

NWIRP Research Study of Recovery from Hurricane Maria's Impacts on Puerto Rico

Infrastructure Systems Supporting Critical Buildings and Emergency Communications

Project Leader: Ken Harrison

Objective: From a study of power, water, and transportation infrastructure impacts, recovery, and decision-making, make recommendations for increasing resilience through changes to codes, standards and practice.

Goals and Authorities of NWIRP Study

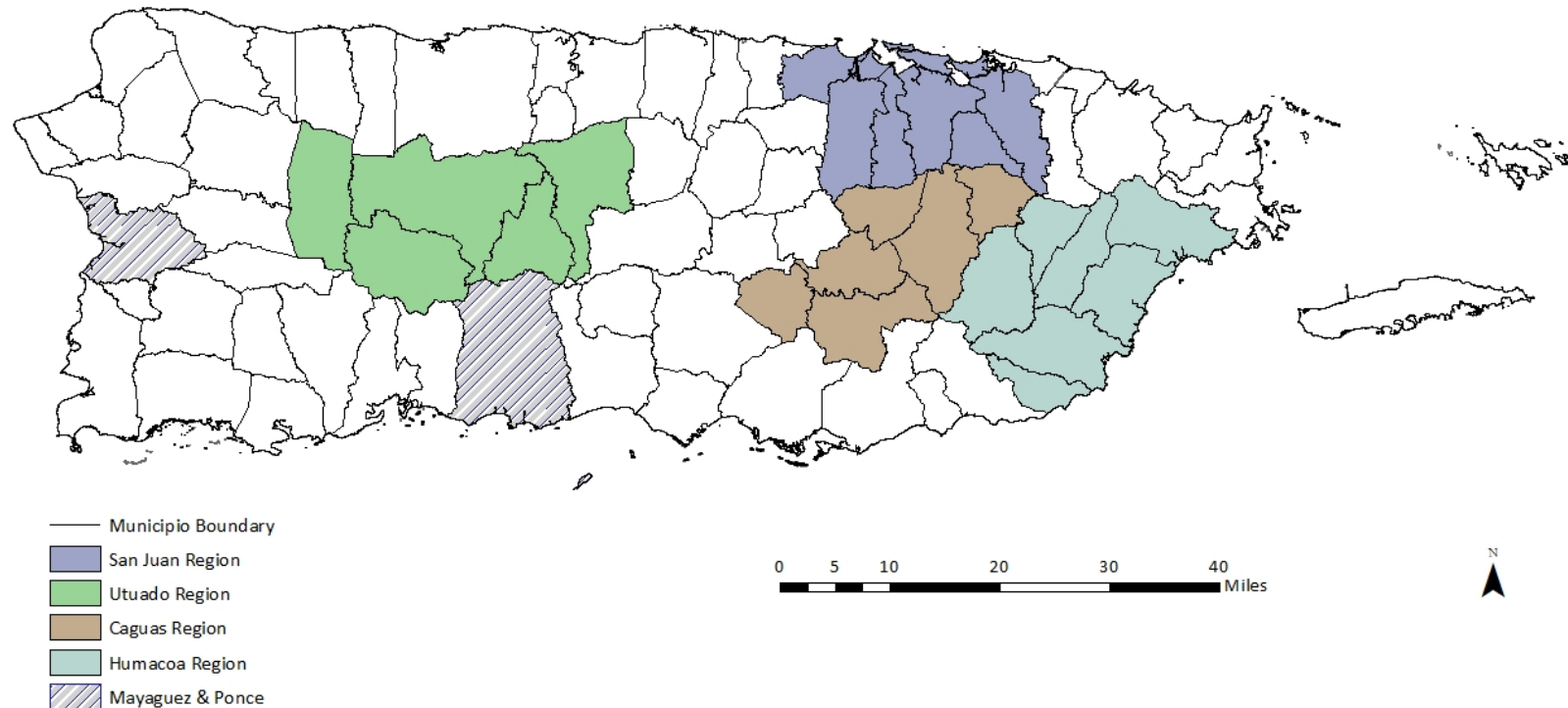
Under the National Windstorm Impact Reduction Act Reauthorization of 2015 (Public Law 114-52), NIST is conducting a scientific study of Hurricane Maria's impacts on Puerto Rico and subsequent recovery processes, with the goals of characterizing:

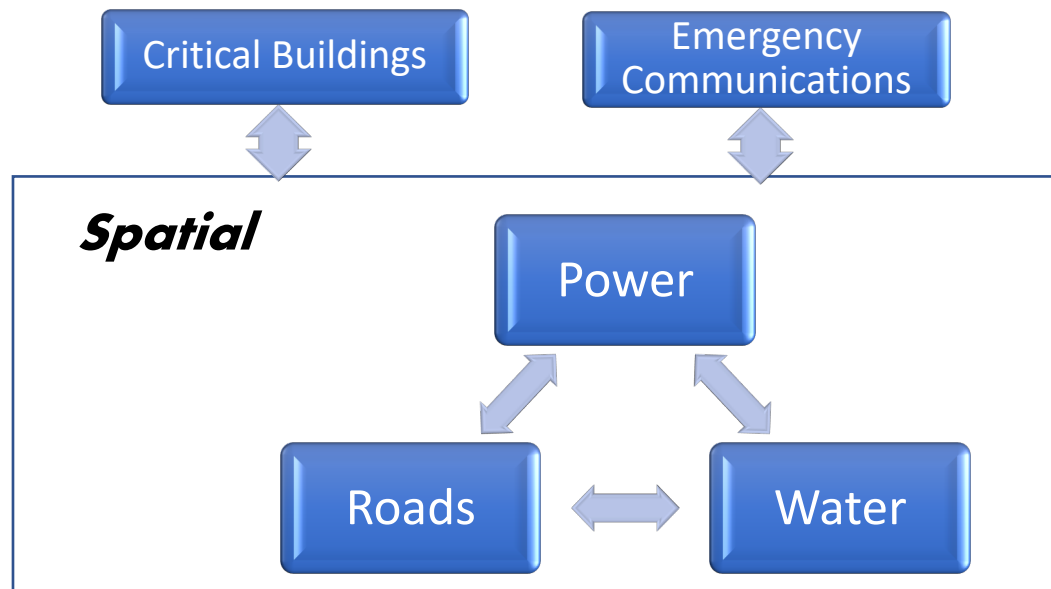
- (1) *The impacts to and recovery of small and medium-sized manufacturers (SMMs), as well as businesses in retail and service industries;*
- (2) *The impacts to and recovery of education and healthcare services;*
- (3) *The impacts to and recovery of infrastructure systems in Puerto Rico, with a focus on infrastructure that supports the functioning of critical buildings (i.e., hospitals and schools) and emergency communications.*

NIST infrastructure study areas

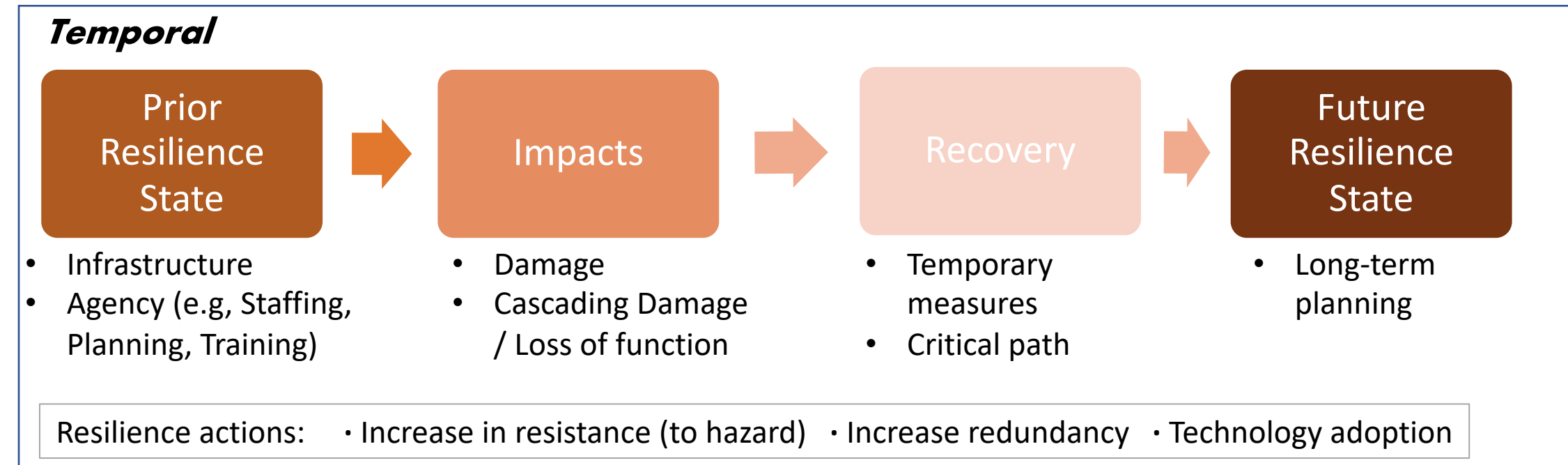
- Municipio (municipality) selected as the study unit
- Municipios selected within the four shaded regions shown below
- Addition of two municipios to align with other projects is being considered

Study Areas for NIST Hurricane Maria Program

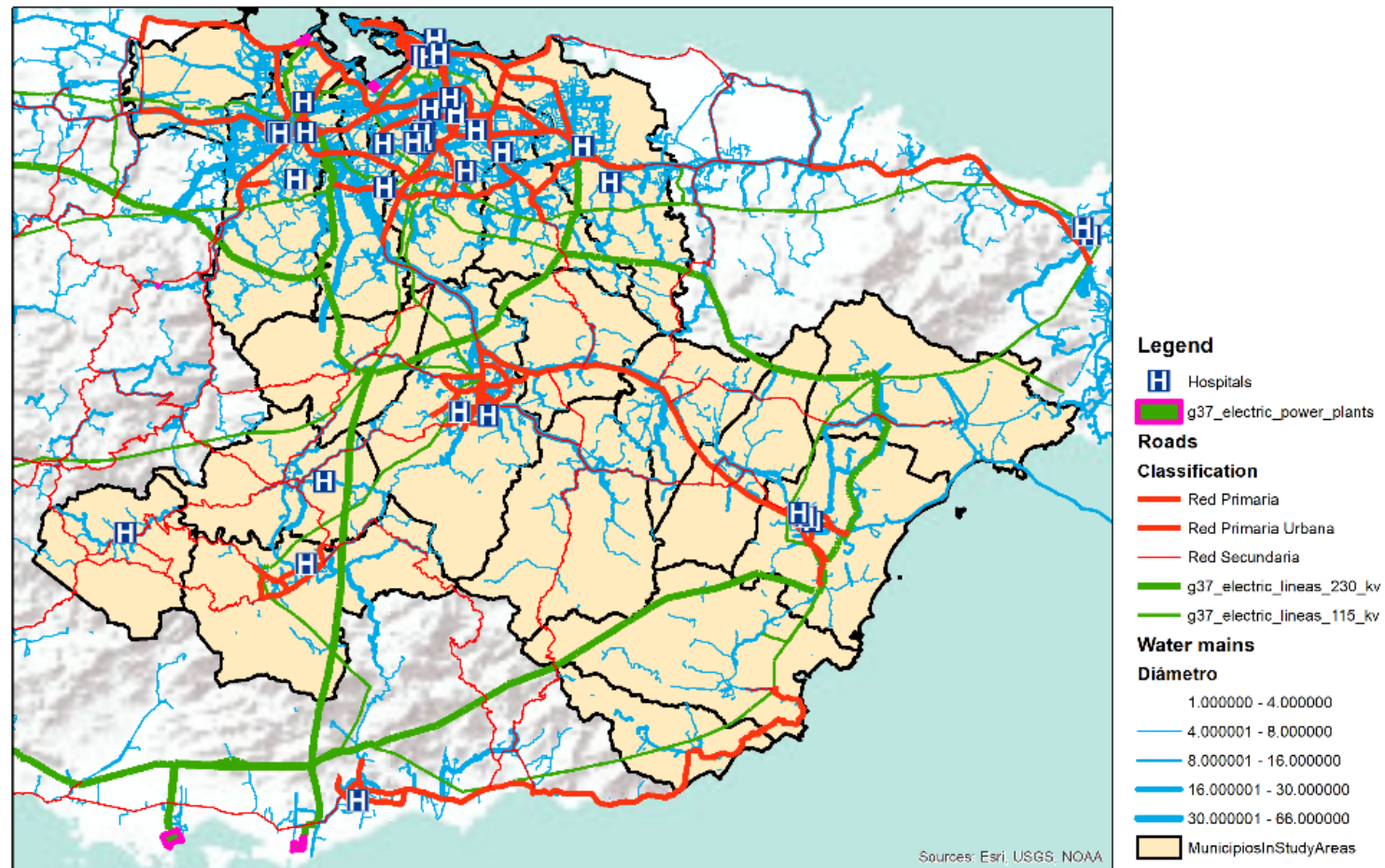
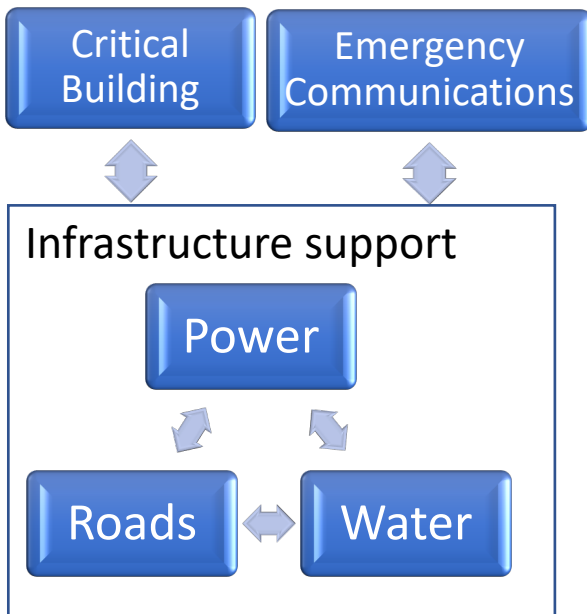




Study Scope



Dependencies



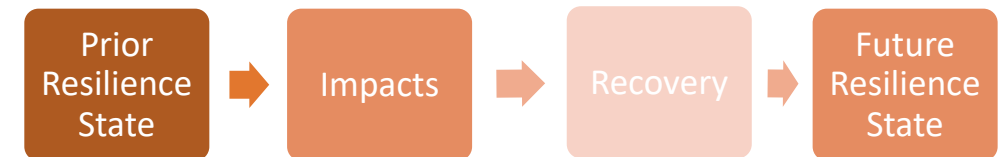
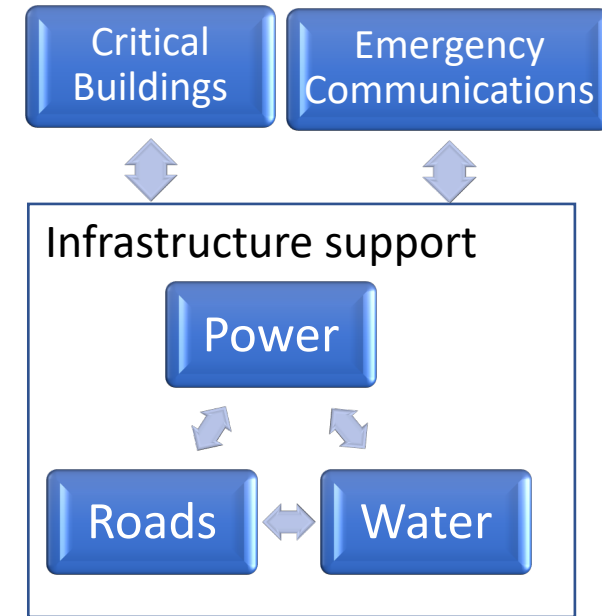
Map: hospitals and high-capacity **water**, **power**, and **transportation** links

- Function loss can propagate across these systems to critical buildings
- System redundancies can stem loss, keeping critical buildings functioning
- Recovery of networks, and in turn that of critical buildings, is dependent on network topology—e.g, road access to damaged power lines

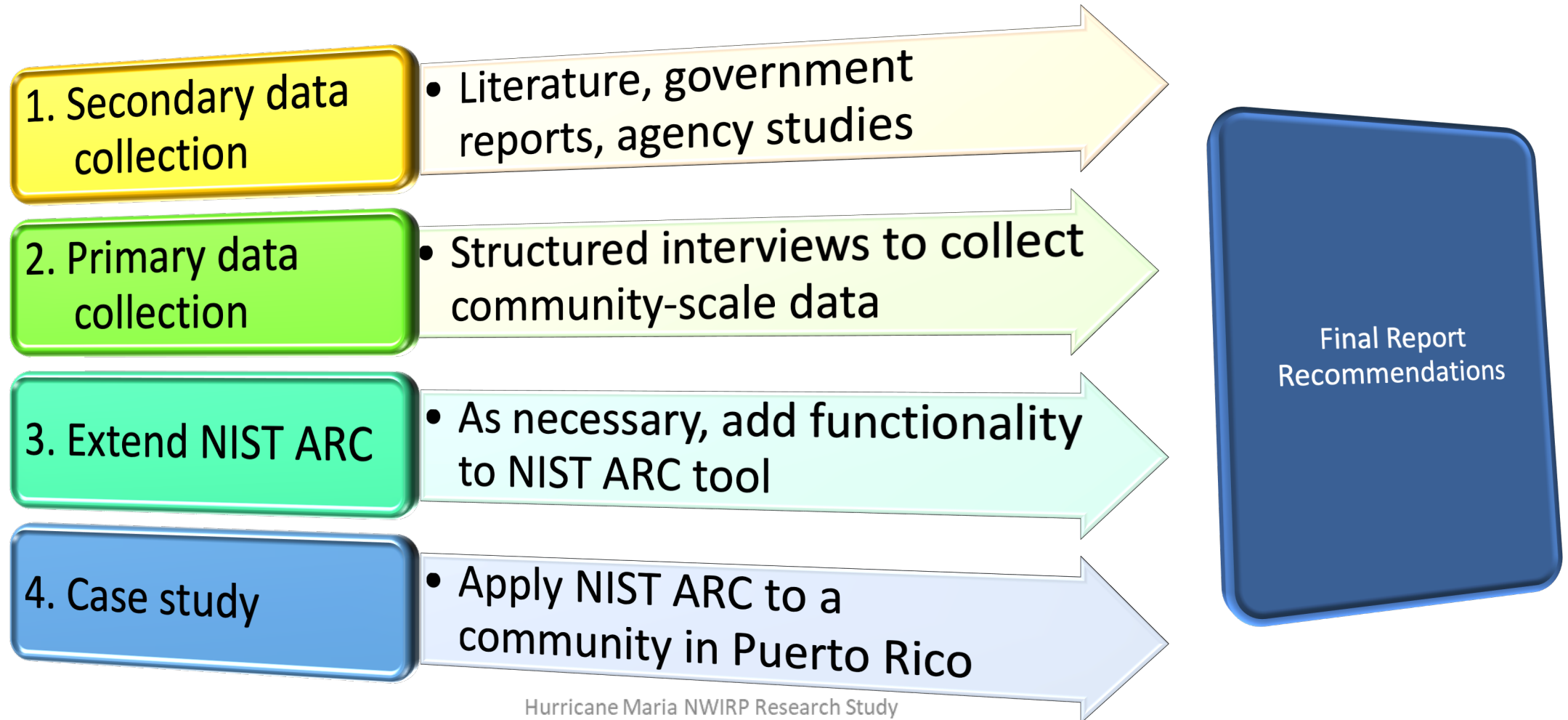
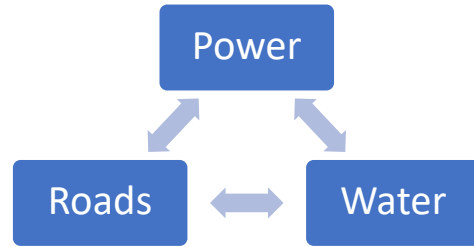
NIST Alternatives for Resilient Communities (ARC) tool

NIST ARC is a new interactive tool for developing alternative sets of actions meeting community resilience and cost goals, given hazard and interdependency information, and socio-economic data.

Assists with the process of developing viable alternatives for stakeholder consideration.



Project Plan



Recent Progress: general capacity building

- Travel to PR in FY20 Q1 for meetings:
 - Power (PREPA)
 - Water (PRASA)
 - Transportation (Ports Authority)
- Points of contacts (POC's) have been established for these agencies + DTOP
- Survey contract awarded (Q1), kickoff (Q2)
- New PREP hires (half-time) are adding to NIST team's expertise:
 - Tingting Zhao: transportation systems
 - Zeinab Farahmandfar: water systems

Recent Progress: Plan implementation

1. Secondary data collection

- Information from agency POCs
- Agency infrastructure data: GIS, DTOP geospatial incident

2. Primary data collection

- Progress on 1st three steps (next slide)

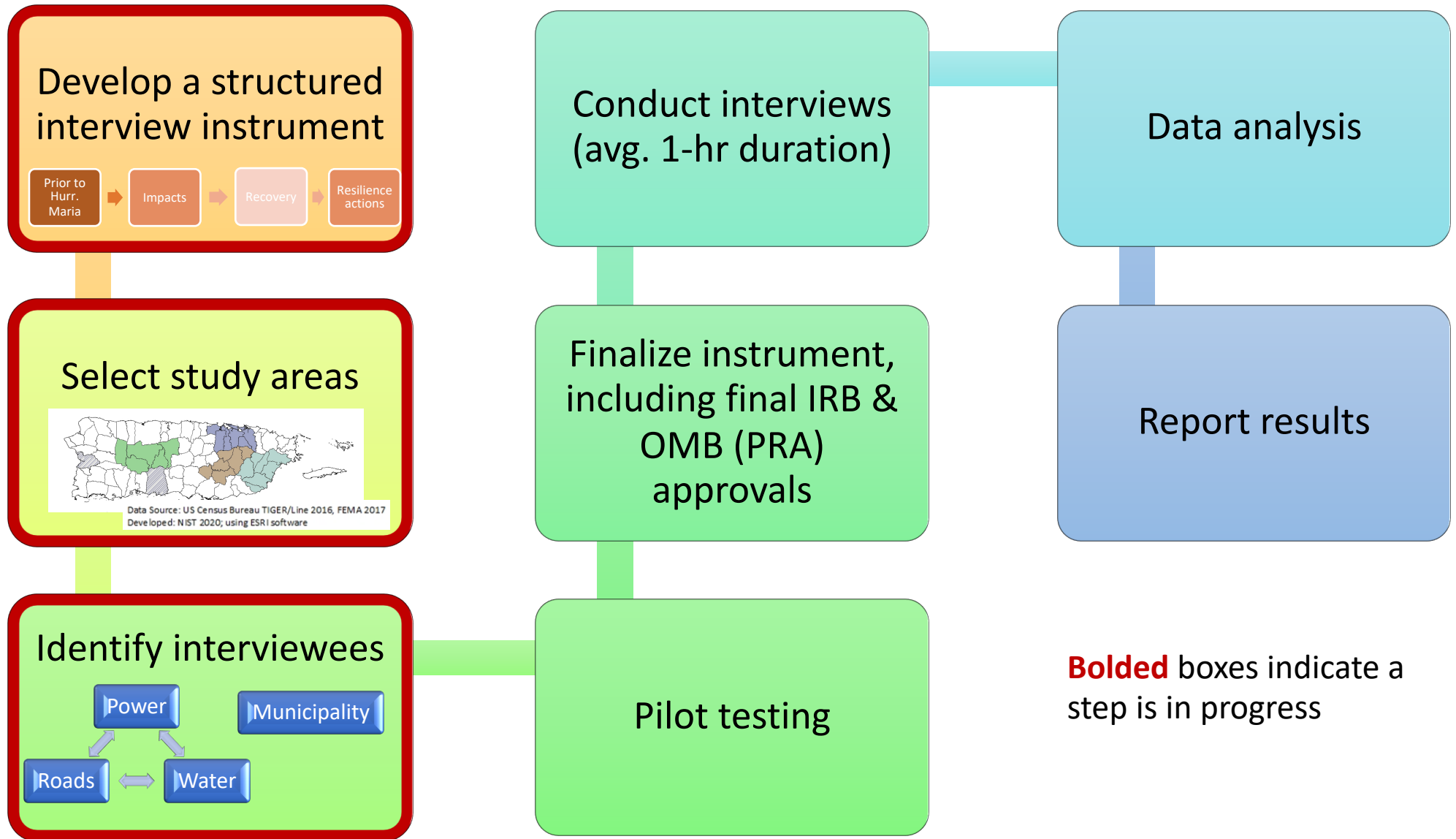
3. Extend NIST-ARC

- NIST ARC release in Sep. 2020

4. Case study

- Not yet started

2. Primary data collection (Progress)



Next steps

1. Secondary data collection

- Collection of detailed agency data through POC's

2. Primary data collection

- Finalize pre-pilot instrument, interviewee pool

3. Extend NIST-ARC

- Prioritize NIST ARC changes for this project

4. Case study

- Short list candidates (though dependent on primary data collection results)

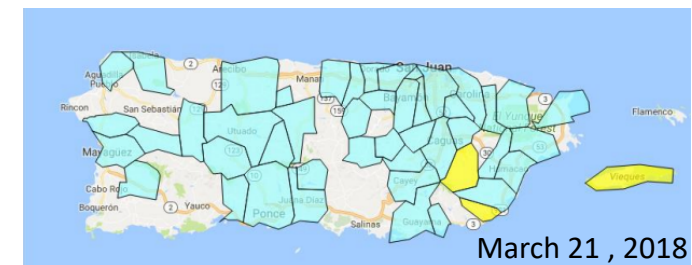
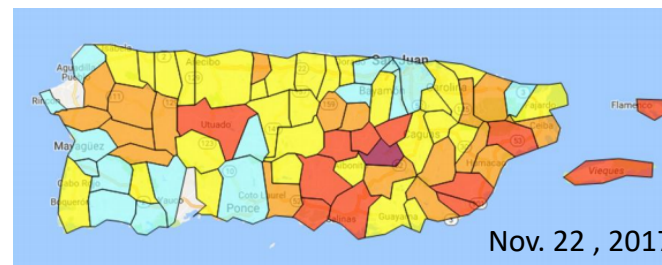
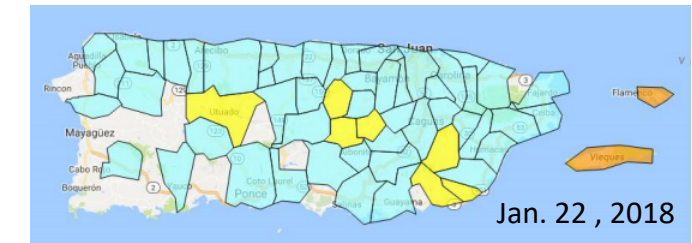
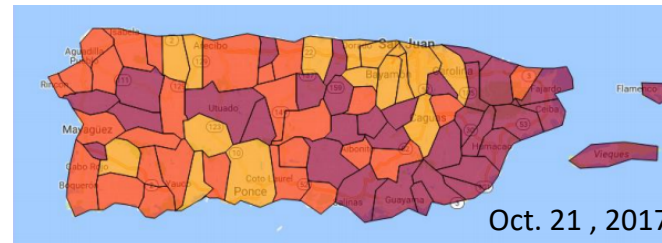
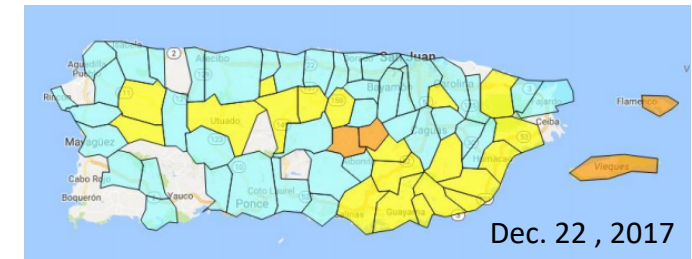
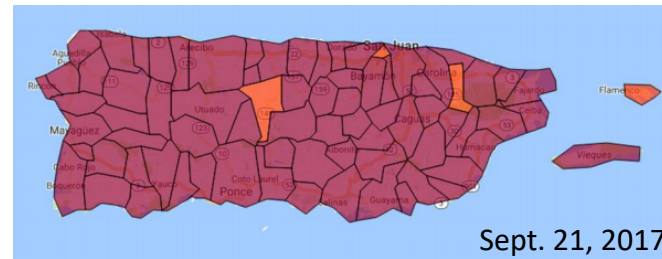
Project: Physical Performance of Wireless Communications Systems during Hurricane Maria

Cell Sites Out-of-Service, by County (%)

1 - 20 21 - 40 41 - 60 61 - 80 81 - 100

Project Objective:

- To investigate causes of the loss of functionality and extended-duration outage of the wireless communication system in Puerto Rico following Hurricane Maria.



Source: FCC

Investigation Plan: Wireless communications

- Collect data on damage caused by Hurricane Maria to cell towers, equipment, cabling, and related components of wireless communications systems, from regulatory agencies, telecommunications companies, and telecommunications support industries
- Collect data on other causes of service outages, including loss of power and damage to backhaul
- Collect information on codes, standards and regulations governing the design and construction of cell towers and wireless communication equipment
- Determine the hazard levels experienced at cell site locations using information from the Hazard Characterization project
- Evaluate tower and equipment performance with respect to the hazard levels experienced at each site and code design requirements

Recent Progress: Wireless communications

- Non-Disclosure Agreement with American Tower Corporation, allowing for data sharing
- Received post-storm photo library documenting conditions at over one hundred tower sites from American Tower
- Successful data collection trip to PR in October 2019
 - Field visits to 4 tower sites and one roof-mounted tower
 - Productive meetings with
 - JRT (Regulatory Board of Telecommunications of Puerto Rico)
 - PR Wireless (local Sprint, BoostMobile and Open mobile provider)
- Building codes and standards for telecommunication structures adopted by Puerto Rico from 1968 to the present have been collected
 - The history of wind load provisions in building standards has been documented to provide context to the date of construction of any tower or building studied.



Next steps: Wireless communications

- Create geo-database for tower locations, hazard exposure, code requirements and damage
- Analyze tower and communications equipment performance as a function of hazard levels and code requirements
- Identify and document codes, standards, regulations and practices governing the design and construction of communications towers and the supported equipment related to wind load and other hurricane-related hazards.

