This presentation premiered at WaterSmart Innovations

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Watersmart Innovations, Oct. 8, 2010

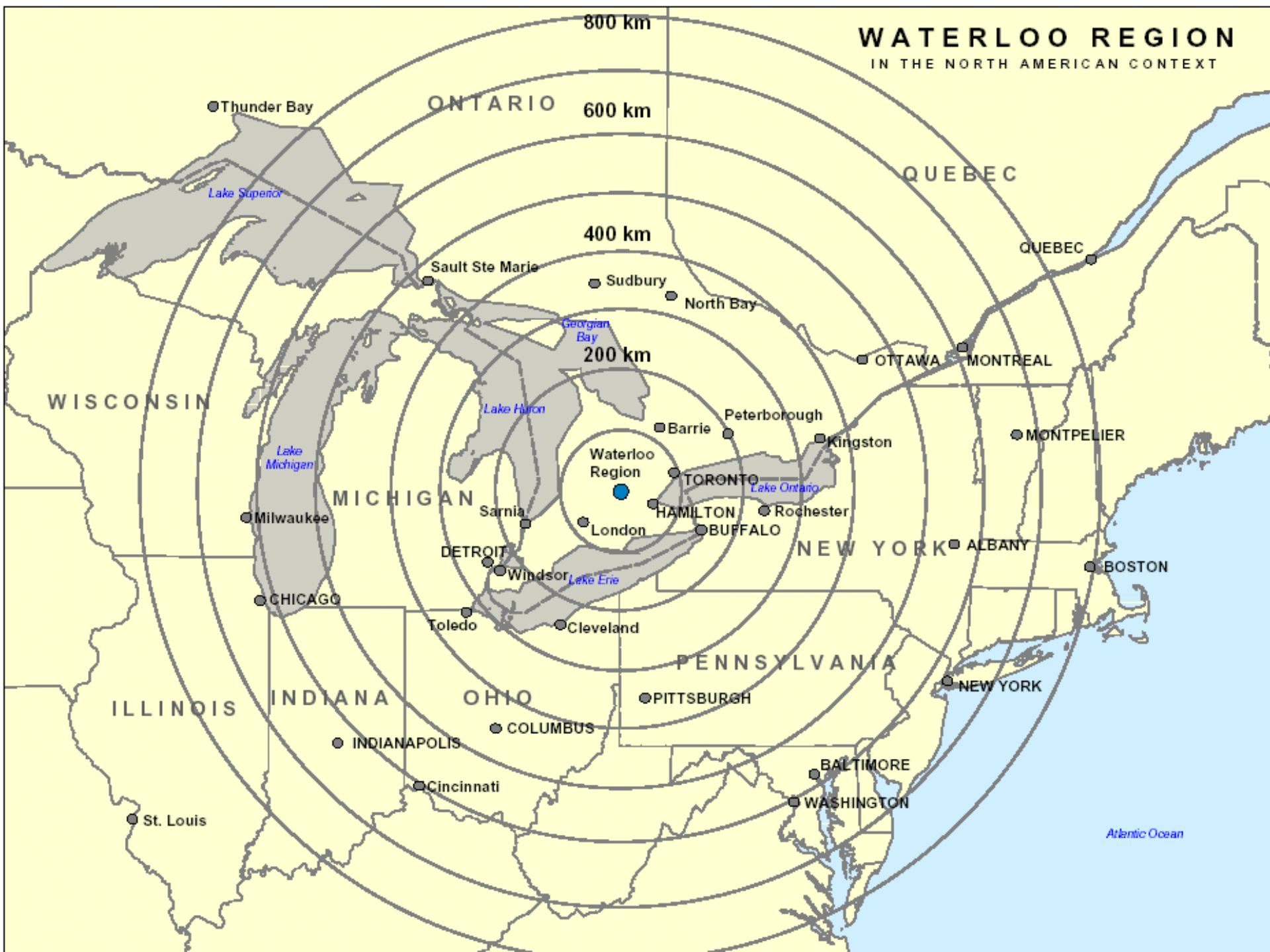
Residential Water Softener Performance Testing

Steve Gombos, Manager, Water Efficiency, sgombos@regionofwaterloo.ca

Region of Waterloo

The Region of Waterloo

- Province of Ontario
- Home of the Blackberry
- Population over 500,000 people
- Cities of Cambridge, Kitchener, Waterloo
- Includes 4 rural townships
- 80% of water from groundwater sources
- 20% of water from Grand River
- Pipeline to Lake Erie by 2035?


WATERLOO REGION
IN THE NORTH AMERICAN CONTEXT
800 km
600 km
400 km
200 km
ONTARIO
QUEBEC
WISCONSIN
MICHIGAN
NEW YORK
PENNSYLVANIA
OHIO
INDIANA
ILLINOIS
Thunder Bay
Lake Superior
Sault Ste Marie
Sudbury
North Bay
Georgian Bay
Lake Huron
Lake Michigan
Waterloo Region
Barrie
Peterborough
Kingston
TORONTO
Lake Ontario
HAMILTON
Rochester
BUFFALO
Sarnia
London
DETROIT
Windsor
Lake Erie
Milwaukee
CHICAGO
Toledo
Cleveland
PITTSBURGH
COLUMBUS
INDIANAPOLIS
Cincinnati
St. Louis
OTTAWA
MONTREAL
QUEBEC
MONTPELIER
ALBANY
BOSTON
NEW YORK
BALTIMORE
WASHINGTON
Atlantic Ocean

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Water Efficiency Master Plan

- Practiced water conservation since 1974
- Implement programs from second generation “Water Efficiency Master Plan”
- Includes budgeting for R & D projects

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Presentation Outline

- Why are we testing water softeners?
- Details about the test methodology
- Test results to date
- Conclusions
- Next steps

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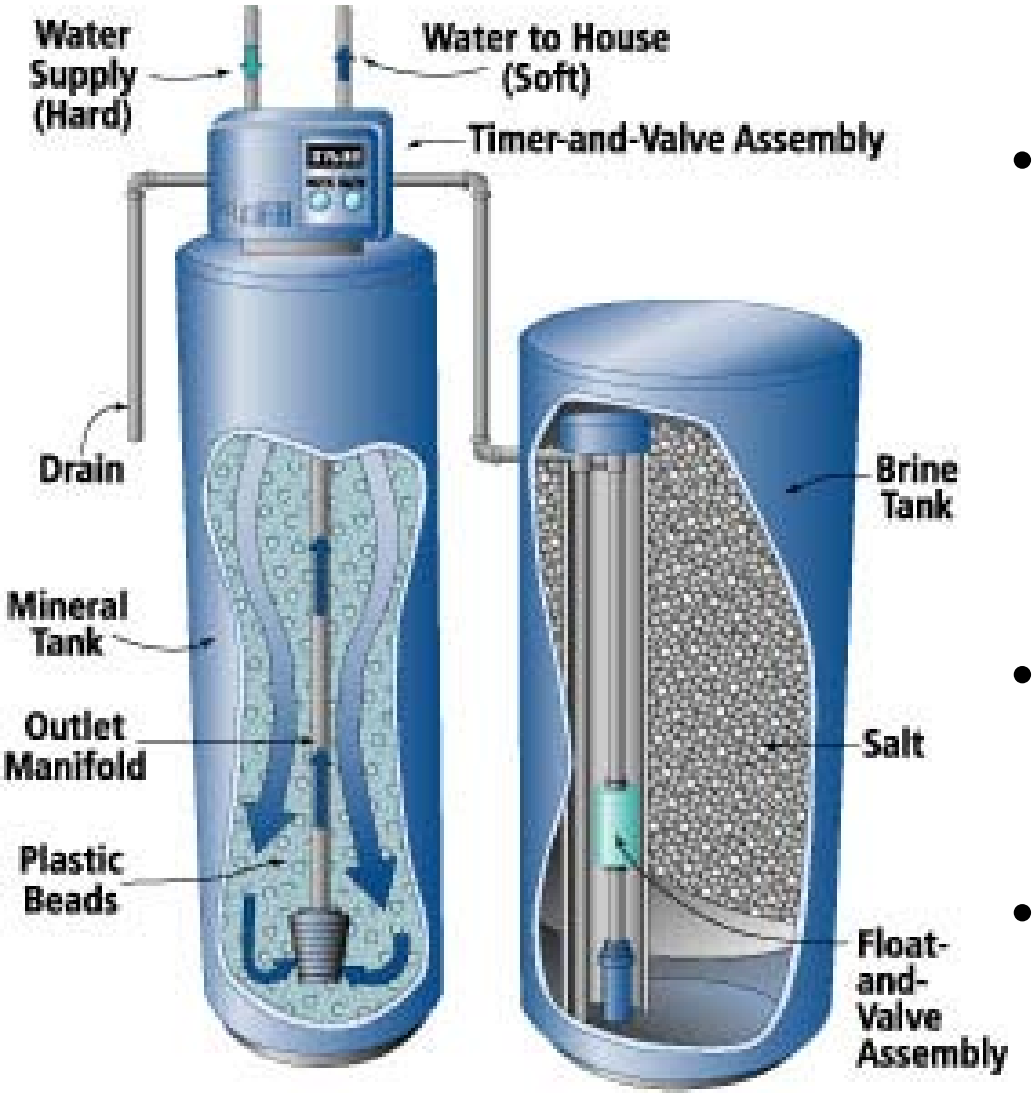
Dealing With Hard Water

- Groundwater with high calcium & magnesium is "hard"
- 10.5 grains per gallon (gpg) is considered high (180 mg/L)
- Waterloo Region average 22 gpg (376 mg/L)
- Some wells 38 gpg (650 mg/L) hardness
- Some of highest levels in the country

Ion Exchange Water Softeners

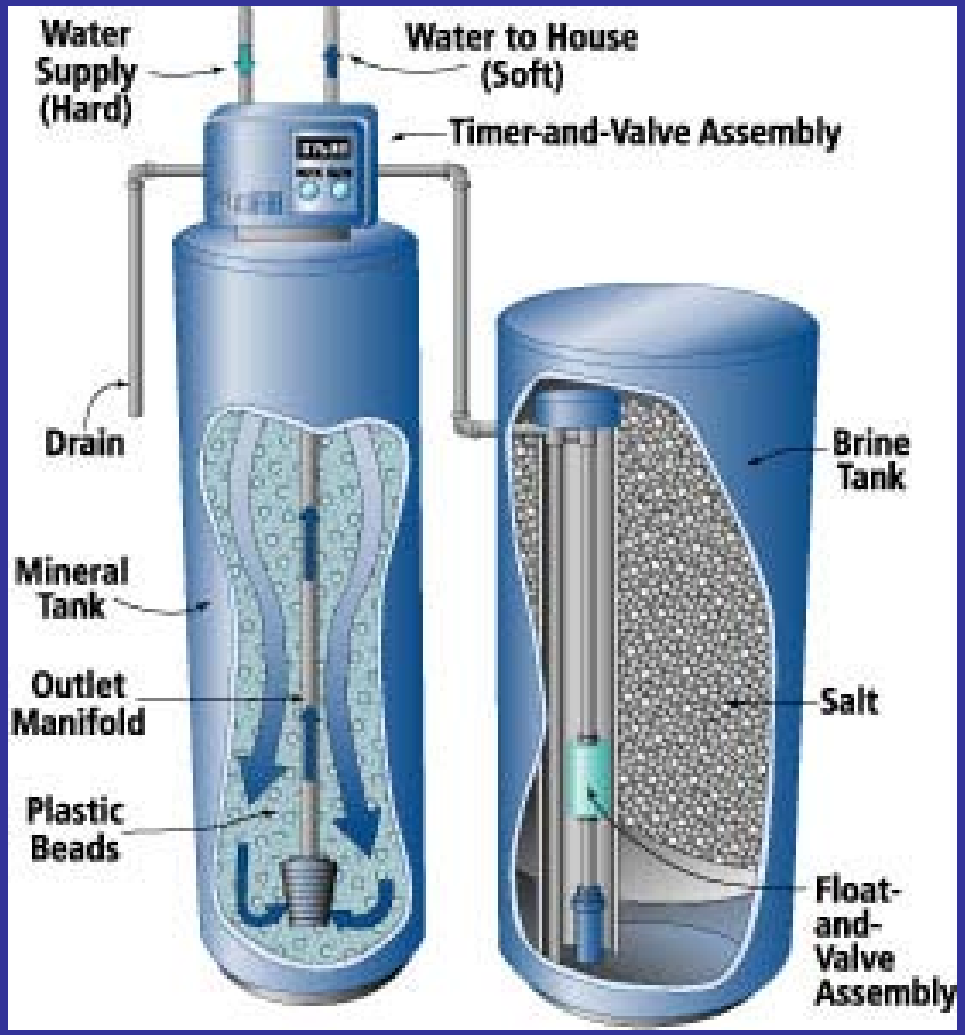
- Softer skin
- Cleaner dishes
- Better for clothes washing
- Prevents scale buildup on pipes, fixtures & appliances

Ion Exchange Process



- Water passing through mineral tank loses calcium & magnesium as ions stick to plastic beads and are replaced with sodium
- Soft water is drinkable, but salty
- Alternative to sodium is potassium

Ion Exchange Recharge Phase



1. Backwash phase removes “dirt” from mineral tank.
2. Recharging mineral tank with sodium from brine solution displaces calcium & magnesium, which is washed down the drain.
3. Final phase rinses mineral tank & loads brine for next cycle

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Water Softener Efficiency

- Most common sold now are demand initiated regeneration (DIR) units
- DIRs regenerate based on volume of water used
- Least efficient models with clock timers are rarely sold now
- Reputed most efficient models use sensors to measure hardness & trigger recharges

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Water Used For Softening

- Recent models average 159 litres per recharge
- 72% of homes in Waterloo Region have them (134,723 HH)
- 1,319 million litres Waterloo Region
- Enough to supply 4,500 households
- Probably higher - older softeners more inefficient
- Baseline demand water use

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Impacts of Softener Salt

- About 32,333 tonnes of salt into Region of Waterloo sewers annually
- Loading of 88 tonnes per day
- Actual is probably much greater because many homes still use old, inefficient softeners

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Why Test Water Softeners?

- No independent test results found re: water consumption, salt usage and controller efficiency
- Wanted to measure local softener performance
- Compare results with ANSI/NSF 44 Performance Standard
- Fill information gaps related to treatment type, size & efficiency of softeners
- Understand how they work better

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2009-2010 Softener Research

- Approved by Council
- 50% funding partnership with City of Guelph in year 1; continued partnership in 2010

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Main Goals of Study

- Measure performance
- Use results to educate residents, plumbers, retailers
- Measure potential impacts on Water Demands, WW treatment & environment
- Gather info for future policies & programs

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Core Study Team

Steve Gombos, Project Manager (sgombos@regionofwaterloo.ca)

Kingsley Blease, Engineering Consultant (Data)

Brent Fitzpatrick, Instrumentation Consultant

Wayne Brabazon, Project Coordinator

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Study Method

- Testing at William St. Pumping Station, Waterloo
- Three softeners tested at one time
- Recreate typical household demand/flow profile
- Measure parameters digitally
- Data downloads to engineering consultant for verification and analysis (every 5 days)
- Electronic data logs 2-30 mins., SCADA controls
- Meters, scales, hardness analyser certified accurate

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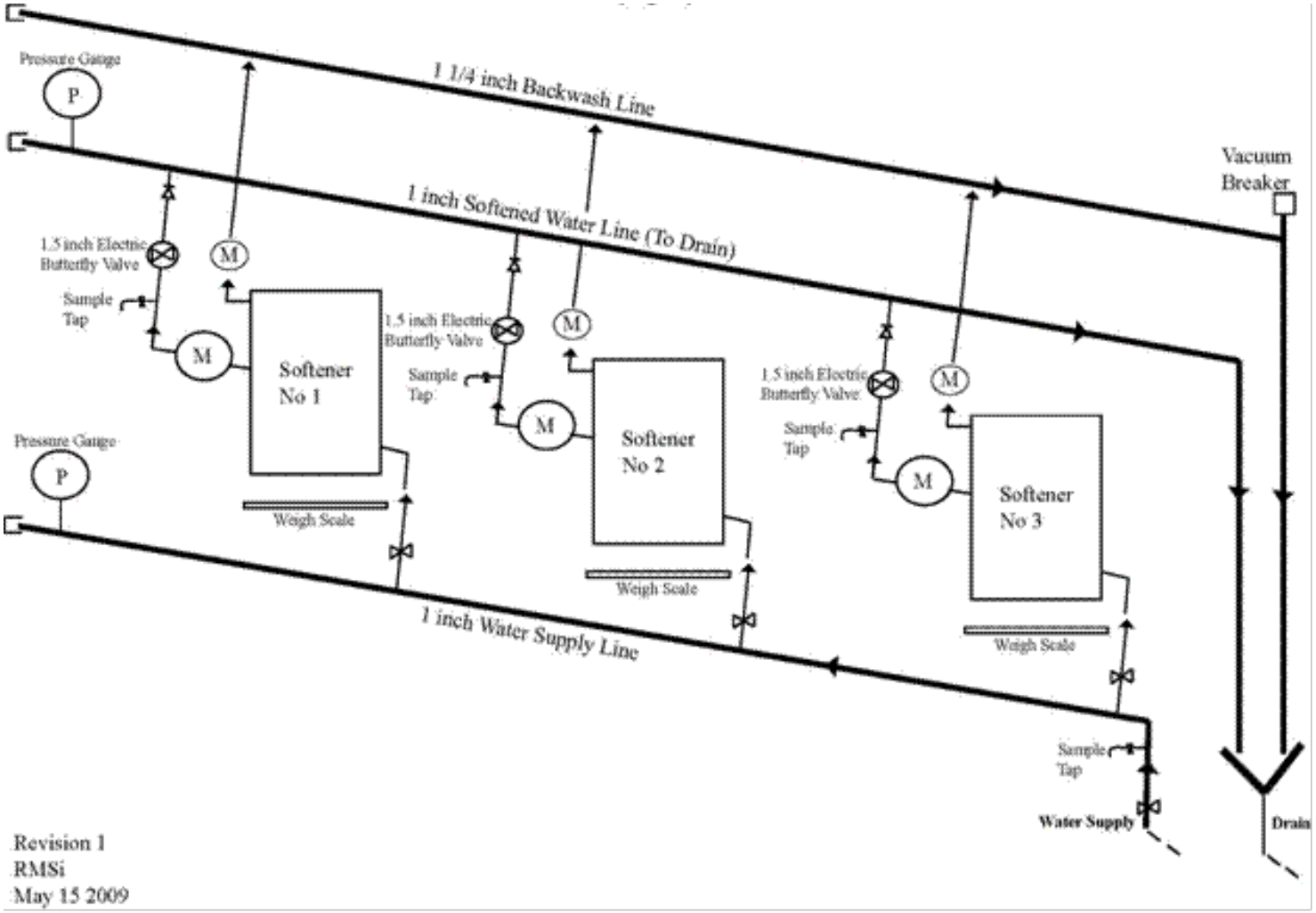
Parameters Monitored

- Volume of water supplied – instant/cumulative
- Volume of regenerate water to drain
- Weight of salt (sodium Chloride) used
- Hardness of water before and after softening
- Record of recharging
- Electricity used
- Controllers & settings

* Typical test = 30 days, 10 regeneration cycles*

Test Rig Schematic



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Accuracy

- Seametrics 20mm disc flow meters +/- 2%

(measures wastewater from regenerations)

- Burkert Type 8081 instant flow meters +/- 2%
- Force Flow model PVC150KHA17 high accuracy carboy scales +/- 2.5%
- Hach model APA6000 high range hardness analyser 10-1000 ppm +/- 2.5%

Test Rig Photo

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U.S./Metric Conversions

In Water

1 grain per U.S. Gallon = 17.1 mg/L (ppm) hardness

1 US Gallon = 3.785 litres

As a solid

1 grain of hardness = 0.065 grams of hardness

(mainly calcium & magnesium)

2.204 lbs. = 1 kilogram

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Test Water Hardness

- Test site hardness 580 ppm (34 grains)

Water Quality Association (WQA) hardness:

- Soft < 17 ppm (<1 grain per US Gal)
- Slightly Hard 17 – 60 ppm (1 – 3.5 gpg)
- Moderately Hard 60 -120 ppm (3.5 – 7 gpg)
- Hard 120 – 180 ppm (7 – 10.5 gpg)
- Very Hard > 180 ppm (>10.5 gpg)

Water Use Profiles

1999 AWWA End Use Study and 2005 data logging 60 households

	2005 Study	1999 Study
Number of People per Household	3.06	3.12
Litres Used per Person	229	234
Litres Used per Household	700.74	730.2

The 2005 data was used to develop the water use profiles – **average 700.74 litres per household per day**

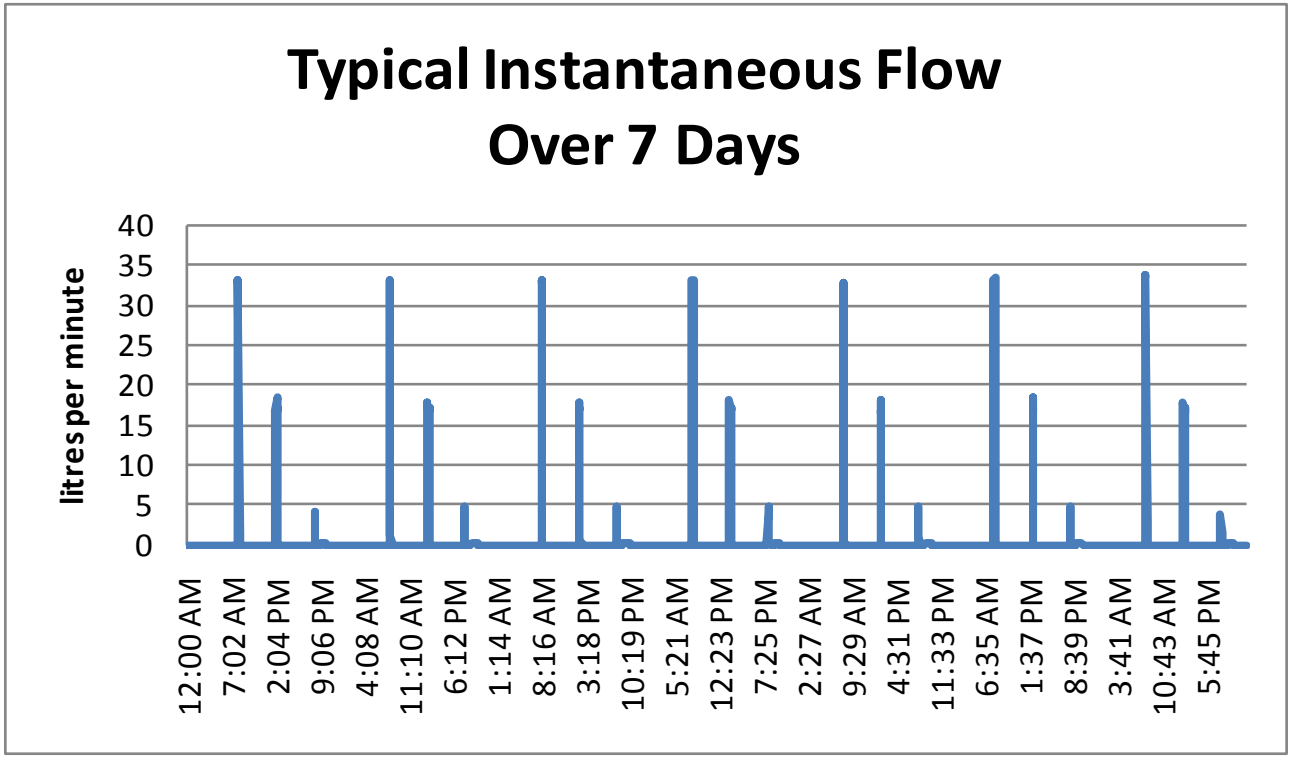
Maximum Flow Rate			
litre per minute			
33	20 lpm Shower and 13 litre Toilet		
33	Bath and 13 litre Toilet		
Minimum Flow Rate			
1	Leak		
Average Flow Rate			
17	Average		

Typical Day Profiles

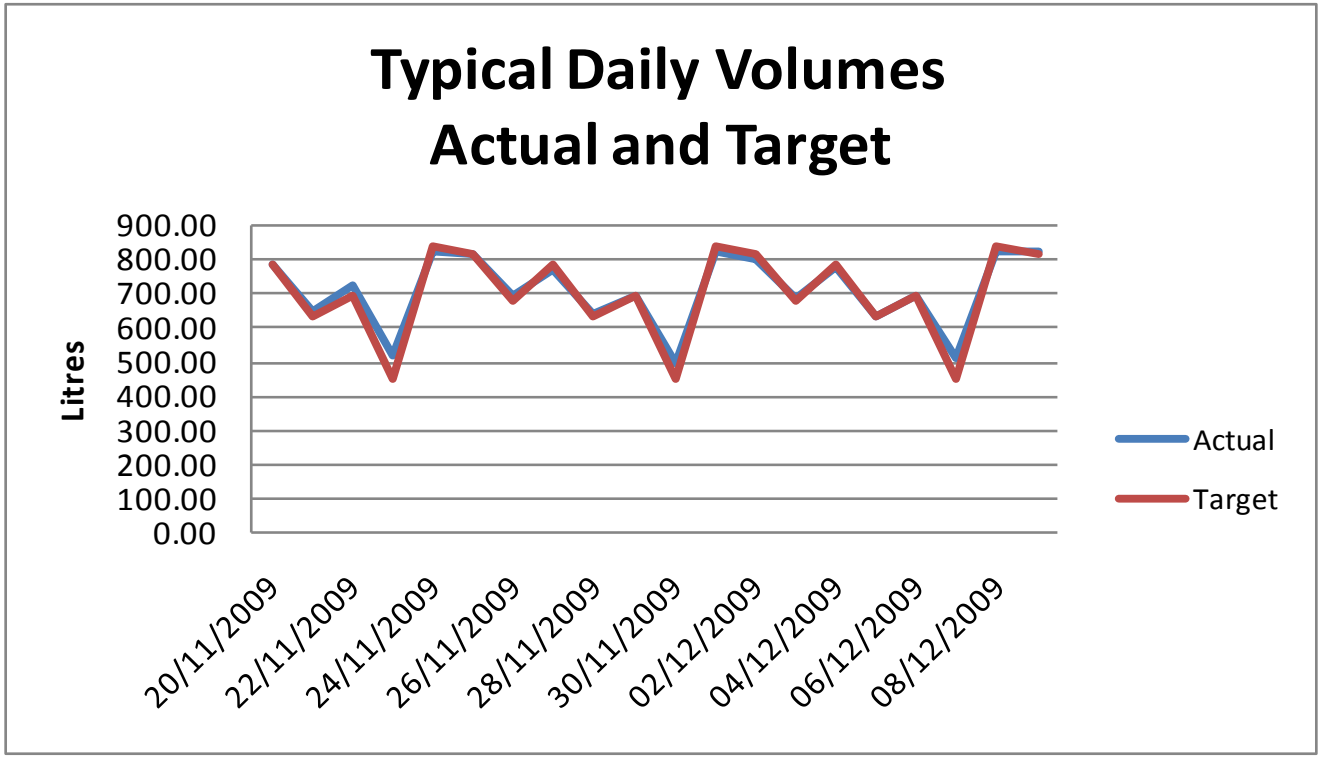
Average Household Tuesday		
Flow Rate	Duration	Volume
lpm	minutes	litres
4	**3.70**	**14.80**
33	**12.15**	**400.86**
17	**20.02**	**340.33**
sub total	35.87	755.99
	10% make up	**84.00**
	Total	839.99

Average Household Thursday		
Flow Rate	Duration	Volume
lpm	minutes	litres
4	**17.69**	**70.77**
33	**10.29**	**339.55**
17	**11.97**	**203.44**
sub total	39.95	613.76
	10% make up	**68.20**
	Total	681.96

Instantaneous Flow Set Up



Actual and Target Daily Volumes



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Size of softeners tested

- Tested units about 30,000 grain capacity
- Able to remove 30,000 grains of hardness; requires about 12 lbs. of salt during regeneration
- Many softeners regenerate at 75% exhaustion to ensure soft water available at all times
- Some electronic controllers use variable buffer based on flow history

Note: 32,000 grain capacity softener contains 1 ft^3 of resin

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Target Softener Control Valves

- Clack/Pentaire (GE, Crystal Clear)
- Fleck (Novatek, Myers, Aquafine, Aquasoft)
- Autotrol
- Culligan
- Ecowater (Kenmore, Northstar, Miracle Water)
- Kinetico
- Some are sold under several brand names
- Packaging: Resin tank inside/outside brine tank
- All are DIR controllers


Kenmore
ELITE

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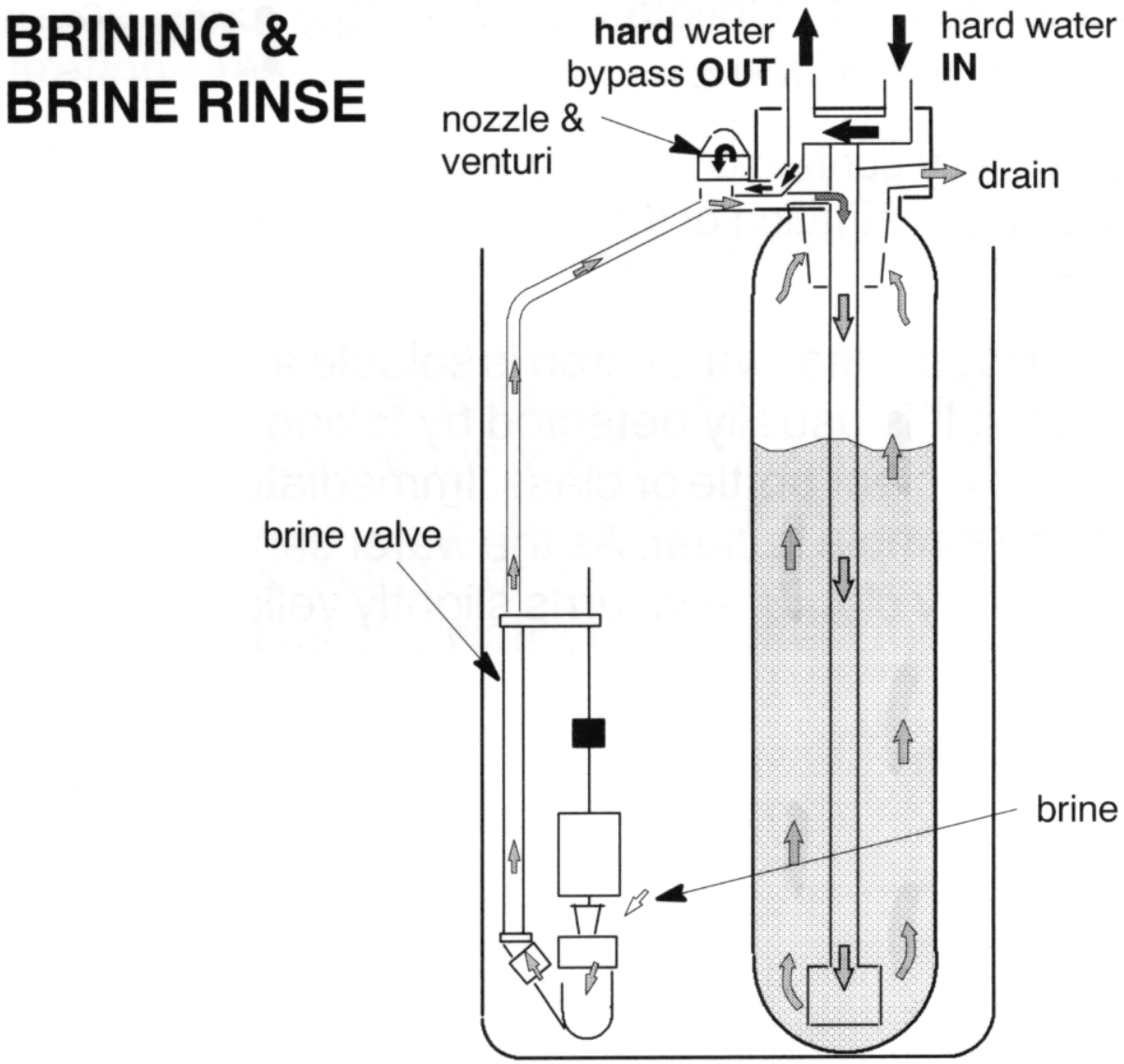
Upflow vs Downflow Controllers

- "Theoretically down flow is more water efficient because not recharging 20% of resin bed that hasn't been exhausted," Kevin Wong Exec Dir, Can. WQA
- Upflow controllers regenerate entire resin bed, whether needs it or not
- Not all manuals describe whether UF or DF
- Sales & service people often give conflicting information

Upflow Ecowater DIR Valve



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Dealers Installed Test Units

- Purchased softeners locally
- Fully informed about our project
- Told to set for HH of 3 people, 34 grains hardness in water
- We found that all installers kept to factory settings
- A few call-backs: dirty valve Kinetico, Culligan Sensor incorrect plumbing, Crystal Clear incorrect part installed

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Softeners Tested To Date

SOFTENER	MODEL	VALVE	COST CAN
Ont. Soft Water	Performa valve 762	Autotrol - DF	$1,049
Ecowater	GS6225D	Ecowater - UF	$1,200
Novatek	NT32SE	Fleck – UF	$1,617
Culligan	Medallist Plus Model 30	Culligan - DF	$2,117
Culligan Sensor	9" QH Gold Series	Culligan - UF	$2,149
Kinetico	2040S Mach Series	Kinetico - DF	$2,895

- All about 30,000 grains of capacity; DF = down flow, UF = up flow

Power Used Was Minimal

SOFTENER	Avg. Kwh per day
Ont. Soft Water	0.06
Ecowater	(too low to detect)
Novatek	0.114
Culligan	0.105
Culligan Sensor	0.16
Kinetico	0 (all mechanical)

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NSF/ANSI Standard 44

Minimal Removal Capacity

3,350 grains per lb. of regenerant salt

1,000 grains capacity per 5 US gal. of regen. water

Metric Conversion

478 grams hardness removed per kg regen. Salt

342 grams hardness removed per 100L regen. Water

Assume Soft Water Achieved at 15 ppm

Waterloo remove 565 grams total hardness from 1 m^3 of hard water

Results per m^3 of soft water produced

SOFTENER	SALT Kg/m^3	NSF/ANSI 44	RANKING
Kinetico	0.8	1.5	1
Culligan	1.0	1.2	2
Novatek	1.2	1.0	3
Ecowater	1.3	0.9*	4
Culligan Sensor	1.3	0.9*	5
Ontario Soft Water	1.6	0.7*	6

*Below NSF/ANSI 44 standard

– Ratio of 1.0 or higher meets NSF/ANSI 44 performance standard

Regen water per m^3 of soft water produced

SOFTENER	WATER LITRES	NSF/ANSI 44*	RANKING
Kinetico	60	2.9	1
Ontario Soft Water	70	2.4	2
Novatek	80	2.1	3
Culligan Sensor	90	1.8	4
Ecowater	100	1.7	5
Culligan	105	1.6	6

*All pass standard – down flow DIR units used least water, ranked 1&2; but Culligan DF ranked 6!

Rankings & Annual Operating Costs

SOFTENER	SALT	WATER	Op'g Cost*	Operating Cost Rank
Kinetico	1	1	$145	1
Novatek	3	3	$215	2
Culligan	2	6	$219	3
Ecowater	4	5	$238	4
Culligan Sensor	5	4	$239	5
Ontario Soft Water	6	2	$254	6

* 2010 Kitchener water/sewer+hydro+salt – 17 yrs payback Rank 1 vs 6

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Regeneration Frequency

- Majority softeners regenerated every 3 days
- Ecowater regenerated every 1.5 days
- Kinetico regenerated every day

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Kinetico

- Kinetic energy to operate
- Never get hard water, as alternate between resin tanks
- Regenerates as needed, day or night
- More often found in commercial applications due to compact size

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Next Units To Test

- Aqa Perla, BWT Germany (dual resin tank)
- GE from Home Depot (Ecowater)
- Crystal Clear (Clack)

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Conclusions

- Most water efficient not always most salt efficient
- Higher price may not = more efficient
- Kinetico clearly most efficient overall
- NSF/ANSI 44 performance standard should be considered a minimum benchmark
- Opportunity for WaterSense to establish significantly higher benchmarks
- Problem is controllers are highly adjustable and can be tweaked to achieve different results

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Conclusions

- Consider local recommendation to ask residents to soften only the hot water, which would keep appliances in shape while reducing water/salt usage
- Clearly a need for education of plumbers and the public
- Need to look at lower-impact, viable alternative treatment technologies

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Next Steps

- Continue testing to end of 2010
- Written report to Council
- Possible continued testing in 2011 – partner with WaterSense?
- Gather more data on status of softeners currently being used in homes (Aquacraft end use study, surveys, actual testing)
- Study results from WRF-08-06, Oct. 2011

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Questions?

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Alternative Water Treatment

- Referred to as "physical water treatment," "magnetic treatment" or alternatives to water softening
- Alternatives to water softening do not actually soften water, but may potentially prevent scale buildup in pipes and appliances
- Direction given to extend Region softener testing project to include magnetic treatment in 2011

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Testing Magnetic Treatment

- U.S. Water Quality Association (WQA) Magnetics Task Force Report, refereed by a list of PhDs & water quality experts in 2001
- 106 papers reviewed against scientific method
- 34 papers re: magnetic treatment deemed scientifically valid

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WQA Magnetics Task Force

- Papers studied did not provide clear answers on magnetic treatment

"In that body of literature, there are indications that physical water treatment does work, that it does not work, that it may work, but only in certain circumstances, and that it may work in conjunction with or as a result of coincidental trace chemical or ionic leaching mechanisms or other combination technologies."

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Magnetic Task Force Suggested

- Consensus standard under ANSI be developed
- Additional research be conducted
- Publish WQA report to advance science

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Water Reuse Research Foundation

- U.S.-based non-profit research foundation dedicated to advancing municipal water reuse
- Advocates salt reduction in treated wastewater to allow reuse & crop irrigation
- Awarded $263,000 contract in 2008 to evaluate "Alternatives to Domestic Ion Exchange Water Softeners"
- WRF-08-06 publication date: October 1, 2011

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WRRF Study Scope

- Assess effectiveness of alternative domestic technologies to alleviate negative impacts of hard water
- Compare energy, chemical consumption and water use of alternatives with existing ion exchange water softeners
- Region of Waterloo deferring local testing of alternative water treatment technologies pending WRRF study results

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Potassium Chloride

- More desirable from environmental perspective
- Works in ion exchange same way as salt
- Better for irrigating plants
- OK to drink
- Cost $12 per 20 kg compared to $5 for salt
- Harder to find at retail outlets
- Further testing required

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Questions?