

MnTAP Industrial Chloride Reduction Project

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Project Goals

- Identify best management practices for reducing chloride discharge from water softening operations
- Perform site visits and recommend salt saving water softener changes
- Create BMPs document to help businesses reduce industrial chloride discharge from water softener



Figure 1: An industrial water softener

<https://www.hillwater.com/industrial-water-softeners.aspx>

Incentives to Change - Chloride

- 50 bodies of water in Minnesota was listed as impaired, in 2020, 40 are in the seven county TCMA.
- 230 mg/L of chloride pollutes water (1 teaspoon of salt can pollute 5 gallons of water).

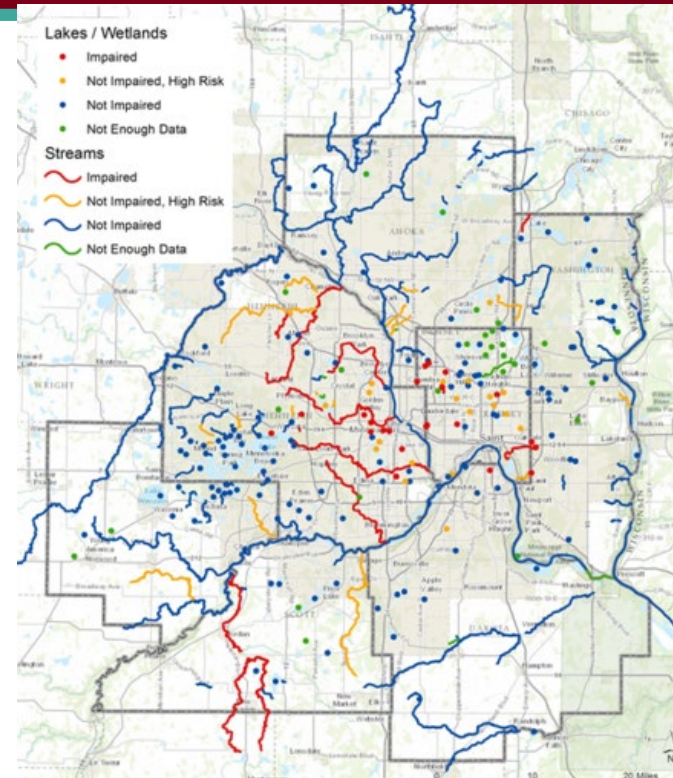


Figure 2: Chloride impairments and high-risk waterbodies: TCMA

https://stormwater.pca.state.mn.us/index.php/TCMA_Chloride_Management_Plan_-_TCMA_Chloride_Conditions

Incentives to Change – Water Softener

- Chloride Contribution to WWTPS:
 - 21% Industry
 - 16% Commercial water softening
 - 49% Household water softening
- Technology to remove chloride exists but not feasible and resource intensive.

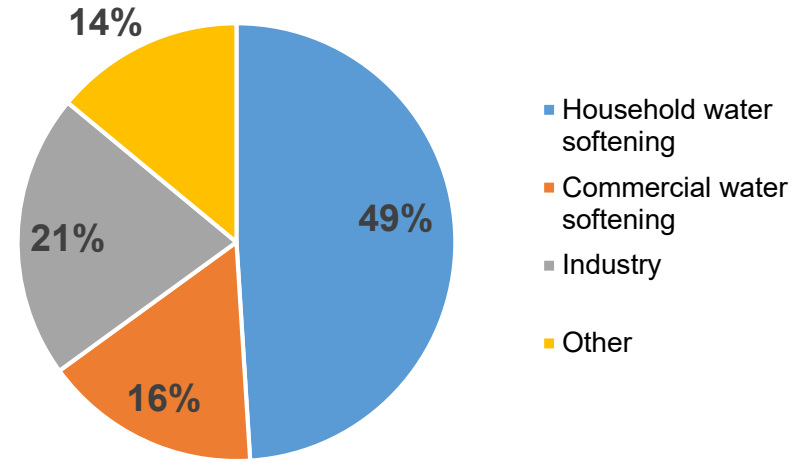


Figure 3: Fraction of chloride contributed from domestic, commercial and industrial sources to WWTPs in Minnesota

Overbo A, Heger S, Gulliver J. Evaluation of chloride contributions from major point and nonpoint sources in a northern US state. Science of The Total Environment. 2020 Dec 17:144179.

Water Softener – Why we need it?

- Most of MN water is considered very hard water
- Hard causes a lot of problems
 - Scale formation
 - Soap scum
- US units:
 - 17.1 ppm = 1 gpg

Very Hard	≥ 181 ppm	≥ 11 gpg
Soft	0-60 ppm	0-3.5 gpg



Figure 4: Hard water scale deposition on pipe

<https://modernpumpingtoday.com/controlling-scale-deposits-in-waterlines/>

Water Softener – How it works?

- Resin has ion exchange sites
 - Polystyrene Sulfonate
 - Replace Ca^{2+} or Mg^{2+} with Na^+
- Exhausted resin replenished by running brine through the resin
 - NaCl or KCl

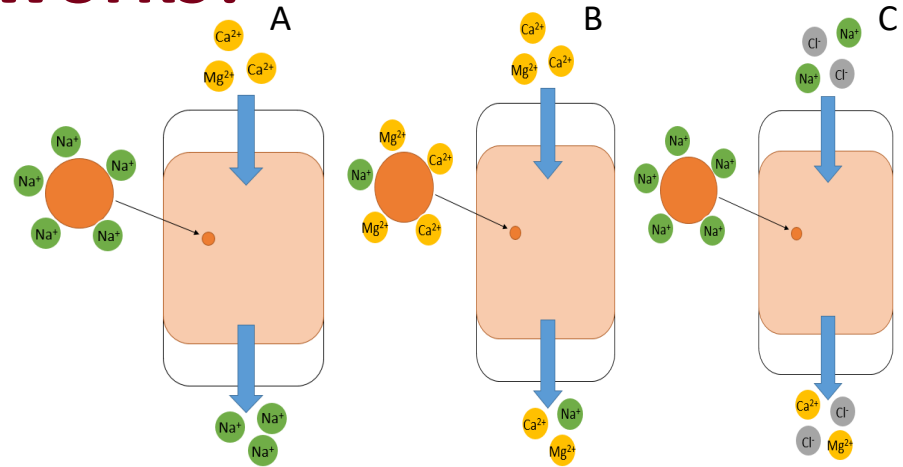


Figure 5: (A) Resin is charged with Na^+ ions and can remove the Ca^{2+} and Mg^{2+} ions. (B) This resin gets exhausted. (C) Regeneration occurs and re-saturates the resin.

Softener Best Management Practices

Softener Decision Flowchart

- Based on informational interviews and BMPs implemented by various agencies and vendors.

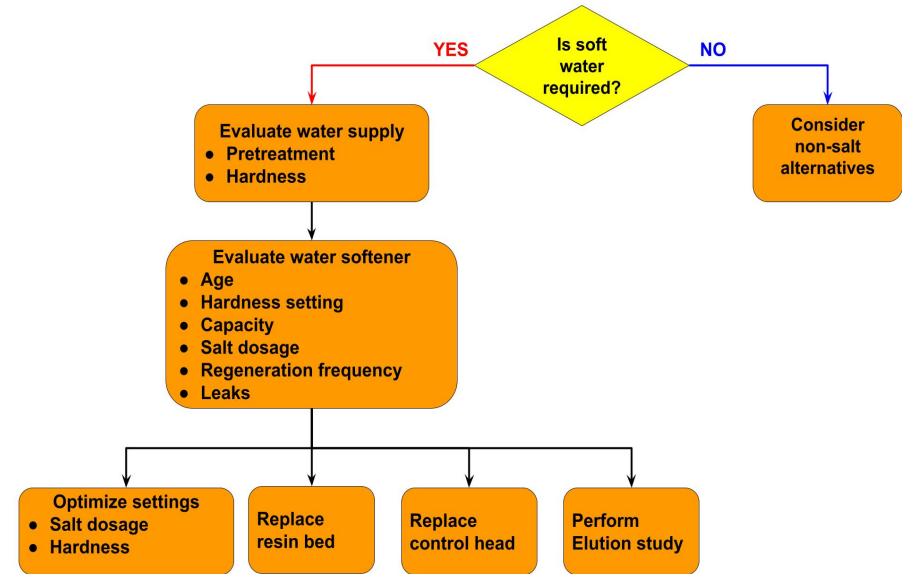
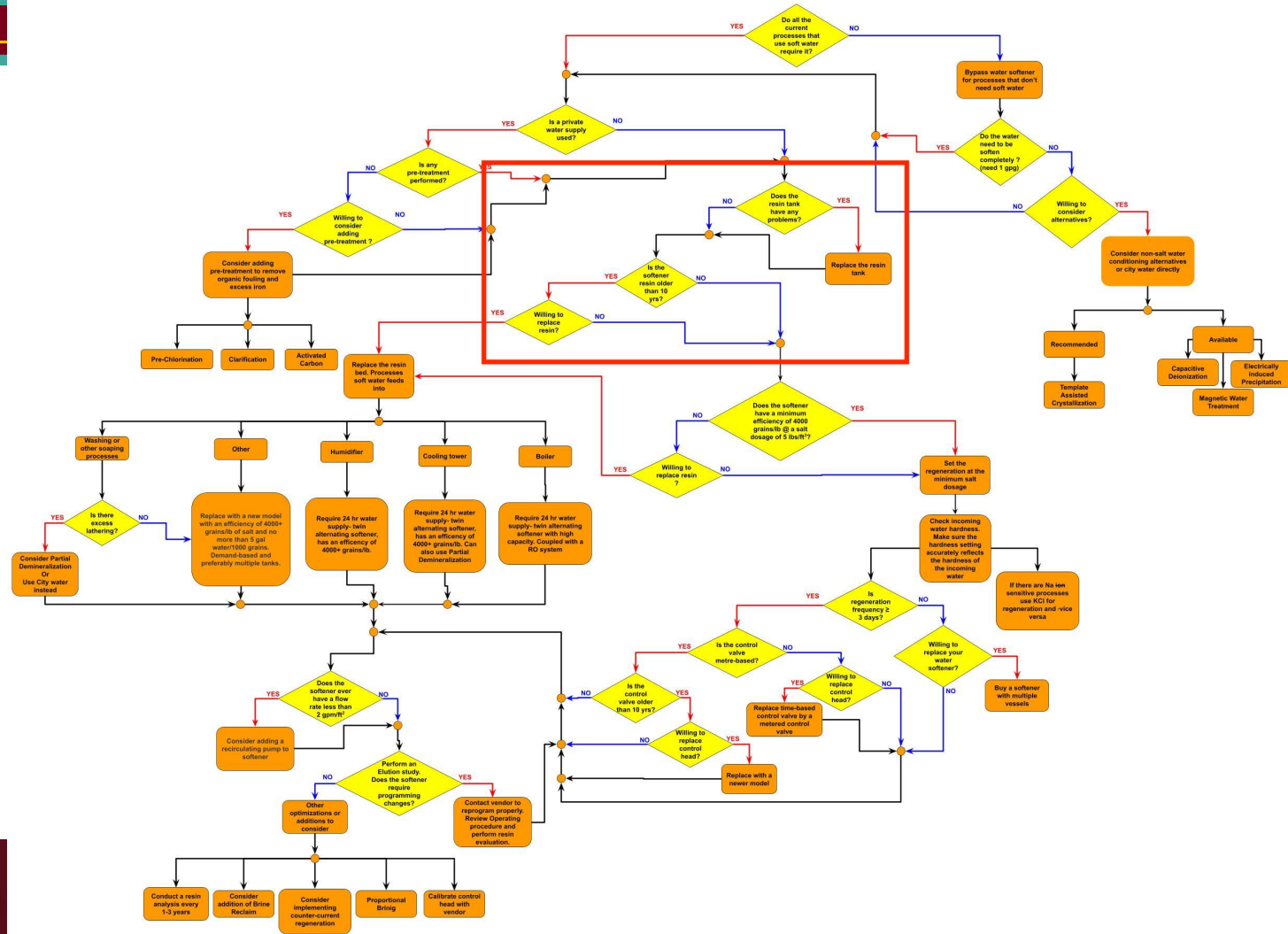


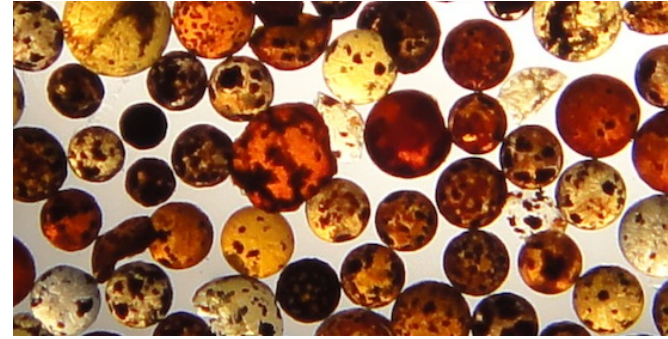
Figure 7: Simplified softener decision flowchart





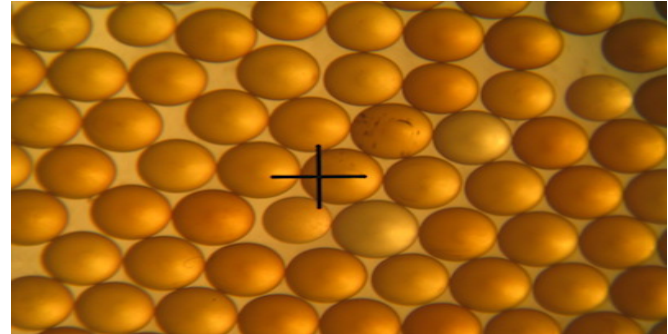
Resin

- Check the Age of the softener resin
- Resin volume loss 1-3 %/yr
- Replace resin bed in 10 yrs for normal use, 15 yrs for reduced use.



A

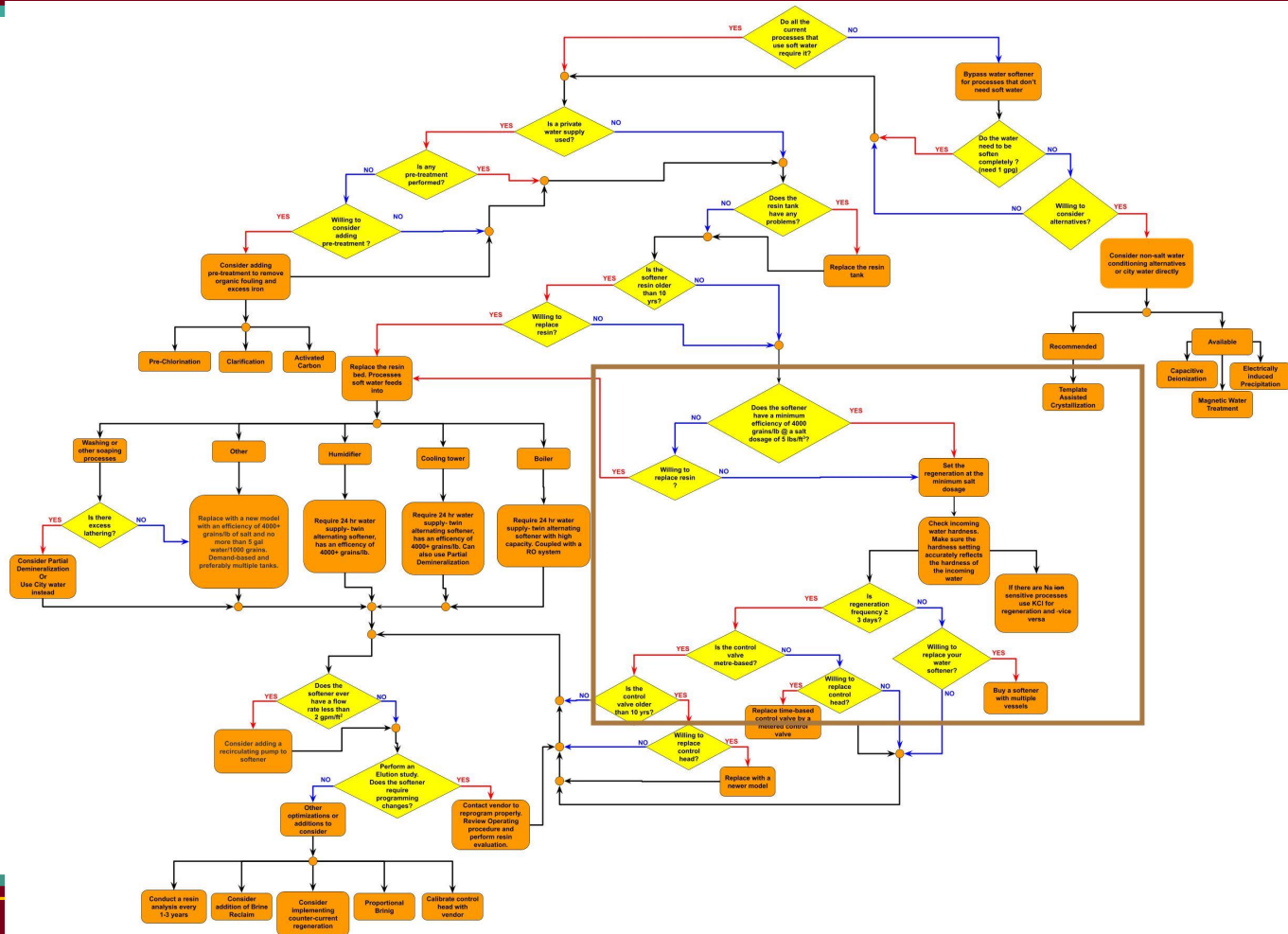
<https://www.wqpmag.com/extending-life-resin-water-softeners>



B

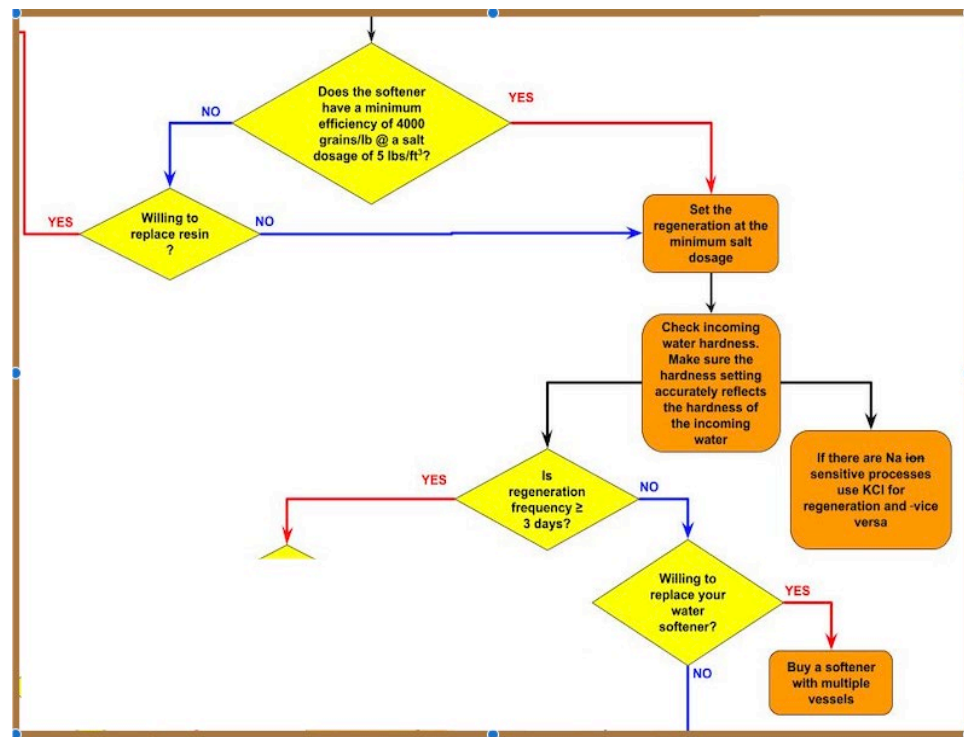
<http://www.decagonlab.com/?page=ion-exchange-resin>

Figure 7: A) degraded resin. B) Healthy resin



Hardness Setting & Salt Dosage

- Accurate Hardness setting
 - Too high: Reduces capacity of softener and wastes salt
 - Too low: Output hard water towards end of capacity
 - Check incoming water
- Lower Salt Dosage
 - Operate at minimum salt efficiency of 4000 grains/lbs





Elution study

- Elution study, good diagnostic tool on regeneration performance
- Optimizations and Preventative Maintenance

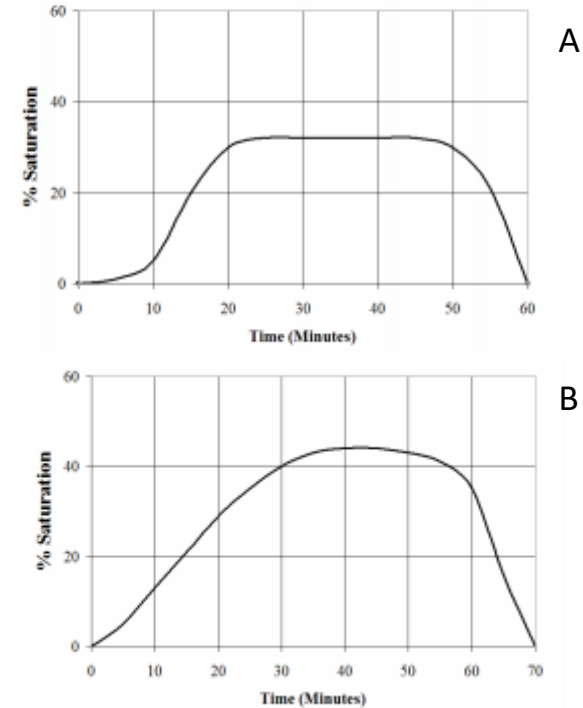


Figure 9: A) good elution curve B) Improper elution curve^[1]

^[1] Water Softener Elution Studies, James McDonald, Crown Solutions Customer Newsletter, 1997

Site Visit

- **Before Site Visit:**

- Collect basic softener information via Pre-visit questionnaire.
- Request pictures of control head to access settings.

- **During Site Visit:**

- Record information on Site-visit questionnaire during site-visits.
- Check settings on each softener individually and recorded programming.

- **After Site Visit:**

- Contact softening company, on-site intern and supervisor for follow-up questions.

Softening Recommendations for Company A

Recommendation	Annual reduction	Total cost	Annual savings	Payback period
1: Change salt dosage and hardness setting	Salt: 41 – 51 tons Water: 81,600 – 446,000 gal	None	\$12,000 - \$14,800	Immediate
1.1: Change hardness setting	Salt: 3.3 – 18 tons Water: 52,700 – 289,000 gal	None	\$1,200 - \$6,500	Immediate
2: Replace resin bed	Salt: 19 tons Water: 295,000 gal	\$26,000	\$6,800	3.8 years
3: Elution Study	--	--	--	--
1.1&2	Salt: 38 tons Water: 599,000 gal	\$26,000	\$13,500	1.9 years
1&2	Salt: 41 – 51 tons Water: 405,000 – 528,000 gal	\$26,000	\$13,800 - \$15,400	1.7 – 1.9 years

Softening Recommendations for Company B

Recommendation	Annual reduction	Total cost	Annual savings	Payback period
1: Change salt dosage and hardness setting – Softener A	Salt: 5.8 – 6.6 tons	None	\$1,200 - \$1,400	Immediate
1.1: Change hardness setting – Softener A	Salt: 2 – 3.2 tons Water: 24,100 – 38,100 gal	None	\$500 - \$800	Immediate
2: Resin core analysis – Softener B	--	\$500	--	--
2.1: Replace resin bed & Change hardness setting – Softener B	Salt: 2.8 tons Water: 32,200 gal/yr	\$4,000	\$700	5.6 years
3: Elution Study – Both softener	--	--	--	--
1&2.1	Salt: 8.6 – 9.4 tons Water: 16,100 – 66,700 gal	\$4,000	\$1,900 - \$2,100	1.9 – 2.1 years
1.1&2.1	Salt: 4.8 – 6 tons Water: 56,300 – 70,300 gal	\$4,000	\$1,200 - \$1,500	2.6 – 3.3 years

Softening Recommendations for Company C

Recommendation	Annual reduction	Total cost	Annual savings	Payback period
1: Change salt dosage setting – Softener B	Salt: 13 tons Water: 41,700 gal	None	\$2,800	Immediate
1.1: Accurate capacity setting – Softener B	Salt: 8.6 tons Water: 71,000 gal	None	\$2,100	Immediate
2: Resin core analysis – Softener A	--	\$500	--	--
3: Elution Study – Both softener	--	--	--	--

Personal Benefits

- Learned a lot about a relatively common but largely neglected piece of industrial equipment.
- Experience working in an industrial setting.
- Worked with a wonderful team of exceptional engineers

