NUEVOS MAPAS DE INUNDACION POR MAREJADAS CICLONICAS: "RUNUP & OVERTOPPING"

OR

HOW IF YOU DON'T INCLUDE WAVE RUNUP AND OVERTOPPING YOU ARE MISSING THE BOAT AS FAR AS COASTAL FLOODING AND DAMAGE IN PUERTO RICO IS CONCERNED

SIMPOSIO SOBRE MANEJO DE RIESGOS COSTEROS, ALTERNATIVAS DE INTERVENCION NATURALES, ESTRUCTURALES E HIBRIDAS

Hotel Verdanza, Isla Verde, PR

22 de noviembre de 2019

Aurelio Mercado Irizarry (UPR Mayaguez)

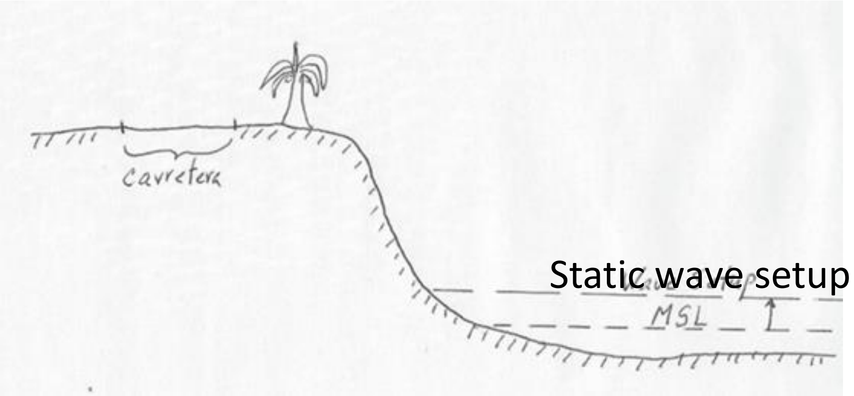
Jaime Reniel Calzada (ERT/NOAA)

Harry Justiniano (UPR Mayaguez)/Carlos Andrade (Exxon-Mobil)

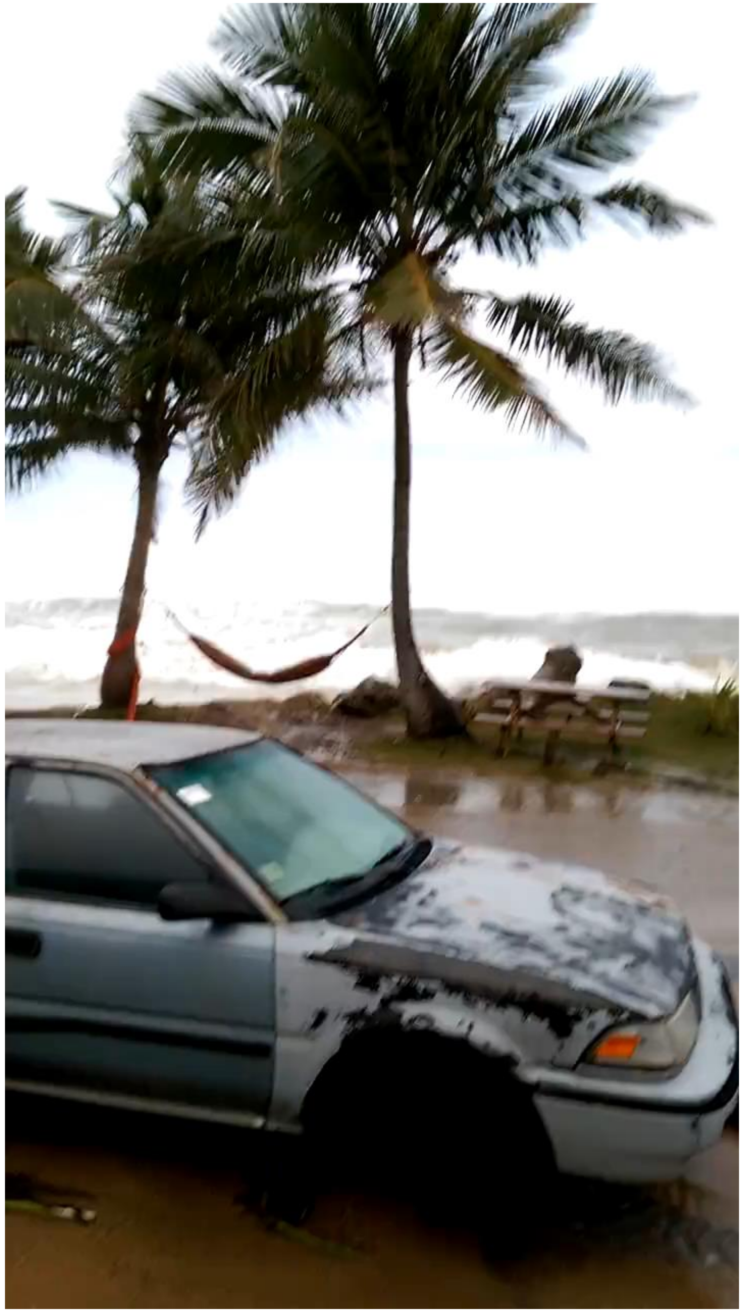
Marine Sciences, UPRM

PROGRAMA DE MANEJO DE LA ZONA COSTANERA

Aguada, Pico de Piedra

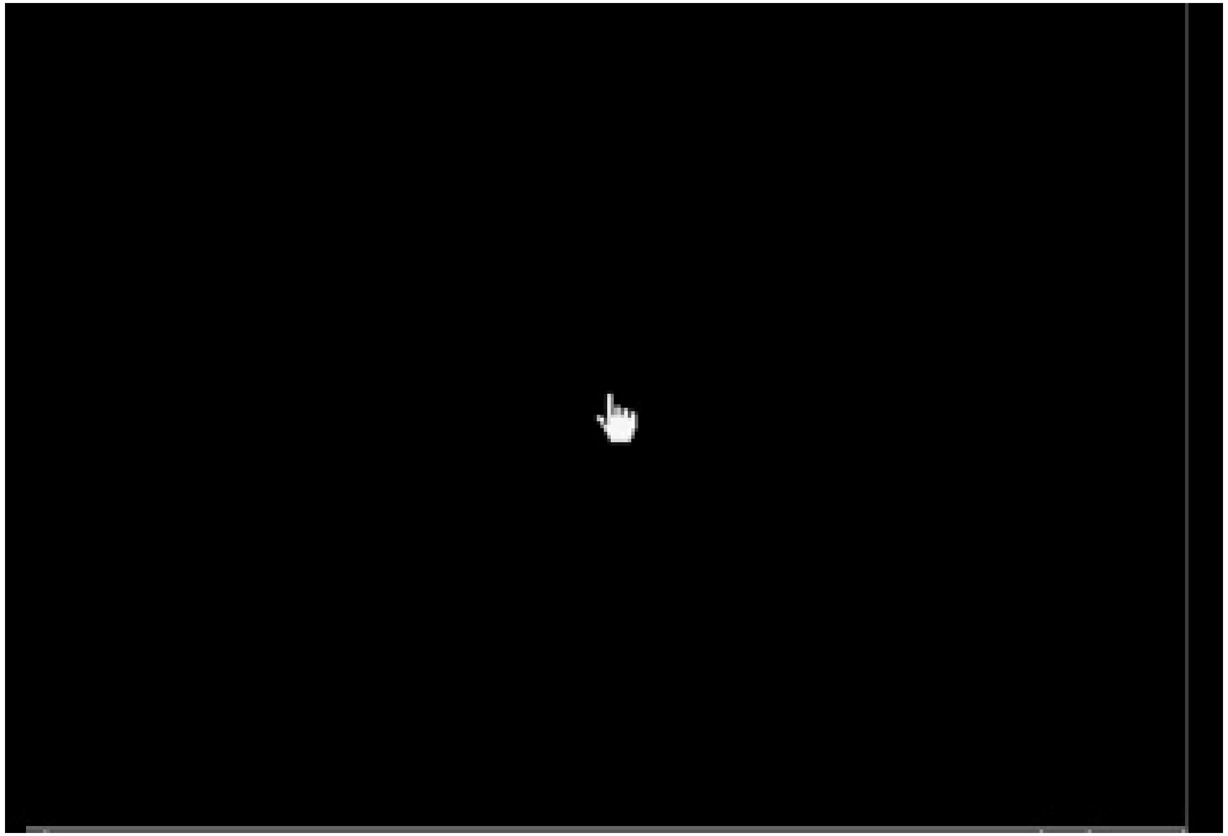


Riley extra-tropical storm, March 2018



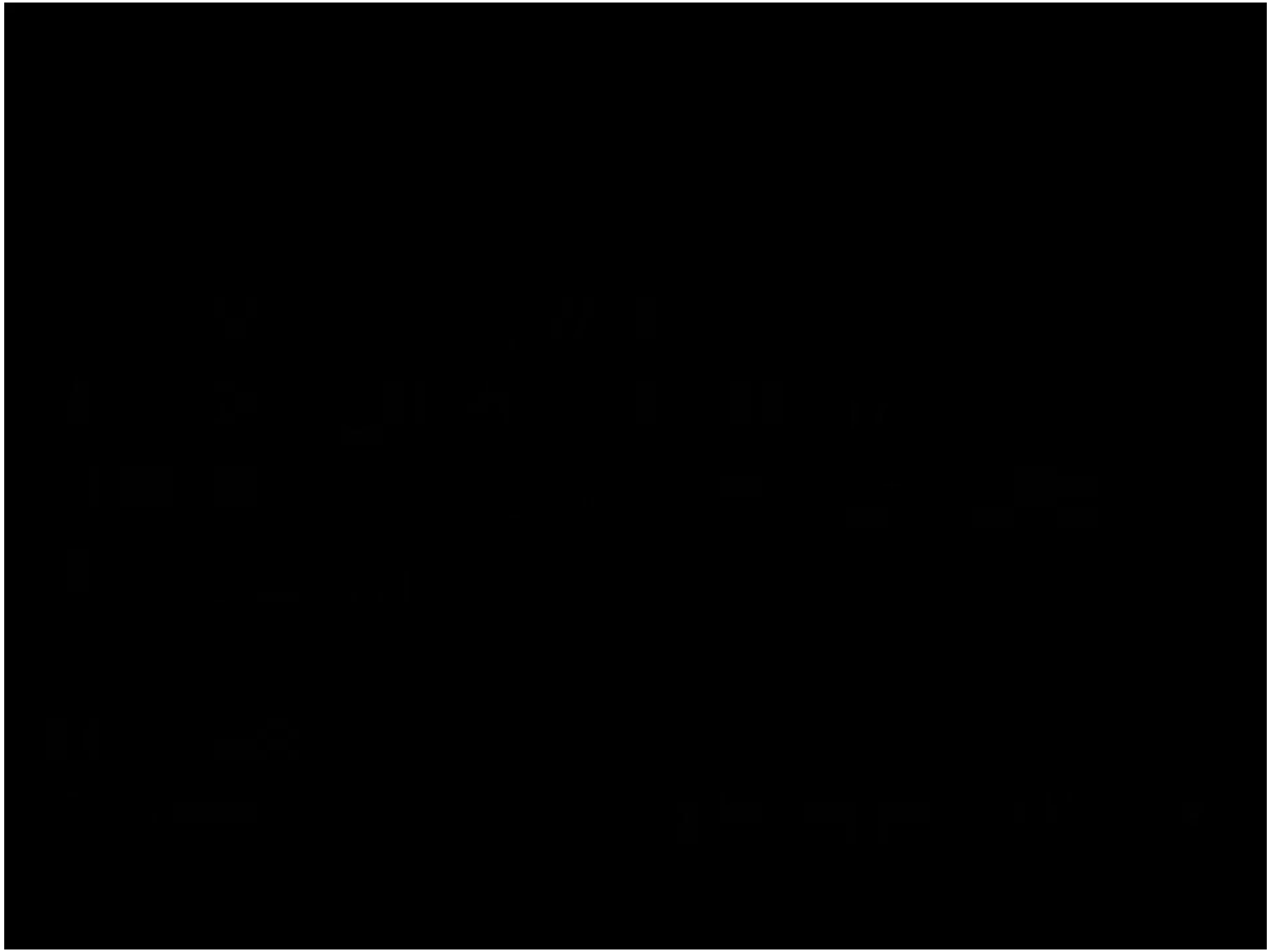
Isabela, Montones – bravata de Riley marzo 2018 (Dra. Sandra Cruz Pol)

Sandy Beach, Rincón
Bravata de Semana Santa 2008



¿Es una marea ciclónica o un tsunami?

Hurricane Haiyan, The Philippines, 2013



1 minuto de duración

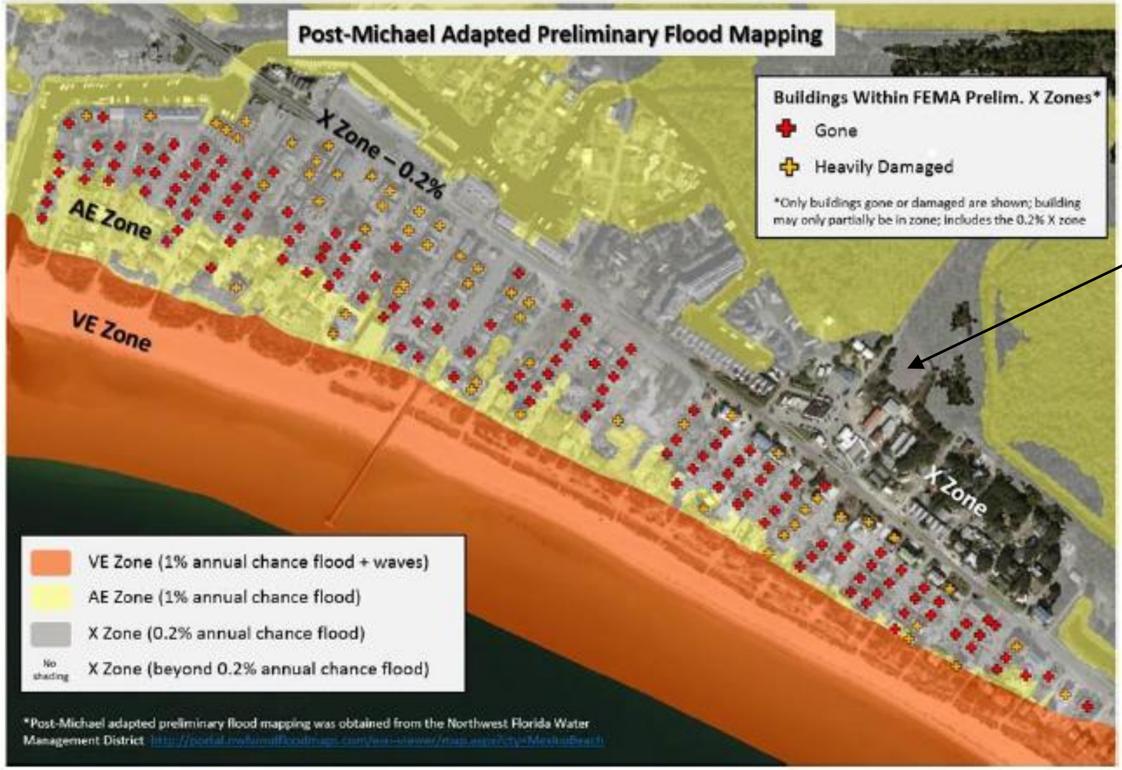
NWS Warning


ELEVATED SURF &
SNEAKER WAVES
Waves run up on a beach significantly farther than other waves.
Will wash over jetties and rocks.
Can surprise beach goers, knock them down and sweep them out to sea.
Stay off rocks, logs, and jetties.
Never turn your back on the ocean.

Coastal communities should exercise caution in using FEMA Flood Maps as the primary indicator of coastal risk.

Published on February 14, 2019

Rob Young | + Follow
Director, Program for the Study of Developed Shorelines at Western Carolina University
10 articles



Mexico Beach, FL
Hurricane Michael

Flood 4-5 feet above ground level

Also holds for SLOSH+SWAN !!!!!!!!!

INSURANCE JOURNAL

U.S. Flood Models Still in Infancy, So Underwriters Must Be 'Cautious Consumers'

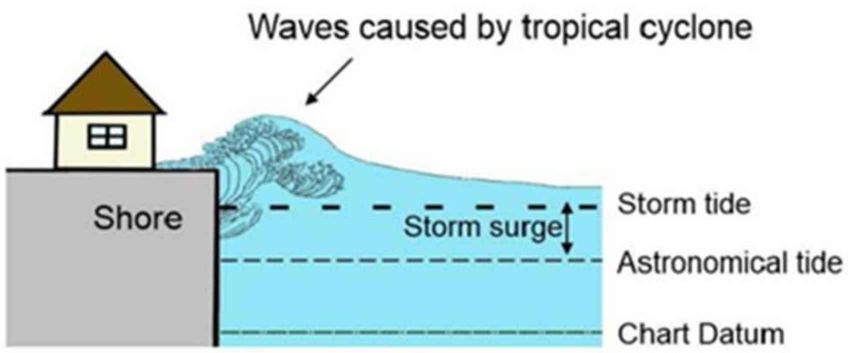
By L.S. Howard (https://www.insurancejournal.com/author/lhoward/) | July 24, 2018

Not Trusting FEMA's Flood Maps, More Storm-Ravaged Cities Set Tougher Rules

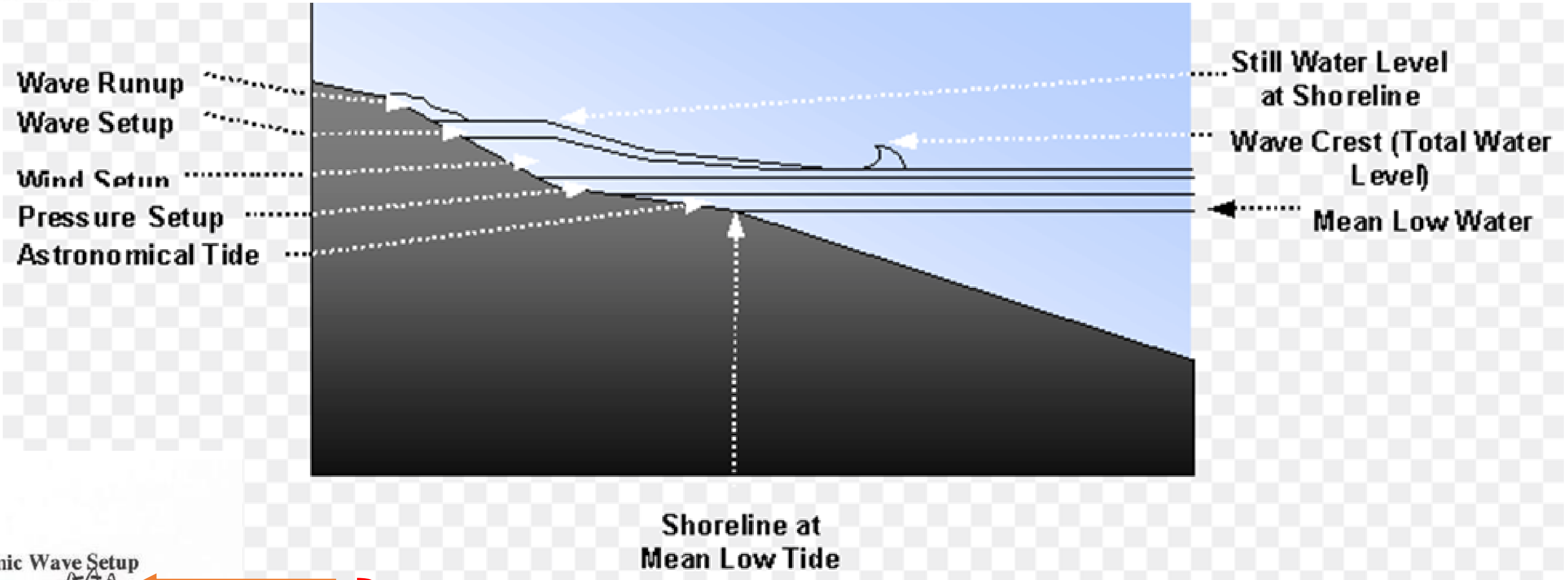
A growing number of cities are looking beyond the usual 100-year floodplain and requiring more homes to be built higher for their own protection.

By James Bruggers
MAR 19, 2019

Wave setup: static + dynamic (infragravity waves, including sneaker/sleeper waves)



¿QUE ES LO QUE ESTAMOS TRATANDO DE CAPTURAR?



Very important in islands like Puerto Rico

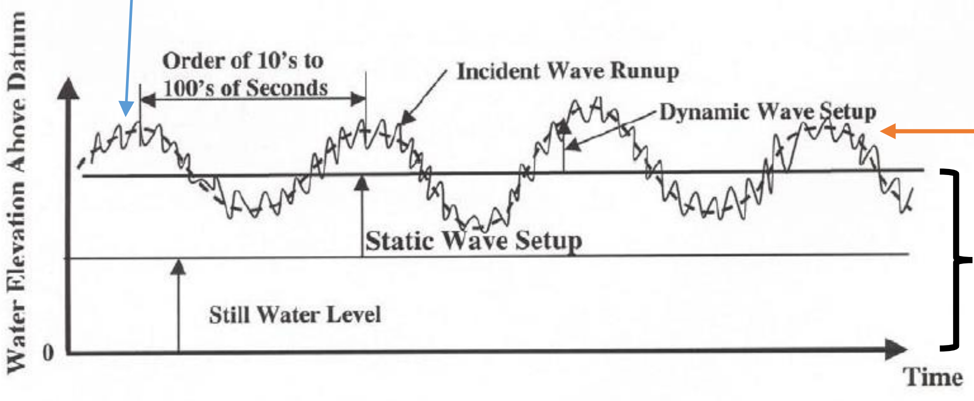
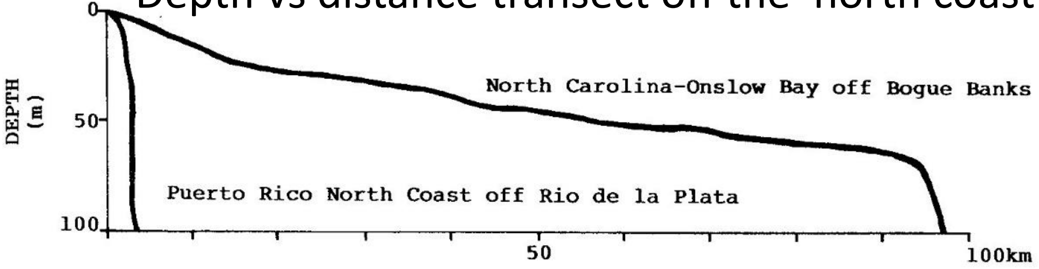


Figure 3. Definitions of static and dynamic wave setup components.

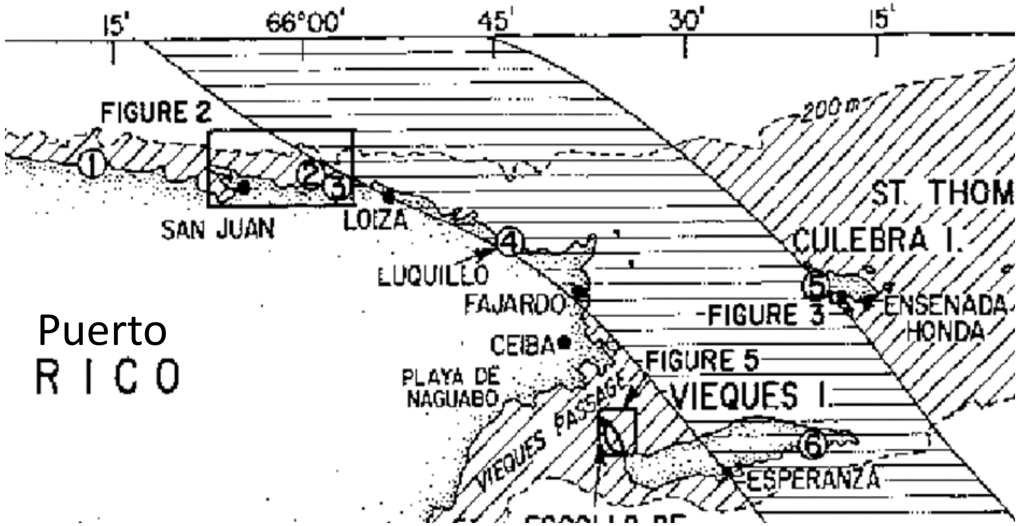
We try to predict this: pressure+wind+wave (static & dynamic) setups plus high-frequency wind waves propagating on top

Storm surge models (with wave coupling) predict this: pressure+wind+wave (static) setups. (ADCIRC+SWAN or SLOSH+SWAN or SCHISM+WWM)

Depth vs distance transect off the north coast

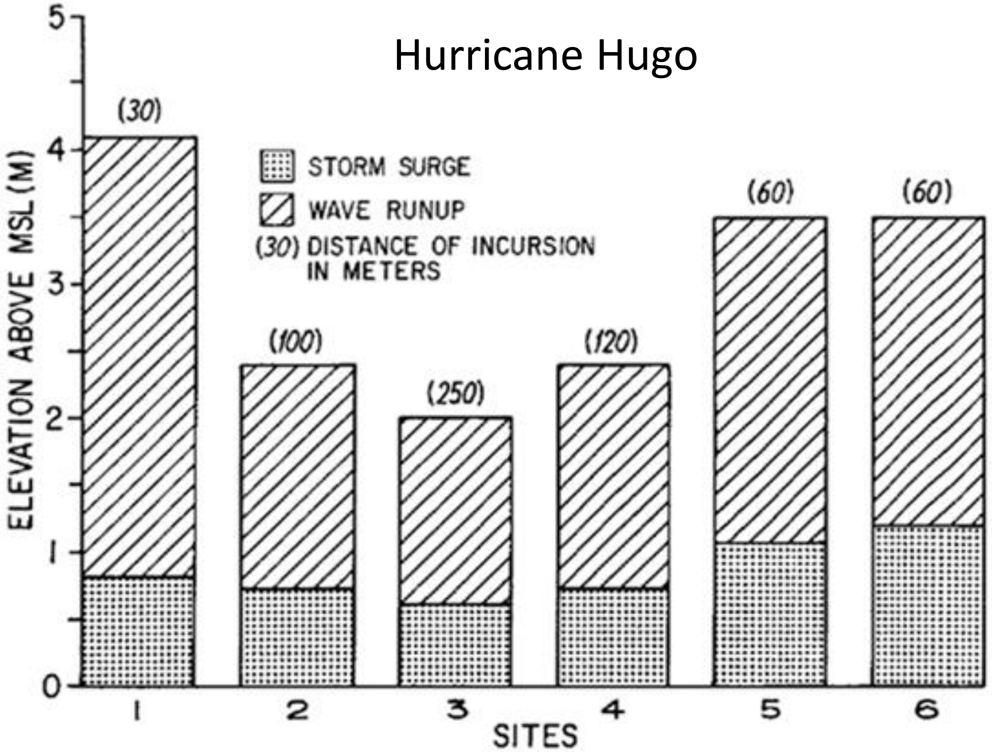


Hurricane Hugo



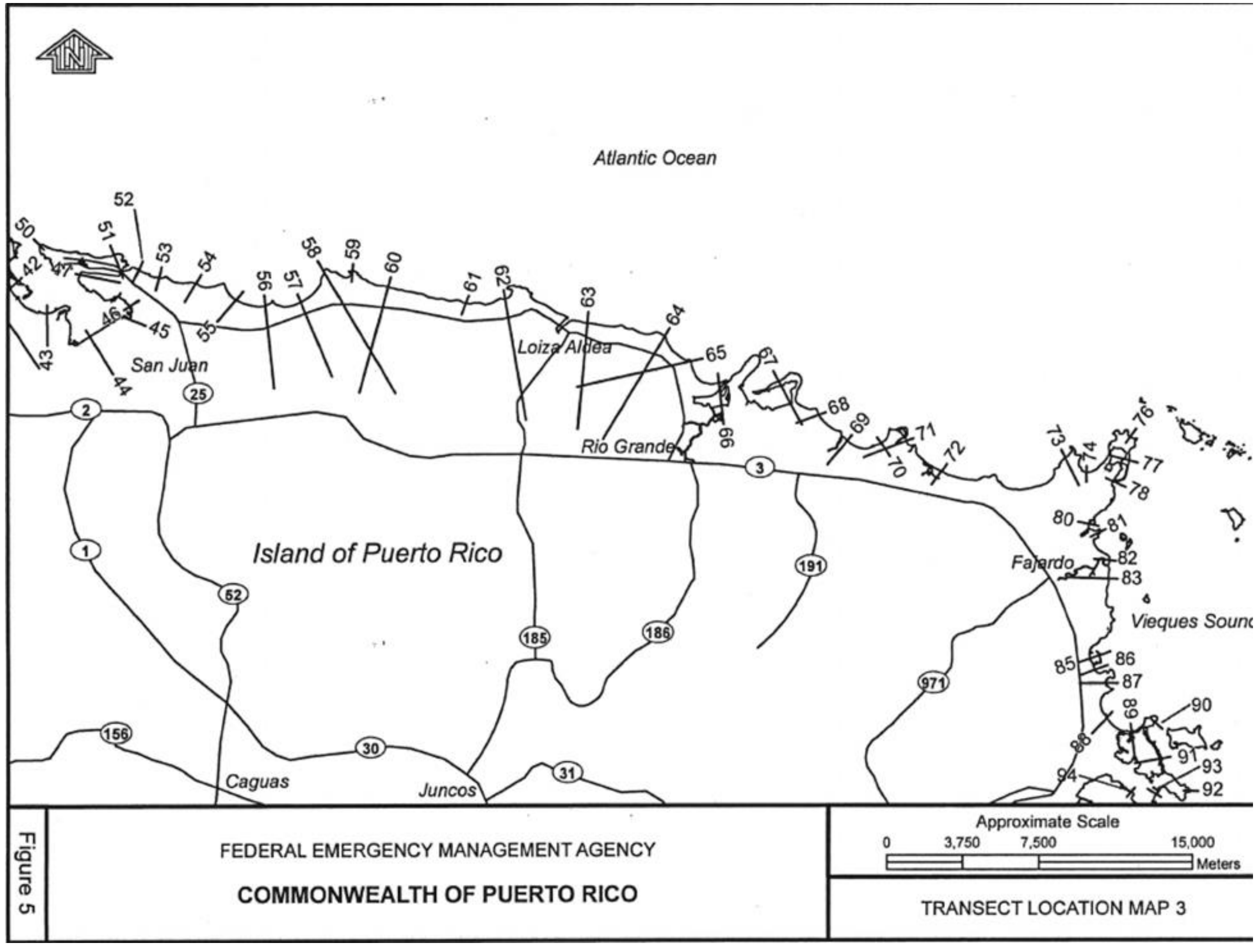
Puerto

Hurricane Hugo



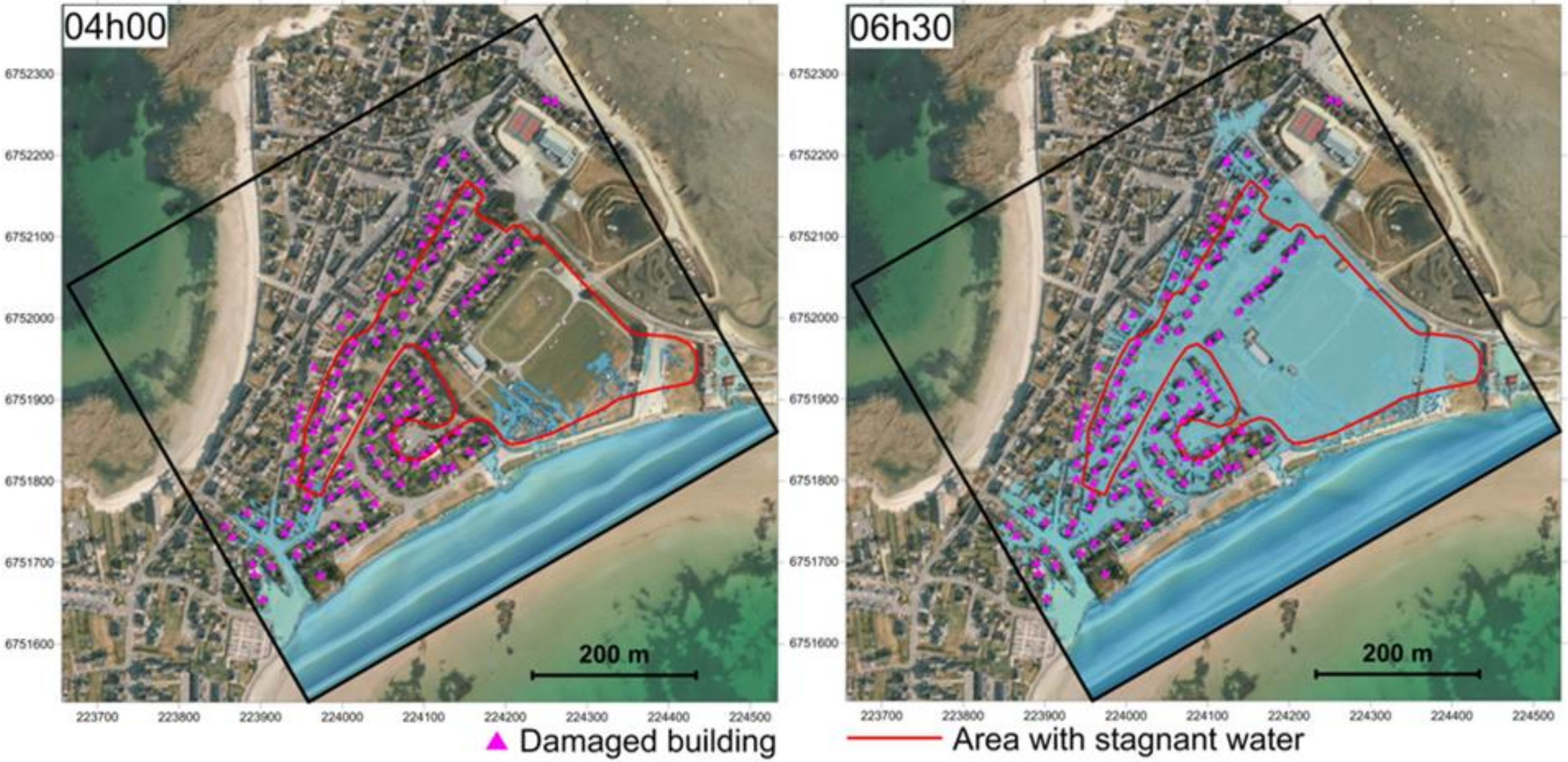
Taken from Rodriguez et al., 1994. Storm wave swash for six sites in Puerto Rico. Site locations are shown in to the left. Storm surge was similar for the six sites, but wave runup varied as a function of location due to the variability of the coastal geomorphology, both due to the bottom profile and horizontal shoreline variability. Landward incursion of storm water is given by the values in parenthesis at the top of each column. Coastal flooding was severe in low lying areas (sites 2, 3, 4). Although storm wave swash was greater in steeper profile areas (sites 1, 5, 6), overall incursion was less.

FEMA methodology to include wave runup and overtopping



Map showing locations of 1-D transects along the north east coast of Puerto Rico, which FEMA used to estimate Base Flood Elevations, and wave runup/overtopping, for FEMA's Flood Insurance Rate Maps. WHAFIS and RUNUP run along transects.

¿QUE ES LO QUE ESTAMOS TRATANDO DE CAPTURAR?



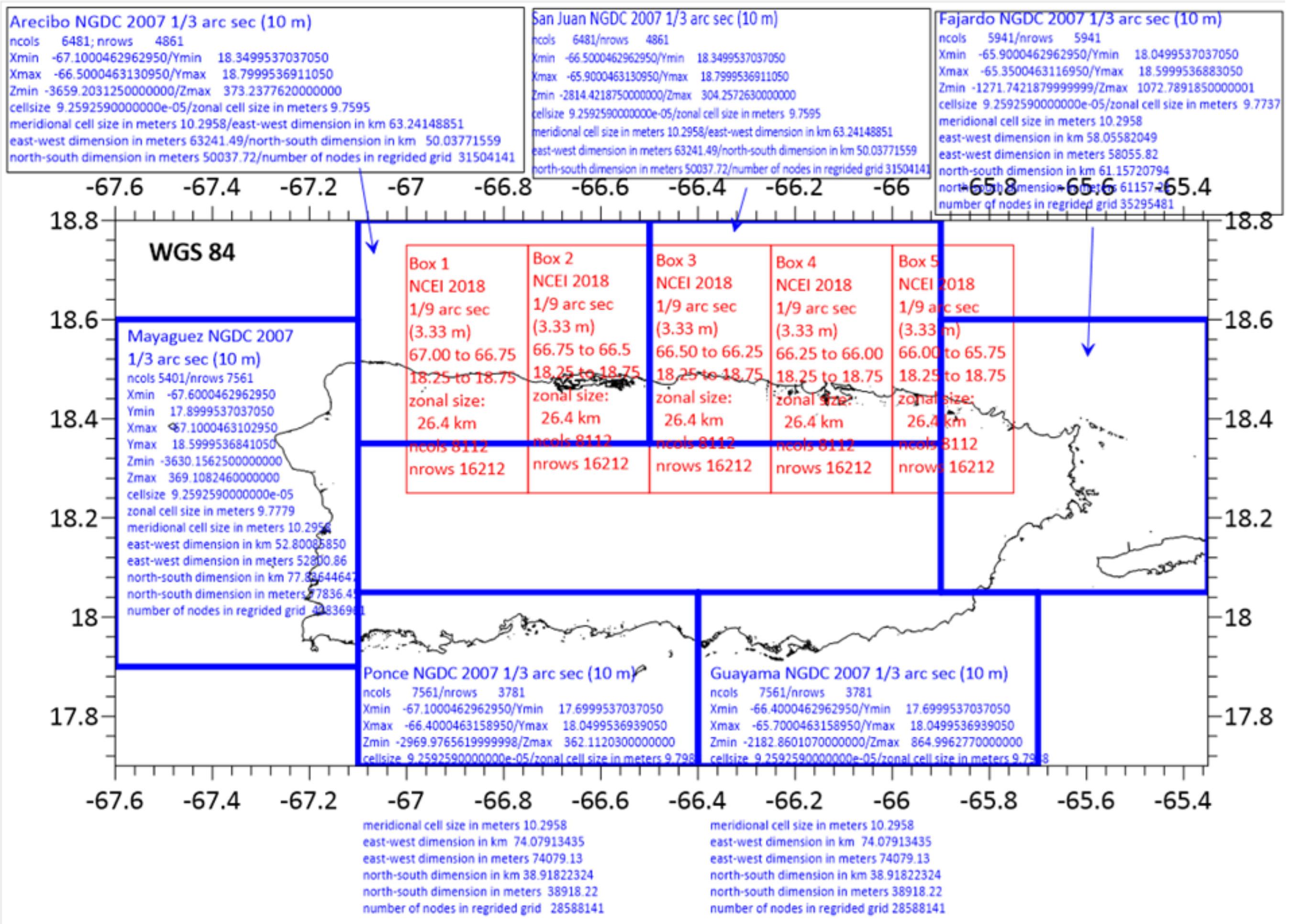
Before wave runup/overtopping

After wave runup/overtopping

Difference in coastal flooding between not including runup/overtopping on the left and with both factors included.

DATA SOURCE: BARE EARTH DEMs from the NATIONAL CENTERS FOR ENVIRONMENTAL PREDICTION (a.k.a. NGDC)

- Areas enclosed in red used 3.3 m DEM
- Areas enclosed in blue used 10 m DEM interpolated to 3 m



Mangrove locations

Google Earth image showing, in red, areas containing mangroves, according to Rahdarian & Niksokhan. For these areas the Manning coefficient at the computational nodes falling inside was given a value of 0.145.

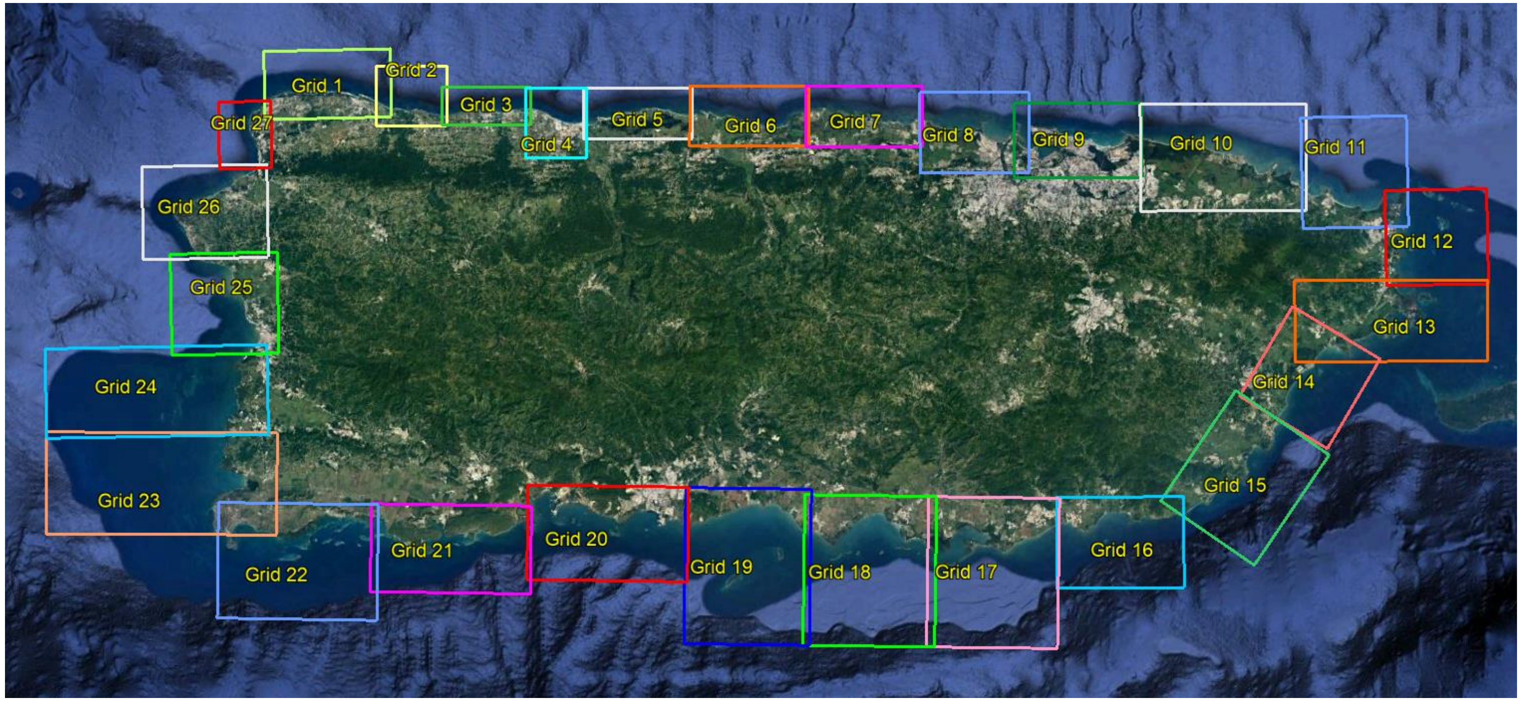
Rahdarian, A. and M. H. Niksokhan, 2017. Numerical modeling of storm surge attenuation by mangroves in protected area of mangroves of Qheshm Island. Ocean Engineering, 145: 304-315.

Reef locations

Google Earth image showing, in white, areas containing the reef type called "linear reefs", according to https://coastalscience.noaa.gov/project/benthic-habitat-mapping-puerto-rico-virgin-islands/. All these areas were assigned a Manning of 0.05.

Cat 1 to 5 simulations carried out for each computational grid at 3x3 meters resolution.

- Hurricane winds taken from Saffir-Simpson scale and blowing perpendicular to offshore boundary
- Pressure setup taken at offshore boundary from Benitez & Mercado 2015 ADCIRC+SWAN study and given as an initial sea surface elevation. Being in deep water, wind and wave setups contributions assumed negligible.
- Tp taken from Benitez & Mercado 2015 ADCIRC+SWAN study. 2D TMA wave spectrum assumed.
- Model computes wind and wave setups. The wave setup includes both static and dynamic setups. Everything computed at the same time.
- Computations carried out in a cluster of 640 processing units, in parallel mode, for 1 hour of simulation time
- All inland area assigned a Manning of 0.03 (flow over grass, or sand)



Schematic showing outline boxes of the XBeach computational grids. The grid generation started from the northwest (Aguadilla – Grid 1) moving eastward (Grid 27).

WAVE MODEL: XBEACH

Directly quoting from https://oss.deltares.nl/web/xbeach/,
"XBeach is a two-dimensional model for wave propagation, short & long waves and mean flow, sediment transport and morphological changes of the nearshore area, beaches, dunes and backbarrier during storms. It is a public-domain model that has been developed with major funding from the US Army Corps of Engineers, Rijkswaterstaat and the EU, supported by a consortium of UNESCO-IHE, Deltares (formerly WL|Delft Hydraulics), Delft University of Technology and the University of Miami."
For validation information, please see https://oss.deltares.nl/web/xbeach/validation. There are many more references where validation tests are presented.
The model is updated constantly. In our case we used version 1.23.5387M XBeachX BETA release. It was run in its phase-resolving, non-hydrostatic, mode.

Supporting study:

- Used ADCIRC+SWAN.
- Pressure setup and Tp taken from this study

Computational mesh

Storm Surge Modeling in Puerto Rico in Support of Emergency Response, Risk Assessment, Coastal Planning and Climate Change Analysis

Report prepared for the
Caribbean Coastal Ocean Observing System (CariCOOS)/NOAA
University of Puerto Rico/Mayagüez, P.R.
and
Puerto Rico Coastal Zone Management Program
Department of Natural and environmental Resources

by
Jose Benítez (Ph.D. candidate)
and
Aurelio Mercado Irizarry (Professor)

Department of Marine Sciences/University of Puerto Rico/Mayaguez

July 2015

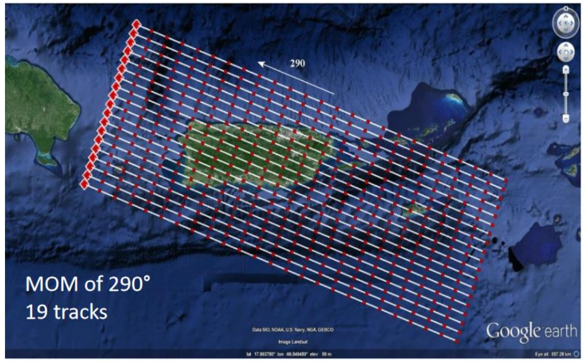


Figure 9 – Collection of tracks with a heading of 290° (clockwise from North). Nineteen tracks with a separation of 5 nm were found to be sufficient for this heading.

Cat	Central pressure (mb)	RMW (nm)	Vf (kn)	Vmax (kn	Separation between tracks (nm)
1	980	25	10	78	5
2	969	25	10	92	5
3	950	20	10	108	5
4	926	15	10	131	5
5	900	10	10	150	5

What is it that we are evaluating?

The equivalent of FEMAs Base Flood Elevation (BFE). But relative to ground level. FEMA gives the BFE relative to MSL. And the 100-year SWEL is replaced by the SWEL due to the corresponding category 1-5 hurricane. This SWEL includes tide+pressure+wind+wave (static) setups. zs_max is based on the crest of the high frequency waves (T < 25 sec) plus the crest of IGWs, both riding on top of the SWEL. zs_mean is based on a 1 hour mean (filters high frequency waves and IGWs – results more similar to the SWEL).

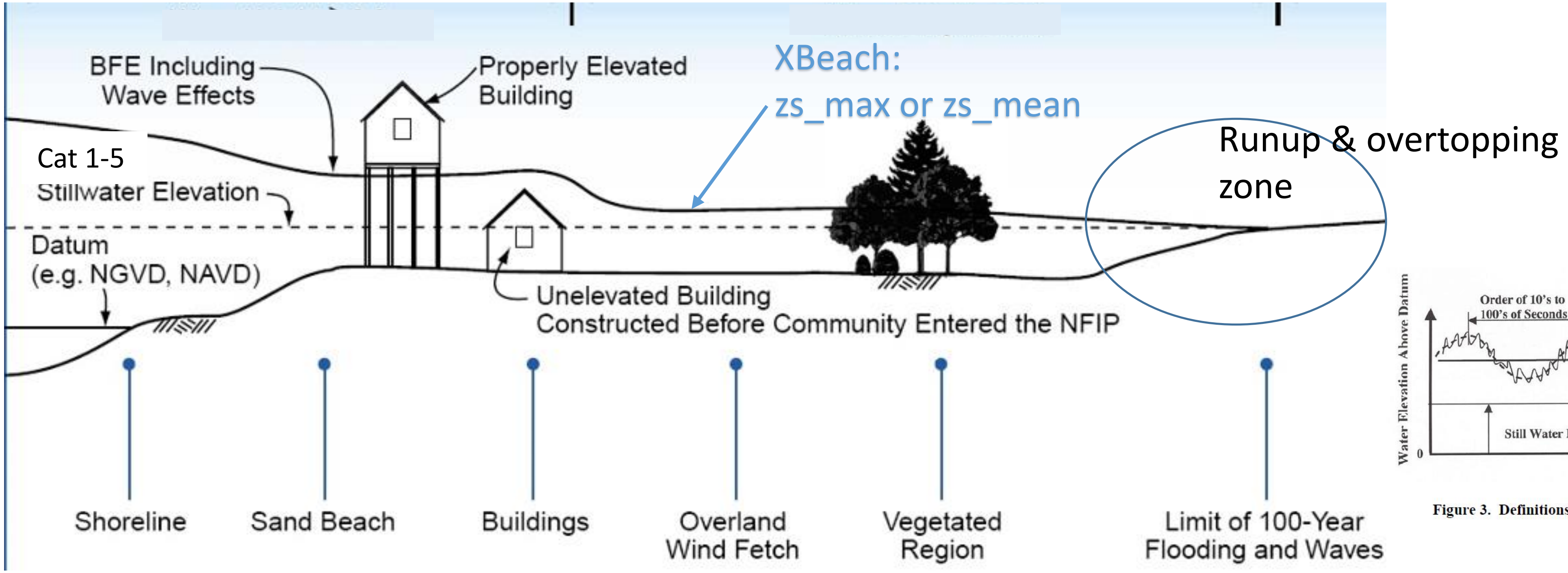


Figure borrowed from FEMA

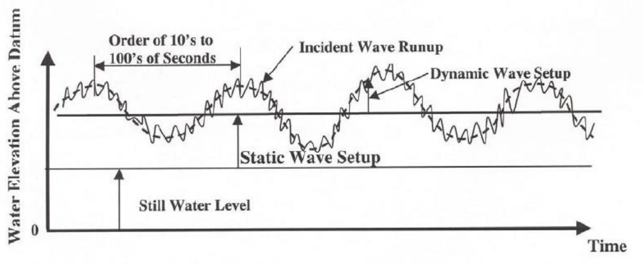
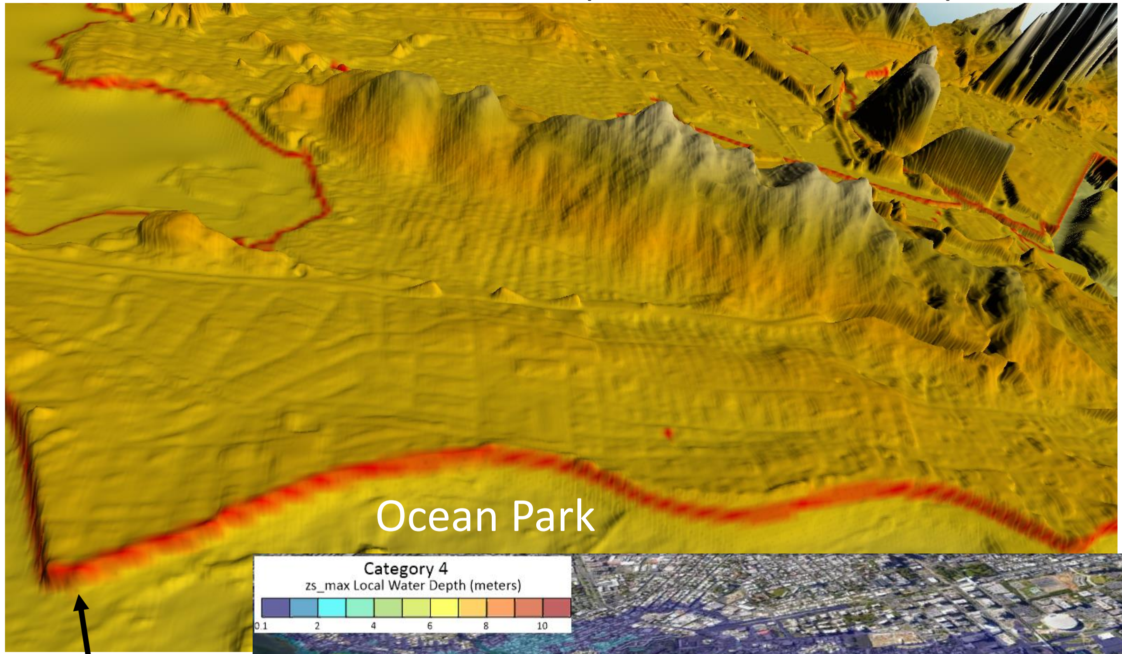
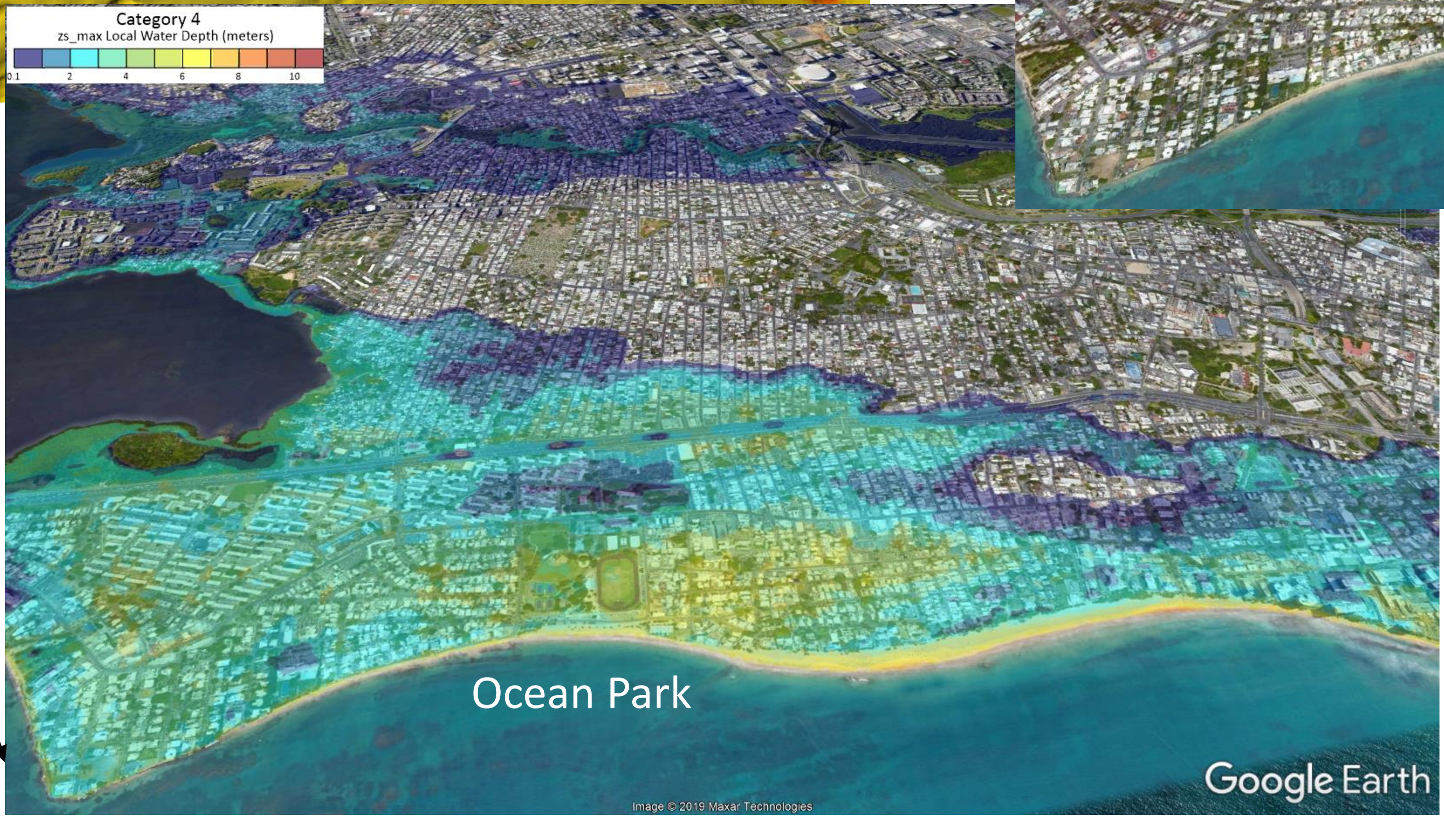


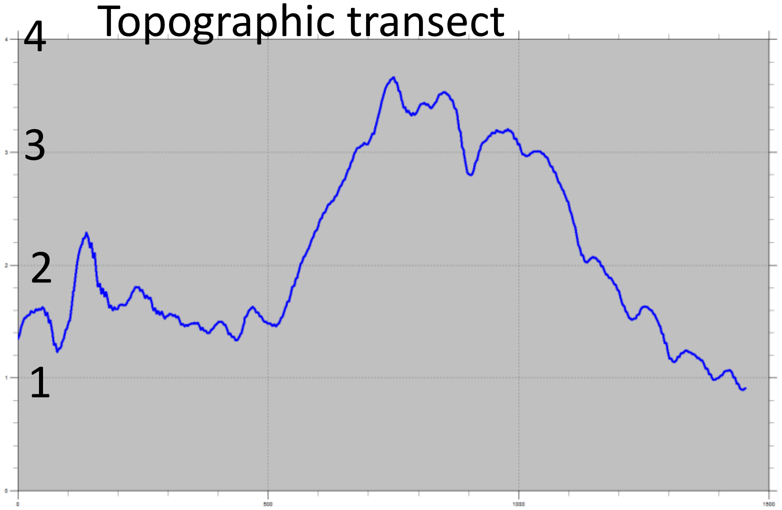
Figure 3. Definitions of static and dynamic wave setup components.

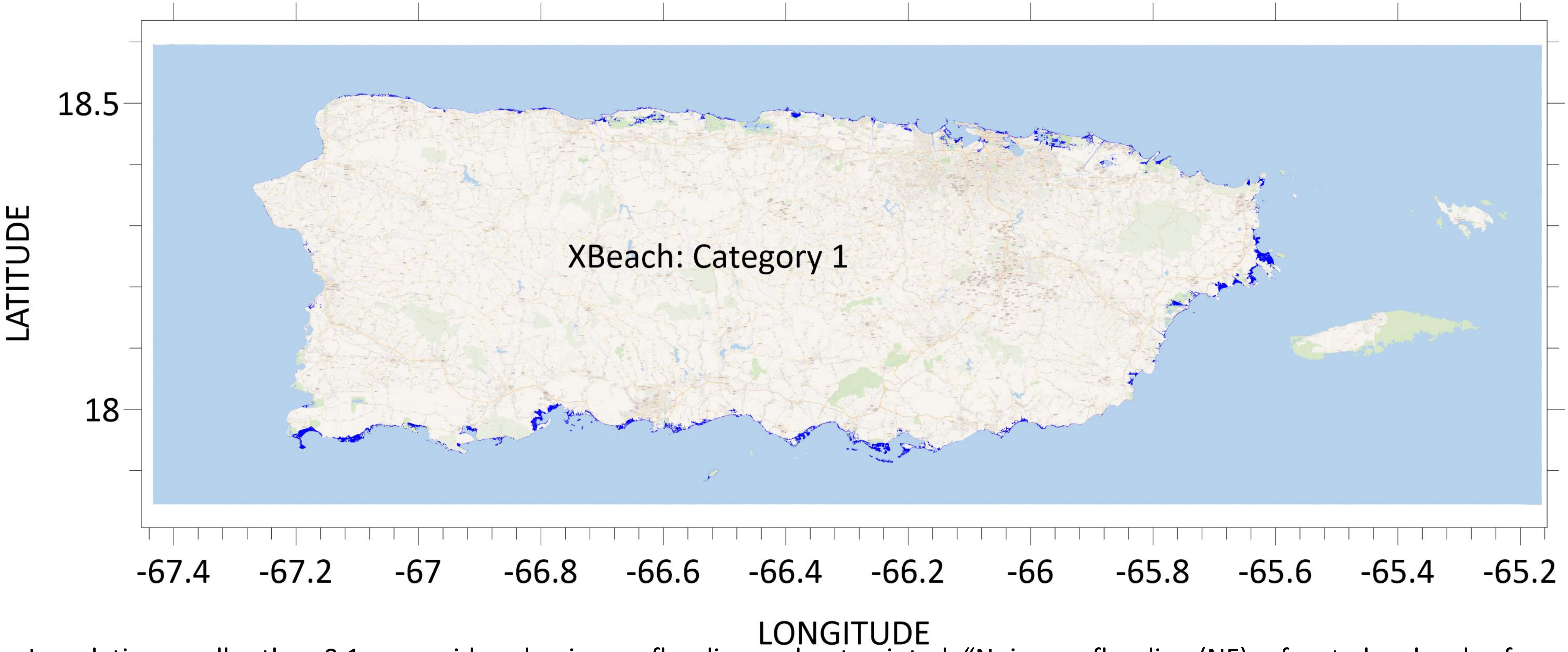
Ocean Park 3.3 meters DEM (view from the sea)



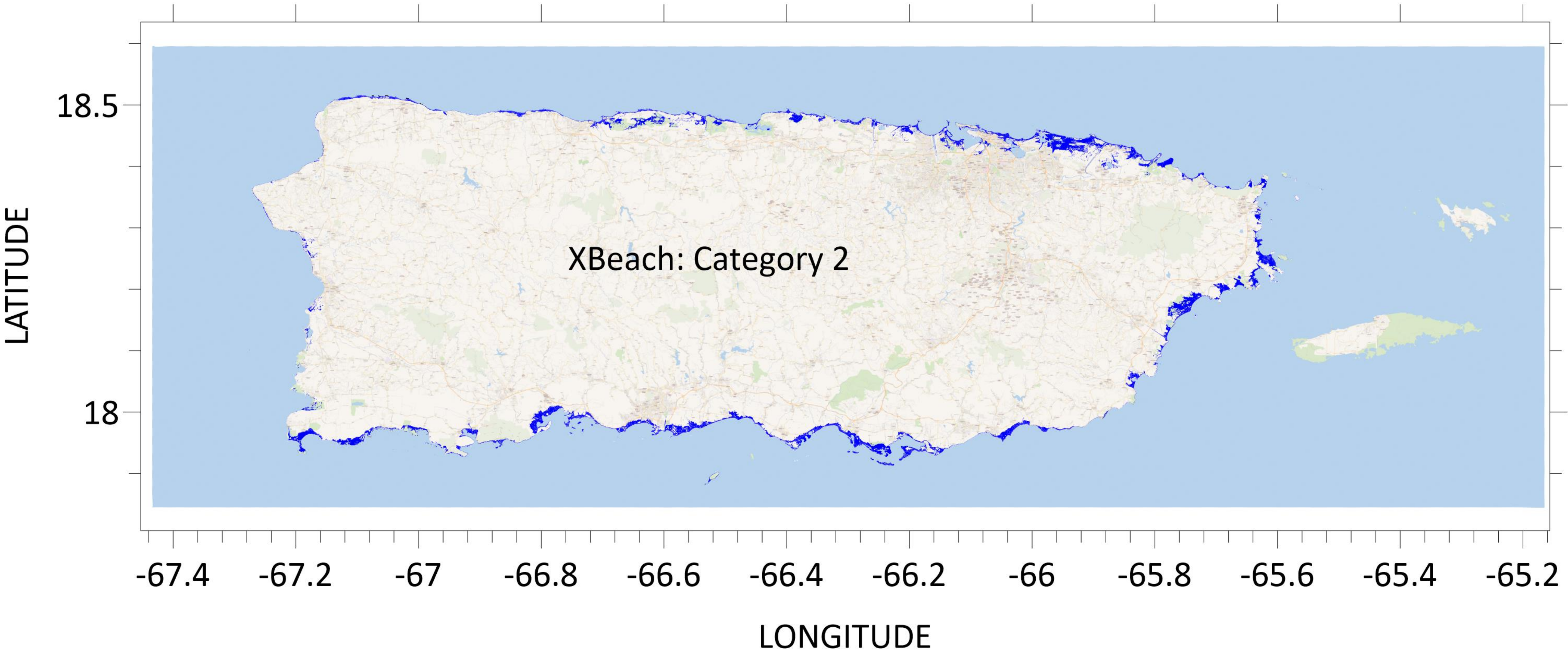
Pta. Las Marias

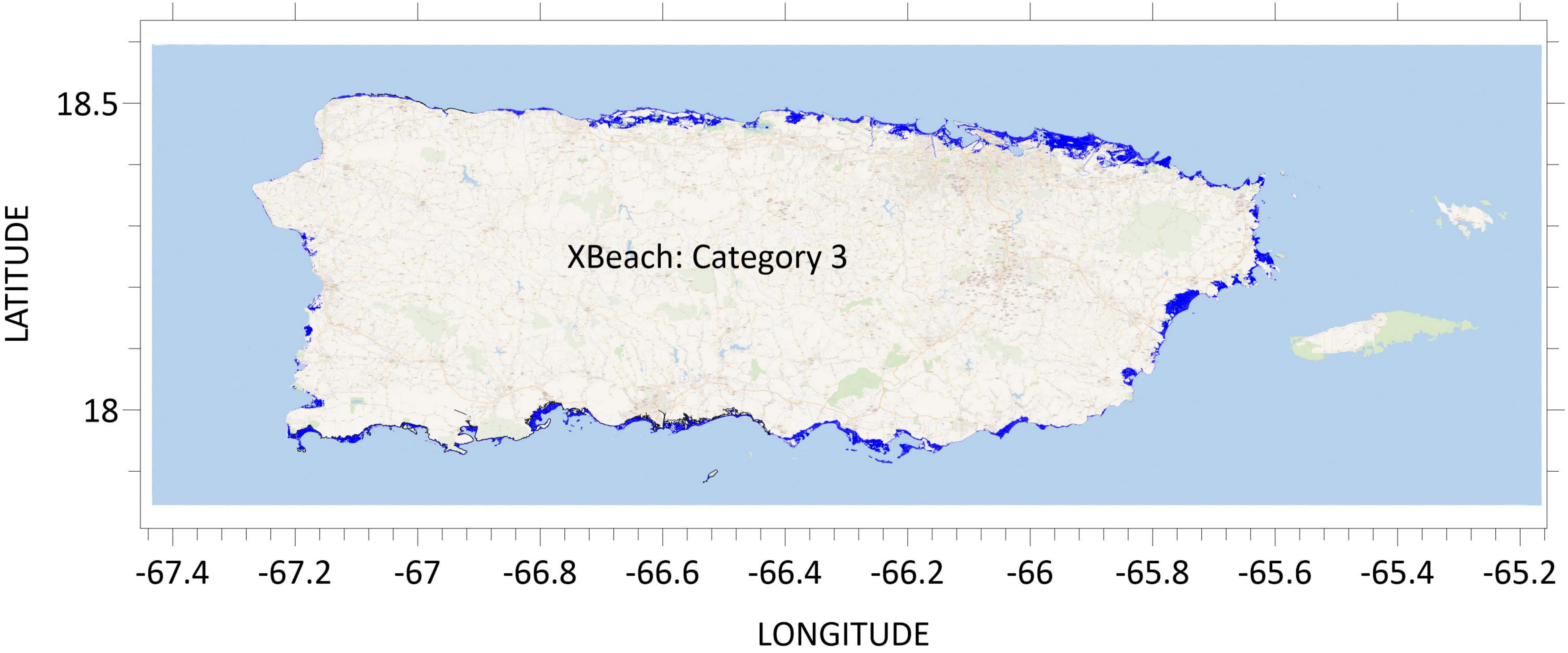




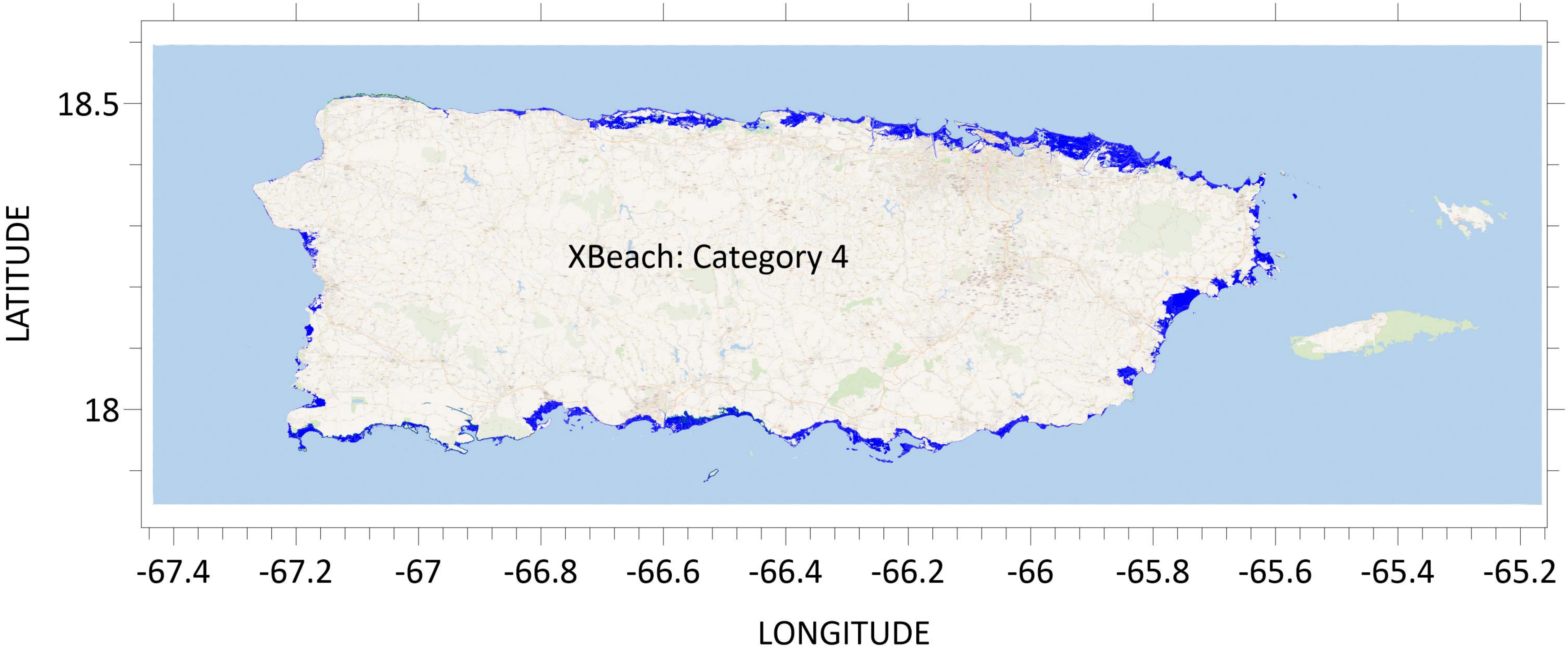


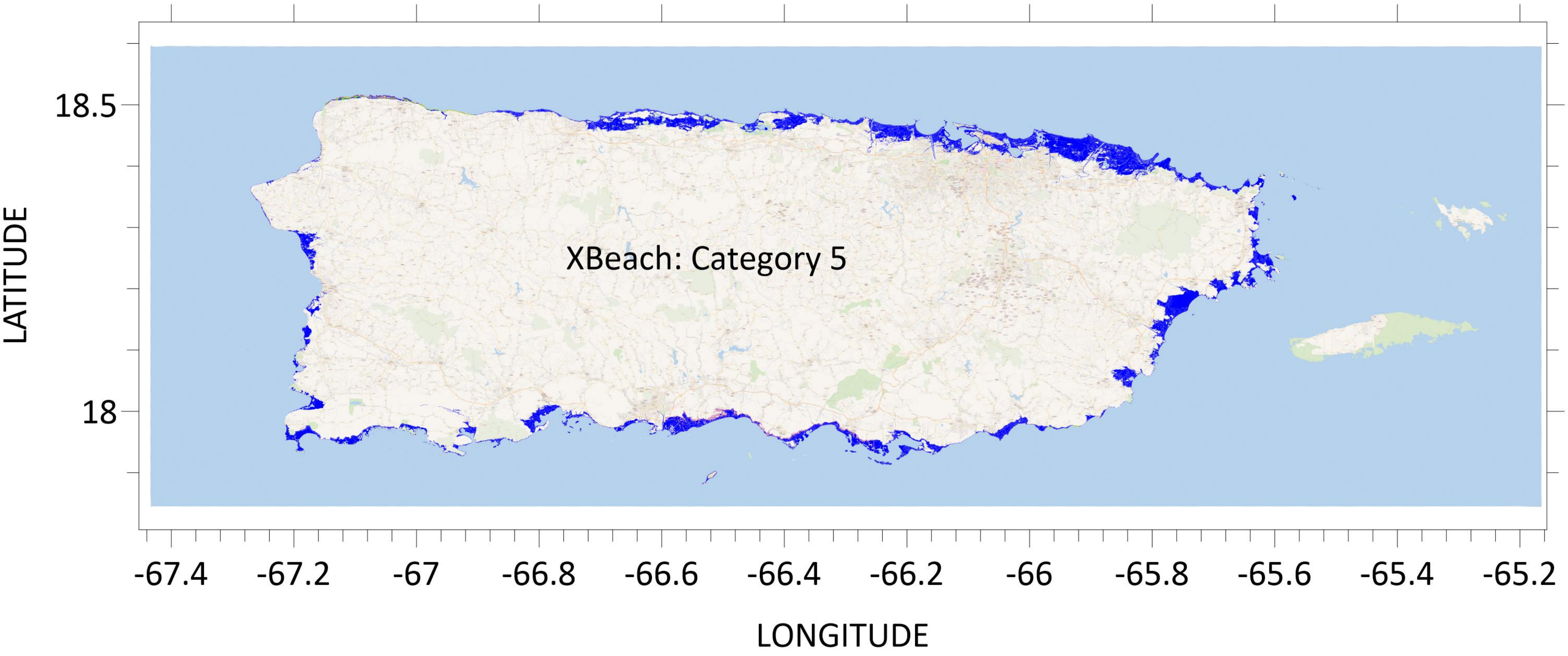
Inundation smaller than 0.1 m considered nuisance flooding and not painted. “Nuisance flooding (NF) refers to low levels of inundation that do not pose significant threats to public safety or cause major property damage, but can disrupt routine day-to-day activities, put added strain on infrastructure systems such as roadways and sewers, and cause minor property damage.” Moftakhari, H. R., A. AghaKouchak, B. F. Sanders, M. Allaire, and R. A. Matthew, 2018. What Is Nuisance Flooding? Defining and Monitoring an Emerging Challenge. Water Resources Research, 54: 4218–4227.


18.5
18
LATITUDE
XBeach: Category 2
-67.4
-67.2
-67
-66.8
-66.6
-66.4
-66.2
-66
-65.8
-65.6
-65.4
-65.2
LONGITUDE



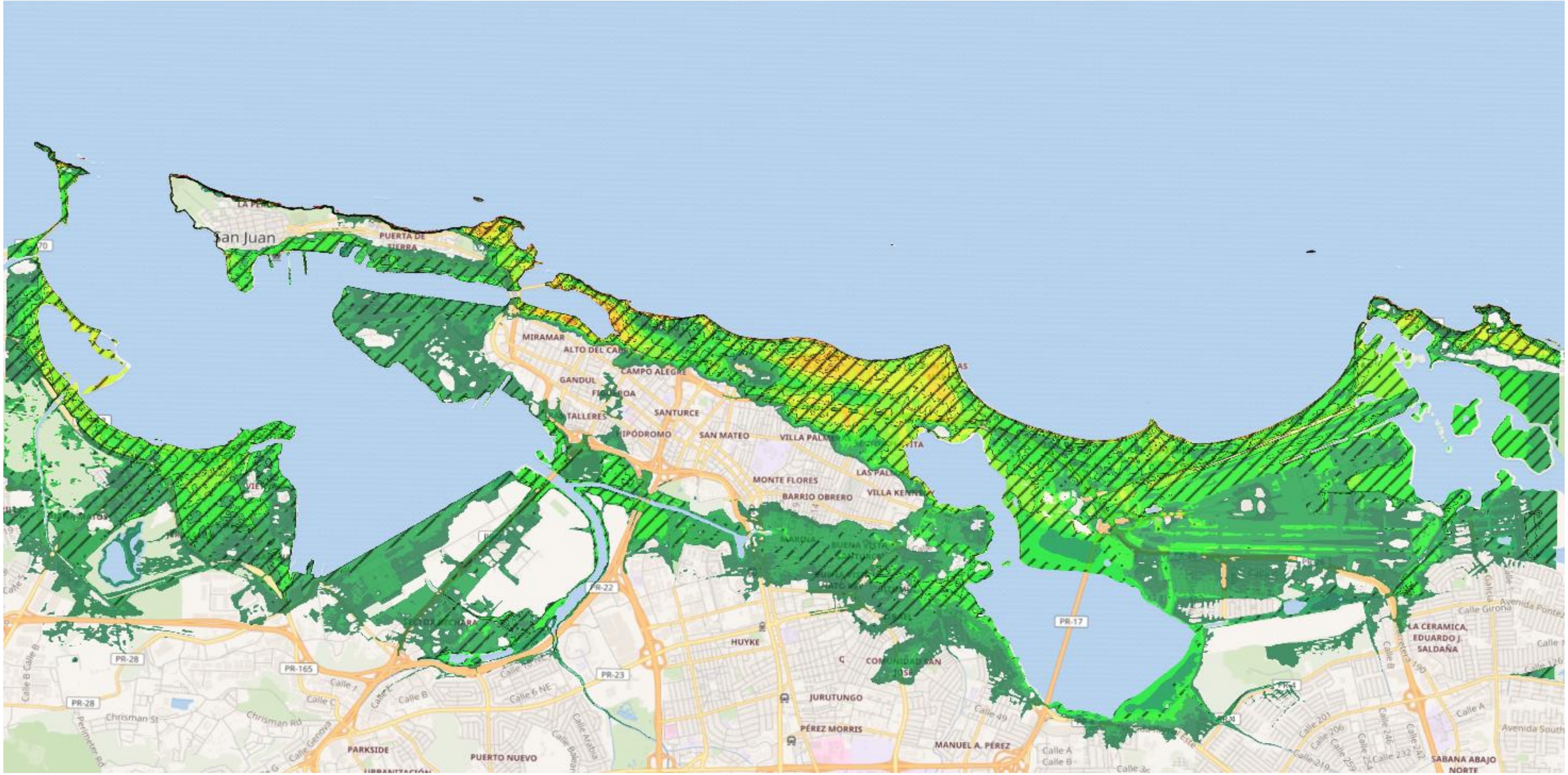
XBeach: Category 3
18.5
18
LATITUDE
-67.4
-67.2
-67
-66.8
-66.6
-66.4
-66.2
-66
-65.8
-65.6
-65.4
-65.2
LONGITUDE


XBeach: Category 4
LATITUDE
18.5
18
LONGITUDE
-67.4
-67.2
-67
-66.8
-66.6
-66.4
-66.2
-66
-65.8
-65.6
-65.4
-65.2

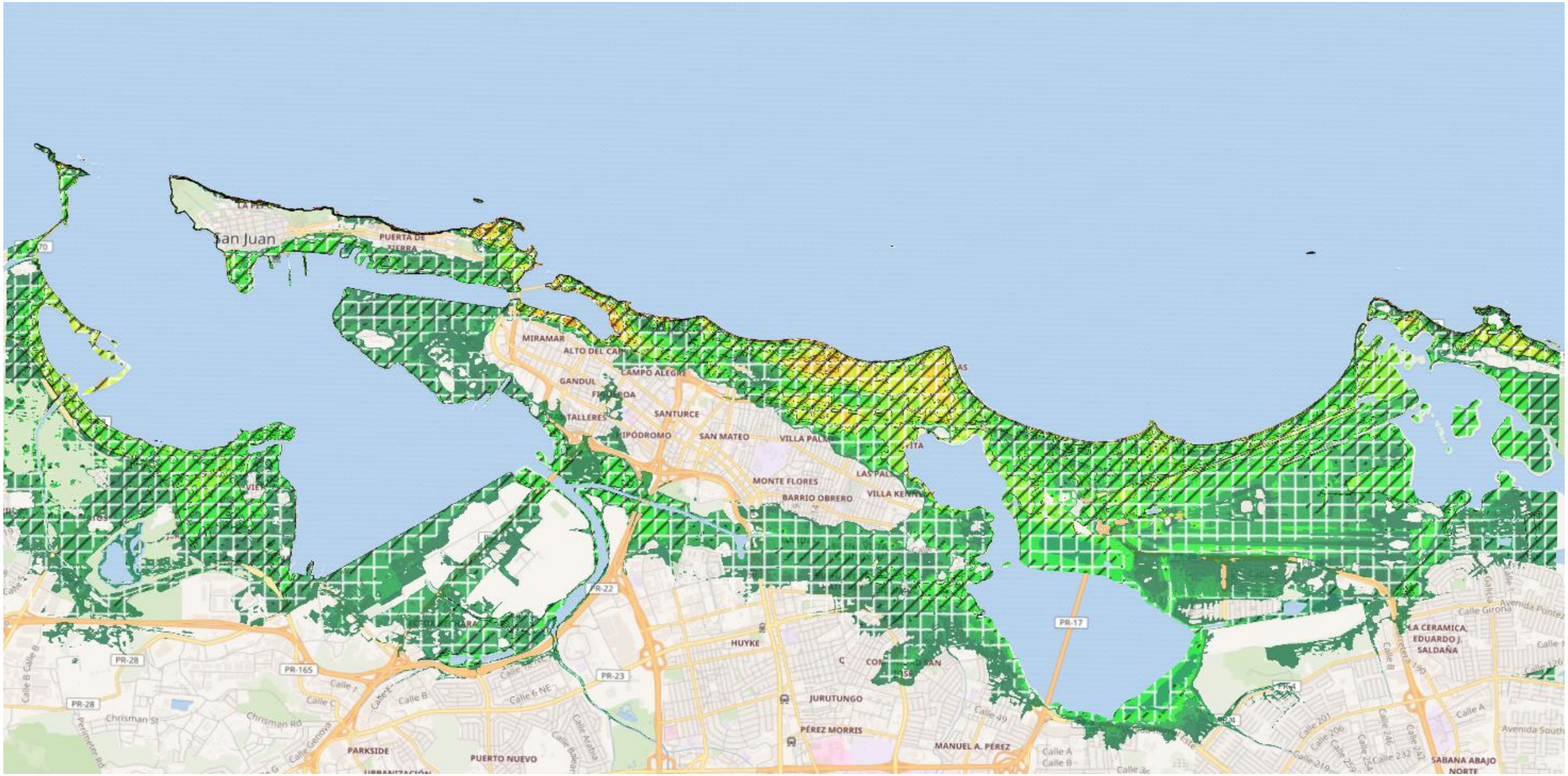

XBeach: Category 5
LATITUDE
18.5
18
LONGITUDE
-67.4
-67.2
-67
-66.8
-66.6
-66.4
-66.2
-66
-65.8
-65.6
-65.4
-65.2

XBeach: Category 3 Hurricane

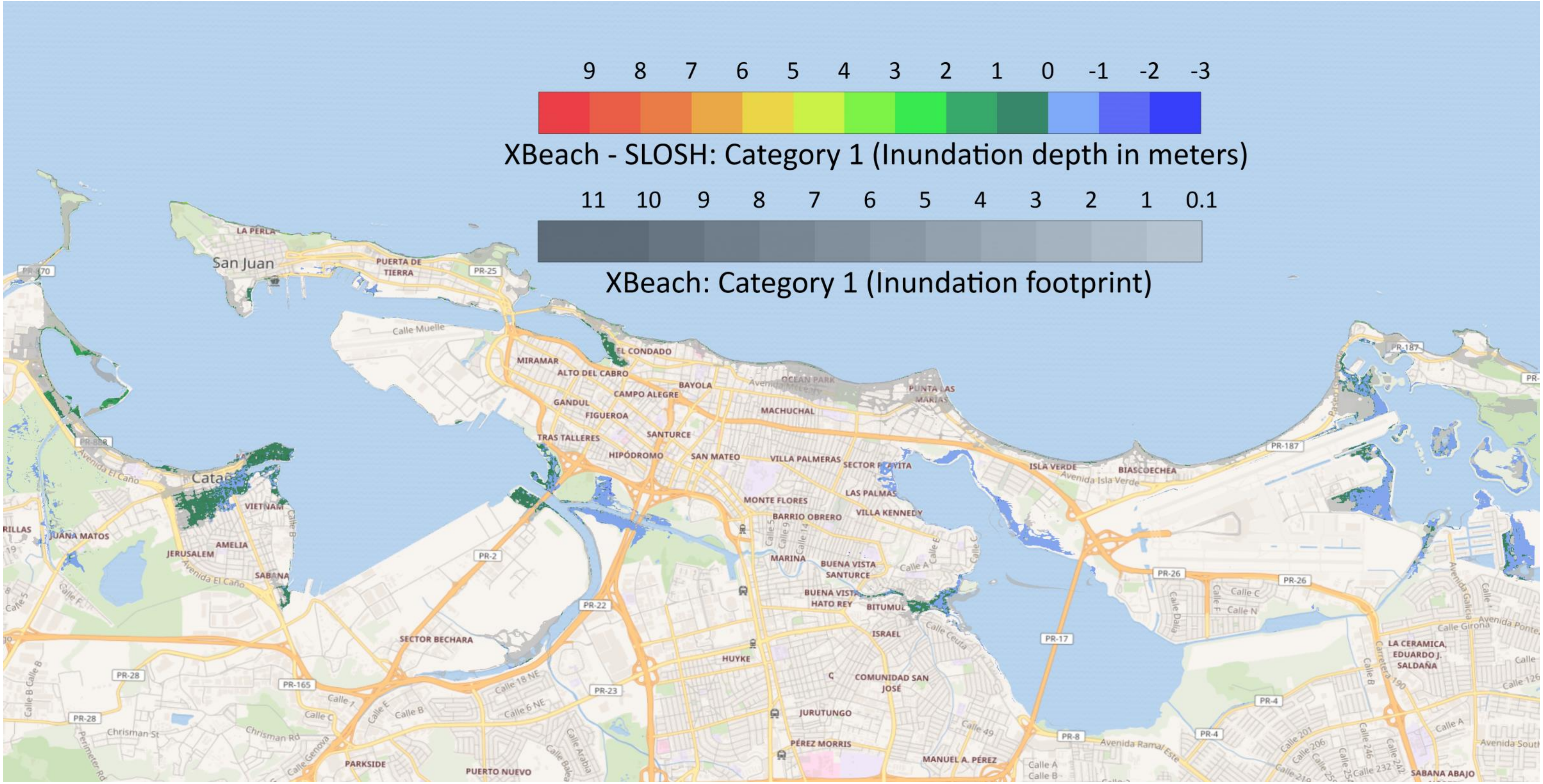
XBeach: Category 3 (Hatched) and Category 3 run on top of 1 meter sea level rise (colored)



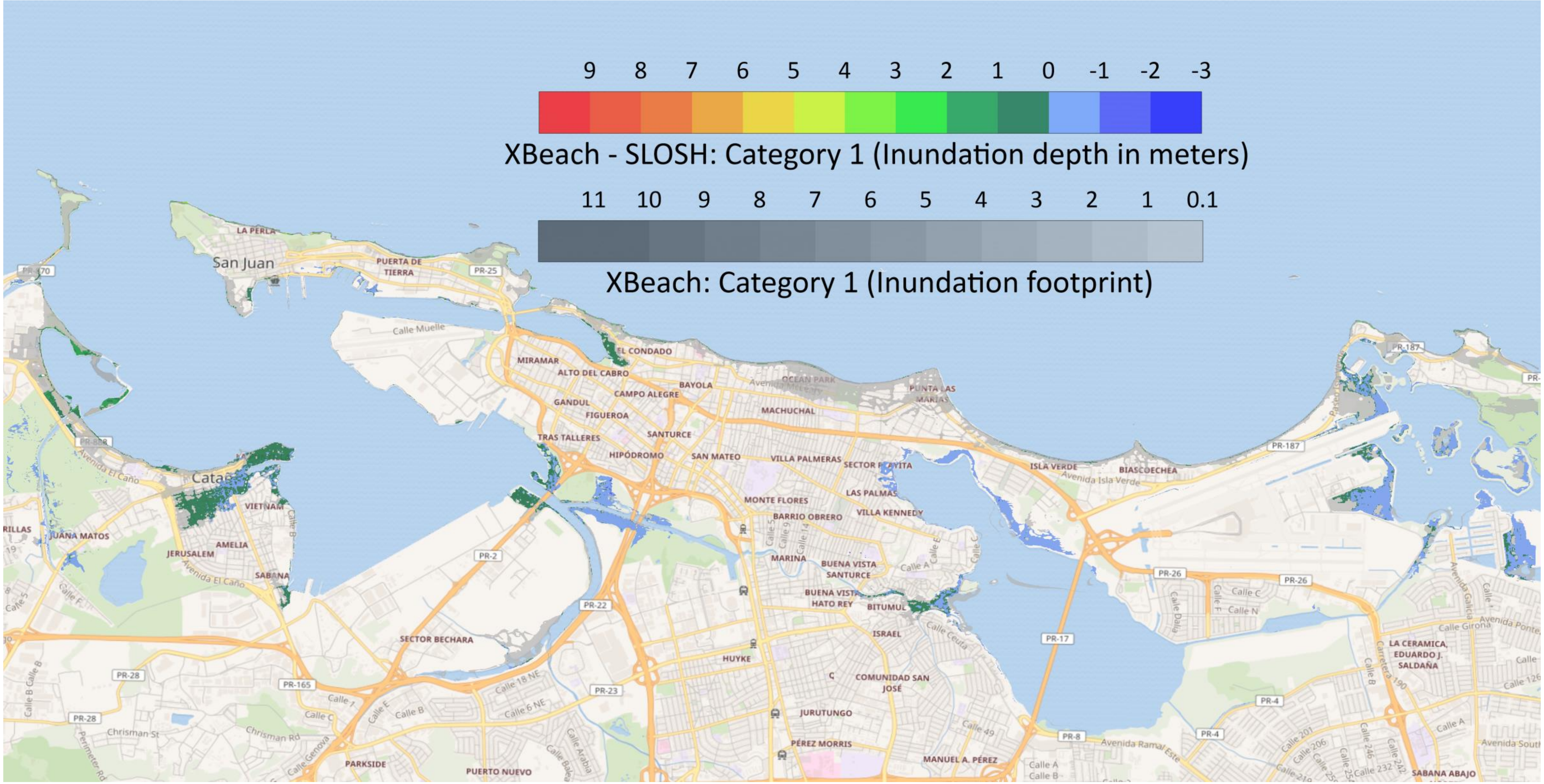
XBeach: Category 5 (Square Hatching)



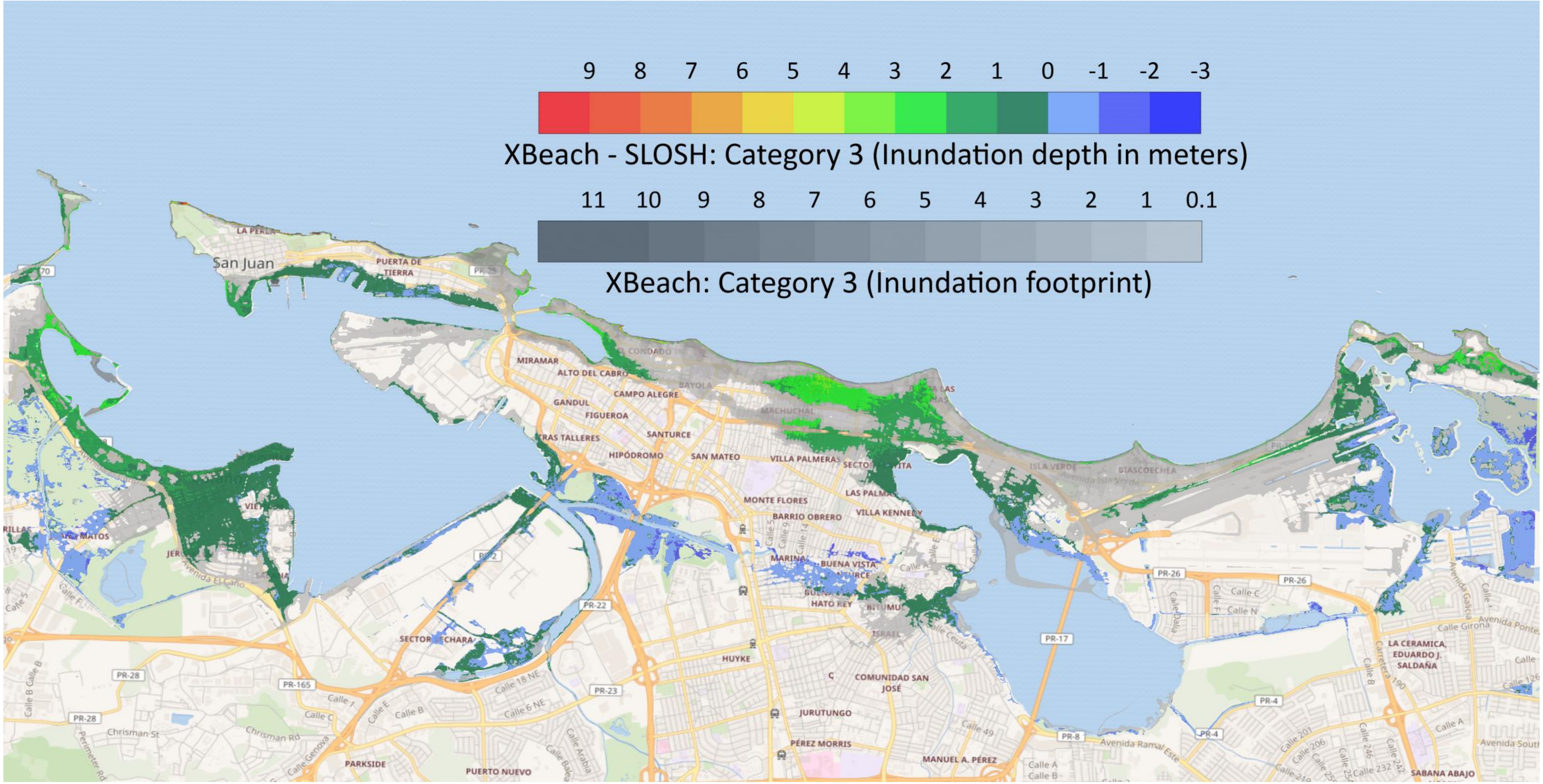
Difference between XBeach and SLOSH (XBeach has gray shading; colored painted areas is where both XBeach and SLOSH flood)
Based on zs_max for XBeach



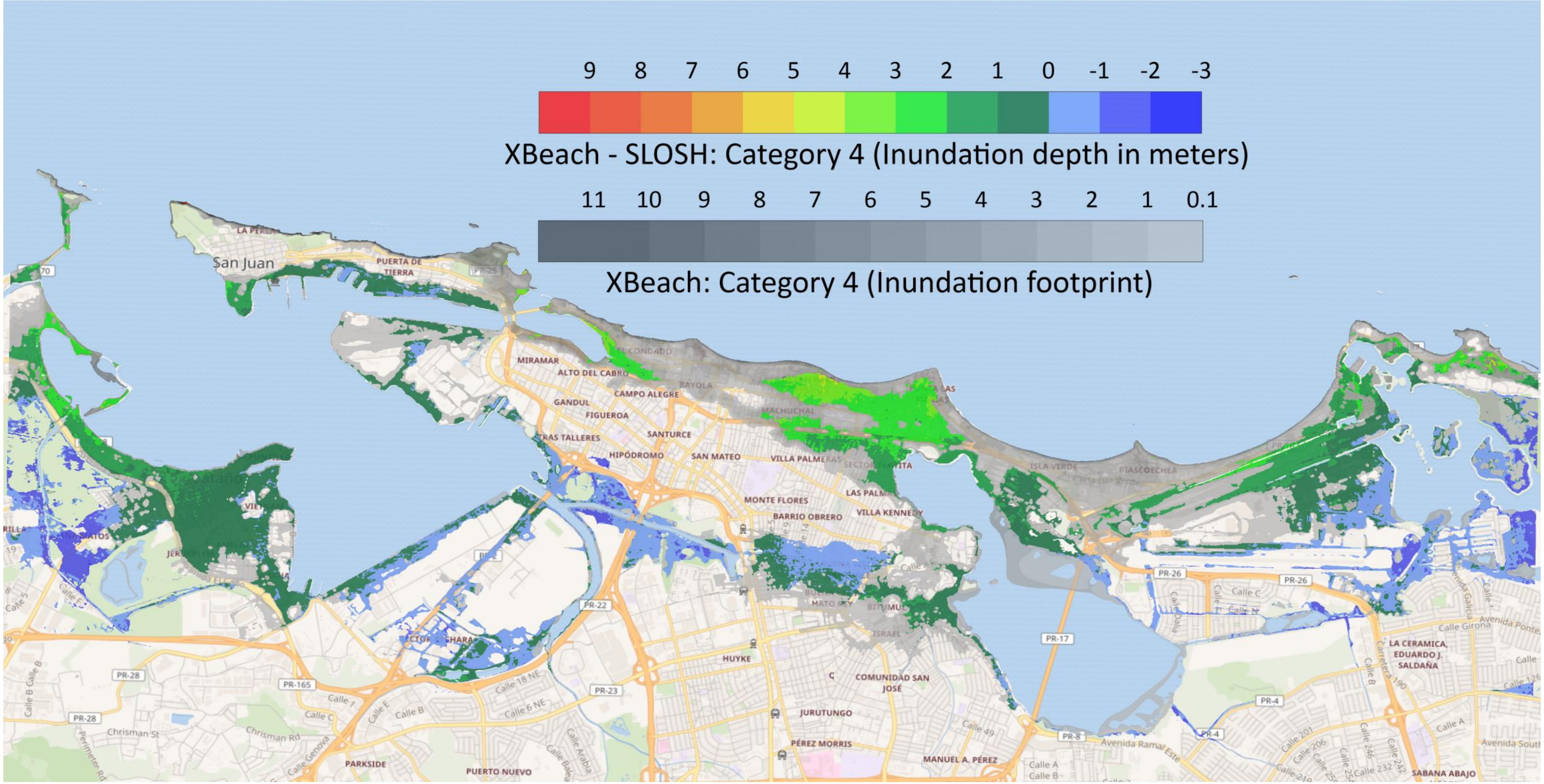
Difference between XBeach and SLOSH (XBeach has gray shading; colored painted areas is where both XBeach and SLOSH flood)
Based on zs_max for XBeach



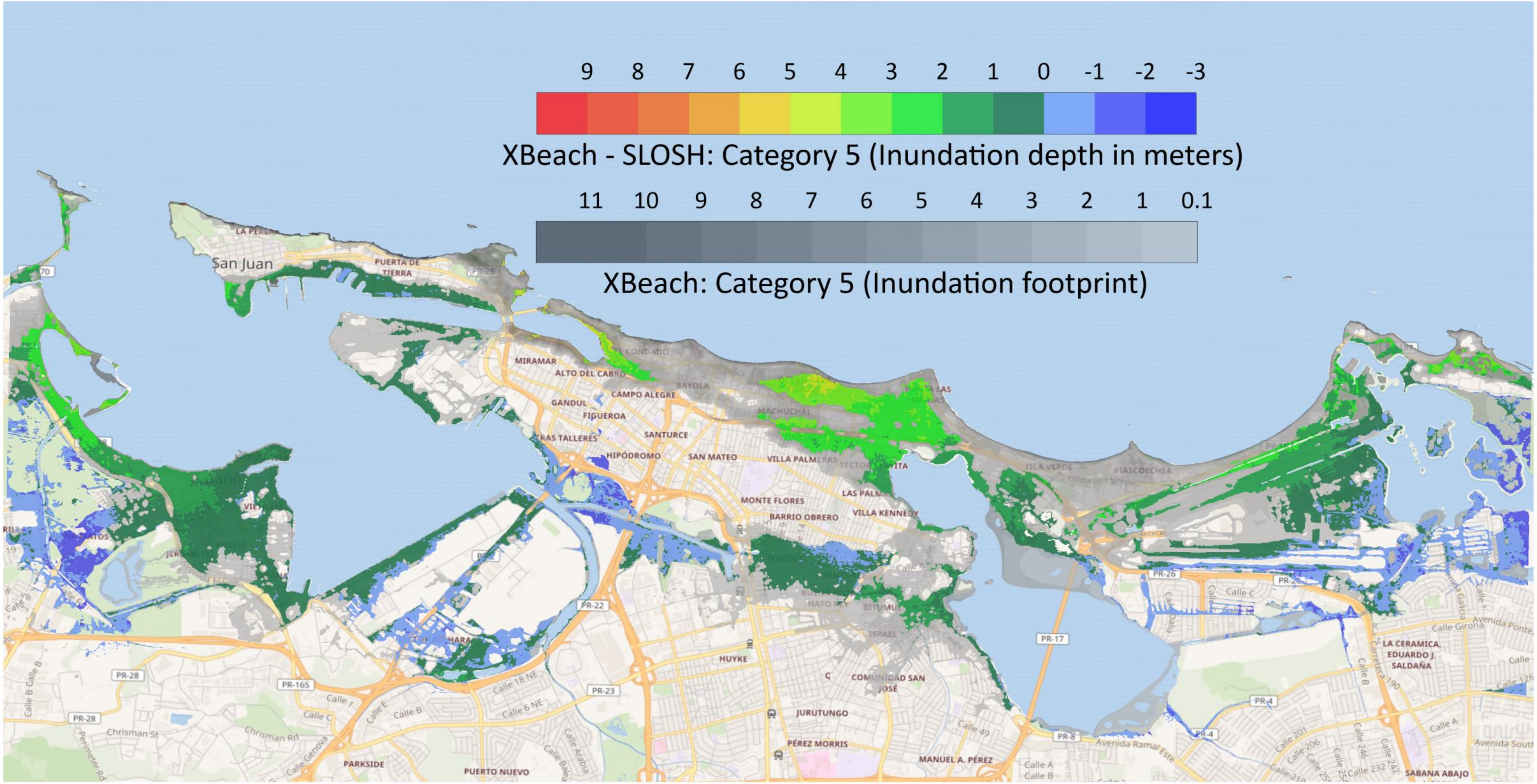
Difference between XBeach and SLOSH (XBeach has gray shading; colored painted areas is where both XBeach and SLOSH flood)
Based on zs_max for XBeach



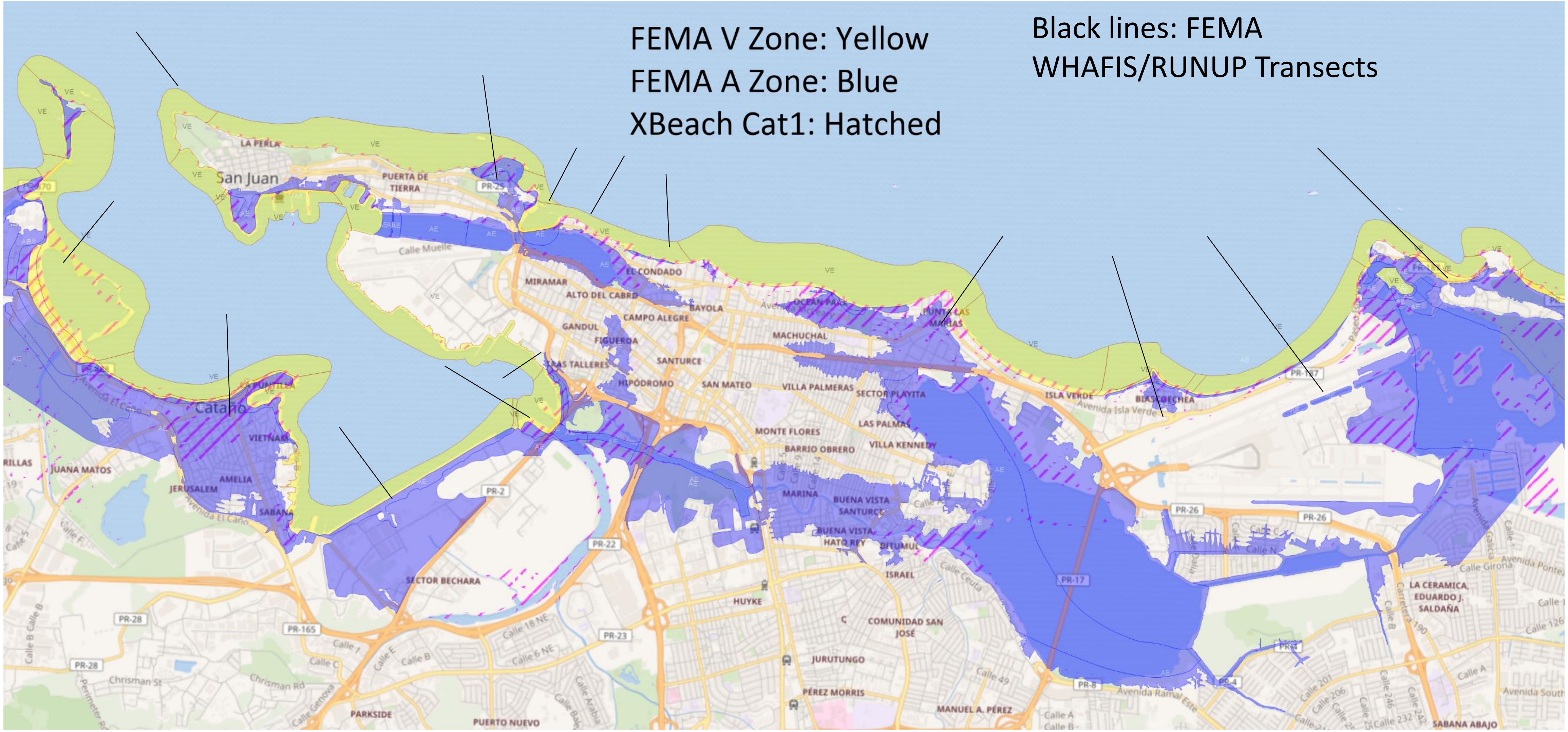
Difference between XBeach and SLOSH (XBeach has gray shading; colored painted areas is where both XBeach and SLOSH flood)
Based on zs_max for XBeach



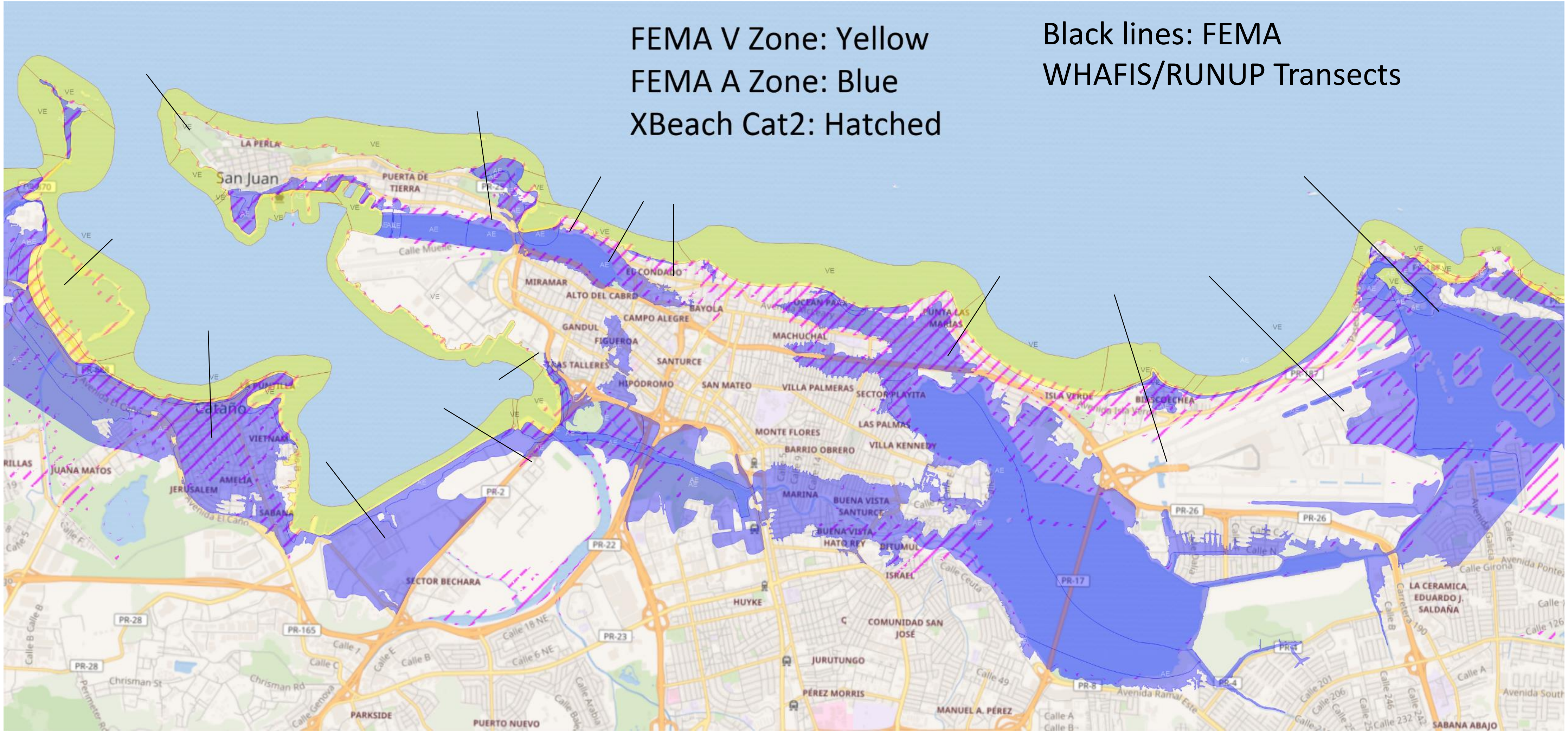
Difference between XBeach and SLOSH (XBeach has gray shading; colored painted areas is where both XBeach and SLOSH flood)
Based on zs_max for XBeach



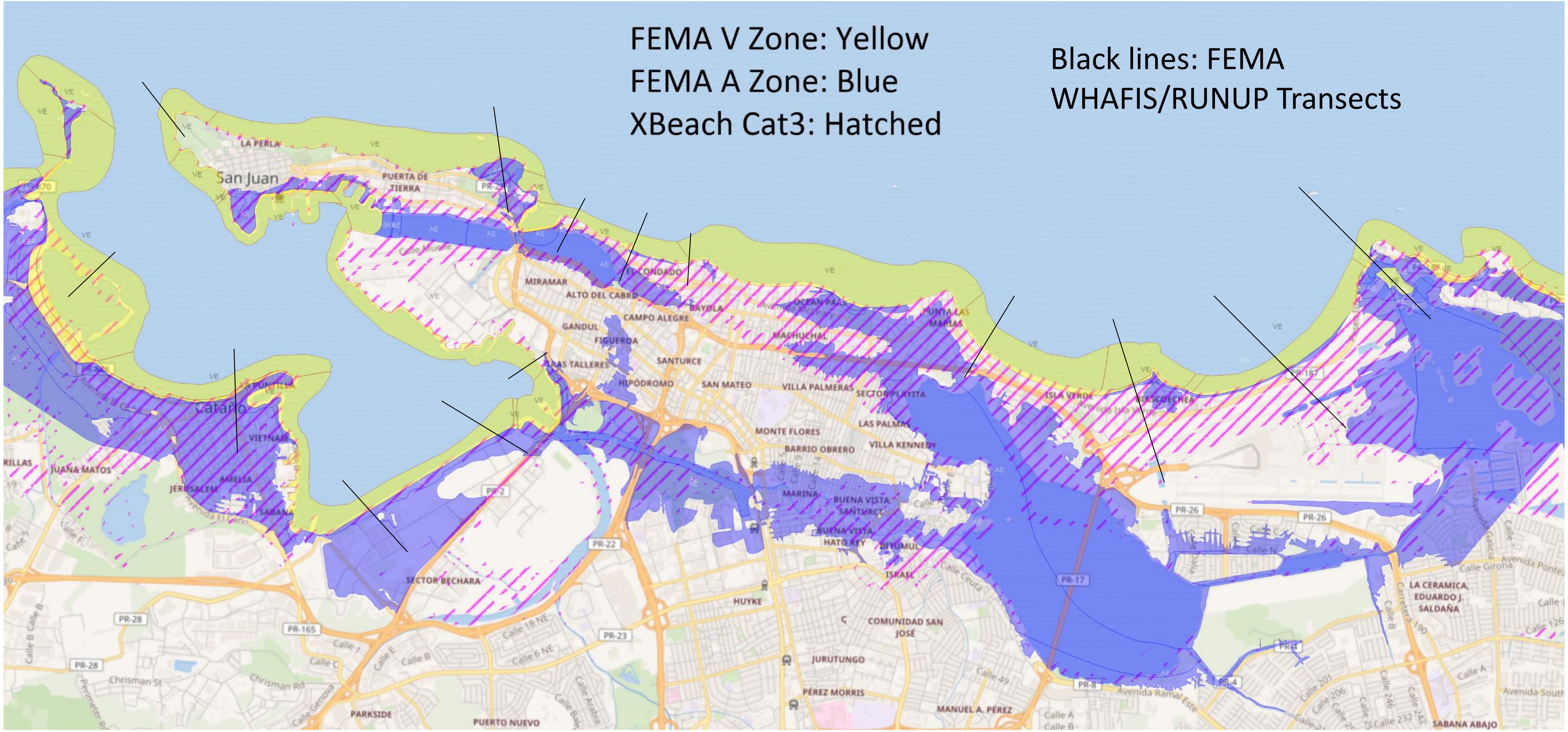
Comparison of XBeach and FEMA Advisory FIRMs



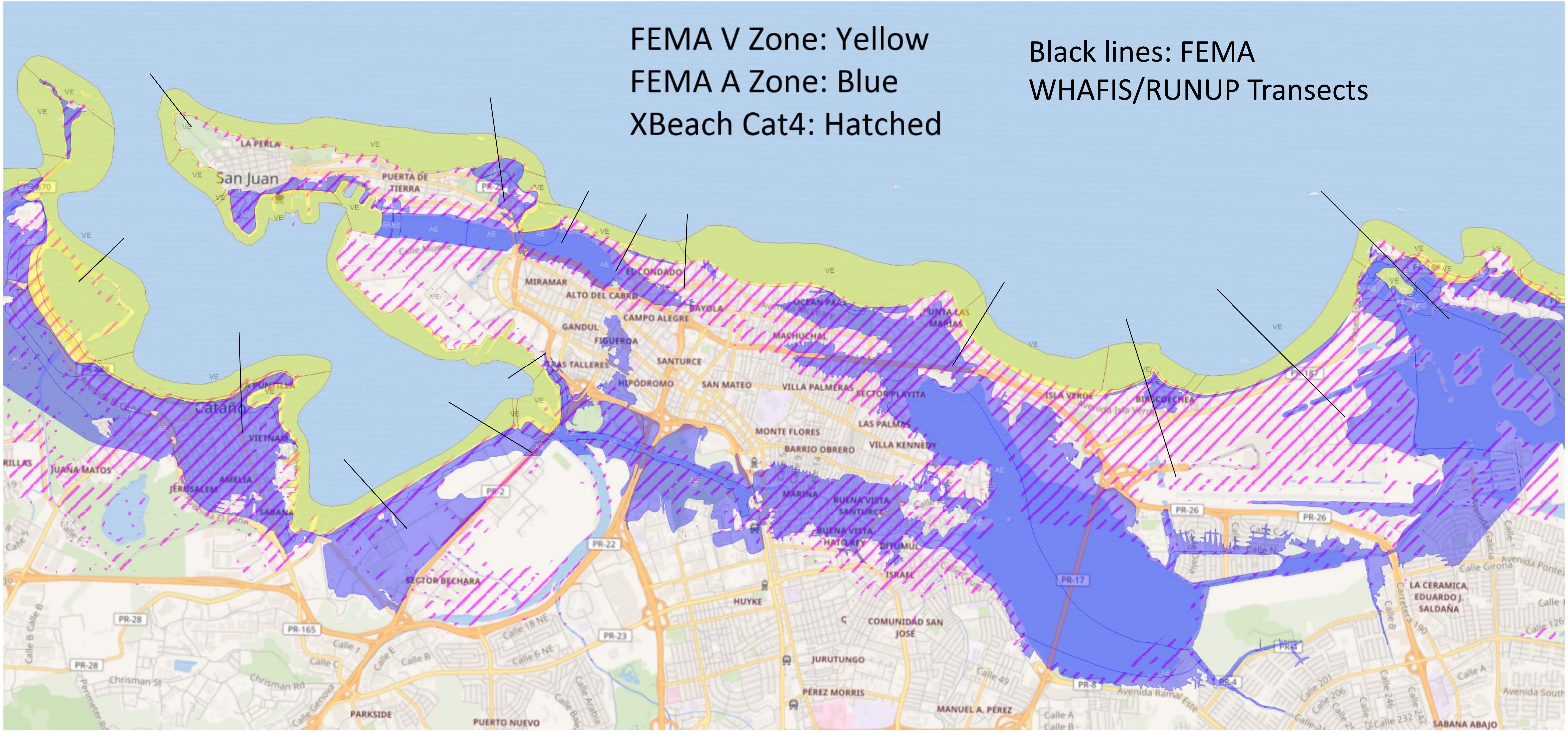
Comparison of XBeach and FEMA Advisory FIRMs



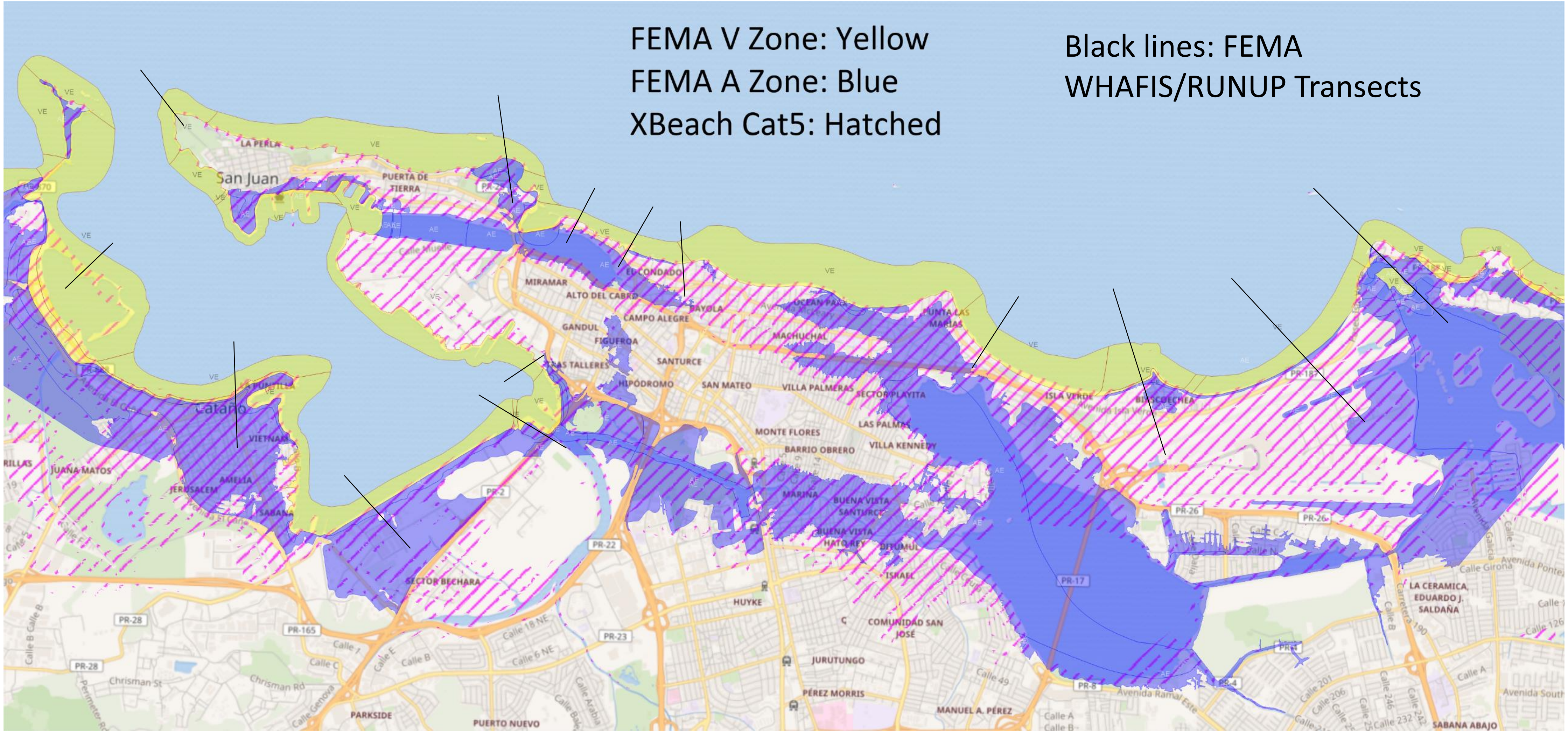
Comparison of XBeach and FEMA Advisory FIRMs



Comparison of XBeach and FEMA Advisory FIRMs



Comparison of XBeach and FEMA Advisory FIRMs



SLOSH Cat 1

XBeach Cat 1 zs_max

SLOSH Cat 4

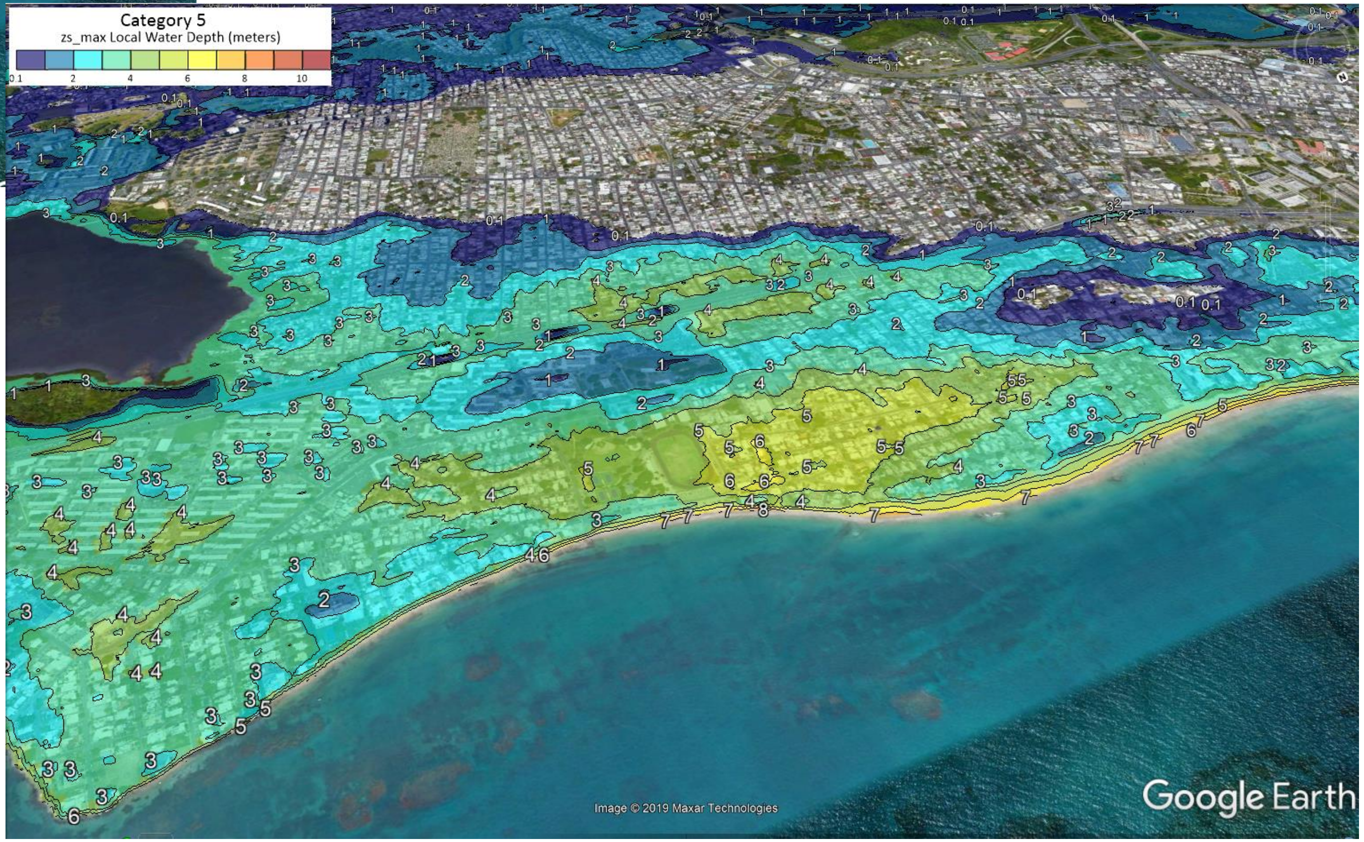
XBeach Cat 4 zs_max

FEMA

Red (V Zone)/Blue (A Zone)/Pink (X Zone)/Yellow (AO Zone)

SLOSH Cat 5

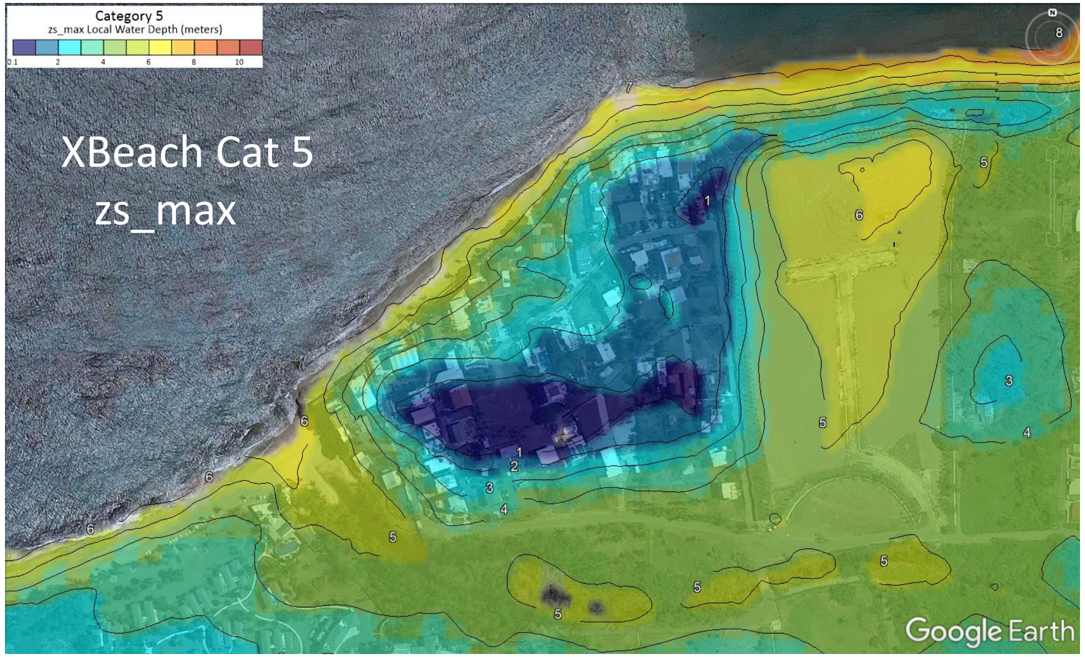
XBeach Cat 5



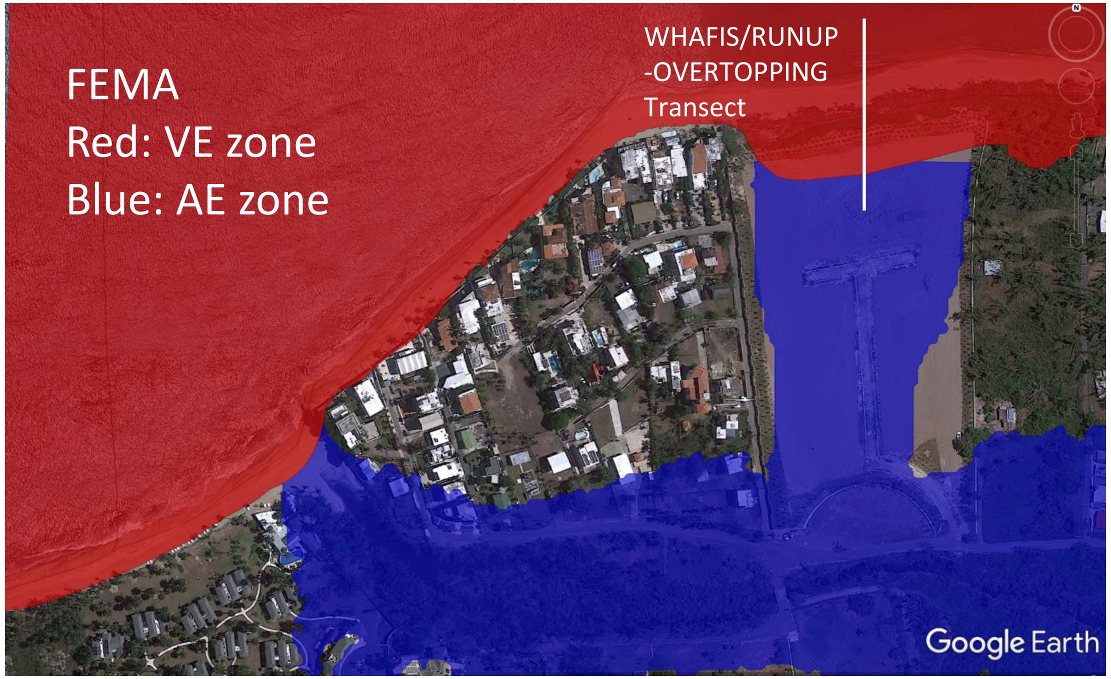
FEMA

Red (V Zone)/Blue (A Zone)/Pink (X Zone)/Yellow (AO Zone)


Isabela: Shacks
Beach
Google Earth


Category 5
zs_max Local Water Depth (meters)
XBeach Cat 5
zs_max
Google Earth


SLOSH Cat 5
Google Earth


FEMA
Red: VE zone
Blue: AE zone
WHAFIS/RUNUP
-OVERTOPPING
Transect
Google Earth

MUCHAS GRACIAS

AURELIO MERCADO-IRIZARRY
DEPARTAMENTO DE CIENCIAS MARINAS/UPRM
aurelio.mercado@upr.edu/aurelio.mercado@gmail.com
787-265-5461/787-429-4506
coastalhazardspr.wordpress.com
Facebook: Oceanografia Fisica - UPRM