

Retired Homes and Elderly Building Evacuation Plan: Aguada

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Abstract — On September 20, 2017, Puerto Rico was struck by a category 4 hurricane that left billions of dollars in damages and thousands of people died. But the most casualties from this catastrophe were from the elderly community. This project involves identifying retired homes and elderly buildings that are located in flood zones to illustrate the evacuation routes in any emergency situation involving hurricanes and tsunamis.

Key Terms — Aguada, Elderly Buildings, Flood Zone, Retired Homes.

INTRODUCTION

Hurricane Maria has been considered one of the most terrifying events that occurred on the Island of Puerto Rico. A special coverage article in El Nuevo Día newspaper recounted how the hurricane brought torrential rains that dump around 40 inches of water on the ground. The rivers: Grande de Loíza, Grande de Manatí, Grande de Arecibo, as well as La Plata, between Comerío and Bayamón; Cibuco in Corozal; Espíritu Santo in Río Grande; the Guayama, Río Piedras and the Puerto Nuevo overflowed and caused flooding in almost 78 municipalities, causing terror, anguish, and devastation. The article continues to explain how the brutal winds catch up to 200 miles per hour, swallowed trees, bend traffic lights, fracture light towers, removed roofs, and many other things. Maria is a glass-crushing machine. Thousands of people went bankrupt. It kicks up a raging sea with waves up to 25 feet high. It eats up the beach and throws tons of sand on the most touristy streets of the island. The hurricane left 100% of the island in the dark and 60% of the population did not have drinking water. The 78 municipalities remained without communication, with 92.7% of the communications towers down. The coffee and banana harvests had been completely lost, those

losses alone represent \$740 million. The authorities calculated the total damages would reach 100,000 million dollars. “Maria left behind an island split in half, a population torn to the core and forced to go back 40 years in time [1].”

“The older adults in Puerto Rico were particularly affected by the widespread effects of Hurricane Maria. A study prepared by the Milken Institute of Public Health, attached to George Washington University, in collaboration with the Graduate School of Public Health of the University of Puerto Rico, estimates excess mortality at 2,975 between the months of September 2017 to February 2018 associated with the passage of Hurricane María. The study indicates that during this period there were 16,608 deaths, of which 77% correspond to the elderly population and it is highlighted that the risk of dying was 45% higher if the person lived in a municipality below the level of poverty [2].”

Figure 1 presents the trajectory of Hurricane María that cross the Island from side to side.



Figure 1
Hurricane Maria Trajectory Map [1]

“The recommended special flood hazard areas (starting with 1%) are identified as flood zones and are divided into:

- A: Areas susceptible to flooding from the one percent (1%) flood event. The mandatory requirements for the acquisition of flood insurance apply to this zone.
- AE: Areas susceptible to flooding from the one percent (1%) flood event determined by detailed methods. The mandatory requirements

for the acquisition of flood insurance apply to this zone.

- AO: Areas susceptible to flooding from the shallow one percent flood event where the average depth is between one (1) and three (3) feet.
- Coastal: has a wave effect with a height of 1.5 to 3 feet.
- VE: is of high coastal risk due to storm surge [3].”

Law #3 from September 27, 1961 [4] established: “the towns and cities of Puerto Rico, with areas susceptible to flooding due to rain, rising tides, surges, overflowing of rivers or streams, or other forces of nature that affect the lives and properties of the present and future inhabitants of said areas, as well as the health, safety, order, convenience, prosperity, economic stability and well-being of the community at large.

In the "Zones Susceptible to Floods", it will be illegal from now on to:

- Construct any building or structure, deposit fill, make substantial improvements to existing buildings or structures, or other developments in flood-prone areas that have not complied with the requirements and provisions of the Regulation on Zones Susceptible to floods, from the effective date of the same.
- Sell, lease or in any other way transfer land in said areas without notifying the potential tenant, occupant, or owner of the same by any lawful means that must be complied with the requirements and provisions of the Regulation on Areas Susceptible to Floods for any construction, use or development. Said warning shall be included in the written document on the transaction in question.

Penalties for violations of this law:

- Any person who voluntarily, illegally, and maliciously contravenes the provisions of Article 8 precedent will be guilty of a less serious crime and, convicted, will be punished with a maximum fine of five hundred dollars (\$500) or maximum imprisonment for a term

of six (6) months, or both penalties at the discretion of the court.

- Provided that the reported infringement consists of having carried out some construction, landfill deposit, substantial improvement to existing building or structure or other developments located in a "Zone Susceptible to Flooding" the sentence that is handed down, will provide that part of the building, expansion or development object of the complaint that does not comply with the requirements and provisions of the regulation of areas susceptible to flooding will be demolished, removed or corrected within thirty (30) days following the signing of the sentence issued. The order of the court shall be served by the bailiff. In those cases where the court order affects one (1) or more homes, it will be completed by the bailiff with the personnel of the Department of the Housing [4].”

These facts are the main reason this investigation was developed, not only to inform the public of the consequence or risk of establishing a property in a flood zone, but also to consider and manage this situation that has been happening for many decades, and still remains in the present day.

METHODOLOGY

The area of study will be focused on the county of Aguada, Puerto Rico. See a map of Aguada in Figure 2. “Aguada is part of what is known as the Western Coastal Plains, so its relief is largely flat, that is, 58 % of Aguada's surface is highland or hilly terrain, and the remaining 42% of the land is flat. His district has some mountains, among them is located part of the San Francisco Mountain, cradle of the Central Cordillera of the island. In the Cerro Gordo neighborhood, is the Cerro Gordo, 260 meters (853 feet) high. The hilly area is used mainly for the cultivation of farinaceous vegetables and coffee. The rest of the land is used for pasture and minor fruits. The plain area is used mainly for the cultivation of sugar cane [5].”



Figure 2
Aguada Map

The map that locates the Retired Homes and Elderly Buildings that are inside of flood zone will be made using the ArcGIS Pro program. To start locating the Homes and Buildings, a database where the layers are going to be saved must be created first. This is done by going to the “view” tab and activating the “Catalog Pane”. Then is necessary a right-click on the Folder file and pressing “New File Geodatabase”. The database should be named “Retired Home and Elderly Building”. Figure 3 presents a view of the “New File Geodatabase” tool.

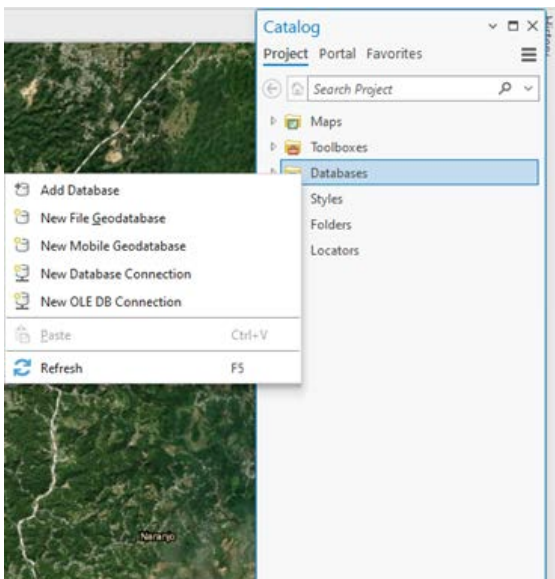


Figure 3
“New File Geodatabase” Tool

The next step is creating the layers that are going to be analyzed. To do this a right-click has to be made on the “Retired Home and Elderly

Building” database and then pressing “New” and then “Feature Class”. The name of preference for this project then will be inserted. The name used was “Retired_Home”, and the “Feature Class Type” must be Points (See Figure 4).

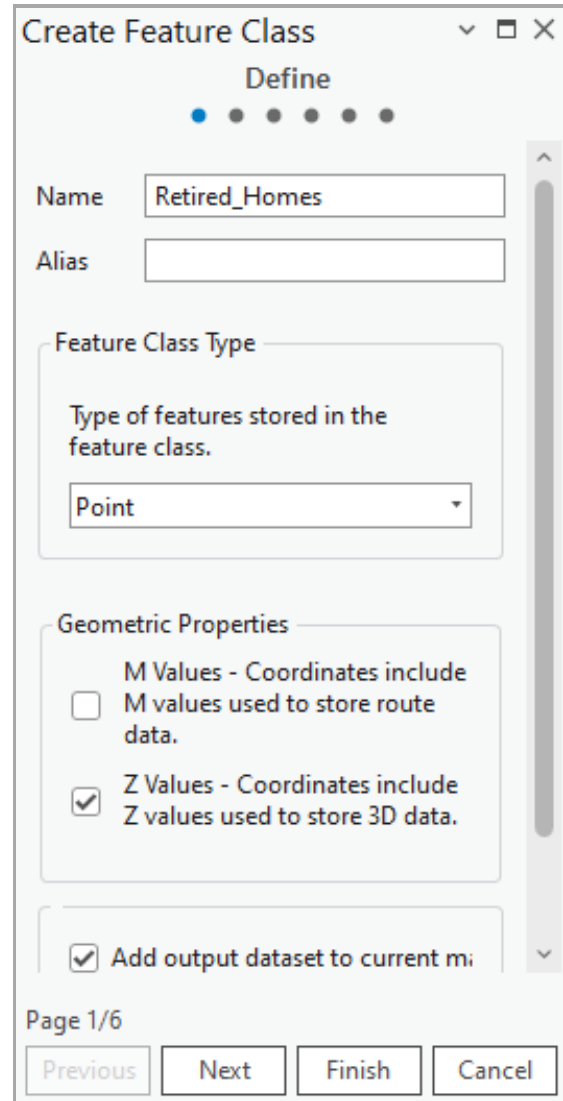


Figure 4
Create Feature Class (Point)

The process has to be repeated for the Elderly Building, shelters, and Assembly Point. After creating the four-point layers the “edit” tab is pressed, then the user has to go to the “Create” toolbar. This will open the Create Feature Panel (See Figure 5), which shows all the Feature layers created previously.

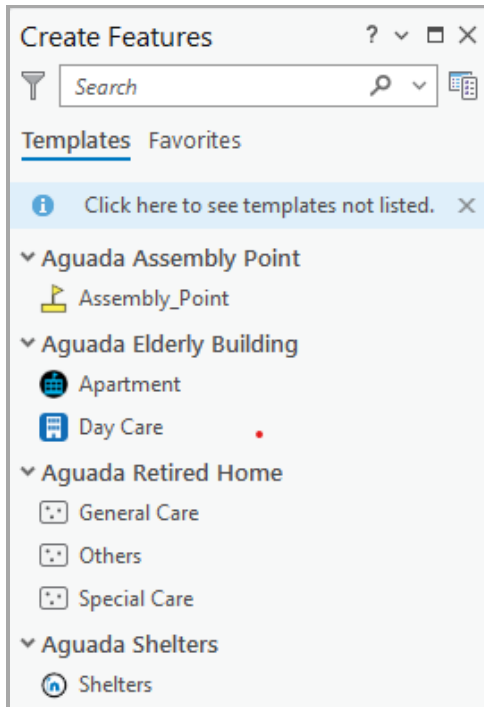


Figure 5
Create Feature Panel

On the tab on the Retired Home layer, the user can begin to locate the structures. For the other three layers, the same steps have to be repeated. The result can be seen in Figure 6.



Figure 6
Retired Home, Elderly Building, Shelter, and Assembly Point Map

To establish the flood zone area the web page “Junta de Planificación (JP)” has to be accessed, and on the download tab, the shapefile (.SHP) [6] has to be selected and downloaded to the computer desktop. In the ArcGIS Pro catalog pane the user has to go to the folder of the project, right-click and press “Add Folder Connection”. Then they have to drag the shapefile folder to the project. Figure 7 illustrates all the layers available, provided by the “Junta de Planificación” webpage.

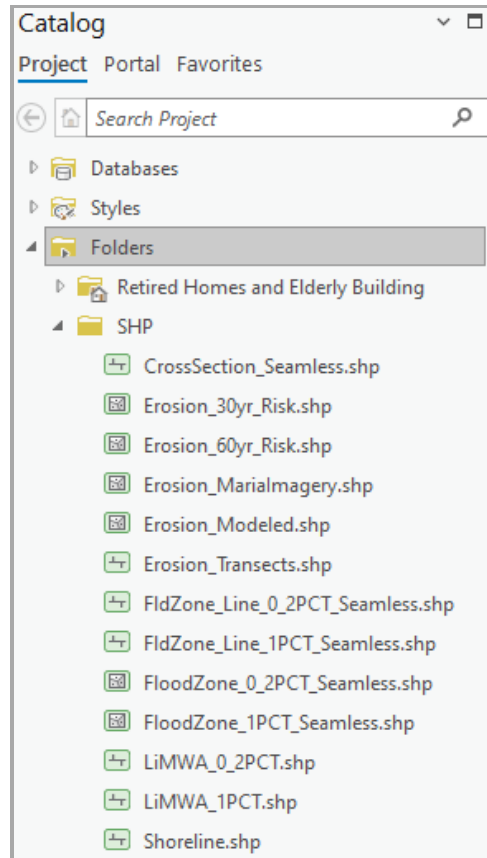


Figure 7
Layers Provided by the JP Webpage.

The next step is to choose the layer “FloodZone_1PCT” and add it to the map, making sure the layer is placed below the point layers, so it does not obstruct the location points. Figure 8 shows the polygon layer of the flood zone.



Figure 8
Polygon Layer of the Flood Zone and the Area That Covers it.

To identify which structures are inside of the flood zone using the “Select by location” tool the following must be done: Tab on the analysis and press “tool”, on the search bar, write select by location. In the “input feature” field place the

Retired home and Elderly Building layers for the “relationship” field place (Within), on the “selecting features” field place (FloodZone_1PCT) layer, and for the “Selection Type” just leave it on (new selection). Finally, the run tap is pressed, and input data starts to be processed (See Figures 9 and 10).

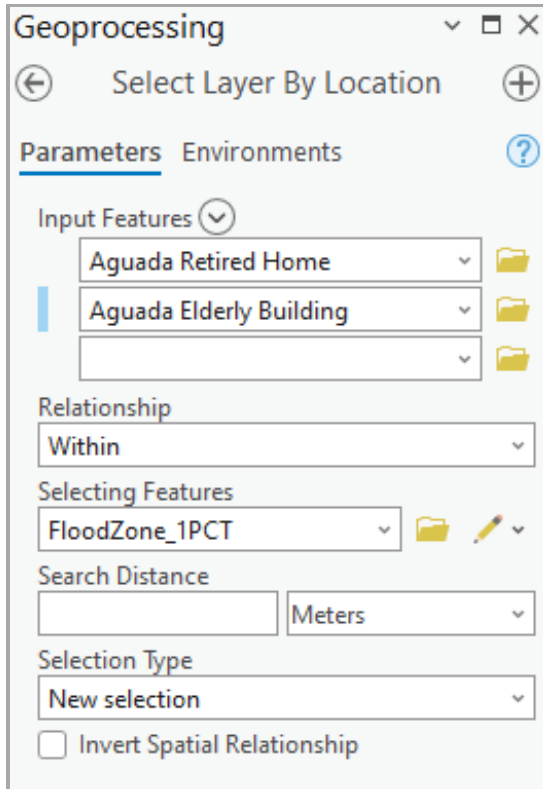


Figure 9
Input Data That Will be Processed by the “Select by Location” Toolbar.



Figure 10
Result From “Select by Location” Toolbar.

With the identified structures, the researcher must now locate the shortest route that reaches the assembly point. To do this the previous step from “Create Feature Class” has to be repeated, only this time the “Feature Class Type” must be line (See

Figure 11), the chosen name was “Evacuation_Route”.

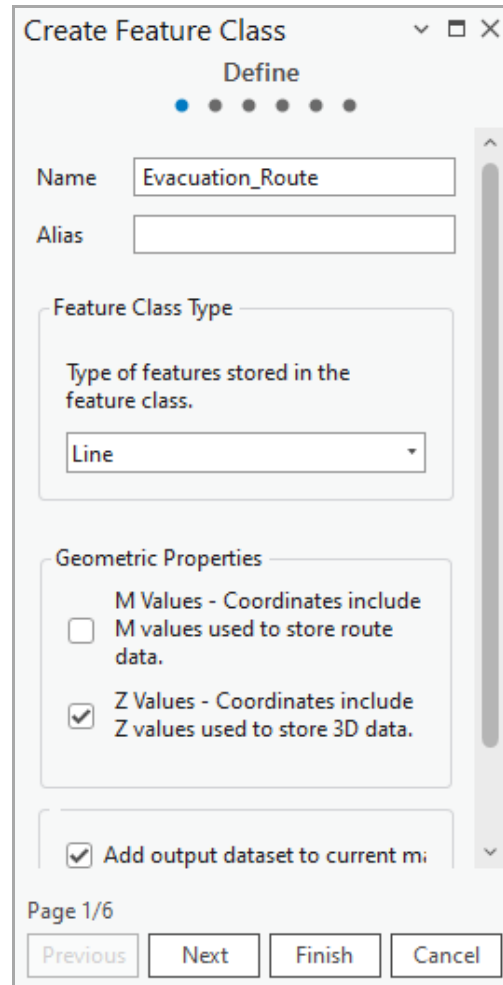


Figure 11
Create Feature Class (Line)

Again, go to the “edit” tab and choose the created Layer, and located the shortest route to the assembly points. Figure 12 presents the result of the evacuation route in the map.



Figure 12
Result of the Evacuation Route

A table was created and is shown in Figure 13.

	OBJECTID * ▲	Shape_Length *	Shape *
1	1	1718.354442	Polyline
2	2	3908.700235	Polyline
3	3	1692.051717	Polyline
4	4	5177.565553	Polyline
5	5	5513.499041	Polyline
Click to add new row.			

Figure 13
Attribute Table From Evacuation Route. The Units Are in Meters (m)

CONCLUSION

In the investigation, after completing the procedure with the GIS, it was discovered that two (2) Retired Homes:

- “Hogar de Anciano Maria Isabel”
- “Hogar de Anciano Miry”

and two (2) Elderly Building:

- “Aguada Elderly”
- “CAMPEA: Centro De Actividades Múltiples Para Personas De Edad Avanzada”

were located inside of the flood zone which means are the most vulnerable to a Huracan or Tsunami, due to the low elevation they have with respect to the mean sea level. Another discovery was that “CAMPEA” has the longest distance to their nearest assembly point, with a distance of 5,177.565 meters or 5.177 kilometers. With the elderly population rising every day, the government or private businesses must take action to fix this situation before another similar event like Hurricane Maria or like the more recent event of Hurricane Fiona, on September 18, 2022. The recommendation is to establish a nearby Assembly Point at least five (5) meters above the Flood zone or to relocate the structure to a safer place. For future development for this type of business, it is important to consult with a Professional Surveyor (PS) to verify and confirm if the property is inside of a flood zone.

More details of this project can be found at the following link:
<https://storymaps.arcgis.com/stories/1a190b90dd394f65a744be8cfe65f9e5>.

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