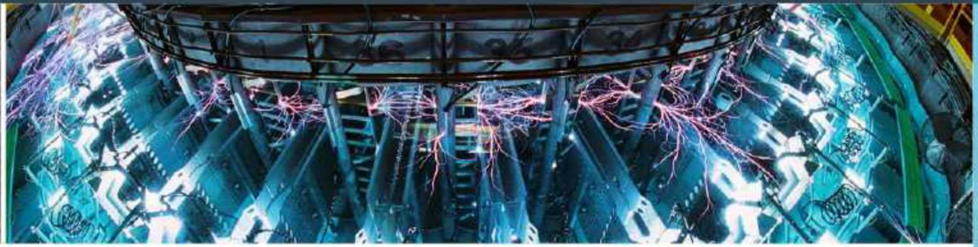
SAND2020-6857PE

Water Atlas Extension



PRESENTED BY

Vincent Tidwell, Thushara Gunda and Natalie Gayoso

Sandia National Laboratories

Project Close-Out Briefing

July, 7, 2020

Takeaways

- Our nation's electric generation capacity is growing and with it the need for water:
  - Boiler make-up;
  - Cooling water;
  - Emission control; and
  - Construction.
- Where is water available, what sources and how expensive will it be? ***The Water Atlas helps fill this gap.***
- There are over 1200 thermoelectric power plants in operation in the U.S. Their operations could be compromised by insufficient water supply or degraded water quality.
- Assessment of actual risk requires plant-level details not widely available in national databases. Failure to account for these will lead to:
  - Misclassification of actual threat, and
  - Overestimation of impact without regard to mitigative measures taken.

Scope of Work

- **Task 1:** Extend the Water Atlas to consider the states of Alaska and Hawaii. Update lower 48-states to reflect recent USGS publications.
- **Task 2:** Survey coal-fired power plants in the U.S. to determine their water-related risks (drought, flood and water quality) and the measures they have taken to manage those risks.
- **Task 3:** Add a metadata layer to the Water Atlas that documents data source and key assumptions related to each data entry.

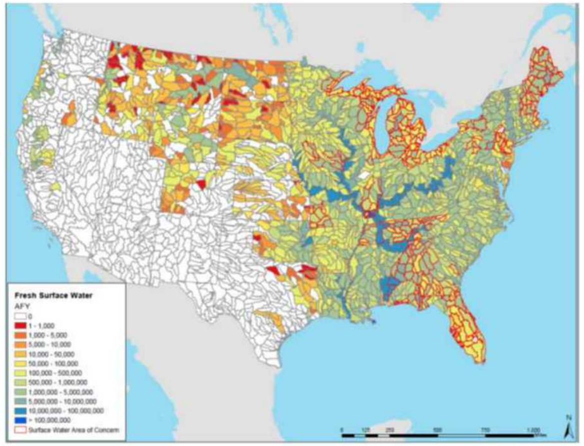
Water Atlas

- Water availability was mapped for five alternative sources of water:
  - Fresh Surface Water,
  - Fresh Groundwater,
  - Appropriated Water,
  - Brackish Groundwater, and
  - Wastewater.
- Data considered both physical and institutional constraints on water development. To accomplish this, data were collected directly with help of state water management agencies.
- Complimentary maps of water cost and future use were developed.
- In all cases metrics were mapped at high spatial resolution, 8-digit HUC, or roughly 2250 watersheds.

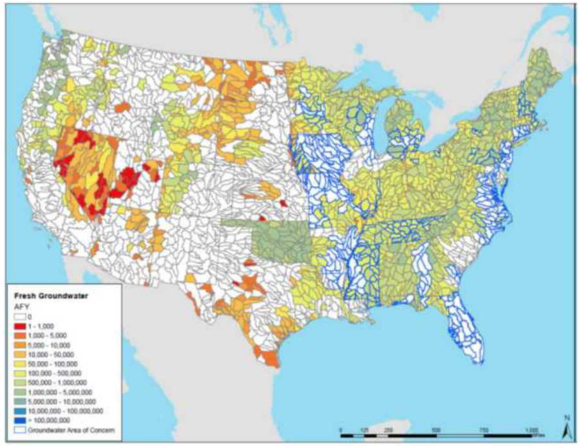
Water Supply Availability

- Data provide indication of where different sources of water are available for future development.
- Outlined watersheds indicate areas with no defined limits but where development will receive higher scrutiny.

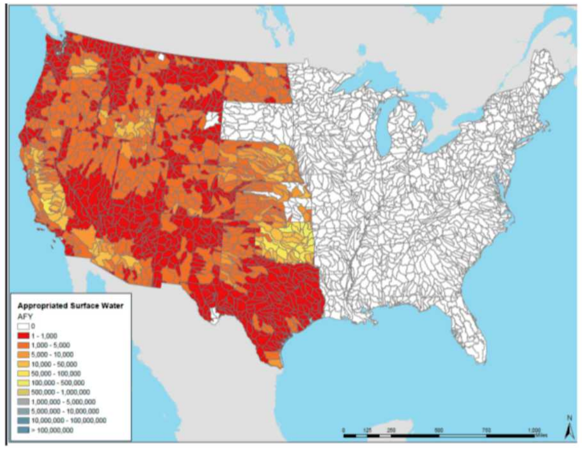
Fresh Surface Water



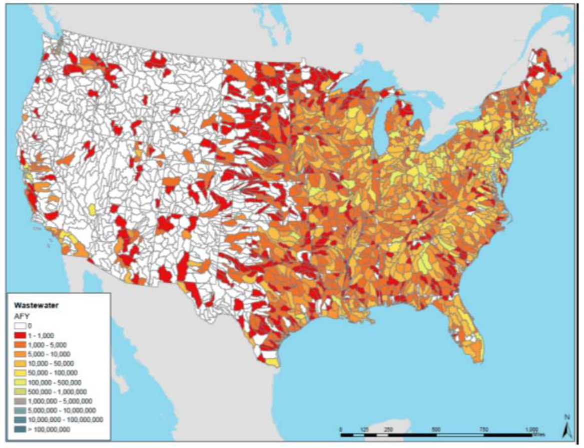
Fresh Groundwater



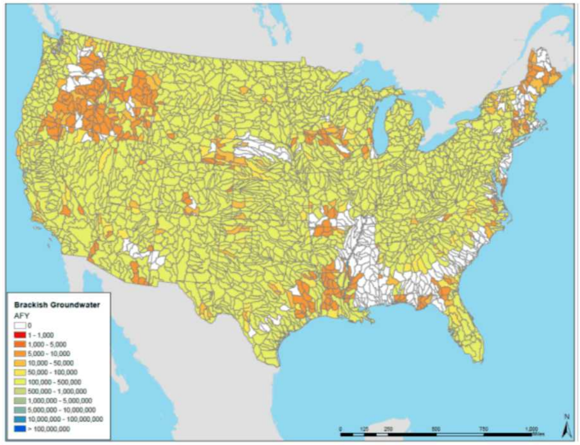
Appropriated Water



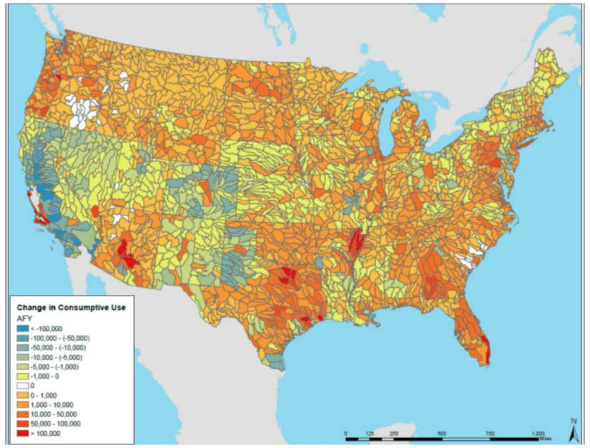
Municipal Wastewater



Brackish Groundwater



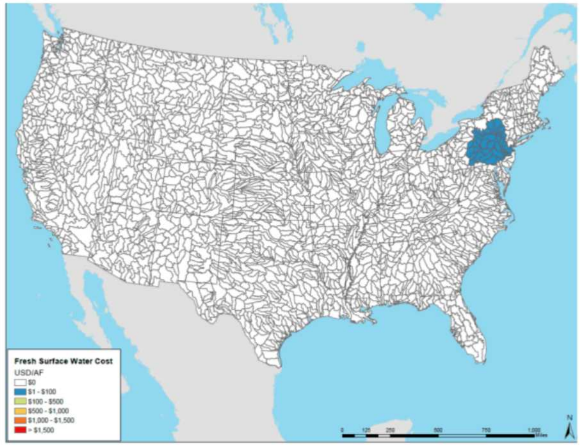
Consumptive Demand 2010-2030



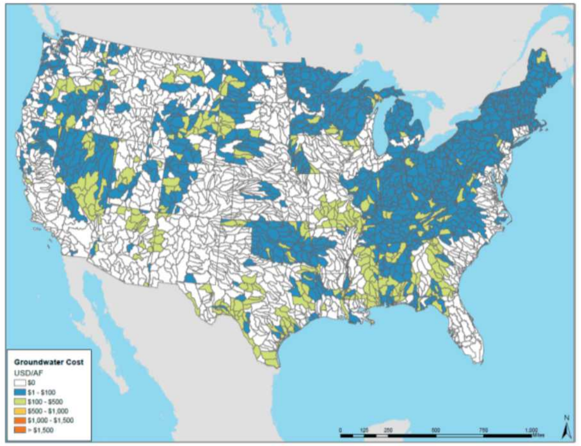
Water Cost

- Goal is to establish a consistent and comparable measure of cost to deliver water of potable quality to the point of use.
- Basic costs considered:
  - Capital costs:
    - Purchase water,
    - Wells,
    - Conveyance, and
    - Treatment.
  - Operation and Maintenance:
    - Electricity,
    - Labor,
    - Consumables, and
    - Disposal.

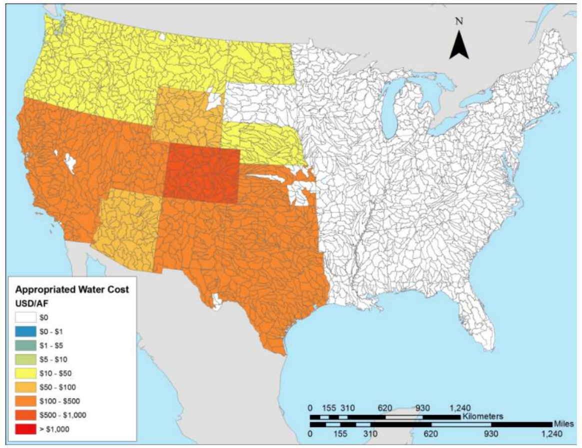
Fresh Surface Water



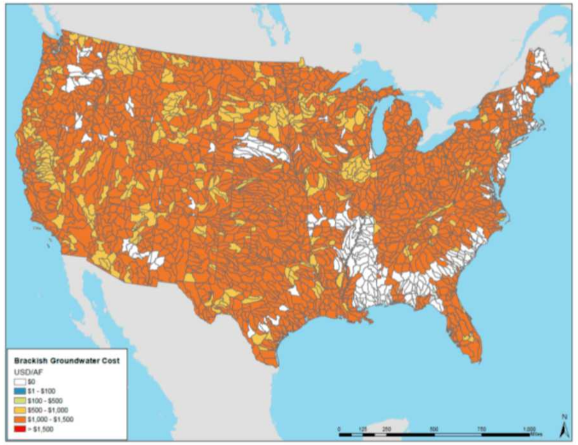
Fresh Groundwater



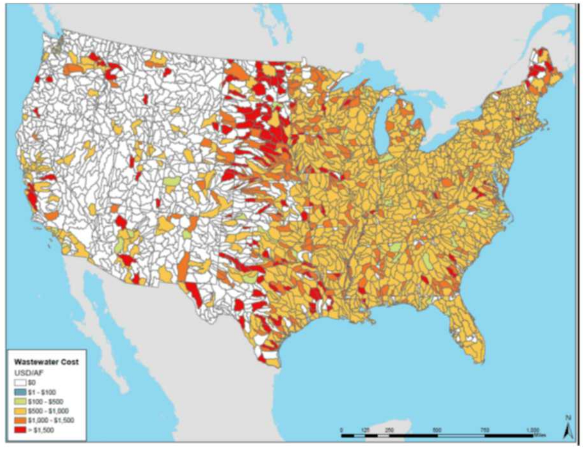
Appropriated Water



Municipal Wastewater

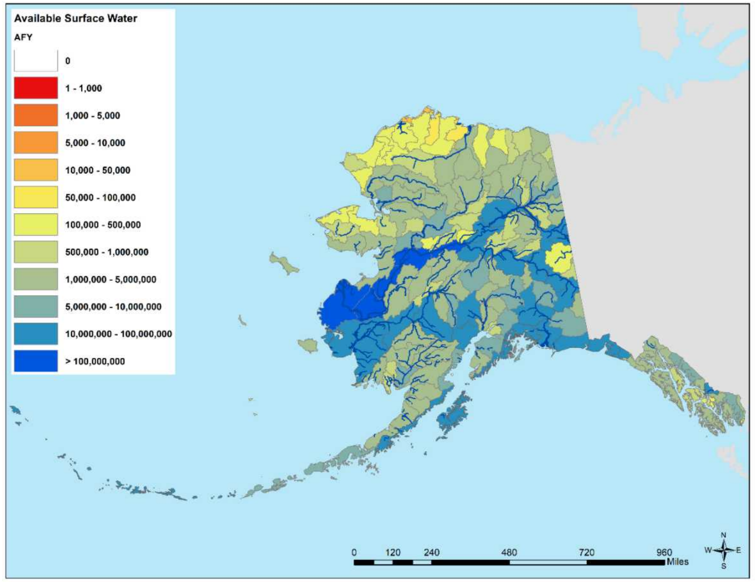


Brackish Groundwater

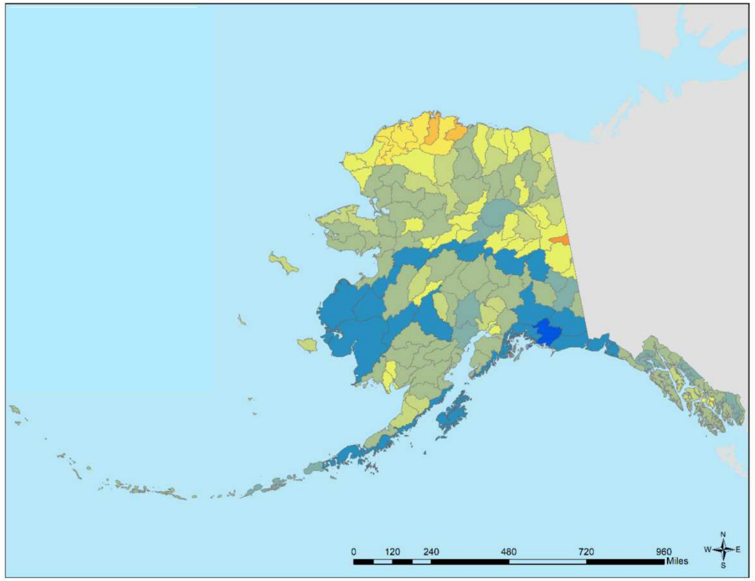


Water Supply Availability: Alaska

Fresh Surface Water

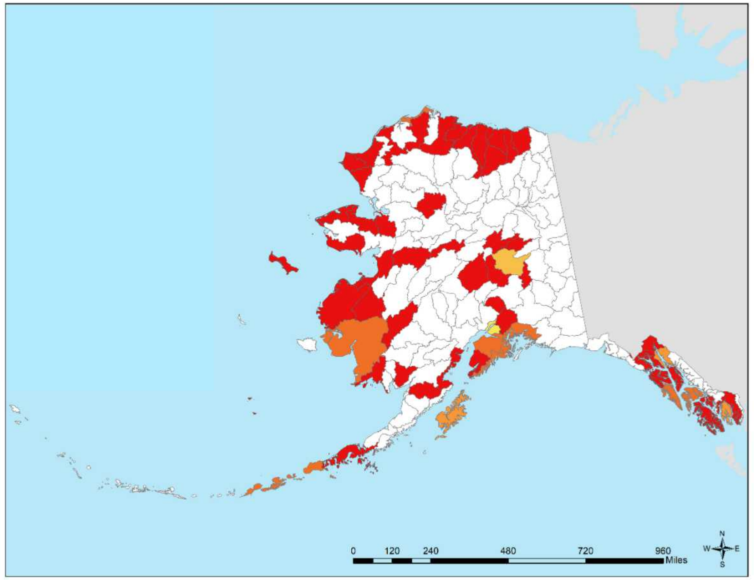


Fresh Groundwater

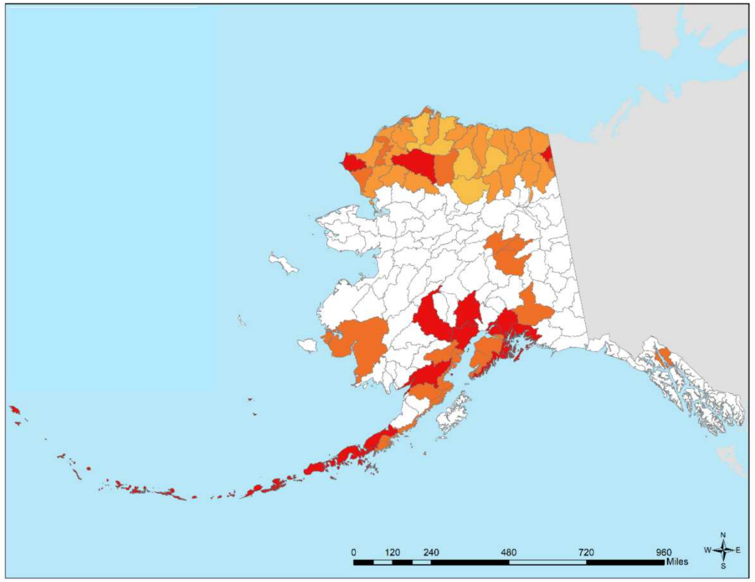


Appropriated Water

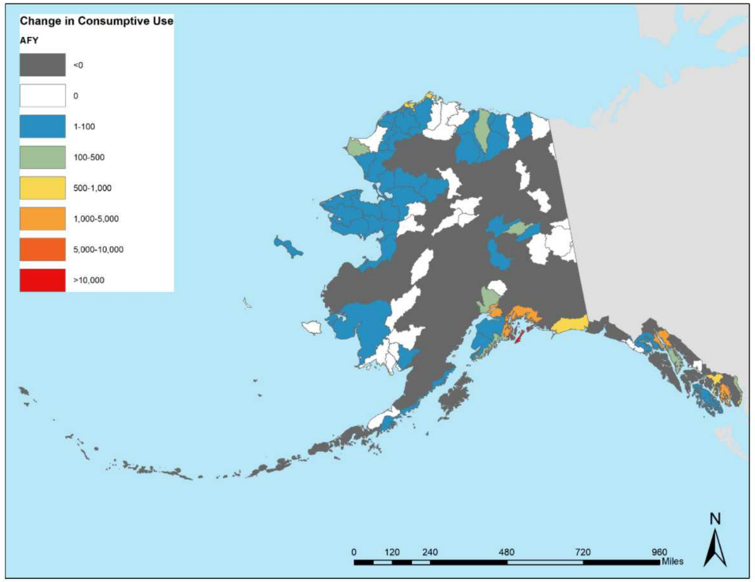
Municipal Wastewater



Brackish Groundwater

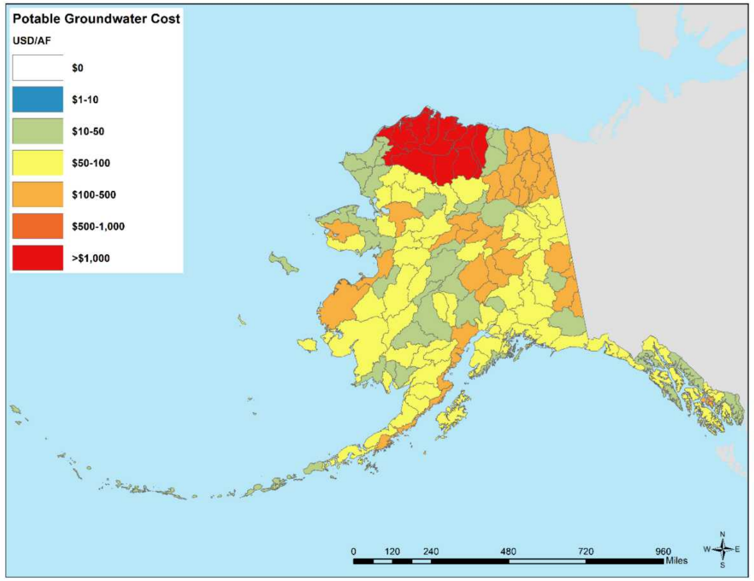


Future Need 2010-2030



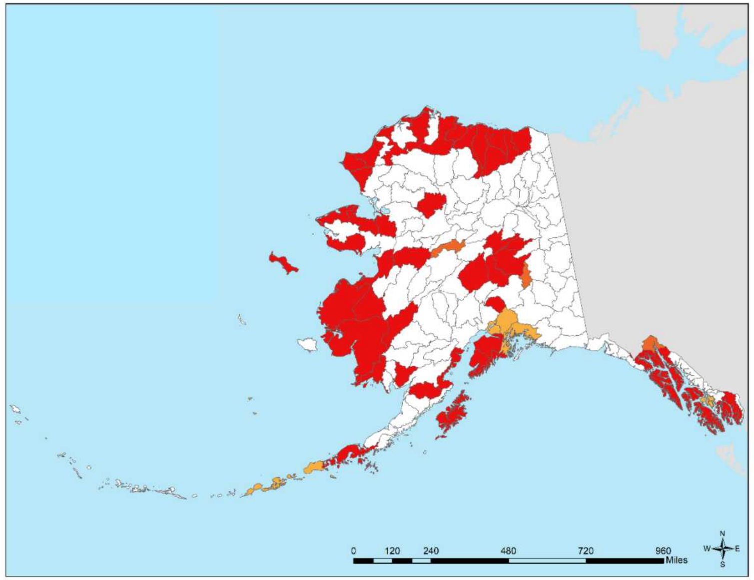
Water Cost: Alaska

Fresh Groundwater

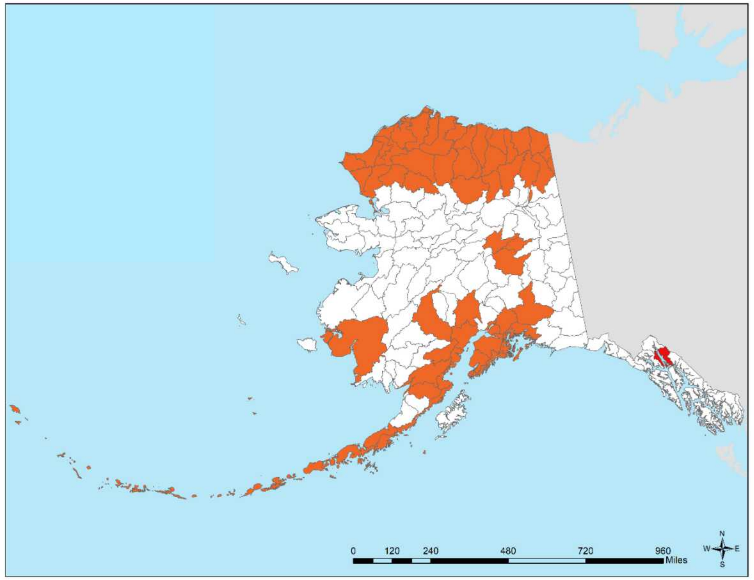


Appropriated Water

Municipal Wastewater

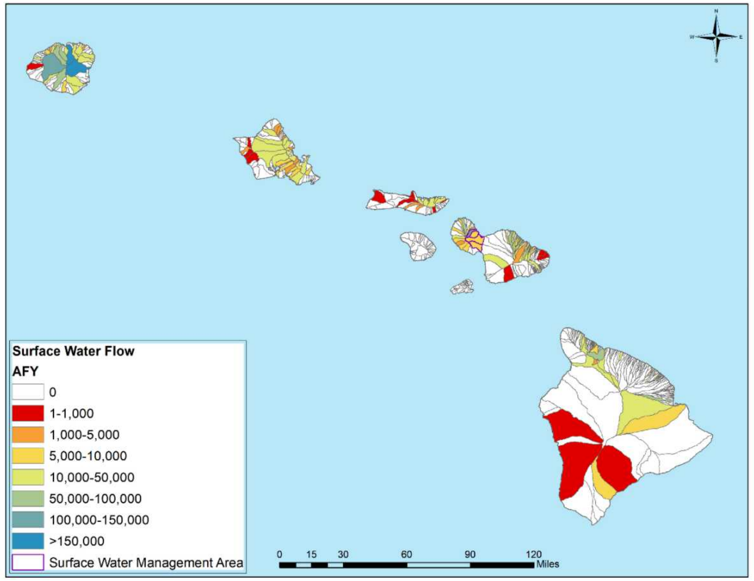


Brackish Groundwater

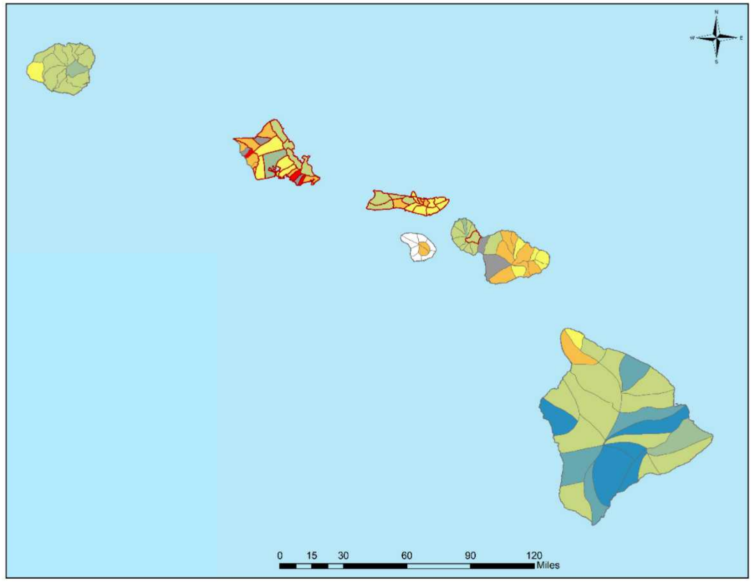


Water Supply Availability: Hawaii

Fresh Surface Water

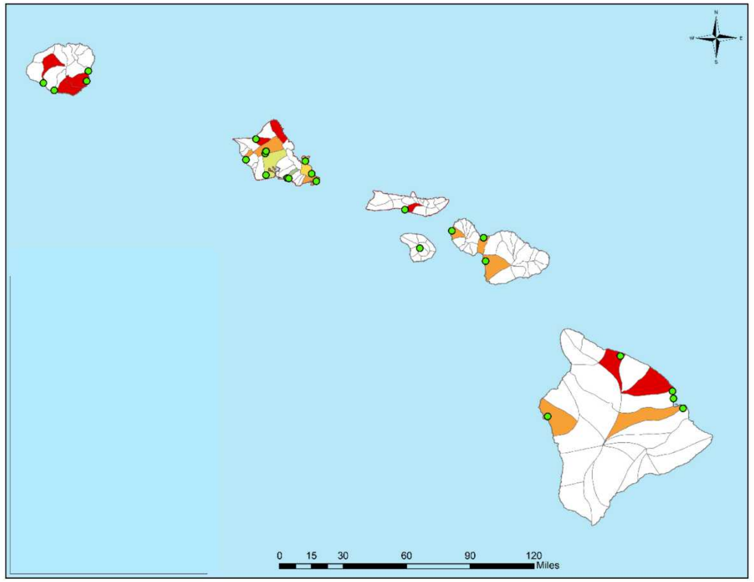


Fresh Groundwater

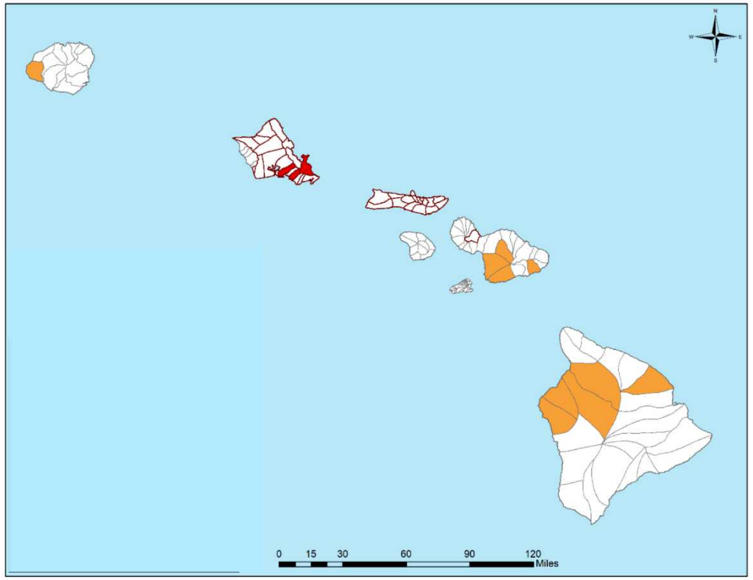


Appropriated Water

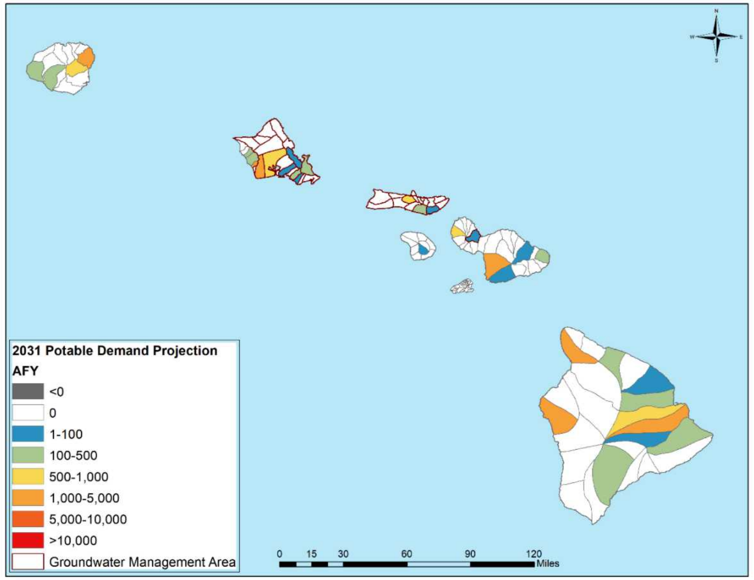
Municipal Wastewater



Brackish Groundwater

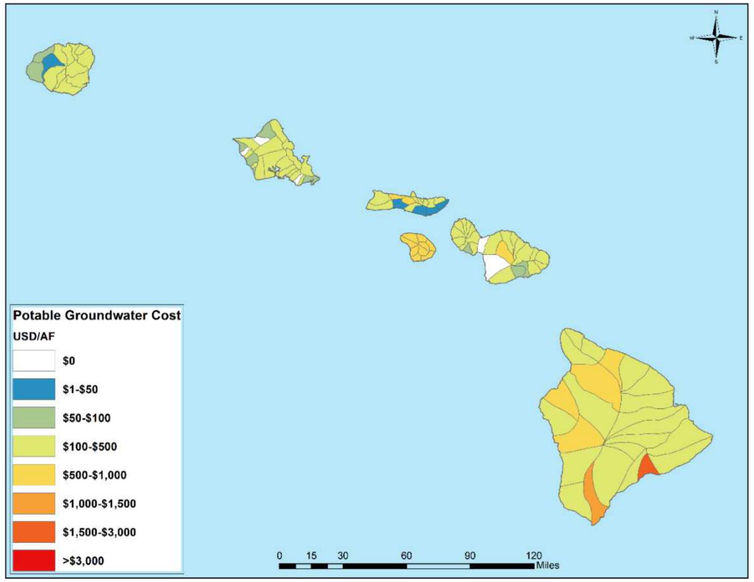


Future Need 2010-2030



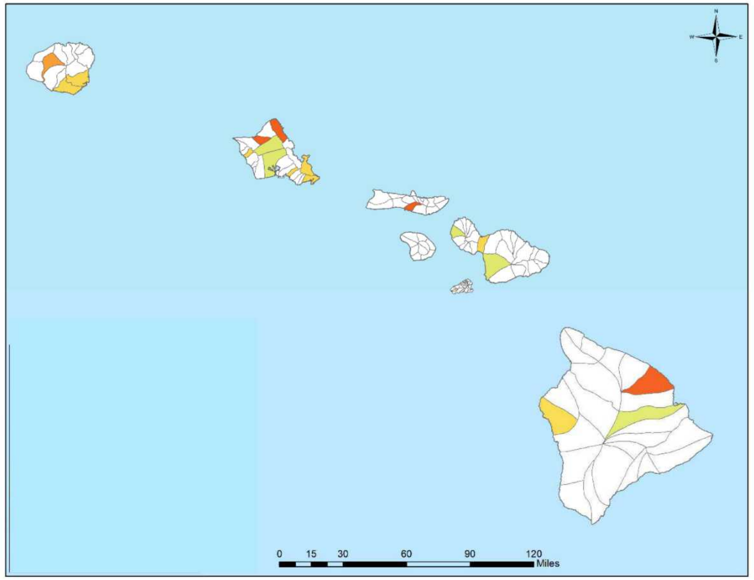
Water Cost: Hawaii

Fresh Groundwater

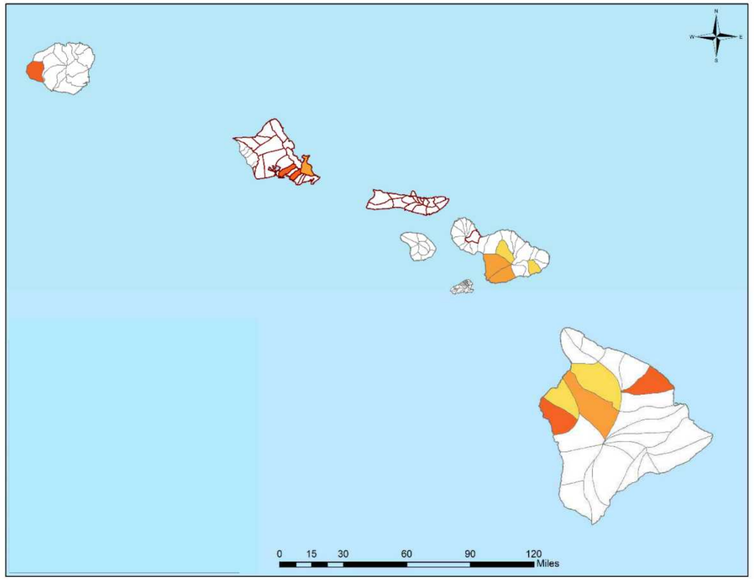


Appropriated Water

Municipal Wastewater



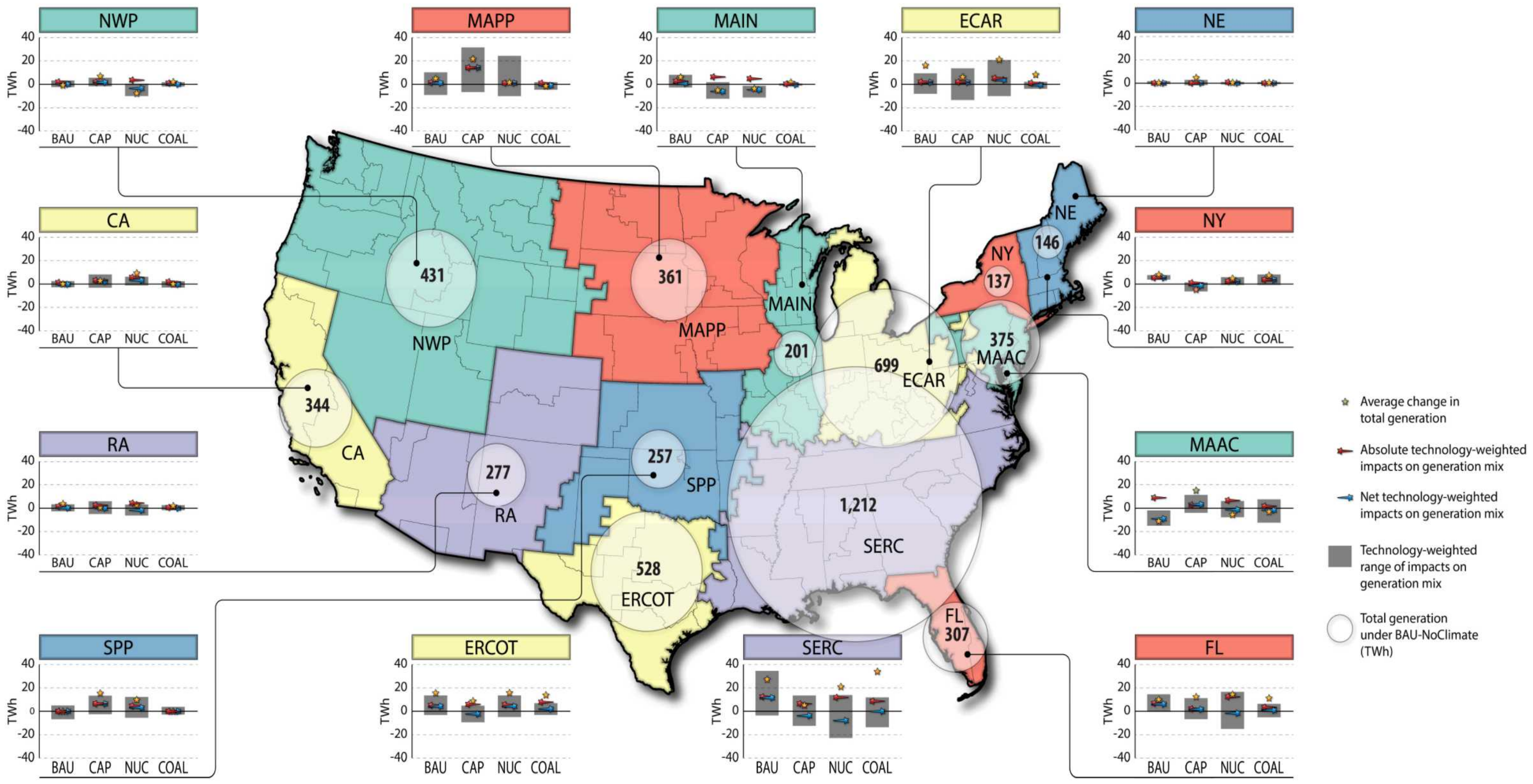
Brackish Groundwater



Data Use

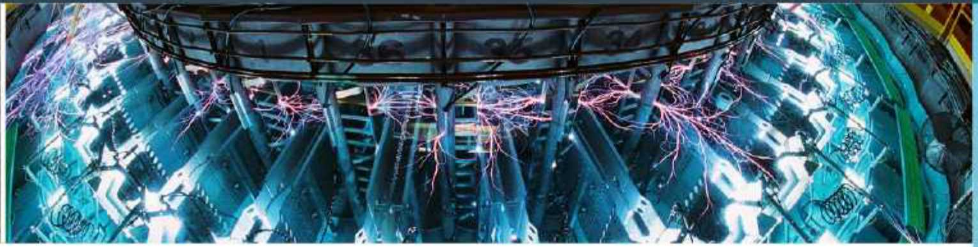
- Data deployed in ReEDS, a capital expansion model for the electric industry
- Currently being used by WECC and ERCOT to support integration of water into long-term transmission planning

NREL
Regional Energy Deployment System Model
(ReEDS)



Source: Cohen et al. in review

Importance of Plant-Level Characteristics for Assessment of Water-Related Threats to Electric Power Sector



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Sandia National Laboratories

ASME Power Conference 2020

August 4, 2020

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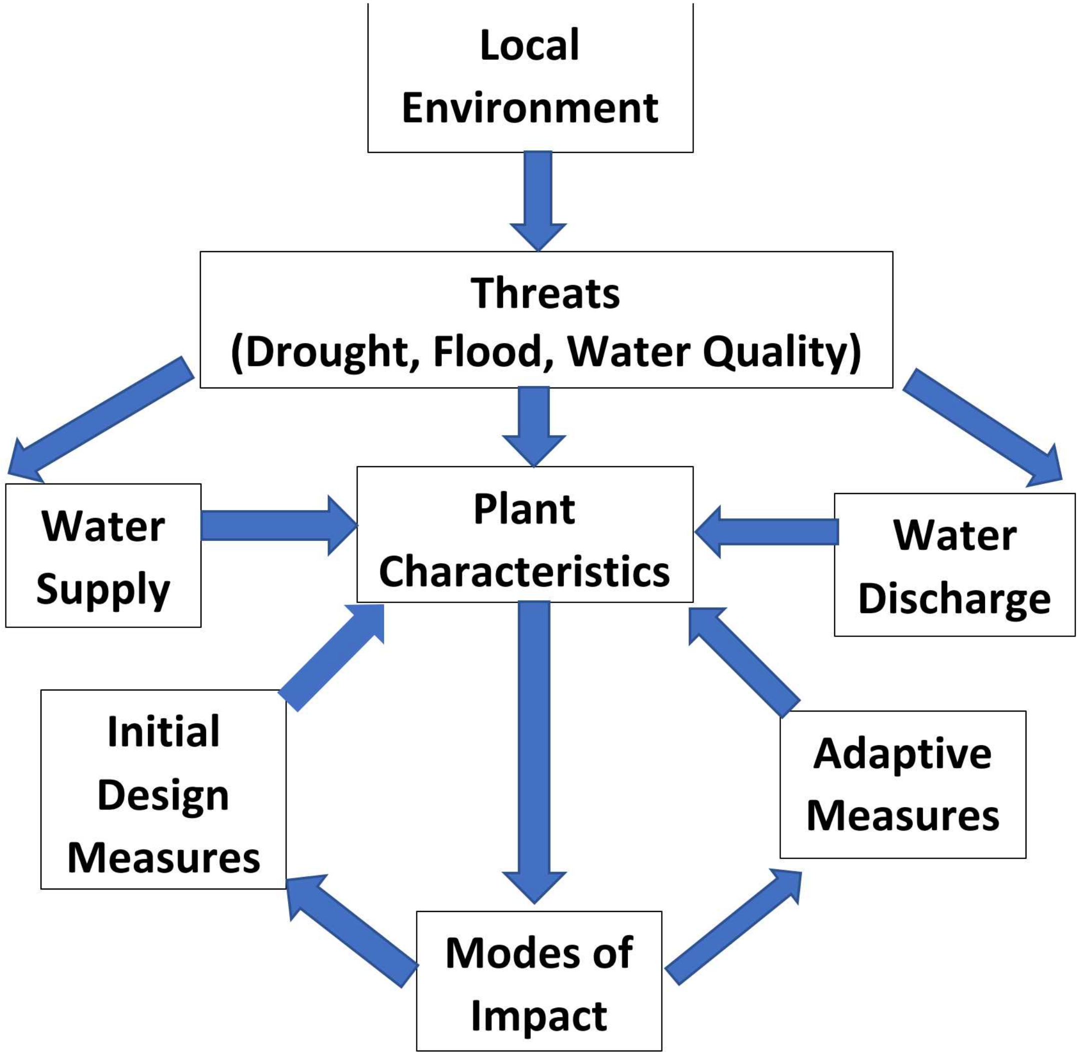
Problem

- Thermoelectric power generation is threatened by disruption to water supply (quantity and quality).
- Threat assessments attempt to project how this threat is evolving with changing climate, technology, and resource demand.
- Current assessments fail to consider critical plant-level data:
  - Unique modes of impact due to drought, flood, and water quality; and
  - Local mitigation measures employed.

Objective

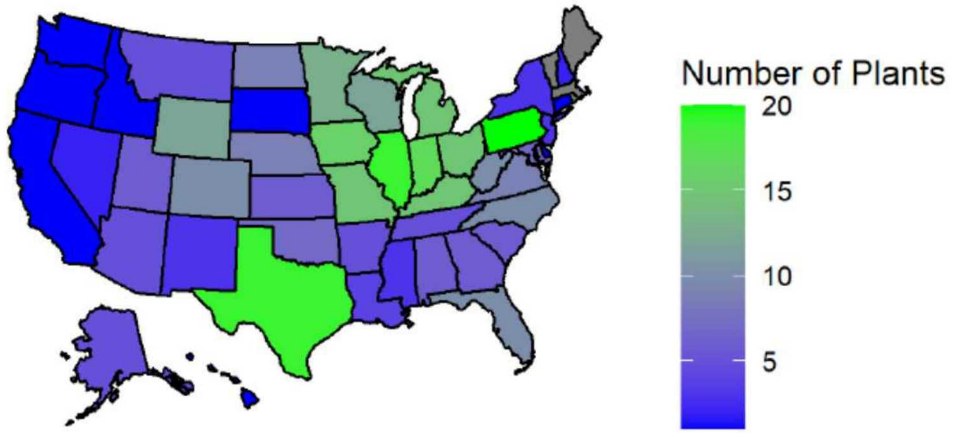
Conduct plant-level survey to determine:

- Specific modes through which extreme conditions impact power plant operations, and
- Specific measures implemented by owners/operators to mitigate water-related threats.



Questionnaire

- Contacted power plant operators.
- Semi-structure interview process conducted by phone.
- Approximately 30 questions.
- Limited to coal-fired generation.



Coal-Fired Plants Operating in U.S.

Water-Related Threat Questions

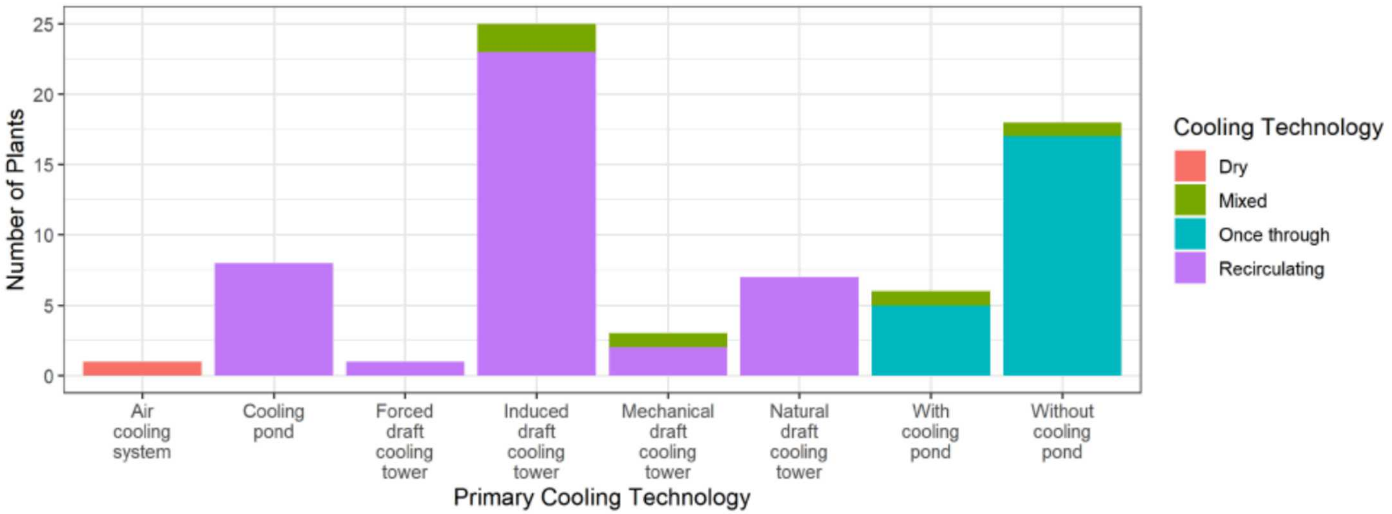
Fuel	Coal	Coal	Coal	Coal
Number of Units	5	2	2	4
Generation Capacity (MW)	1140	376	2240	2090
Location (lat/lon; state)				
Water Source (type, %)	Surface water (100%)	Surface water (100%)	Surface water (100%)	Surface water (100%)
Water Source (name)				
Annual Water Withdrawal (MGD)				1162.9
Water Permitting Requirements (State-level, municipality, other provider?)	State Water Reporting (Use)	In the Southeast, don't have concerns about water rights. Access is	State Water Reporting (Use)	State Water Reporting (Use)
Drought-related Constraints? (env flow, river operations, other users, power plant efficiency; gw: drawdowns) Frequency?				
Flood-related constraints? Frequency?	No b/c of reservoir upstream		No b/c of reservoir upstream	No b/c of reservoir upstream
Water quality-related Constraints? (thermal, biological, salinity, etc.)	None		No issues present	None
Peaking vs constant load considerations?	Peaking plant		Baseload plant	Baseload plant
Mitigation Strategies	Reservoir operations protocols manage water supply and coordinate withdrawals between neighboring power plants (coordinated with water supply extremes)		Added supplemental water supply with intake on Dan River	Reservoir operations protocols manage water supply and coordinate withdrawals between neighboring power plants (coordinated with water supply extremes)
Cooling Technology	Once-through	Recirculating pond	Once-through	Once-through
Any Storage/Cooling Ponds on-site?	No	Yes	No	No
Discharge Permitting Requirements (State-level; temps, etc.)	State NPDES (State has been more aggressive in terms of water regulations: so putting treatment technologies on all coal plants.)	State NPDES (State has been more aggressive in terms of water regulations: so putting treatment technologies on all coal plants.)	State NPDES (State has been more aggressive in terms of water regulations: so putting treatment technologies on all coal plants.)	State NPDES (State has been more aggressive in terms of water regulations: so putting treatment technologies on all coal plants.)
Drought-related Constraints? (env flow, river operations, other users, power plant efficiency; gw: drawdowns)? Frequency of issues?	N/A		N/A	N/A
Flood-related constraints? Frequency?	N/A		N/A	N/A
Water quality-related Constraints? (thermal, biological, salinity, etc.) Frequency of issues?	Thermal limits exists but has not caused any problems. With ash pond closed and ww system upgraded, selenium issue has also been addressed.		Was a problem in the 1980s (standards issues) - discharge of coal pond goes to River while discharge of cooling intake to nearby creek. Can adjust discharges as needed to account for low flows.	Summer, there's always a competition for cool water between McGuire and Marshall - for both thermal limits and fisheries (used to stock striped bass but now hybrid striped bass). Group looks at that balancing specifically. Most of the time they make it work. Rarely derate.
Peaking vs constant load considerations?	N/A		N/A	N/A
Mitigation Strategies	N/A		N/A	Monitor thermal conditions and coordinate discharge with neighboring plants.
How does coal ash management influence water operations at the site?	Bottom ash (recycled water). Everything else in dry. Inactive ash pond.		Bottom ash (recycled water). Everything else in dry. Inactive ash pond.	Bottom ash (recycled water). Everything else in dry. Inactive ash pond.
Other				None
Metadata				
Availability				
Discharge				
Miscellaneous				

Respondents

- *Identification of plant-level contacts was difficult—successful for only 33% of plants (based on capacity)*

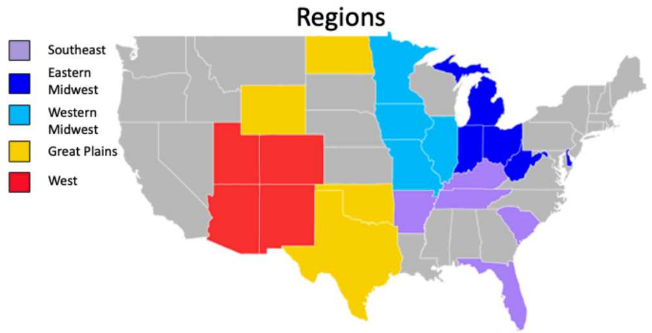
	Total	Interviewed	Interviewed (% of Total)
Utilities	220	32	14.5
Plants	353	69	19.6
States with Coal Plants	46	23	50.0
Plant Capacity (GW)	279.5	91.9	33.0

- *Covered broad range of geographies, plant characteristics, water sources, and water discharge practices.*



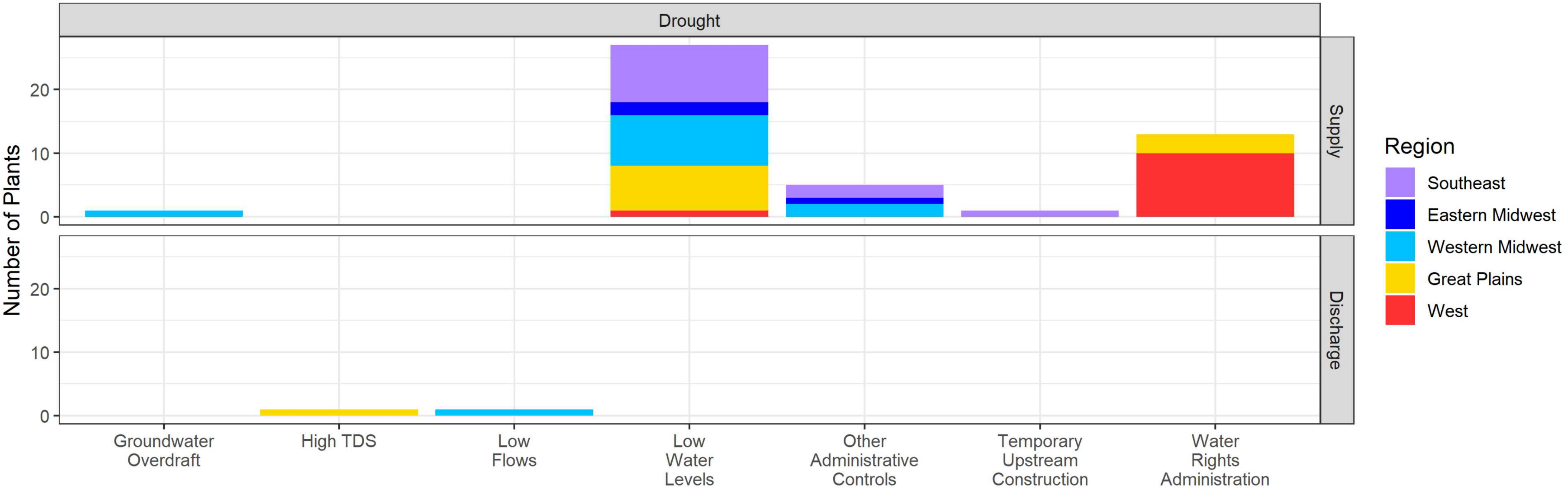
Results: Water Supply

Institutional Controls on Water Supply by Region

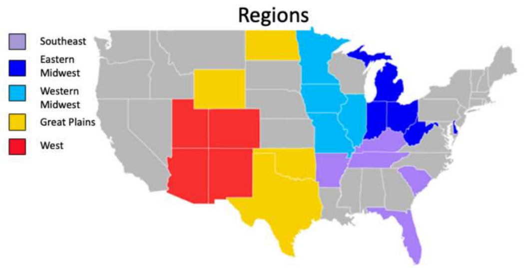


Results: Drought

Modes of Impact that Drought has on Water Supply and Discharge

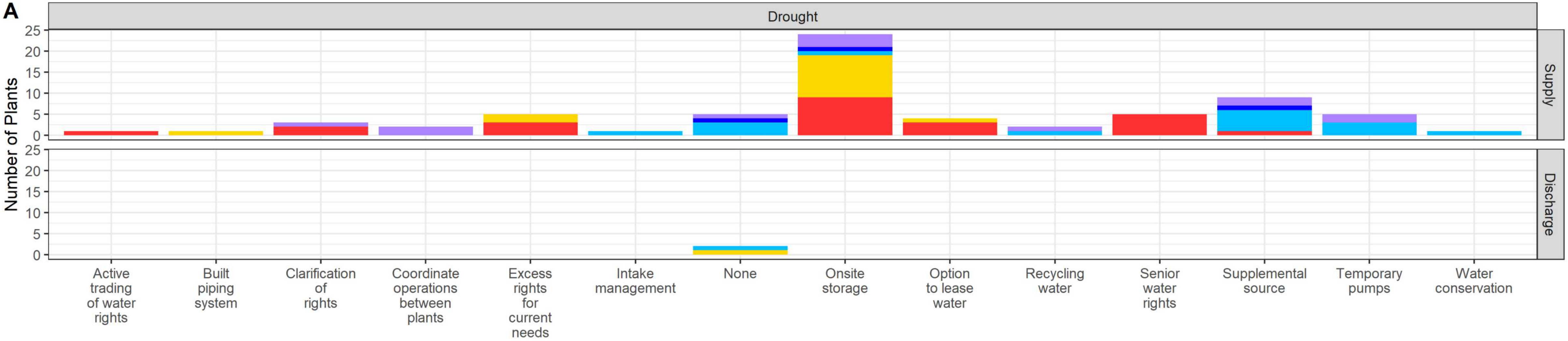


- 49 plants reported drought related threats
- 5 modes of impact on supply
- 2 modes of impact on discharge

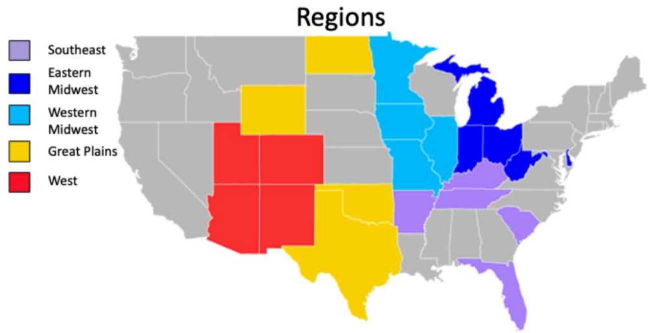


Results: Drought

Mitigation Measures taken to Manage the Impact of Drought on Water Supply and Discharge

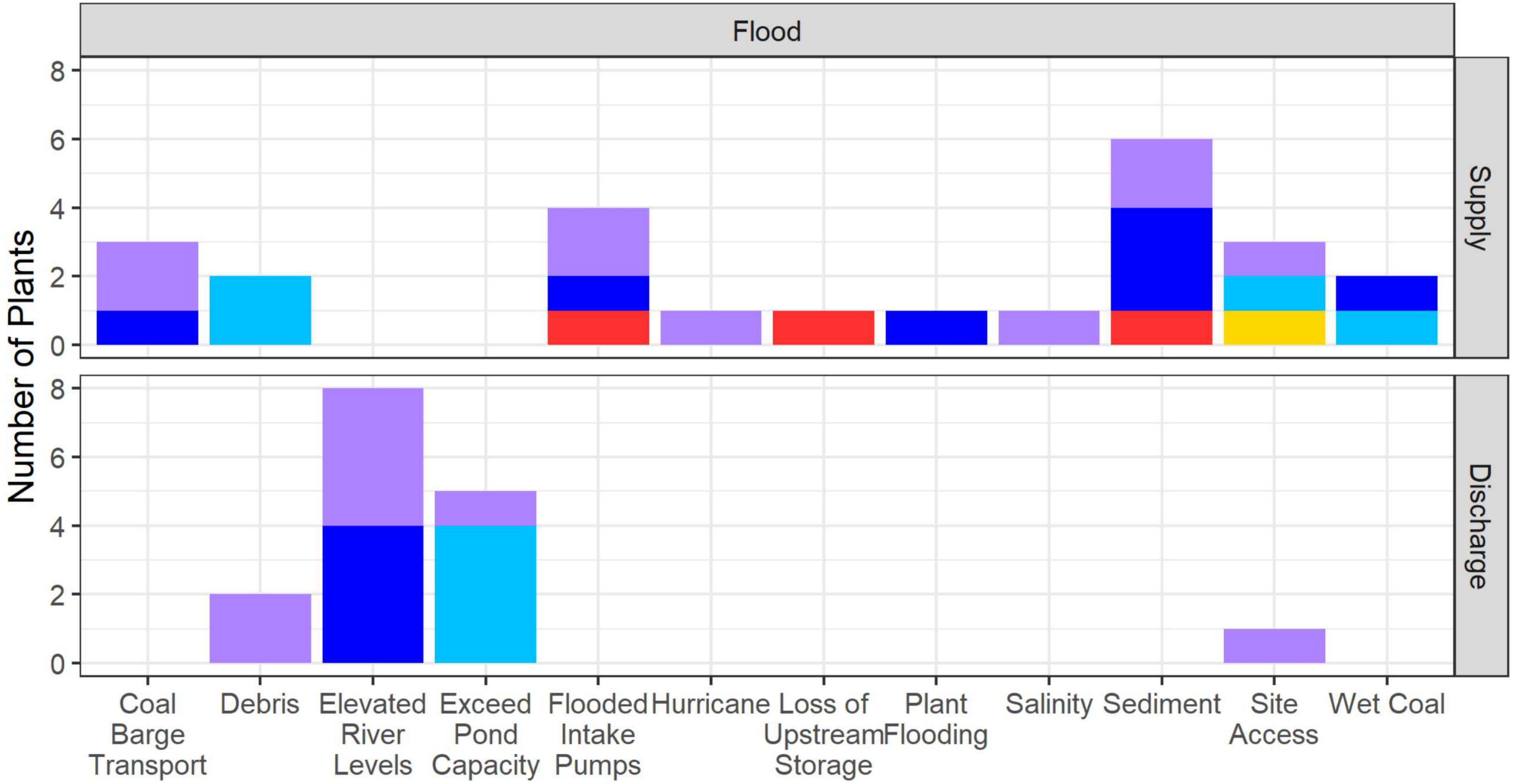


- In only 7 cases was no action taken
- 13 measures taken to manage supply
- Discharge-related drought impacts are usually not managed

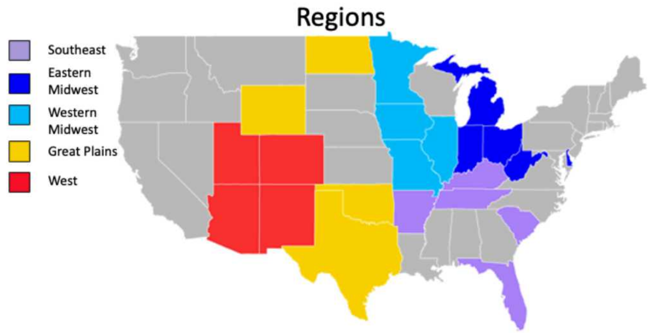


Results: Flood

Modes of Impact that Flood has on Water Supply and Discharge

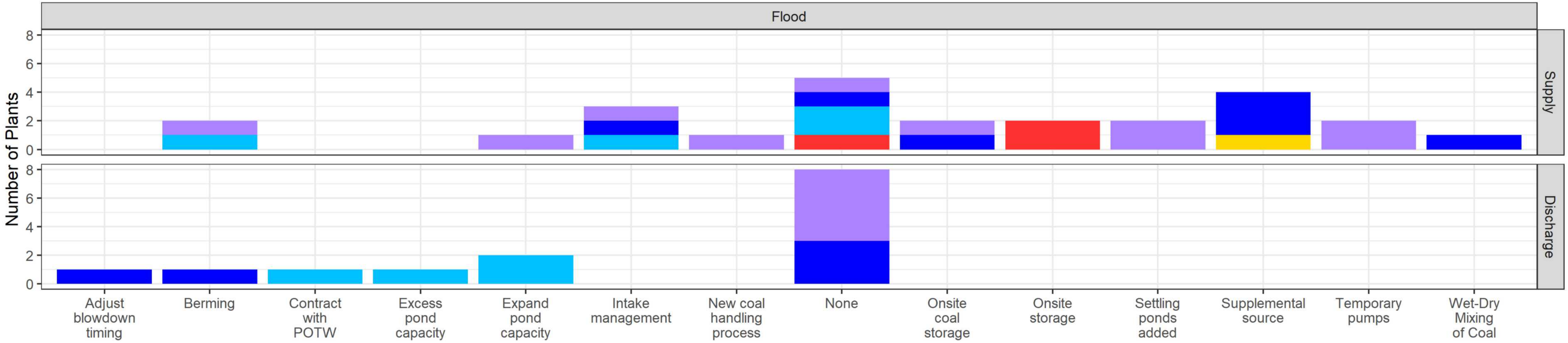


- 32 plants reported flood related threats
- 10 modes of impact on supply
- 4 modes of impact on discharge

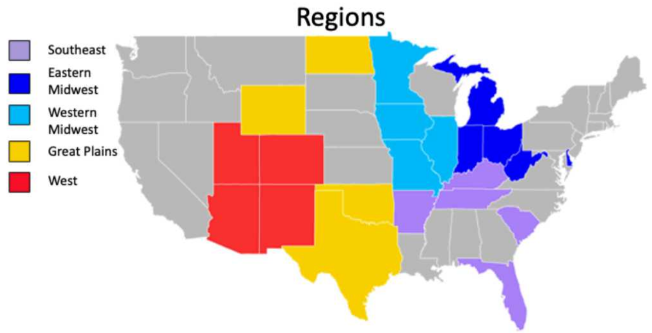


Results: Flood

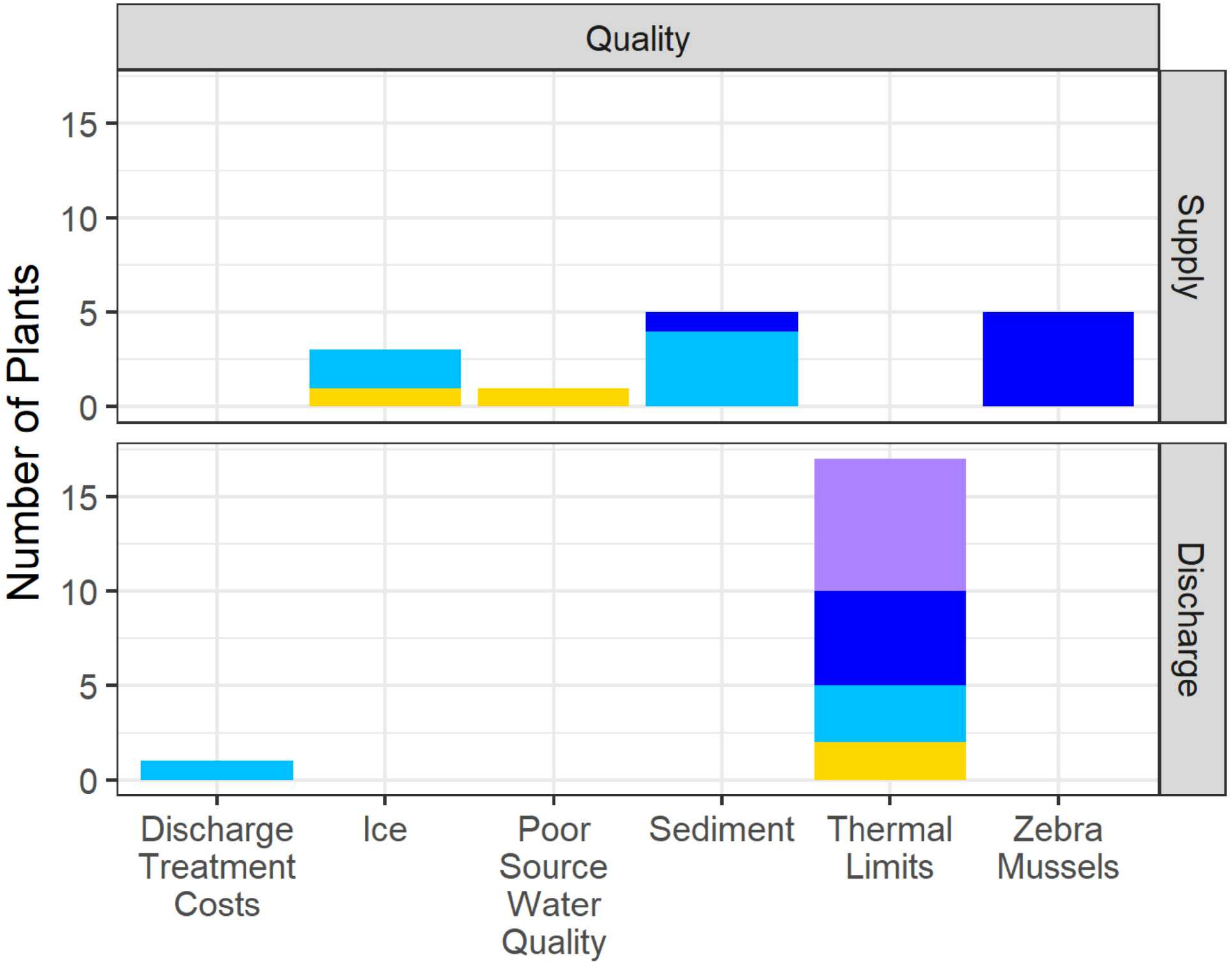
Mitigation Measures taken to Manage the Impact of Flood on Water Supply and Discharge



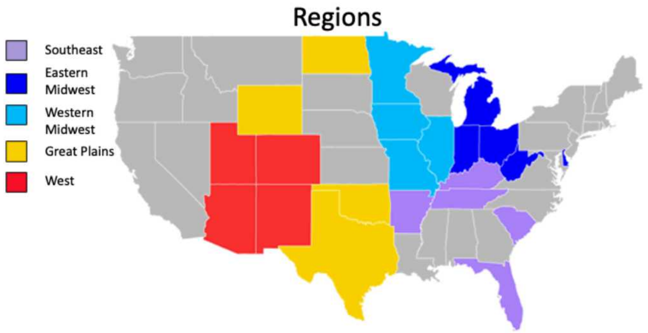
- In 13 cases no action was taken
- 10 measures taken to manage supply
- 5 measures taken to manage discharge



Modes of Impact that Water Quality has on Water Supply and Discharge

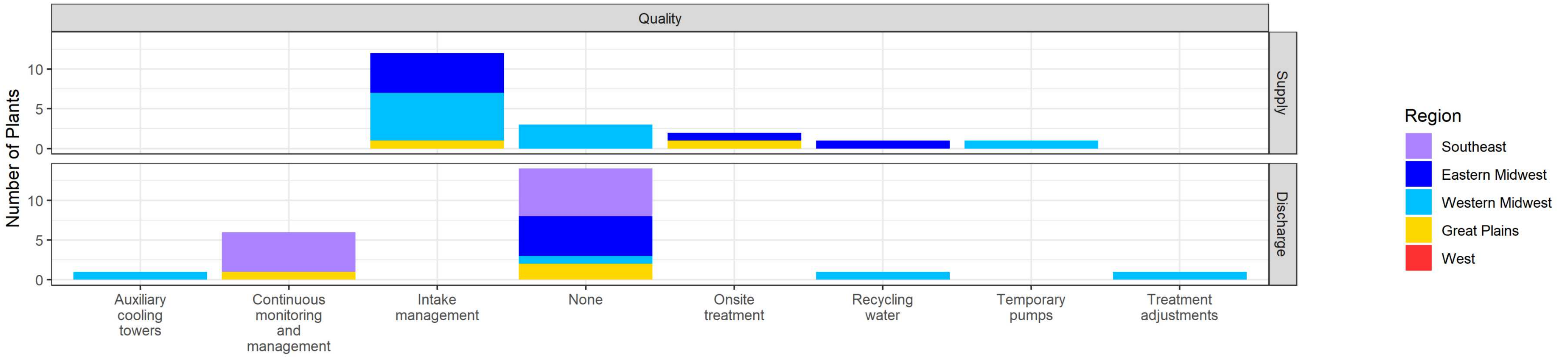


- 32 plants reported water quality related threats
- 4 modes of impact on supply
- 2 modes of impact on discharge

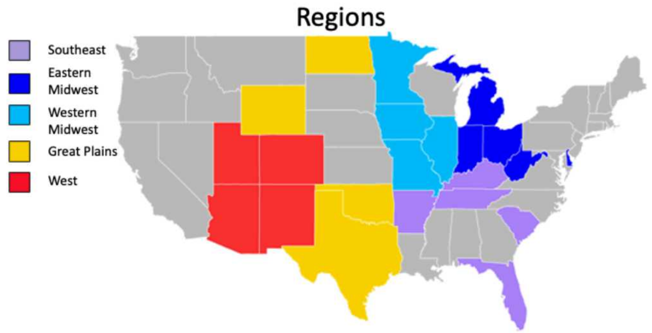


Results: Water Quality

Mitigation Measures taken to Manage the Impact of Water Quality on Water Supply and Discharge



- In 17 cases no action was taken
- 4 measures taken to manage supply
- 4 measures taken to manage discharge

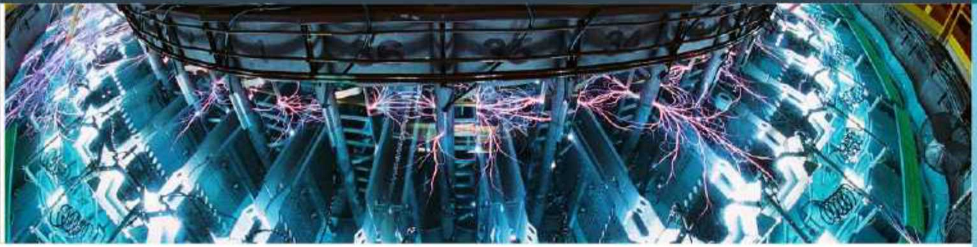


Take Aways

- Key information missing from the open literature:
  - Unique threats posed to plants due to their location and design (***25 unique modes***), and
  - Physical and managerial measures taken to mitigate threats (***115 measures across 69 plants***).
- Each plant is largely unique; however, some broad trends exist relating threats and actions taken.
- Value of such information:
  - Reduce misclassification of actual threat, and
  - Lower overestimation of impact without regard to mitigative measures taken.

Extension Projects



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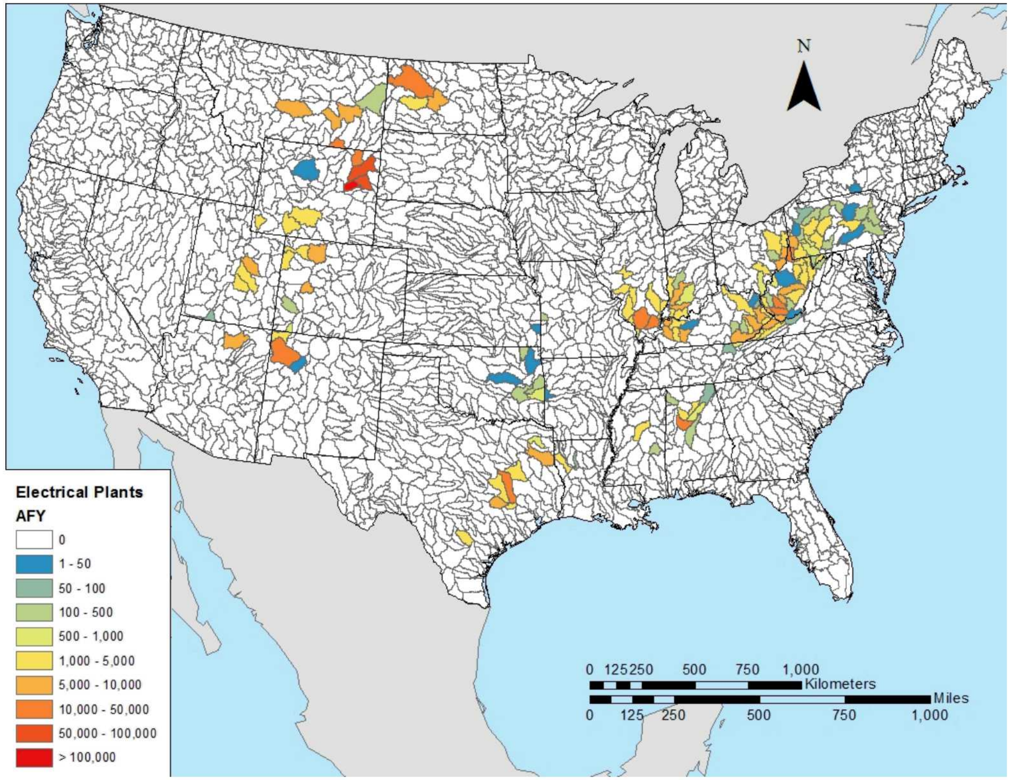
Upstream and downstream water use in the coal industry

- ***Compliment existing estimates of coal-fired power plant water use (withdrawal and consumption) with fuel and waste cycle water use data.***
- ***Build off past work from roughly 5 years ago.***
- ***Used USGS coal production data coupled with general water intensity values for coal mining.***

Coal Mining Water Use



Tidwell et al. 2016

Upstream and downstream water use in the coal industry

Coal Province	Percent of 2014 US coal production (%, energy basis)	Total estimated 2014 water consumption (m^3)	Estimated freshwater consumption (m^3/process GJ)
Northern Great Plains	39%	9.4×10^{6}	1.1×10^{-3}
Appalachia/Eastern	33%	1.3×10^{8}	1.8×10^{-2}
Interior	16%	4.2×10^{8}	1.2×10^{-1}
Gulf Coast	3%	4.3×10^{7}	5.8×10^{-2}
Rocky Mountain Region	8%	3.6×10^{7}	2.1×10^{-2}
US Total or Average		9.4×10^{8}	3.0×10^{-2}

Grubert and Sanders 2018

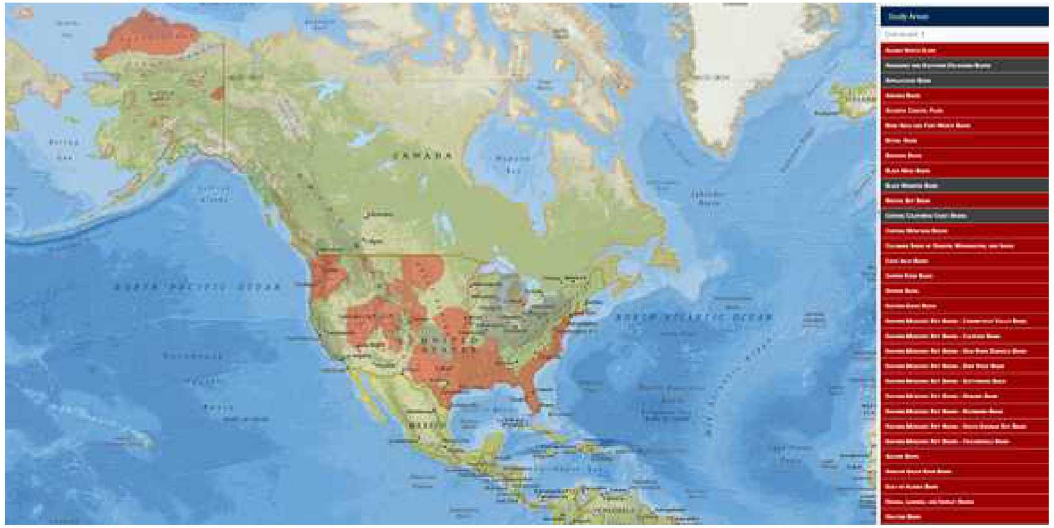
- *Update estimates using recently published data by Grubert and Sanders where additional data streams were used to improve water intensity estimates.*
- *Current limitation is that their analysis was limited to five regions instead of HUC8.*
- *As time permits will extend to coal processing and ash handling.*

Idea 2

Geologic storage coupled to energy development

- Energy production is becoming increasingly dependent on geologic storage for various waste streams.
- There is the potential for competition over deep saline aquifers:
  - CO_2 sequestration, and
  - produced water disposal.
- USGS has mapped out and estimated geologic repositories for CO_2 sequestration.
- There is a great deal of information on produced water disposal; however, it has not been compiled into a comprehensive database.

CO_2 Sequestration Database



USGS 2020

- Where might energy development be constrained by lack of storage?
- Where might CCUS and oil and gas compete for the same storage?

Geologic storage coupled to energy development

Oil and Gas Plays

- Here we propose to couple existing information on geologic storage for CO_2 and produced water together:
  - Saline aquifer disposal capacity,
  - Storage demand by fossil-fueled power plants, and
  - Storage demand for produced water.
- This would be a scoping level effort to identify available data and the level of effort required to complete the database and visualization interface.