Case Study Applications of Water Network Tool for Resilience (WNTR)

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Motivation and Background

- Recent natural disasters and environmental emergencies highlight vulnerability of water infrastructure

- General guidance on preparedness and resilience is available

Potential Hazards	Potential Impacts
Natural disasters	Infrastructure damage
Terrorist attacks	Service disruption
Cyber attacks	Loss of access to facilities/supplies
Hazardous material release	Loss of pressure or change in water quality
Climate change	Environmental impacts
	Financial impacts
	Social impacts

https://www.epa.gov/waterutilityresponse

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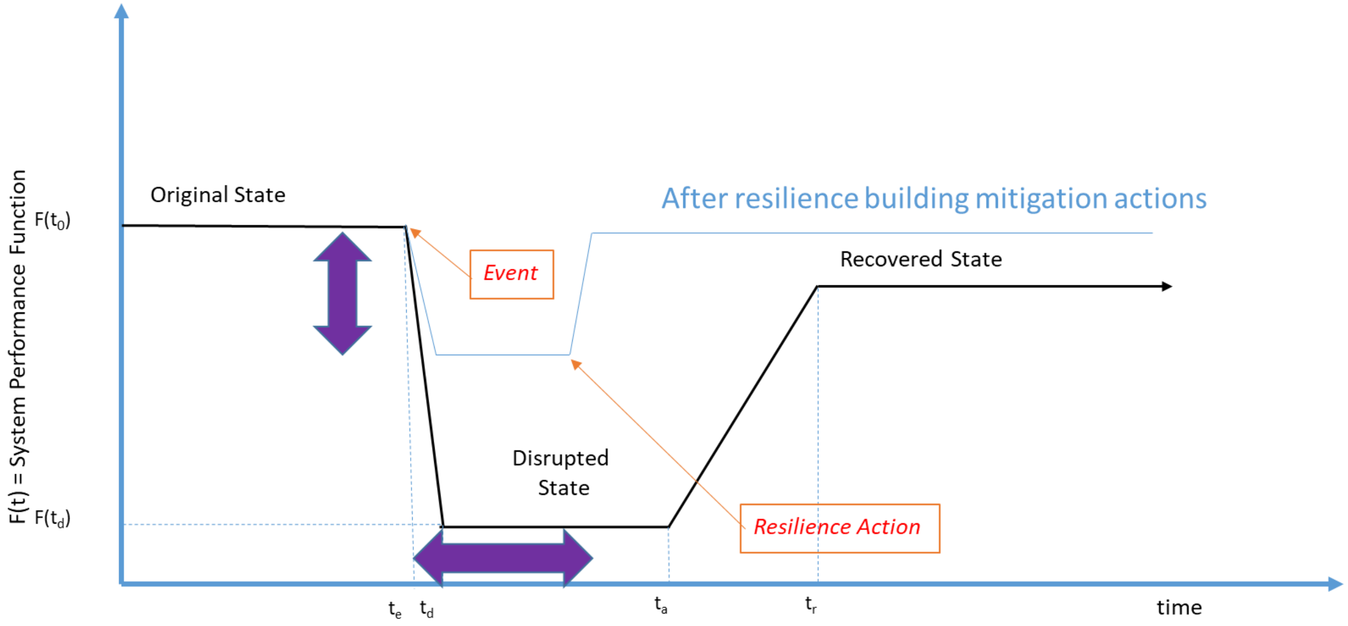
Building Resilience to Disasters

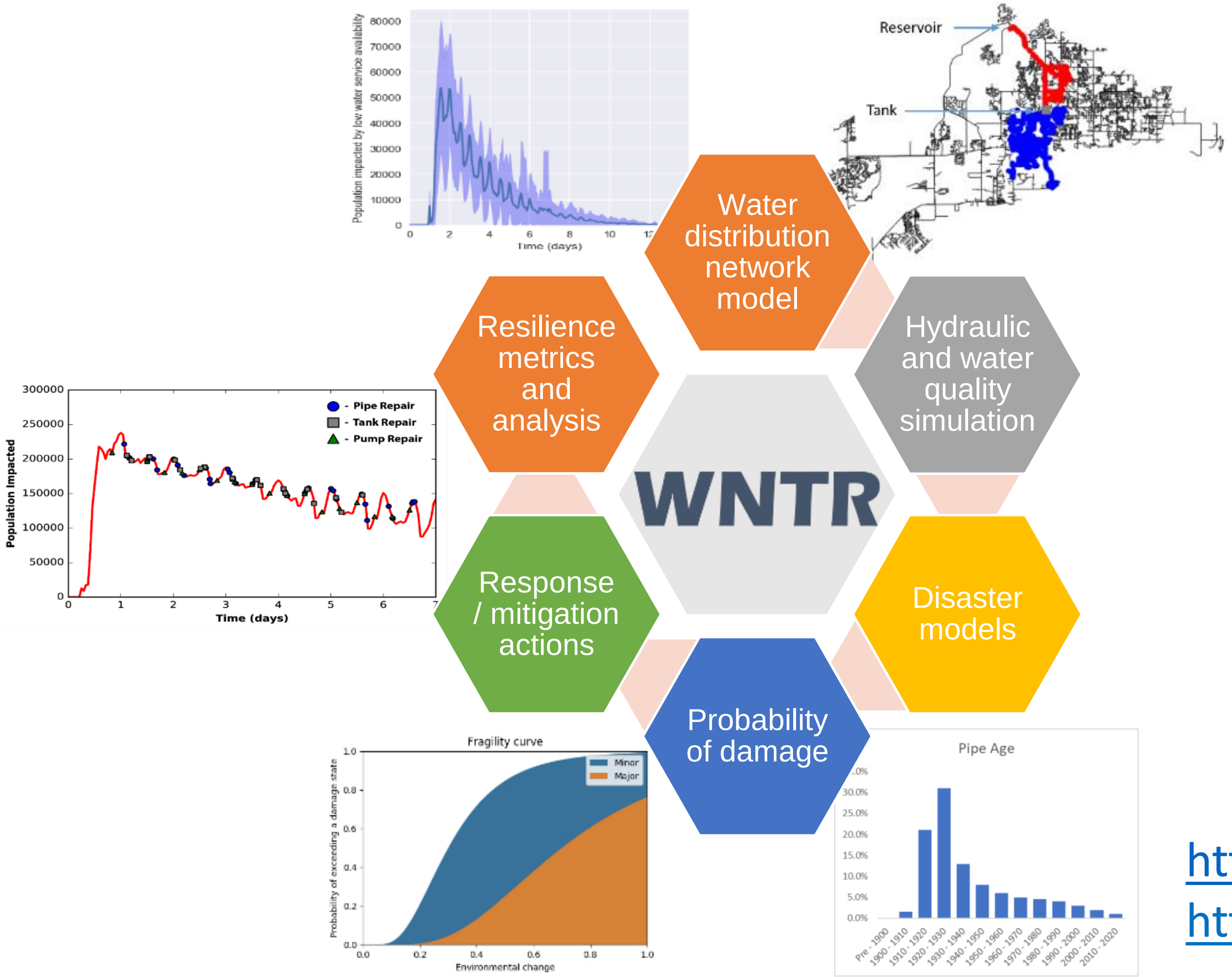
- Goal of a resilient system is to minimize the magnitude and duration of disruption

- Quantitative site-specific analysis would help to justify capital investments in building resilience



Water Network Tool for Resilience (WNTR)

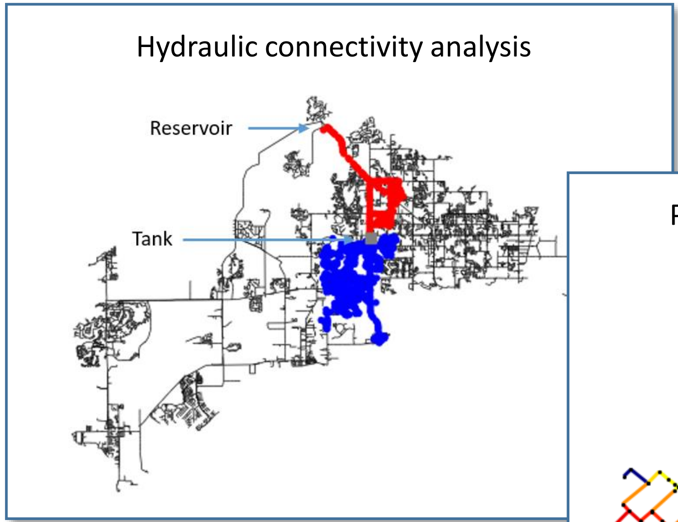
- Designed to analyze water distribution system failure and recovery

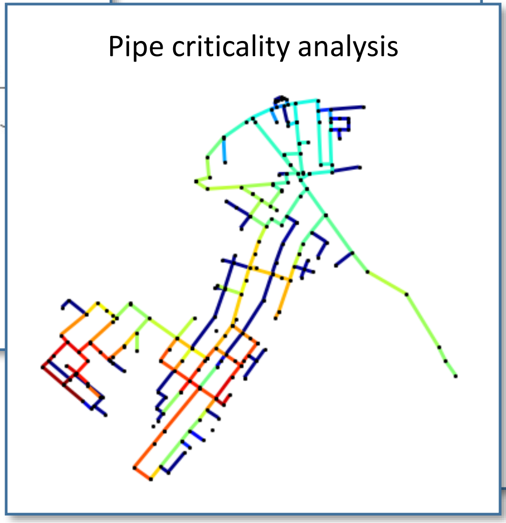


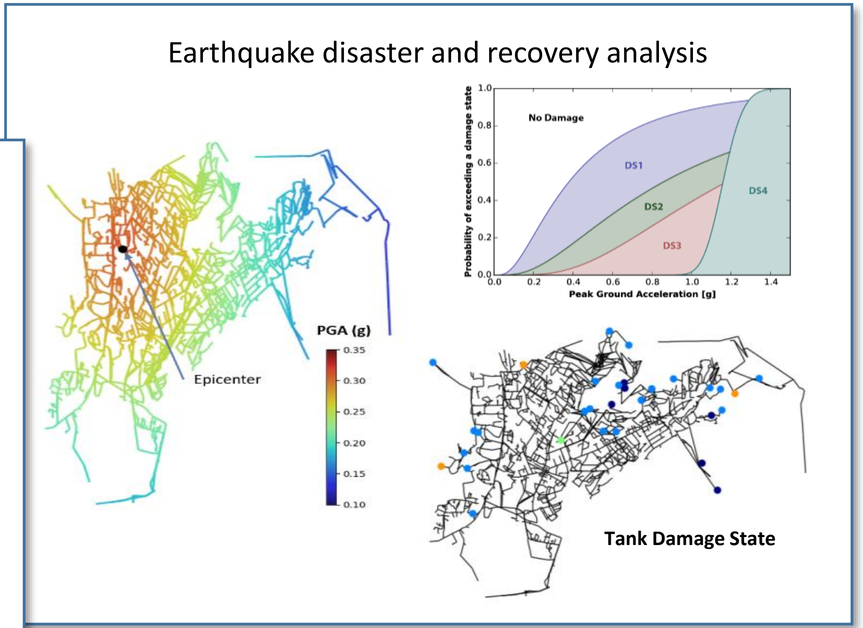
https://github.com/USEPA/WNTR
http://wntr.readthedocs.io

Resilience Analysis Options

- Hydraulic connectivity during normal and abnormal times of service
- Component criticality analysis (rank individual component failures)
- System resilience analysis (system wide damage and recovery actions)



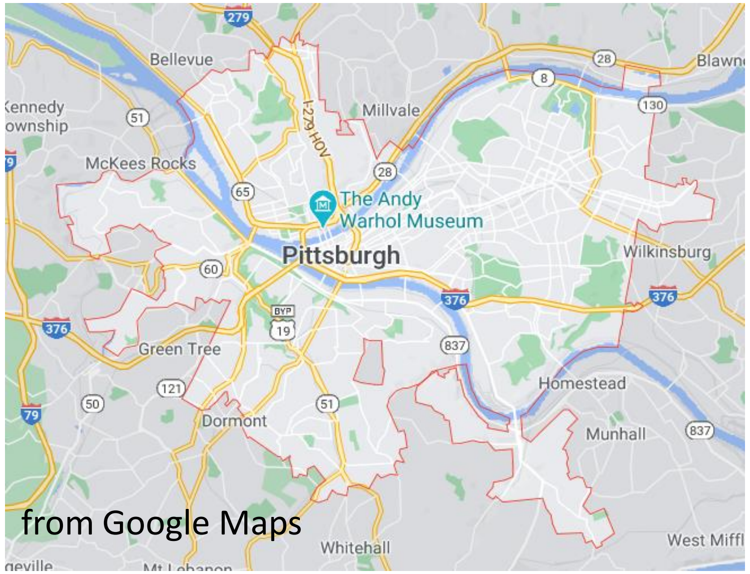




Case Study Applications

- Poughkeepsie Water System – Poughkeepsie, New York
- Pittsburgh Water and Sewer Authority (PWSA) – Pittsburgh, Pennsylvania
- Water and Power Authority (WAPA) – St. Croix & St. Thomas/St. John, US Virgin Islands

from Google Maps



from Google Maps

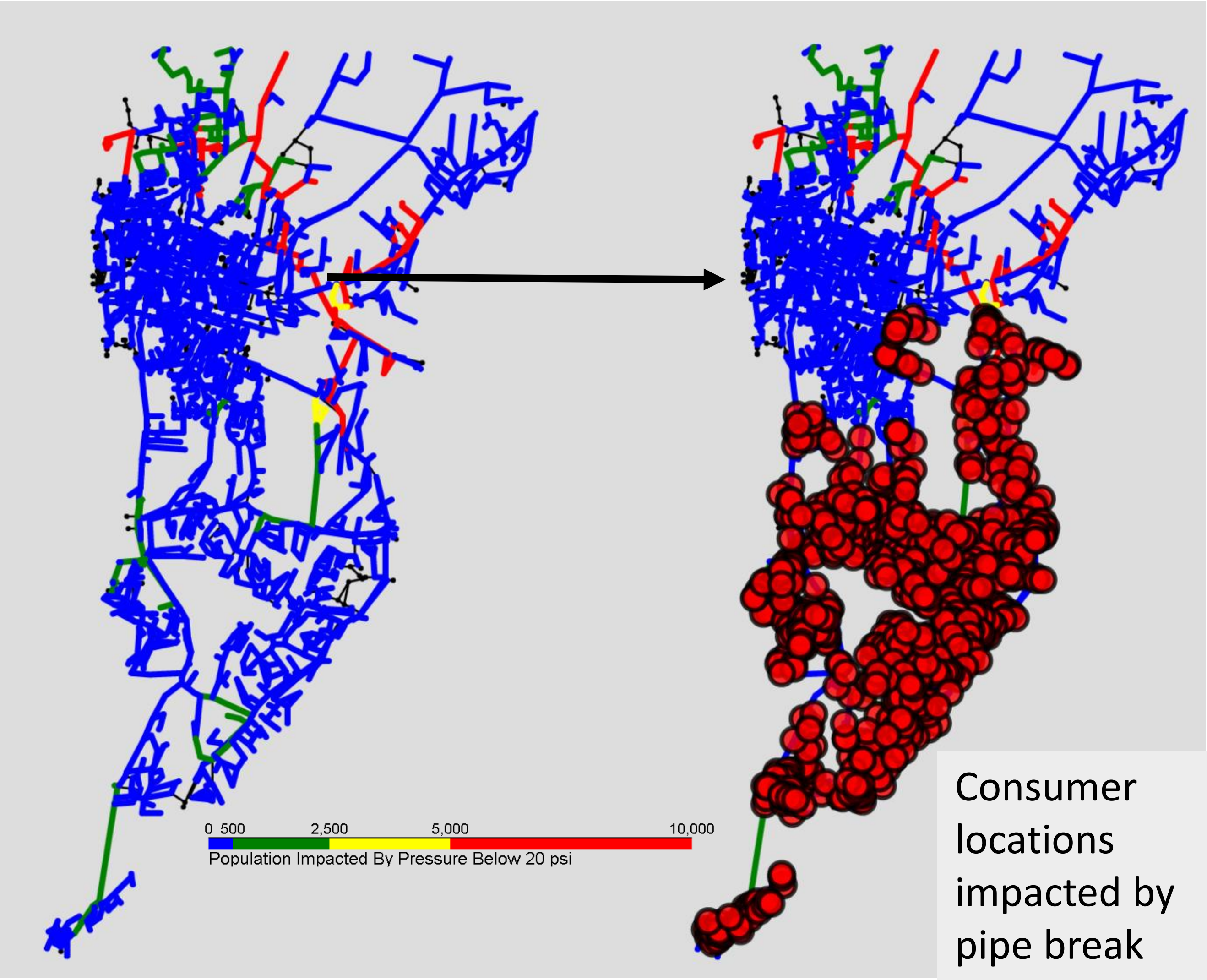
from ISTOCK

Poughkeepsie (POK) Case Study

- Utility
  - Source: river
  - Population served: 80,000
  - Water treated: 10 MGD
  - System storage: 23 MG
- Model
  - 2 reservoirs & 3 tanks
  - 6622 junctions & 7198 pipes
- Disaster scenarios
  - Fire, pipe, & segment criticality analysis
  - Loss of source water

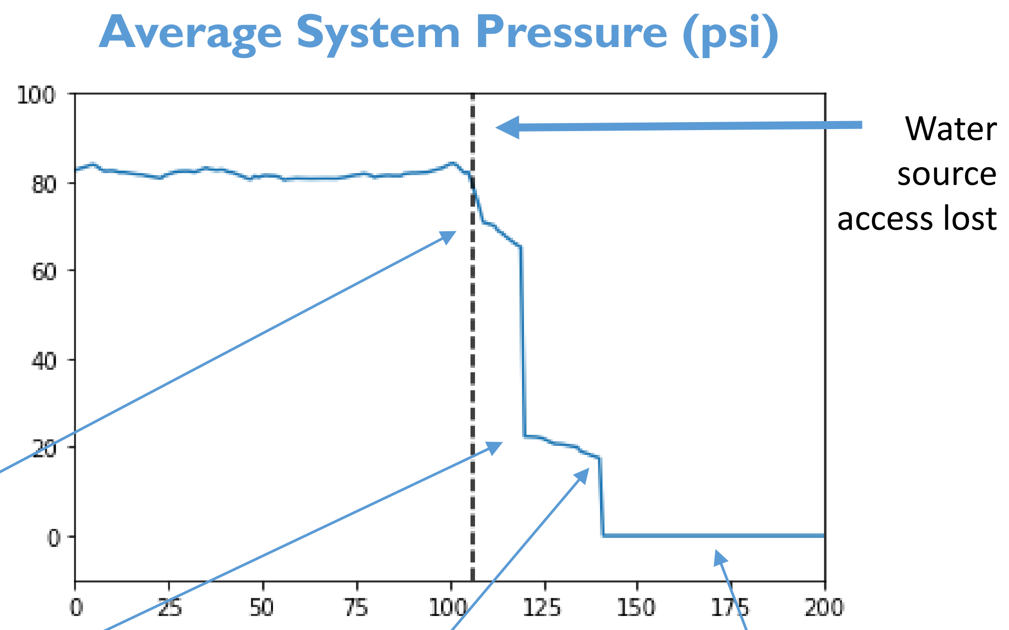
POK Segment Criticality Analysis

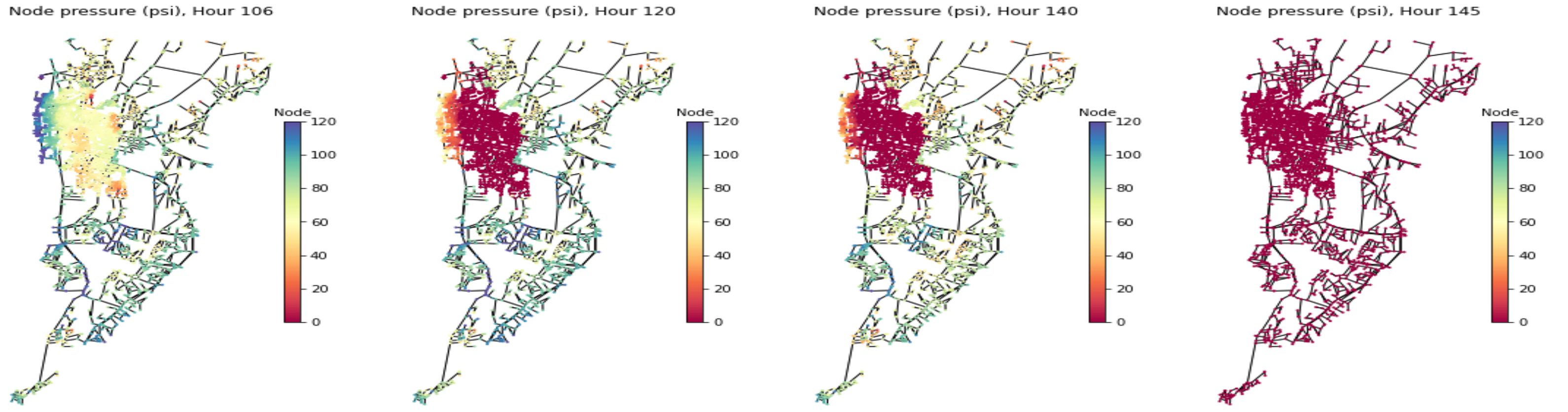
- Identified population impacted by low pressure conditions (< 20 psi) caused by segment pipe breaks
- Simulated segment breaks for 48 & 96 hours during low & high storage times
- Determined length of break is more important



POK Compromised Source Water Analysis

- Examined loss of source water due to river contamination, treatment plant failure, winter storm freezing water intake, or power outage
- Simulated quick restart, long restart & conservation efforts
- Average system pressure drops below 20 psi 14 hours after system shutdown





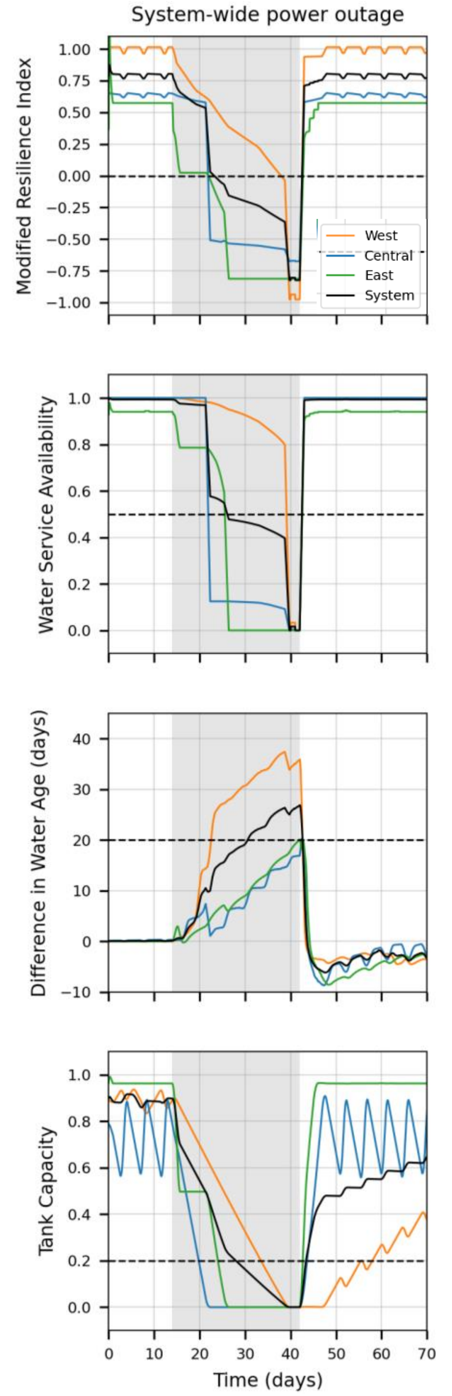
US Virgin Islands (WAPA) Case Study

- Utility
  - Two systems: St. Croix (STX) & St. Thomas/St. John (STSJ)
  - Source: reverse osmosis facilities
  - Population served: STX- 7,235 & STSJ - 6,553
  - Water treated: STX- 2.9 MGD & STSJ - 1.9 MGD
  - System storage: STX- 23 MG & STSJ - 37 MG

- Model
  - STX - 710 junctions, 1 reservoir, 7 tanks, 871 pipes & 8 pumps
  - STSJ - 160 junctions, 1 reservoir, 6 tanks, 181 pipes & 7 pumps
- Disaster scenario
  - Long term power outage

WAPA Power Outage Analysis

- Simulated 4-week system-wide, source & distribution power outages with 2-week recovery on both systems
- Examined impacts on entire system & West, Central & East regions
- Calculated 4 resilience metrics: modified resilience index (MRI), water service availability (WSA), water age & tank capacity
- STSJ system-wide power outage results
  - MRI, WSA & tank capacity drop below thresholds (dashed line)
  - MRI & WSA return to baseline within 2-week recovery but water age and tank capacity do not

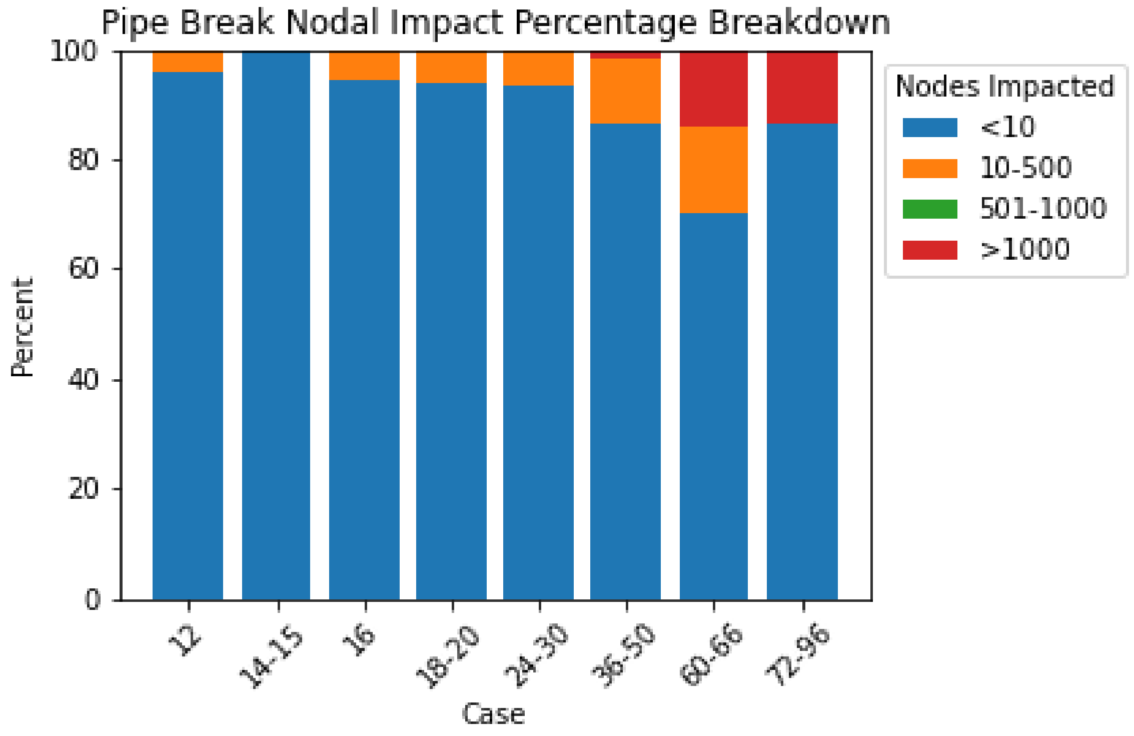


Pittsburgh (PWSA) Case Study

- Utility
  - River source
  - 300,000 population
  - 70 MGD water treated
  - 455 MG system storage
- Model
  - 2 reservoirs, 13 tanks & 49 pumps
  - 69,922 junctions & 74,007 pipes
- Disaster scenarios
  - Pipe criticality analysis
  - Pump outage

PWSA Pipe Criticality Analysis

- Identified population impacted by low pressure conditions (< 20 psi) caused by individual pipe breaks
- Simulated 48-hour breaks for 13,579 pipes 12-in and greater
- Majority of breaks impacted less than 10 nodes, especially smaller diameter pipes
- A few pipe diameters 60-in & larger impacted more than 1000 nodes



EPA United States Environmental Protection Agency

Summary and Future Work

- Provide “deeper dive” into understanding resilience of individual drinking water system
- Inform capital and operational investments
- Assist in training exercises for emergencies
- Perform additional case studies
  - PWSA: landslides
  - Fort Campbell Army Base: 14-day water & energy directive
  - DC Water: pipe criticality with firefighting
  - Wildfires

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https://github.com/USEPA/WNTR

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