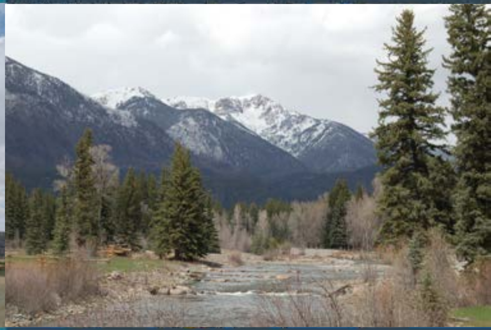


Water Atlas Extension




Vincent Tidwell, Thushara Gunda, Becky Jeffers

PRESENTED BY

Energy and Water Systems Integration 8825

Annual Program Review: Crosscutting Research

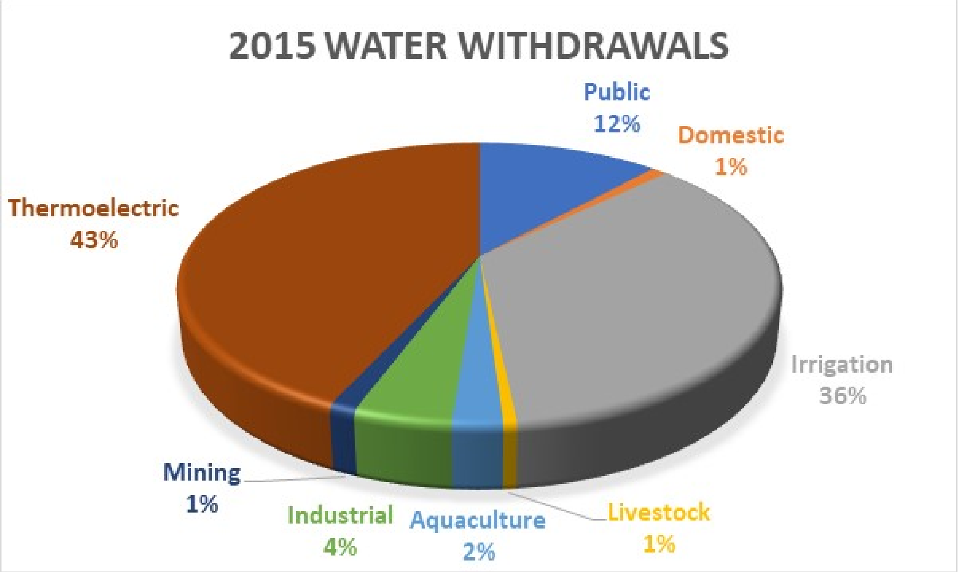
Pittsburg, PA April 9-11, 2019

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?
- 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.
- While power plants face a range of challenge from water extremes, contingency planning to mitigate these risks is not uncommon.
- Identification of such measures requires plant-level details not widely available in national databases.

Challenge

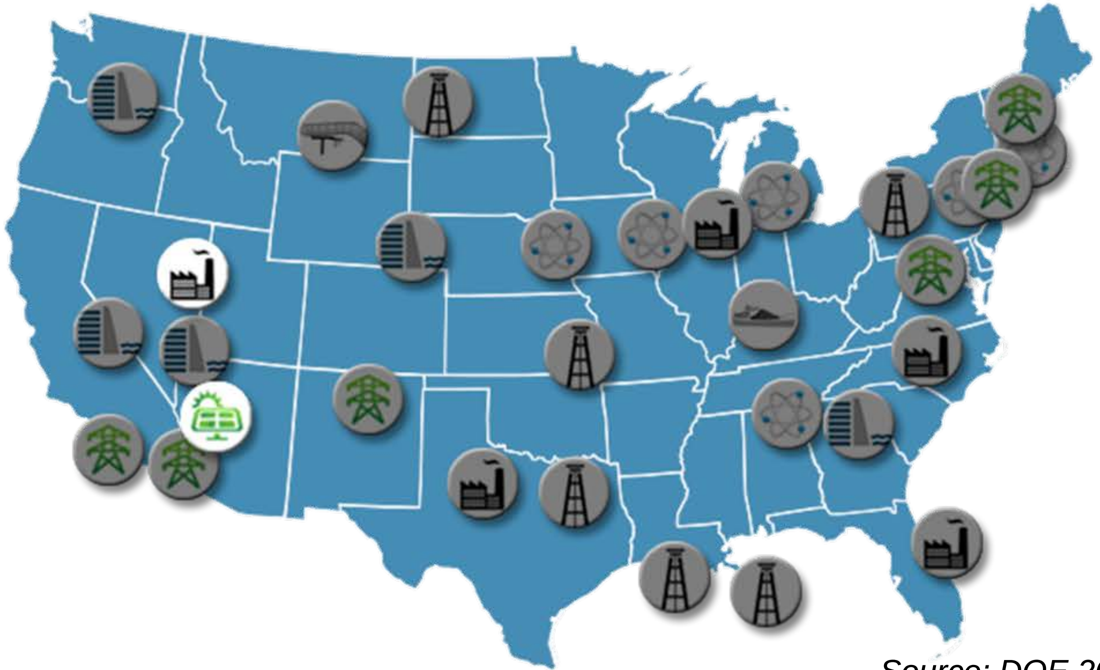
Thermoelectric energy production withdraws more water in the U.S. than any other use sector.



Source: USGS 2018

Energy-Water Nexus issues are playing out all across the U.S.

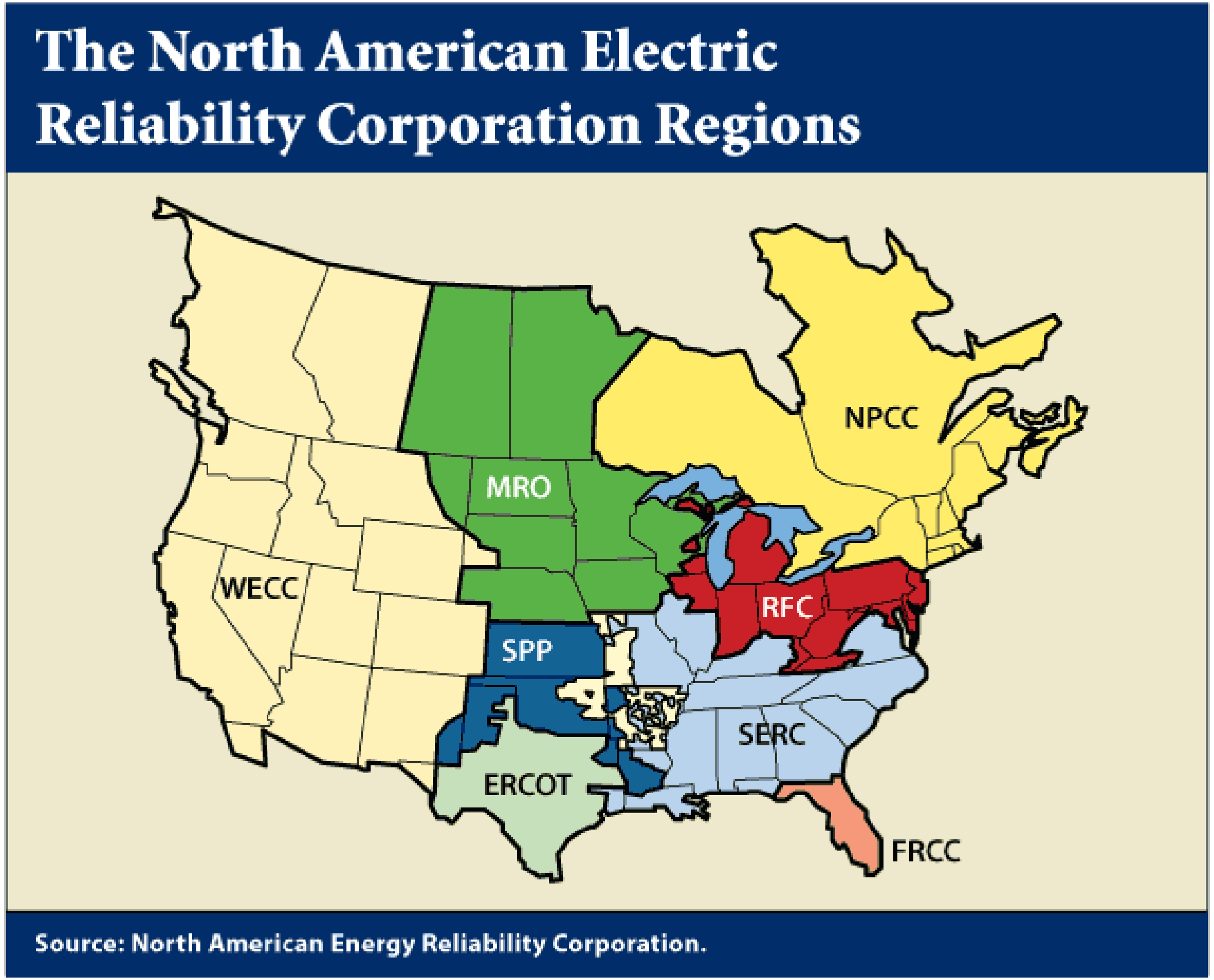
- Power plant outages
- Constrained hydropower
- Infrastructure damage by extreme events
- Curtailed energy resource extraction
- Permitting of New Facilities



Source: DOE 2013

Need

- Interconnections are conducting long-range transmission planning (20 yrs.)
  - Siting of new power plants
  - New transmission capacity
- Where will the next drop of water come from?



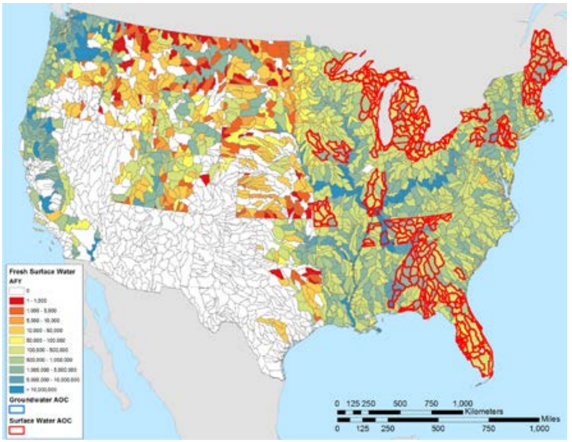
Objectives

- Map water availability for five alternative sources of water:
  - Fresh Surface Water,
  - Fresh Groundwater,
  - Appropriated Water,
  - Brackish Groundwater, and
  - Wastewater.
- Data should consider both physical and institutional constraints on water development. In fact, data should be collected directly with help of state water management agencies.
- Map water cost and future use.
- In all cases map metrics at high spatial resolution, 8-digit HUC, or roughly 2250 watersheds.
- Complete mapping for *Hawaii* and *Alaska.*

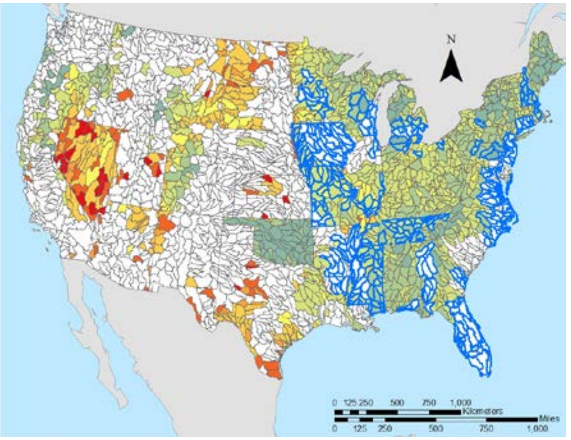
Water Supply Availability

- 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.

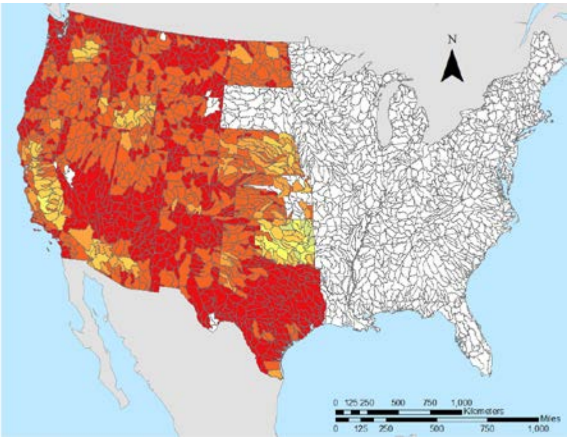
Fresh Surface Water



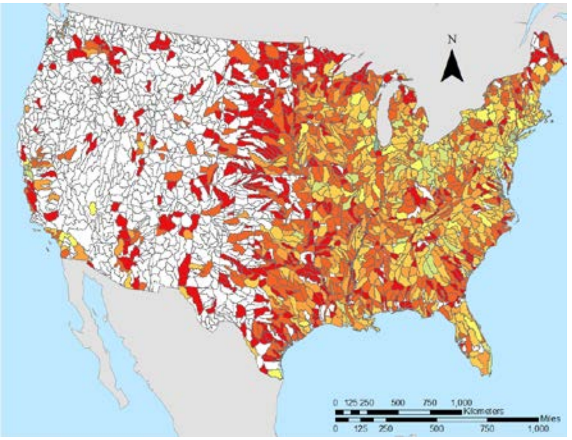
Fresh Groundwater



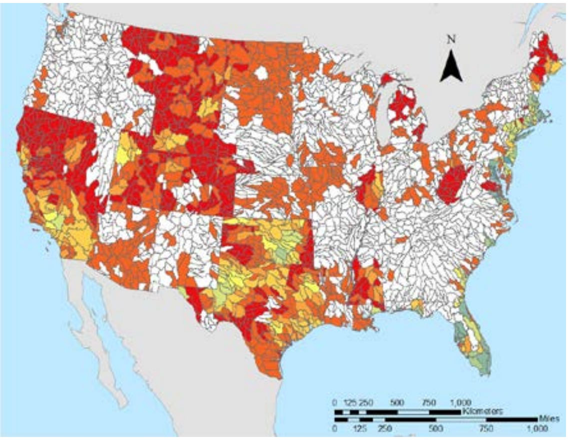
Appropriated Water



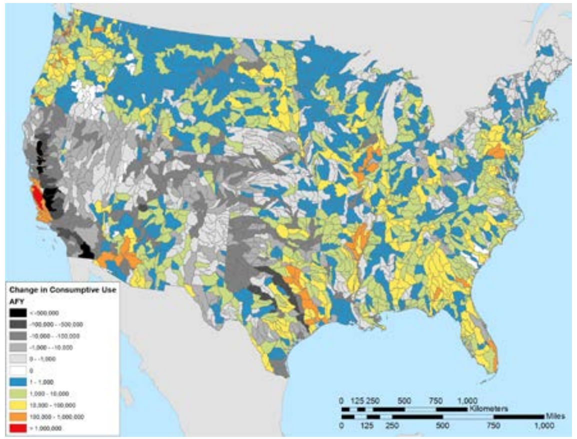
Municipal Wastewater



Brackish Groundwater



Consumptive Demand 2010-2030

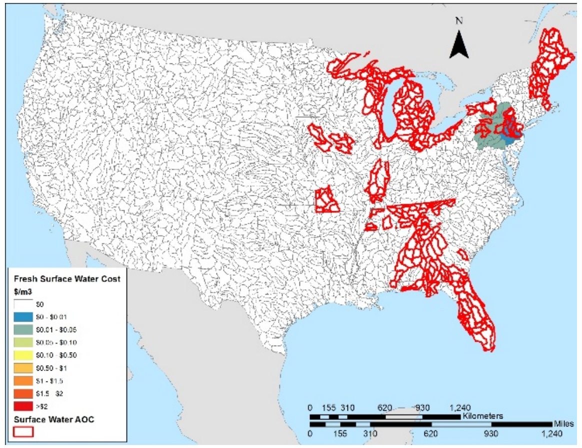


Source: Tidwell et al. 2018

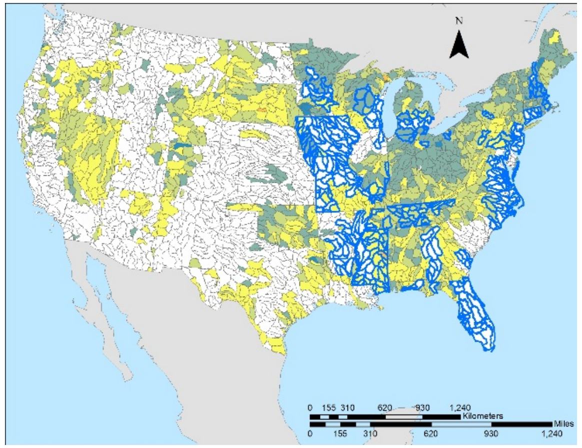
Water Cost

- 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.

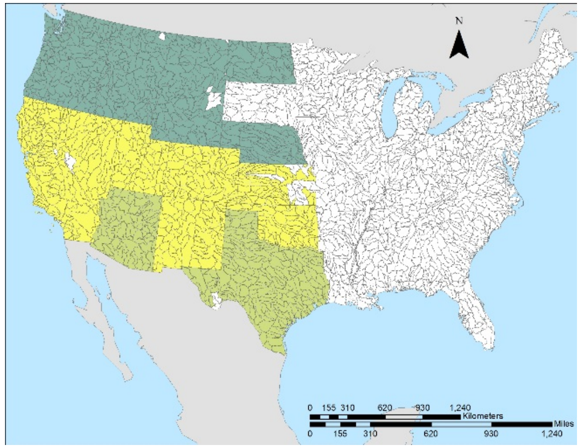
Fresh Surface Water



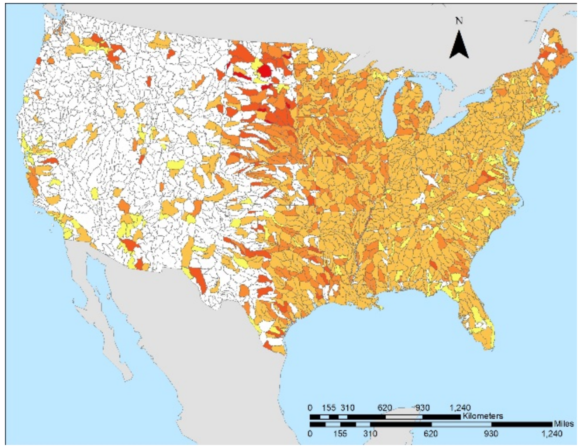
Fresh Groundwater



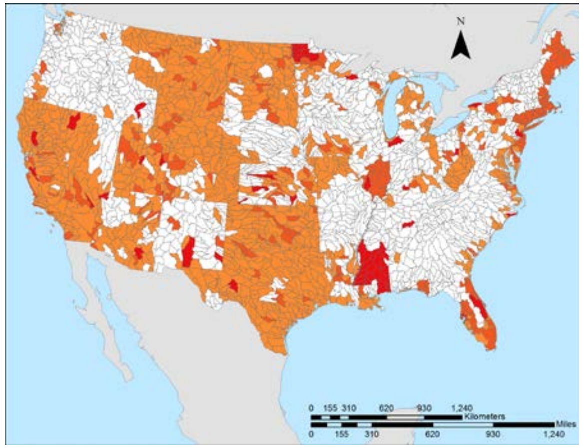
Appropriated Water



Municipal Wastewater



Brackish Groundwater

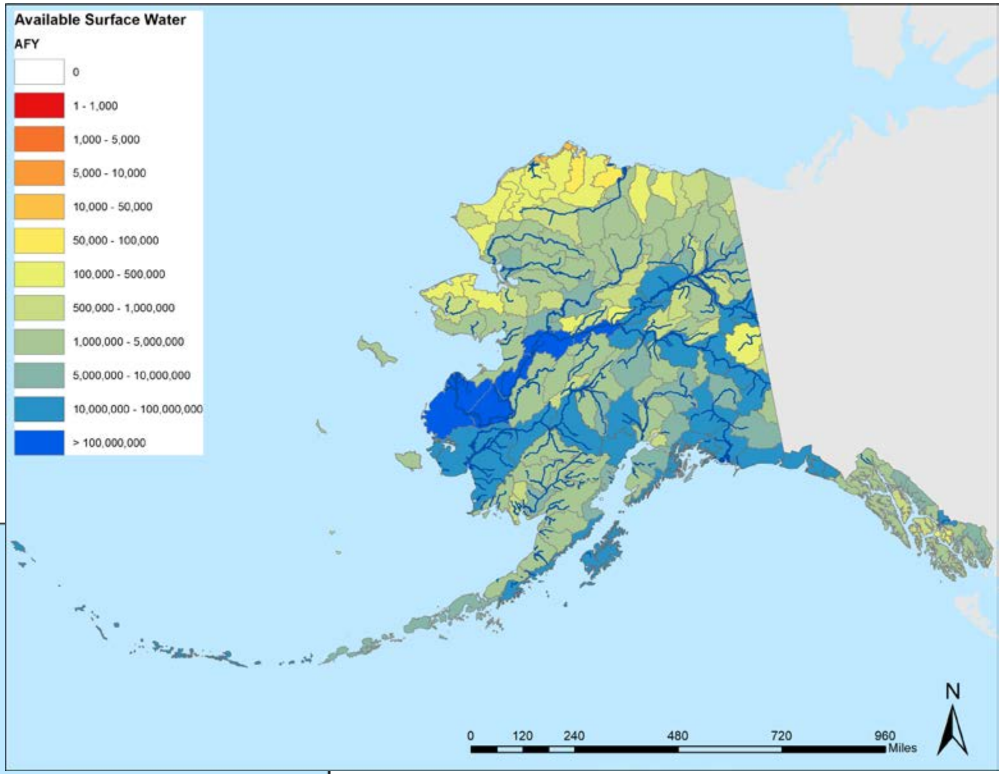


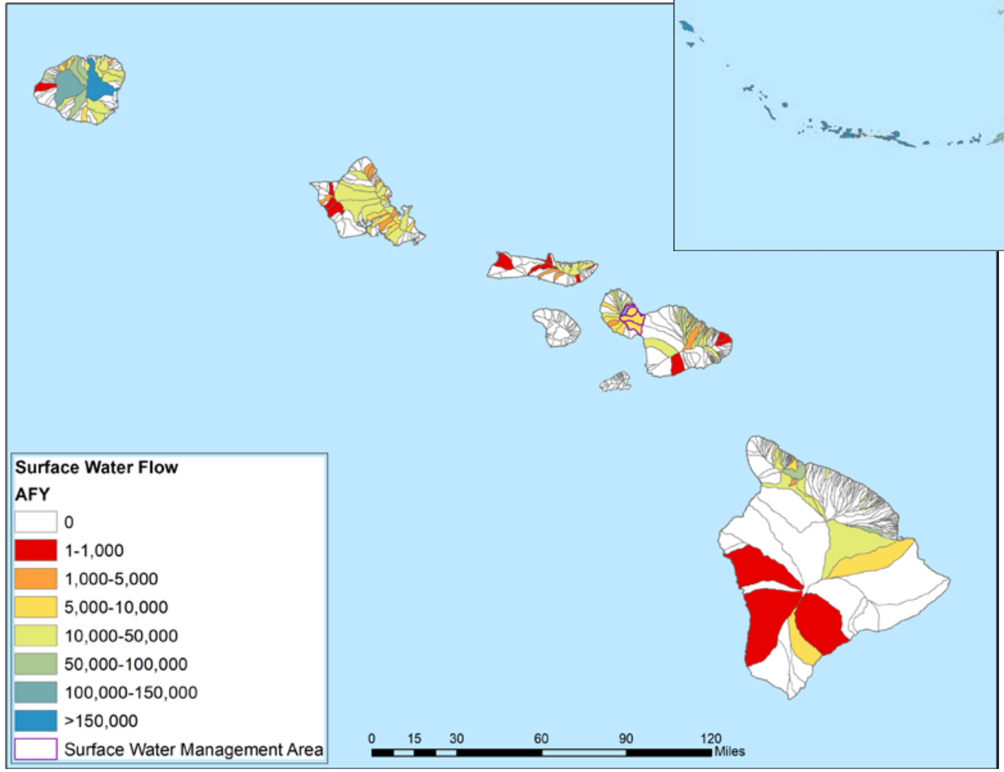
Source: Tidwell et al. 2018

Water Availability: Fresh Surface Water

- Surface water beyond current use that is available for new development.
- Based on environmental constraint:

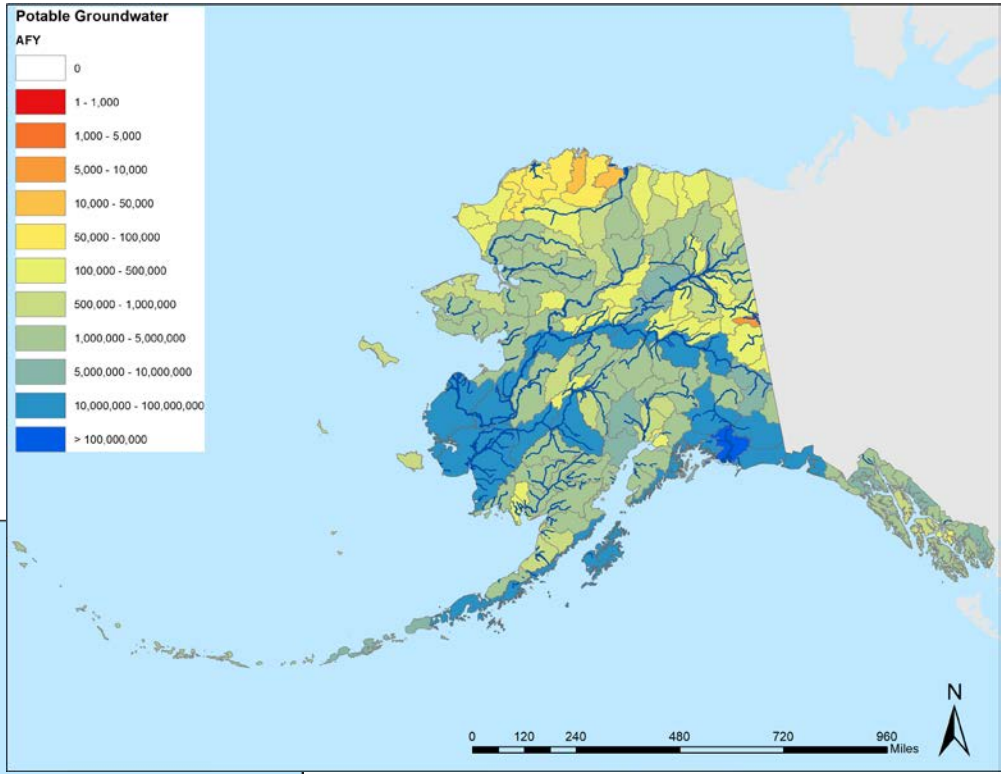
$$Q^{j}_{sw} = 0.5 * \left(Q^{j}_{p} + C^{j}\right) - C^{j}$$

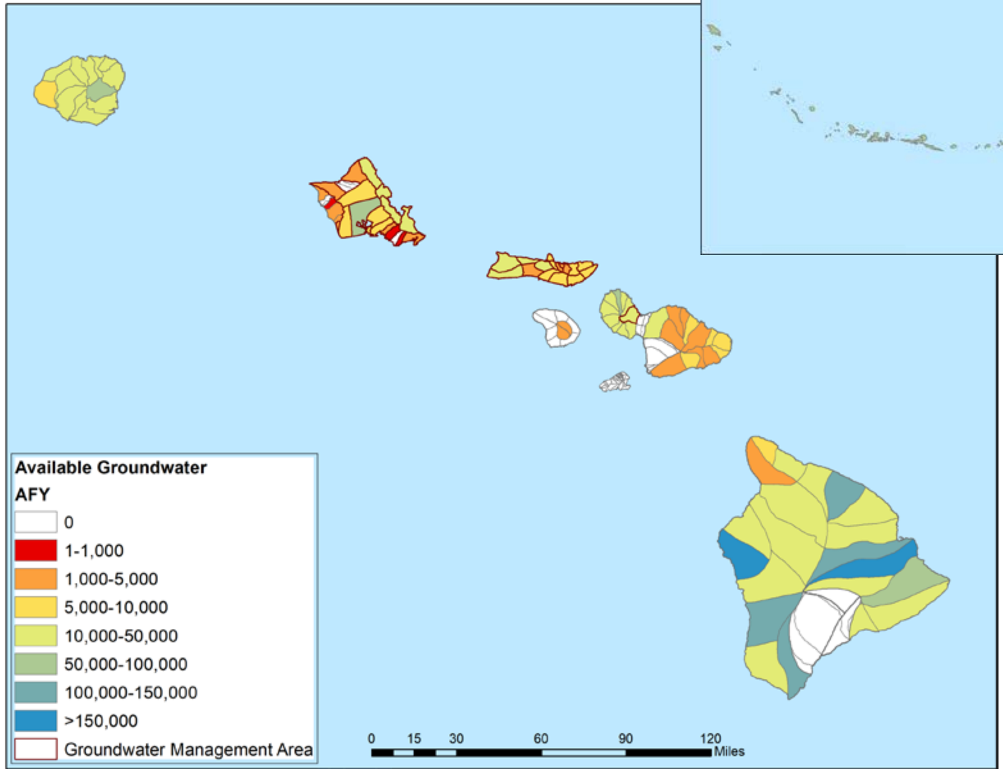




Water Availability: Fresh Groundwater

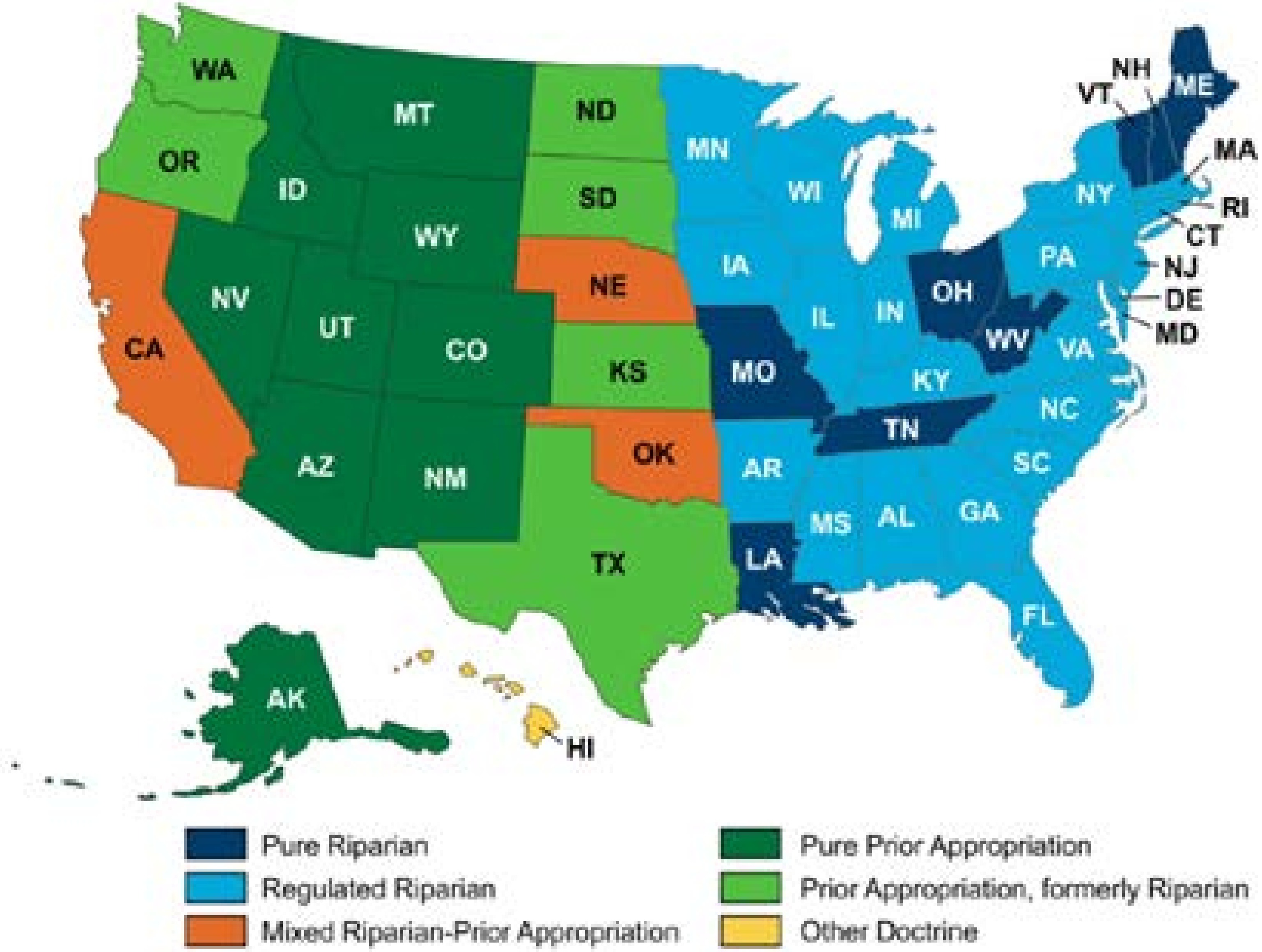
- Groundwater beyond current use that is available for new development.
- Difference between sustainable recharge and pumping while considering:
  - Areas of overdraft, and
  - Principle aquifers.





Water Availability: Appropriated Water

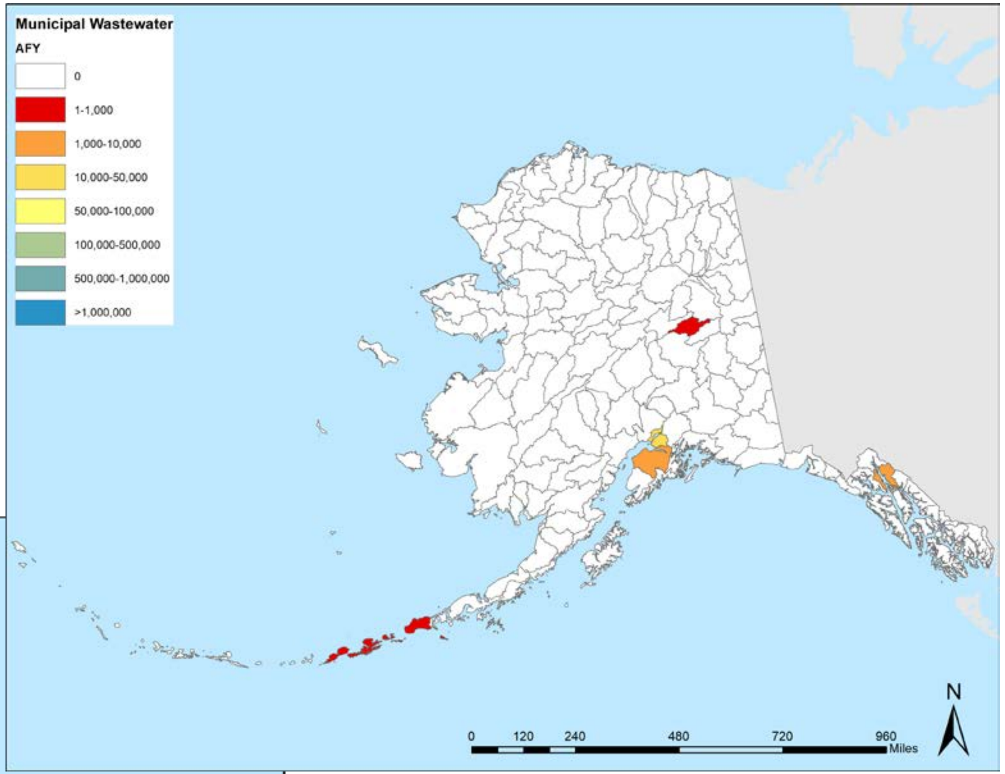
- Water potentially available for transfer from one use to another (generally agriculture to municipal or industrial use)
- Limited to 5% of irrigation demand in any watershed based on feedback from state water managers.

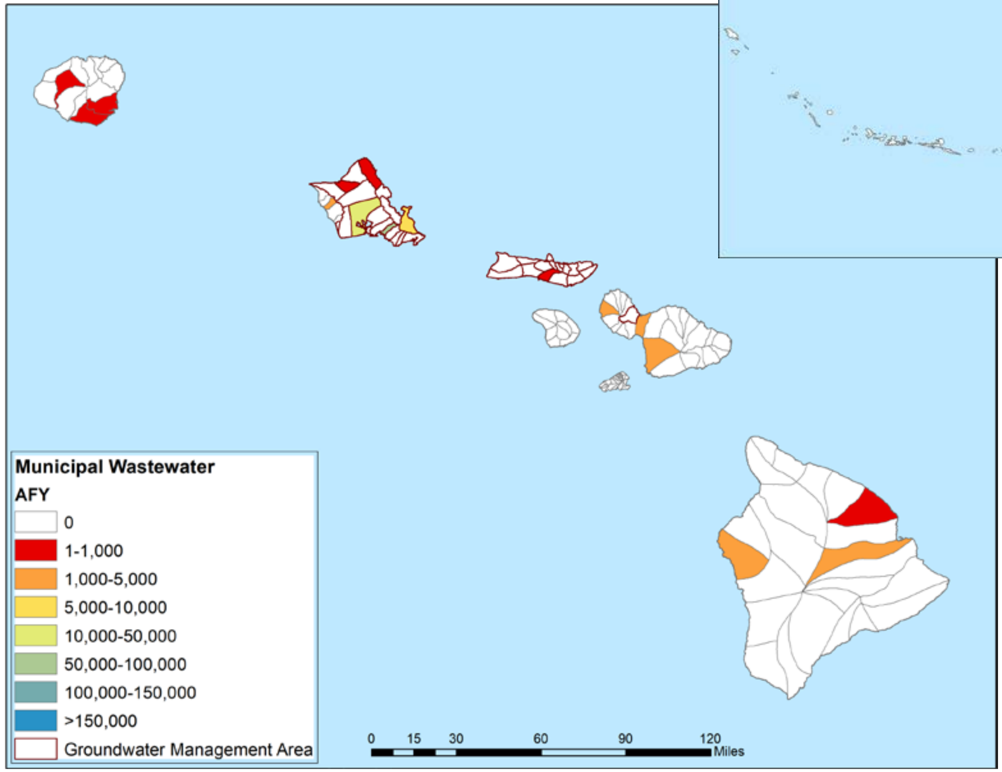


Source: DOE 2014

Water Availability: Wastewater

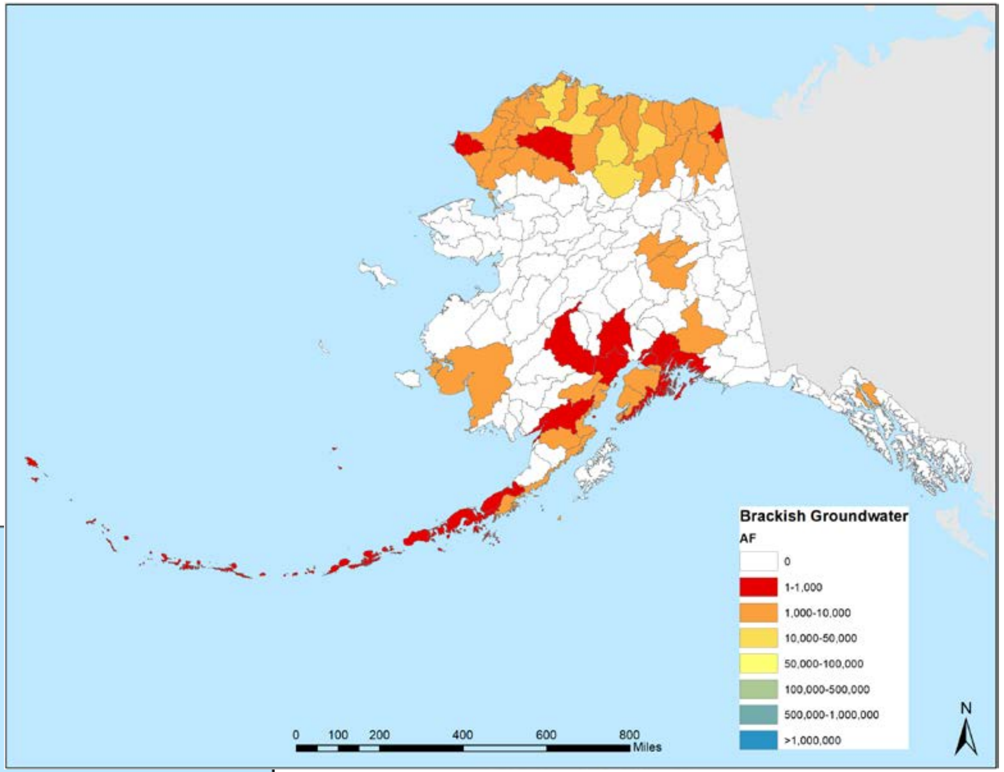
- Projected future wastewater (2030) available for re-use.
- Considers wastewater currently being reused.

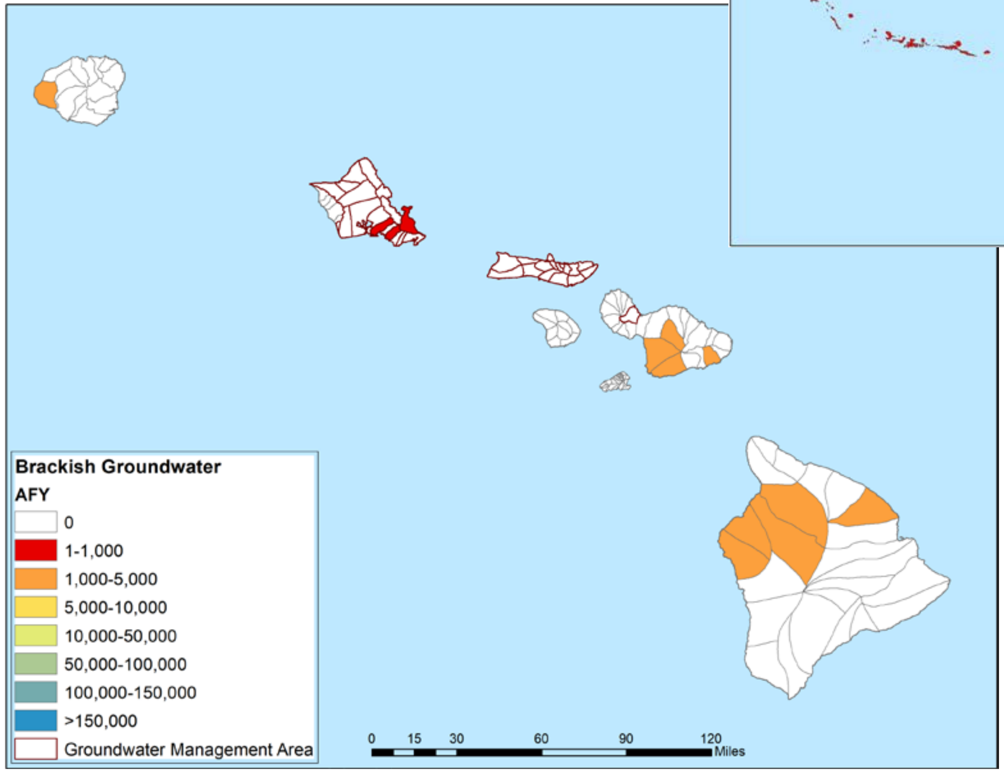




Water Availability: Brackish Groundwater

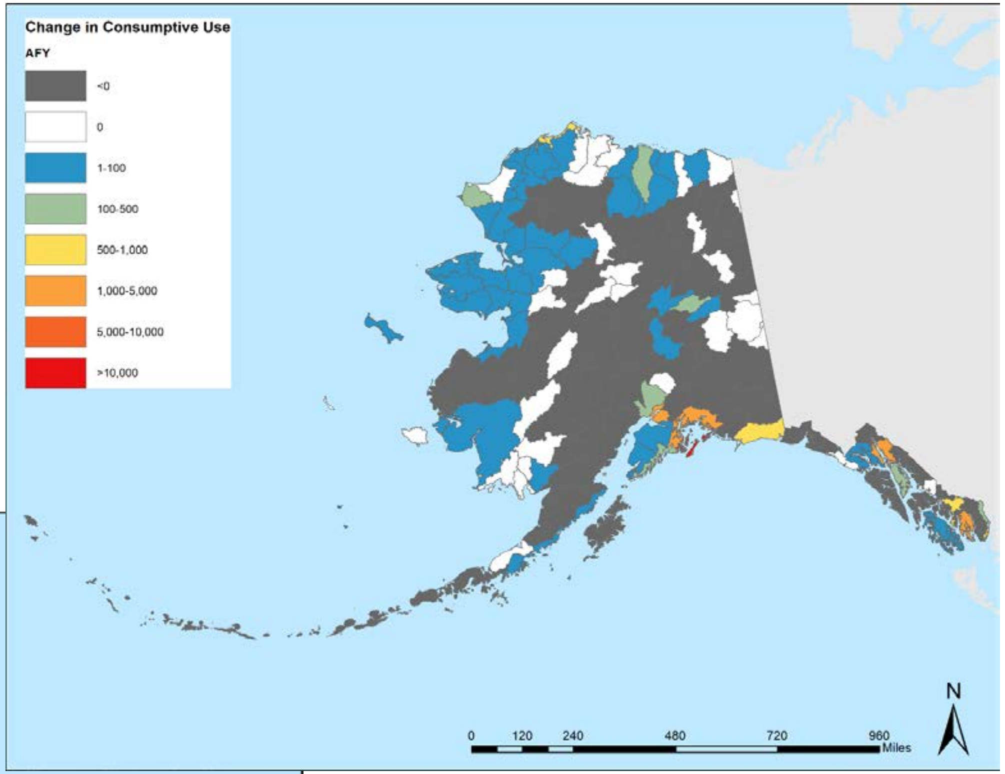
- Brackish water defined by salinities between 1,000 and 10,000 ppm TDS no deeper than 2500 ft.
- Estimates are data limited based on:
  - Current brackish water use, and
  - USGS well logs that indicated brackish water availability.

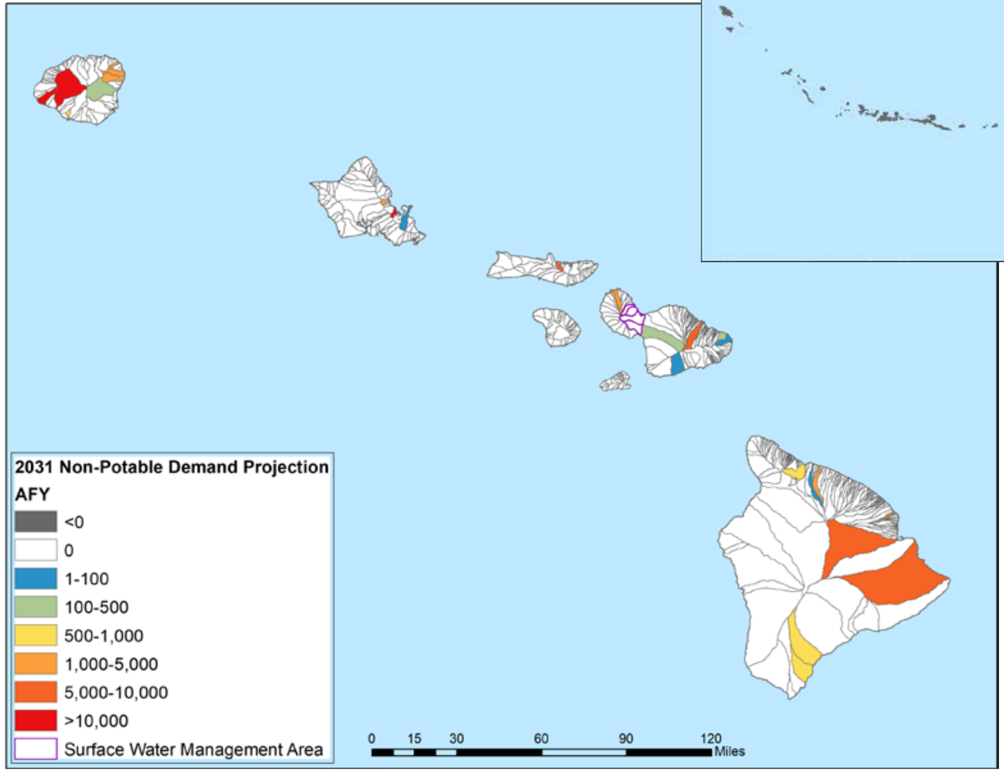




Projected Future Use 2010-2030

- Water needed for development after 2010.
- Based on estimates directly from states.
- Does not include thermoelectric water demand.



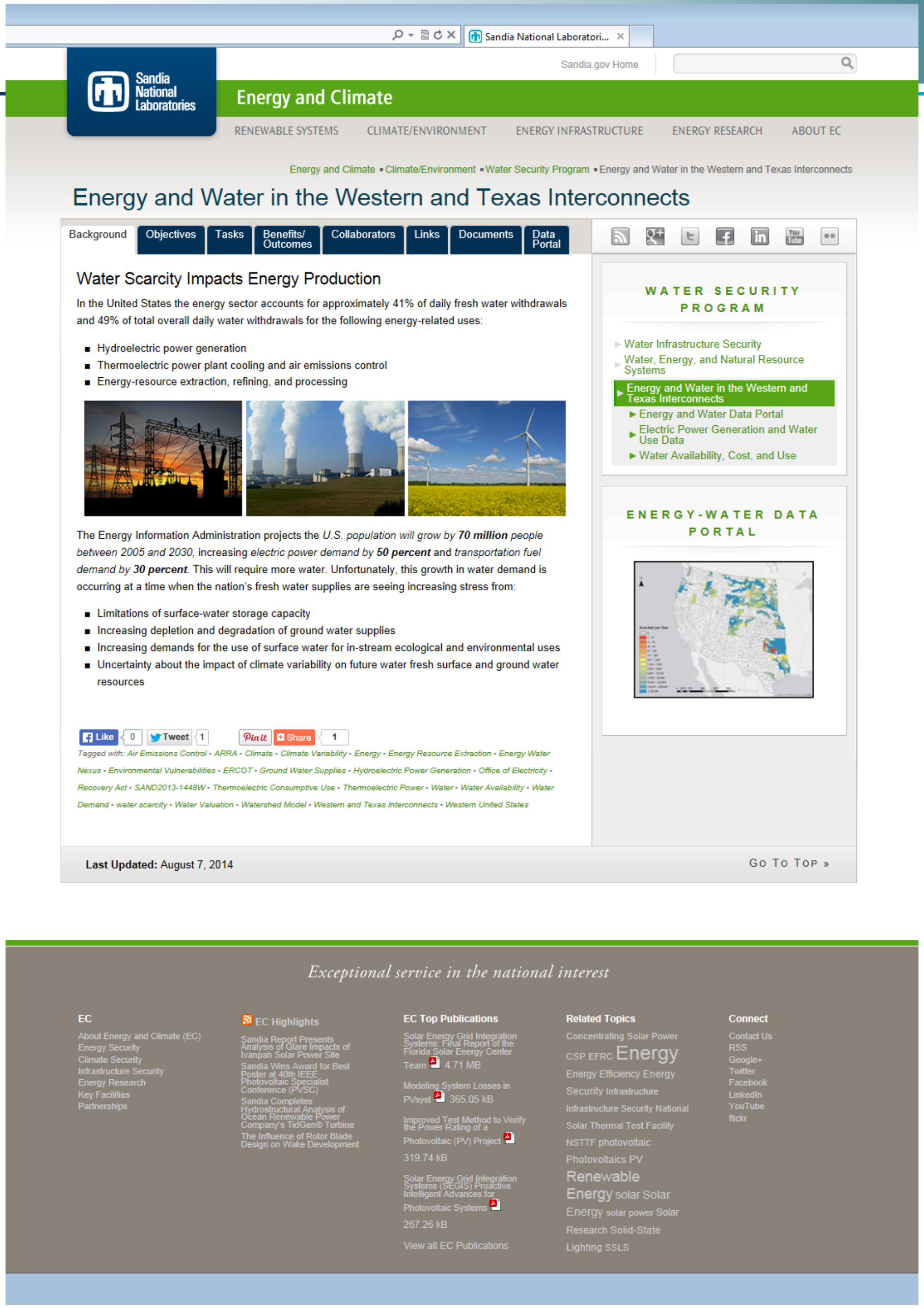


Non-Potable Demand Projection

Data Access

Project data available at:

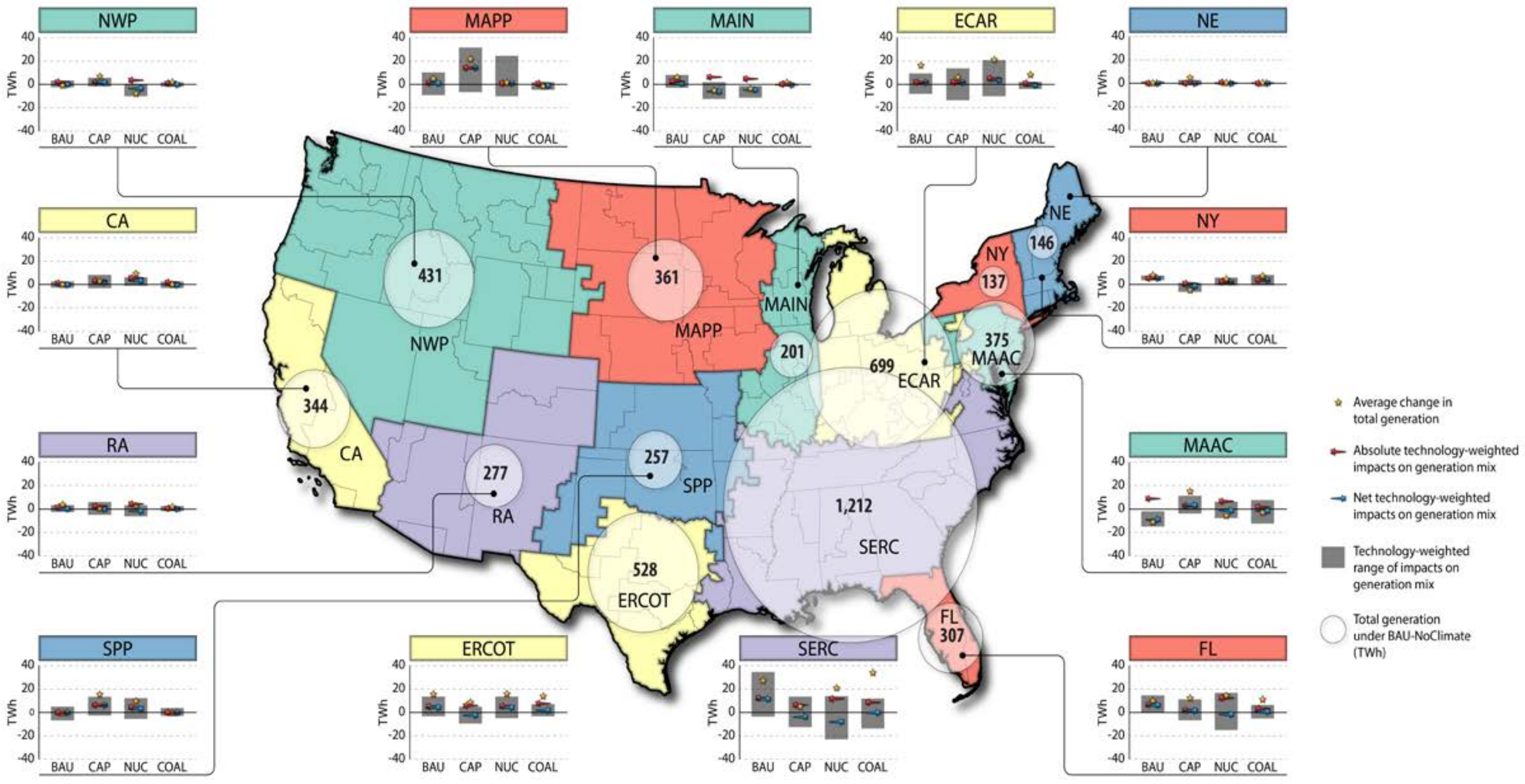
http://water.sandia.gov



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

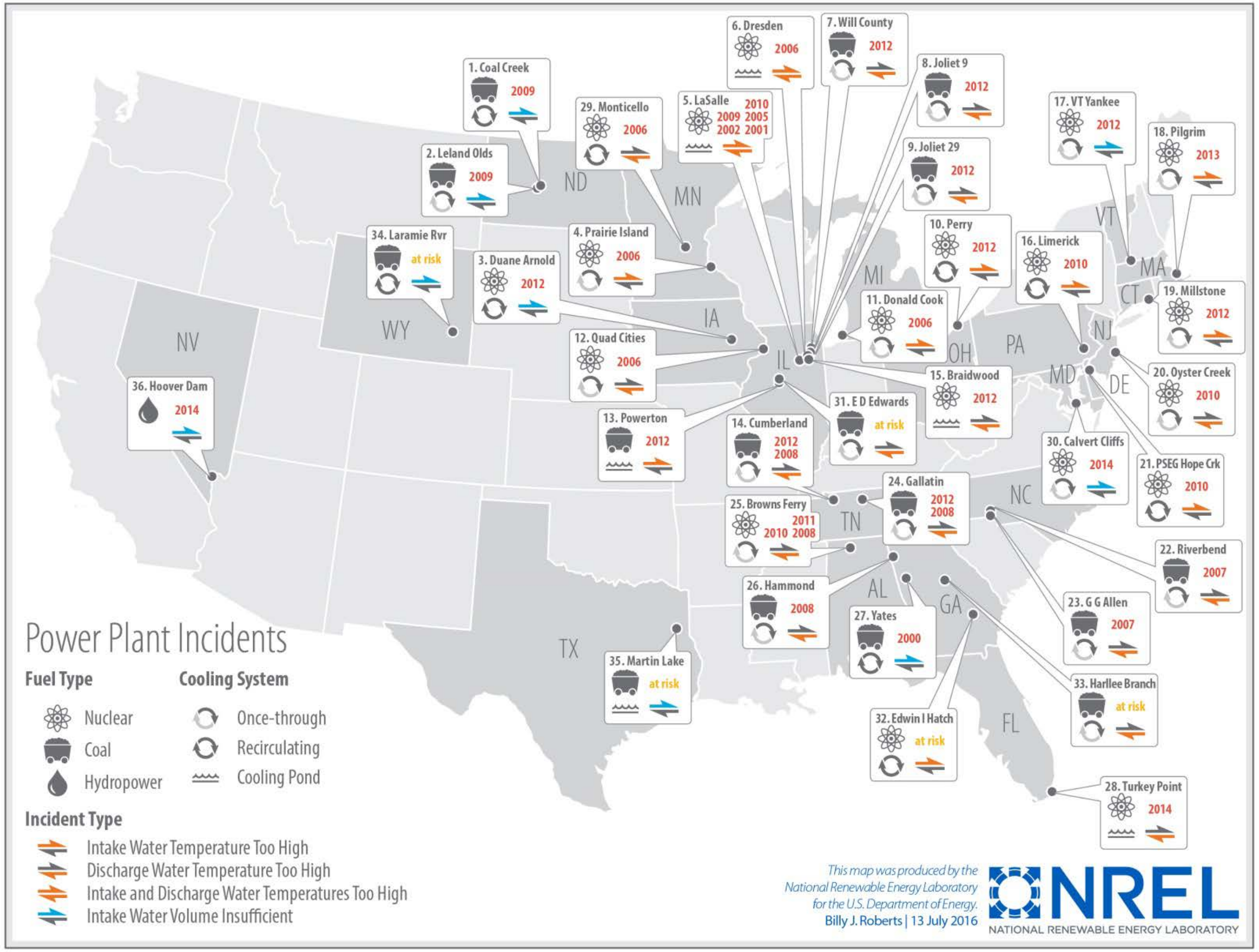
NREL
Regional Energy Deployment System Model
(ReEDS)



Source: Cohen et al. in review

Challenge

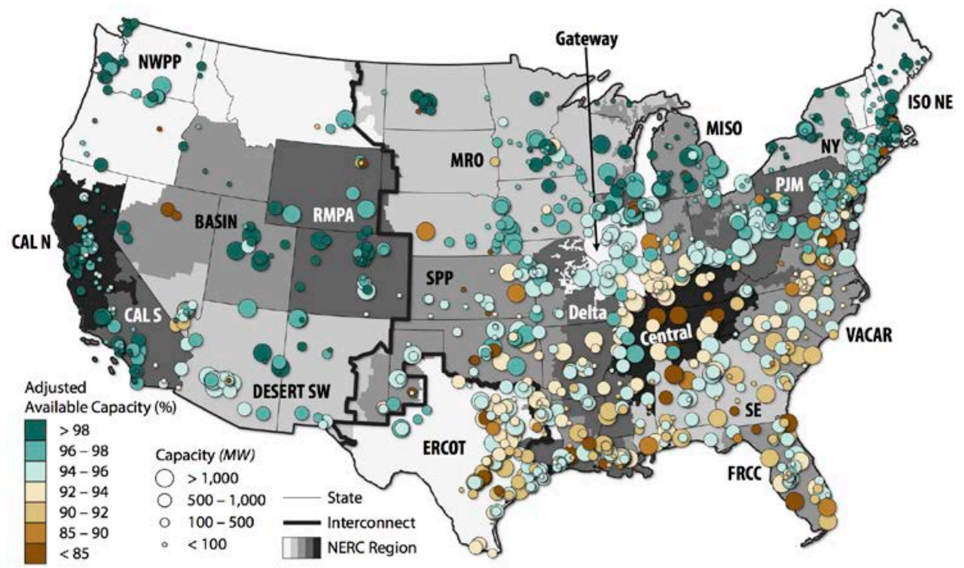
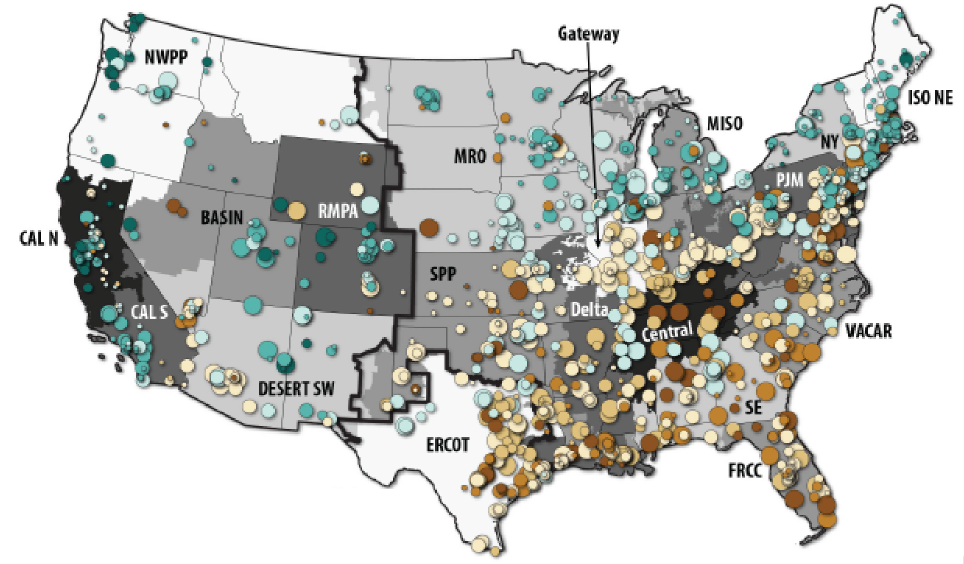
- Thermoelectric power plant operations have been impacted by water extremes:
  - Insufficient water supply,
  - Thermal loading of cooling water discharge, and
  - Flooding (not shown in figure).



Source: McCall et al. 2016

Need

- Project how changing climate and energy demands could intensify impact on power plant operations
- Current analyses fail to consider contingency planning at the power plant level
- Such data is not broadly available.

<table>
<tr><td></td><td>Climate-Water Impacts Without
Power Supply Systems Context:
Adjusted Available Capacity (AAC)</td></tr>
<tr><td>Current Climate</td><td>
</td></tr>
<tr><td>Future Climate</td><td>
</td></tr>
</table>

Source: Miara et al. 2018

Objective

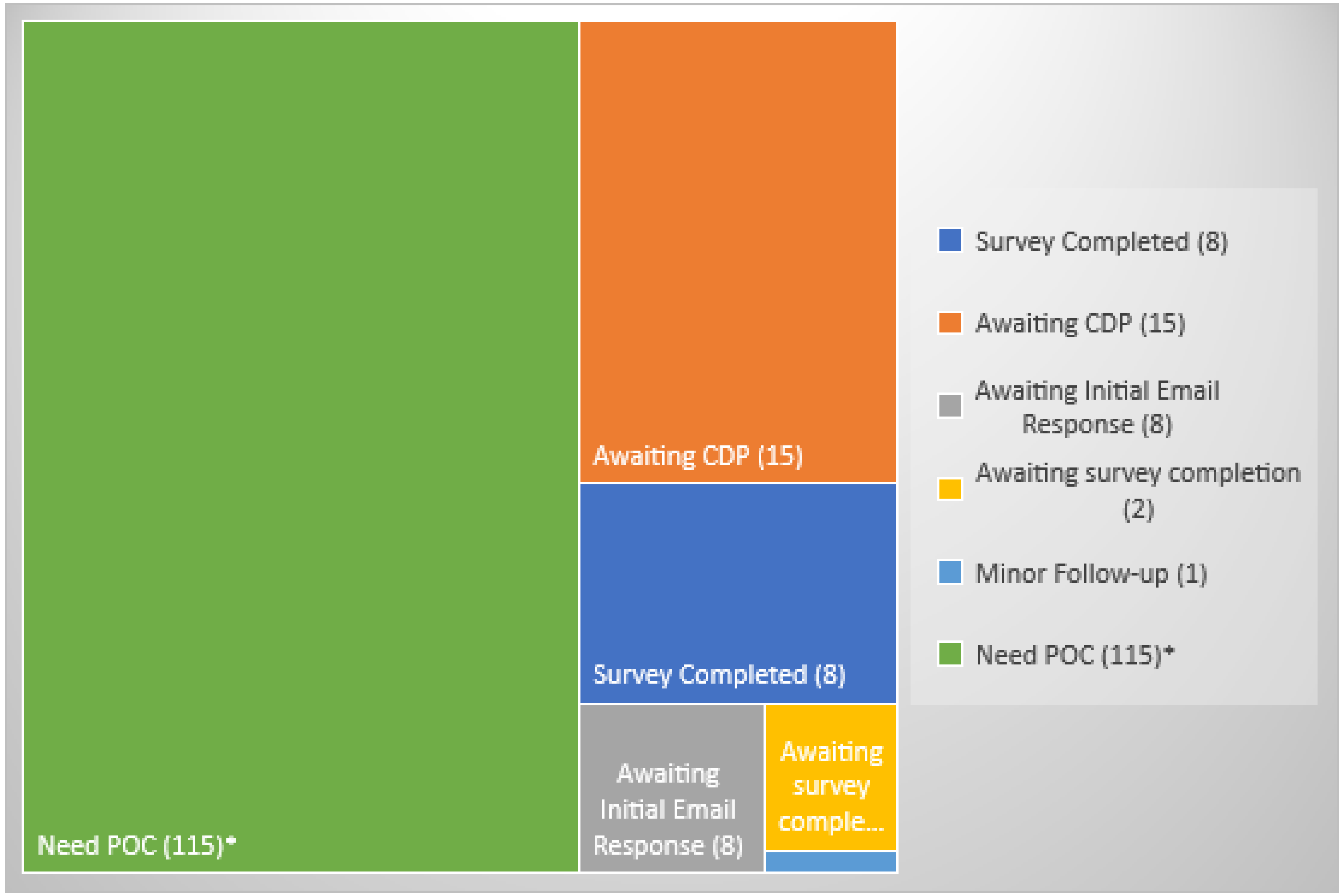
- Conducting interviews with individual power plant/utility environmental managers to collect data:
  - Water supply risks,
  - Water discharge risks, and
  - Company culture.

Metadata	**Fuel**	Coal	Coal	Coal
	Number of Units	2	3 (one owned by PacifiCorp)	3
	Generation Capacity (MW)	2269.6	1128.8	2409.3
	Location (lat/lon; state)			
Availability	**Water Source (type, %)**	Surface water (100%)	Groundwater (100%)	Surface water (100%)
	Water Source (name)		Lake Wells	
	Annual Water Withdrawal (MGD)	0	11.3	1.7
	Water Permitting Requirements (State-level, municipality, other provider?)	State: rights associated with (a mining entity) and are allocated to as the operator	None. Not as regulated as in other counties because it is "beneficial use"	State
	Drought-related Constraints? (env flow, river operations, other users, power plant efficiency; gw: drawdowns) Frequency?	Semi-senior in water rights. Definitely had a perceived vulnerability there that prompted the contingency plan with the – in 2004, a fear that the water supply would be significantly reduced because of the multi-year drought. Didn't actually have a reduction but was close to it. So in 2005, put together the plan. Was in direct response to a real threat. Also, when state put together the sharing agreement in place as well. Never actually had to use the contingency plan water.	Built on the most prolific aquifer in the state of so no real supply challenge there except self-induced: Had a relationship with an ag company for many years, leased their wells. In 2007, lease was set to expire and farmer wanted more $ and company tried to condemn his property and take over his wells, which didn't go over so well. So ended up drilling own wells on own land to replace the ag wells – water belongs to them.	Senior water rights (no real water issues here). Had an allocation from the Dept of interior to use 32K ac-ft/yr so the well was drilled to a certain depth and was deepened to below that pool so even if Lake was drained to Deadpool, then plant would still have ability to withdraw water from Deadpool area
	Flood-related constraints? Frequency?	None known	None known	None known
	Water quality-related Constraints? (thermal, biological, salinity, etc.)	None that impact plant operations	Wells have varying water quality, higher quality wells typically operated as the priority	None that impact plant operations
	Cost considerations for water availability (purchasing rights, etc.)?	After the shutdown of Units 1-3, released the contingency agreement that had been put in place with the	Groundwater rights in this area of the state are for beneficial use so there are no GW rights to purchase.	Adequate supply for plant operation
	Peaking vs constant load considerations?	Adequate supply to accommodate 100% power operation	Adequate supply to accommodate 100% power operation	Adequate supply to accommodate 100% power operation
	Mitigation Strategies	Used to have a contingency plan of having an option with the but shut down 3 of their units (25% of capacity) so no longer need the contingency option. Still have a shortage agreement with users in that area so they have an advanced understanding of their concerns including their likelihood of concerns – worked with resource planning folks to get a look at the right thing to do.	Wells are close to river – general stream adjudication is still a concern for them if gw wells are deemed to be pumping subflow. So signed an agreement with local city to get a transfer to sw rights (purchased for a price) – haven't fully executed it because adjudication hasn't gotten that far yet but can be executed if needed. Gw declines were seen so did a lot of modeling of pumping in the aquifer – have shut down unit 2 at Cholla and capacity factor has reduced at the power plant – have also made a committment to burn no more coal by 2025. So now going from 20K ac-ft to 12K ac-ft with no unit 2 and by 2025, will have secured the plant (Bob doubts they will do anything up there because natl gas would have to go through tribal lands).	2019 scheduled shut down
Discharge	**Cooling Technology**	Recirculating (Once through Cooling with pond)	Complex/Recirculating	Recirculating
	Any Storage/Cooling Ponds on-site?		On site cooling pond	
	Discharge Permitting Requirements (State-level; temps, etc.)	Discharge permit for blowdown to Wash	Discharge to ash ponds	
	Drought-related Constraints? (env flow, river operations, other users, power plant efficiency; gw: drawdowns)? Frequency of issues?	Shortage Sharing agreement in place with all users in the area.	None	
	Water quality-related Constraints? (thermal, biological, salinity, etc.) Frequency of issues?	Discharge regulation on both temperature and TDS	None	
	Cost considerations for discharges (derating, etc.)?	None	None	
	Peaking vs constant load considerations?	None	None	
	Mitigation Strategies	None	None	
	How does coal ash management influence water operations at the site?			
	Other	Company also engages with engage with different workgroups and agencies located in the state – has been on Governor's Water Augmentation Council, State Desal		
Sources	**Metadata**			
	Availability			
	Discharge			
	Miscellaneous			

Process

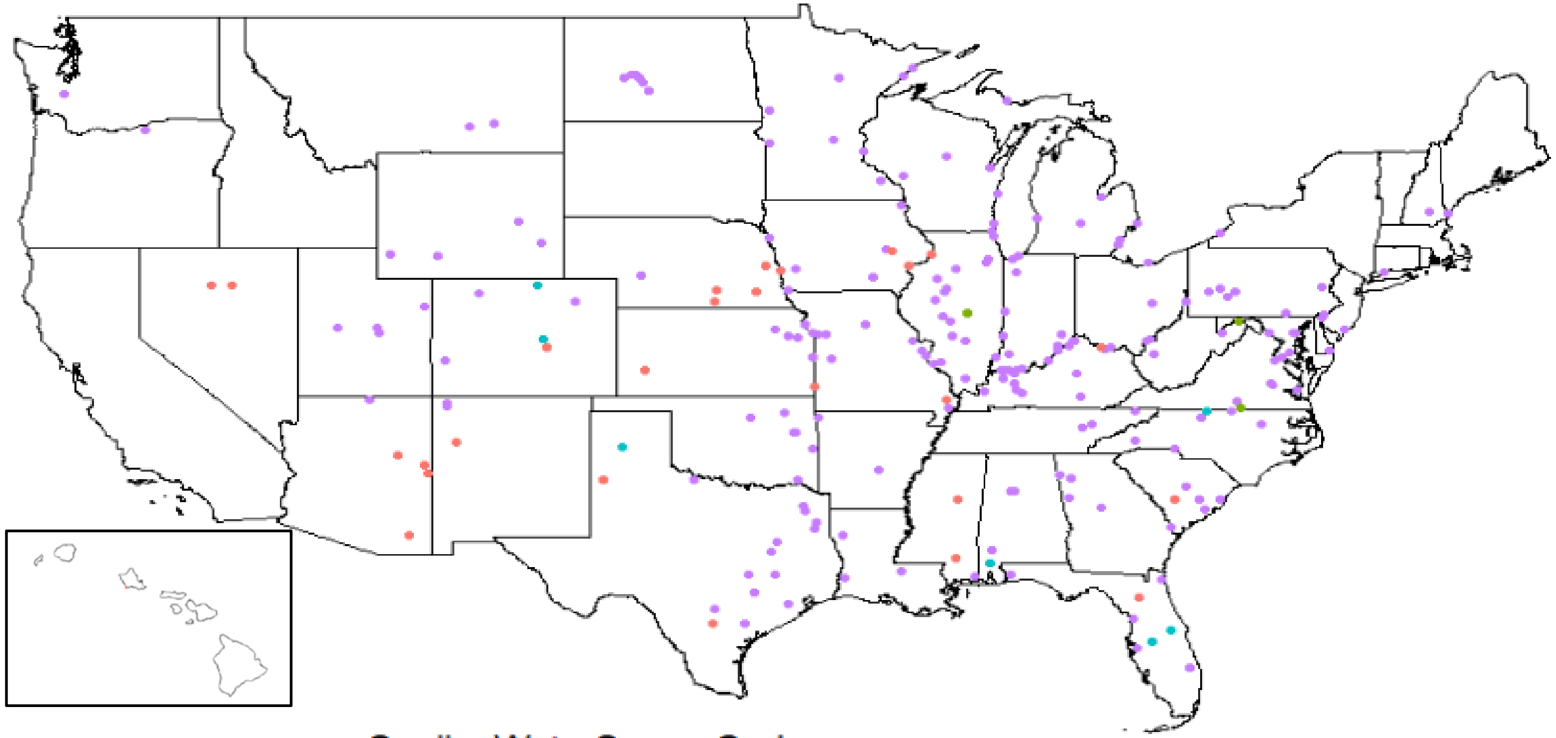
- Identify contact at plant/utility. This is a real challenge.
- Schedule interview and pre-populate database.
- Either collect data on phone call or for larger utilities have contact finish survey.
- Review and aggregated information.

Current Progress



Key Questions

- What are perceived risks?
- What remedial actions have been taken?
- How does action vary by:
  - Geography,
  - Size of utility,
  - Size of plant,
  - Cooling type, and
  - Water source?



CoolingWaterSourceCode

- Surface Water
- Groundwater
- Wastewater
- Brackish Water

Source: EW Dtb

Initial Results

Threat	Comments	Contingency Measures

Water Supply	• Highly managed in West with clearly structured water rights
	• In many cases rights are not owned by power company
	• Limited cases of priority administration being implemented yet most plants have contingency plans
	• Use of wastewater to avoid supply issues
		• Purchase of senior rights
		• Where rights are suspect have secured:
		  o Options to buy from senior rights holders, or
		  o Developed alternative water source.
		• On-site storage

Water Supply	• Limited management in East with occasional permitting required • Some states have set drought priorities and thermoelectric power is generally #2 below municipal water	• Coordination with Corps of Engineers or similar authority • Use pumps when water levels fall below intakes

Initial Results

Threat	Comments	Contingency Measures
Wastewater	• Limited issue in West • Largely closed loop systems so limited discharge	• Many plants have moved to zero liquid discharge to maximize water use and limit issues with discharge management
Wastewater	• Thermal discharge limits are wide-spread and consistent problem • Emission scrubber blowdown is evolving issue	• Temporally manipulate operations to meet permit standard (e.g., max, daily average) • Auxiliary cooling towers (unique cases) • Simply derate and make up elsewhere

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?
- 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.
- While power plants face a range of challenge from water extremes, contingency planning to mitigate these risks is not uncommon.
- Identification of such measures requires plant-level details not widely available in national databases.