private sector authorities."

Development of the Plan

Development of the Operational Earthquake Plan of Puerto Rico began in April 2019 by the ISP's Research and Planning team. More than 150 professionals and scientists participated in meetings, interviews, physical inspections, and workshops for the development of the Operational Earthquake Plan. To achieve an integration of the emergency management community, the operational strategies of this Plan were discussed and developed with the Interagency Coordinators of the 32 main government agencies and by Municipal Emergency Management Directors who considered the particular characteristics of their municipalities. Identification and analysis of Vulnerabilities, Risks, and Impact (VRI) of critical infrastructure were carried out on the 78 municipalities. Some of these are critical roads and bridges, stilt houses conglomerates, fuel, and chemical storage sites, geological hazard areas, and national interest critical infrastructures. These analyses are part of this Plan (See VRI Municipal Appendices).

This Plan was created in compliance with guidelines established by the U.S. Department of Homeland Security (DHS), the Federal Emergency Management Agency (FEMA), the Federal Preparedness Guide 101 (CPG 101) version 2 of 2010, National Response Framework 2016, presidential order, Number 5 Homeland Security Presidential Directive #5 - National Incident Management System (NIMS) 2017 and Law No. 20 of April 10, 2017, Continuity Guidance Circular 2 (CGC2), Department of Public Safety, Emergency Management Negotiated and Disaster Management of Puerto Rico (PREMB). This Plan provides for the PREMB's ministerial duty to coordinate the preparedness, mitigation, response, and recovery efforts of the Government of Puerto Rico and municipalities before, during, and after an emergency or disaster. Also, it follows the federal regulation of the NRF 2016, which indicate that "Any emergency will be attended by the local jurisdiction first (municipality), if it does not have the necessary resources, jurisdictions regions will provide support and if the regions do not have the necessary resources, the state will provide them. If the emergency or disaster over passes the state's capabilities, the federal government and FEMA will provide the

necessary support to respond to and recover from the emergency or disaster" (NRF 2016).[9]

This plan has been developed according to scientific studies, historical documents, various sources of information, interviews with experts in the different subjects concerned, development of various vulnerability, risk and impact analyses, academic references, and onsite field inspections that were carried out in each municipality of Puerto Rico. Participants in the scientific team include professionals from the Puerto Rico Seismic Network, the Federal Emergency Management Agency (FEMA), Georgetown University, and members of the University of Puerto Rico's Engineering Department, municipal emergency managers, staff, and expert consultants in the emergency management and national security fields. This analysis was the basis for the development of the response and recovery strategies included in this Plan to identify priorities, reduce response time, maximize resource utilization, and identify operational objectives.

During the municipal visits, the inspectors interviewed municipal staff to identify and collect data from high-risk areas and make an inventory of municipal resources that can be used during an emergency following as per NIMS's Incident Resource Inventory System (IRIS) guidelines. The identified resources were classified by type and category following the Requirements of the Resource Typing of each municipality. This inventory can also be uploaded to the Computer Aided Dispatch (CAD) an incident management system currently in use at the municipal and state level.

[9] (2016) Federal Emergency Management Agency. *National Response Framework*. Third Edition. US Department of Homeland Security. Washington, D.C. https://www.fema.gov/media-library-data/1466014682982-9bcf8245ba4c60c120aa915abe74e15d/National_Response_Framework3rd.pdf

Promulgation Document

The following Plan was prepared following guidelines established by the U.S. Department of Homeland Security (DHS), the Federal Emergency Management Agency (FEMA), and following the guidelines outlined in the Comprehensive Preparedness Guide 101 (CPG 101) version 2 of 2010. The primary purpose of this plan is to establish preparedness strategies, response, and recovery stages needed to protect life from an earthquake with catastrophic results in Puerto Rico. This Plan aims to be inclusive, targeted at all communities, and to allow equity among all citizens. For this reason, this Operational Earthquake Plan of Puerto Rico takes effect immediately under the protection and authority conferred on it by the Laws and Executive Orders of the Government of Puerto Rico, Homeland Security Presidential Directive #5, Law #20 April 2017 Department of Public Safety (DSP) and the Puerto Rico Emergency Management and Disaster Management Agency (PREMB) and Executive Order Number OE-2005-36 on the Implementation of the National Incident Management System (NIMS).

This plan requires the participation of all state agencies, departments, or regional offices located in the municipalities and orders the faithful fulfillment of the duties and responsibilities assigned therein. In addition, it orders to maintain and maintain complete coordination with each other with private organizations, industry, and commerce, municipalities, state and federal agencies, as required by the Homeland Security Presidential Directive #5 and the National Response Framework.

Under the powers conferred by Law 20-2017, the Acting Commissioner of the Puerto Rico Emergency Management Bureau is responsible for the implementation and maintenance of this Plan in collaboration with the other applicable state and federal agencies. In addition, reference material from the U.S. National Earthquake Information Center, Pacific Tsunami Warning Center, Caribbean Tsunami Warning Program, and the Puerto Rico Seismic Network was used.

Therefore, it is Public Policy of the Acting Commissioner to make available, human, economic, technical, and professional resources to ensure that the government has an effective and functional plan to minimize the loss of life or property in case a major earthquake happens.

Given in San Juan, Puerto Rico on the 16 day of april 2021

Nino Correa Filomeno
Acting Commissioner
Puerto Rico Emergency Management Bureau

Approval and Implementation

The Operational Earthquake Plan was created in compliance with the FEMA's Comprehensive Preparedness Guide (CPG) 101 Version November 2, 2010.

Mr. Nino Correa Filomeno, Interim Commissioner of the Puerto Rico Emergency Management Bureau stamps his signature on the date provided in this document authorizing the approval and implementation of this plan and granting the authority to implement and review this plan to the Puerto Rico Emergency Management Bureau subject to all mandates and legal responsibilities.

By stamping his signature, the Acting Commissioner states that this document will be the Emergency Authority that will govern the operations of the Government of Puerto Rico by implementing the Operational Earthquake Plan of Puerto Rico with the necessary exceptions and amnesties to make sure the emergency operations are implemented accordingly to guarantee the well-being, safety, and health of the entire population of Puerto Rico in the event of a catastrophic earthquake in Puerto Rico.

Nino Correa Filomeno
Acting Commissioner
Puerto Rico Emergency Management Bureau

Changes Log

# Change	Page	Basic Plan	Annex	Date	Name	Signature
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Plan Distribution

	Organization/Agency	Received by	Date	Signature
01	Department of Transportation and Public Works (DOT)			
02	Department of Agriculture			
03	PR Fire Bureau			
04	Forensic Science Institute			
05	PR Department of Health			
06	PR State Department			
07	Emergency Medical Services			
08	PR Treasury Department			
09	The Capitol			
10	PR Planning Board			
11	Natural Resources Dept.			
12	Budget and Management Office			
13	General Service Administration			
14	Telecommunications Bureau			
15	Tourism Company			
16	Transportation and Other Services Bureau			
17	PR Ports Authority			
18	PR Emergency Management Bureau (PREMB)			
19	PR Department of Sports and Recreation			

	Organization/Agency	Received by	Date	Signature
20	Department of Corrections			
21	Governor's Office			
22	PR Department of the Family			
23	PR Aqueduct and Sewer Authority (PRASA)			
24	PR Electrical Power Authority (PREPA)			
25	Department of Justice			
26	PR Police Bureau			
27	Department of Housing			
28	Department of Education			
29	Department of Economic Development and Commerce			
30	9-1-1 Emergency Services			
31	PR Permits Office			
32	Business Emergency Operations Center, BEOC			
33	PR National Guard			
34	Municipal Emergency Management Offices			
35	US Army Corps of Engineers			
36	Federal Bureau of Investigations (FBI)			
37	US Customs and Border Patrol (CBP)			
38	Homeland Security Investigations (HSI)			

	Organization/Agency	Received by	Date	Signature
39	Federal Emergency Management Agency (FEMA)			
40	Department of Homeland Security			

Table of Content

Planning Elements

A. Purpose

The purpose of this is Plan is to establish operational functions that provide strategic guidance for the proper management of the response and recovery after a major earthquake with catastrophic consequences in Puerto Rico. The Operational Earthquake Plan of Puerto Rico identifies priorities, reduces response time, maximizes resource utilization, identifies operational objectives, and defines roles and responsibilities at the federal, state, and municipal levels.

The Operational Earthquake Plan aims to provide municipalities, emergency coordinators, and state personnel operating in the state Emergency Operations Center a plan with proactive and prioritized actions to coordinate the operational response to a high-intensity earthquake affecting part or all of the island.

The Operational Earthquake Plan considers the risk of substantial loss of life and critical infrastructure during an earthquake that can be considered catastrophic and that is considered the worst scenario for the island. The loss of critical infrastructure would represent an environmental and economic impact not only in Puerto Rico, but also in the United States and many parts of the world. In addition, this Plan provides the necessary operational tasks for the initial and sustained response to a high-intensity earthquake with catastrophic consequences.

B. Scope

The Operational Earthquake Plan of Puerto Rico is a plan that is designed for the federal government represented by the Federal Emergency Management Agency (FEMA), the state government represented by the Department of Public Safety (DSP), the PR Emergency Management Bureau (PREMB), state agencies, municipalities, and the private industries represented by the Business Emergency Operations Center (ESF 17). This document contains the Incident Command System (ICS) organizational structures that PREMB, the 32 emergency response agencies and municipalities will carry out during and after a major earthquake with disastrous consequences. On the other hand, FEMA will coordinate with federal agencies under the umbrella of the US Department of Homeland Security and the other branches of the U.S. government that will provide support after the incident. FEMA has preset the allocated resources that will be sent in the first 72 hours "Pushing Resources" as soon as a catastrophic earthquake occurs in Puerto Rico. PREMB will coordinate with state agencies and municipalities the resources needed to respond to a catastrophic earthquake in Puerto Rico that in addition had the potential to cause a tsunami in the region. Municipalities are the first line of response to an incident and are the ones that will handle incidents that occur in their jurisdictions until their response capabilities or resources are scarce or the incident surpasses its capabilities. The responsibility of the State is to provide the necessary support that municipalities request through their Mayors or Directors of Emergency Management.

C. Situation

The geographical location and geological composition of the Puerto Rico archipelago makes it very vulnerable to earthquakes. An earthquake occurs every time the rocks that form the Earth's outer solid layer, known as the Earth's crust, are separated or slide causing friction. This happens when the forces that move the Earth's tectonic plates exceed the resistance of the rocks that form the edges of the plates[10] producing catastrophic consequences. The Main Island (Puerto Rico) is surrounded and crossed by many seismic faults that can produce high-intensity earthquakes (see Figure 1.2). There are faults in Puerto Rico that can generate earthquakes greater than magnitudes between 7 and 8 on the Richter scale. Continuously the North American Plate is colliding with the Caribbean Plate on which Puerto Rico is located and that energy accumulates and is released in the form of an earthquake generating ruptures or failures. The energy accumulates until the rocks no longer resist and a rupture or displacement occurs causing an earthquake. Puerto Rico is located on the boundary between the plates of North America and the Caribbean making it a highly active region. There is evidence of oblique subduction and lateral displacement between the two plates. According to Bolt (2003) most of the largest earthquakes in history, such as the Chile earthquake in 1860 and Alaska in 1964, originate in subduction zones. [11]Seismic activity is mostly concentrated in eight zones; The trench of Puerto Rico, the faults of the North and South Slope of Puerto Rico, Zona del Sombrero, Cañón de la Mona, Pasaje de la Mona, Virgin islands and Anegada, Trinchera de Muertos, and the southwest region of the island (e.g. Valle de Lajas, Guayanilla and Yauco area).

[10] Molinelli J. (n.a.) How to Protect yourself in case of earthquake? What geological hazards do earthquakes accompany? Civil Defense of the Municipality of San Juan.
[11] Bolt., B.A. (2003). Reverte series science and society. Earthquake. Loreto, Barcelona: Editorial Reverte.

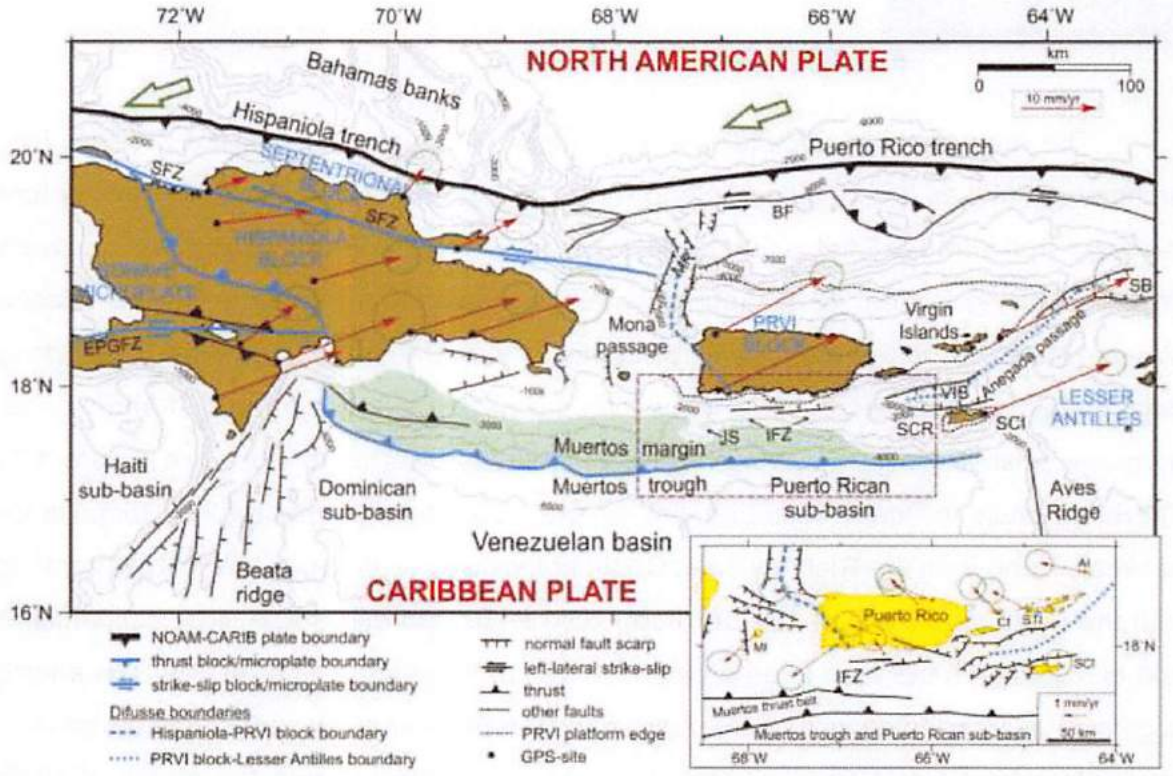

Figure 1.2 Tectonic plates

Geological Faults of Puerto Rico (PR Seismic Network)

Among the areas of greatest seismicity are:

1. Puerto Rico Trench
2. North Region of Puerto Rico
3. El Sombrero
4. Mona Canyon
5. Virgin Islands Depressions
6. Anegada Road
7. Trinchera de Los Muertos
8. South Region of Puerto Rico

Puerto Rico has a long history of earthquakes that have caused major damage in the past. Several earthquakes that have occurred off the coast of Puerto Rico have affected the island such as in the years 1520, 1615, 1670, 1751, 1787, 1867, and 1918.[12]

Studies show that earthquakes of a possible magnitude of 7.0 have occurred in the interior of the island in the past.[13] However, a high-intensity seismic event with catastrophic consequences has not occurred in the inland part of the Island.

There are factors and variables that affect the impact and catastrophic consequences of a high-intensity earthquake, such as; population density, the high potential for a tsunami to occur, the geological material where the structures are located, the distance from the epicenter, the intensity of the earthquake, the behavior of the infrastructure, poor construction practices and special populations.

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[12] C.S. Mueller, A.D. Frankel, M.D. Petersen, and E.V. Leyendecker (2004) Documentation for 2003 USGS Seismic Hazard Maps for Puerto Rico and the U.S. Virgin Islands. US Geological Survey.
[13] Mann P. (2005) *Special Paper 385.* Institute for Geophysics, Jackson School of Geosciences, University of Texas at Austin, 4412 Spicewood Springs Road, Building 600, Austin, Texas 78759, USA

The graph below shows the number of earthquakes that have been recorded by the Puerto Rico Seismic Network from the year 2000 to 2020. (See Figure 1.3)

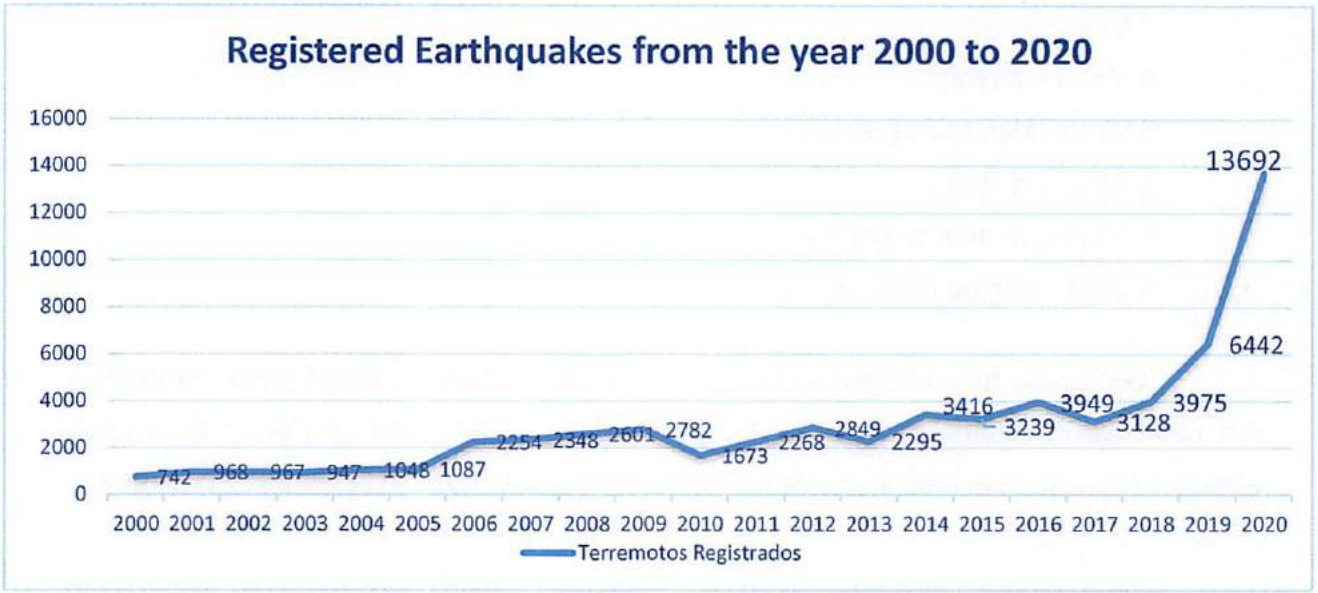


Figure 1.3

The year 2019 finished with a total of 6,442 registered seismic events. This represents an increase of 2,467 more earthquakes compared to 2018. It means an increase in seismic activity of 62% in just twelve months.

The following table presents several statistical data on earthquake occurrences recorded by the Puerto Rico Seismic Network from 2000 to 2020. This statistical summary of the last 20 years recorded 62,670 seismic events in the Puerto Rico region (see Figure 1.4). For statistical purposes, we divided the 20 years into four periods of five years each. The table shows a consistent increase in the (average) means of each period. The most significant increase is between the first and second periods with a 134% increase. The other significant increase is between the third and fourth periods with a 64% increase. This is observed when comparing the fourth period (2015-2019) compared to the third period (2010-2014). On the other hand, the statistical behavior of the events can be observed in their standard deviation (separation or distance from the average) between the period 2005 to 2014 is observed with an average between the two periods of 591.5. However, the standard deviation from the period 2015 to 2019 is almost double or 91% away from the average event between 2005 and 2014.

Due to the seismic sequence that occurred in early 2020, 13,692 seismic events were recorded in the Puerto Rico area (see Figure 1.5). The U.S. Geological Survey has conducted a series of studies that indicate that seismic activity on the southwestern region of the island will continue over the coming months and years, but the likelihood of an event larger than 6.4 magnitudes is expected to decrease over time, although it cannot be ruled out.

Period	Earthquakes Total	Median	% Median Difference between periods	Standard Deviation (Total Data Population)
2000-2004	4,672	934		102
2005-2009	11,072	2,214	137%	593
2010-2014	12,691	2,500	13%	590
2015-2019	20,544	4,108	64%	1,128

Figure 1.4

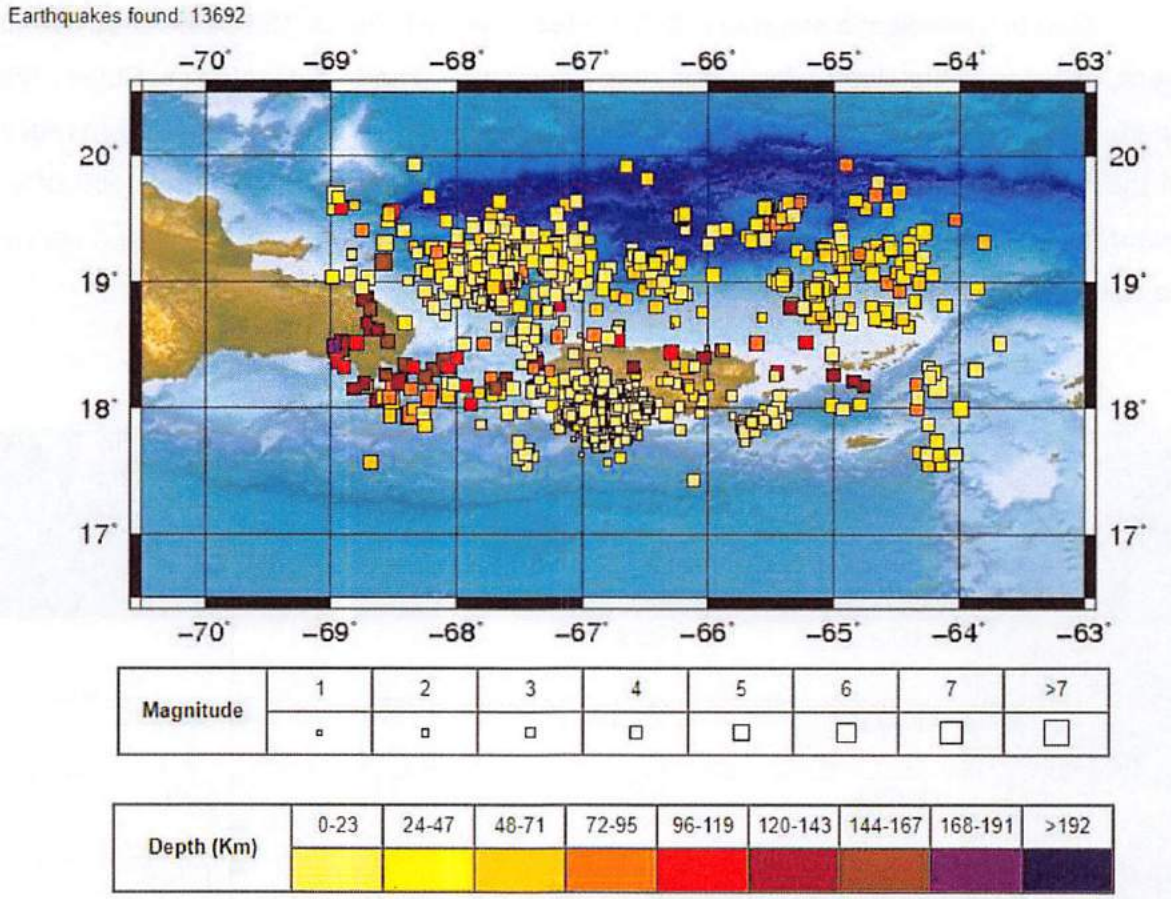


Figure 1.5 Seismic events recorded in 2020[14]

Since 1918 Puerto Rico had not had a major earthquake event that had caused as much fear in the population as the one that occurred on January 7, 2020, at 4:24 a.m magnitude 6.4 on the Richter scale. The beginning of 2020 was characterized by a series of earthquakes in the southwest area of Puerto Rio between the municipalities of Guánica and Guayanilla. These events were by no way predictable. During the first week of January, hundreds of earthquakes were recorded that caused thousands of houses, buildings, and a school to collapse, and several hospitals in the region to be affected. This earthquake caused not only regional damage but caused most of the island to run out of electricity. In total, the earthquake affected approximately 15,195[15] structures.

[14] RSPR (2019) General Catalogue of Sismos. Puerto Rico Seismic Network. University Campus of Mayaguez. University of Puerto Rico. Department of Geology.
[15] FEMA (2020) ACT Rapid Evaluation Data.

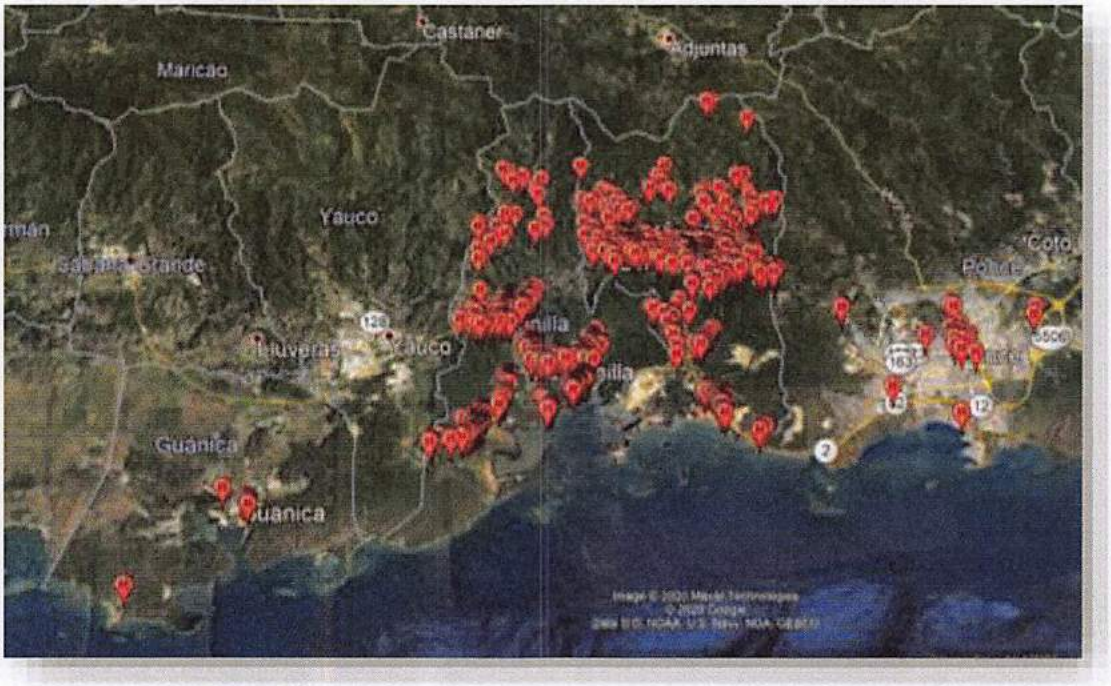
Agripina Seda School in Guánica collapsed on its foundations

The earthquake caused doors and windows to fall apart and were therefore blocked or out of their frames

Houses on stilts or columns fell directly to the ground

Damage to Structures in the South Region due to earthquake January 7, 2020

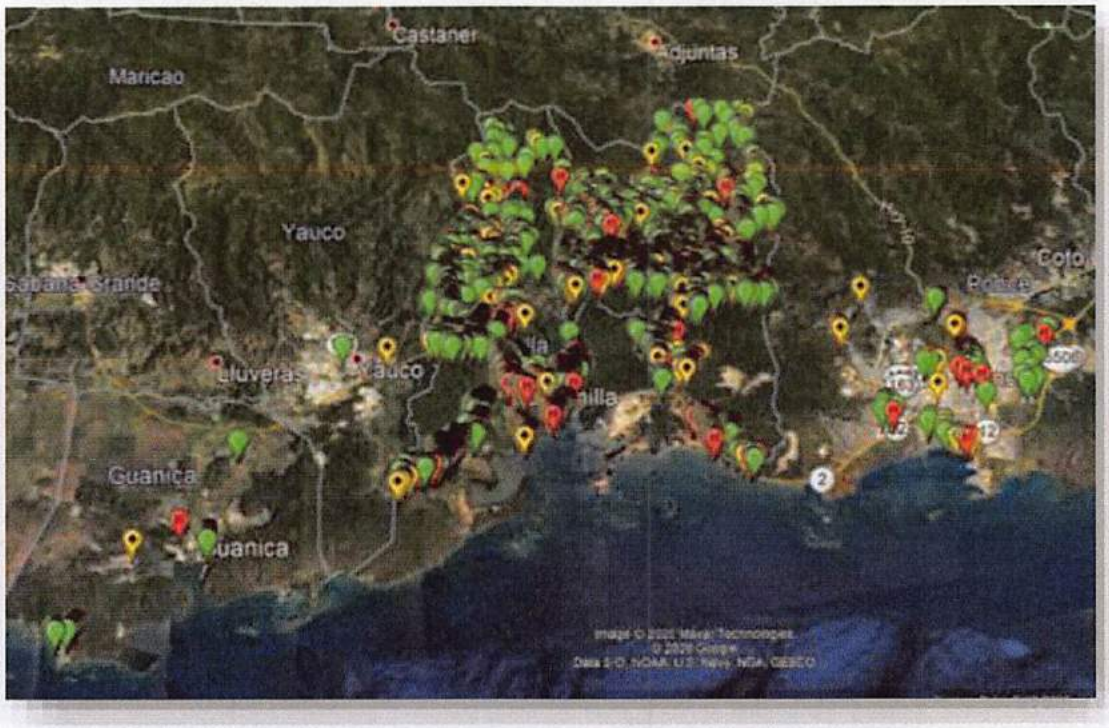
Severe Damage or Total Collapsed Structures – 1,162



Moderate Damages to Structures – 3,084

Minor Damages to Structures - 10,949

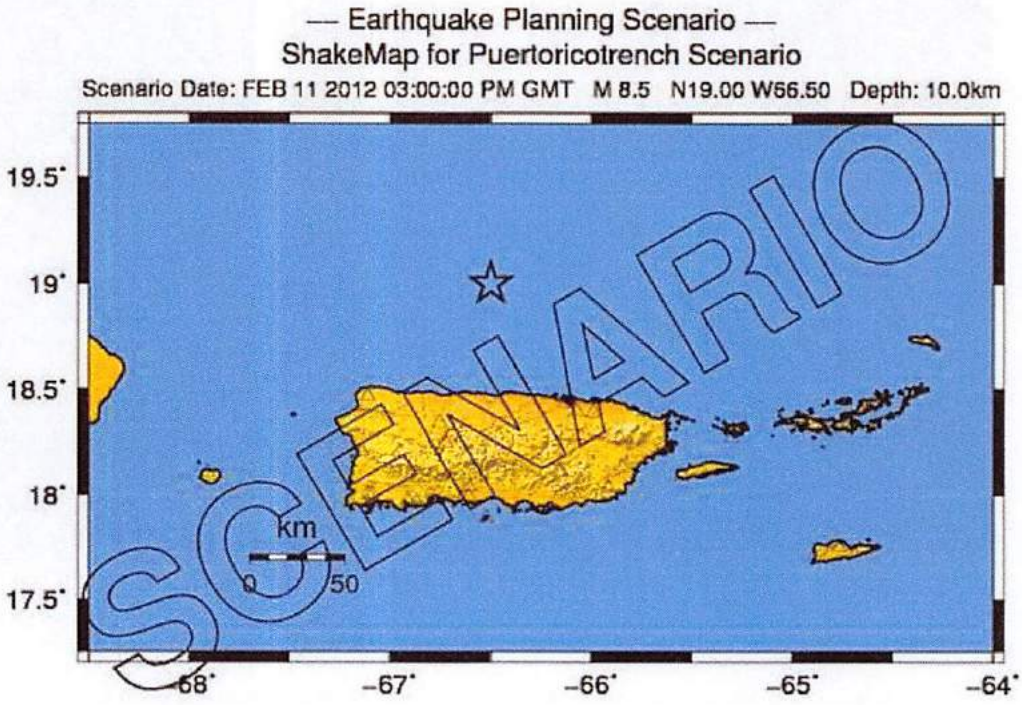
Total Damage to Structures - 15,195



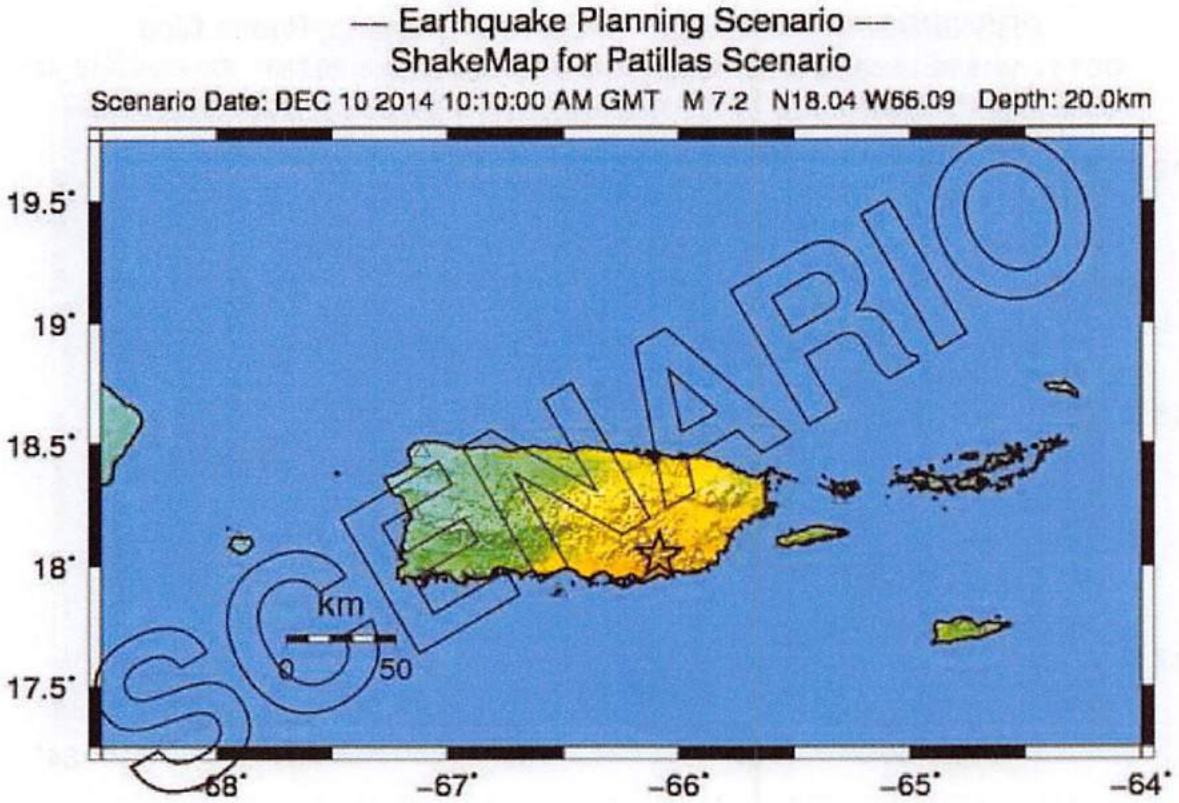
D. Planning Scenarios

The risk analysis of this Plan includes the communities that are most vulnerable where there would be a greater impact of loss of life caused by a high-intensity earthquake. The result of this analysis is visually represented through layered maps of Puerto Rico in a Geographic Information System (GIS) that identifies the areas of greatest impact and which could have the greatest negative consequences for the Island. The seismic maps "Shake maps" made by the Puerto Rico Seismic Network for the development of the Operational Earthquake Plan establish some of the possible scenarios that can or have occurred historically on the Big Island. (See the color legend where the different intensities of the scenarios are represented). The yellow, orange and red colors mean that the scenario presented would represent the intensity on the Mercalli Scale of an earthquake that is perceived as Strong (VI) causing serious damages up to Extreme (XII) causing catastrophic damages.

Scenario #1



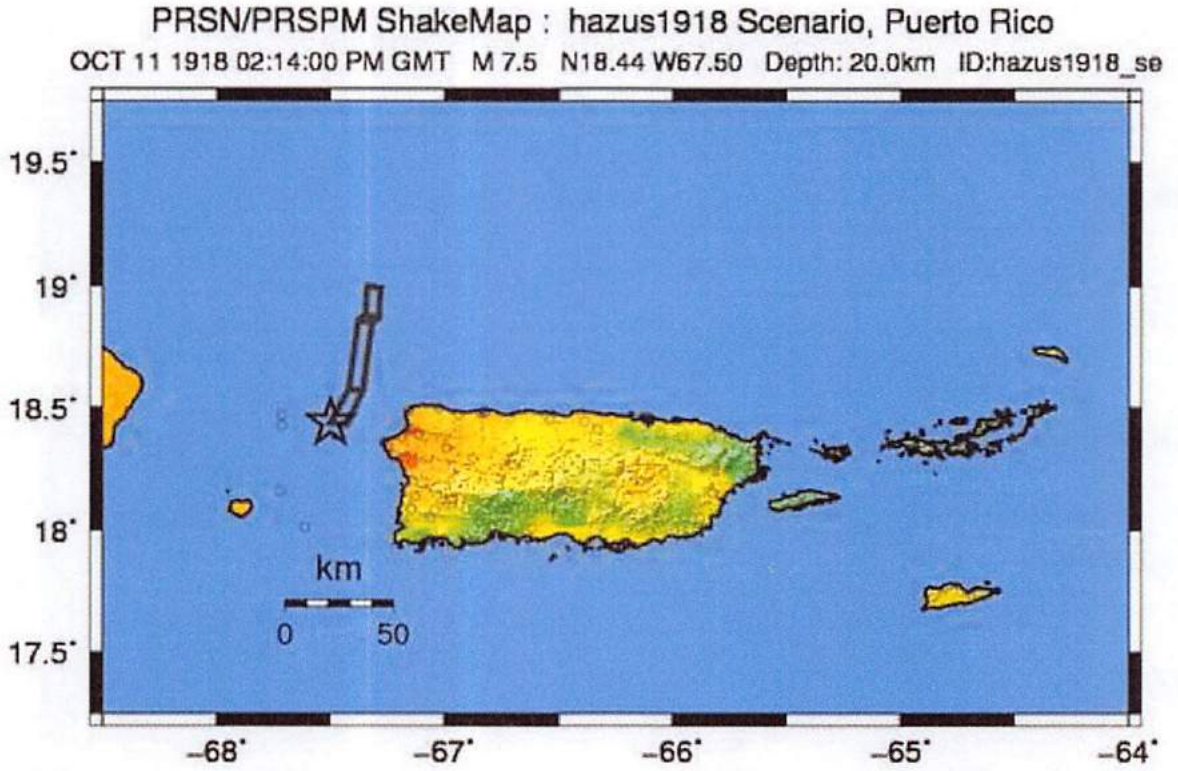
Scenario #2



PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Mod./Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<0.05	0.3	2.8	6.2	12	22	40	75	>139
PEAK VEL.(cm/s)	*<0.02*	*0.1*	*1.4*	*4.7*	*9.6*	*20*	*41*	*86*	*>178*
INSTRUMENTAL INTENSITY	I	II–III	IV	V	VI	VII	VIII	IX	X+

Scale based upon Worden et al. (2011)

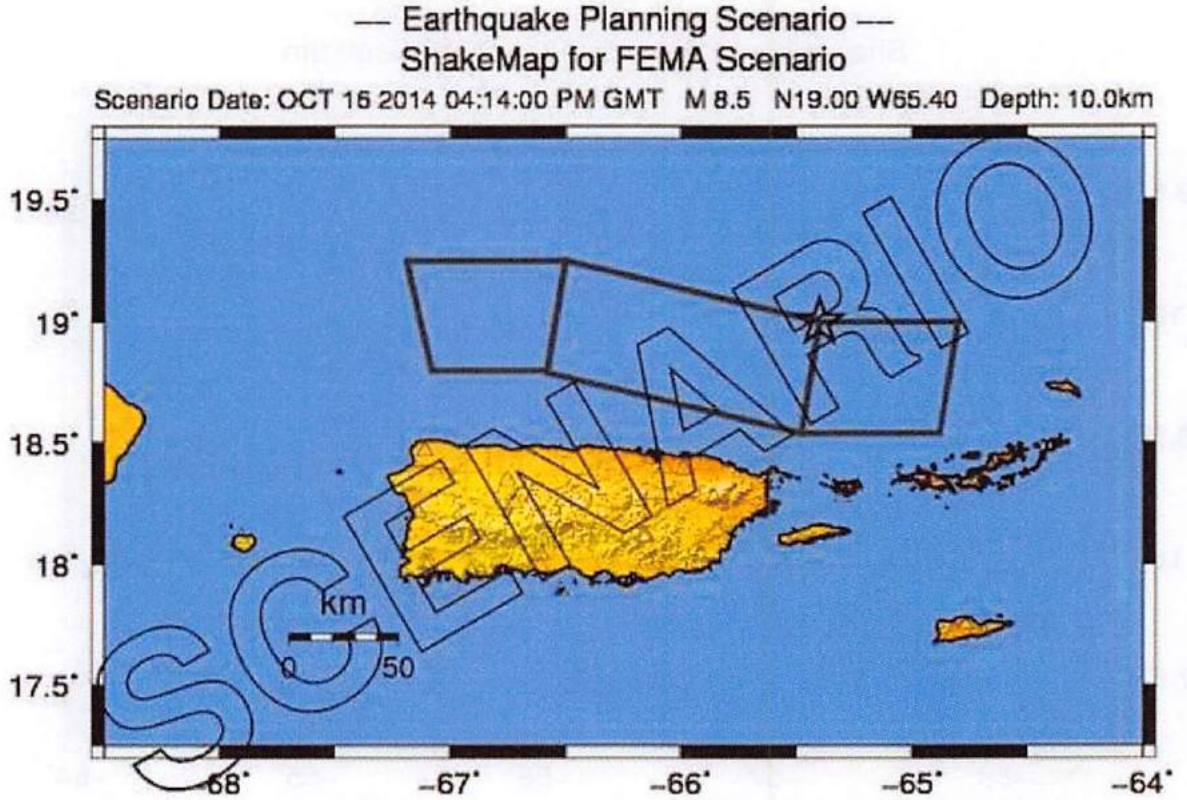
Scenario #3



PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Mod./Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<0.05	0.3	2.8	6.2	12	22	40	75	>139
PEAK VEL.(cm/s)	*<0.02*	*0.1*	*1.4*	*4.7*	*9.6*	*20*	*41*	*86*	*>178*
INSTRUMENTAL INTENSITY	I	II–III	IV	V	VI	VII	VIII	[illegible]	[illegible]

Scale based upon Worden et al. (2011)

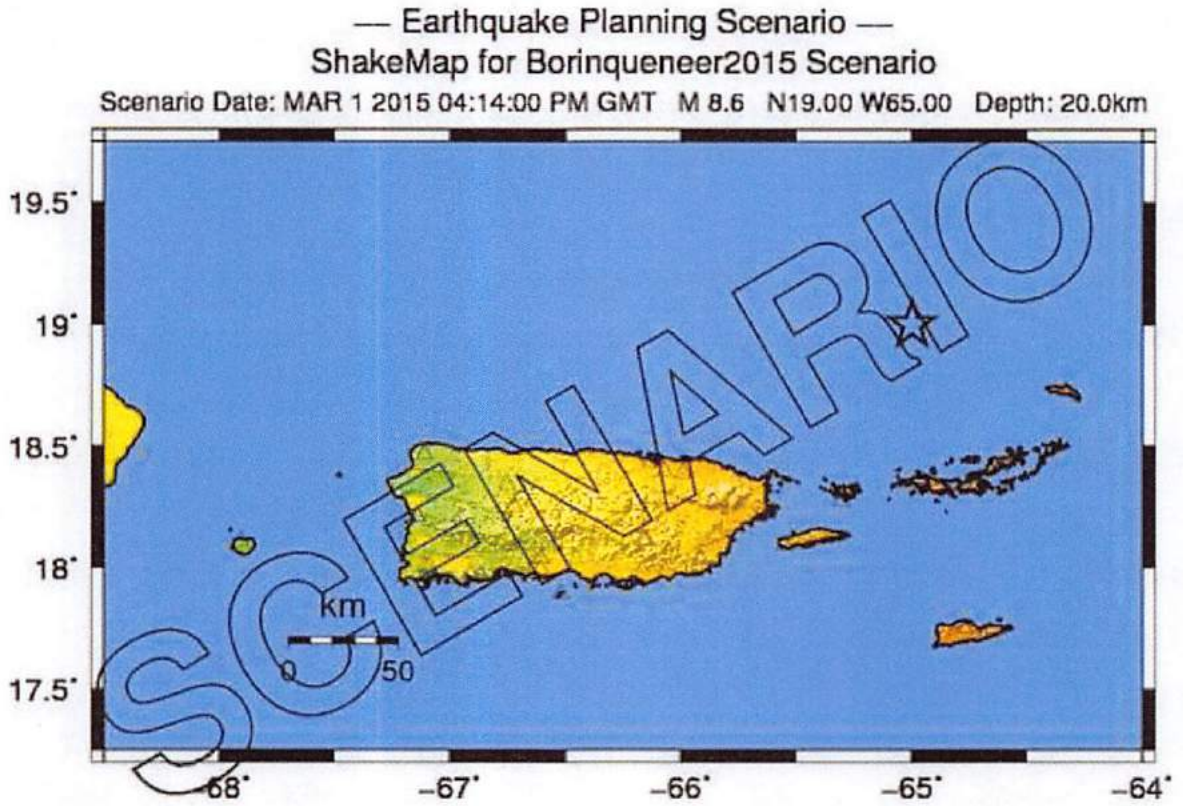
Scenario #4



PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Mod./Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<0.05	0.3	2.8	6.2	12	22	40	75	>139
PEAK VEL.(cm/s)	*<0.02*	*0.1*	*1.4*	*4.7*	*9.6*	*20*	*41*	*86*	*>178*
INSTRUMENTAL INTENSITY	I	II–III	IV	V	VI	VII	VIII	[illegible]	[illegible]

Scale based upon Worden et al. (2011)

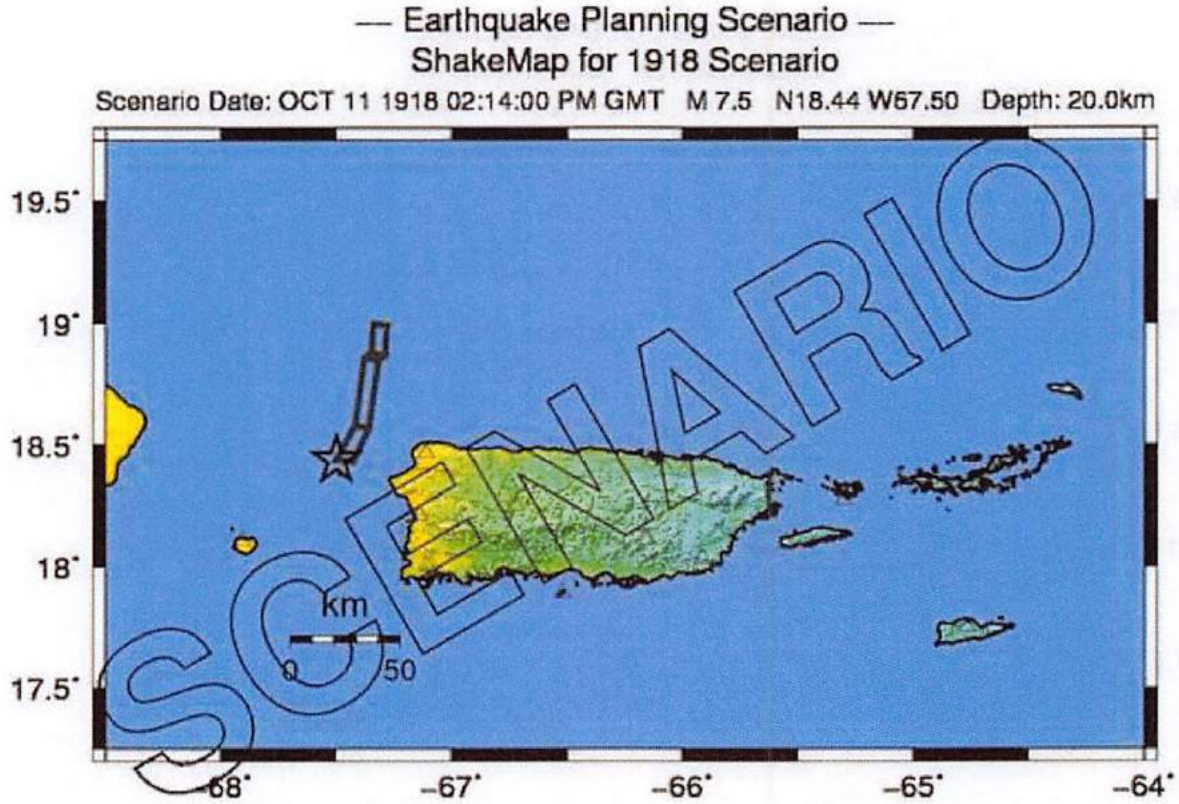
Scenario #5



PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Mod./Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<0.05	0.3	2.8	6.2	12	22	40	75	>139
PEAK VEL.(cm/s)	*<0.02*	*0.1*	*1.4*	*4.7*	*9.6*	*20*	*41*	*86*	*>178*
INSTRUMENTAL INTENSITY	I	II–III	IV	V	VI	VII	VIII	IX	X+

Scale based upon Worden et al. (2011)

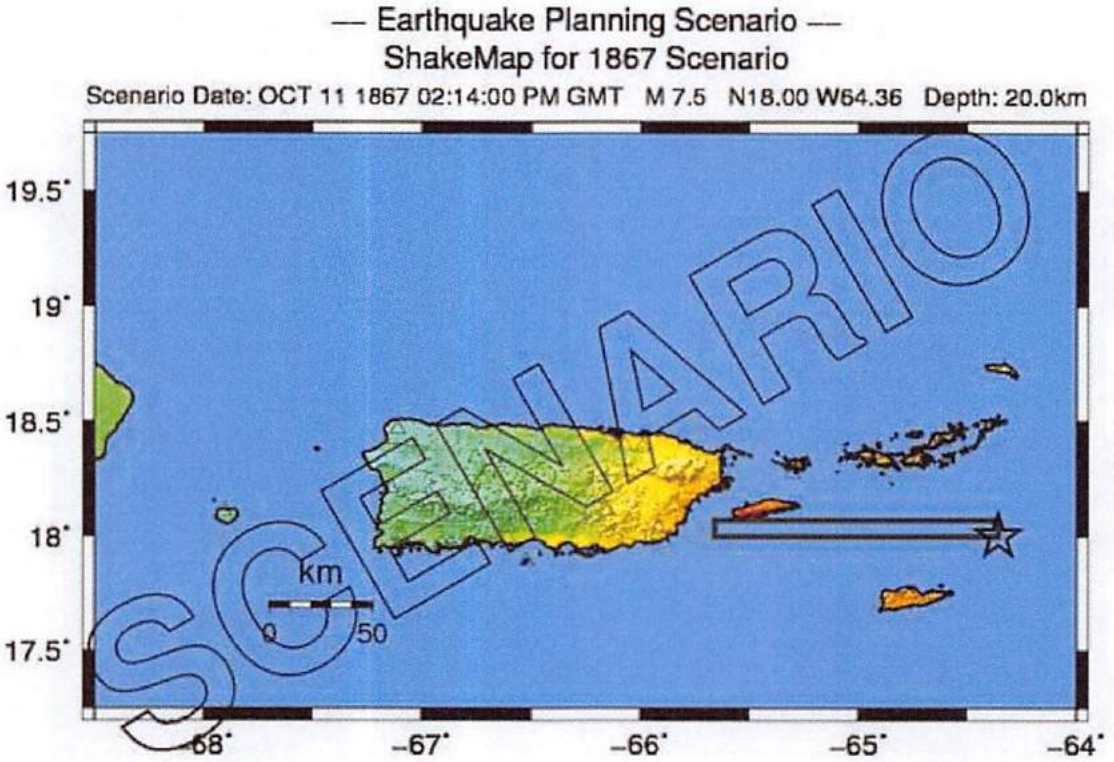
Scenario #6



PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Mod./Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<0.05	0.3	2.8	6.2	12	22	40	75	>139
PEAK VEL.(cm/s)	*<0.02*	*0.1*	*1.4*	*4.7*	*9.6*	*20*	*41*	*86*	*>178*
INSTRUMENTAL INTENSITY	I	II–III	IV	V	VI	VII	VIII		

Scale based upon Worden et al. (2011)

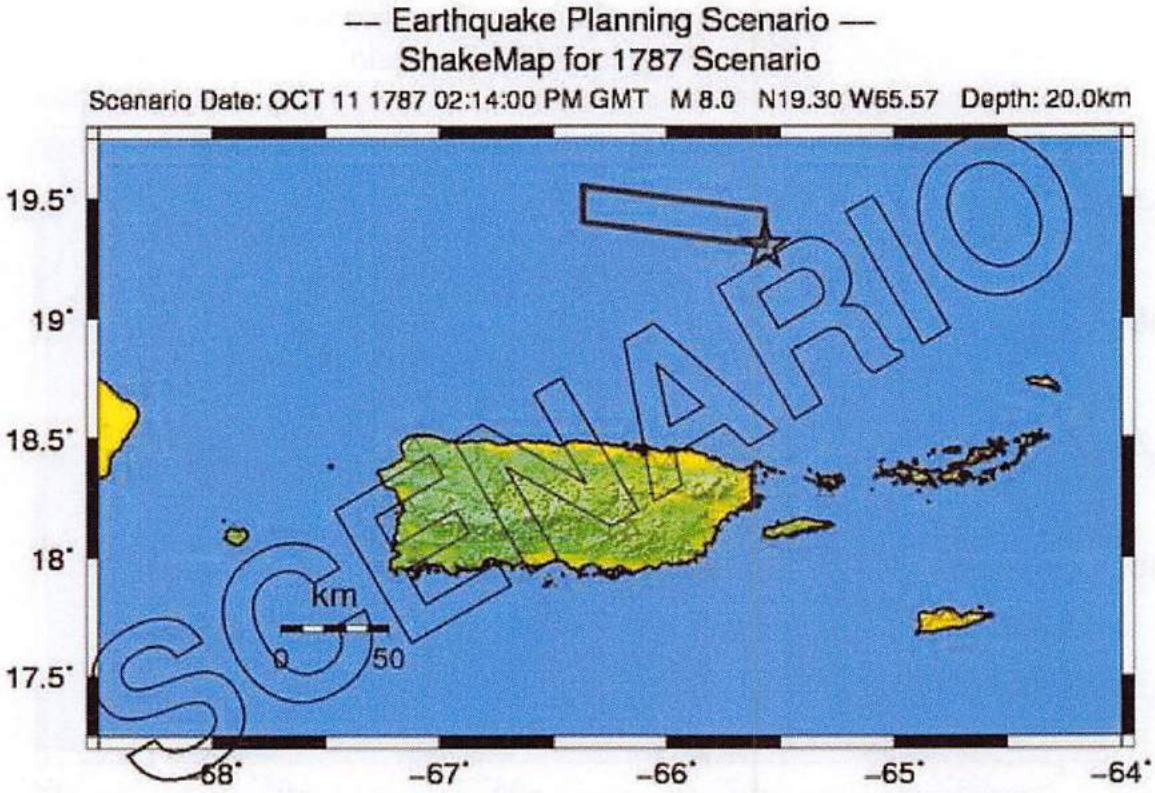
Scenario #7



PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Mod./Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<0.05	0.3	2.8	6.2	12	22	40	75	>139
PEAK VEL.(cm/s)	*<0.02*	*0.1*	*1.4*	*4.7*	*9.6*	*20*	*41*	*86*	*>178*
INSTRUMENTAL INTENSITY	I	II–III	IV	V	VI	VII	VIII	IX	X+

Scale based upon Worden et al. (2011)

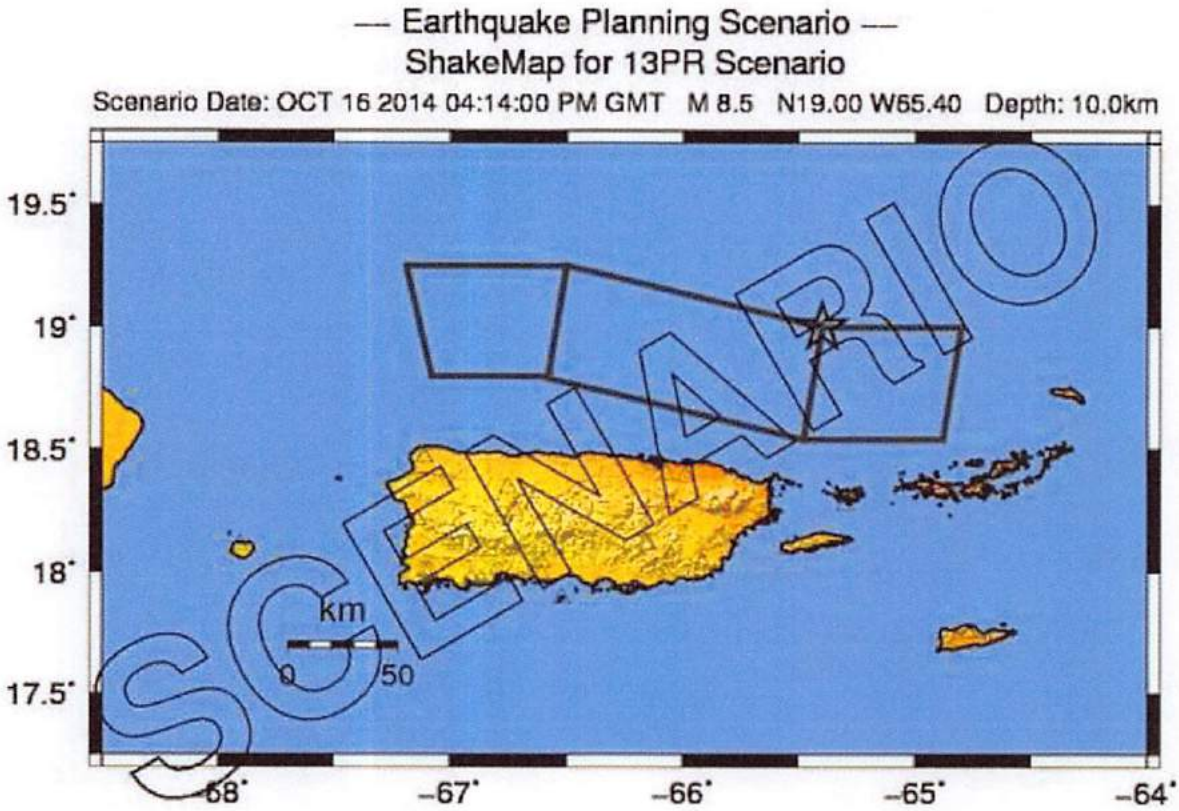
Scenario #8



PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Mod./Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<0.05	0.3	2.8	6.2	12	22	40	75	>139
PEAK VEL.(cm/s)	*<0.02*	*0.1*	*1.4*	*4.7*	*9.6*	*20*	*41*	*86*	*>178*
INSTRUMENTAL INTENSITY	I	II–III	IV	V	VI	VII	VIII	IX	X+

Scale based upon Worden et al. (2011)

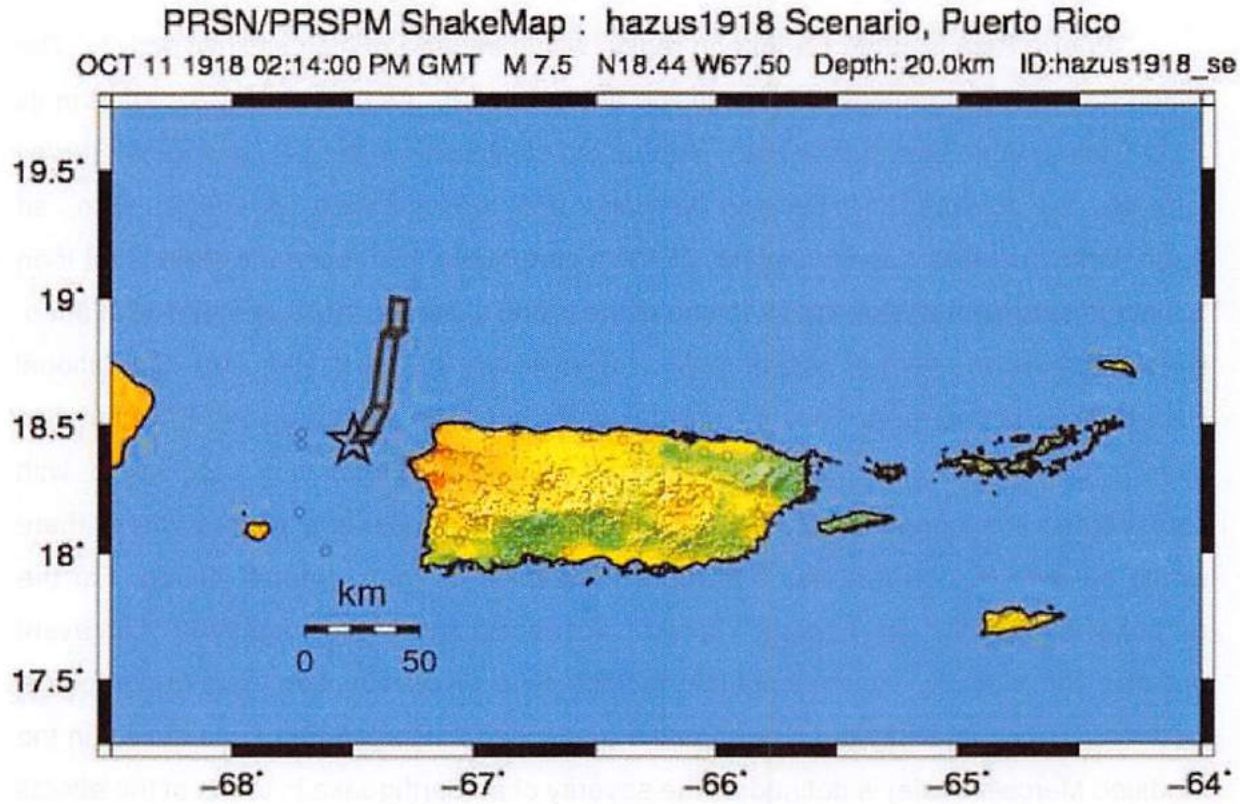
Scenario #9



PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Mod./Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<0.05	0.3	2.8	6.2	12	22	40	75	>139
PEAK VEL.(cm/s)	*<0.02*	*0.1*	*1.4*	*4.7*	*9.6*	*20*	*41*	*86*	*>178*
INSTRUMENTAL INTENSITY	I	II–III	IV	V	VI	VII	VIII	IX	X+

Scale based upon Worden et al. (2011)

Scenario #10



PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Mod./Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<0.05	0.3	2.8	6.2	12	22	40	75	>139
PEAK VEL.(cm/s)	*<0.02*	*0.1*	*1.4*	*4.7*	*9.6*	*20*	*41*	*86*	*>178*
INSTRUMENTAL INTENSITY	I	II–III	IV	V	VI	VII	VIII	IX	X+

Scale based upon Worden et al. (2011)

E. General Risk Assessment

Puerto Rico is in the Caribbean region within an area of high seismic activity. The island has multiple geological faults inside and around it. As part of FEMA's effort in its 2012 Catastrophic Earthquake Plan, a group of scientists from the US Geological Survey (USGS), the Puerto Rico Seismic Network, and the University of Puerto Rico, an earthquake scenario was developed. FEMA's earthquake plan scenario states that if an 8.5 magnitude earthquake occurs in one of the island's internal faults at only 10 km deep, it would cause an event of catastrophic consequences in Puerto Rico. The Operational Earthquake Plan of Puerto Rico not only takes the scenario performed by FEMA but also uses studies and additional information collected representing scenarios with catastrophic consequences as well. FEMA's scenario presents a picture where there would be over 90,000 fatalities and more than twice as many people injured. For the purposes of this plan, consideration is taken not necessarily of the magnitude of an event but also the intensity, socio-economic factors, type of construction, and geographical location. [16][17]The intensity of an earthquake (described in Roman numerals I to XII in the Modified Mercalli Scale) is defined as the severity of an earthquake in terms of the effects on the surface of the earth, humans, and structures. Therefore, intensity measures the apparent degree of jolt felt in different places based on the damage caused and the perception that people had. Intensity is determined in a particular location, noting the effects of shaking on objects, buildings, people, and on the ground itself. The intensity scale generally used in the United States and the Caribbean is called the Modified Mercalli Intensity Scale. This scale goes from level I which represents a meaningless seism and level XII which implies total destruction. The Operational Earthquake Plan considers a major earthquake event with intensity from VI (Strong) to XII (Catastrophic). [18]

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[16] FEMA (2012) Puerto Rico Catastrophic Earthquake Annex. Federal Emergency Management Agency Region II. Appendix 2 Page A2-1

[17] FEMA (2012) Puerto Rico Catastrophic Earthquake Annex. Federal Emergency Management Agency Region II. Appendix 8 Page A8-1

[18] RSPR (2019) Glossary of terms for RSPR earthquake and tsunami products. Puerto Rico Seismic Network. University of Puerto Rico. Department of Geology http://redsismica.uprm.edu/Spanish/glosario/index.php#intensidad

Modified Mercalli Scale	
I. Imperceptible	Detected only by instruments
II. Very Mild	Felt by a few people
V. Mild	Felt by a few people inside buildings
IV. Moderate	Felt by people outside buildings
V. Little Strong	Felt by almost everyone
VI. Strong	Felt by everyone
VII. Very Strong	Causes moderate damages
VV. Destructive	Causes considerable damages to structures
IX. Very Destructive	Causes severe damages, and panic among the population
X. Disastrous	Causes severe destruction
XI.Very Disastrous	Disastrous collapses
XII. Catastrophic	Total destruction

Modified Mercalli Scale

On the other hand, the magnitude according to the USGS is the number that characterizes the relative size of an earthquake. The magnitude is based on the measurement of the maximum movement recorded in a seismograph.[19] The total energy released by an earthquake increases for each unit of magnitude by a factor of 32. In other words, if a tremor of magnitude 6.0 is detected, it is 32 times greater (or higher intensity) than one of 5.0.

Magnitude can be measured in different ways using seismograms and varies with different seismometers. Some methods are based on body waves (they travel at great depths within the Earth's structure), and others are based on surface waves (which travel primarily through the earth's shallowest layers), but all are very reliable.

Tsunami Centers or Seismic Networks can calculate a magnitude and preliminary location for an event with the minimum amount of data to make an estimate, and therefore promptly notify the public if the earthquake is meaningful and if there is a chance of a tsunami. In these cases, time is a determining factor in issuing tsunami messaging. Preliminary magnitudes can have errors of half a unit of magnitude or more and are

[19] USGS (2020) Earthquake glossary. US Geological Survey

updated with the arrival of more data. Some methods are based on waves through a body (which travel at great depths within the Earth's structure), and others are based on surface waves (which travel primarily through the earth's shallowest layers). [20]

The Modified Mercalli scale identifies the intensity of an earthquake. Intensity is a measure of non-instrumental perceptibility of damage to structures, surface effects of the soil, and human reactions to earthquake tremors. It is a descriptive method that has traditionally been used to set the size of the earthquake. Being a subjective measure, it is obtained by interviewing people who observed or were at the event, and their impression of it. Since observers and human structures are scattered more widely than any seismological observatory could reasonably assess the effect of the earthquake and therefore provide information to help characterize the distribution of soil movement in a region while depending on depth. Discrete scales are used to quantify seismic intensity. Levels are represented by Roman numerals and each degree of intensity provides a qualitative description of the effects of an earthquake as defined by the Puerto Rico Seismic Network.

As part of the Operational Earthquake Plan development process, field inspections were carried out in the 78 municipalities of Puerto Rico. During these visits, inspectors interviewed emergency management personnel, police, and public works in each municipality to identify and collect the data of high-risk conglomerates such as stilt houses, critical bridges, and critical infrastructure sectors. An inventory of resources was also carried out that can be used during an emergency following the NIMS Incident Resource Inventory System (IRIS) guidelines. The US Department of Homeland Security (DHS) classifies critical infrastructure into 16 sectors: communications systems, primary transportation systems including ports and airports, primary health care systems, large-capacity commercial facilities, critical manufacturing, energy production, and distribution systems, chemical sector, essential dams, food processing and distribution, potable water systems and treatment plants, financial services sector, essential government

[20]RSPR (2020) Glossary of terms for RSPR earthquake and tsunami products. Puerto Rico Seismic Network. http://redsismica.uprm.edu/Spanish/glosario/index.php

facilities, information technology, waste or nuclear material, emergency services and defense systems.

Puerto Rico's demographic analysis shows that Puerto Rico has an estimated population of 3,468,963 in 2017. The census shows that 735,420 (21.2%) people have some form of functional disability, 1,203,730 (34.7%) are under 5 years of age or younger and 1,037,219 (29.9%) are people over 65 years of age. The study also indicates that 44.9% of Puerto Rico's population lives below the U.S. national poverty level. In addition to economic dependence, an age-dependent population of 64.6% in the population of children under the age of 17 and over 65 is also highlighted. Taking all the factors of social dependence can be determined that 57.5% of Puerto Rico's population is dependent on the government and its institutions in some way. This represents a vulnerable-dependent population of 1,994,653 which the government will have to consider to offer emergency services in case a catastrophic earthquake happens. [21]

Puerto Rico Seismic Threat Study (USGS, 2003)

A 2003 study by the U.S. Geological Survey revealed that the West-Southwest area of Puerto Rico is the most vulnerable to earthquakes. This is without considering secondary hazards such as tsunamis, liquefaction, and seismic wave amplification that most affect low coastal areas and the landslides that can be generated in the mountainous areas. This study presents an analysis of the seismic threat that exists in Puerto Rico and the US Virgin Islands. The study was conducted along the boundaries between the northeastern Caribbean Sea and the Atlantic Ocean at the intersection with the Greater Antilles and the Lesser Antilles. This chain of islands demarcates the boundaries[22] between the tectonic plates of North America and the Caribbean.

The study identifies that the seismicity in the Puerto Rico and the Virgin Islands area is mostly related to the oblique subduction of the North American plate under the terraces of the plate boundary area along the plaque that interacts to the south with the

[21] USCB (2017) 2013-2017 American Community Survey 5-Year Estimates. United States Census Bureau. American Fact Finder. Subtracted from https://factfinder.census.gov

[22] RSPR (2020) Seismic Information. Earthquake Prediction. Puerto Rico Seismic Network. Department of Geology of the University Campus of Mayaguez. University of Puerto Rico. Extracted from http://redsismica.uprm.edu/Spanish/informacion/sisnotas_predic.php

Puerto Rico Trench. Also, the study indicates that the seismicity in the area can be due to the interaction of several microplates within the boundaries of the area.[23]

In a pre-USGS 2003 study, Dr. William McCann, in 1987 stipulated in a study that there was a 33 to 50% probability that an earthquake of strong intensity VII or more on the Modified Mercalli scale could occur over a 50-year period in the Puerto Rico[24]area.

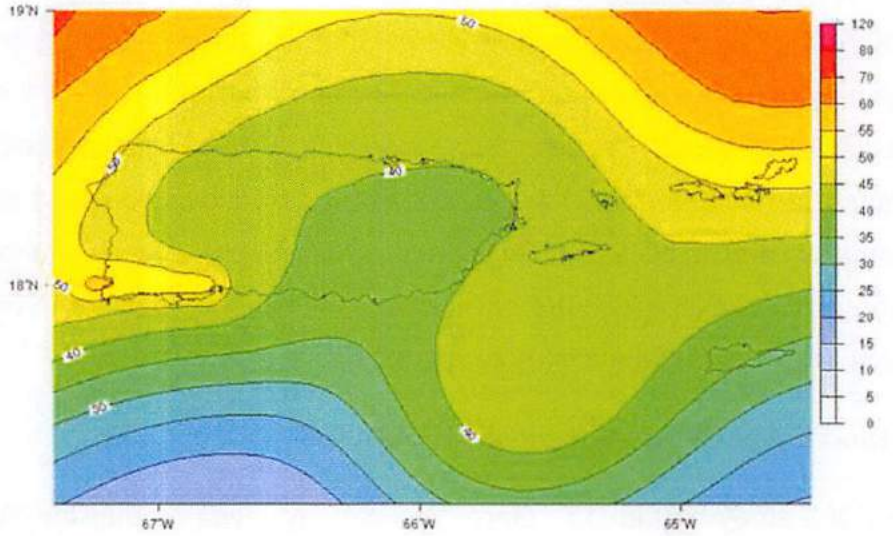


Fig 4: PGA (%g) with 2% probability of exceedance in 50 years from all modeled sources

Earthquake Threat Map of Puerto Rico (USGS, 2003)

[23] C.S. Mueller, A.D. Frankel, M.D. Petersen, and E.V. Leyendecker (2004) Documentation for 2003 USGS Seismic Hazard Maps for Puerto Rico and the U.S. Virgin Islands. US Geological Survey.

[24] McCann, W., (1987). Preliminary Seismic Hazard Map.

F. Earthquake Risk, Vulnerability, and Impact Analysis

A risk represents an event that has the potential to cause deaths, injuries, property damage, infrastructure damage, agricultural losses, environmental damage, business disruptions, interruption of supply chain or other types of damages or loss. Earthquakes represent the primary incident that can cause loss of life or property. Secondary hazards include, but are not limited to dam failures, landslides, spills or leaks of hazardous materials, collapse of structures, fires, tsunamis, among others.

Vulnerability indicates the level of exposure to harm or loss of life or property caused by an incident. Puerto Rico's population is vulnerable to a wide range of secondary hazards or risks caused by earthquakes.

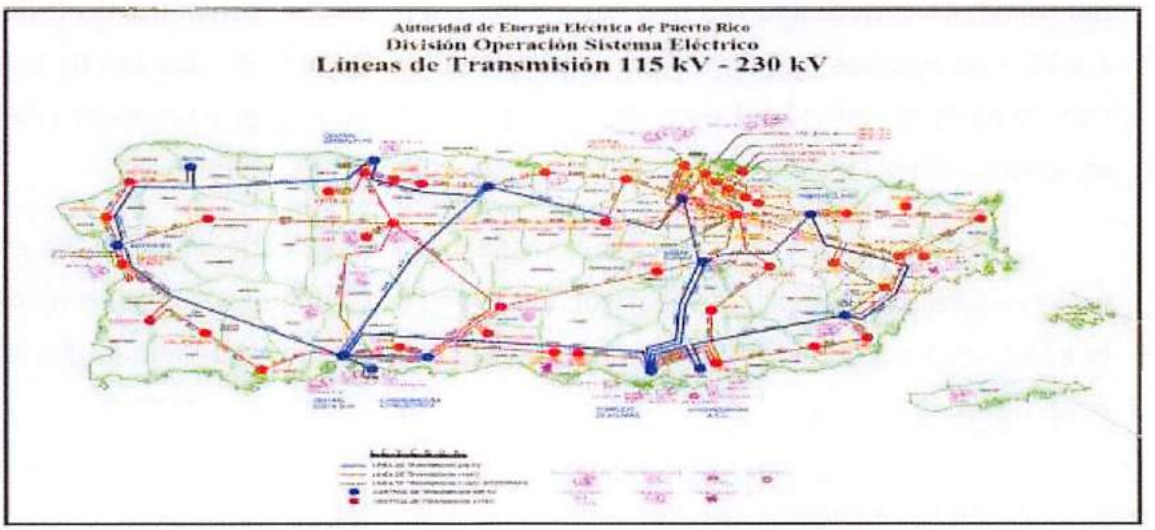
The severity of the consequences of an earthquake is determined not only by the intensity, geographical location, geological composition but also by the level of exposure and vulnerability to which the affected population is exposed.

About a quarter of a million (250,000) people reside in coastal areas within the tsunami evacuation zones. 60 percent of Puerto Rico's population resides in the coastal areas of the island, 44 coastal and two non-coastal municipalities (Bayamón and Canóvanas) of the 78 municipalities in Puerto Rico are exposed to coastal floods caused by tsunamis. Communities on the island that are located on soft ground (or have been filled) may experience intensities strong enough to damage many types of structures.

This analysis will give emergency managers a better perspective on the potential areas of greatest impact in the event of a high-intensity earthquake. It helps responders to know what could be the areas where more casualties could be found after a major earthquake.

The main risks associated with a high-intensity earthquake are:

1. **Electrical System Failures (Total or Regional)** - A total or regional electrical failure is the loss of electrical service caused by a disruption in power generation or transmission. The power failure could last for long periods from days to months as happened after Hurricane Maria passed in 2017. Immediately after a high-intensity earthquake, transmission towers and electrical equipment will begin to move causing safety systems to be activated to protect themselves and avoid further damage to the electrical infrastructure. However, with continuous seismic movement, many towers would collapse, transmission and distribution lines would be disconnected, generation equipment would displace on the ground and some units would collapse. Explosions and fires would occur inside generation plants as many of the mechanical systems will be in function during the sudden movement of the earthquake. Most of Puerto Rico's power generation plants are found in tsunami-sensitive coastal areas and soft soils where the liquefaction effect could occur. The system recovery process would be more complex than a hurricane event as it would not give time to protect generation or transmission systems in advance of a seismic event.



Liquefaction Susceptibility at Central Palo Seco and San Juan[25]

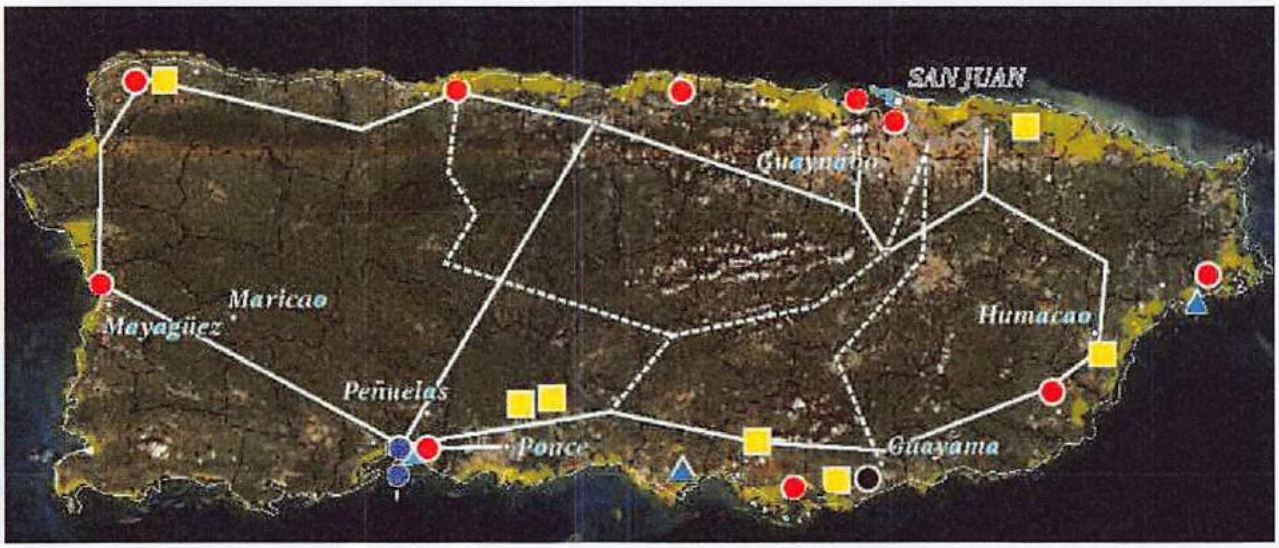
As can be seen in this image the power plants of Palo Seco in Cataño and Central San Juan in San Juan are located on soft geological material such as the fill material in the San Juan Central and Sand and Alluvial Deposits as is the case of Palo Seco. According to the study conducted by the United States Geological Survey on the 2008 Bayamón and San Juan Quadrangle Liquefaction Susceptibility Map, it concludes that the area where the Palo Seco Generation Plant is located is in an area that has a susceptibility to liquefaction at a "Medium/High" level. On the other hand, the Generation Plant of Central San Juan is located in an area of susceptibility to liquefaction classified as "Very High". Both facilities are susceptible to a liquefaction event making them more vulnerable in the event of a high-intensity earthquake affecting the area. The case of the Palo Seco and San Juan plants are not isolated. Most of the most important generation power plants of the island are located in coastal areas where the geological composition is mostly soft soils, unsealed loose material, or rock sediment that may be susceptible to the liquefaction effect.

The following table classifies the type of geological composition and the value of liquefaction susceptibility.

[25] USGS (2008) Liquefaction Susceptibility of the Bayamón and San Juan Quadrangles, Puerto Rico. US Geological Survey

Geologic Unit	Description	Estimated % Liquefiable Texture	Estimated Liquefaction Triggering Acc. M_w 6.5	M_w 8.0	Typical Groundwater Depth	Liquefaction Hazard[2]
Qs	Holocene swamp deposits	50%	0.10g	0.05g	<1.5	VERY HIGH
Qaf/Qs[##]	Artificial fill over swamps	<50%	0.1-0.20g	0.05-0.15g	<3.0	VERY HIGH
Qac	Late Holocene alluvial channels	<75%	0.15g	0.1g	<1.5	HIGH
Qb	Holocene beach deposits	80%	0.15-0.20g	0.1-0.15g	<1.5	MEDIUM HIGH
Qt	Late Pleistocene to Holocene terrace deposits	35%	0.2g	0.15g	<3.0	MEDIUM
Qaf	Artificial fill	<50%	0.2g	0.15g	1.5 - 6	MEDIUM
Qafe	Artificial road embankment fill	<50%	0.25g	0.15-0.2g	1.5 - 6	MEDIUM
Qay	Holocene alluvium	40%	0.2g	0.15g	<3.0	MEDIUM
Qaf/Qay	Artificial fill over alluvium	<50%	0.2g	0.15g	1.5 - 6	MEDIUM
Qss	Late Pleistocene(?) dune sands	80%	>0.3g	>0.20g	3 - 10	LOW MEDIUM
Qvf	Late Pleistocene to Holocene valley fill	<30%	>0.3g	>0.25g	1.5 - 6	LOW
Qf	Late Pleistocene to early Holocene fan deposits	<10%	>0.3g	>0.25g	1.5 - 6	LOW
Qfo	Mid Pleistocene to Pliocene fan deposits	<10%	>0.3g	>0.3g	1.5 - 6	LOW
Qao	Late Pleistocene-Pliocene alluvium	<30%	>0.3g	>0.25g	1.5 - 6	LOW
Qtb	Late Pleistocene to Holocene blanket deposits	<10%	>0.3g	>0.25g	1.5 - 6	LOW
QTt	Pleistocene alluvium	<10%	>0.3g	>0.3g	3 - 10	LOW VERY LOW
Br	Bedrock	0%	NA	NA	3 - 10	NEGLIGIBLE

Liquefaction Susceptibility Values



Puerto Rico's Power Generation Systems Location

The graph above shows that most of the generation power plants are located in tsunami-prone areas.

Aguirre and Aguirre Combined Cycle Power Plant

AES Coal Power Plant in Guayama

2. Hazardous Materials and Environmental Pollution – Puerto Rico has many public and private organizations that store large quantities or work with hazardous materials that, if an escape, spill, or explosion occurs from an earthquake, could endanger the population. Exhausts may be due to the rupture of natural gas lines, gas stations, laboratories, schools, and hospitals, used water treatment plants, pharmaceuticals, or facilities that store chemicals. These hazardous materials also pose a danger on our roads as they are transported throughout the island. See the Risk, Vulnerability, and Impact Analysis (VRI) Annex by Municipality for details.

A hazardous material is any solid, liquid, or gaseous substance that, due to its physical, chemical, or biological characteristics, can cause harm to humans, the environment, and goods.

Hazardous materials are identified in nine classes as defined by 49 CFR 172.101 and 172. Hazardous materials are sorted by explosives, gases, flammable liquids and fuels, flammable solids, oxidizing substances, organic peroxides, toxic and infectious substances, radioactive material, corrosives, and miscellaneous hazardous material.

In several municipalities, the US Environmental Protection Agency (EPA) identified several contaminated sites that have been designated as "Superfund" locations under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). Most incidents have to do with the discharge or leakage of hazardous materials into the soils and bodies of water to which the population

would have been exposed. The map below [26] shows the places where these incidents and major pollution have occurred and have required long-term cleaning, decontamination, and remediation processes or are in a corrective action process in Puerto Rico. For the list of facilities See Appendix 6 of this Plan.

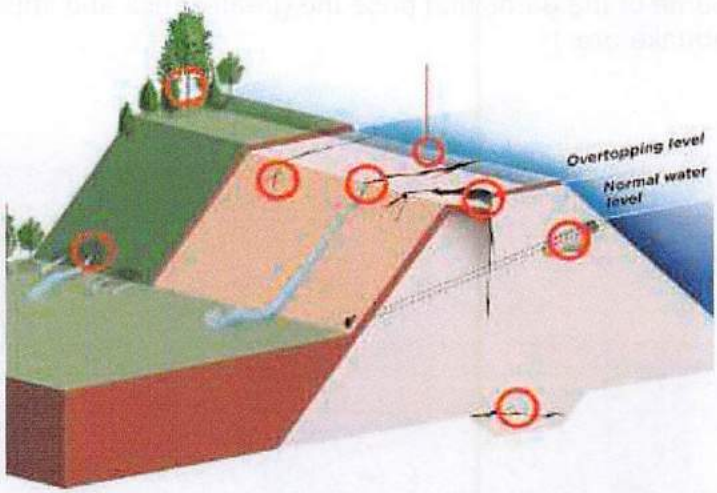
In the event of a high-intensity earthquake, it could destabilize these facilities, disrupt cleaning processes, delay remediation processes, or further extend contaminated areas.

[26] 2020 EPA National Priority List Puerto Rico. Corrective Action Sites
https://www.epa.gov/hwcorrectiveactionsites/caribbean-rcra-cleanup-facilities-contacts

3. **Dam Break** – A dam break caused by an earthquake could cause thousands of deaths in a very short time due to the flash flooding it would cause in communities downstream. In Puerto Rico, 35 dams belong to the ESA, AAA, and the Natural Resources Department of P.R. Most of these dams (27) were built before the 1960s. Some of them are ground-built reliefs. As an example, the dams of greater risk are Carraizo Dam in Trujillo Alto that affects Trujillo Alto, Carolina, Canóvanas and Loíza, La Plata Dam in Toa Alta that affects Toa Alta, Toa Baja and Dorado. Dos Bocas Dam in Arecibo which affects Arecibo and Barceloneta. On the other hand, the municipality of Utuado could be affected by the collapse of Las Garzas and Caonillas dams. See the Risk, Vulnerability and Impact Analysis (VRI) Annex to the municipality that applies for details of the rest of Puerto Rico's dams.

Safety and Security

A high-intensity earthquake could cause mechanical problems, cracks, collapse, and other damages. The effect of Internal Erosion "Piping" or liquefaction can also cause a dam to collapse or cause major damages. The effect of "Piping" occurs when there is internal erosion that reaches a point outside the dam where it could expand rapidly in the event of an earthquake, eroding the earth wall until it finally collapses. In the case of liquefaction, the base of the dam may be susceptible to its base taking characteristics of a liquid and therefore weakening to collapse. Another form of dam breakage could be the "Over topping" under certain particular conditions or if the earthquake damages the floodgates of the dam avoiding the controlled flow of water and going over the dam uncontrollably.



Ground dam fault type model[27]

Guajataca Dam failure during Hurricane Maria 2017

Guajataca Dam after repairs in 2020

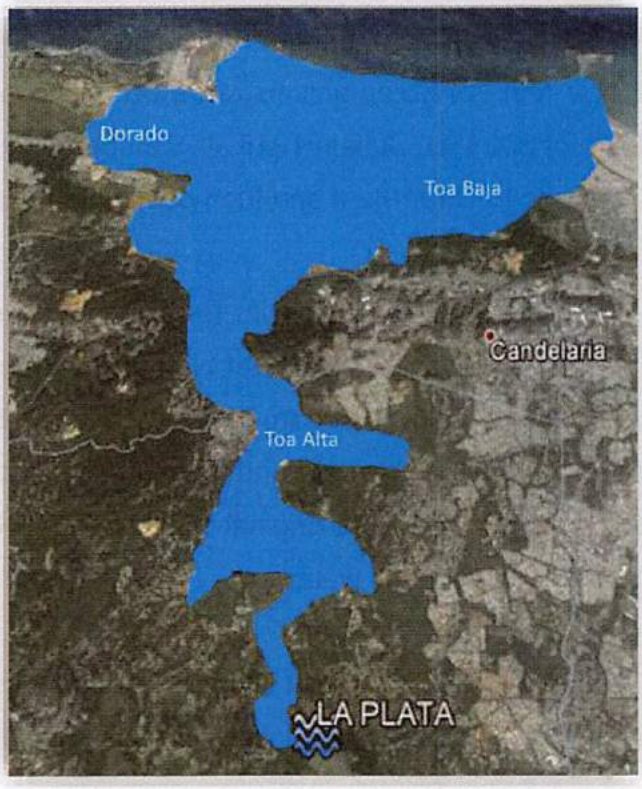
[27] NDNR (2020) Dam Safety. Common Problems at Dams. Association of State Dam Safety Officials https://dnr.nebraska.gov/dam-safety/common-problems-dams.

Some of the dams that pose the greatest risk and impact in the event of an earthquake are:

Flood map by the collapse of Dam Carraízo in Trujillo Alto[28]
18.327804, -66.015714

If a total collapse of the Carraizo dam occurs at 95% of its capacity there would be approximately 123,265 people that could be affected downstream. These possible victims would be among the municipalities of Trujillo Alto, Carolina, Canóvanas, and Loíza. The dam was built with an original reserve capacity of 23,500 acre-feet (7.6 billion gallons of water), to provide domestic water in the San Juan Metropolitan Area.

[28]Nieves B. (2015) Risk Analysis for Operational Emergency Plan for The Collapse of Prison Dam. ISP



Collapse Flood Map of the Silver Dam in Toa Alta[29]
18.343259, -66.236069

If a total collapse of the La Plata dam occurs at 95% of its capacity there would be approximately 30,000 people directly affected downstream. These possible victims would be between the municipalities of Toa Alta, Toa Baja, and Dorado. The La Plata dam has a capacity of 37,000 acres-feet of water (12 billion gallons of water). It is a specific structure with a height of 131 feet, with a catchment area of 181 square miles.

The Dos Bocas Dam is located between Utuado and Arecibo, ten miles southeast of Arecibo. It receives waters from the Viví and Pellejas rivers and the Caonillas Reservoir. The normal capacity of 30,420 acre-feet (10 trillion gallons of water), maximum depth of 80 feet, and five miles long. Built between 1940 and 1942 by the current ESA for hydroelectric generation. PREPA uses this reservoir as part of the Superaqueduct system that transfers water to the metropolitan area.

[29]Nieves B. (2015) Risk Analysis for Operational Emergency Plan for La Plata Dam Collapse. ISP

The Caonillas Dam is located three miles east of Utuado. It receives waters derived from the rivers Viví, Pellejas, Jordan, and the upper Rio Grande de Arecibo. Its normal capacity is 46,012 acre-feet (14 billion gallons of water), it is about three miles long and has a maximum depth of 200 feet. Built-in 1948, its waters are used for the production of electricity at The Caonillas I Power Plant and then passed to Lake Dos Bocas.[30]

The Las Garzas reservoir was built in 1943, part of the Garzas hydroelectric system. The dam is dirt and measures 202 feet high and 910 feet long over the Vacas River of the municipality of Adjuntas. This dam is classified by the Electric Power Authority (2002) as a larger dam (by height criterion) and high risk due to the number of residents and property located below the dam. The original capacity (1943) of the Garzas Dam was 4,702 acres-feet (1.5 trillion gallons of water).

In the Risk, Vulnerability, and Impact Studies (VRI) of each municipality included in this plan you can find the dams that are located in each jurisdiction (See VRI studies of each municipality).

[30] AAA (2020) Reservoirs and Dams. Puerto Rico Aqueduct and Sewerage Authority. http://www.acueductospr.com/NIVELES/EMBALSES/embalseCAONILLAS.html

Cerrillos Dam in Ponce

Patillas Dam

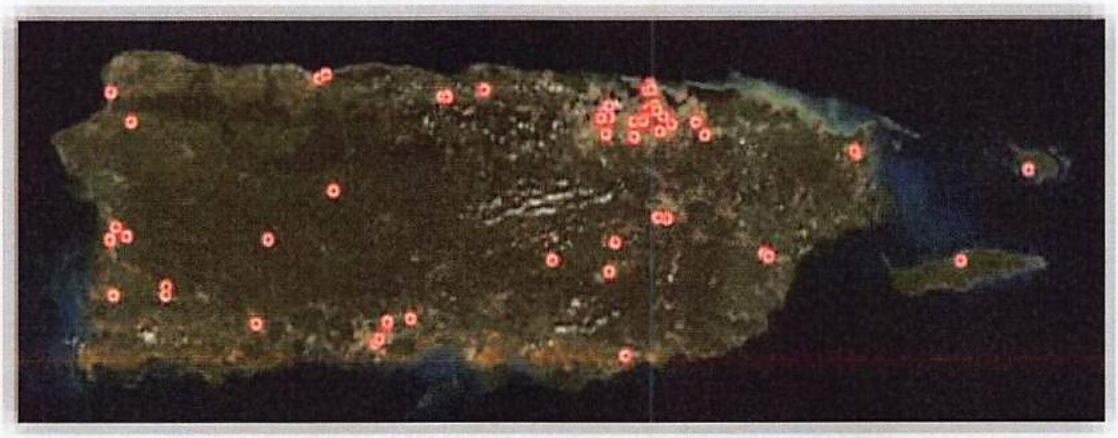
4. Fires and Explosions – Gas line ruptures, flammable liquid spills, explosions, short circuits, mechanical or manufacturing equipment displacing on the ground during the earthquake, fires in power generators caused by electrical failures are some of the causes of fires and explosions that would occur after a high-intensity earthquake in thousands of homes, public buildings, and businesses. The control of these fires should be a priority based on the threat posed by the health and safety of the population, and the availability of resources. Fires during earthquakes are regularly associated with broken gas lines that when contacted with a spark cause fires that are often uncontrollable as earthquakes cause fuel or chemical pipes to break. There are not enough hydrants around the island or firefighting resources around the island. In the 1906 San Francisco earthquake, 90% of the damage was caused by fires.

During an earthquake in manufacturing facilities, distribution warehouses, or large buildings the structures will move as the buildings as the seismic waves may amplify the movement with horizontal forces on the ceiling that can be three to four times greater than those that occur on the ground. An earthquake can cause equipment that is not properly anchored to move, slip or even overturn regardless of size or weight. Pipe, coupler, and sleeve connections may bend and split due to vertical, horizontal, and rotational movements with catastrophic fire and explosion failures.

Resources to extinguish thousands of fires in multiple jurisdictions simultaneously in Puerto Rico are limited. Citizens will have to extinguish fires by themselves using the means available to them. View each municipality's VRI to see each municipality's firefighting capabilities.

5. Public Health Emergencies – During a high-intensity earthquake, it must be considered that hospitals could be affected and some of these may become inoperable and will have to be evacuated. The first emergencies that will occur are within the same hospitals when medical equipment falls on patients, beds moving abruptly disconnecting patients from their survival equipment, and when the structure of the hospital does not support the intensity of the earthquake putting at risk the hospital structures. In addition, hospital staff would succumb to panic evacuating the building. Hospital staff may not go to their work area due to the risk of possible building collapse or physical harm due to the aftershocks.

Health and Medical



Puerto Rico has 69 Hospitals, 120 Diagnostic and Treatment Centers (CDTs), 64 330 Health Centers, and 45 Dialysis Center Units. See Appendix 7 for the full list of Hospitals in Puerto Rico and their capabilities.

The second challenge that hospitals will have will be when the public shows up in the emergency rooms to seek medical assistance. Most of these patients will have trauma injuries, open fractures, internal bleeding, dislocations, bruises, and amputations. Patients with mostly trauma would have to be transported to the Puerto Rico Medical Center "Centro Médico" which is the only Trauma Center in Puerto Rico causing a medical surge. At this time hospitals will have to establish their mass victim incident management protocols and use the Simple Triage And Rapid Treatment START-TRIAGE system for adult patients and the JumpSTART system for pediatric patients.[31] The START is a triage method used by first responders to quickly classify victims during a mass casualty incident (MCI) based on the severity of their injury. The casualties will be classified by colors. Each color represents the acuity and the need for treatment. See the table below for details:

Color	Acuity	Need for Treatment	Comments
RED	Emergent	Immediate	Threat to life, limb, or organ
YELLOW	Urgent	Delayed	Significant injury or illness but can tolerate a delay in care
GREEN	Non-Urgent	Minimal / Non-urgent	Can safely wait for treatment
BLACK	Expired or Expected	No treatment; Expectant: Treat if resources are available	Consider transport and care for expectant patients after initial "Reds" are cleared, if resources exist and it does not delay care for Yellows. FEMORS offers guidelines on palliative care.

Potential disease outbreaks are situations expected after an earthquake due to water system pollution, solid waste, environmental pollution, human waste, human and animal remains, and the few health resources that will be available after an earthquake due to lack of potable water and electricity. Thousands of people will turn to emergency rooms with minor, severe injuries, trauma, and burns, creating a medical surge in hospitals. In Puerto Rico, there are only 69 hospitals for a population of 3.4 million. Some hospitals may be inoperable and others are located in tsunami-prone areas.

[31] FLDOH (2020) Hospital Medical Surge Planning for Mass Casualty Incidents

Outbreaks and Epidemics – After a catastrophic earthquake outbreaks of leptospirosis, gastroenteritis, hepatitis will occur due to lack of hygiene, consumption of non-potable water. Arboviral diseases such as Dengue, Chikungunya, and Zika that are transmitted by the Aedes Aegypti mosquito could also develop during the island's response and recovery process.

In shelters/camps, there could be an outbreak of viral infection of various diseases such as Influenza (A and B), COVID-19, Scrabiosis (Human Scabies), Mycoplasma, and Pneumonia which require medical treatment, continuous monitoring, and hospitalization.

After an earthquake regional coalition must be activated. The Puerto Rico Department of Health (PRDOH) should establish emergency communications with these hospitals through their communication systems that can include email, phone calls, radios, and even "runners" to establish a list of the most affected hospitals. Hospitals will need to consider setting up mobile hospitals in a secure area of the hospital's parking lot or mobilizing all portable hospitals or Shelters to open space's locations. Many hospital staff will not arrive to work and others will leave the facilities to search for their family members. Hospitals will have to increase staff work shifts to 12 hours and cancel employees' vacations. Under these under-staffed circumstances, the Department of Health would activate the Medical Reserve Corps (MRC). This group of volunteers is trained to install portable hospitals, provide psychological assistance services, and provide medical services if requested by the hospital. Each hospital is responsible for validating the MRC's volunteers' credentials.

In shelters/camps, the PRDOH will send epidemiologists to monitor potential outbreaks. As a preventive measure, emergency response personnel and the most vulnerable populations in the camp would be vaccinated.

COVID-19 Pandemic – The planet is currently in the middle of a COVID-19 virus pandemic. It has been declared a pandemic as COVID-19 is an infectious disease that spreads from person to person, causes deaths, and has infected millions of people on several continents. This situation further complicates the management of shelters and evacuations after an earthquake. COVID-19 is a disease caused by a coronavirus that is part of the family of the Severe Accute Respiratory Sindrome (SARS). COVID-19 is highly contagious and has a high mortality level. According to the CDC, the most common symptoms of COVID are fever, cough, breathing problems, chills, tremors in the body, muscle pain, headache, sore throat and the recent loss of taste and smell. However, there are many cases where people may be infected with COVID, but not have any symptoms.

COVID-19 [32] is transmitted from person to person directly or indirectly through deposits of fomites or droplets of infected people that remain on the surfaces for several days. Therefore, open shelters or camps will need to ensure that there is a social distancing of at least 6' between persons, ensures that all people wear masks at all times and staff should maintain a constant disinfection process to minimize the possibility of contagion in shelters or camps. In the event of a high-intensity earthquake occurring, the life-saving and protection protocol will take priority. See Appendix 5 for COVID-19 Prevention Measures.

[32] CDC (2020) How COVID-19 spreads. Center for Diseases Control and Prevention. https://www.cdc.gov/coronavirus/2019-ncov/prevent-getting-sick/how-covid-spreads.html?CDC_AA_refVal=https%3A%2F%2Fwww.cdc.gov%2Fcoronavirus%2F2019-ncov%2Fprepare%2Ftransmission.html

6. **Landslides** – Many parts of the inland part of Puerto Rico is vulnerable to landslides during a high-intensity earthquake. A landslide by definition refers to the sudden movement of declining terrestrial materials. The most susceptible places to landslides are mountainous areas and where floors are composed of loose materials or poor soil material compaction. During an earthquake there will be a many landslide that will block roads and highways worsening the first responder's response. Also, landslides will cause the disruption of the supply chains of basic commodities, fuel, water, etc. See Risk Analysis, Vulnerability and Impact Analysis (VRI) per municipality for details.

Collapse of Barrio Mameyes, Ponce Puerto Rico, 1985 (180 dead approx.)

7. **Houses on Columns or "Stilts"** – As part of this plan, an inventory of houses built on columns or stilts in Puerto Rico has been carried out. The College of Engineers and Surveyors of Puerto Rico and Dr. José Molinelli Freytes Geomorphologist and Professor of the University of Puerto Rico have expressed that in Puerto Rico there are an estimated about 100,000 houses on stilts or houses that do not meet the required building codes. For the purpose of this plan, residences that have been built on columns that were not built according to the building codes established by the relevant authorities are considered houses in "stilts". Some of these houses could be on slopes, plains or mountains.

A study carried out at the Department of Civil Engineering and Surveyors of the University of Puerto Rico in Mayaguez found that all the residential structures on stilts, typically on the mountainous area of Puerto Rico, would collapse if each house is subject to the designed earthquake model used in the Uniform Building Code of 1997. [33]See the Risk, Vulnerability and Impact Analysis (VRI) Annex by Municipality for details.

Stilt houses in Guánica that collapsed during the earthquake of January 7, 2020

[33] Martínez J., López R., González Y. (2013) *Seismic Rehabilitation of Houses in Zancos*. Puerto Rico Strong Movement Program. Department of Civil Engineering and Surveyors. University of Puerto Rico in Mayaguez. Page 1. ISBN: 978-1-934325-99-5, 1-934325-96-6

Stilt residences on the slopes of Bayamón Township
(ISP Risk, Vulnerability and Impact Analysis)

Stilt residences on the slopes of Trujillo Alto Municipality
(ISP Risk, Vulnerability and Impact Analysis)

8. **Infrastructure Conglomerates** – Infrastructure is the main part of a jurisdiction's quality of life and economic development. During a major earthquake, several of the essential systems and infrastructures will be severely affected and many essential services will be disrupted. According to a study by the American Society of Civil Engineers (ASCE), infrastructures like bridges, dams, potable water systems, ports, energy sector, roads, solid waste and used water are in poor condition and below national standards.[34]

For the purposes of this plan, the following sectors were identified as critical infrastructure clusters:

1. **Critical Bridges** – These are bridges that if they collapse due to a major earthquake it would isolate communities or critically disrupt important areas for municipalities or regions within the Island. According to the Federal Highway Administration in Puerto Rico, there are 2,325 bridges. Of these, 11.7% are in poor condition, 69% are in acceptable condition and only 19% are in good condition. Of the total bridges in Puerto Rico that are still in use 20% (456) were built between 1842 and 1951, 28% (659) between 1952 and 1973, 29% (670) between 1974 and 1995 and 23% (540) were built between 1996 and 2017. [35]According to ASCE, bridges are regularly designed for a lifespan of approximately 50 years. However, in Puerto Rico there are 870 bridges that have over 50 years of built and 171 of these are over 90 years old.

   This is extremely relevant because in the event of a high-intensity earthquake with catastrophic consequences on the island many of these bridges will collapse[36]. See the Risk, Vulnerability and Impact Analysis (VRI) Annex by Municipality for details.

[34] ASCE (2019) Report Cardo f Puerto Rico's Infrastructure. American Society of Civil Engineers Puerto Rico Section Infrastructurereportcard.org/puerto-rico

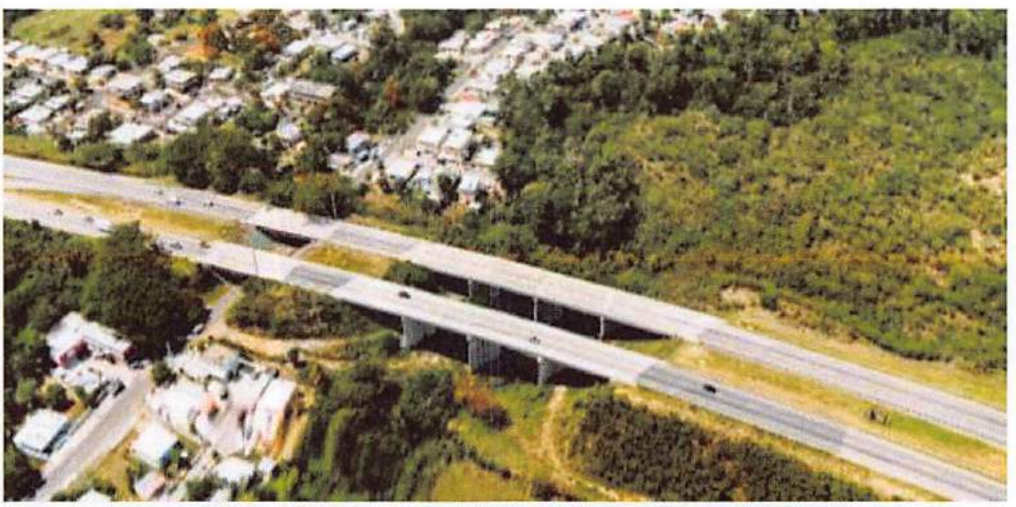
[35] FHA (2019) Bridge Condition by Year Built. US Department of Transportation. Federal Highway Administration. Retrieved from https://www.fhwa.dot.gov/bridge/britab.cfm

[36] PRHTA (2019) 2028 Puerto Rico Transportation Asset Management Plan. Chapter 5 Risk Identification and Management. Puerto Rico Highway and Transportation Authority. Page 5-19 Section 9.7

[37]

[37] FHA (2019) Bridge Condition by Year Built. US Department of Transportation. Federal Highway Administration. Retrieved from https://www.fhwa.dot.gov/bridge/britab.cfm

Highway 52 Cayey



Highway 52 Caguas

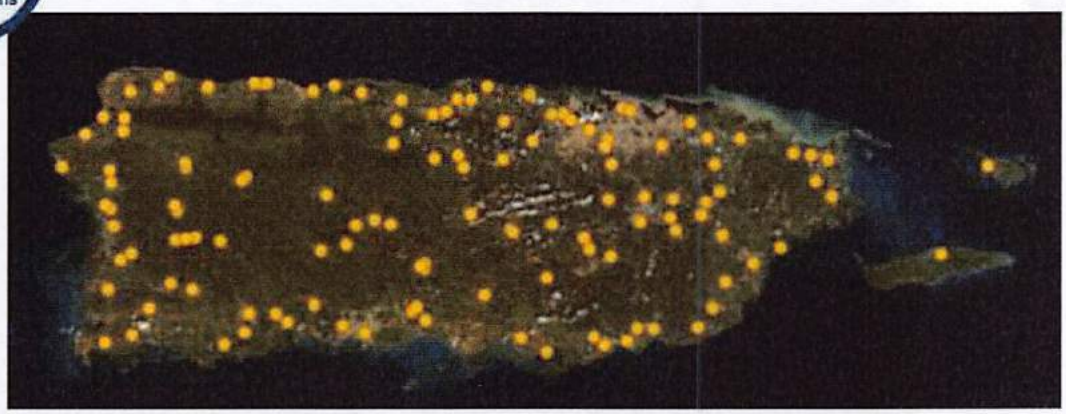
a. **Food Distribution** – They are a group of companies dedicated to the distribution of food located within a specific area and are responsible for much of the island's food supply. In the process of analyzing this Plan, we identified what we call The Bayamón Food Distribution Corridor. This conglomerate of companies is within a radius of only half a mile. The companies that make up this conglomerate account for approximately 80% of the distribution of all the food that is imported to the island. This critical conglomerate is composed by Goya Foods, B. Fernandez, José A Santiago, PR Supplies, Ballester & Hnos. and V. Suarez & Co. In addition to all these companies being within a radius of just under a mile, within the radius of this conglomerate is Puma Energy, which stores and distributes millions of gallons of gasoline, diesel and jet fuel. A high-intensity earthquake could cause food storage racks to collapse inside each warehouse and could also cause large fires.

1. PR Supply, 2. B Fernandez, 3. Jose A Santiago, 4. GOYA, 5. V Suarez & Co. These companies import and distribute 80% of all the food in P.R.

The following illustration shows the proximity of flood zones in the event of tsunamis. The yellow box indicates the position of the Bayamón Food Distribution Corridor. Evacuation routes from Cataño, Toa Baja and the disruption of the #5 road south of the conglomerate could isolate these companies after an earthquake and tsunami disrupting the island's essential food supply chain.

b. **Critical Infrastructure** – Critical infrastructures are assets, systems or networks that are vital to the island and the United States, which if their operations are disrupted or destroyed it would weaken the safety, economy and/or health of the general population. See the Risk, Vulnerability and Impact Analysis (VRI) Annex by municipality for details.

The following geographical illustration demonstrates some of the critical infrastructures in municipalities.



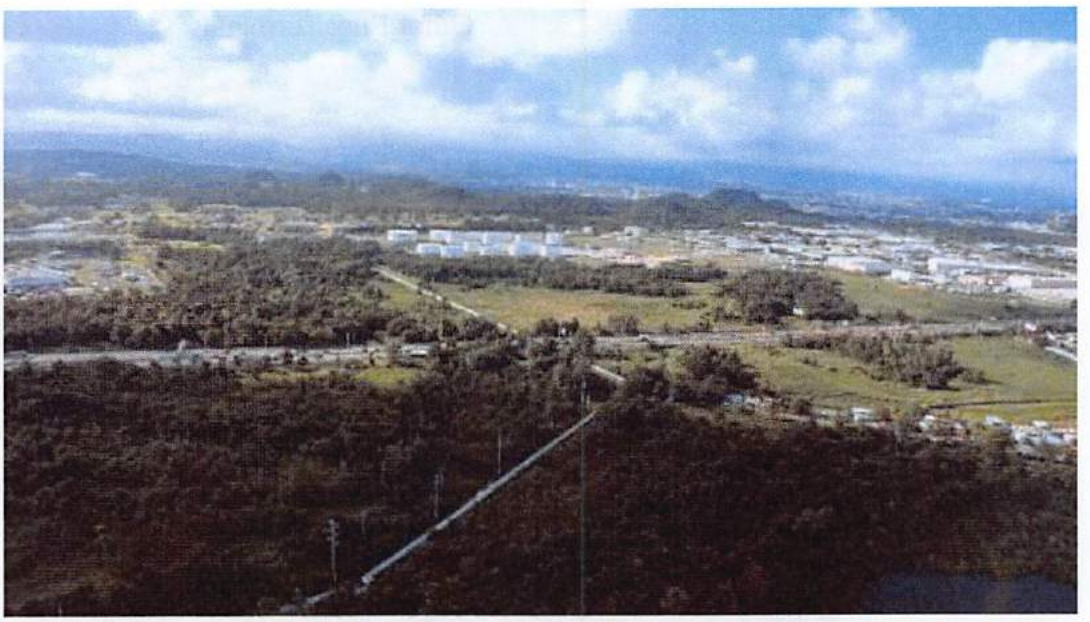
The US Department of Homeland Security (DHS) classifies critical infrastructures in 16 Sectors. These sectors are: Chemical, Commercial, Communications, Critical Manufacturing, Public Health, Emergency Services, Dams, Energy, Food/Agriculture, Water, Defense, Financial, Information Technology, Government Facilities, Nuclear and Transportation sector.

In Puerto Rico there are hundreds of critical infrastructures in all sectors identified by DHS.

Critical Infrastructure information is Confidential and will not be disclosed in the Operational Earthquake Plan. All information about critical infrastructure is classified as Protected Critical Infrastructure Information (PCII).

c. **Fuel** – Puerto Rico must import 100% of the fuel it consumes. Two of the island's main importers and distributors are in the metropolitan area. Both companies transfer fuel through exposed pipes from boats docking in San Juan Bay to their respective facilities. During an earthquake these pipes and piers could be seriously affected. Fire, spillage, explosions and fuel supply disruption are some of the identified risks.

Total Petroleum fuel transfer pipeline: .68 miles



Puma Energy fuel transfer pipeline: 2.2 miles

Puma Energy storage and distribution facilities

Other Fuel Terminals

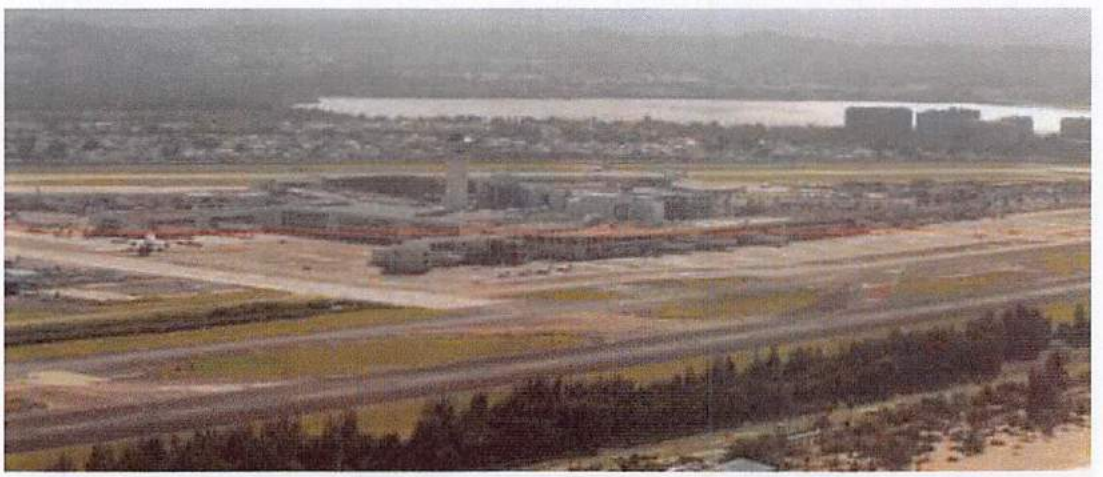
Buck Eye Terminal in Yabucoa (SOL Petroleum)

Liquified Natural Gas Terminal of Eco Electrica

d. **Airports and Heliports** – Puerto Rico's geographical characteristic of being an island between the Atlantic Ocean and the Caribbean Sea requires that most basic supplies, medicines, fuels, chemicals, food and others have to be transported by air or sea. The main airports with the highest passenger and cargo capacity are Luis Muñoz Marín International Airport (SJU) in Carolina, Rafael Hernandez Airport in Aguadilla (BQN), José Aponte de la Torre Airport (RVR) in Ceiba, and Mercedita Airport (PSE) in Ponce. On the island there are Federal Aviation Agency (FAA)-certified helipads that can be used as Heli-Spots during emergencies.

Transportation

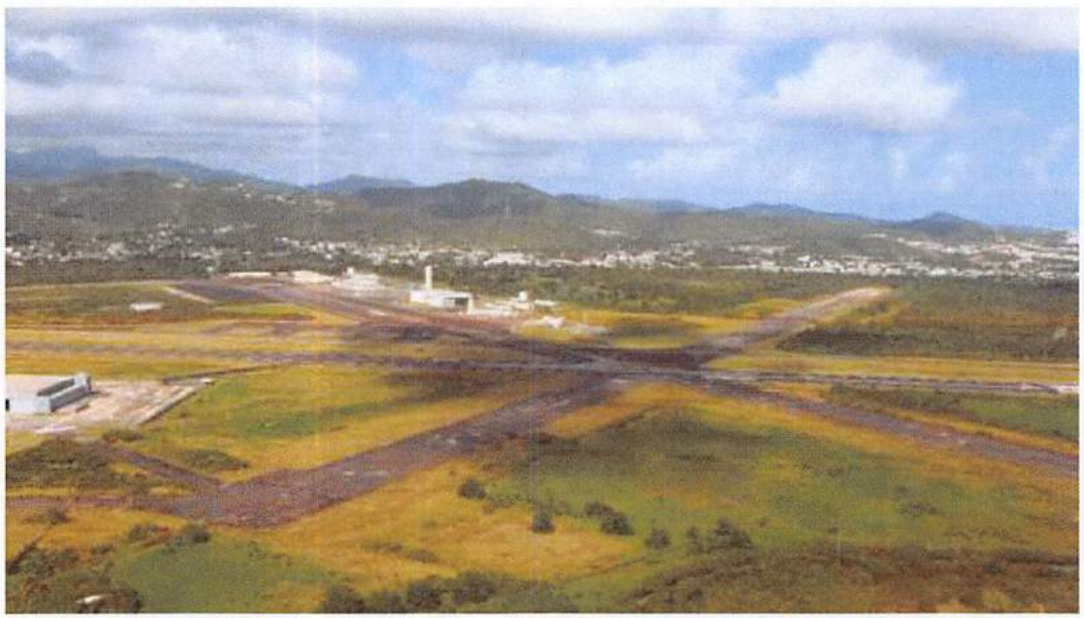
In the event of a high-intensity earthquake causing damage to the international airport (SJU), air operations will take place at the Rafael Hernandez Airport (BQN) in Aguadilla. Also, ceiba RVR and Ponce PSE could be used as alternate airports.



Luis Muñoz Marín International Airport (SJU) Carolina
Runway 8/26: 10,400ft. / 10/28: 8,016ft.

Rafael Hernandez Airport (BQN) Aguadilla

Runway 8/26: 11,702ft.



José Aponte de la Torre Airport (RVR) Ceiba

Runway 7/25: 11,000ft.

The following table identifies airports and helipads registered with the FAA.

#	TYPE	LOCID	CITY	NAME	FAC USE	LATITUDE	LONGITUDE
1	AIRPORT	PR20	ADJUNTAS	ADJUNTAS	PR	18.180228	-66.756944
3	AIRPORT	BQN	AGUADILLA	RAFAEL HERNANDEZ	PU	18.494861	-67.129444
2	HELIPORT	PR23	AIBONITO	BAXTER-AIBONITO	PR	18.139682	-66.266279
4	AIRPORT	ABO	ARECIBO	ANTONIO/NERY/JUARBE POL	PU	18.451111	-66.675556
5	HELIPORT	PR33	BAYAMON	BAYAMON RGNL HOSPITAL	PR	18.36745	-66.153778
6	AIRPORT	PR24	BOQUERON	CULLINGFORD FIELD	PR	17.976389	-67.170833
7	AIRPORT	PR10	CABO ROJO	BOQUERON	PR	18.013019	-67.145456
8	AIRPORT	RVR	CEIBA	JOSE APONTE DE LA TORRE	PU	18.245269	-65.643381
9	HELIPORT	PR53	CIDRA	SABANERA	PR	18.190833	-66.120833
10	HELIPORT	PR06	CULEBRA	HILL	PR	18.3	-65.283333
11	AIRPORT	X95	FAJARDO	DIEGO JIMENEZ TORRES	PU	18.30801	-65.661828
13	HELIPORT	PR26	FAJARDO	VILLA MARINA	PR	18.331342	-65.632939
12	SEAPLANE BASE	PR03	FAJARDO	FAJARDO HARBOR	PR	18.339675	-65.624606
14	HELIPORT	PR21	GUAYNABO	FORT BUCHANAN	PR	18.415	-66.131944
15	HELIPORT	1PR3	GUAYNABO	SAN PATRICIO	PR	18.406061	-66.106011
16	HELIPORT	2PR2	GUAYNABO	CARIBBEAN CONSTR MAIN OFFICE	PR	18.314792	-66.093517
17	HELIPORT	PR68	HATO REY	MORA DEVELOPMENT CORP	PR	18.415278	-66.075833
18	AIRPORT	X63	HUMACAO	HUMACAO	PU	18.138017	-65.800718
19	HELIPORT	PR04	HUMACAO	SQUIBB	PR	18.14885	-65.793773
20	HELIPORT	PR28	ISABELA	R.H.	PR	18.494181	-67.024172
21	AIRPORT	CPX	ISLA DE CULEBRA	BENJAMIN RIVERA NORIEGA	PU	18.313289	-65.304324
22	AIRPORT	VQS	ISLA DE VIEQUES	ANTONIO RIVERA RODRIGUEZ	PU	18.134811	-65.493617
23	HELIPORT	PR14	JAYUYA	ORAMA-IAYUYA	PR	18.211068	-66.62934
25	AIRPORT	PR25	LAJAS	LAJAS AIRPARK	PR	18.0125	-67.075
24	HELIPORT	PR15	LAJAS	PARGUERA	PR	17.975	-67.044444
26	AIRPORT	PR07	LAS PIEDRAS	BOQUERON	PR	18.201902	-65.839052
27	HELIPORT	PR32	MANATI	HOSPITAL ALEJANDRO OTERO LOPEZ	PR	18.433611	-66.483611
28	AIRPORT	MAZ	MAYAGUEZ	EUGENIO MARIA DE HOSTOS	PU	18.255694	-67.148472
29	HELIPORT	PR09	MAYAGUEZ	SABALOS WARD	PR	18.176111	-67.146667
30	HELIPORT	PR29	MAYAGUEZ	VILLAMIL-MAYAGUEZ MALL	PR	18.158889	-67.146389
31	HELIPORT	PR19	OROCOVIS	OROCOVIS HEALTH CENTER	PR	18.226623	-66.394337
32	AIRPORT	X64	PATILLAS	PATILLAS	PU	17.982189	-66.01933
33	AIRPORT	PSE	PONCE	MERCEDITA	PU	18.008306	-66.563028
34	HELIPORT	PR11	PUERTO NUEVO	REXACH OFFICE BUILDING	PR	18.415225	-66.126833
35	HELIPORT	PR08	SAN GERMAN	BAXTER-SAN GERMAN	PR	18.086072	-67.027956

#	TYPE	LOCID	CITY	NAME	FAC USE	LATITUDE	LONGITUDE
36	HELIPORT	28PR	SAN GERMAN	LA CONCEPCION HOSPITAL	PR	18.108694	-67.039444
39	AIRPORT	SIG	SAN JUAN	FERNANDO LUIS RIBAS DOMINICCI	PU	18.456827	-66.098139
40	AIRPORT	SJU	SAN JUAN	LUIS MUNOZ MARIN INTL	PU	18.439417	-66.001833
37	HELIPORT	PR22	SAN JUAN	PUBLIC BUILDINGS AUTHORITY	PR	18.449167	-66.066389
38	HELIPORT	PR42	SAN JUAN	EMPRESAS DIAZ - RIO PEDRAS	PR	18.395278	-66.051389
41	HELIPORT	PR30	SAN JUAN	PRTC OFFICE BUILDING	PR	18.411059	-66.101555
42	HELIPORT	PR31	SAN JUAN	SAN JUAN STEAM PLANT	PR	18.428003	-66.105444
43	HELIPORT	PR17	SAN JUAN	PRASA-BARBOSA	PR	18.414114	-66.043777
44	HELIPORT	PR01	SAN JUAN	HATO REY	PR	18.419167	-66.056667
45	HELIPORT	12PR	SAN JUAN	VILLAMIL-304 PONCE DE LEON	PR	18.422633	-66.057025
46	HELIPORT	PR99	SAN JUAN	PUERTO	PR	18.395556	-66.073611
47	HELIPORT	PR12	SAN JUAN	STATE GOVERNMENT NUMBER ONE	PR	18.44939	-66.066554
48	HELIPORT	PR13	SAN JUAN	INSULAR GOVERNMENT NUMBER TWO	PR	18.417447	-66.077666
49	HELIPORT	PR16	SAN JUAN	BANCO POPULAR CENTER	PR	18.427446	-66.058777
50	SEAPLANE BASE	PR34	SAN JUAN	SAN JUAN	PR	18.457778	-66.121111
51	HELIPORT	PR02	TOA ALTA	PRASA - LA PLATA	PR	18.3525	-66.236389
52	AIRPORT	02PR	VEGA BAJA	CUYLERS	PR	18.453333	-66.366944

e. **Maritime Ports** - Puerto Rico's seaports are key to import and export all the products that are consumed and produced on the island. The main port of the island is the Port of San Juan where almost 95% of all cargo in Puerto Rico is transported. The responsibility for the maritime cargo operations in the Port of San Juan relies on four private companies, Crowley, TOTE Maritime, Luis Ayala Colón and Trailer Bridge. The main seaports are the Port of San Juan in San Juan, Port of Ponce, Roosevelt Roads in Ceiba, Port of Fajardo, Port of Yabucoa, Port of Aguirre, and the Port of Mayaguez. It can also be considered the Bay of Guayama where Ro-Ro barges can operate.

Transportation

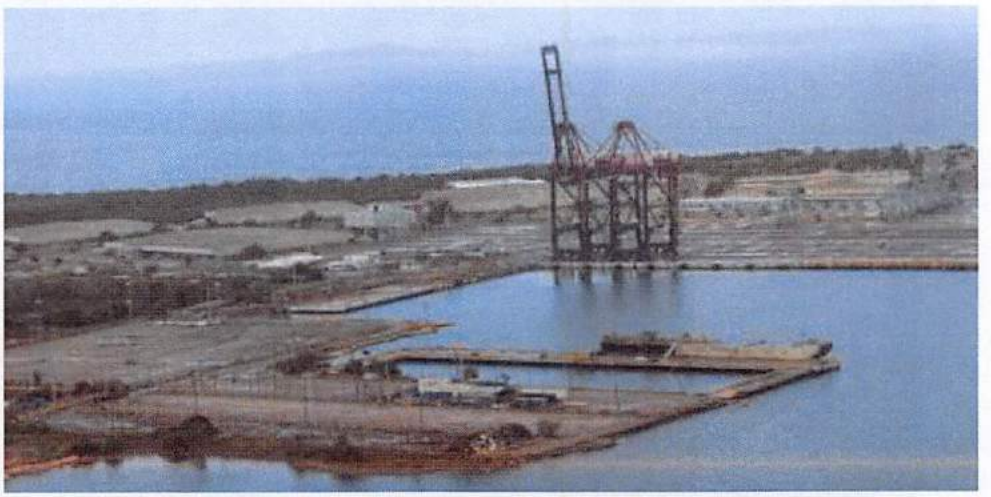
The Port of San Juan is the most critical port on the island due to its large cargo mobilization capacity and where all major maritime cargo companies operate. The Port of San Juan has 22,700 feet of pier, 34 berths and 46 docks. The storage space is 1.1 million square feet, 108 acres of container space, and two major fuel companies use the Port of San Juan to import fuel to the island (TOTAL and PUMA Energy).

TOTE Maritime, Luis Ayala Colón and Trailer Bridge Operational Area

Container storage and distribution area in the San Juan Port

Crowley Operational Area

In case the Port of San Juan is severely impacted by an earthquake or tsunami limiting or disrupting it operations, the Port of Ponce could be considered as an alternate maritime transport point. However, during the development of this Plan, we carried out an inspection of the Port of Ponce and discovered that several docks in the Port of Ponce were affected or destroyed by the 2020 earthquakes. Currently, the port of Ponce does not have all its capacity available, also the Gantry cranes that are necessary to unload the containers of the boats are not in function. The Port of Ceiba could be another option to unload boats or vessels.



Port of Ponce

Port of Ceiba

Ro-Ro barges can dock in Guayama

Buck Eye Pier in Yabucoa

Alternate Operational Logistics for Maritime Ports

If there is a major earthquake that causes major damages to the infrastructure of Puerto Rico's maritime ports, a preliminary damage assessment should be done to all ports on the island to rapidly assess its capabilities to carry out temporary emergency operations. The available ports that could be considered are Arecibo, Ceiba, Mayaguez, Ponce and San Juan. Also, the piers and ports in Yauco, Guayama and Peñuelas could be evaluated for temporary emergency operations. However, the following elements must be taken into account in order to perform these operations:

- Mobilize "Kalmar Reach Stacker" cranes to alternate ports

- In the case of Kalmar cranes cannot be mobilized or were affected, "Crawler" or telescopic cranes can be used to unload boats or barges. Their capacities must be between 150 and 550 tons. These cranes are available in Puerto Rico with several companies. Some of these companies that have these equipment are located in San Juan, Bayamón and Caguas.

Types of vessels and containers capacities:

- **Boats** have an average of 800 containers spaces
- **Flat Deck Barges** have a capacity of 350-400 containers
- **Rollon-Rolloff "RoRo" barges** have 360 spaces

- **Boats**
  - Needs a 980 to 1,000 feet long pier
  - Needs a water depth of 34' to 36'

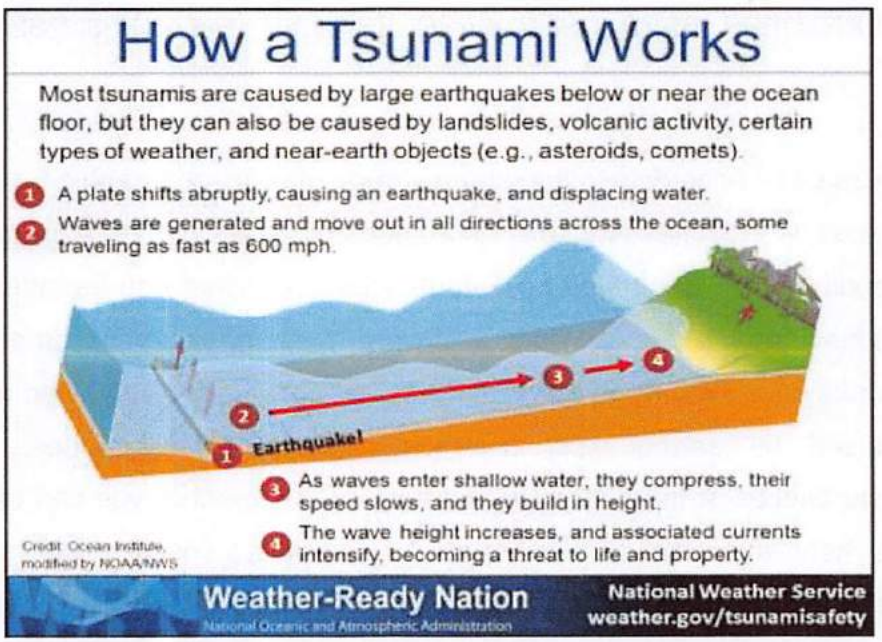
- **Flat Deck Barges**
  - Needs a 300' long Pier
  - Needs a water depth of 16'

- **"RoRo" Rollon-Rolloff**
  - Needs a 150' long pier
  - Needs a water depth of 14'

9. **Mass Evacuations –** During high-intensity earthquakes that cause damage hundreds or thousands of homes may be in danger of may collapse. The evacuation process of the affected population can be very challenging as it involves not only a logistical challenge, but could create an overload in other jurisdictions that do not have the capability to receive the evacuees. Effective evacuation should consider mobilizing the most vulnerable populations first (pregnant women, people with physical disabilities, elders, and families with young children). The rest of the population can be gradually evacuated as understood by the authorities in charge of this task. For the duration of the COVID-19 pandemic, hygiene, decontamination and social distancing measures will have to be taken during the evacuation process. The agencies in charge would be, PREMB, GNPR, DVPR, DFPR, DEPR, DSPR, NPPR, ESF-13, ESF-6, ESF-8, ESF-5.

10. **Tsunami –** According to the Intergovernmental Oceanographic Commission, in its Glossary, it defines tsunamis as a series of waves of extremely long length and period, usually generated by disturbances associated with earthquakes occurring under or near the ocean floor. The word "tsunami" is composed of the Japanese words wave ("nami") in port ("tsu"). Tsunamis are also described as large waves caused by earthquakes, underwater landslides, volcanoes, among other disturbances at the bottom on the seabed. Tsunami waves can travel 500 miles per hour across the sea or ocean. A tsunami is a series of waves, and the time between waves can range from five minutes to an hour. Actual arrival times may differ from estimates and the first wave may not be the largest. Upon reaching the coasts the tsunami waves can reach more than 20 feet high and the flood it causes can reach several miles inland at some specific points in Puerto Rico such as in Loíza, leaving in its path devastation and thousands of deaths if people in the flood zones don't evacuate on time. (See PR Tsunami flood map and evacuation annex). Sixty percent of Puerto Rico's population resides in coastal areas. It should be noted that 42 of the 78 municipalities are exposed to coastal flooding caused by tsunamis. Communities on the island that are located on soft ground may experience intensities strong enough to damage many types of structures.

Tsunami flood map of Puerto Rico[38]



The danger of a tsunami in Puerto Rico is real. Historically, two tsunamis have already occurred off the coast of the island. One happened in 1867 and the second was in 1918. These tsunamis caused destruction on the coasts. So far, the tsunamis that have occurred have been near the Puerto Rico region. However, for a tsunami to occur, an earthquake does not necessarily have to occur near the island. Tsunamis can occur due to earthquakes elsewhere. Tsunamis can also

[38]RSPR (2020) Flood Map and Tsunami Evacuation Routes. Puerto Rico Seismic Network.

occur from underwater landslides, volcanic eruptions, and even the fall of large objects falling from space.

Tsunami and Earthquake Hazard Model in the Caribbean[39]

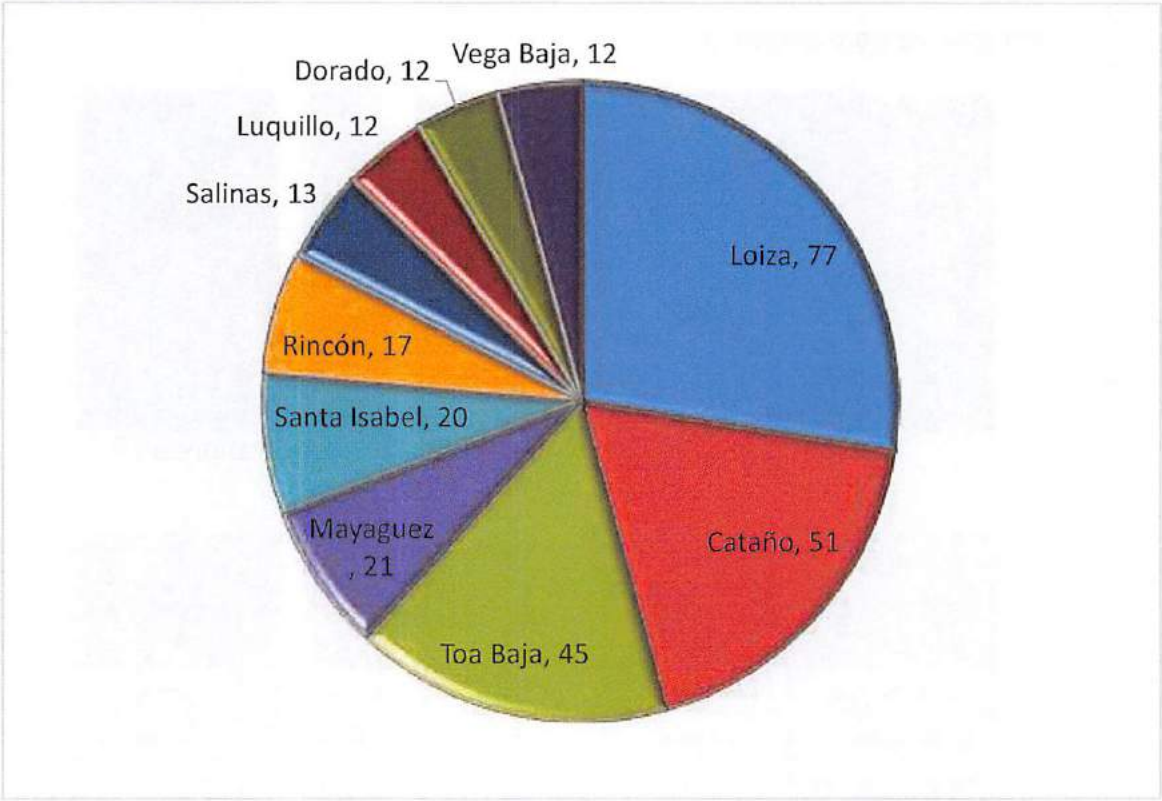
Region	*Hazard based on runups*	*Hazard based on frequency*	*Hazard based on local earthquakes*	*Number of reported deaths*
U.S. Atlantic coast	Very low to low	Very low	Very low to low	None
U.S. Gulf coast	Very low	Very low	Very low	None
Puerto Rico and the Virgin Islands	High	High	High	172
U.S. west coast	High	High	High	28
Alaska	Very high	Very high	High	222
Hawaii	Very high	Very high	High	326
U.S. Pacific island territories	Moderate	High	High	1

Qualitative Tsunami Risk Assessment according to USGS studies[40]

As can be seen in the table above, a qualitative study based on frequency, local earthquakes, models and reported deaths by the USGS and NOAA in 2008 shows that Puerto Rico has a high risk of tsunami due to a potential earthquake.

[39]Brink U., Flores C. Natural Hazards, Coastal and Marine Hazards and Resources Program, Woods Hole Coastal and Marine Science Center. USGS Caribbean Tsunami and Earthquake Hazard Study Models. Agosto 8, 2008

[40] Dunbar P., Weaver C. (208) U.S. States and Territories National Tsunami Hazard Assessment: Historical Record and Sources for Waves. National Oceanic and Atmospheric Administration. U.S. Geological Survey. P. 2-11



The Puerto Rico Seismic Network identified the ten municipalities with the highest percentage of population residing in flood or tsunami impact areas in Puerto Rico[41][42]

[41]RSPR (2017) Puerto Rico Seismic Network. *Tsunami: Puerto Rico Media*Guide. 7 edition. Mayaguez, P.R.

[42] RSPR (2019) Puerto Rico Seismic Network. Guide for Tsunami Warning Focal Point Operators for Puerto Rico. 1st ed. Mayaguez, PR.

Tsunami Alert Protocols for Puerto Rico and the US Virgin Islands

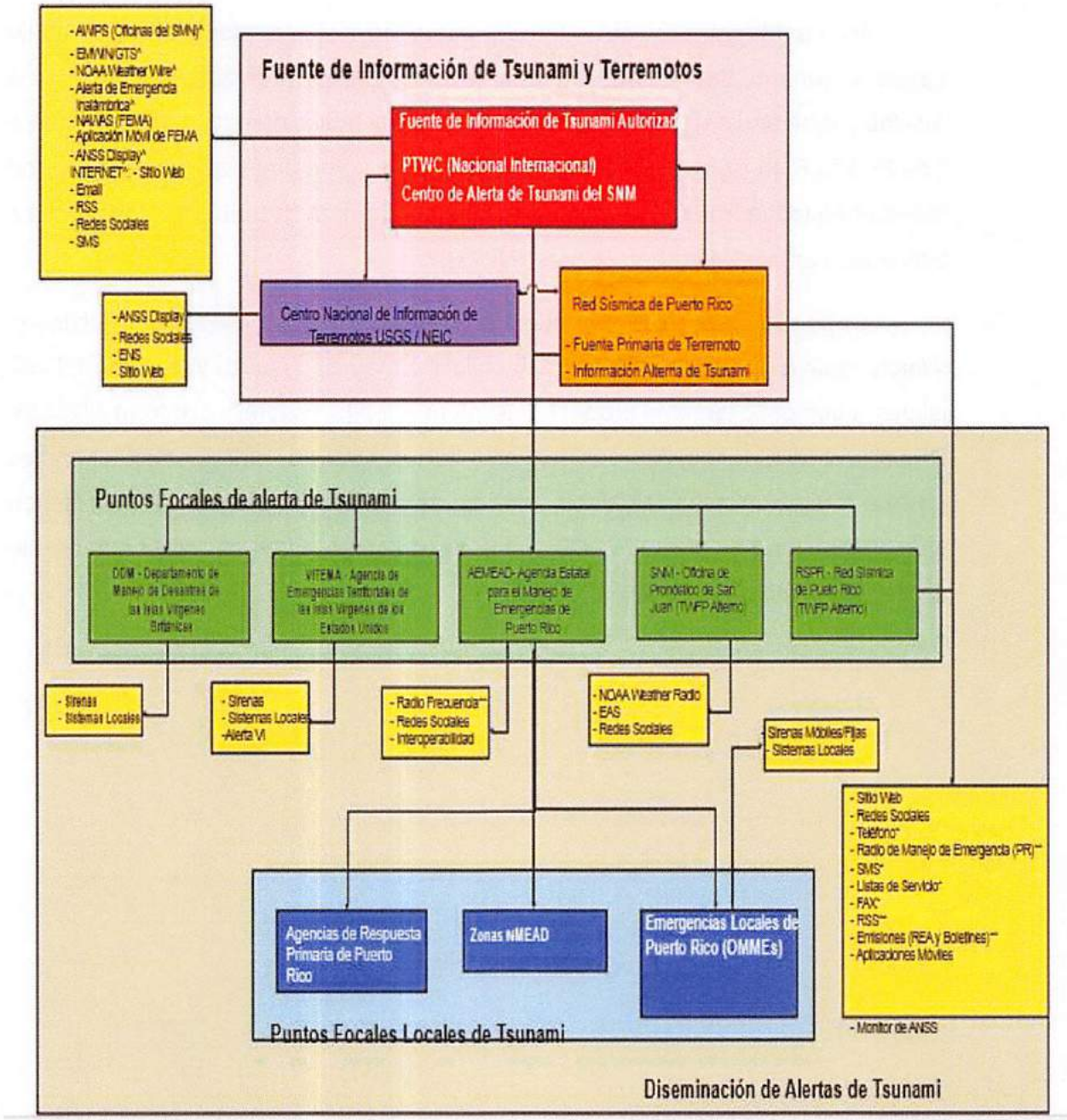
If an earthquake occurs in the Caribbean area or in a nearby area that could cause a tsunami, the Pacific Tsunami Warning Center (PTWC) will analyze the available data and determine the[43] level of tsunami notification to be disseminated. The Puerto Rico Seismic Network (PRSN), at the same time, will disseminate the information to the Puerto Rico Emergency Management Bureau (PREMB) and the San Juan National Weather Service (NWS). [44]

Depending on the information analyzed, a Tsunami Warning, Advisory, Watch, Bulletin or Tsunami Alert Cancellation may be issued. When the PTWC issues a domestic tsunami product, this information is disseminated from PREMB, PRSN and NWS to the different local and state emergency management agencies (in Puerto Rico and the US Virgin Islands, as appropriate). Then the information will be disseminated using the different methods of mass communication available on the state and municipalities.

[43] UNESCO (2017) Center Enhanced Products for the Tsunami and other Coastal Hazards Warning System for the Caribbean and Adjacent Regions (CARIBE-EWS). Intergovernmental Oceanographic Commission Technical Series. October 2017. Version 2.0

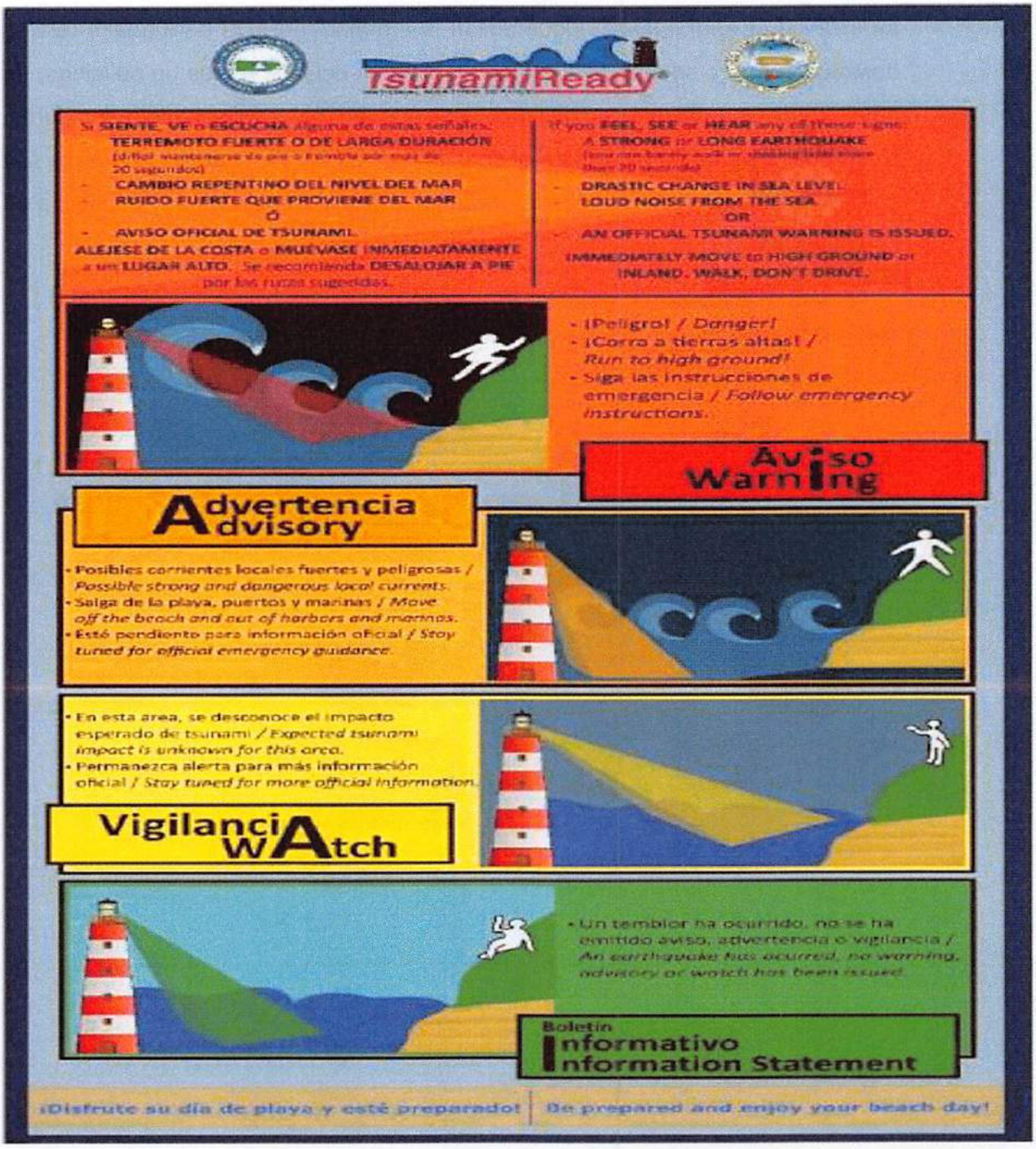
[44] Puerto Rico Seismic Network. 2019. Guide for Tsunami Warning Focal Point Operators for Puerto Rico. 1st ed. Mayaguez, PR.

Tsunami communication protocol for Puerto Rico & USVI[45]

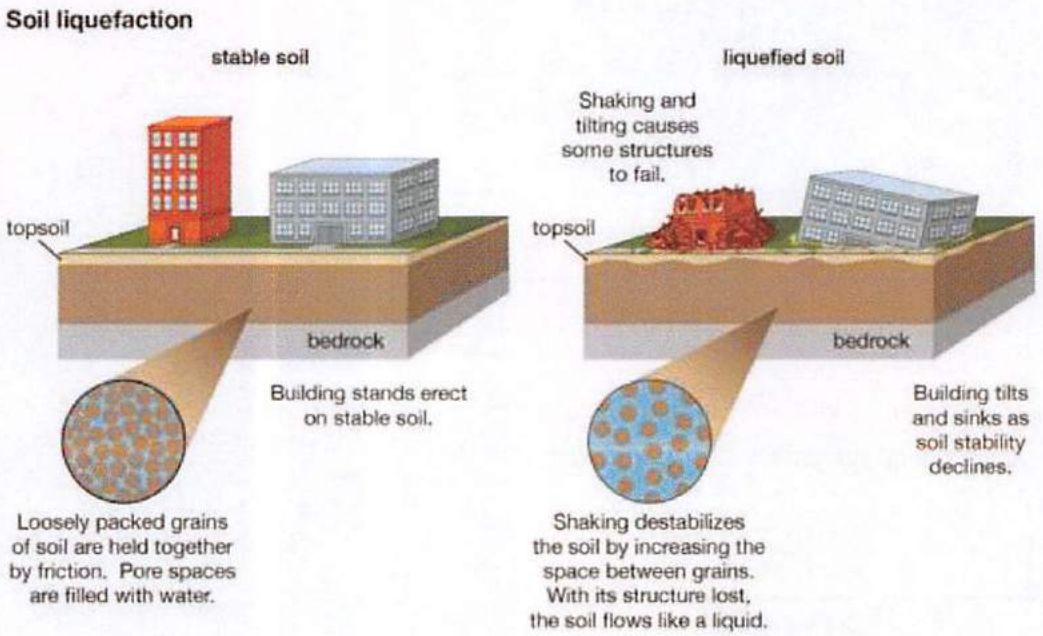


[45]Puerto Rico Seismic Network. 2017. *Tsunami: Puerto Rico Media Guide.* 7ed. Mayaguez, PR.

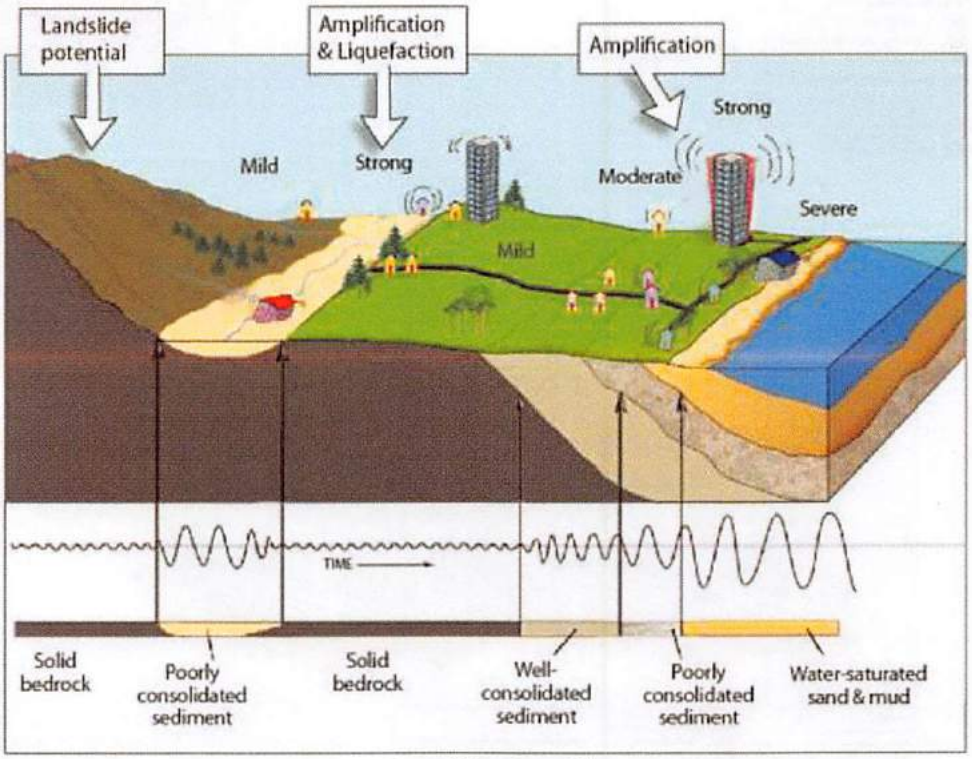
Tsunami Notification System



11. Liquefaction- Soil liquefaction occurs when land, due to water saturation and particularly in recent sediments such as sand or gravel, loses its firmness and flows as a result of earthquakes. Liquefaction is a major cause of earthquake-related destruction (more so than by the direct impact on seismic waves on buildings). In other words, liquefaction can displace, sink or even make collapse infrastructures. Unsurprisingly, the infrastructure of coastal regions are most at risk due to its soft soil compositions (Alluvium, sands, swamps, artificial fill soils, poorly consolidated sediment, etc.).



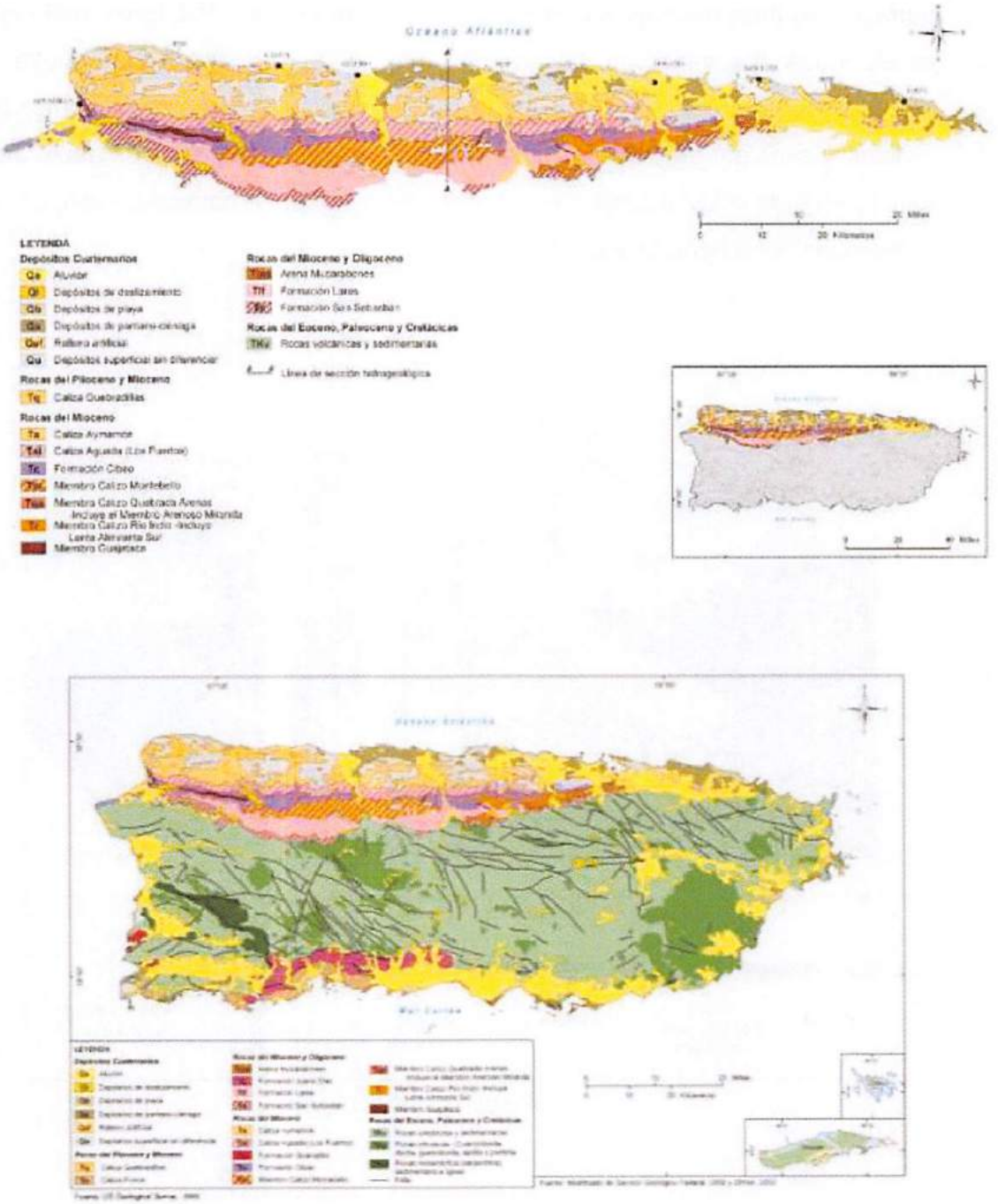
12. **Amplification Effect** – In case of a high-intensity earthquake the amplification effect should be considered which arises when seismic waves travel on a solid surface and then reaches a less solid area which can be filled, loose material or sandy areas, the wave can move easily, amplifying, making the earthquake feel stronger than in other areas making the buildings collapsing partially or completely. Seismic waves are amplified in places where there are soft grounds. These areas usually include alluvial plains and areas where lagoons, canyons, swamps and mangroves have been re-sealed.[46]



Amplification [47]

[46] Molinelli J. (n.a.) How to Protect yourself in case of earthquake? What geological hazards do earthquakes accompany? Civil Defense of the Municipality of San Juan.
[47] ANGLE (2020). Seismic Geohazards & Earthquake Hazard Maps https://serc.carleton.edu/ANGLE/educational_materials/activities/205530.html

Figura 0. Mapa generalizado de la geología de la Región Norte de Puerto Rico. Refiérase a Figura 3-4 para detalles de sección transversal.



Geological Map of Puerto Rico[48]
Most of Puerto Rico's coastal geological composition is Alluvion, Sand deposits and Artificial Fill Soils

[48] USGS (2000) US Geological Survey

13. **Potable water and sewerage system** – In the event of a high-intensity earthquake, underground steel or concrete pipes of the PR Aqueduct and Sewer Authority (PRASA) will suffer damage that will cause major breakages causing service disruption, road blockages and sink holes in many areas. Used water treatment plants will be affected causing contaminated water to flow into bodies of water creating environmental and public health problems. In turn, when an earthquake occurs the island's electrical system will be disrupted directly affecting the pumping and water processing systems on the island.

Filtration and Waste Water Treatment Plants of PR

Broken 66" water pipe in Bayamón

Broken water pipe in Trujillo Alto

Scenarios like the one depicting these photographs will be very common throughout the island as the pipes have many years of use and the seismic movements will break these connections and pipes that would take weeks or months to be repaired due to the high volume of incidents. The Super Aqueduct should be evaluated with priority as it provides water to more than 1.5 million people daily.

14. **Schools –** In Puerto Rico there are 854 schools, 262 of these are certified shelters. Approximately 50% of all schools were built before 1987 when there was still no building code to look at structural resistance during an earthquake. The problem with some of the schools that were built before the 1987 building codes were implemented is that many of these have a structural design defect called "short column". According to a preliminary assessment by the Puerto Rico College of Engineers and Surveyors in the island's public schools in January 2020, it indicates that there are hundreds of schools that have the short column defect. The short column effect occurs when in the construction design a high wall restricts the movement of a column during an earthquake preventing energy from being released by breaking down the "short column" and causes it to collapse and/or become inoperative. This defect causes columns facing classroom doors to collapse during a strong earthquake by blocking students from their classroom. Another [49]effect that some schools might experience is liquefaction. This implies that some school structures could sink partially because the terrain loses to the ability to bear the weight of the structure.

Agripina Seda School in the Municipality of Guánica January 7, 2020

Of the 854 schools in Puerto Rico, about 40 are in tsunami prone area. However, some of these are now closed. Below is the list of schools in tsunami evacuation zones. The PRSN has developed the evacuation zones for all the identified areas. Please note

[49] Perez, O. (2020) College of Engineers: 500 schools could collapse into an earthquake. First hour. January 8, 2020. https://www.primerahora.com/noticias/puerto-rico/nota/colegiodeingenieros500escuelaspodriancolapsarenunterremoto-1385826/

that the evacuation zones are slightly larger than the flood zone suggested by the models used to develop the maps.

School in Tsunami Flood Areas

Municipality	Name	Address	Latitude	Longitude
Loíza	Medianía alta elemental	Carr. 187 km 5 hm 6 Bo Medianía alta	18.42660171000	-65.84243630000
Loíza	Nueva superior de Loíza	Carr. 187 km 5 hm 6 bo medianía	18.42494223000	-65.84261090000
Loíza	Belén Blanco de Zequeira	Urb. San Patricio 205 calle Carlos Escobar	18.43270017000	-65.87886995000
Peñuelas	Su Jorge Lucas Valdivieso	Carr. 2 km 4 Bo Encarnación	17.99722768000	-66.71977092000
Ponce V	Lucy Grillasca	Ave Eduardo Ruberte parque Amalia Marín	17.98619604000	-66.62928297000
Loíza	Celso Gonzalez Vaillant	Carr. 188 km 7 hm 2	18.42634592000	-65.88096889000
Toa Baja	José Robles Otero	Carr. 867 km 5 Bo Ingenio	18.44413461000	-66.22944686000
Toa Baja	Dr Efraín Sánchez Hidalgo	Mariano Abril Costalo 6to Sec Levittown	18.44163897000	-66.16940135000
Toa Baja	Basilio Milán Hernandez	Ave José de Diego esq Sabana Seca	18.43839966000	-66.17359289000

Municipality	Name	Address	Latitude	Longitude
Toa Baja	Carmen Barroso Morales	Calle Ramón Morla 6ta secc. Levittown	18.43414894000	-66.17271077000
Mayagüez	Segundo Ruiz Belvis	Ave Gonzalez clemente res Carmen	18.19454181000	-67.15429129000
Mayagüez	Mariano riera palmer	Calle Méndez Vigo 297	18.20736622000	-67.14973092000
Mayagüez	María Dolores Faria	Ave JC Clemente	18.19630634000	-67.15311531000
Aguadilla	José de diego	Ave Fernando Yumet	18.41737414000	-67.15594975000
Humacao	Su Agapito Lopez flores	Urb. Verde mar calle 6	18.16098704000	-65.75976594000
San Juan I	Dr julio j henna	Villa palmera Calle Henna Esq Providencia	18.44595335000	-66.04786682000
San Juan I	Luis Llorens Torres	Calle Mariasabel, res. Llorens torres	18.44761763000	-66.04107997000
Culebra	Ecológica de Culebra	109 calle Escudero	18.30821770000	-65.30316490000
Salinas	Las mareas	Bo las mareas calle principal	17.94820467000	-66.26469467000
Cataño	Onofre Carballeira	Ave las Nereidas	18.44215620000	-66.12880122000
Cataño	Francisco Oller	Ave las nereidas	18.44180011000	-66.12811344000

Municipality	Name	Address	Latitude	Longitude
Mayagüez	Eugenio María de Hostos (superior)	Calle Nanadich Esq. Vazquez	18.19806764000	-67.14457077000
Mayagüez	Dr Pedro Perea fajardo	Ave Luis Llorens torres	18.20758784000	-67.14693367000
Mayagüez	Esteban Rosado Baez	Carr. 341 Bo. Mani	18.23060143000	-67.17195366000
Ceiba	Puerto Rico Aviation Maintenance Institute	Forestal drive corner, langley drive	18.24264546000	-65.63708182000
Luquillo	Rafael N Coca	Calle Fernández Garcia final	18.37758775000	-65.71711080000
Loíza	Su Nueva bo Medianía	Carr. #187 km 3 hm 9 bo Medianía alta	18.42600095000	-65.84937966000
Ponce II	Sor Isolina Ferre	Calle Solimar Urb. villa del Carmen	17.97786546000	-66.60444453000
Santa Isabel	Pedro Melendez Santiago	Calle libertad Bo playita cortada	17.98423322000	-66.43697740000
Toa Baja	Delia Dávila de Caban	Calle lago las Curias final 5ta Sección Levittown	18.43487100000	-66.18163579000
Toa Baja	Dr pedro Albizu campos	Ave boulevard 4ta secc Levittown	18.44915891000	-66.18144434000

Municipality	Name	Address	Latitude	Longitude
Arecibo i	Angelica Gomez de Betancourt	Carr. 681 hm 3 bo islote	18.47871296000	-66.69346295000
Cabo rojo	Monserrate Leon Irizarry	Carr. 101 km 18 hm 2	18.02733896000	-67.16395518000
Cabo rojo	Segunda unidad bo puerto real	Carr. pr308 km 5.3 sector pr	18.08641463000	-67.18715350000
Mayagüez	Escuela libre de musica y bella artes Ernesto Ramos Antonini	Bvd Eduardo Báez sector buena vista	18.19770247000	-67.14013810000
Ponce V	Dr Alfredo m aguayo	Ave 65 infantería esq Valdivieso bo playa	17.98610272000	-66.61919472000
Ponce II	Angela Cordero Bernard	Calle Solimar Urb. villa del Carmen	17.98058167000	-66.60704831000
San Juan I	Julián e Blanco (ballet)	Calle Martin Travieso, esq. Estrella	18.45080088000	-66.06585777000
San Juan I	Luis Rodriguez Cabrero	Calle Corona res Luis Llorens Torres	18.44904107000	-66.04914946000
San Juan I	Ramón Power y Giralt	Calle Loíza final	18.44933232000	-66.05102483000
Loíza	Jobos	Carr. 187 km 9 hm 8 bo Medianía alta	18.42781000000	-65.86452200000

15. **Public Safety –** A major earthquake incident on the island will bring with it a number of challenges in public safety. Public safety incidents will escalate as the hours pass after a major earthquake. If the earthquake occurs during business and school hours, the first challenge that the Puerto Rico Police Bureau will have will be to control traffic on the streets. If an earthquake occurs during school hours hundreds of thousands of parents will go out looking for their children, people will not obey traffic laws and there will be many car accidents blocking the roads of emergency vehicles. If the earthquake occurs at night, there will be few police personnel who can take control of the streets during the first 24 hours of the incident.

As the hours go by, people will have problems to get back to their homes or meeting points with their relatives. Also, many people might take advantage of the emergency and the lack of electric power to commit crimes. The most common crimes will be house invasion, armed robberies, car thefts and looting.

The other challenge the Police will have is that even when they arrest a suspect, they will not be able to process the person because the courts will be closed and prosecutors might not be available.

The biggest challenge the Police will have after a high-intensity earthquake is that most of the agents may not show up for work because they would be taking care of their families or personal emergencies.

Due to the lack of staff and resources to provide security to citizens, the Puerto Rico National Guard would be activated to provide public safety support for the duration of the emergency.

16. **Search and Rescue Operations -** Natural disasters that occur without warning like earthquakes typically damage infrastructure very quickly, injures people, and many lives are lost in a matter of minutes. The location, intensity and impact of an earthquake cannot be predicted. Therefore, the Search and Rescue (SAR) Operations cannot be pre planned or the resources could not be prepositioned. Puerto Rico Search and Rescue operators have been training for many people to respond to a Mass Casualty Incident (MCI). However, many of these SAR operators are no longer working on the Government.

The immediate response to an earthquake event will focus on saving lives. Primary operations will be the evacuation of people who are in imminent danger and conducting search and rescue operations of people who are trapped under the rubble or cars. The priority will be to save as many people as possible. The probability of survival will depend on how quickly the victims can be rescued. The first 24 hours will be critical when it comes to saving people. Operators shall always take the necessary precautions to carry out operations safely.

The primary responsibility for search and rescue operations will first be carried out by the trained professional personnel of each municipality. If the municipality does not have the necessary personnel or equipment to carry out search and rescue operations, the director of the Municipal Emergency Management Office or the mayor will contact PREMB's Zone Director who will begin by making the necessary regional efforts to support the municipality. Also, the municipal or regional director may activate SAR volunteer groups that have the experience and credentials to carry out SAR support operations. If the Zone Director understands that state or regional resources are not sufficient, the Zone Director will contact the Emergency Operations Center (EOC) to activate resources at the Puerto Rico State Government level to support municipalities. At the state level, the specialized Puerto Rico Urban Search And Rescue (PRUSAR) team can be activated to support municipalities. The Puerto Rico National Guard in turn has a specialized team called Chemical, Biological, Radiological, Nuclear and high-yield Explosive (CBRNE) Enhanced Response Force Package(CERFP) which will be able to assist in search and rescue operations on the island. If search and rescue

resources are still insufficient, PREMB's Commissioner will recommend that the Governor activate properly authorized collaborative agreements with other U.S. States called Emergency Management Assistance Compact (EMAC). These agreements will allow specialized personnel from the United States to come to Puerto Rico and assist in the search and rescue efforts on the island. During this process, specialized incident management personnel called Incident Management Team (IMT) would also be activated, which are highly qualified groups with experience handling Type I incidents.

During an earthquake event with catastrophic island-wide consequences, personnel and equipment resources will be extremely limited. Even using 100% of the available rescuers and equipment will not be enough to be able to handle a catastrophic event of this magnitude. Taking this into account, the Operational Earthquake Plan considers groups of search and rescue volunteers, groups of volunteers trained in the Community Emergency Response Team (CERT), private companies, private emergency brigades, amateur radio operators, non-governmental organizations, Active Volunteer Disaster Organizations (OVADs) and faith-based organizations to provide support to SAR operations in general.

G. Construction Codes

Building codes are important to establish structural requirements for the design and construction of buildings and structures in Puerto Rico. The purpose of these codes is to update and insert the latest technological advances and construction best practices in to the planning and infrastructure development to provide safety to the inhabitants of houses and buildings in case of an incident that may put at risk their lives. The first building codes sought to prevent structures from collapsing. The goal of modern codes is for the structure to cope the earthquake with controlled damage, but no collapse, no loss of life. Over the years several Building Codes have been made in Puerto Rico: The first code was adopted in 1968, known as "Planning Regulation 7".[50] (Regulation 7); In 1987, the 1982 Uniform Building Code (UBC) was adopted; In 1998, UBC was adopted in 1997; In 2011, the [51] 2009 International Code Council (ICC) was adopted. [52]Specifically, the building code of 1987 incorporates details that allow structures to absorb energy during an earthquake. The 1987 code is made in response to lessons learned from the February 9, 1971 earthquake in San Fernando, Southern California where there was a large 6.5 magnitude earthquake on the Richter scale and with an intensity of XI in the Mercalli scale, causing hospitals, bridges and buildings to collapse. Research into this and many other devastating cases resulted in the development of codes and designs that mitigate damage to structures during an earthquake and therefore save lives.

[50] Charón J., RamirezJ., Portela G. Quick Inspection for Structures to be Considered for Vertical Evacuation. Puerto Rico Seismic Network.
[51] Building Performance Assessment: Hurricane Georges In Puerto Rico, FEMA 339 (1999)

[52] 2011 Puerto Rico Building Code

H. Capabilities Assessment

The Operational Earthquake Plan recognizes the limitation in essential capabilities to respond to and recover from a high-intensity earthquake with catastrophic consequences.

Capability Limitations:

1. Extreme vulnerability of communications and electrical energy infrastructure.
2. Economic limitations at State and Municipality level.
3. Delay in the response processes of the Federal Government due to the geographical location of the island.
4. Limitation in the healthcare system during a mass casualty incident that considers 90,000 fatalities and more than 180,000 injured people.
5. Lack of staff and resources (teams) in municipalities for the response to catastrophic incidents.
6. Limitation for mental health services for the population.
7. Limitation of mental health services and emotional support to responders.
8. Logistical limitations in the transportation system.
9. Limitation in redundancy systems. There are a lot of critical infrastructures in vulnerable areas.
10. Limitation in maritime port infrastructures. The San Juan Port is the only commercial port that is operating 100%.
11. The majority of the population depends on the government to survive. 60% of Puerto Rico's population receives government assistance through the Nutrition Assistance Program (PAN). Municipalities and the state will have to serve a large portion of the population that does not have resources.
12. Limitation in the development of a Culture of Resilience.
13. All disaster relief aid will have to be imported by air or by boat.

I. Plan Assumptions and Potential Impact

An earthquake occurs without warning. An earthquake of catastrophic consequences would destroy structures causing a number of injured people and fatalities. At the same time, it could cause serious damage to critical infrastructure, disruption of government services, and island utilities. The collapse of energy and potable water systems, as well as environmental damage, will affect the ability of governments, the private sector and communities to achieve rapid response and recovery.

For the purposes of this plan, it is considered that an earthquake of catastrophic consequences could cause a Tsunami that could affect coastal areas of the island.

It should be considered that after an earthquake aftershock of equal or greater intensity may occur for several hours, days or weeks after the original earthquake. These aftershocks, like the original earthquake, could cause the following incidents: landslides, dam breakage, coastal floods, cracks on the ground, collapse of structures, leaks of hazardous materials, fires, liquefaction, among others.

Due to Puerto Rico's geographical location, after a catastrophic incident, the island could be completely isolated due to the ports and airports vulnerabilities to tsunamis and liquefaction. This means that federal aid could take days to arrive. Supplies and food for the population could also be severely affected. A high-intensity earthquake that causes damage will undoubtedly leave a high number of homeless people, displaced and in need of shelter for long periods of time.

As part of the assumptions of this plan, FEMA's official report was taken into account, comparing the planning assumptions for a catastrophic hurricane versus the actual impact of Hurricane Maria, listed as the most devastating incident in Puerto Rico and FEMA history. The presumption of planning used by FEMA fell short compared to the consequences or Real Impact after the[53] Hurricane Maria event. For the purposes of this Plan, the Actual Impact of a previous catastrophic event (Hurricane Maria) will then be

[53] (2018) Federal Emergency Management Agency. *2017 Hurricane Season FEMA After Action Report July 12, 2018.* Page 9. US Department of Homeland Security. Washington DC.

taken as the basis. The factors for assuming the impact varied significantly during Hurricane Maria's event and will therefore be considered the worst of the scenarios.

	FEMA's Planning Assumption	Real Impact
Population	53%	95%
Cellphone Service	73%	88%
Hospitals	73%	95%
Electric Systems	56%	92%
Emergency Operations	75%	99%

General Assumptions and Potential Impact

The following assumptions should be taken into consideration when implementing Incident Action Plans in the municipalities and agencies:

1. This Plan is automatically activated as soon as the earthquake occurs.
2. Within the first 24 hours, the Governor or his successor will declare a state of emergency and request a Presidential Emergency Declaration that must be prepared in draft in advance.
3. The President of the United States of America would authorize an emergency declaration for Puerto Rico.
4. In the event that the earthquake occurs during working hours, the Metropolitan area (San Juan, Dorado, Bayamón Cataño, Toa Baja, Toa Alta, Trujillo Alto, Guaynabo and Carolina) could have a floating population of 1.5 million people increasing the number of casualties affected by the earthquake in the same region. Response resources in the metropolitan area limited.
5. Special populations (Blind, Deaf, Tourists, Pregnant, Elders, People with Physical Disabilities, Dialysis patients, etc.) would be more vulnerable to an earthquake.
6. Cellular communications will saturate and may collapse.
7. Due to the extent of the damages on roads and bridges many people will get stranded on the roads and will not be able to return to their homes.

8. Intersections and road will be blocked by poles, rubble, and by people trying to go out and find their family members. This will cause people will leave their cars in the middle of the roads and start walking to their homes. This will block traffic in many places by not allowing emergency vehicles to mobilize to address emergencies and complicating the situation.
9. School and hospital structures could be seriously affected and those that do not have structural reinforcements, do not comply with building codes, or their facilities have design defects could be structurally affected or even collapse partially or completely.
10. Much of the critical infrastructure is in tsunami flood zones and others are located on soft soils where amplification will be greater and therefore receive more structural damage.
11. Buildings or structures built on liquefiable soils could sink or be seriously affected.
12. After an earthquake there will be thousands of people sleeping outside their homes as they will be afraid of aftershocks and will not want to return home.
13. People will set up open camps in parks, baseball parks, open spaces, etc.
14. Thousands of buildings and houses will have structural damage.
15. Thousands of people will be displaced.
16. Hundreds of people will be trapped inside collapsed structures.
17. Energy, water and gas services will be disrupted.
18. There will be thousands of deaths and many more injured especially if the earthquake occurs during working hours. The working and student population will be more affected.
19. Most fatalities will occur within the first 48 hours, but over the next few days and weeks the number of fatalities will increase.
20. Many people will activate their family emergency plan.
21. A large number of emergency personnel will need emotional and psychological support due to the number of victims and the great devastation of which they will witness as they move through the roads and even the Emergency Operations Center.

22. Thousands of residences that have been built on columns or in "stilts" informally or without following existing building codes will collapse by their own weight and others on the slopes of the mountains could slip down the cliff.
23. Non-governmental organizations and voluntary groups will be activated automatically.
24. Mass transport systems will be interrupted. Ports and airports will cease operations until damage is assessed, and damage can be certified not to jeopardize operations. Repairs could last weeks or months.
25. The earthquake will generate millions of tons of debris on streets and avenues, preventing emergency units such as police patrols, ambulances, rescue units and firefighters from passing through.
26. After a high-intensity earthquake, aftershocks are expected to psychologically affect people and responders.
27. People won't want to stay overnight inside their homes.
28. The most vulnerable or old PRASA water pipes will break. Repairs could take weeks or months.
29. The earthquake could happen before, during or after a severe weather. This will complicate the response and recovery efforts.
30. There will be an increase in diseases as many people will sleep exposed to weather conditions and insects.
31. Agreements have been signed with other U.S. jurisdictions called Emergency Management Assistance Compact (EMAC).
32. Agreements have already been signed for the activation of Incident Management Assistance Teams (IMAT).

Assumptions during the response phase

1. For the purposes of this plan, it is considered that only 50% or less of the employees of the response agencies can assume their role in their agency within the first 24 hours.
2. The COVID-19 pandemic would limit the number of response personnel available.
3. If the earthquake occurs outside of working hours, responders will take hours or days to reach their workplaces. Municipalities will activate their earthquake and tsunami response plan.
4. A major earthquake with catastrophic consequences will lead to a high demand and competition for resources within municipalities, the state and private organizations. Prioritization of the response will be essential to allocate the available resources of the municipality or state agencies.
5. Municipalities are responsible for the first response in their jurisdictions.
6. Municipalities will activate collaborative agreements and contracts with contractors after the earthquake occurs.
7. The initial damage assessment will be delayed due to the damage or collapse of communications systems.
8. Municipalities will have many challenges when trying to extinguish fires that occur in their jurisdictions as the resources of the Puerto Rico Fire Bureau is limited in the municipalities.
9. Firefighters will have trouble performing the extinguishing efforts as the water systems from PRASA will be affected and hydrants may be inoperative.
10. The number of victims trapped in buildings, houses or vehicles will exceed the local and State's capabilities.
11. Hundreds of people will be trapped in elevators.
12. Hundreds of people with physical disabilities will have trouble evacuating buildings.
13. Hundreds of people will take injured people to pharmacies and medical offices (optometers, ophthalmologists, psychologists, etc.) thinking that they will be able to receive emergency services there because they think they are all "Doctors".
14. There will be a shortage of public safety personnel to provide protection.

15. Hundreds of bridges that are old will collapse.
16. Hospitals will have significant structural damage. The total evacuation of some hospitals to other medical facilities will be considered and medical shelters will be established.
17. Open camps will have to be established as shelters as traditional shelters cannot be used until they are evaluated.
18. There will be major challenges in transporting the injured, evacuated and people with physical disabilities or mobility problems. Alternative solutions will have to be used for such mobilizations. People with mobility problems will have to be transported in civilian vehicles, people with morbid obesity will have to be mobilized with vans and people with survival equipment will have to be mobilized with all their equipment by the saturation of ambulance services, evacuations and patient transfers from hospitals.
19. There will be a shortage of heavy equipment to remove debris.
20. There will be an excess of fatalities that will exceed the capacities of the Institute of Forensic Sciences.
21. The Port of San Juan will be severely affected and will not be able to receive aid merchandise as cranes unloading the ships could collapse.
22. A curfew will be set after the first 24 hours.

J. Emergency Management Phases

Preparedness

This phase remains in force throughout the year and contains the following actions: public education, maintenance of inventories of supply warehouses, acquisition and maintenance of emergency equipment, training and exercises.

Throughout the year municipalities and the state will train and guide citizens on citizen Preparedness projects such as Tsunami Ready and the Community Emergency Response Team (CERT), among others. Preparedness is part of the operational phase 1.

Mitigation

This phase remains in place throughout the year and contains the following actions: development of policies, laws and codes to strengthen structures to minimize damage and development of mitigation projects. Mitigation belongs to operational phase 1.

Response

This phase automatically begins with after high-intensity earthquake occurs. The actions that follow this phase are: saving lives, conducting search and rescue operations, stabilizing incident scenes, providing health services, keeping the public informed, providing care and shelter to affected people. The Response is part of the operational phase 2 (A, B, C).

During the response phase, the Lifelines identified by FEMA will be taken into consideration. These lifelines help focus response goals by emphasizing the preservation of life as a priority. Lifelines consist of seven categories: 1- Safety, 2- Food, Water and Shelter, 3- Public Health, 4- Energy, 5- Communications, 6- Transportation, and 7-Dangerous Materials

Recovery

During the response phase there are actions that can be taken to re-establish basic services to the general population and begin the transition to the recovery phase. This phase contains the following actions: restoring critical infrastructure operations, government services, and reconstitution. Annex A contains recovery actions in operational phases 2C and 3A.

K. Concept of Operations (CONOPS)

CONOPS

The purpose of the Operational Earthquake Plan Concept of Operations is to provide municipalities, emergency coordinators and state personnel operating in the state's Emergency Operations Center with a plan with proactive and prioritized actions for operational coordination and response to a high-intensity earthquake affecting the entire island.

The Operational Earthquake Plan of Puerto Rico specifies the roles and responsibilities of municipal, state, federal, private sector, and non-governmental organizations.

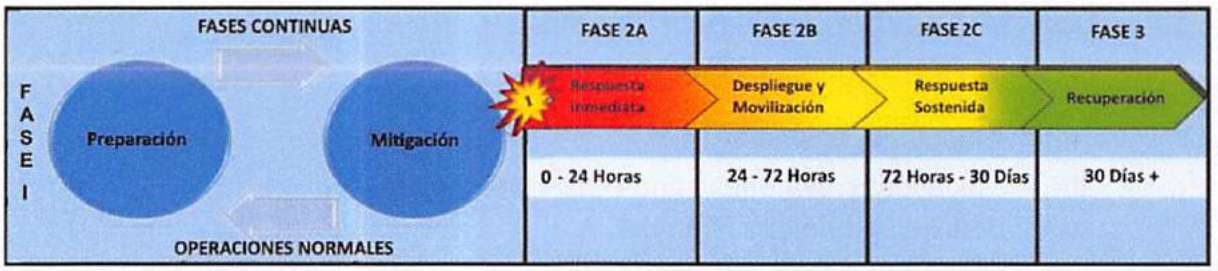
This Plan has 15 operational objectives that are aligned with the Joint Operational Catastrophic Incidents Plan of Puerto Rico (JOCIP). These objectives are broken down into operational time, essential functions, tasks, limitations and contingencies.

1. Operational Objectives of the Plan

I. Operational Structure
II. Resource Activation
III. Situational Awareness and Public Information
IV. Activating Shelters "Camps"
V. Providing Safety to Responders
VI. Damage Assessment
VII. Environmental Response
VIII. Search and Rescue Operations
IX. Mass Care
X. Medical Surge and Mass Fatality
XI. Operational Response
XII. Restoring Public Services
XIII. Restore Critical Infrastructure
XIV. Recovery of the Economy
XV. Federal Support

2. Operational Phases

The emergency operational phases of the Operational Earthquake Plan of Puerto Rico are; Phase I – This phase is aimed at the ongoing process of preparation and mitigation tasks that remain constant and do not affect the normal operations of agencies or organizations. At this stage the incident has not yet occurred; Phase II – This phase begins immediately when a strong earthquake occurs on the island. This phase is subdivided into A, B and C to indicate the actions to be taken by authorities and organizations over a period of time to prioritize and identify the necessary resources; Finally, Phase III is the formal recovery phase where services to citizens are expected to be re-established and operations continued. This phase also includes actions that can begin within some of the response phases. Below is the graph of the operational concept of the Operational Earthquake Plan.



I = Incident

PHASE 1

Phase 1 of the Operational Earthquake Plan includes the preparation and mitigation efforts that all sectors (public and private) will carry out throughout the year to prepare governments and the general population for the possibility of a high-intensity earthquake occurring on the island. These efforts will follow the public policy of the Government of Puerto Rico. These efforts include: development of mitigation projects, implementation of emergency plans, exercises, risk analysis, development of regulations and laws, among others. In addition, they are not limited to the professional development of emergency responders, but also to the general population including voluntary groups, representatives of private enterprise and other sectors that are directed to these efforts. Emphasis will be placed on the education of the population including government officials and employees, teachers and students, the private sector and the people in general.

PHASE 2

Phase 2A (0 x +24hrs)

Phase 2A begins immediately after an earthquake occurs. This phase specifies the actions to take from the time of the "Hour 0" incident to the first 24 hours. Phase 2A operational tasks are divided into the following periods: 0 to 2 hours, +4 hours, +8 hours, +12 hours, up to the first 24 hours.

The operational priorities of Phase 2A are to save lives, recognize potential adjacent risks, find an open safe place as a meeting points, stabilize scenes, make a preliminary damage assessment, identify potential earthquake hazards such as electrical hazards, gas leaks, hazardous material spills, fires or tsunamis, always taking into account that earthquake aftershocks could occur. In addition, risk communication procedures to the general population and coordination of search and rescue operations will be established.

Phase 2A Objectives (0 x +24hrs)

- Set up activate the Emergency Operations Center EOC using NIMS (ICS)
- Activation of this plan and its procedures is automatic.
- Make way on the roads to mobilize response units.
- Start Search and Rescue Operations in the affected municipalities.
- Reduce risks to life, safety and public health.
- Provide care, shelter and medical services to the general public.
- Assess damage to essential services infrastructure to the population.
- Keep the public informed.
- Support public and private medical facilities.
- Start re-establishing essential basic utility services (energy, communications, water, etc.).

PHASE 2B (+24 x +72hrs)

Search and rescue activities continue in the affected municipalities. Supply and equipment movements are carried out to carry out an initial damage assessment in the affected communities and estimate the number of victims. To support decision-making, PREMB staff across zones and the EOC of each municipality must ensure that the initial damage assessment and victim estimate is distributed among all sectors involved in the response. During the first hours of this phase information related to the incident, number of victims, resource constraints and other relevant information should be brought or transmitted to the PREMB EOC as soon as possible.

Phase 2B Objectives (+24 x +72hrs)

- Maintain Search and Rescue Operations.
- Perform damage assessment to critical infrastructures.
- Assess damage to ports and airports.
- Evaluate critical bridges and roads.
- Extinguish earthquake fires.

- Contact local companies that produce or store essential products (Food, Water, Medicines, etc.) to verify their inventories and know their capabilities to continue operating after the event.
- Establish open camps for people who do not want to return home due to aftershocks or because their houses have been damaged.
- Provide vital supplies and services to special populations.
- Keep citizens informed with accurate and up-to-date information. Maintain risk communication.
- Set Distribution Points. (See Distribution Plan Annex)
- Support hospitals while managing the sudden increase in patients.
- Injured people and Dialysis patients living in Vieques and Culebra should be mobilized to the "Main Island".
- Provide security for critical infrastructure and open camps.
- Establish direct contact with mayors.
- Coordinate with FEMA the receipt of resources that come on the way from FEMA when they activate their 72-hour "PUSH Resources" protocol.
- Guidance to the public on the handling corpses that may still trapped in structures or that may be laying on the ground for several hours or days.
- Enable all communications redundancies available and set "Hot Spots" so people can communicate with family and friends.
- A curfew is set for civilians. Essential Public and Private Emergency Personnel are exempted from it.
- Establish Family Reunification Protocols and Centers.

PHASE 2C (+72 @ +120hrs)

Sustained Response and Needs Analysis are established - Post Emergency. During this phase the State Government is integrated into municipal, federal, volunteer and private enterprise response efforts. We also proceed to estimate the psychosocial impacts of the community, the relocation of families, the cost of destroyed assets and the magnitude of the effects caused in the economy by the interruption of business operations and losses. These evaluations provide information on the recovery processes and costs that will be needed in the short and long term, as well as the magnitude of assistance that will be required from the Federal Government.

Phase 2C Objectives (+72 x +120hrs)

- Restore the operations of facilities, whether public or private, that provide essential services for the health, safety and well-being of the community, including critical infrastructure, hospitals, food industries, utilities and transportation.
- Accelerate service restoration to begin recovery processes.
- Assess damage to health or dialysis centers and provide support so they can continue their operations and prevent patients from having to go to a hospital for lack of treatment.
- Support industries that produce health-critical products locally and internationally.
- Stabilize search and rescue scenes.
- EMACs and IMTs work in collaboration with government staff.
- Open the road access of all Rack Fuels and fuel warehouses that are on the island.

PHASE 3 - Recovery

Recovery activities from a catastrophic earthquake in P.R. will last approximately 10 to 25 years depending on the extent of the damage. The Federal Government will support the jurisdiction affected by assistance programs as needed.

There will be a transition to the recovery phase when there is already a better idea of damage to homes, businesses and infrastructure; the direct impact on the population and the effect on the economy, and in turn, work has begun to restore services and repair the affected assets. The rapid start of recovery operations is critical to restore trust with the community.

The following criteria shall be considered for a transition from the response phase to the recovery phase:

1. The cessation of firefighting and/or control
2. The cessation of evacuations
3. Reducing search and rescue operations
4. Safe havens have been established and open camps have already been closed.
5. Ports and airports are mostly operating
6. It can be observed that law enforcement and order have control of the streets
7. Resources activated through the Collaboration Agreements have already finished.
8. Operations in the shelters have decreased and the closure of some shelters has already started.
9. Municipal and state governments are already offering basic services to citizens.
10. Aftershocks have decreased, standing structures are considered stable and has minimized the risk to life.
11. Basic utilities (Water, Energy and Communications) are already stable.
12. Most companies have re-established their operations.
13. Local FEMA assistance centers are already operating around the island.

At this point the EOC might consider decreasing the number of personnel activated and/or carrying out recovery tasks from an alternate facility to the EOC.

3. Authorities who can activate the plan

This plan will be activated automatically when a high-intensity earthquake occurs.

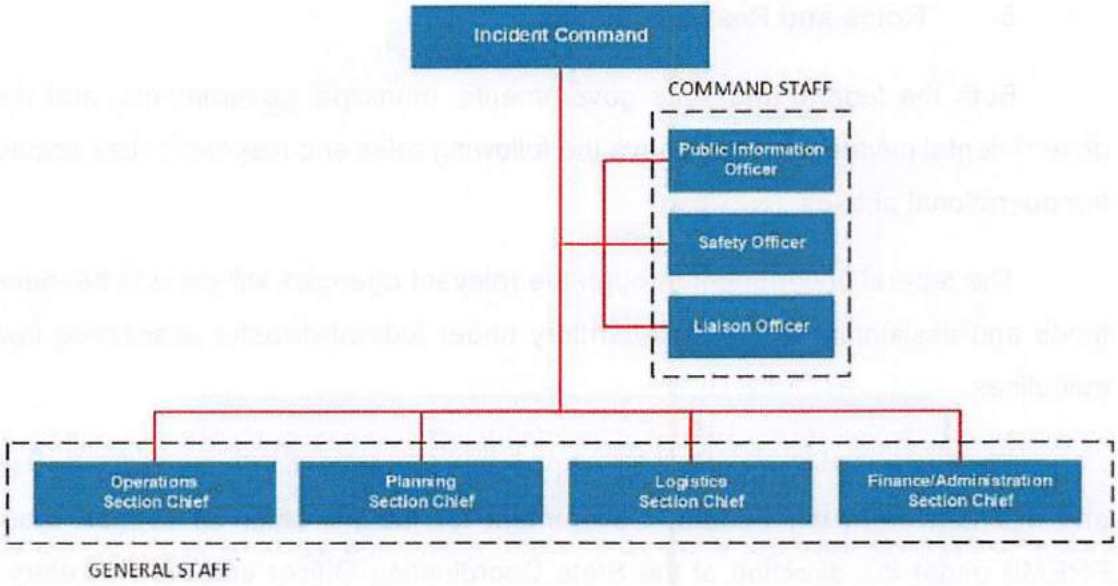
4. Incident Command System (ICS)

The ICS is a standardized incident management system for all kinds of hazards, coordinated events or emergencies. ICS is a flexible and scalable structure. ICS can be used for all kinds of incidents with different scopes and complexity. The ICS is the state and federal standard for incident management and control.

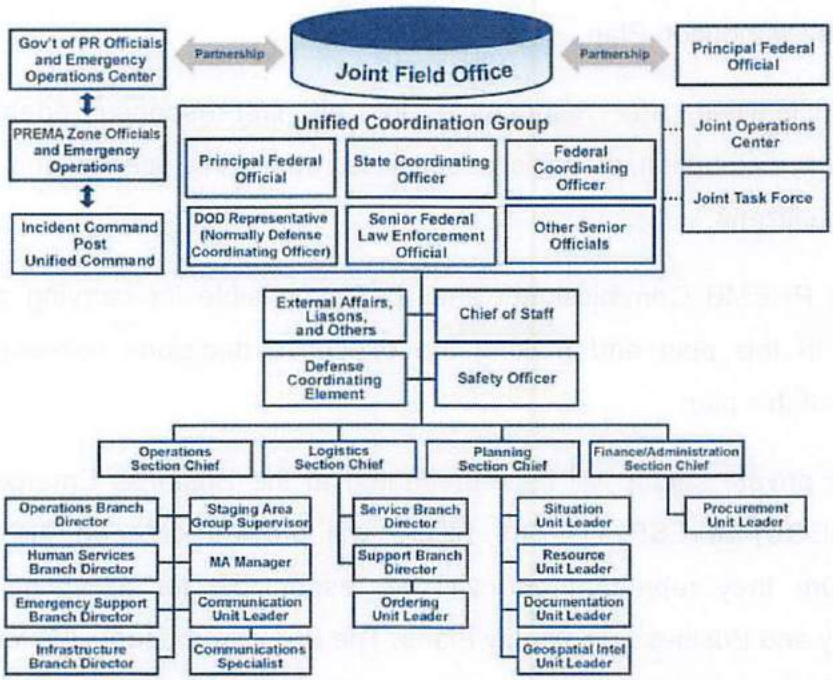
The ICS establishes a common terminology that allows multiple response and support organizations to work together through various functions and scenarios. The recommended span of control in the ICS structure is 3 to 7 subordinates per supervisor.

The state and its agencies will establish their incident command structure in accordance with federal Incident Command System (ICS) regulations and the National Incident Management System (NIMS).

The Federal Government will establish a unified command system in coordination with the state government until the state government can take full control of the situation and regain all its responsibilities. The Government of Puerto Rico will activate essential Emergency Support Functions during incident handling in all its phases.



Basic Incident Command System Structure



Federal Joint Field Office Structure

5. Roles and Responsibilities

Both the federal and state governments, municipal governments, and the non-governmental private sector will have the following roles and responsibilities according to the operational phases described.

The federal government through the relevant agencies will provide the necessary funds and assistance to the state/territory under federal disaster assistance laws and guidelines.

The State Government will be responsible for requesting emergency declarations and disasters from the Federal Government for the activation of support resources. PREMB under the direction of the State Coordinating Officer and the Secretary of the Department of Public Safety, will coordinate response and recovery efforts with non-governmental organizations, municipalities and state agencies. The state is responsible for providing all support requested by municipalities. It is also responsible for coordinating the distribution of basic commodities to municipalities and distribution centers established in the State Distribution Plan.

Municipalities are responsible for all first-response operations, damage assessment, distribution of basic necessities, stabilizing scenes and providing direct services to citizens.

The PREMB Commissioner shall be responsible for carrying out the activities described in this plan and making the executive decisions necessary to meet the objectives of this plan.

The private sector will be represented at the Business Emergency Operations Center (BEOC) at ESF 17. The BEOC will provide data on the critical industry infrastructure they represent and will be responsible for activating its Operational Emergency and Business Continuity Plans. The BEOC represents the following industrial sectors: Transportation, Water, Energy, Financial Services, Chemicals, Critical Manufacturing, Health, Food, Information Technology, Agriculture and Commerce. The BEOC will assign to the Emergency Operations Center a liaison team that will keep the channels of communication between government officials and the private sector open.

Non-governmental organizations are responsible for activating their emergency plans and coordinating their aid missions with PREMB and municipalities.

6. Emergency Support Function (ESF)

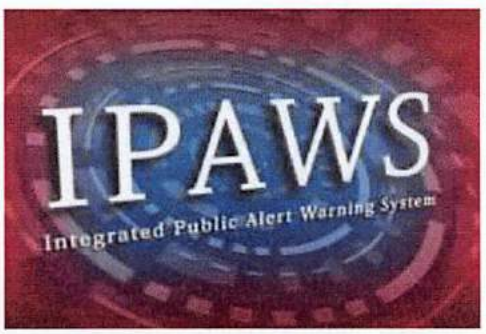
Emergency Support Functions (ESFs) are the coordination structure that the PREMB and FEMA will use at the interagency level to support the response to an incident. ESFs are mechanisms for grouping the most common functions used between the state and the federal government during a disaster. Each ESF has a leading agency and several support agencies. For every ESF identified in the state, there is a counterpart at the federal level. This coordinating structure allows an agile coordination between the federal and state governments. The following table demonstrates PREMB's ESFs.

# ESF PREMB	Support Function
1	Transportation
2	Communications
3	Public Works
4	Firefighting
5	Emergency Management and Planning
6	Mass Care
7	Logistics
8	Public Health and Medical Services
9	Search and Rescue
10	HazMat
11	Agriculture
12	Energy
13	Public Safety
14	Recovery
15	Public Information
16	Military Support
17	Business Emergency Operations Center (BEOC)
18	Government Services

L. Public Information and Warning

As part of the Incident Command System, each municipality will have in its EOC a Joint Information Center (JIC) that will collect and process all information related to the incident. The processed information will be sent to the PREMB zones and in turn to the PREMB central EOC where the Government's Central JIC will make the relevant reports following the Joint Information System (JIS) protocols set out in the ICS.

Effective communication between emergency operations will be maintained at all times. To keep the people informed of risk and support situations, the Government will use all means of public notification that are still operational after the incident. The means to be used to communicate with the general population are not limited to the use of radio stations, loudspeakers, social media, mass alert sirens (Tsunami Sirens), internet pages, television alerts, the Emergency Alert System (EAS), Integrated Public Alert Warning System (IPAWS), messages on electronic boards (Billboards), portable light signs (Road Trailers), newspapers, loose sheets, written messages, messages over the amateur radio network, messengers (Runners) and any other that may be available.



M. Logistics

After an earthquake incident with catastrophic consequences some of the ports of entry to the island will be severely affected. Depending on the damage caused by the earthquake and the conditions in which the different seaports and airports remain, they will be able to operate depending on their capabilities. If Luis Muñoz Marín International Airport is affected and cannot be used to move air cargo, Rafael Hernández International Airport in Aguadilla, Mercedita Airport in Ponce and Ceiba Airport will be considered if it is in operational condition. Regional airports may be used for passenger transport on small aircraft and helicopters. In the case of seaports, if the Port of San Juan is disabled, operations may be transferred to the docks of Ponce, Mayaguez and Ceiba. In turn, 30 official helipads authorized by the FAA have been identified in Puerto[54]Rico.

Once the necessities have been identified PREMB will proceed to activate the Distribution Plan which begins with the opening of the Warehouses that are located in various points of the island. Municipalities and non-governmental organizations will be responsible for carrying out the Government's Distribution Plan.

[54] (2019) Heliports. Air.nav. Subtracted from http://www.airnav.com/airports/pr?use=R&type=H

N. Succession of Authority

In the event that PREMB's Commissioner is unavailable or a victim of the incident, the following succession of command shall be established:

1. Secretary of Public Safety Department
2. State Coordinating Officer
3. Commander of the PR National Guard
4. PREMB's Deputy Commissioner
5. PREMB's Operations Director

O. Federal Support

The Federal Emergency Management Agency (FEMA) will coordinate Federal support for the Government of Puerto Rico by enabling a rapid and effective response to provide the needs of survivors. For FEMA this type of incident is classified as Level I. FEMA's priorities will be to provide life-saving capabilities, protect property and the environment, and complement the needs of the population in a post-catastrophic environment. FEMA will establish a process of sending "Pushing Resources" resources for the first 72 hours without the state necessarily requesting it. See Annex K.[55]

[55] Presidential Policy Directive -8 (PPD-8), National Preparedness, 2011

P. Training

As part of the implementation of the Operational Earthquake Plan training must be carried out on the staff of the state agencies, federal agencies, municipalities, private companies, non-governmental organizations and communities of Puerto Rico. The trainings are not limited to the implementation of this plan but also should include Incident Command System, CERT, search and rescue, emergency management, among others.

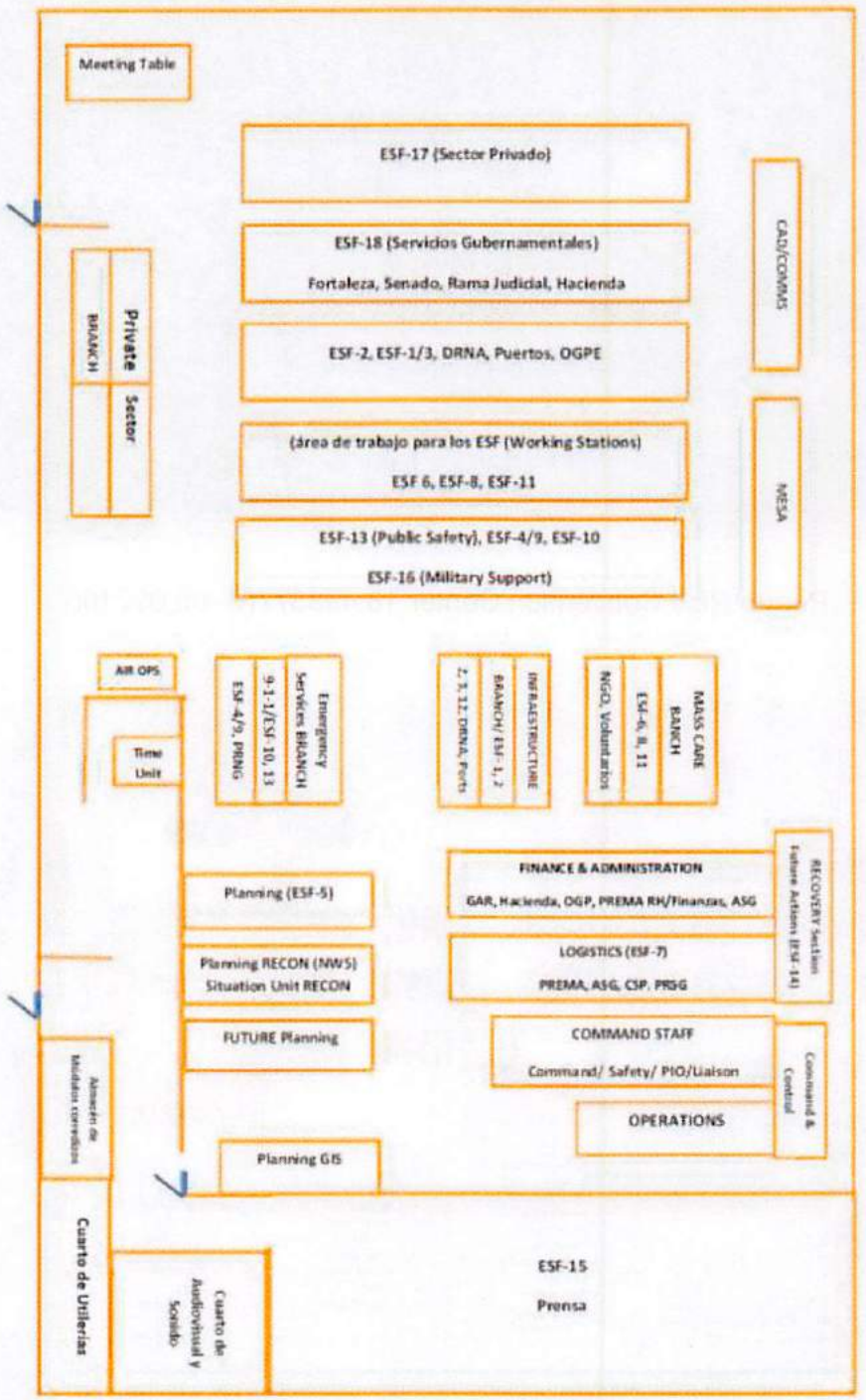
Q. Exercises

To validate the effectiveness of this plan, a series of exercises will be conducted in compliance with the Homeland Security Exercise and Evaluation Program (HSEEP) of the US Department of Homeland Security (DHS). The government of Puerto Rico will carry out a series of exercises during the year that will be designed to validate different parts of this plan in its different phases of emergency. Each agency and municipality must develop at least two table exercises per year and a large-scale exercise.

R. Plan Maintenance

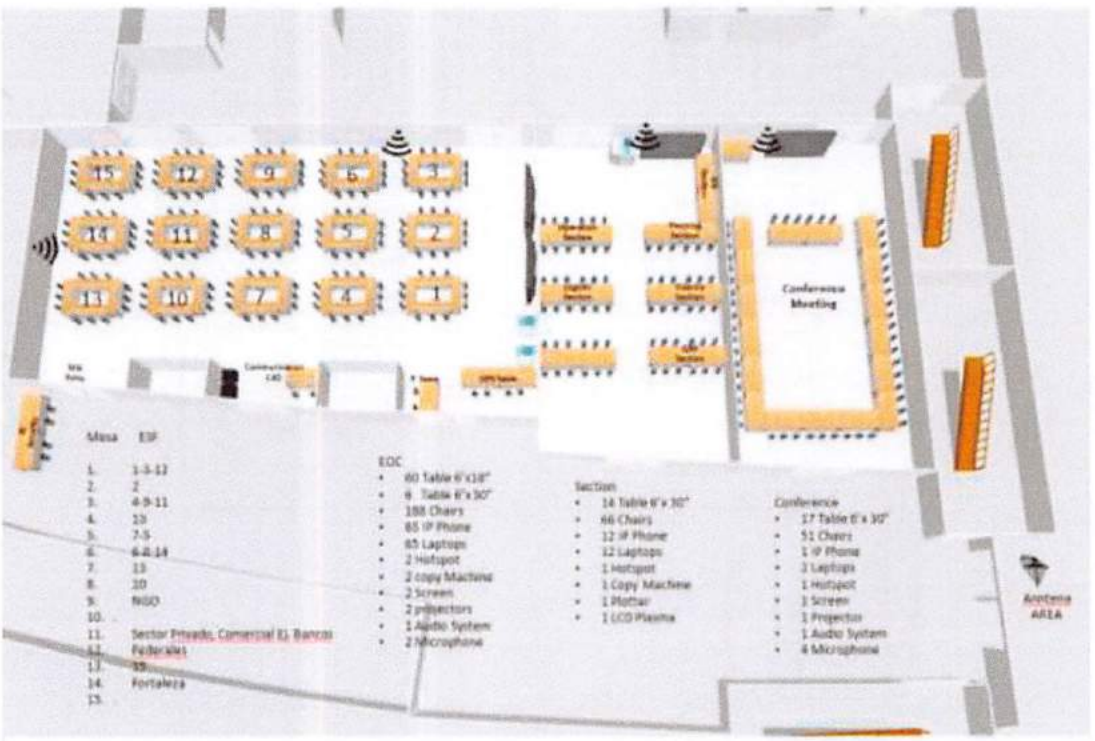
This plan is designed as a living, interactive document subject to ongoing revisions and changes that will depend not only on lessons learned at previous events but also on incidents or events that occur anywhere on the planet and that offer considerations that we need to integrate into our plan. Similarly, revisions and changes to this plan will result from the scientific studies and development of adaptive technologies that are continuously carried out in universities and scientific research centers as well as those changes that suggest the new federal regulations, presidential guidelines and policies established by the federal government and its national security agencies as well as the local ones. Also, the results and the post-evaluation of each exercise or drill that is developed to validate the knowledge of our responders and officials responsible for emergency management in PR will be taken into account for the purposes of reviewing and updating this document. This plan is therefore not intended to establish a minimum specific term for review and updating as it is a continuous working document. In the event that none of the above circumstances are manifested, the plan will be reviewed at least once a year.

S. State Emergency Operations Center Design



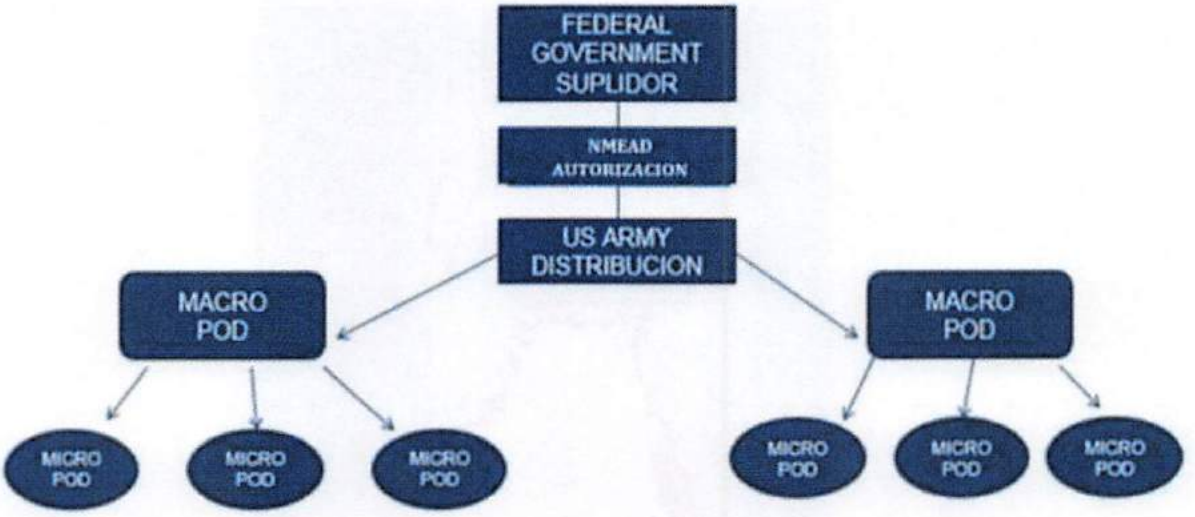
T. Alternate EOC

Puerto Rico Convention Center 18.453577N, -66.092106

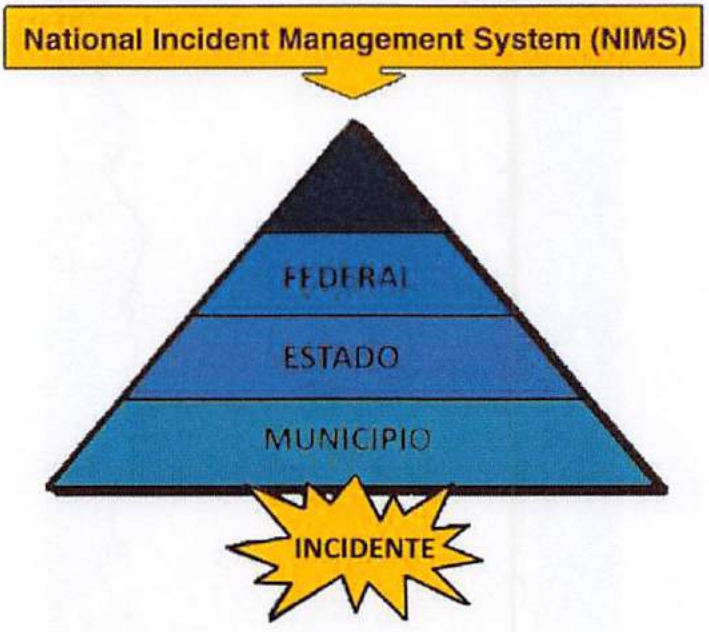


Alternate EOC Design

U. Points of Distribution Flowchart (PODS)



1. Incident Management and Stepped Support Request



V. Tsunami Flood Zones

W.Shelters and Camps

Minimum Requirements for Open Camps/Shelters during a Pandemic (COVID-19)

After an earthquake, camps/shelters open to the general population and response staff working in the area should be established.

Be sure to consider the following elements prior to the establishment of these open camps/shelters:

- Level of contagion with COVID-19 in the population to be mobilized
- Investigate in the field to be used, your current and previous use.
- Investigate whether there is any environmental situation in the area or terrain that could cause short-term or long-term health damage.
- Evaluate the topography of the site to identify the possible flow of run-off or accumulation of water from heavy rains.
- Identify nearby bodies of water.
- Investigate whether the area has or is prone to receiving a communications signal.
- Identify all paths to the area.
- Make sure it's not a flood area
- Make sure the area is not within a tsunami hazard zone.
- If possible, set up open camps/shelters away from tall buildings, trees, power lines, rocky or mountainous areas.

Suggested components for open camps/shelters:

- Entry, check-in and closing area
- Isolation area
- Response Staff Shelter Area
- General Population Refuge Area
- Food Preparation and Dining Area
- Medical Services Area
- Area of Social and Government Services

- Recreation Area
- Pet Area (if allowed)
- Bathrooms and Showers

Entry, Registration and Closing

- At the entrance of the shelter/camp an area will be established with a tent or more 20' x 20' where a process of temperature intake and hand disinfection will be carried out.
- Social distancing among evacuees at least 6' away will be demarcated.
- At all times there will be a health care professional overseeing this area.
- Establish a registration area. Personnel must wear personal protective equipment at all times.

General Population Shelter Area

- In this area the general population will be able to sleep and rest.
- Cots will be placed for people to sleep in.
- The space required per person is 110 square feet according to the FEMA Mass Care/Emergency Assistance Pandemic Planning Considerations (2020) guide. (NOTE: In non-pandemic circumstances the space per person is 40 square feet according to the FEMA P-785[56]guide.)
- The area should be 1,000' away from parking or roads, and 250' from the activity or dining areas.
- The size of the area will depend on the type of tents used.
- It must be located in an area quiet enough to be able to sleep, away from the dining room and parking area.
- If the area is not air-conditioned there should be no electric generators or vehicles on less than 300' away due to noise and toxic gases

[56] FEMA (2020) FEMA Shelter Field Guide P-785. FEMA Page 8

Response Staff Shelter Area

- In this area the response staff will be able to sleep between shifts.
- The space required per person is 110 square feet according to the FEMA Mass Care/Emergency Assistance Pandemic Planning Considerations (2020) guide.
- The size of the area will depend on the type of tents used.
- It must be located in an area quiet enough to be able to sleep, away from the dining room and parking area.
- If the area is not air-conditioned there should be no electric generators or vehicles on less than 300' away due to noise and toxic gases.

Recreation Area

- Areas for recreation and development of activities for the evacuee's population will be identified. Areas for sports, music or entertainment for adults and children will be identified.
- The number of people in the recreational area should be coordinated with health personnel.

Medical Services Area

- An area will be established in an air-conditioned tent or mobile hospital (e.g. Western Shelter) of a minimum size of 20' x 40' to provide medical services to the evacuees population, workers and responders in the area.
- An air-conditioned area shall be established in a tent or mobile hospital (e.g. Western Shelter) of a minimum size of 20' x 40' which shall be exclusively for persons who may be infected with COVID-19.
- The area will be visibly identified.
- The area must be kept clean, disinfected and with the equipment properly secured.
- Service schedules will be established.
- An ambulance must be in the camp or if it is not in "Stand By" if an incident occurs in the camp/shelter.

Area of Social and Government Services

- An area will be established to provide social and government services to evacuees.
- The area can be demarcated with a tent or more 20'x40' keeping at all times the social distancing of 6' between people.
- In this area, services related to citizen support can be provided by the municipal or state government.
- This area can be used to provide guidance to the affected population.

Showers

- A minimum of 1 shower should be established for every 20 people.
- Showers should be located near the shelter areas of the general population and response staff, approximately 50 feet away.
- Establish a drain for used water should be at least 5 feet deep by 5 feet wide. If possible, it should be filled with gravel or sand to prevent mud from filling and attracting insects. Water retention or pumping systems can also be used. Used shower water cannot be discarded in bodies of water.
- Drainage should be located away from nearby bodies of water.
- Use only potable water.
- At all times it must be lit and safe.
- The number of people who will be able to use the shower area will be determined by medical staff to maintain social distancing.

Bathrooms

- Portable latrines or bathrooms should be located approximately 100' away from the bedroom or kitchen areas.
- The Logistics Specialist should consider locating them near the shower area to ensure water availability and safety.
- It should be located away from nearby bodies of water.
- At all times it must be lighted and safe
- 1 latrine for every 20 people.
- The following should be maintained at all times:
  - Detergents that ensure odor control and to disinfect the area
  - Enough toilet papers
  - Handwashing station with paper towel
  - Trashcan with integrated lid

Food Preparation Area/Dining Area

Food Preparation Area

- It should be a covered area that provides food protection from weather.
- It must be closed on 3 sides to minimize dust contamination.
- Food containers must be off the ground, on wooden pallets, or tables so that containers do not contaminate the surfaces where food is prepared.
- This area must have a dish washing area and equipment.
- The area must be disinfected at all times.

Dining room

- It should be a covered area that provides protection to food from weather
- The flow of the row to follow should be outlined with rope for people who will receive food.
- People will be encouraged to take the "to-go" food. If you can't take your food, you can stay in the dining room by taking the safety measures.
- The dining area must have chairs and tables.
- The dining room must have a strong surface on the floor to prevent chairs from being buried by the weight of people.
- The tables will be separated at least 10 feet from each other to maintain social distancing.
- It must have 1 trashcan with a capacity of 40-55 gallons for every 10 tables with plastic garbage bag generated.

Handwashing Stations

- Handwashing is of paramount importance in disease prevention. One handwashing station should be established for every 20 people. These must also have hand sanitizer.
- Suggested areas for location or hand washing stations:
  - Entrance
  - Bedroom areas
  - Medical areas
  - Food Preparation Area/Dining Area
  - Bathrooms
  - Animal Shelter Area
  - In all public areas
- Only potable water and liquid or powdered soap should be used.
- Stations must have hand sanitizer.
- They must have paper towel to dry their hands and a built-in lid.
- Establish a drain for used water, a retention or pumping system to a tank.

Animals Shelter Area

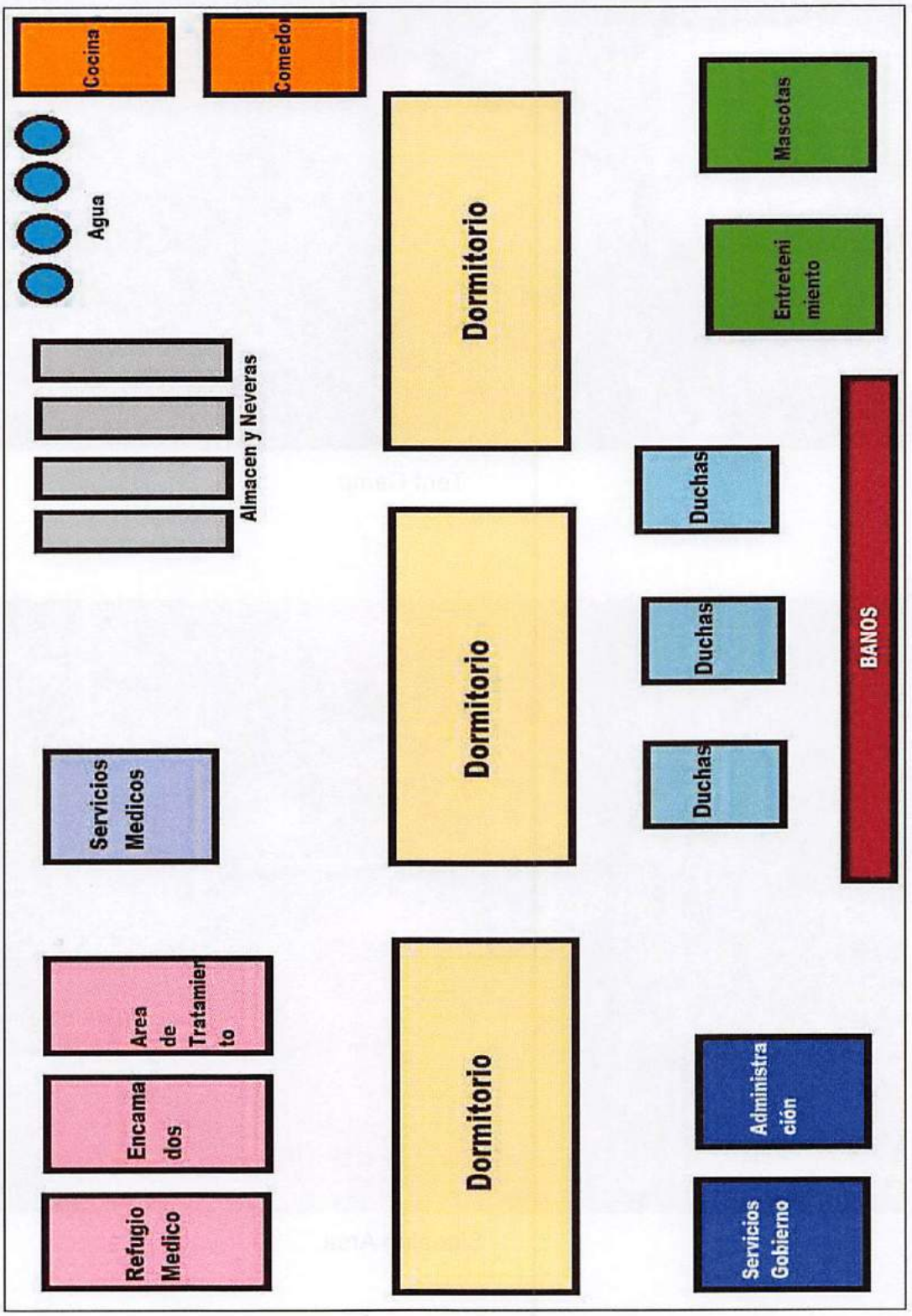
- The size of the area will depend on the type of tents used.
- It should be a covered area that provides protection to animals from inclement weather.
- It should have a designated area to feed the animals.
- It must have a clearly identified area so that animal owners can take them to do their needs outside the camp.
    - The perimeter of this area should be cordoned off and outlined with "spray paint".
- Animal food must be stored in sealed containers.
- An area cleaning itinerary should be established with the camp administrator.

Security

- Shelter/camp facilities must be free of alcohol, drugs and weapons.
- Anyone arriving with coVID-19 symptoms will not be allowed entry to the shelter/camp until they are evaluated by medical staff and/or given a negative COVID test.
- All persons on the Sex Offender Registry should be identified.
- Persons with active protective orders must be identified.
- In case a minor disappears, the ADAM Code protocol must be activated
- A system should be established for the registration of evacuees.
- A census should be conducted every 12 hours
- The designated area must be free of visual obstructions around the perimeter. Natural surveillance should be allowed.
- The shelter/camp must be guarded and secured by the Municipal Police, State Police and National Guard (if activated) 24/7.
- The perimeter must be illuminated at night with lighting systems with a high lumen White Light, Metal Halide or LED.
- Preventive patrols must be carried out at all times 24 hours a day.

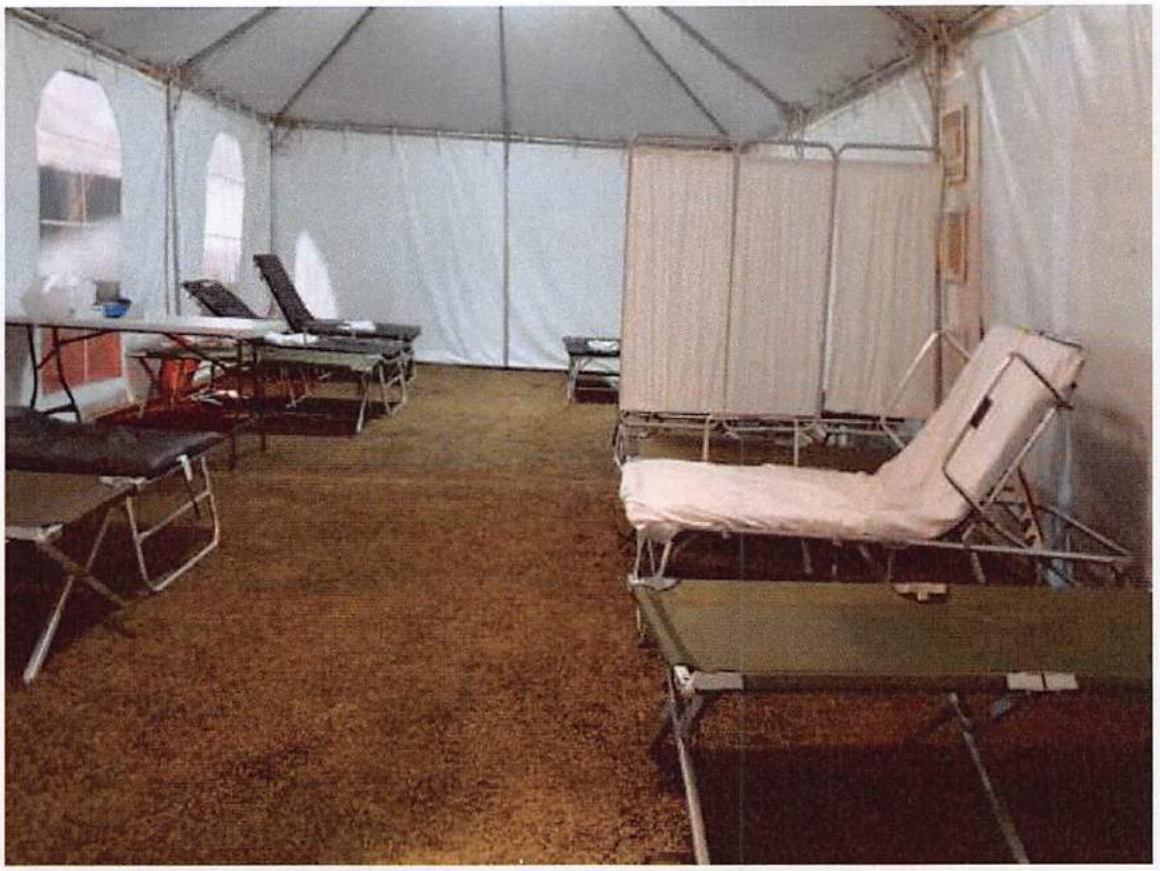
- Incidents that occur inside the shelter/camp will be attended by the Municipal Police or the State Police. Military police officers will provide support if necessary.
- All tents and areas must be properly identified by function name or numbers.
- Perimeters must be established within the area to separate areas where there is equipment, generators, kitchens, fuels, etc. So, the kids don't come near us.
- Any electrical, temperature or safety hazard must be identified.

Camp Layout Design

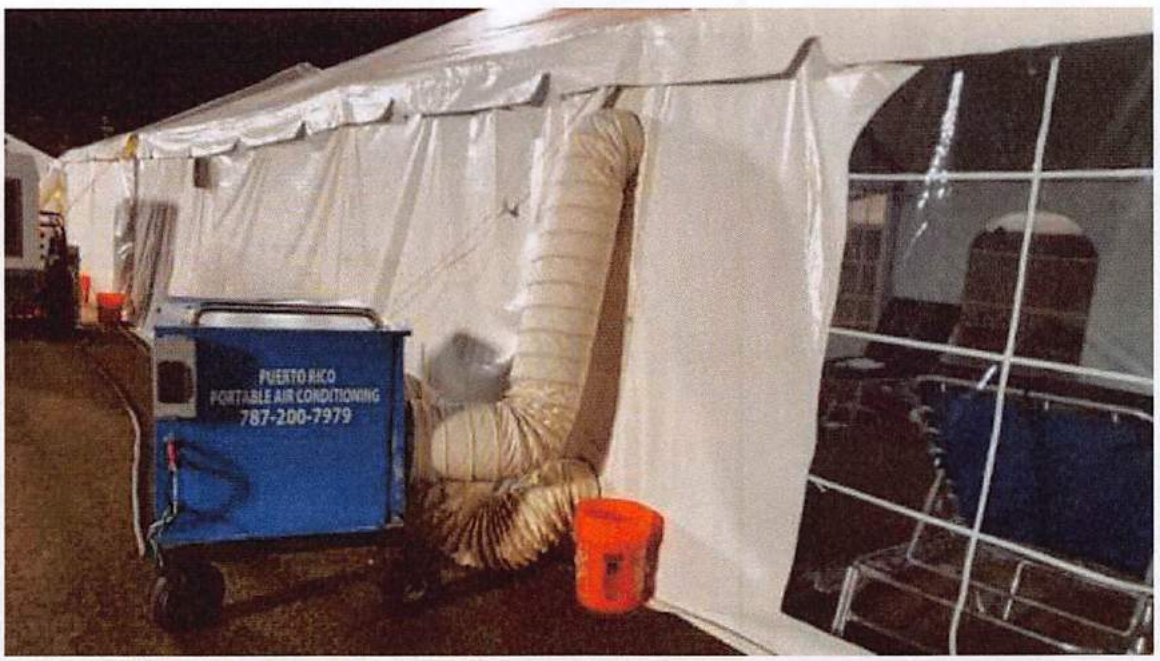


Tent Camp

Sleeping Area

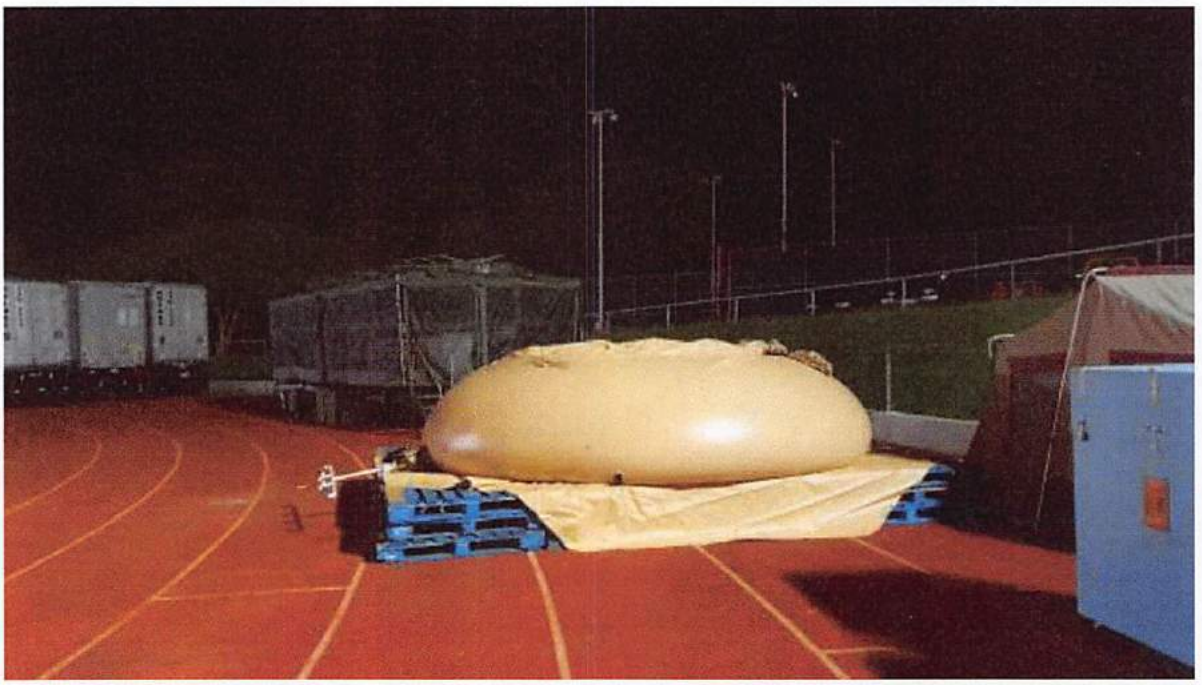


Medical Area



Portable AC Units

Showers



Water Cisterns

Portable Bathrooms

Recreational Area

X. Legal Authority and References

Authorities, references and legal bases used in the implementation of the Operational Earthquake Plan of Puerto Rico.

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