

A Rapid Assessment of Dam Inventory Lessons Learned from Two Category 4 Hurricanes Impacting Puerto Rico

Shudipto Rahman, FEMA Region II

Curtis Smith PE, Regional Support Center, Stantec



FEMA

Photo credit NOAA/NASA

V2/6/21/2018

Guajataca Dam – post Maria



Two Category 4 Hurricanes - One PR - 36 Dams - Many Agencies

Hurricane Events

- **Irma:** one the strongest hurricane on record (tracked 50 mi north of Puerto Rico)
- **Maria:** third costliest hurricane in US history (direct hit, devastated PR)

Federal Agencies

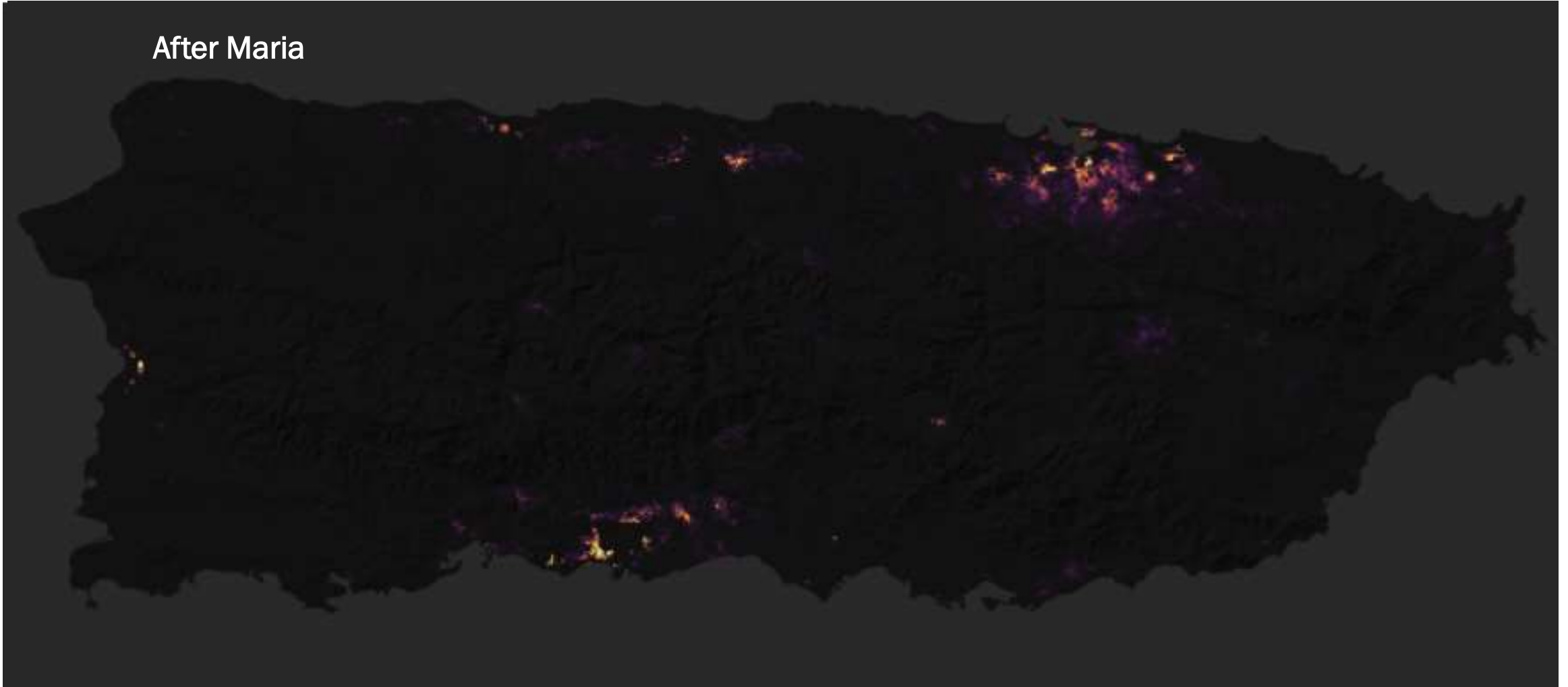
- **FEMA:** National Dam Safety Program
- **USACE:** National Inventory of Dams and Federal sponsor
- **USGS:** Gauge records
- **NOAA:** Weather forecasting
- **Bureau of Reclamation:** History of dams work in PR

State Agencies

- **PREPA:** Puerto Rico Electric and Power Authority (owner and regulator of dams)
- **PRASA:** Puerto Rico Aqueduct and Sewer Authority (owner of dams)
- **DNER:** Dept of Natural and Environmental Resources (owner of some dams)
- **PREMA:** Puerto Rico Emergency Management Agency (responsible for emergency management)

Logistical Communication Challenges

After Maria



Logistical Communication Challenges



US Army Corps
of Engineers®



FEMA



Mobility Challenges



Location of PR Dams



Response at FEMA Region II

A rapid assessment of dam inventory

Three phased approach:

- 1. Known conditions (immediate)**
- 2. Population at risk (1-2 days)**
- 3. Screening level assessment (3-4 days)**

Response at FEMA Region II

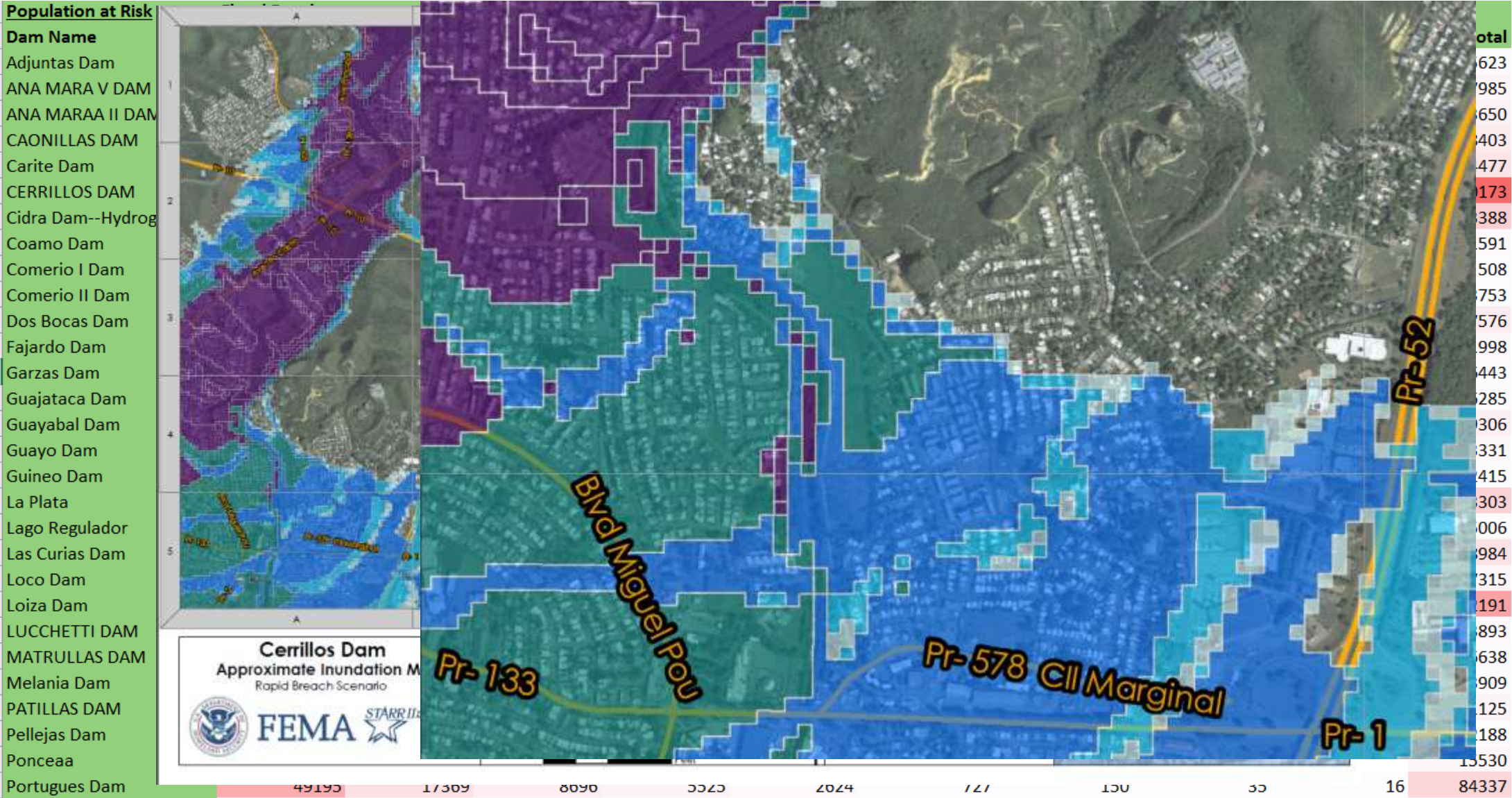
Phase 1: Known conditions / dam height



Analysis Priority	Dam_Name	Year_Completed	NID_Height
1	GUAJATACA DAM	1927	120
2	LA PLATA DAM	1974	131
3	TOA VACA DAM	1972	215
4	LOIZA DAM	1954	95
5	CERRILLOS DAM	1992	323
6	CAONILLAS DAM	1948	235
7	GARZAS DAM	1943	201
8	GUAYO DAM	1956	190
9	DOS BOCAS DAM	1942	188
10	LUCCHETTI DAM	1952	169
11	GUAYABAL DAM	1913	130
12	COMERIO II DAM	1913	128
13	PATILLAS DAM	1976	127
14	MATRULLAS DAM	1934	120
15	CIDRA DAM	1946	115
16	FAJARDO DAM	2002	115
17	GUINEO DAM	1931	115
18	CARITE DAM	1913	104
19	PRIETO DAM	1955	98
20	YAHUECAS DAM	1956	90
21	VIVI DAM	1950	85
22	ADJUNTAS DAM	1950	80
23	LAS CURIAS DAM	1946	75
24	LOCO DAM	1951	74

Response at FEMA Region II

Phase 2: Population at Risk




Response at FEMA Region II

Phase 3: Screening level assessment

RÍO GRANDE DE

ADJUNTAS, P
PHASE I - INSPE



INSPECTION AND RE
THE SAFETY OF DAMS
PUERTO

SAN JUAN, PU
AUGUS

Dam Name	No. of Reports	Priority Level	Observations/Comments	Inspection Date	Type	Core	Foundati on	Primary_Purpos e
GUAJATACA DAM	2	High	<p>1. Stability analyses combined with the creep-type nature of the movement and the absence of cracking in the highly plastic soils suggest that static stability of the embankment does not appear to be an urgent concern at this time.</p> <p>2. Four seeps were observed and measured. No change in amount of flow compared to previous inspections.</p> <p>3. The spillway is currently designed for a flood less than the PMF. The chute walls may be overtopped during very large discharges.</p> <p>4. Cracking and deformations have occurred in the spillway chute throughout the life of this structure. Modifications were performed in the early 1980s to repair damaged areas and to completely replace the upstream portion of the spillway structure.</p> <p>5. Although it has generally operated satisfactorily, significant sliding movement of the dam occurred during construction, as well as in later years. As a result, the dam was modified in the early 1980's, in part to address the sliding problem.</p> <p>6. Five inclinometers have experienced "shearing-type" movements that prevent passage of the inclinometer probe down the full length of the casing. The spillway appears to be constructed mostly on ancient landslide materials.</p> <p>7. Recommendations for general maintenance issues.</p> <p>8. General photographs are available for review.</p>	12/12/2006	Earth	HEK	RK	Hydroelectric
LA PLATA DAM	1	Low	<p>1. Sliding factors of safety are above 2.5 for all reservoir levels up to the PMF. Calculations indicate tension becomes a concern with water at elevation 54.4m.</p> <p>2. Significant erosion due to spilling water was observed at the rocks downstream on both abutments. Some erosion of downstream channel slopes. Undermining of downstream abutment chutes.</p> <p>3. During the PMF with all gates operating, the PMF can pass. If the gates are unopened, the dam would be overtopped by up to 5.6m.</p> <p>4. Foundation drains were unable to be inspected. The outlet structures were working satisfactorily.</p> <p>5. No mishaps since construction.</p> <p>6. None.</p> <p>7. Recommendations include rehabilitating the foundation drains, repairing the crane, inspection of the relief wells gallery, and general maintenance items.</p> <p>8. Photographs were available for review.</p>	7/15/2011	Gravity	HCK	RK	Water Supply
TOA VACA DAM	1	High	<p>1. Stability analysis results not available. No settlement observed along crest.</p> <p>2. No wet areas upstream or at abutments. History of seepage exiting in large area on downstream right abutment. photographs show significant seepage flows in weirs, but no increase in flow recorded. Per inspection report, seepage is apparently at foundation rock cut near the discharge structure and has been observed/measured since construction.</p> <p>3. Spillway capacity for PMF unknown.</p> <p>4. Gate system well maintained, but some corrosion. Some leakage observed at manual control valves in spillway gallery. Previous leak in outlet tunnel repaired.</p> <p>5. Unknown performance history.</p> <p>6. Minor deterioration of upstream riprap. No slides observed on reservoir slopes. Depression observed near spillway left guide wall causing displacement of wall, but no changes since previous inspection.</p> <p>7. Maintenance recommendations in inspection report.</p> <p>8. Good photographs of seepage area and flow in seepage weirs.</p>	8/6/2009	Other	IEK	RK	Irrigation

OTOS



abutment.



stream left abutment.

Recommendations

Consider the following initiatives in NY or Nationwide:



Online platforms (like DSS-WISE) for analysis and data dissemination



Breach analyses in digital GIS format (and available on an online platform)



Redundant availability of inspection reports and emergency action plans



Integration into FEMA flood hazard mapping.



Nation Dam Inventory at a glance:

- 15,948 high hazard dams
- 1,687 dams 100+ ft (max: 770 ft)
- Average dam age: 60 years (oldest: +200 years)



FEMA

2018-2022



S
He

FEMA Mission: H

STRATEGIC GOALS

I. BUILD A CULTURE OF PREPAREDNESS



1.1 Incentivize investment
risk, including pre-dis
and reduce disaster c



1.2 Close the insurance g



1.3 Help people prepare f



1.4 Better learn from pas
improve continuously

OBJECTIVES

FEMA Vision:
A prepared a

STRATEGIC GOALS

III. REDUCE THE COMPLEXITY OF FEMA



3.1 Streamline the disaster survivor and
grantee experience



3.2 Mature the National Disaster Recovery
Framework



3.3 Develop innovative systems and
business processes that enable FEMA's
employees to rapidly and effectively
deliver the agency's mission



3.4 Strengthen grants management,
increase transparency, and improve
data analytics

OBJECTIVES

THE
KITY



streamline the disaster survivor and
grantee experience

mature the National Disaster Recovery
Framework

Develop innovative systems and
business processes that enable FEMA's
employees to rapidly and effectively
deliver the agency's mission

Strengthen grants management,
increase transparency, and improve
data analytics



FEMA



FEMA

Questions