EPA United States Environmental Protection Agency

Water Resources Adaptation to Global Changes: Risk Management through Sustainable Infrastructure Planning and Management

Y. Jeffrey Yang, Daniel J. Murray, James A. Goodrich

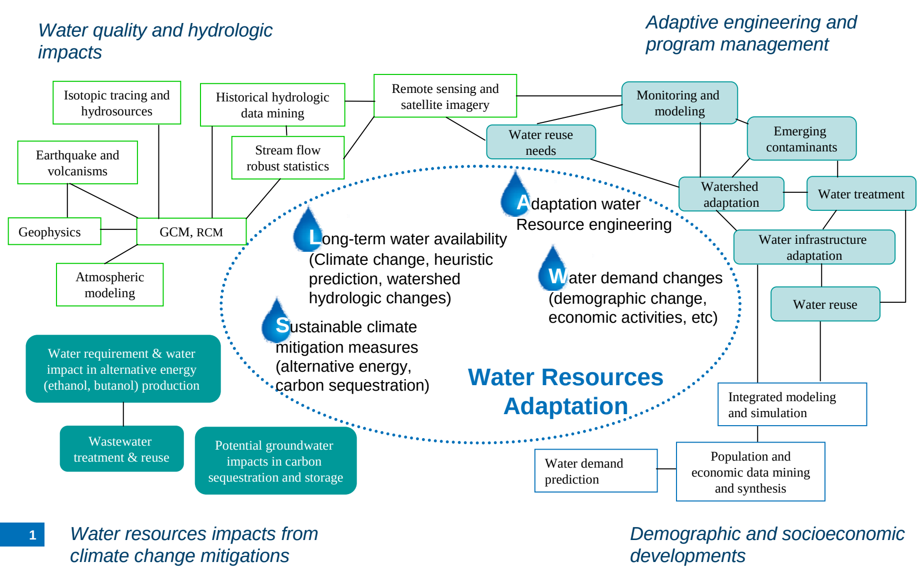
Water Down Under International Conference
Adelaide, Australia

April, 2008

Office of Research and Development
National Risk Management Research Laboratory

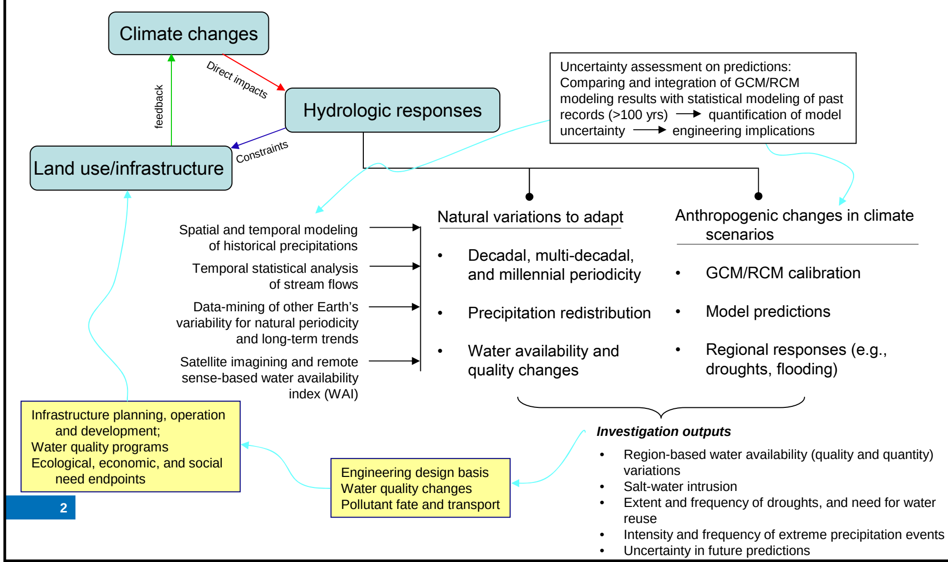
EPA United States Environmental Protection Agency

EPA Water Resources Adaptation Program (WRAP)



1

Define hydrological Change and Water Quality Impacts Affecting Water Programs



2

Likely Impacts on Water Resources Engineering and Management

Global change	Characteristics	Likelihood of impacts: DW supply	Storm water	Wastewater	Likely region of manifestation (examples)
Direct climatic impacts					
Drought	Cyclic drought, increased frequency and duration	Very likely			Southwestern states, south California and Florida
Flash floods	High precipitation intensity	Likely	Very likely	Likely	New England and north Atlantic states, Ohio River basins
Early snow melt	Change of hydrologic region in receiving rivers and groundwater replenishment	Likely	Very likely		Northwestern states (e.g., Washington, Oregon)
Sediment and nutrient loading in surface water	Increased sediments (turbidity) and nutrients (e.g., N,P) in source water of drinking water plants	Very likely			Atlantic East coast, Ohio River basins, and Midwest
Salt water intrusions	Increased salt water intrusion due to anticipated sea level rises	Very likely	Possible	Likely	East Coast and Gulf Mexico costal areas particularly the permeable Floridian aquifer systems, California Central Basin and aquifers along the coast
Indirect climatic impacts					
Alternative water resources development	Water quality in increased alternative water resources (e.g., wastewater reuse) development	Likely	Possible	Possible	California, Florida, southwestern United States, High Plain states
Ethanol and alternative energy production	High water usage demand in raw material production and increased use of pesticides and agriculture chemicals	Likely	Likely	Likely	Midwest and High Plains states in the Mississippi River basin
Groundwater overproduction	High demand excessively lowers groundwater table and accelerates dissolution of inorganic contaminants	Very likely			High arsenic levels in Silurian-Devonian sandstone aquifers

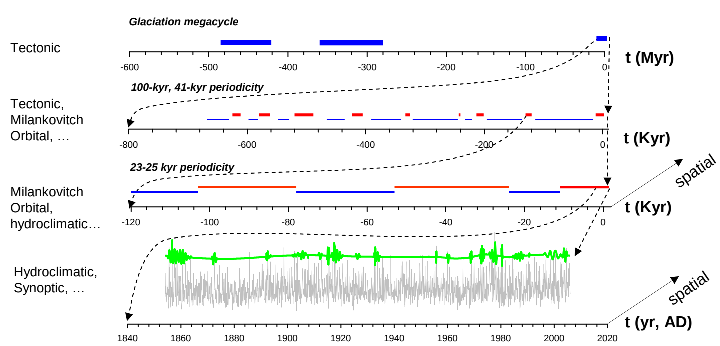
3

Predicting Climate-related Hydrologic Changes:

Hydroclimatic periodicity and local variations

4

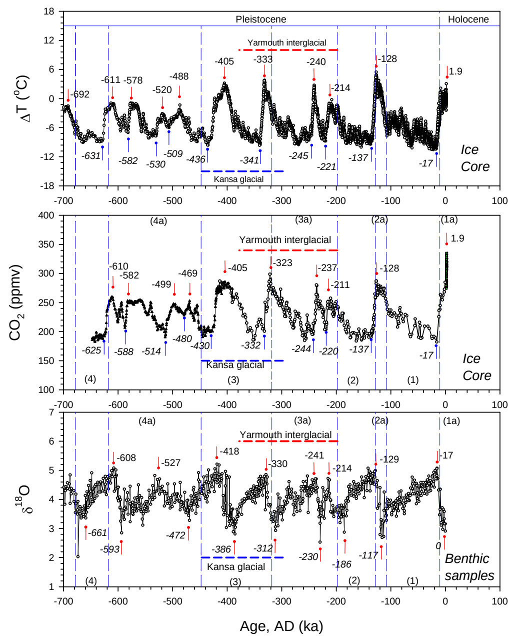
Hydroclimatic Periodicity Hierarchy



5

United States Environmental Protection Agency

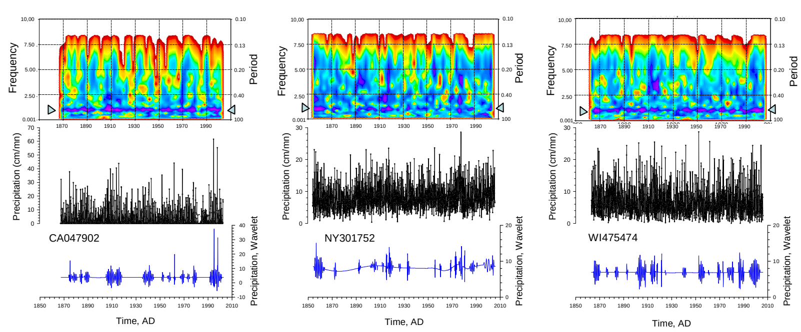
Hydroclimatic Periodicity Hierarchy in Polar Ice Cores: The Variations in Pleistocene-Holocene Period



6

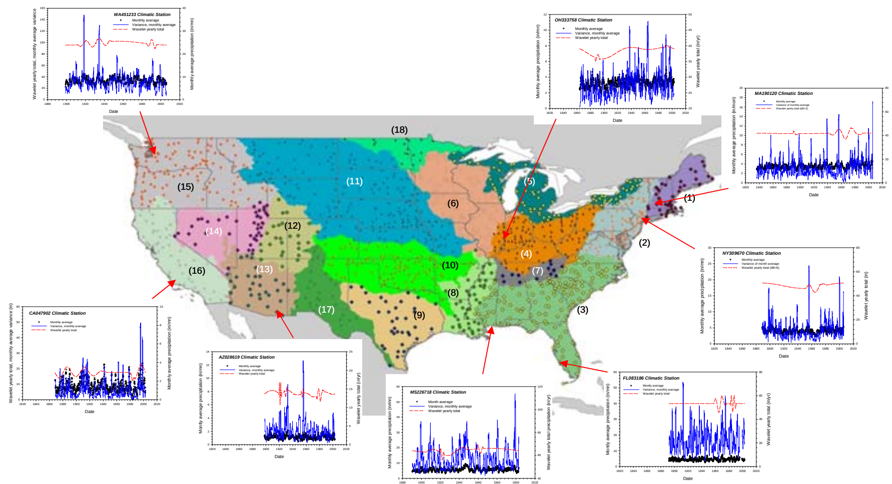
United States Environmental Protection Agency

Hydroclimatic Periodicity Hierarchy



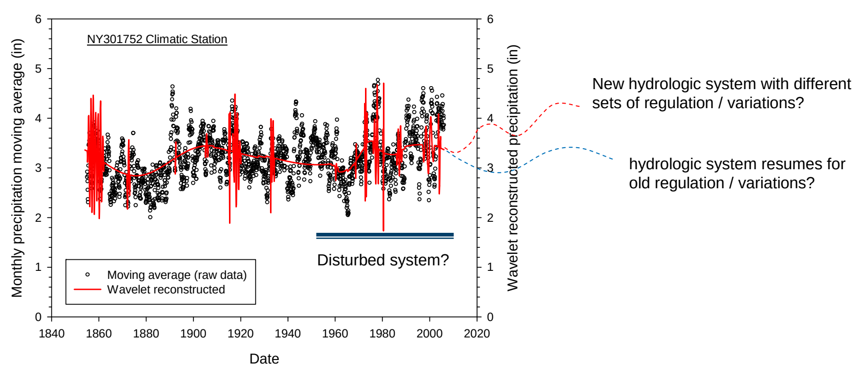
7

Nationwide Hydrological Characterization and Regional Studies: Map it Out

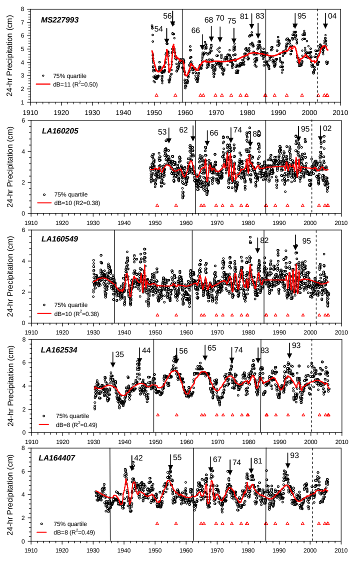


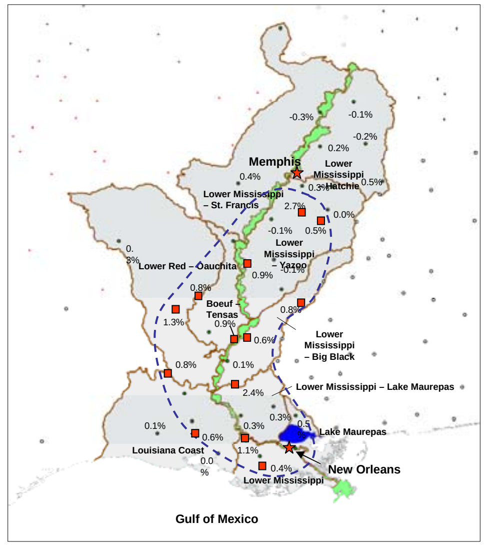
Watershed basins in color: 1) ***New England***; 2) ***Mid-Atlantic***; 3) ***South Atlantic – Gulf of Mexico***; 4) ***Ohio region***; 5) Great Lakes; 6) Upper Mississippi; 7) Tennessee region; 8) Lower Mississippi; 9) Texas – Gulf of Mexico; 10) Arkansas – White Red; 11) Missouri; 12) Upper Colorado; 13) ***Lower Colorado***; 14) Great Basins; 15) ***Pacific Northwest***; 16) ***California***; 17) Rio Grande; and 18) Souris – Red Rainy.

Implications for Water Resources Engineering and Management



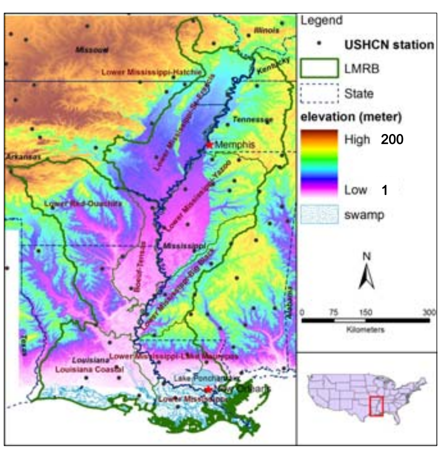
Local Precipitation Variability – A Case Study in Lower Mississippi River Basin, U.S.

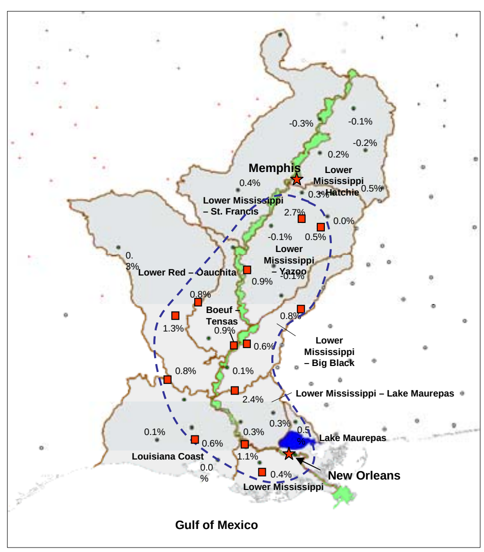




10

How to Account for Variations due to Local Topography in Water Resources Adaptation?

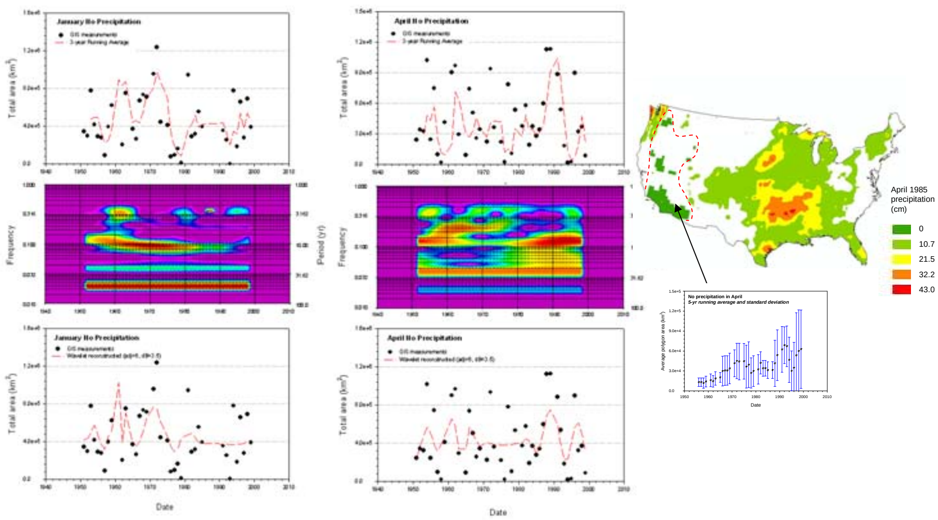




11

United States Environmental Protection Agency

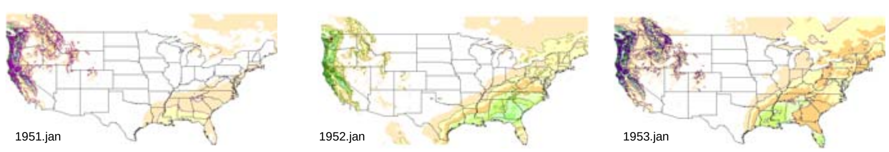
GIS Temporal and Spatial Analysis of No Precipitation Areas for Potential Droughts



United States Environmental Protection Agency

Model Predictions, Uncertainties, and How to Use in Water Resources Adaptation?

HADCM3 Climate Model Predictions



GIS Modeling of Actual Precipitation Measurements

13

EPA United States Environmental Protection Agency

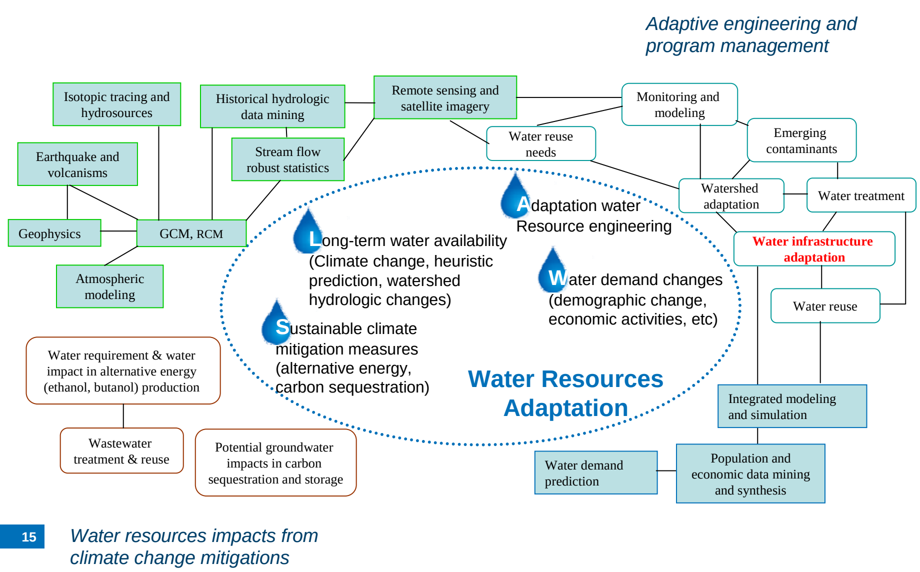
Adaptive Engineering and Management Key to Increase Infrastructure Resilience Considering the Uncertainties

- Major hydrologic changes are region-specific as a result of precipitation redistribution, changes in high-intensity precipitation, run-off characteristics, stream peak and base flows, and surface water quality
- The region-specific changes require custom-designed adaptation strategies
- Uncertainties exist in predictions due to imprecise model representation, uncertain future evolution of controlling hydroclimatic processes, complex local topographic and land use feedbacks
- Watershed and water infrastructure adaptation is the focus of the EPA WRAP research. The aim is to improve functional and capacity flexibility, namely the resilience of water infrastructure and management programs

14

EPA United States Environmental Protection Agency

Sustainable Water Supply and Water Resource Adaptation to Global Changes



15

EPA United States Environmental Protection Agency

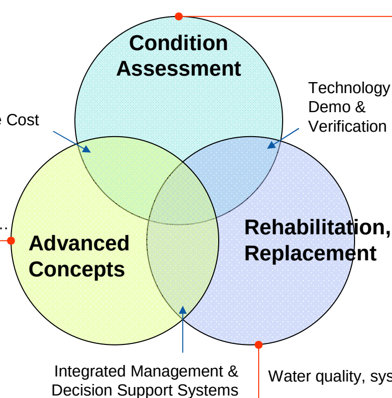
Water Infrastructure Adaptation for Better Risk Management

16

EPA United States Environmental Protection Agency

Water Infrastructure Adaptation in EPA 21st Century Sustainable Infrastructure Research

Condition assessment, water quality and asset management…



- CCTV and other non-intrusive methods
- Gravity sewer IF/EF detection methods
- Pressured network (e.g, drinking water pipe) leak detections
- Advanced data analysis, management, and decision support systems

Global change, energy, sustainability…

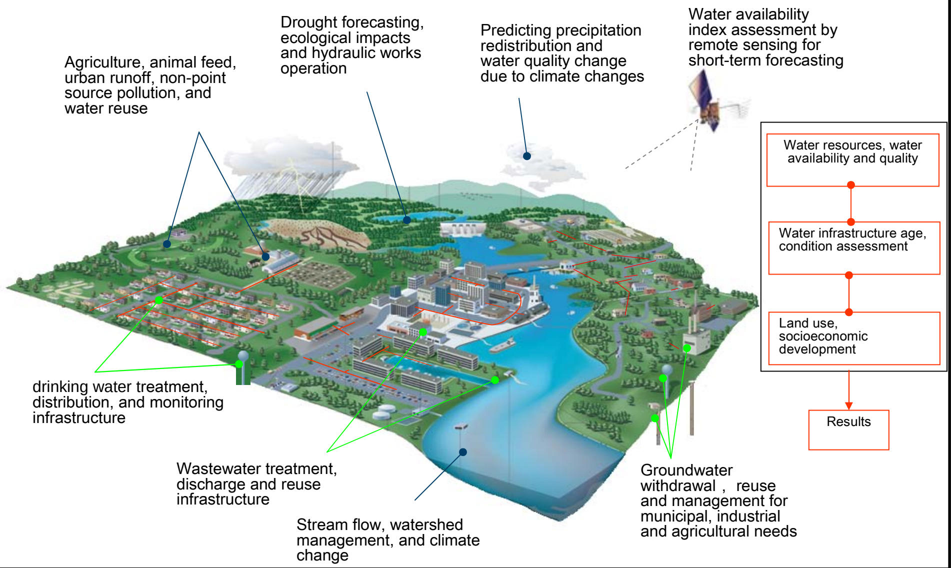
- **Multi-scale infrastructure assessment and adaptation strategies**
- **Dual systems and non-centralized system management**
- **Energy-saving and water conservation**
- **Alternative water sources development and utilization**
- **Innovative collection system designs**

Water quality, system rehabilitation and replacement…

- Pressure pipe rehabilitation technology demo/verification
- Pressure pipe rehabilitation methods and materials
- Gravity sewer rehabilitation methods and technologies
- Odor and corrosion control

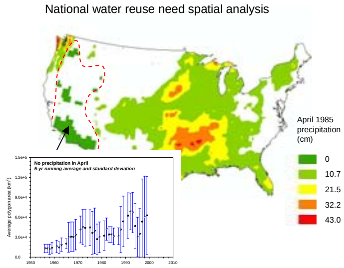
17

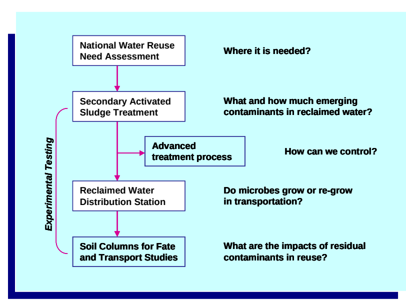
Multi-scale infrastructure assessment and adaptation strategies：Major elements at watershed scale



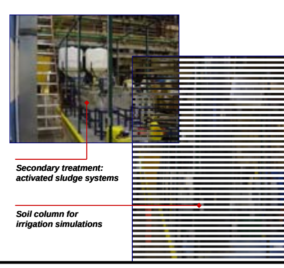
Water Availability – Develop Alternative Water Sources

National water reuse need spatial analysis





Wastewater reuse experimental testing



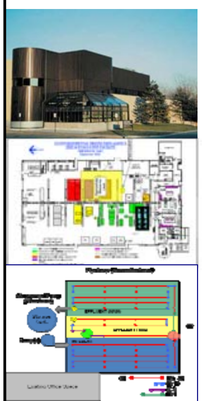
Secondary treatment: activated sludge systems

Soil column for irrigation simulations

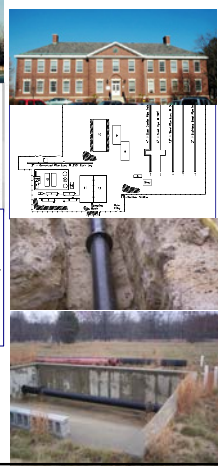
Low-pressure MBR development for wastewater reuse

Water Availability – Reduce Water Loss through pipe leak detection, network rehabilitation

Pilot-scale Experimental Station at EPA T&E facility (Cincinnati, OH)



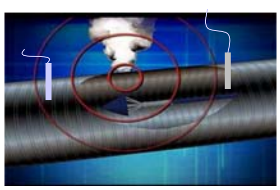
Field-scale Experimental Station at EPA-Edison Facility (New Jersey)



- EPA leak detection research is to find economic and effective technologies to reduce water loss and prevent water contamination and quality deterioration in the pipe
- Two major research centers: pilot-scale experimental station at Cincinnati T&E facility, field-scale experimental station at New Jersey Edison facility
- Non-intrusive detection focus:
  Sonar; laser; zoom cameras;
  In-line SmartBall; smart pigs;
  Acoustic sensor monitoring;
  Ultrasonic thickness testing;
  Broadband electromagnetic testing;
  Magnetic flux leakage;

20

Water Availability – Reduce Water Loss through pipe leak detection, network rehabilitation

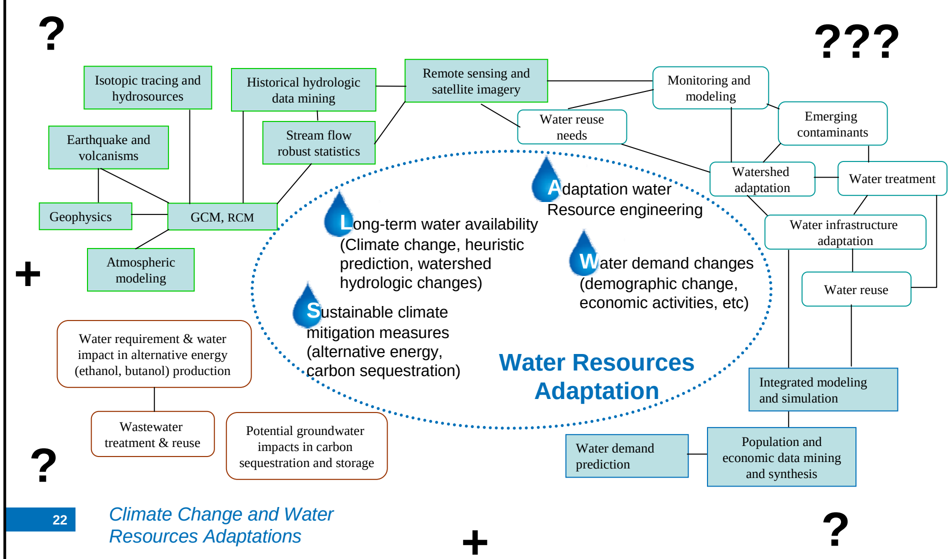


- Acoustic detection technology has been commercially available for pipe leak detections and widely used in the U.S. It is relatively economical compared to other non-intrusive leak detection technologies
- Disadvantage: The detection performs during night time without background noise and the detection accuracy varies normally in a long segment between two sensor locations
- EPA research aims to yield acoustic detection techniques more accurate and precise, and more robust from background noise interference. The approach uses networked acoustic sensors, newly generated algorithms, and a designated detection sequencing.
- The research is ongoing at EPA T&E facility in Cincinnati

21

EPA United States Environmental Protection Agency

Uncertainties and The Need for Adaptive Approaches to Secure Water Supplies



EPA United States Environmental Protection Agency

Questions and Comments

yang.jeff@epa.gov