Managing Minnesota's Chloride Problem: An Analysis of the Role of Centralized Softening

Baishali Bakshi, Elise Doucette, Scott Kyser

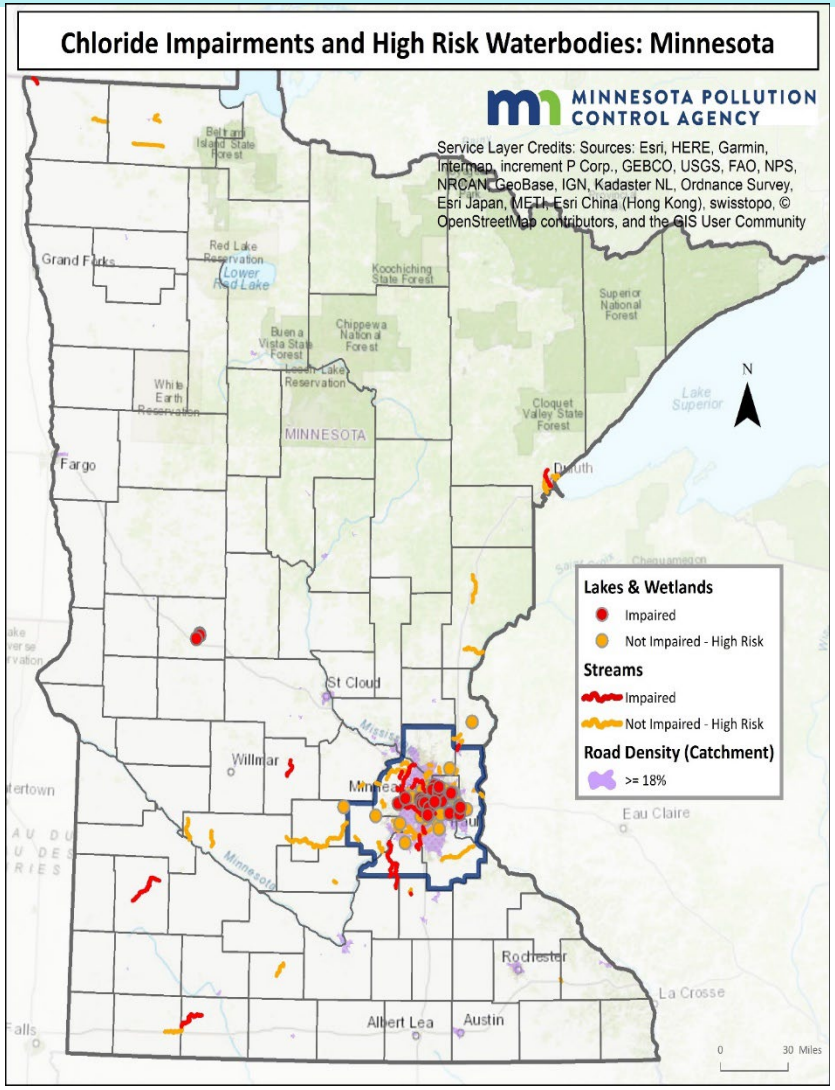
Salt Symposium, Bolton and Menk Inc.

August 6, 2024

Chloride is toxic to aquatic organisms, WQS: 230 mg/L

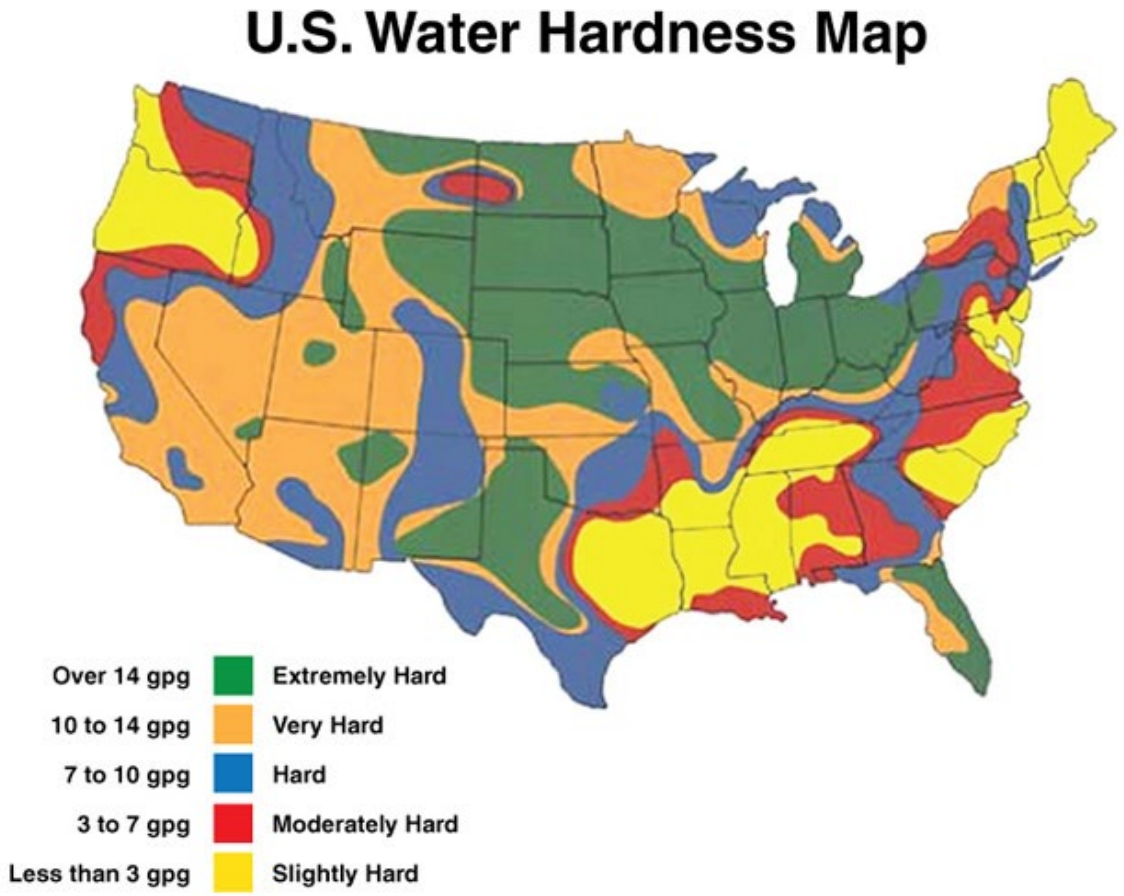



- It is a permanent pollutant
- Many waterbodies are already impaired

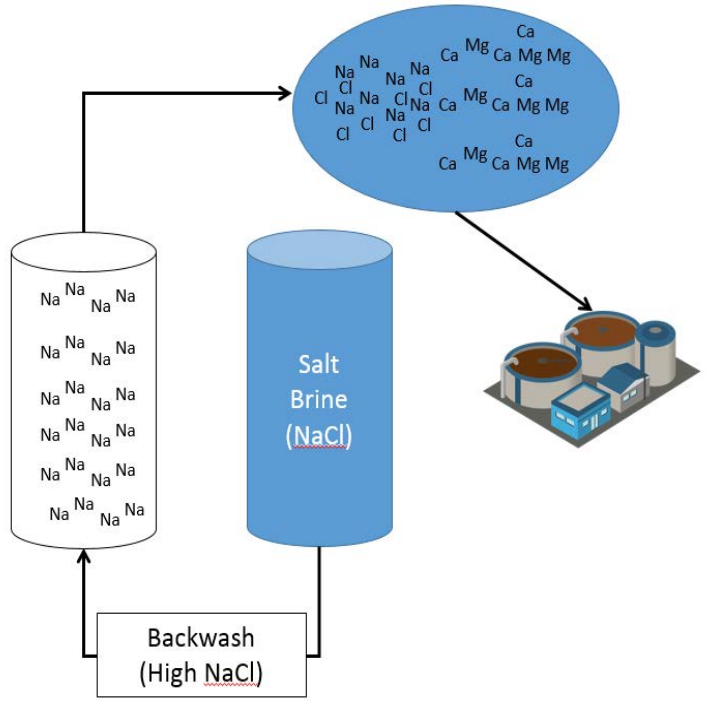


MINNESOTA POLLUTION CONTROL AGENCY

Home Water Softening: Need and Consequence



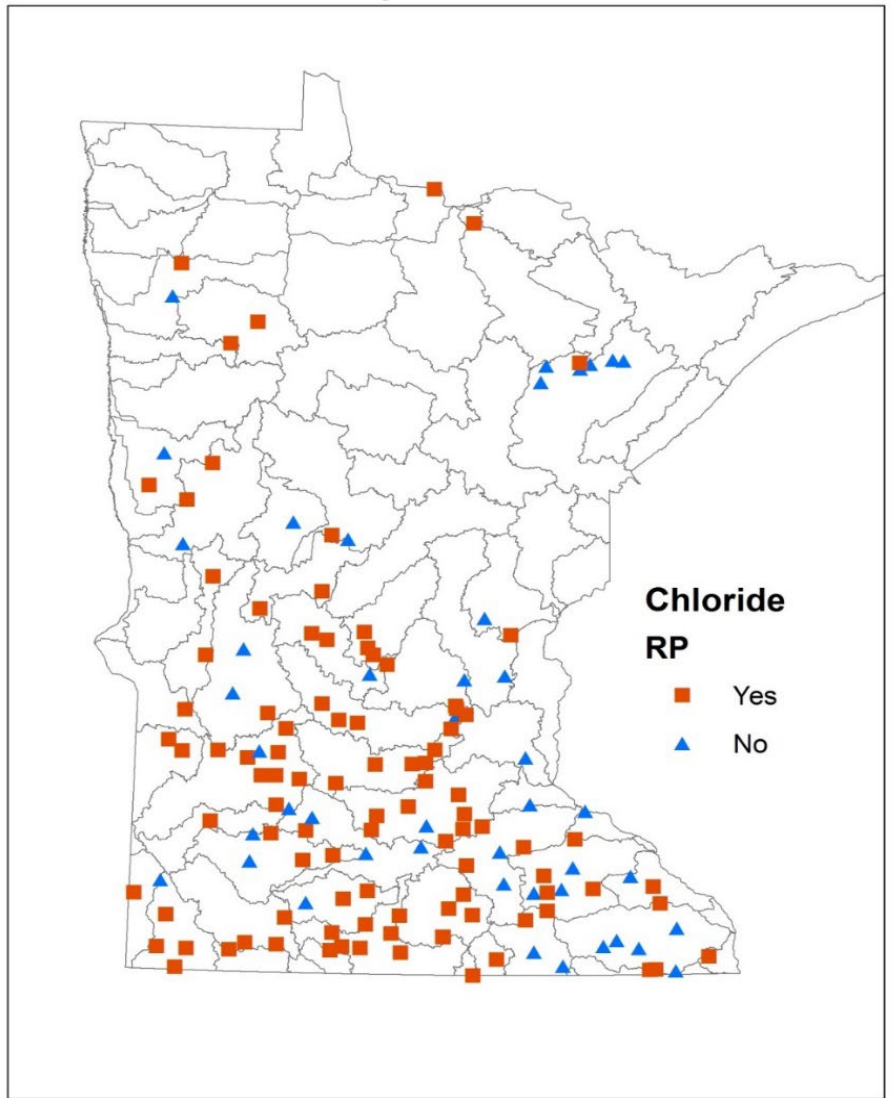
Ion-Exchange (IX) Softener: 65% of salt to WWTP

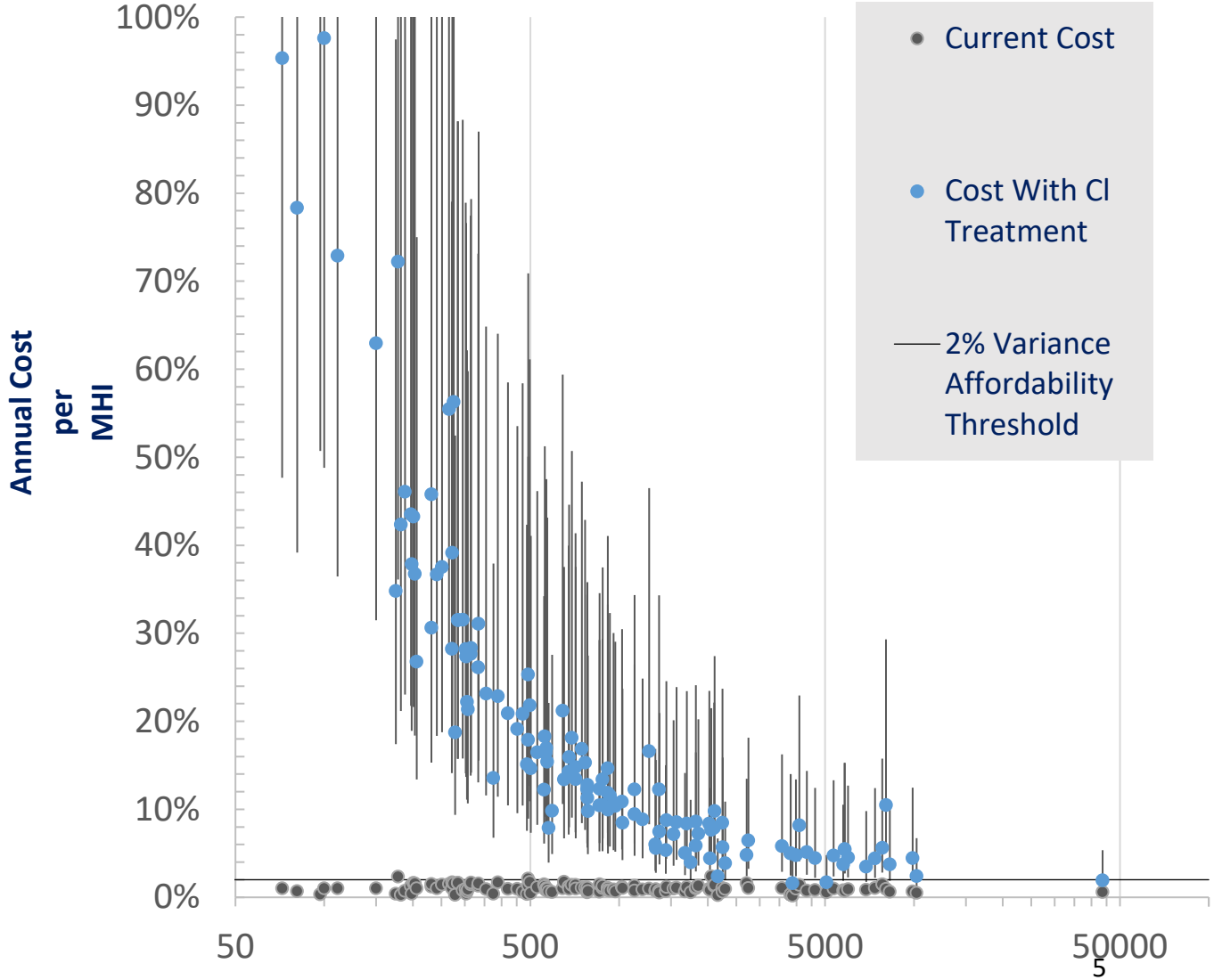


Backwash Resin Regeneration

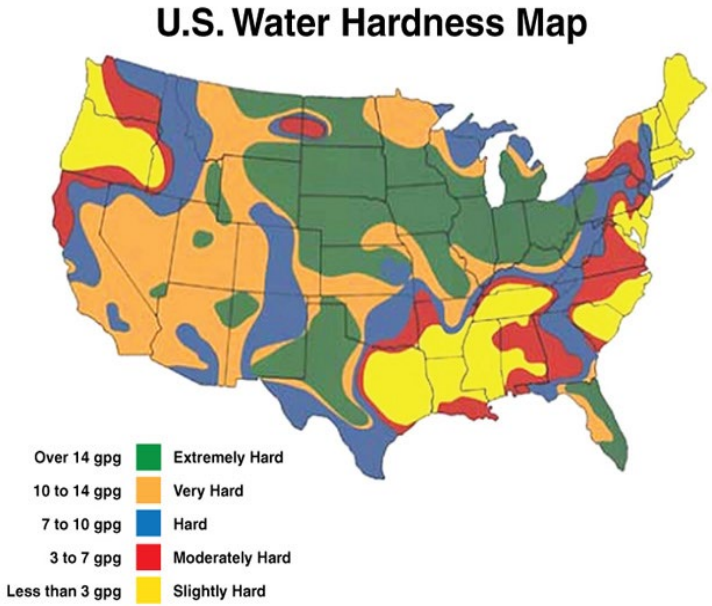
Impact on Facility Compliance

65% will get chloride limits

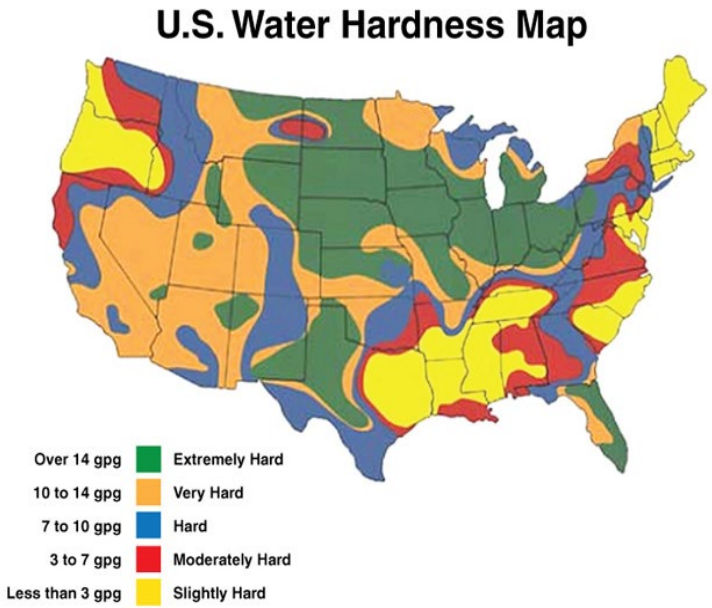




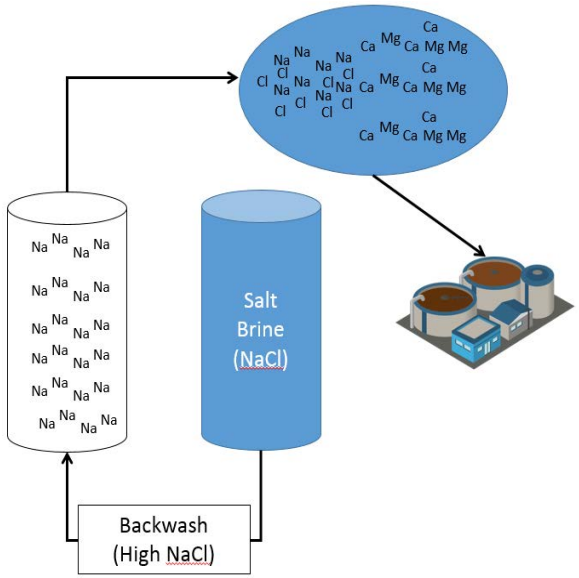
MINNESOTA POLLUTION CONTROL AGENCY


U.S. Water Hardness Map
Over 14 gpg
Extremely Hard
10 to 14 gpg
Very Hard
7 to 10 gpg
Hard
3 to 7 gpg
Moderately Hard
Less than 3 gpg
Slightly Hard

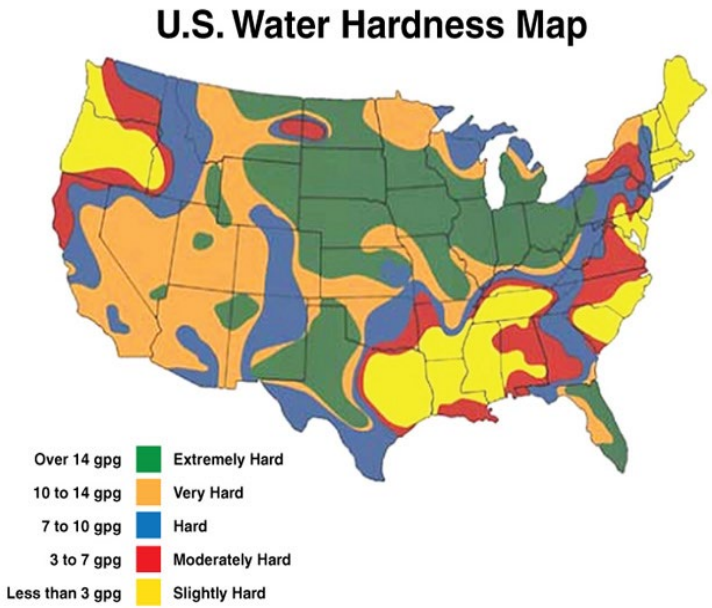
The Problem!!!



The Problem!!!

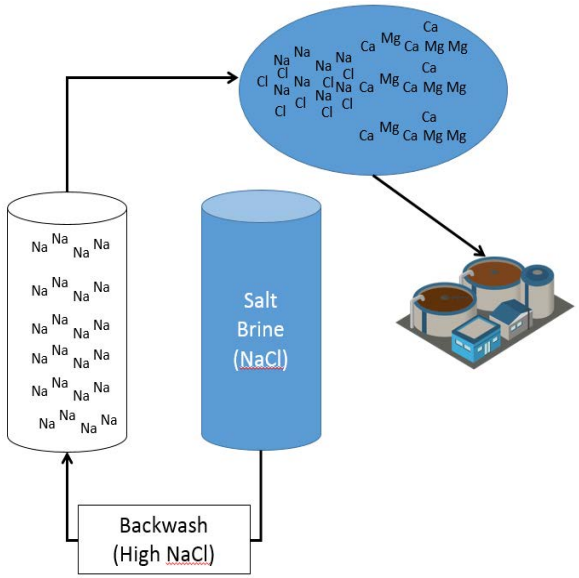


Backwash Resin Regeneration

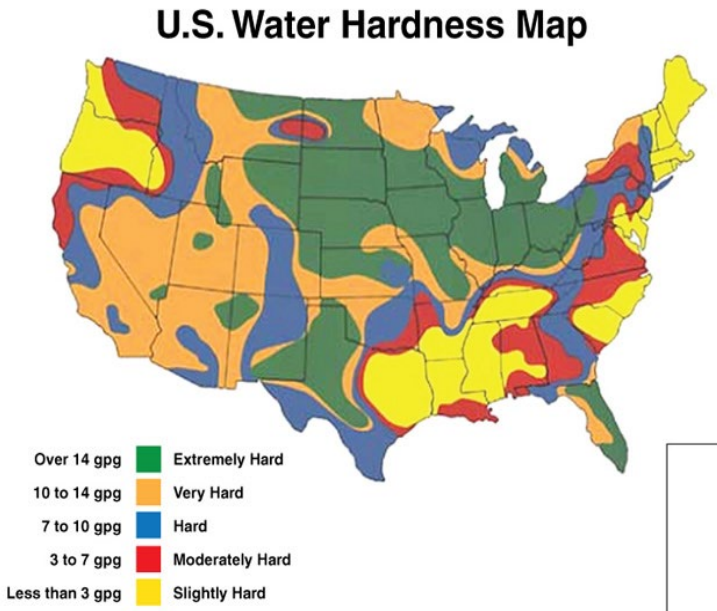


The Problem!!!

IX Softener: 65% of salt to WWTP

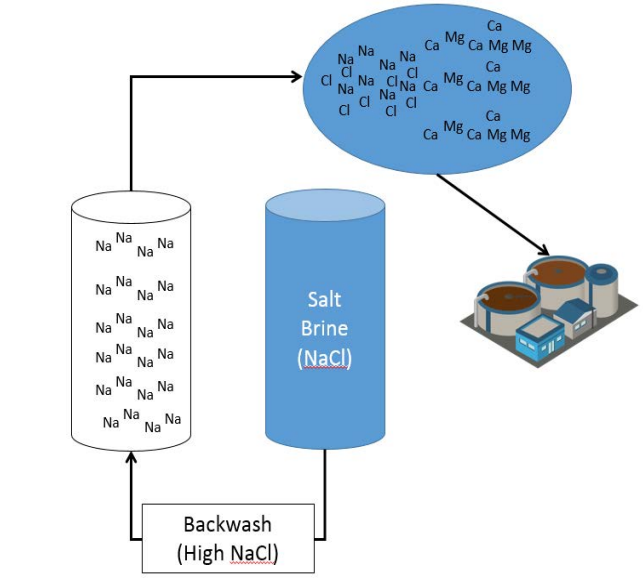


Backwash Resin Regeneration

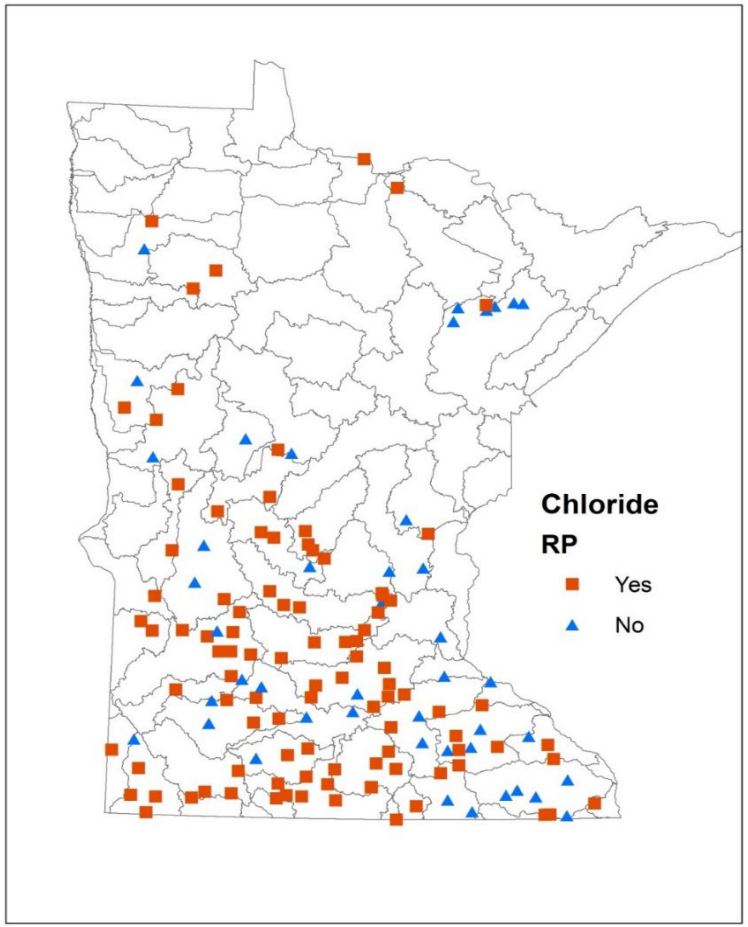


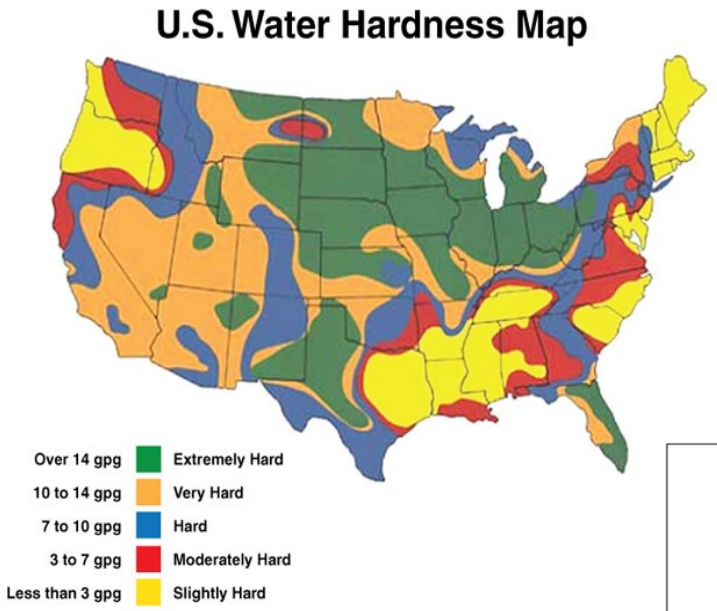
The Problem!!!

IX Softener: 65% of salt to WWTP



Backwash Resin Regeneration

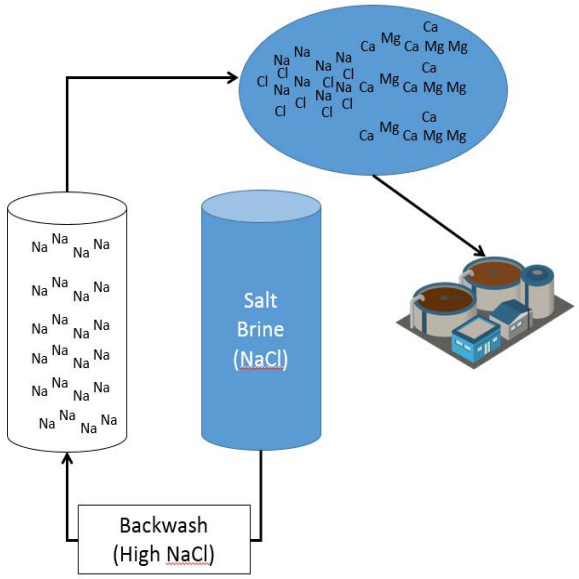




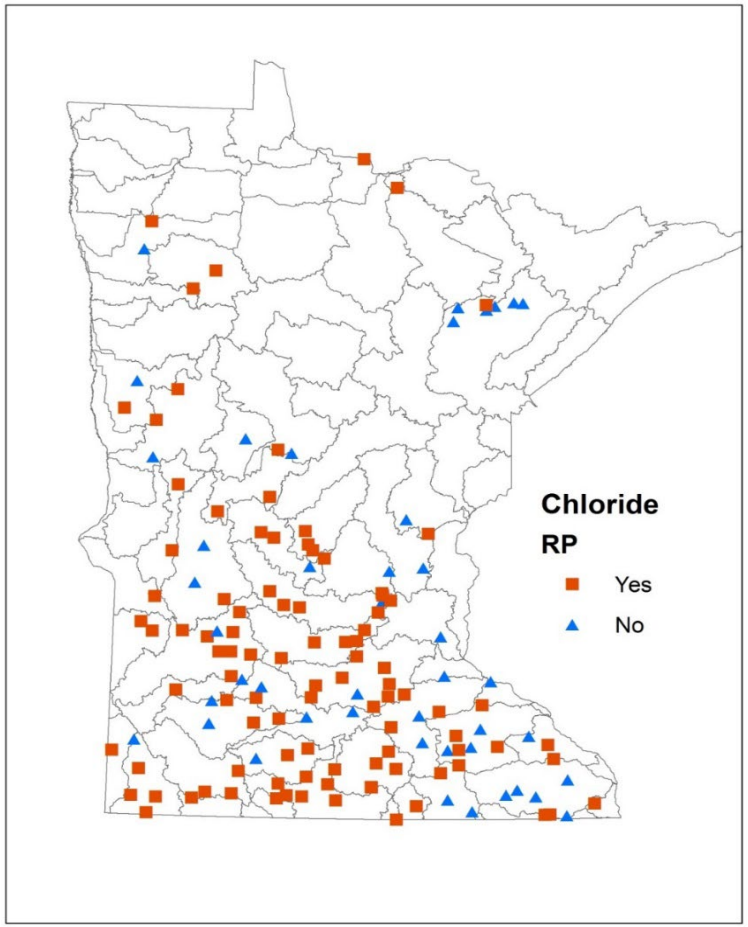
The Problem!!!

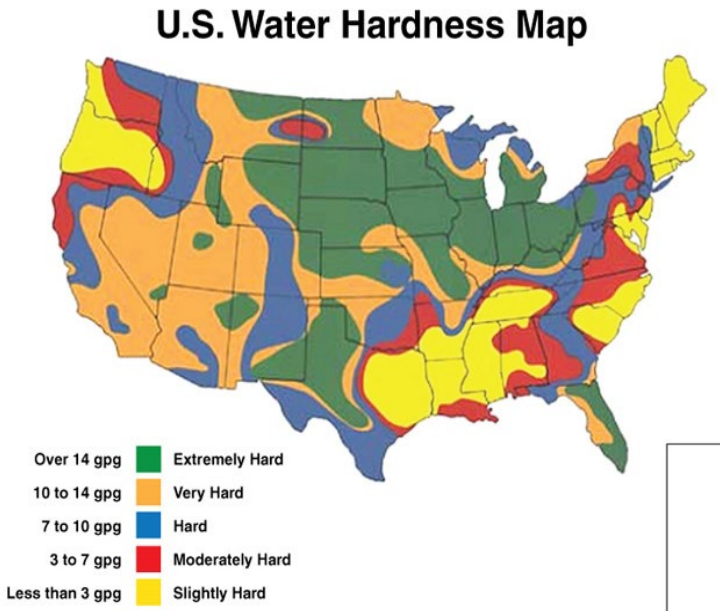
65% will get chloride limits

IX Softener: 65% of salt to WWTP



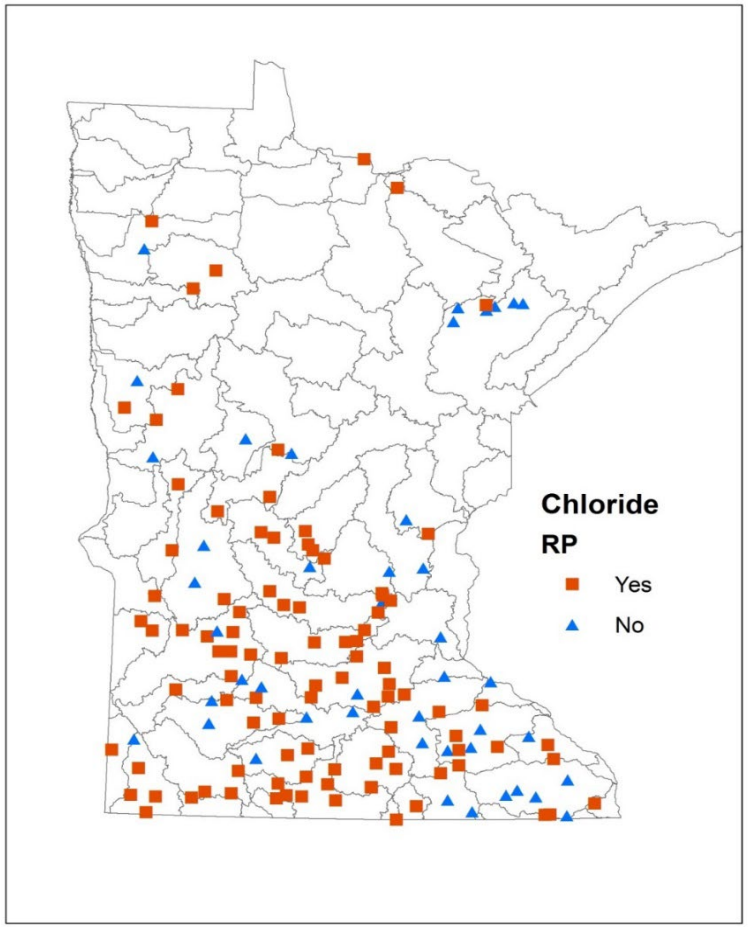
Backwash Resin Regeneration

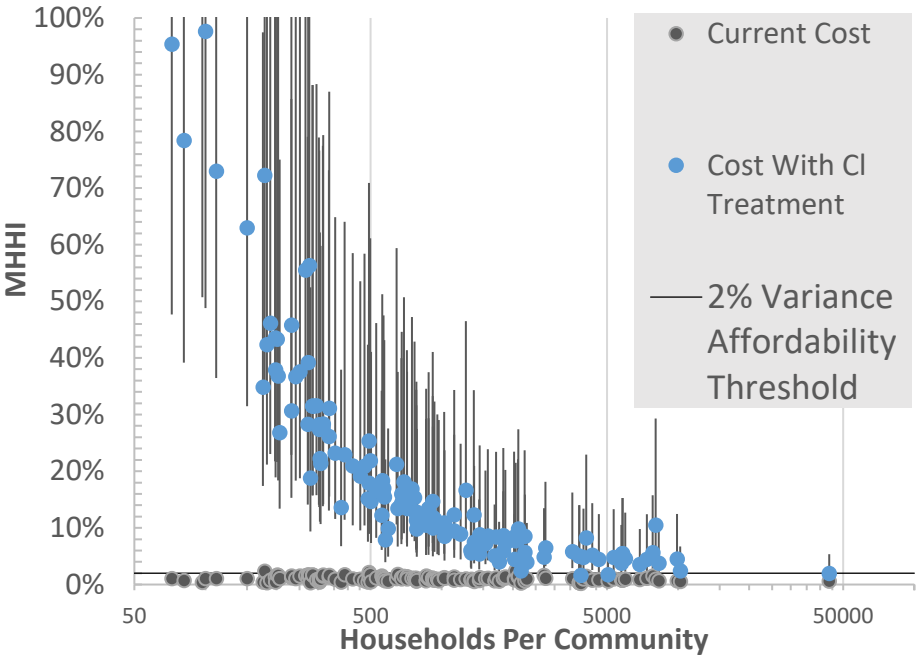




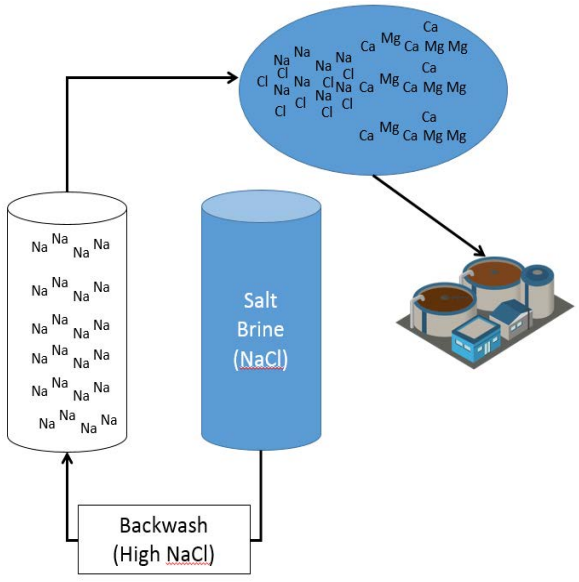
The Problem!!!

65% will get chloride limits



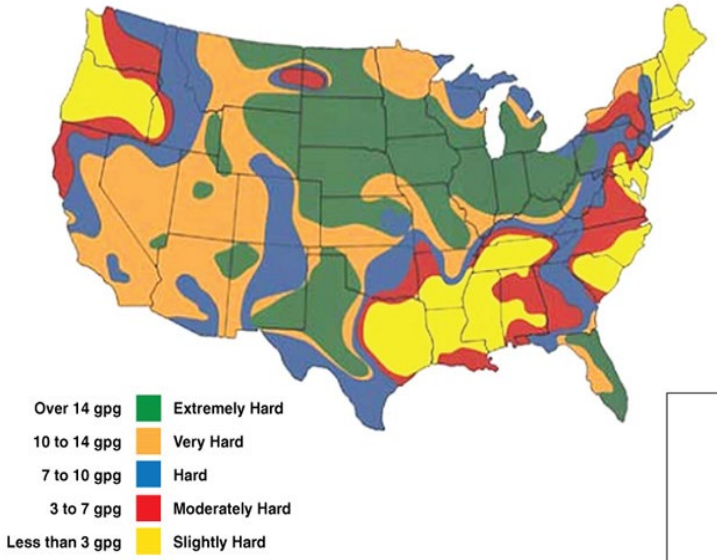


IX Softener: 65% of salt to WWTP



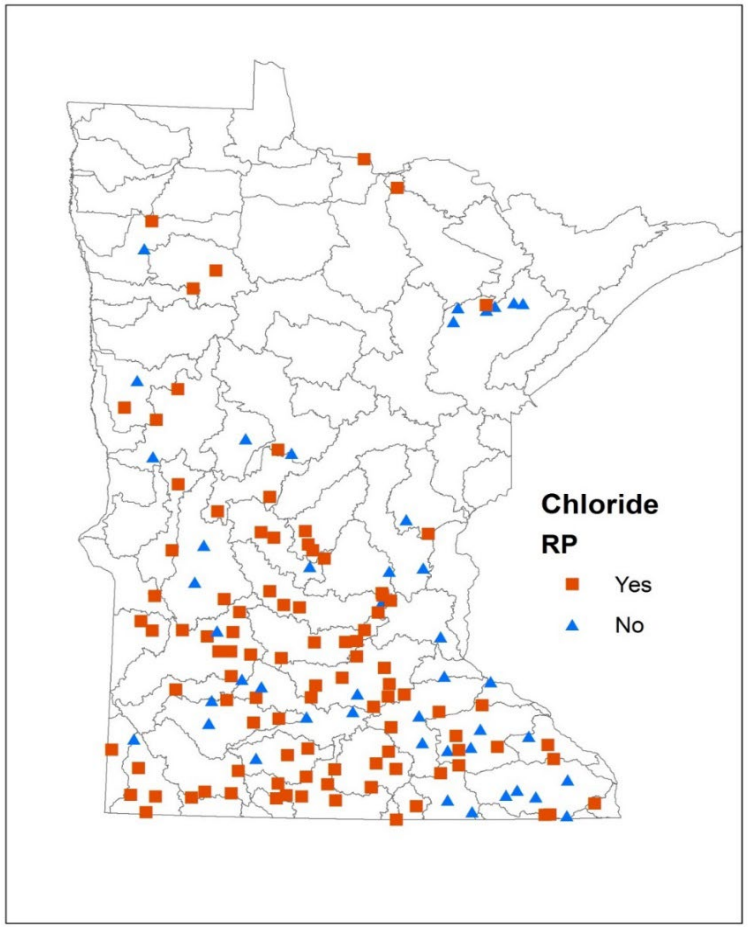
Backwash Resin Regeneration

U.S. Water Hardness Map

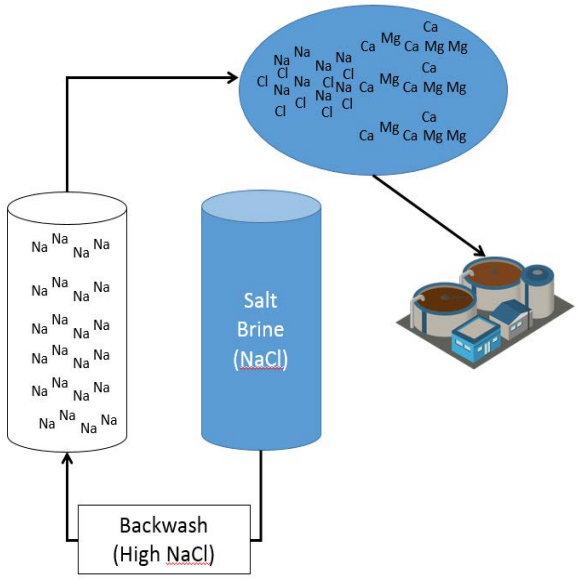


The Problem!!!

65% will get chloride limits

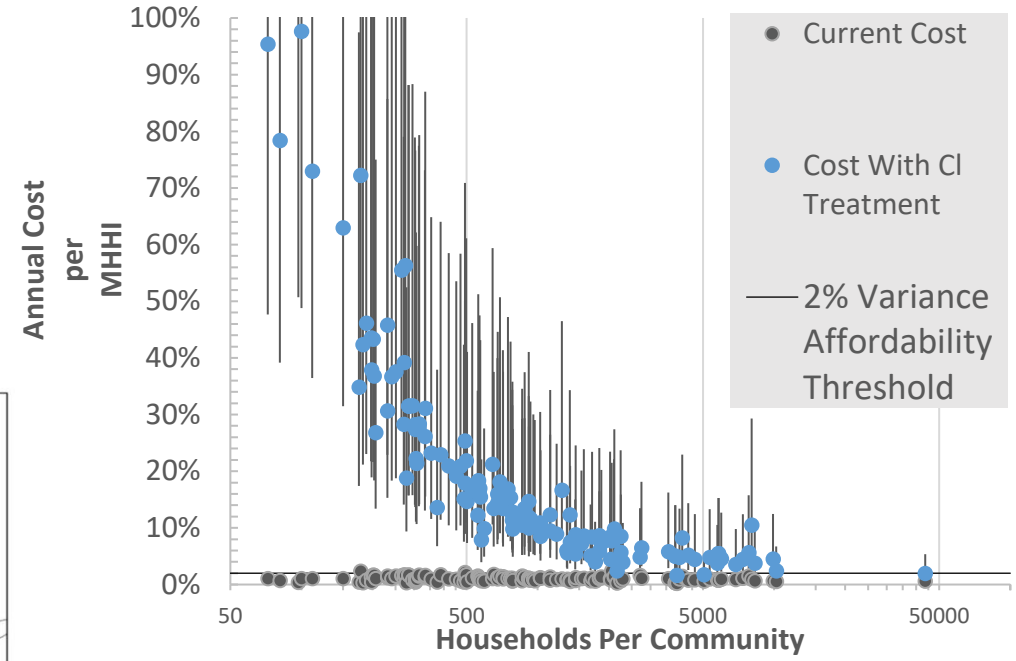


IX Softener: 65% of salt to WWTP

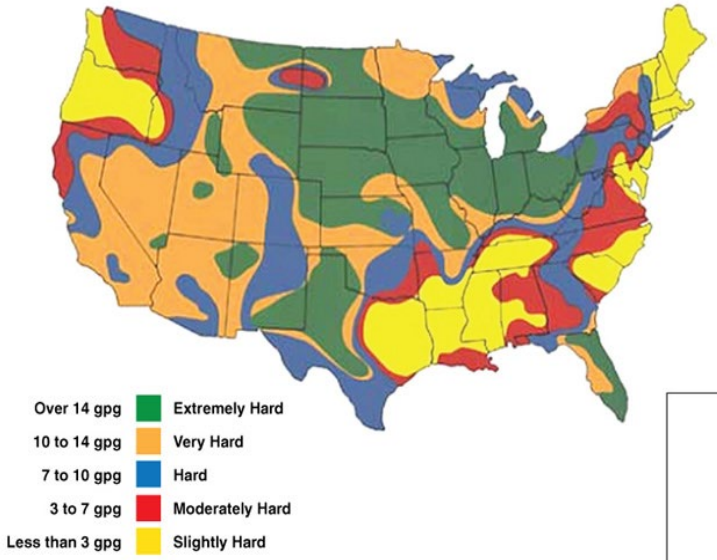


Backwash Resin Regeneration

Technology at WWTP is Expensive!

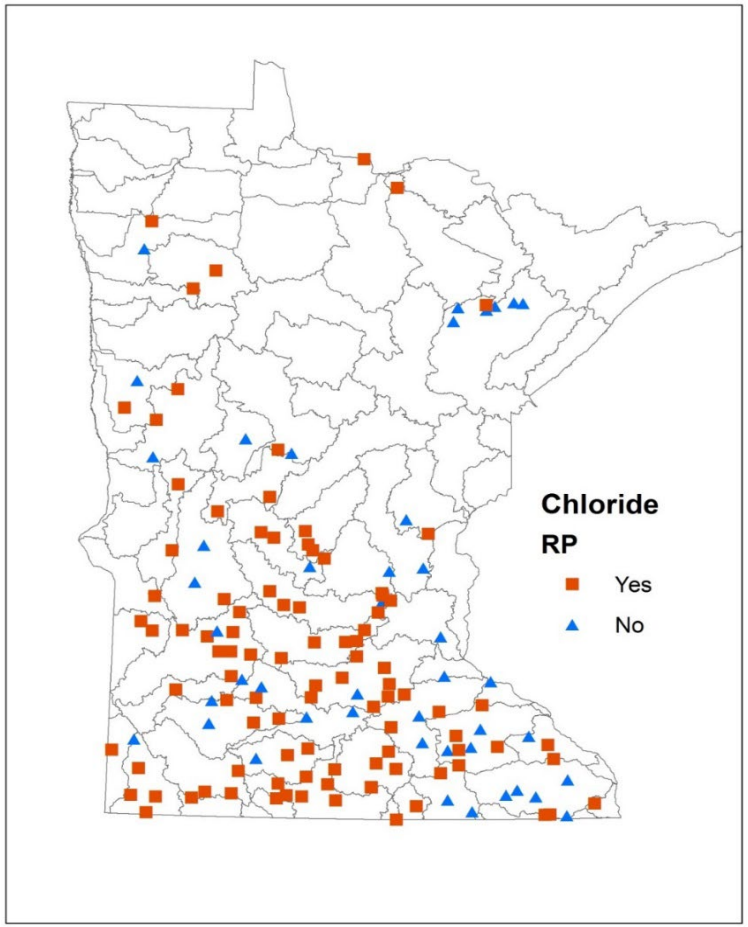


U.S. Water Hardness Map

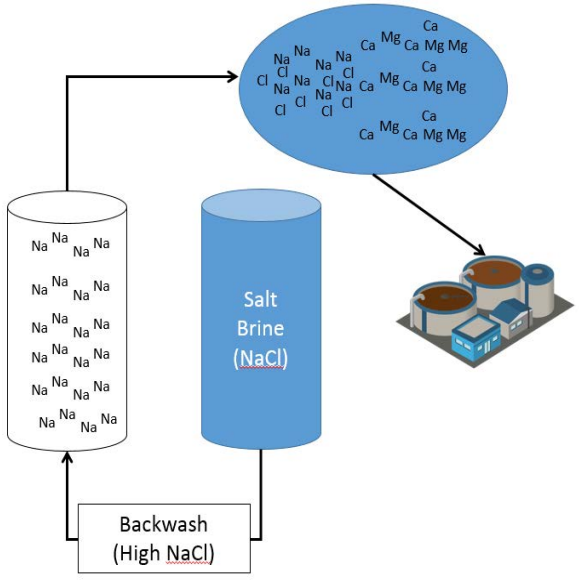


The Problem!!!

65% will get chloride limits

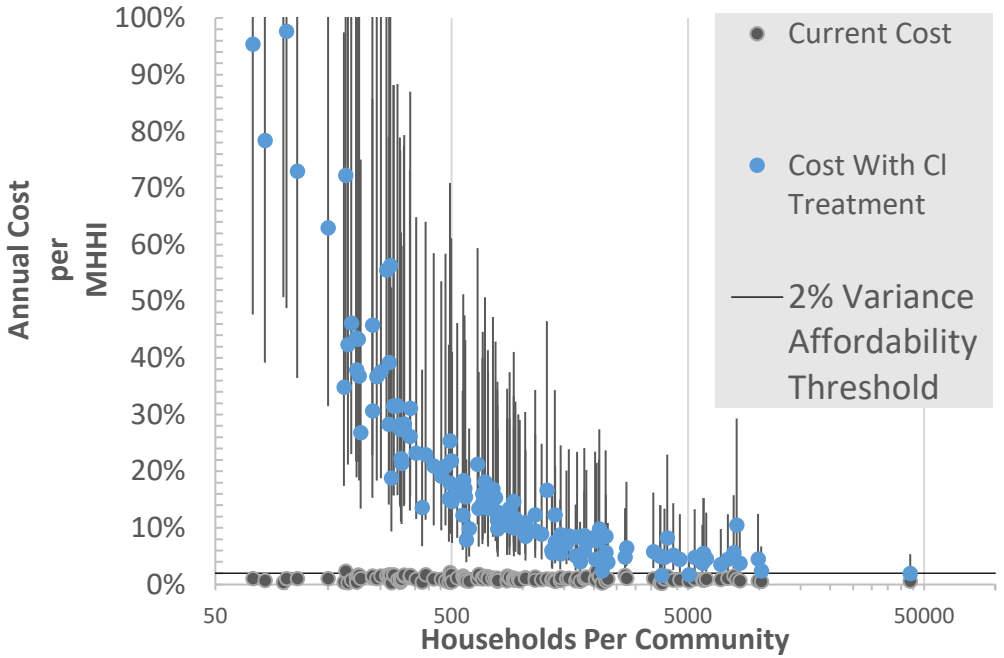


IX Softener: 65% of salt to WWTP

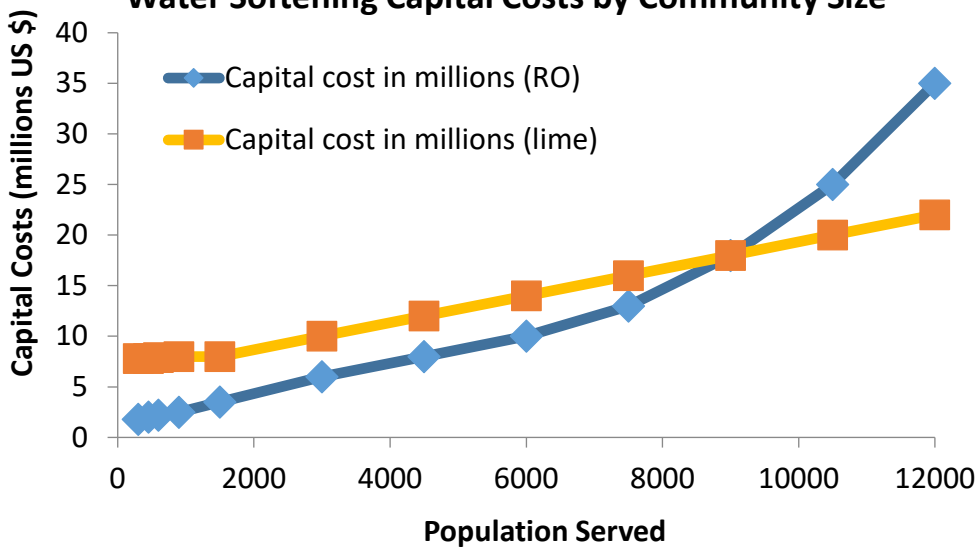


Backwash Resin Regeneration

Technology at WWTP is Expensive!

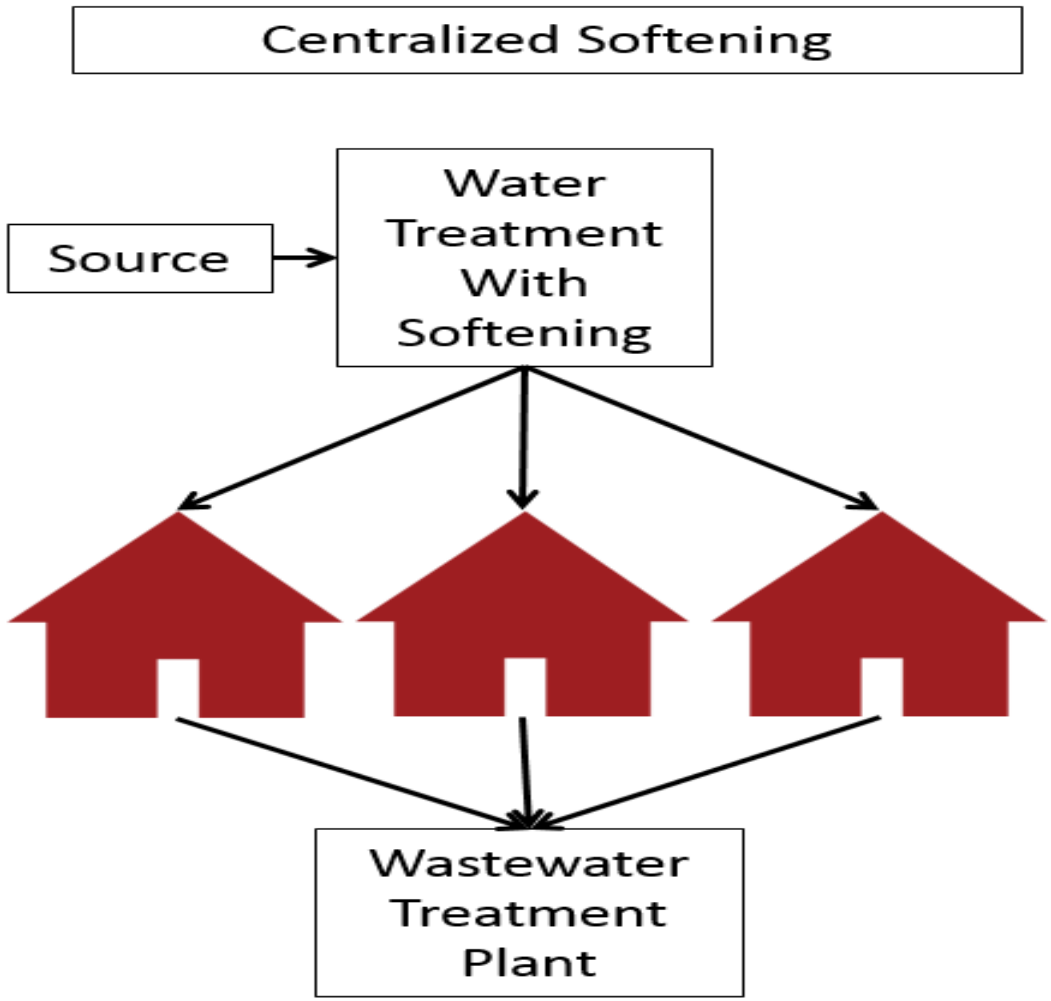


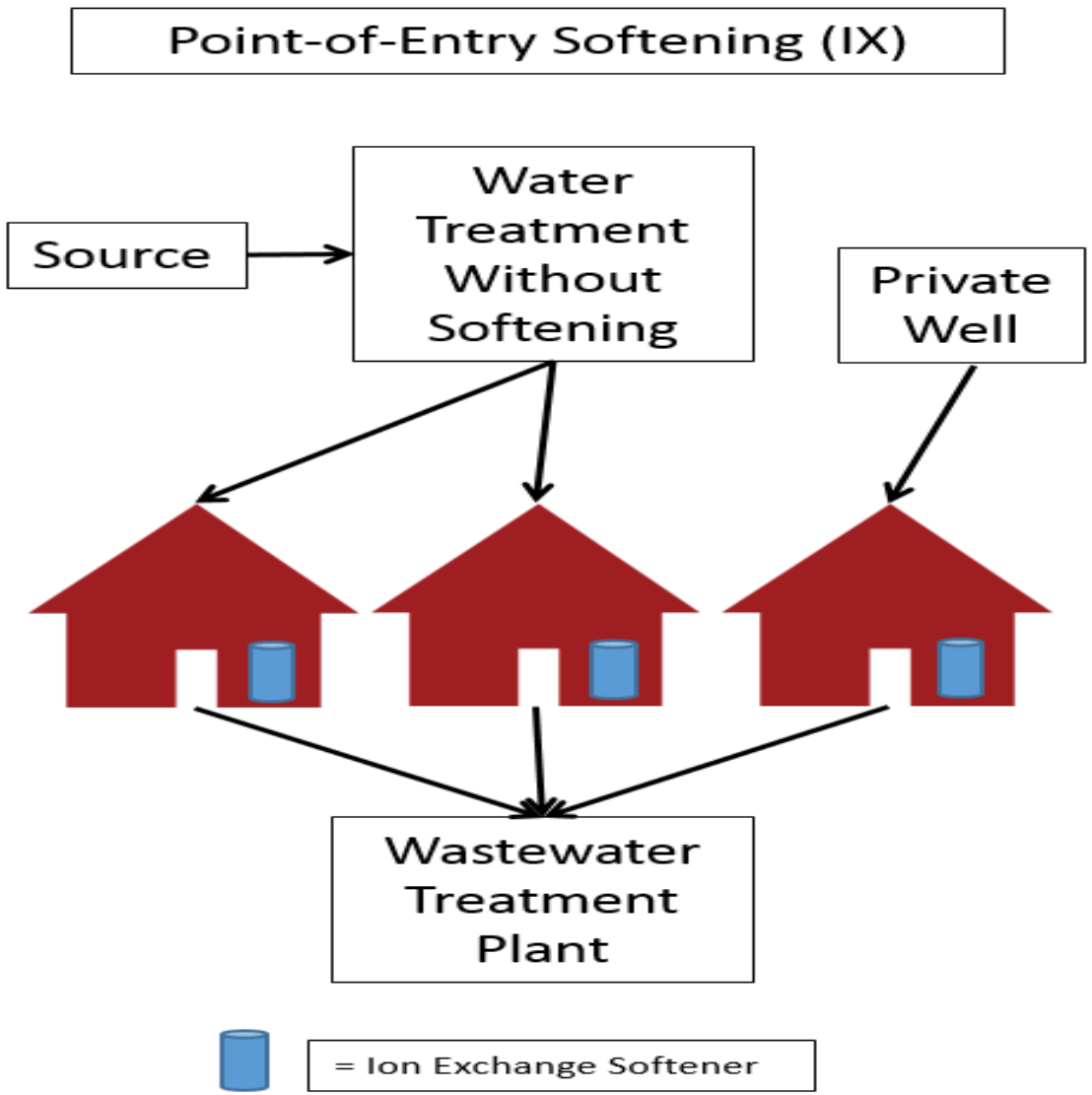
Water Softening Capital Costs by Community Size



- Can Centralized Softening help meet chloride water quality goals, while providing an alternative to home water softening, at reasonable cost?

Central Softening: Reduce Need for Home Softeners





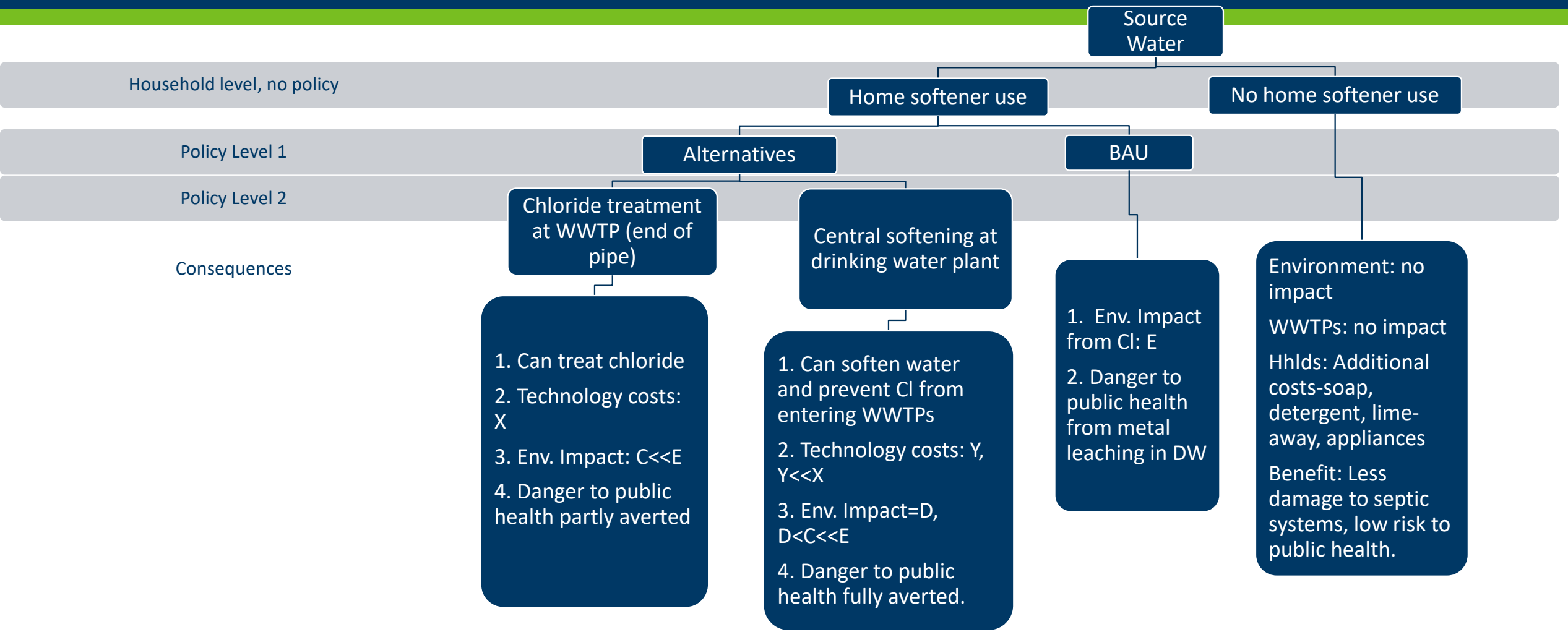
Chloride and Water Softening: Options and Treatment Technologies

		Alternative	WWTP chloride reductions possible?	Ability to bring WWTP into chloride compliance (~230 mg/L)?	Technical feasibility	Implementation feasibility	Estimated relative cost
Reduce chloride loading to WWTP	Drinking water source reduction	Centralized lime softening	Yes	Likely*	Yes	Feasible	High
		Centralized RO softening	Yes	Likely*	Yes	Feasible	High
		Ferric chloride --> Ferric sulfate	Yes	Unlikely	Yes	Feasible	Low
	Upgrade Water Softeners	Upgrade to high salt efficiency Point-of-entry softeners	Yes	Unlikely	Yes	Feasible	Medium
		Upgrade industry to high efficiency softeners	Yes	Unlikely	Yes	Feasible	Medium
		Outlaw ion exchange point-of-entry water softeners	Yes	Likely	Yes	Not Feasible	Medium
		Create softener column exchange and Collection Program	Yes	Likely	Yes	Not Feasible (Regulation)	High
		Switch to non-ion exchange softeners	Yes	Likely	No	Feasible yet Unproven	Medium
		Increase residential softening target	Yes	Unlikely	Yes	Not Feasible	Medium
Treat chloride at WWTP	WWTP chloride treatment	RO effluent - Concentrate discharged to surface water	Yes	Likely	No	Not Feasible (Permitting)	High
		RO effluent - Concentrate crystalized/evaporated	Yes	Likely	Yes	Not Feasible (Energy)	Very High
		RO effluent - Concentrate deep well injection	Yes	Likely	No	Illegal	Very High
		Chlorination to UV disinfection	Yes	Unlikely	Yes	Feasible	Medium
		Ferric chloride to ferric sulfate	Yes	Unlikely	Yes	Feasible	Low
		Chloride precipitation with silver nitrate	Yes	Possible	Yes	Not Feasible	Very High
		Chloride anion exchange	Yes	Possible	No	Not Feasible (Untested)	Very High
		Electrodialysis	Yes	Possible	Yes	Feasible	High
		Any biological treatment process	No	Impossible	No	Not Feasible	NA
				*If all residential wells eliminated and in-home softeners disconnected			

Chloride and Water Softening: Options and Treatment Technologies

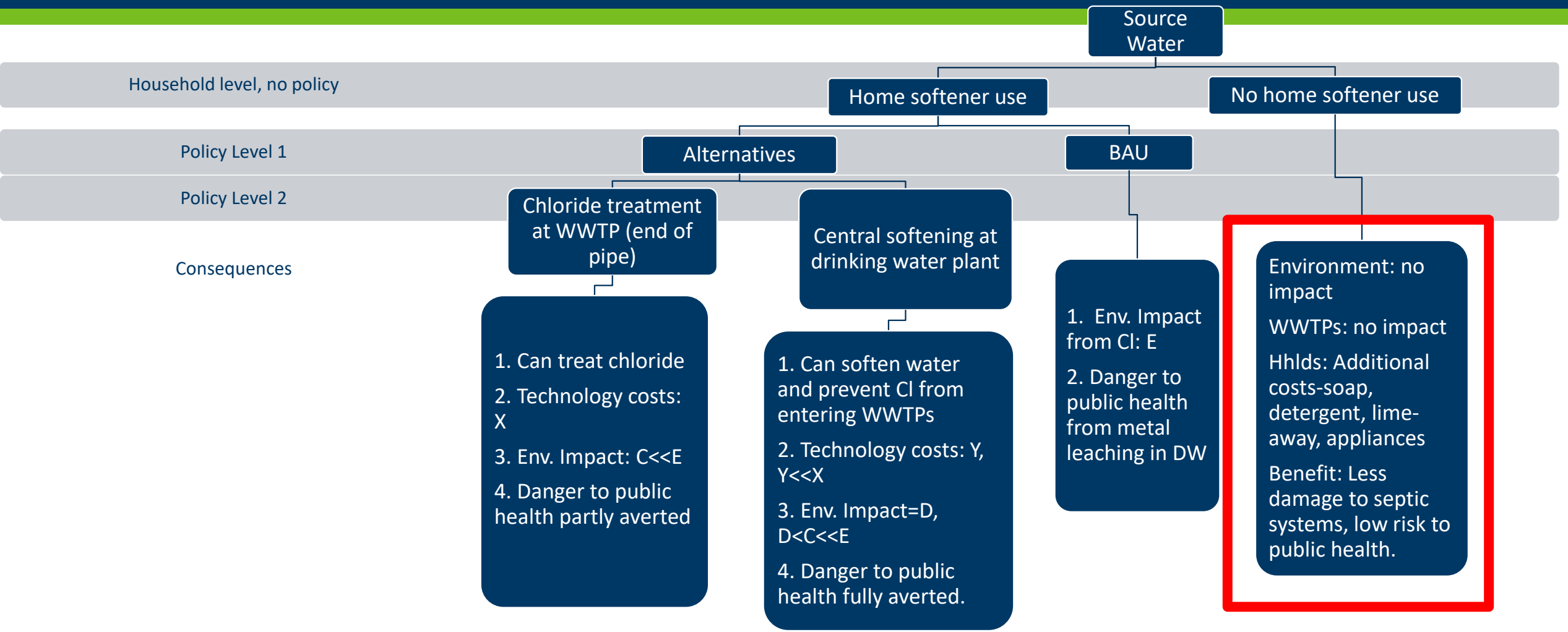
		Alternative	WWTP chloride reductions possible?	Ability to bring WWTP into chloride compliance (~230 mg/L)?	Technical feasibility	Implementation feasibility	Estimated relative cost
Reduce chloride loading to WWTP	Drinking water source reduction	Centralized lime softening	Yes	Likely*	Yes	Feasible	High
		Centralized RO softening	Yes	Likely*	Yes	Feasible	High
		Ferric chloride --> Ferric sulfate	Yes	Unlikely	Yes	Feasible	Low
	Upgrade Water Softeners	Upgrade to high salt efficiency Point-of-entry softeners	Yes	Unlikely	Yes	Feasible	Medium
		Upgrade industry to high efficiency softeners	Yes	Unlikely	Yes	Feasible	Medium
		Outlaw ion exchange point-of-entry water softeners	Yes	Likely	Yes	Not Feasible	Medium
		Create softener column exchange and Collection Program	Yes	Likely	Yes	Not Feasible (Regulation)	High
		Switch to non-ion exchange softeners	Yes	Likely	No	Feasible yet Unproven	Medium
		Increase residential softening target	Yes	Unlikely	Yes	Not Feasible	Medium
Treat chloride at WWTP	WWTP chloride treatment	RO effluent - Concentrate discharged to surface water	Yes	Likely	No	Not Feasible (Permitting)	High
		RO effluent - Concentrate crystalized/evaporated	Yes	Likely	Yes	Not Feasible (Energy)	Very High
		RO effluent - Concentrate deep well injection	Yes	Likely	No	Illegal	Very High
		Chlorination to UV disinfection	Yes	Unlikely	Yes	Feasible	Medium
		Ferric chloride to ferric sulfate	Yes	Unlikely	Yes	Feasible	Low
		Chloride precipitation with silver nitrate	Yes	Possible	Yes	Not Feasible	Very High
		Chloride anion exchange	Yes	Possible	No	Not Feasible (Untested)	Very High
		Electrodialysis	Yes	Possible	Yes	Feasible	High
		Any biological treatment process	No	Impossible	No	Not Feasible	NA
				*If all residential wells eliminated and in-home softeners disconnected			

Policy Options



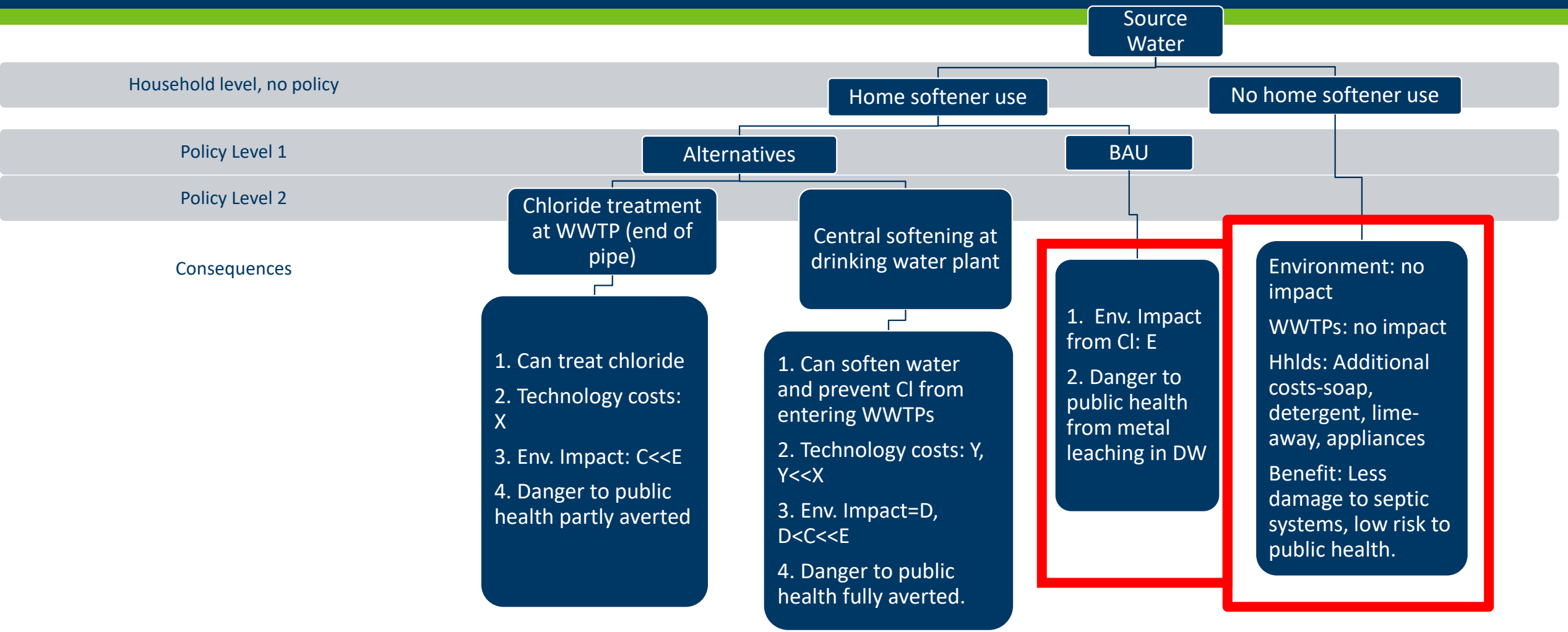
BAU: Business as usual scenario

Policy Options



BAU: Business as usual scenario

Policy Options



BAU: Business as usual scenario

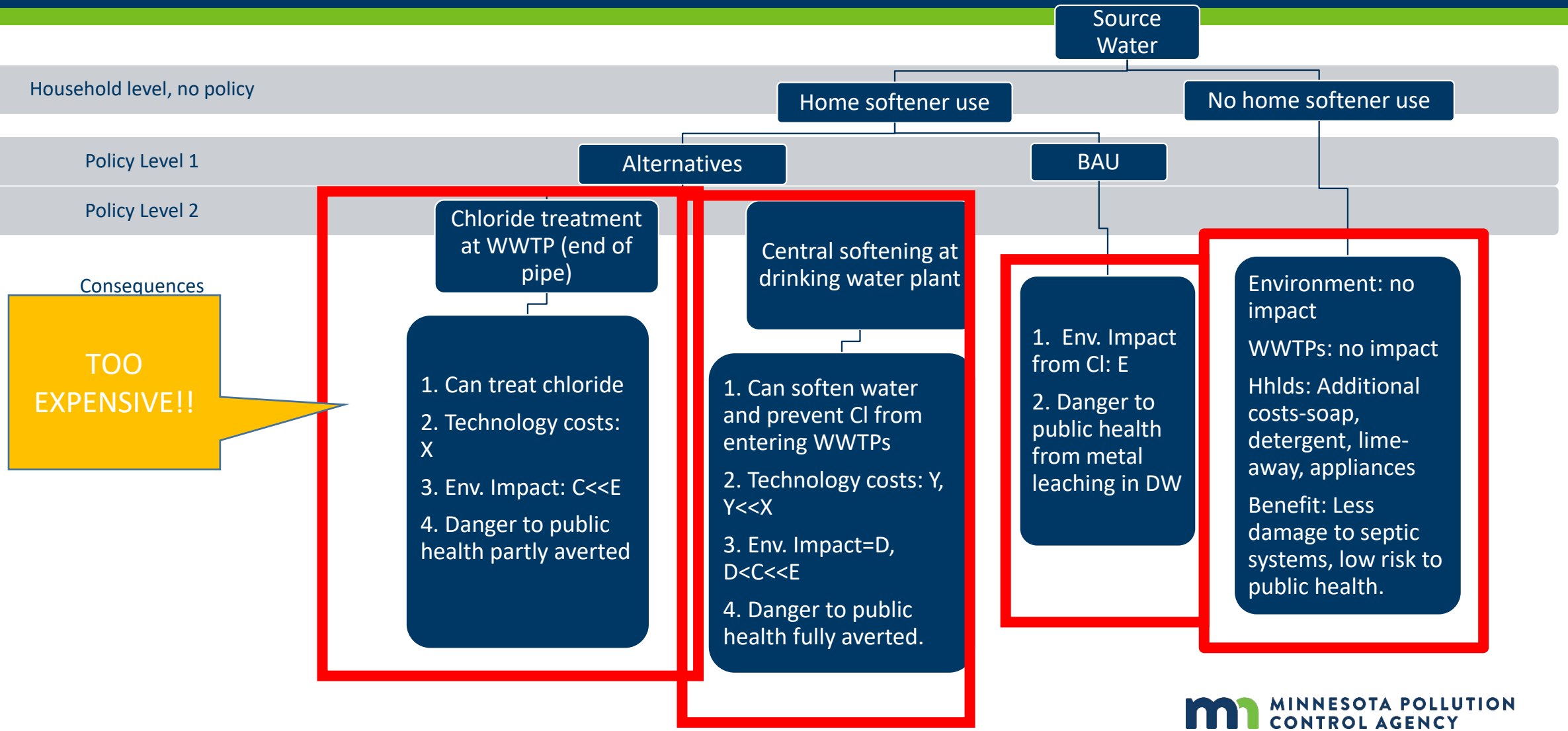
Policy Options

BAU: Business as usual scenario

Policy Options

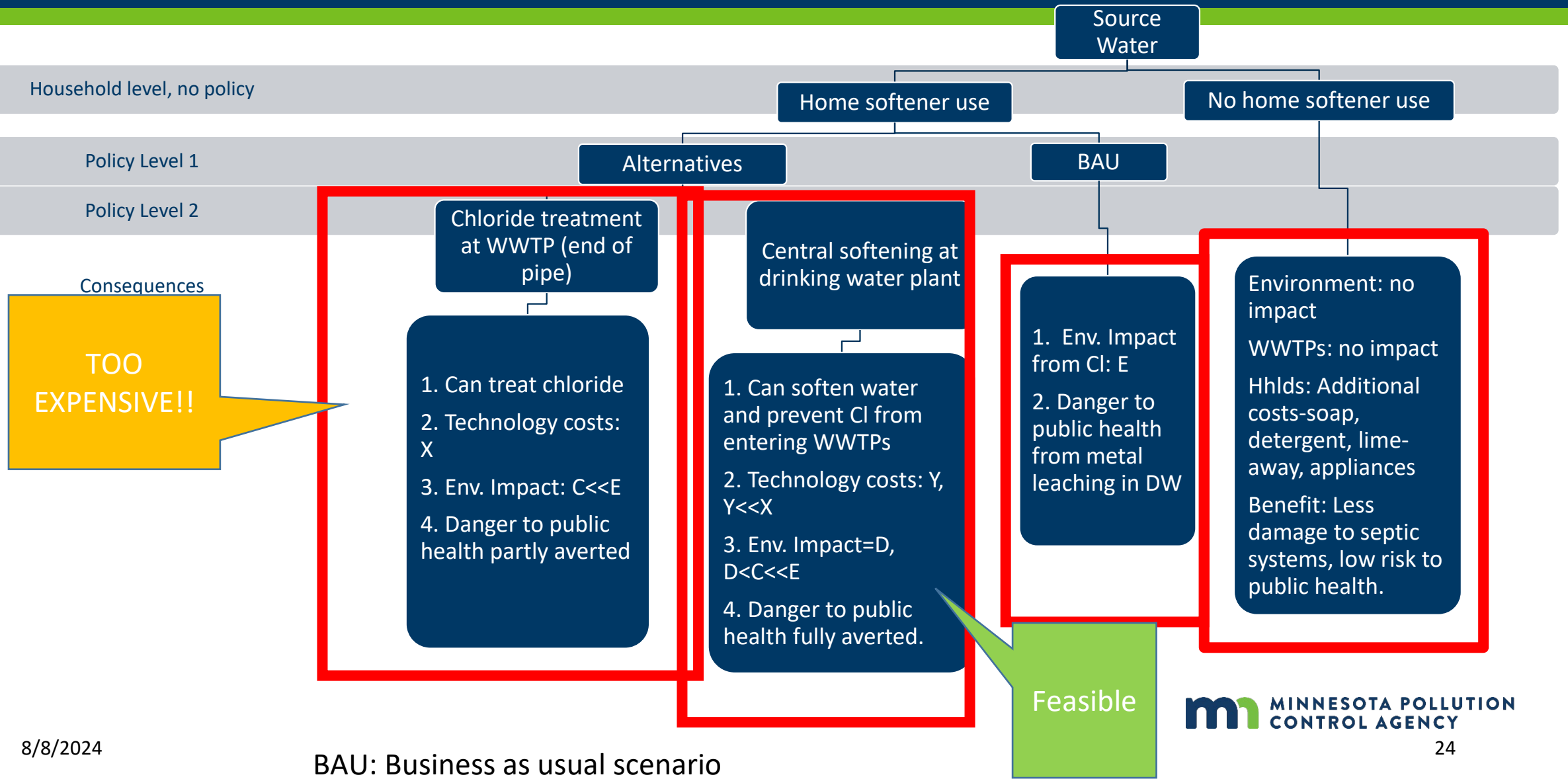
BAU: Business as usual scenario

Policy Options



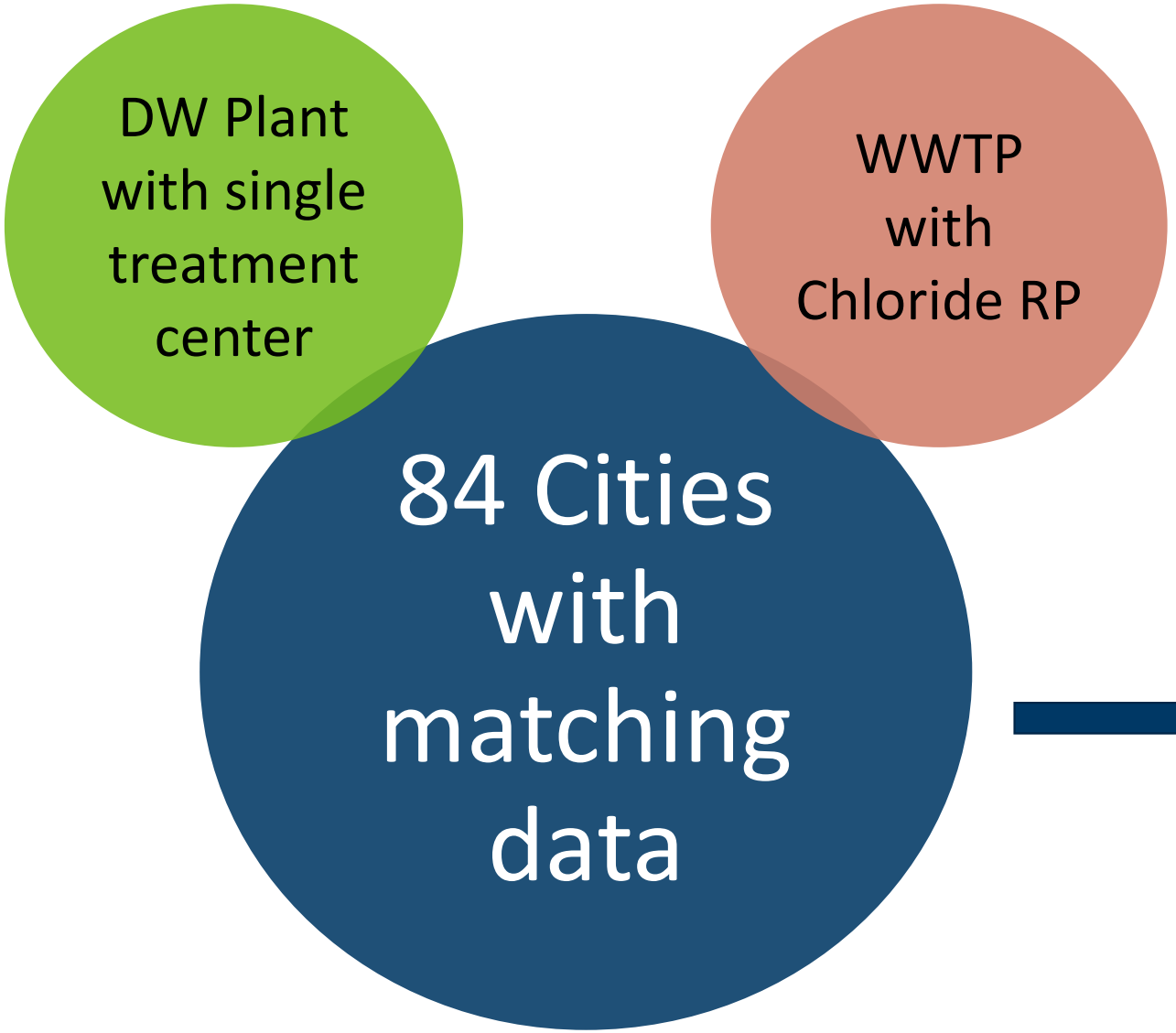
BAU: Business as usual scenario

Policy Options



BAU: Business as usual scenario

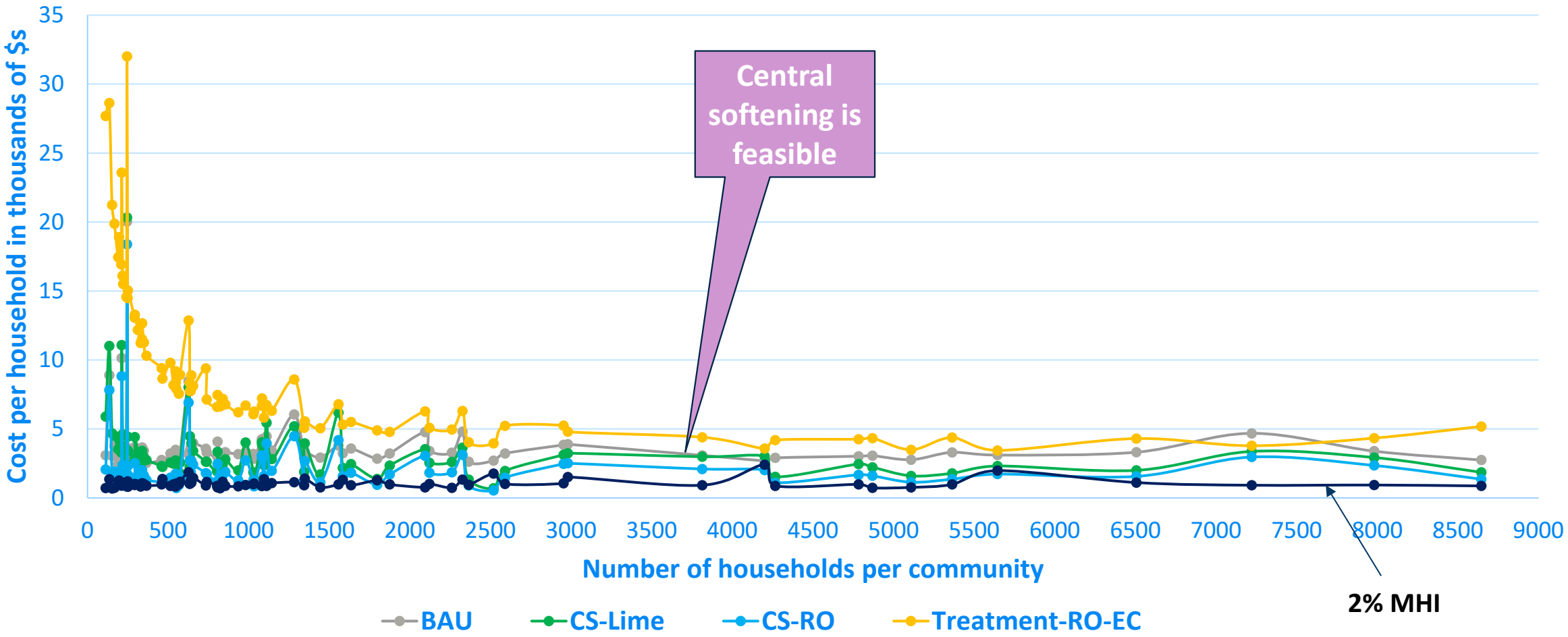
Data for Analysis



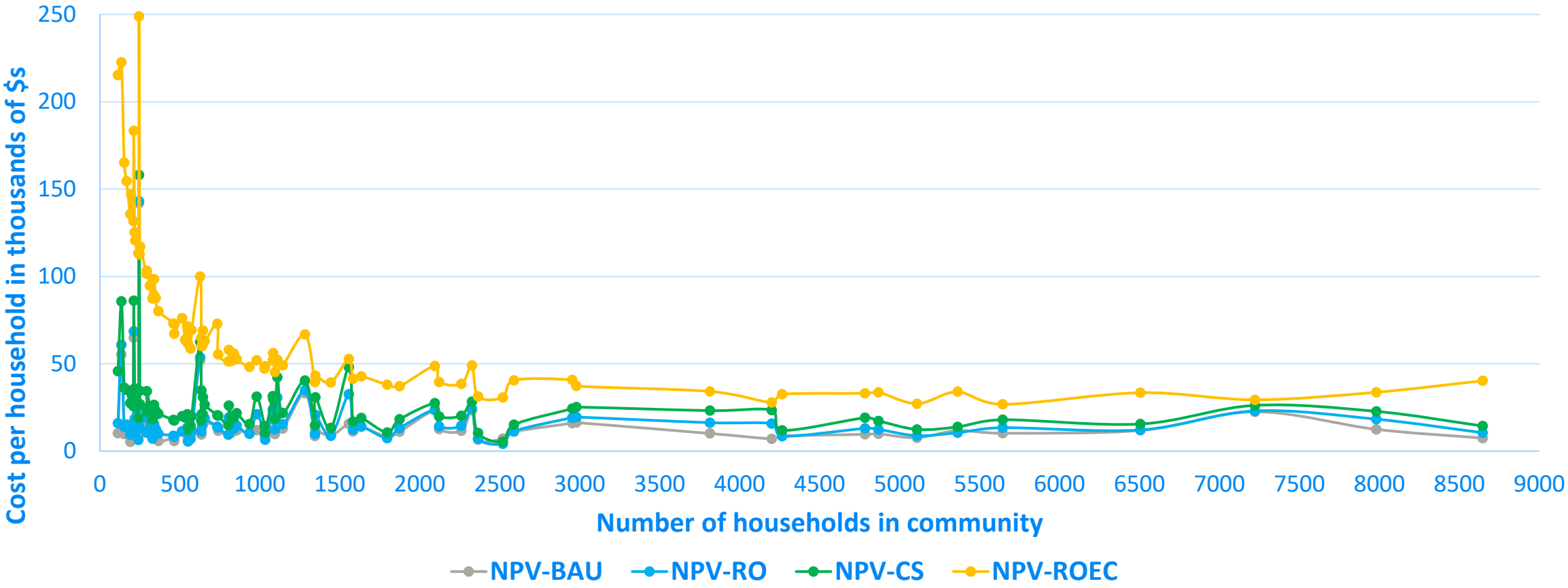
Data	Source
New technology costs	MPCA engineers
Existing technology costs	State Auditor's office
Softener costs	Average market prices
Softener removal costs	Personnel estimates
Community population	ACS, Census Bureau

MINNESOTA POLLUTION CONTROL AGENCY

Annual costs of chloride alternatives in Minnesota communities



NPV comparison of chloride alternatives over home-based softener life



Costs of alternatives in ('000) of $s for selected Minnesota cities

Household level	BAU		Centralized softening				Home softening	
			CS-RO		CS-Lime		RO-EC	
	Annual	NPV	Annual	NPV	Annual	NPV	Annual	NPV
Altura	3.21	11.09	1.90	14.74	4.41	34.31	18.91	147.00
Sherburn	3.04	9.74	1.46	11.36	2.51	19.49	8.39	65.24
Avon	3.98	17.08	2.43	18.89	3.42	26.56	8.12	63.11
Barnesville	3.04	9.77	1.59	12.38	2.37	18.43	5.82	45.25
Pipestone	4.77	23.23	3.05	23.70	3.53	27.43	6.27	48.77
Thief River Falls	2.90	8.70	1.09	8.51	1.53	11.93	4.19	32.59
Worthington	3.02	9.62	1.68	13.05	2.46	19.11	4.26	33.10
Willmar	3.39	12.48	2.35	18.30	2.93	22.76	4.34	33.72
Rochester	3.27	11.58	10.87	84.49	2.52	19.61	3.59	27.93

Avenues for Cost Reduction

- State and federal funding: available but depend on
  - Infrastructure needs-Scoring lists
  - Needs Vs. Funding
  - Affordability Vs. Population served
  - City participation
- Variances- 11 cities have applied.

Drinking Water Revolving Fund (DWRF) loans

- Protect public health
- Provide adequate water supply
- Help communities with financial needs

MPCA Clean Water Partnership Program (CWP)

- 0 interest loans for softener removal
- Softener rebate program
- Information on salt management

MINNESOTA POLLUTION CONTROL AGENCY

Take Aways

- Central softening is a cost-effective solution
  - Central softening-RO is only 1.1 times as costly as BAU option
  - CS-Lime is only 1.5 times as costly as CS-RO
  - WWTP chloride treatment is on average 3 times as costly as CS-Lime
- Benefits of CS
  - Protect water from further ionic pollution
  - Protect public health from potential contamination of drinking water
  - Efficient solution: combines chloride reduction with water softening—avoid costs of home-softeners as well as user fees from end-of-pipe chloride treatment.
  - Economies of scale gains potentially possible for groups of communities sharing DW plants.

Interested parties

- Cities: cost versus options for chloride management
- Environmental groups: water quality improvement, environmental benefits
- Industry: competition
- General public: cost-savings, efficiency benefits, environmental and health benefits