



HAAAs in Water Distribution Systems in Newfoundland & Labrador: Causes and Characteristics

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Outline

- Guideline for HAAs
- Causes of HAAs
- Toxicological Effects of HAAs
- HAAs in Newfoundland and Labrador
- Trends
- Corrective Measures and Best Available Technologies for HAA Control
- ENVC HAA Study
- Path Forward

HAA Guidelines

- Health Canada Guideline for HAA came into effect in 2008

Compound (µg/L)	US EPA (2003)	CCME/ Health Canada (2008)
HAA5	60	80

- Maximum Allowable Concentration (MAC) for HAAs in drinking water is 80 µg/L based on a **locational** running annual average of a minimum of quarterly samples taken in the distribution system
- Sample at point of maximum formation
- Uncertainty over where to sample for HAAs

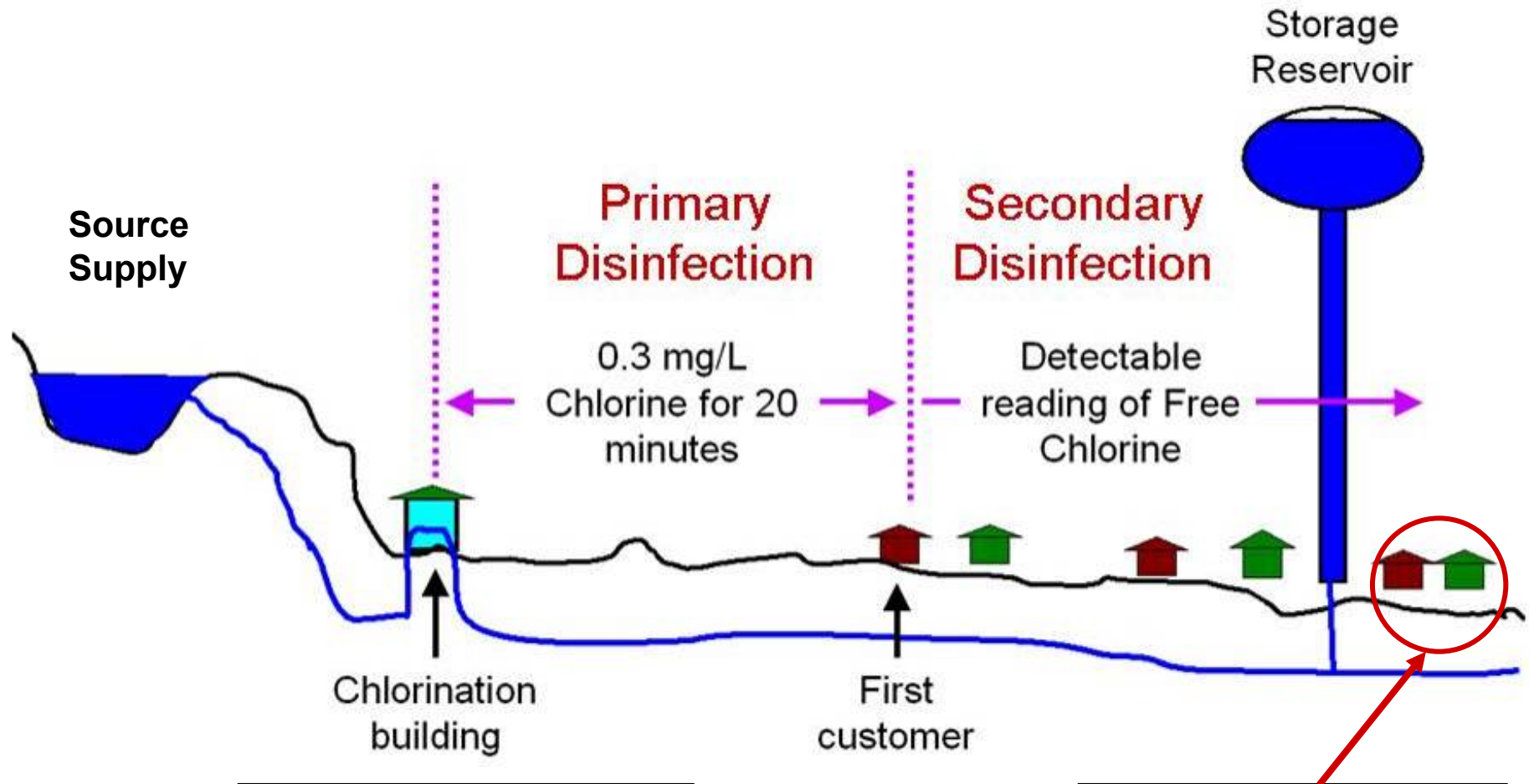
What Is a DBP?

- [Precursor Material] + [Disinfectant] = [Disinfectant by-product or DBP]

Natural Organic Matter	Chlorine	HAA
		THM
Bromide		

- Other factors that play a role in the formation of DBPs:
 - Water Temperature, pH, Contact Time, Disinfectant Dose
- HAAs more likely to form at low pH and high water temperature

Typical Water System




- 95% of disinfection systems in NL use chlorine

- End of system-sampling point for THMs

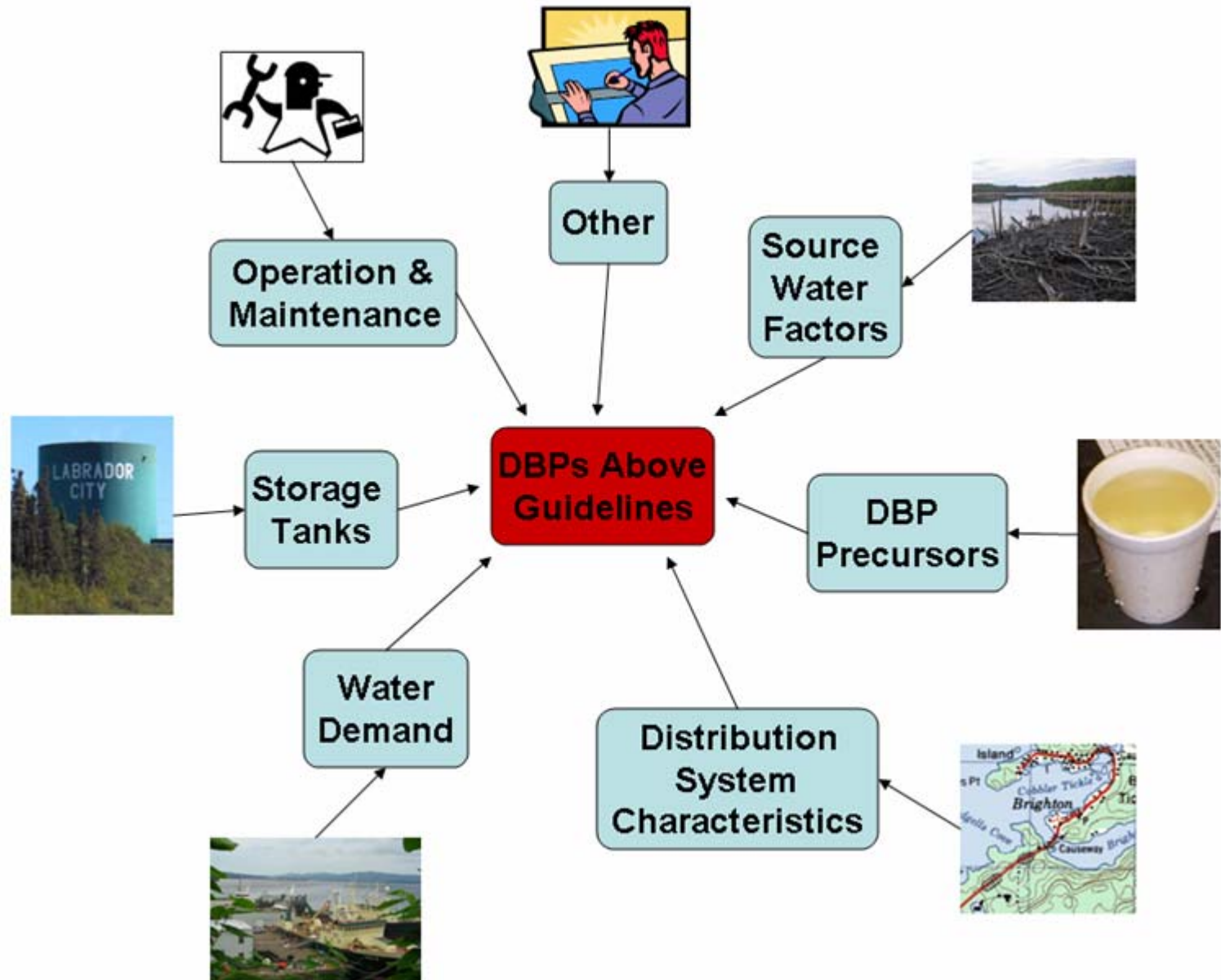
Natural Organic Matter (NOM)

Humic Substances

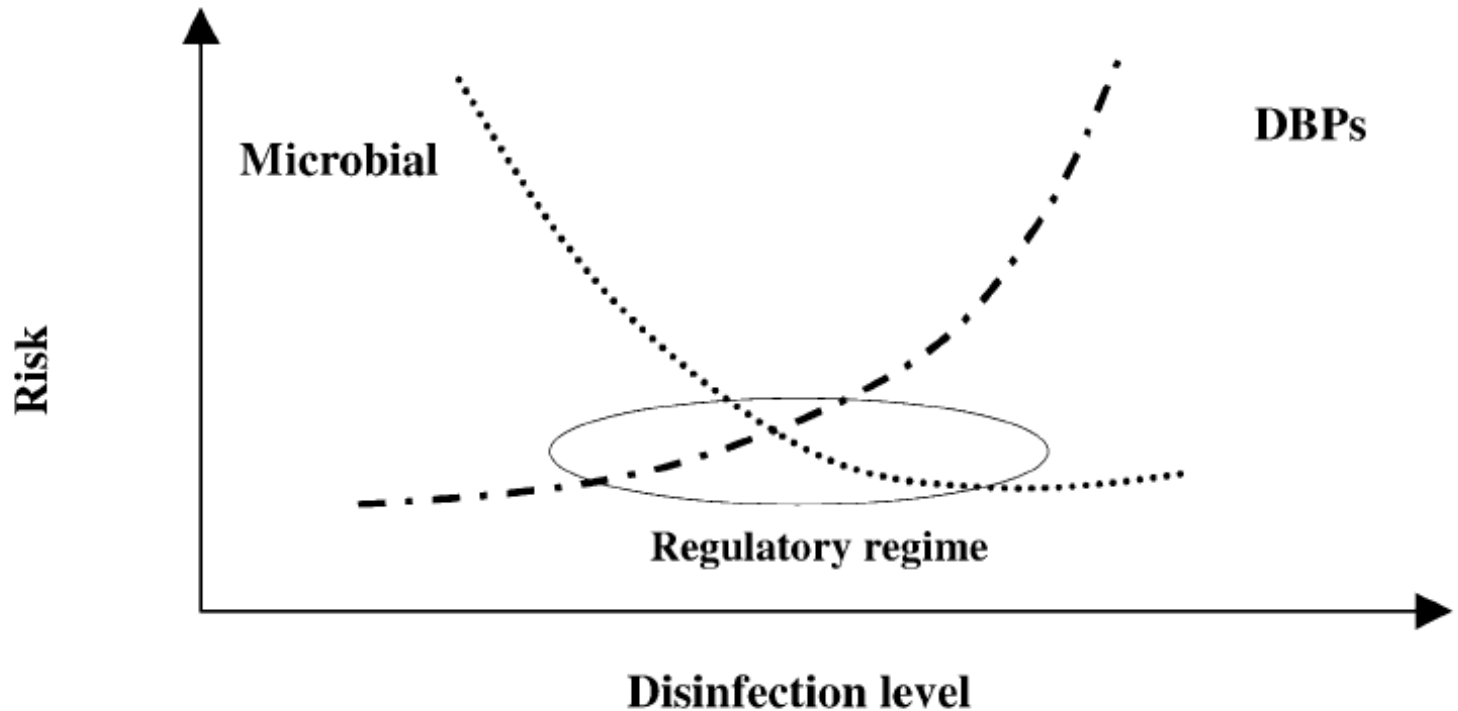
Fulvic Acid		Humic Acid		Humin
Light Yellow	Yellow Brown	Dark Brown	Grey Black	Black
<ul style="list-style-type: none"> -Less coloured -Lower molecular weight -Less C, more O -More acidic -Soluble 		 <ul style="list-style-type: none"> -More coloured -Higher molecular weight -More C, less O -Less acidic -Decreased solubility 		

- High levels of humic acids in raw water favour HAA formation
- Dissolved Organic Carbon (DOC) is the best available indicator of NOM

Probable Causes of HAAs



Toxicological Effects of HAAs



- Main route of exposure is through ingestion
- Health effects are **probable** and based on a lifetime exposure
- Microbial pathogens pose the greatest risk to human health from drinking water

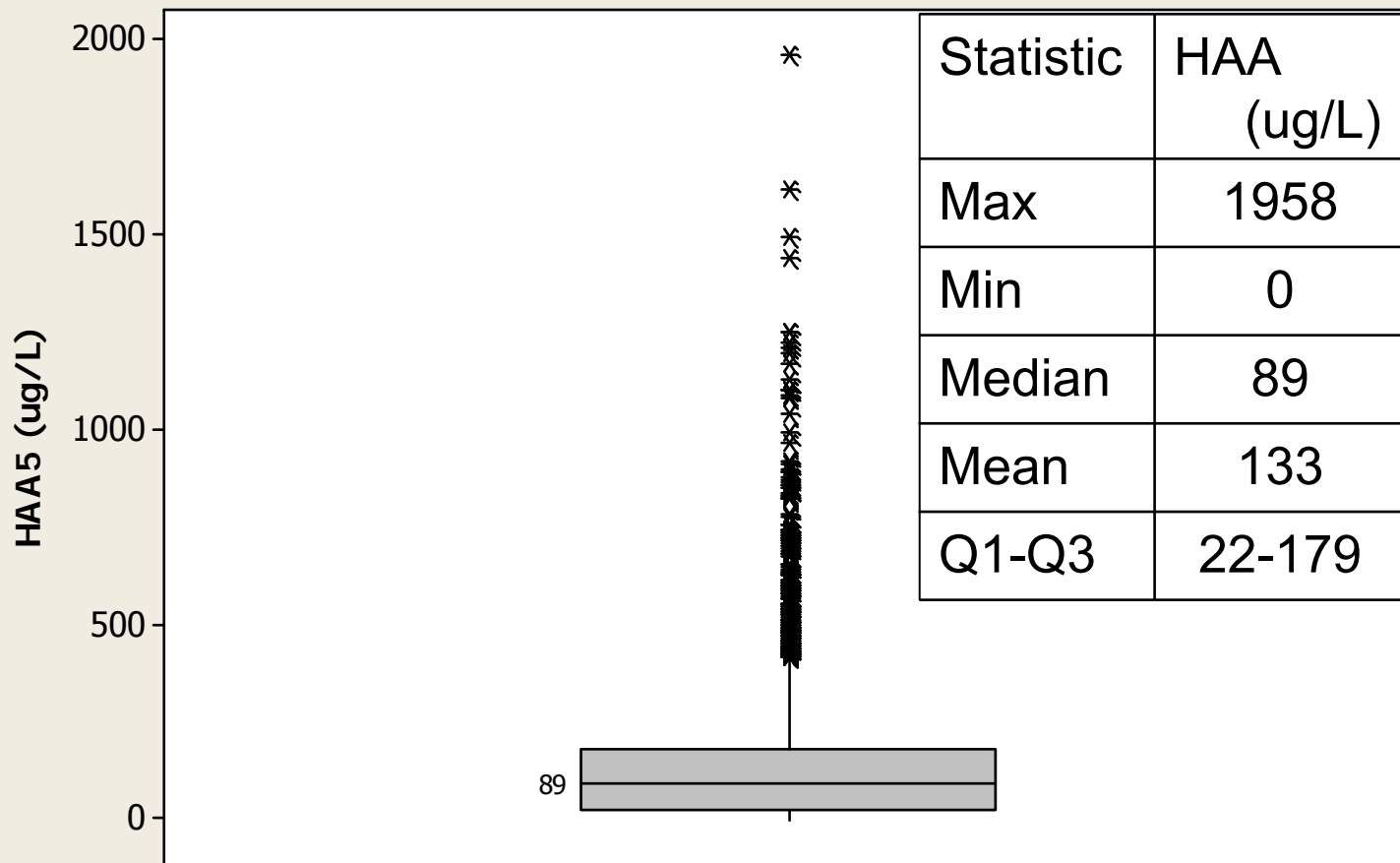
NL Communities with DBP Issues

DBP Type	Number of Drinking Water Systems Out of 536 with Issues (2003-2006)	Number of Drinking Water Systems Out of 556 with Issues (2008-2009)
THM	124	166
HAA	168	193
HAA and THM	107	
HAA and pH	132	

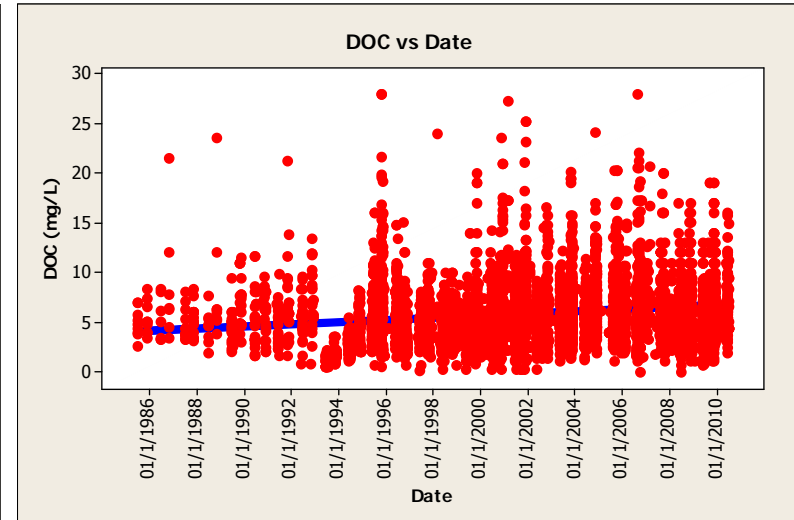
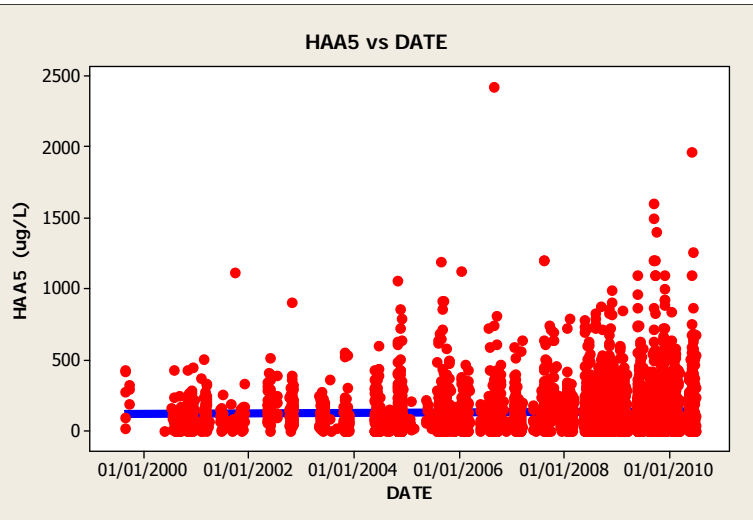
- HAA and THM exceedances occur together 58% of the time
- HAA and pH exceedances occur together 72 % of the time
- 48% of population of NL impacted by HAA exceedances

HAA Behaviour in NL

HAA5 Data: April 2008- Sept 2010



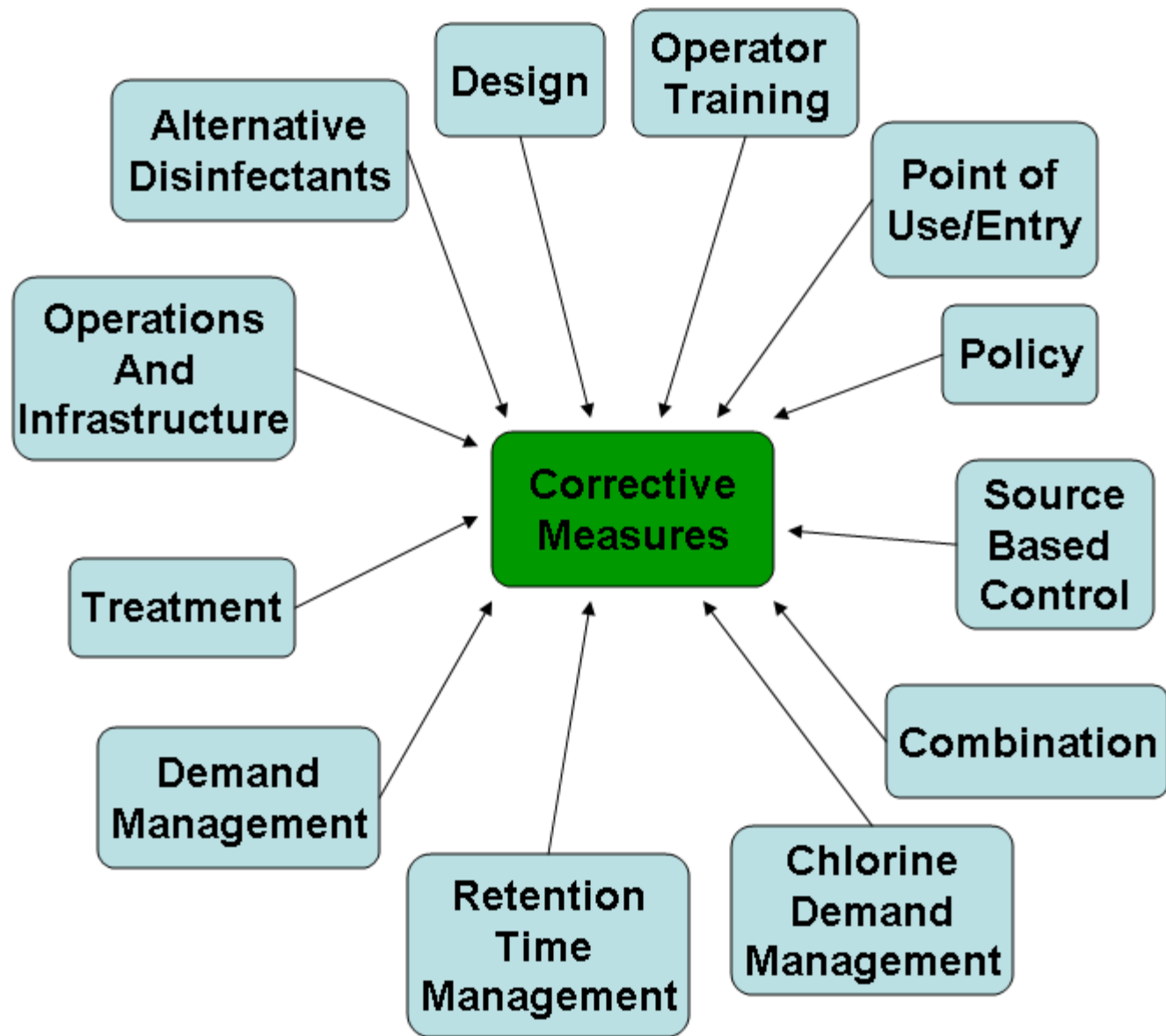
Long Term & Seasonal Trends



- Slight increase in HAAs over time, significant increase in DOC

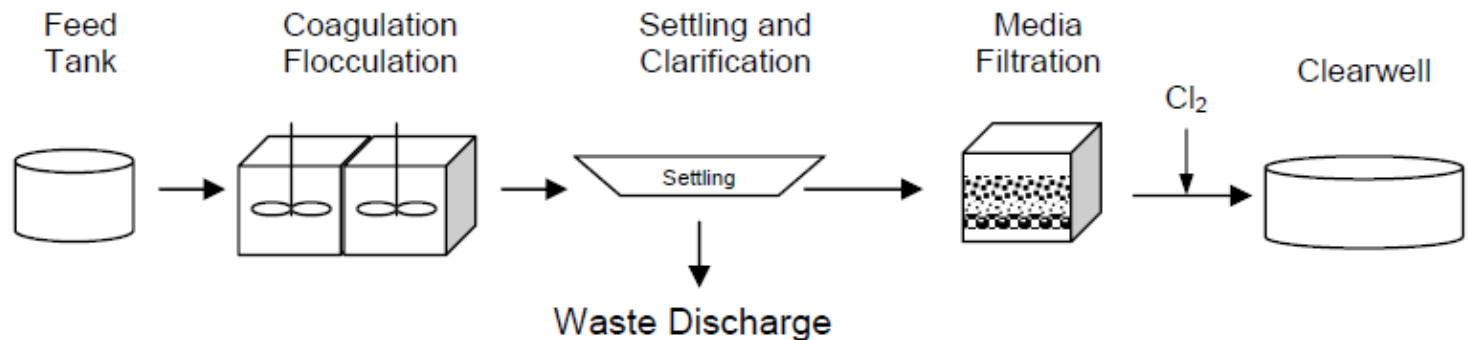
	Spring	Summer	Fall	Winter
pH	low	peak		
Temperature		peak		
DOC/ Colour			peak	
Chlorine Dosage	peak		peak	
HAA		peak		
THMs			peak	

Corrective Measures for HAAs



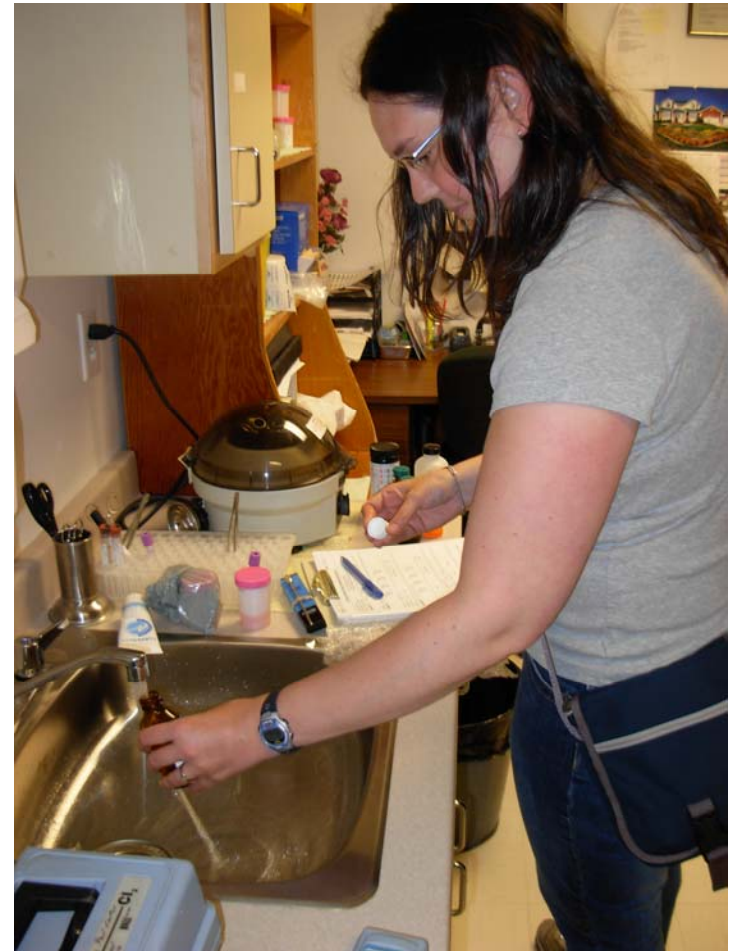
Best Available Technologies for HAA Control

- Enhanced coagulation and media filtration
- Dissolved air floatation
- Ozonation
- pH adjustment
- Reverse osmosis
- Lime softening
- GAC filtration
- Enhanced coagulation and membrane filtration



HAA Study

- Objectives of Study:
 - To identify where to sample based on the new Health Canada guideline
 - Point of maximum formation
 - Understand HAA behavior
 - Trends
 - Causes
- Samples collected over 2008-09
 - 16 samples for each community
 - 4 sites x 4 seasons



Communities from HAA Study

- Arnold's Cove- Eastern
- Brighton- Central
- Channel- Port aux
Basques- Western
- Grand Bank- Eastern
- Keels- Eastern
- Norris Arm- Central
- Point of Bay- Central
- St. Paul's- Western
- St. George's- Western
- Steady Brook- Western
- Sunnyside- Eastern
- 11 communities
representing:
 - long linear systems- 5
 - Branched systems- 6
 - systems with water
storage tanks- 6
 - systems with fish plant
demand- 3
- Samples were taken in
distribution system at:
 - beginning
 - beginning to middle
 - middle to end
 - end

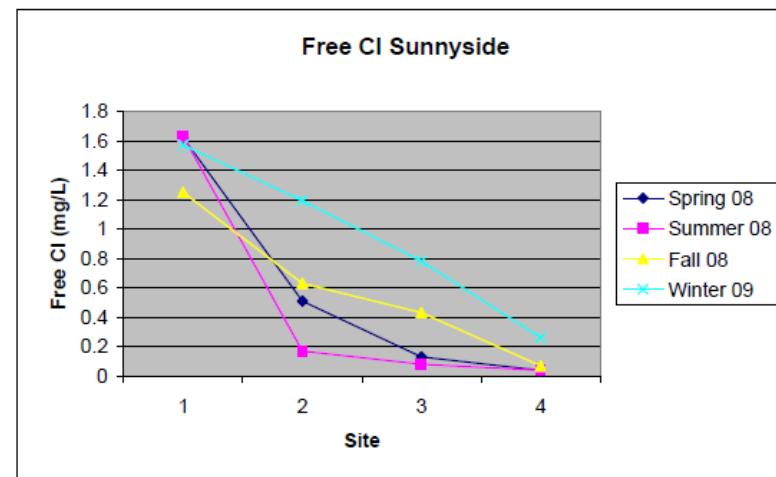
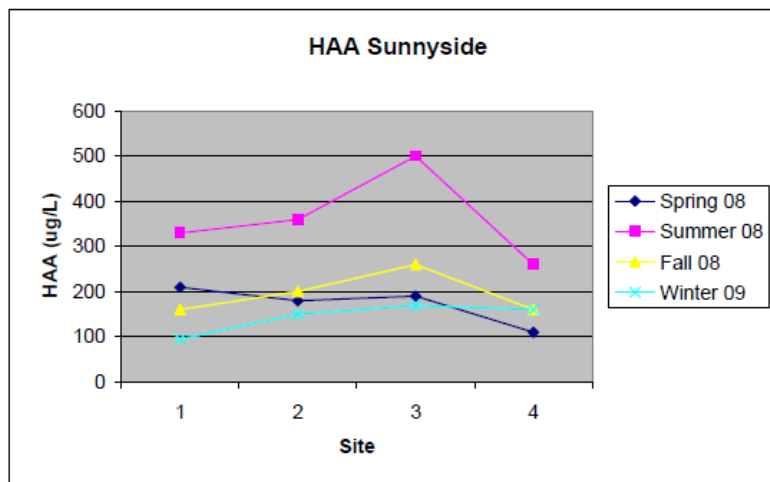
Sunnyside

Treatment	liquid
Pop	450
Fishplant	no
Type	linear
Tank	no
Booster	no
Q (m ³ /d)	790
Peak HAA Location	1,3
Average HAA (ug/L)	211
Average Free Cl (mg/L)	0.19
DOC (mg/L)	6.06
pH	6.07

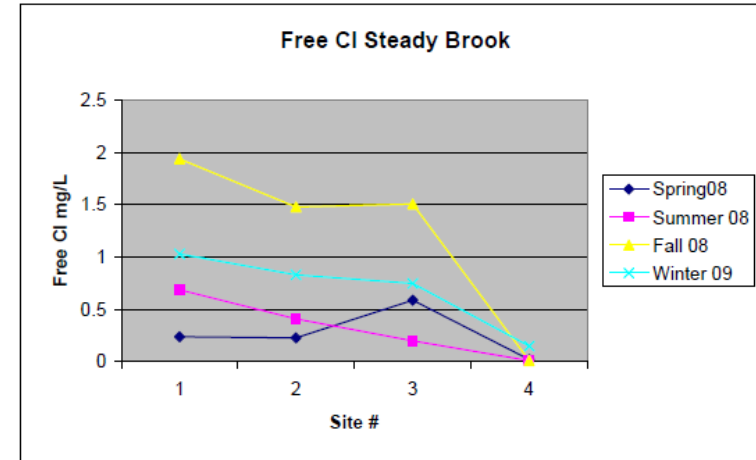
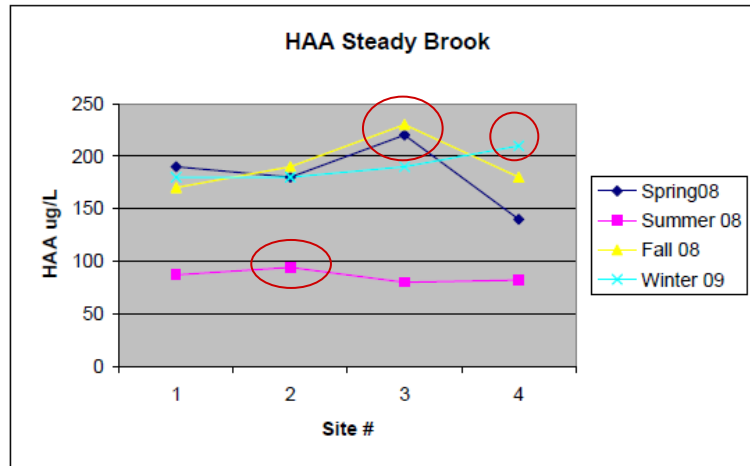


Water Resources
Management
Division

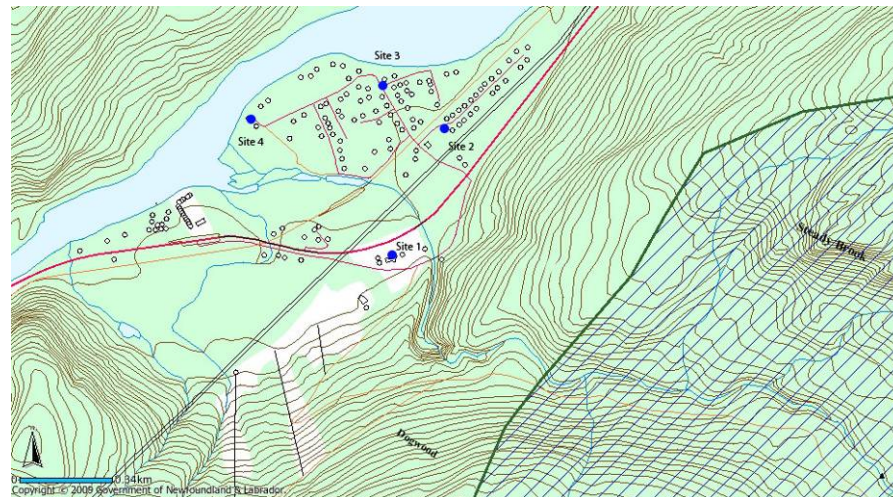
Department of
Environment &
Conservation



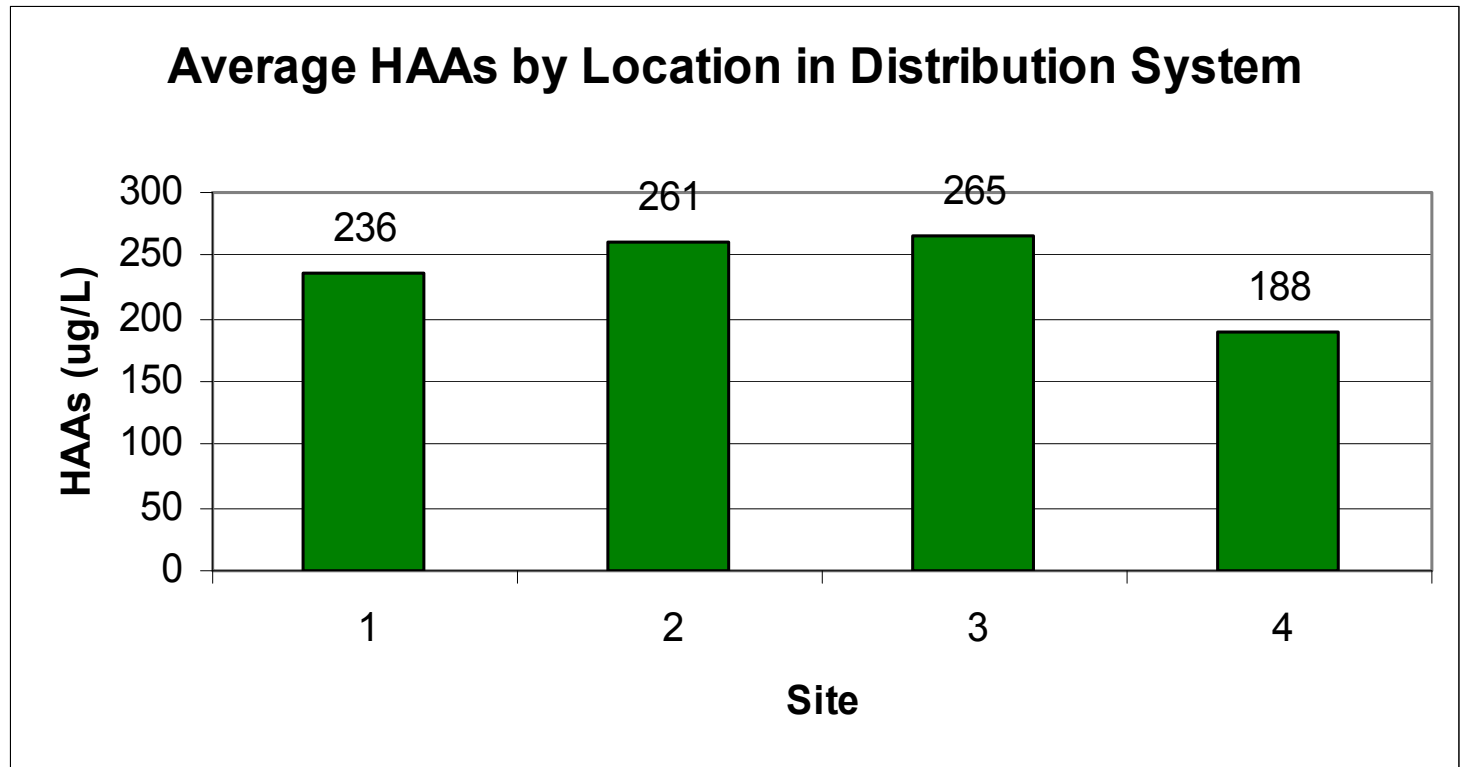
HAA Study Results



- Barely a trace of free chlorine at the end of most systems
- HAA peak occurs earlier in the system in summer, end of the system in winter

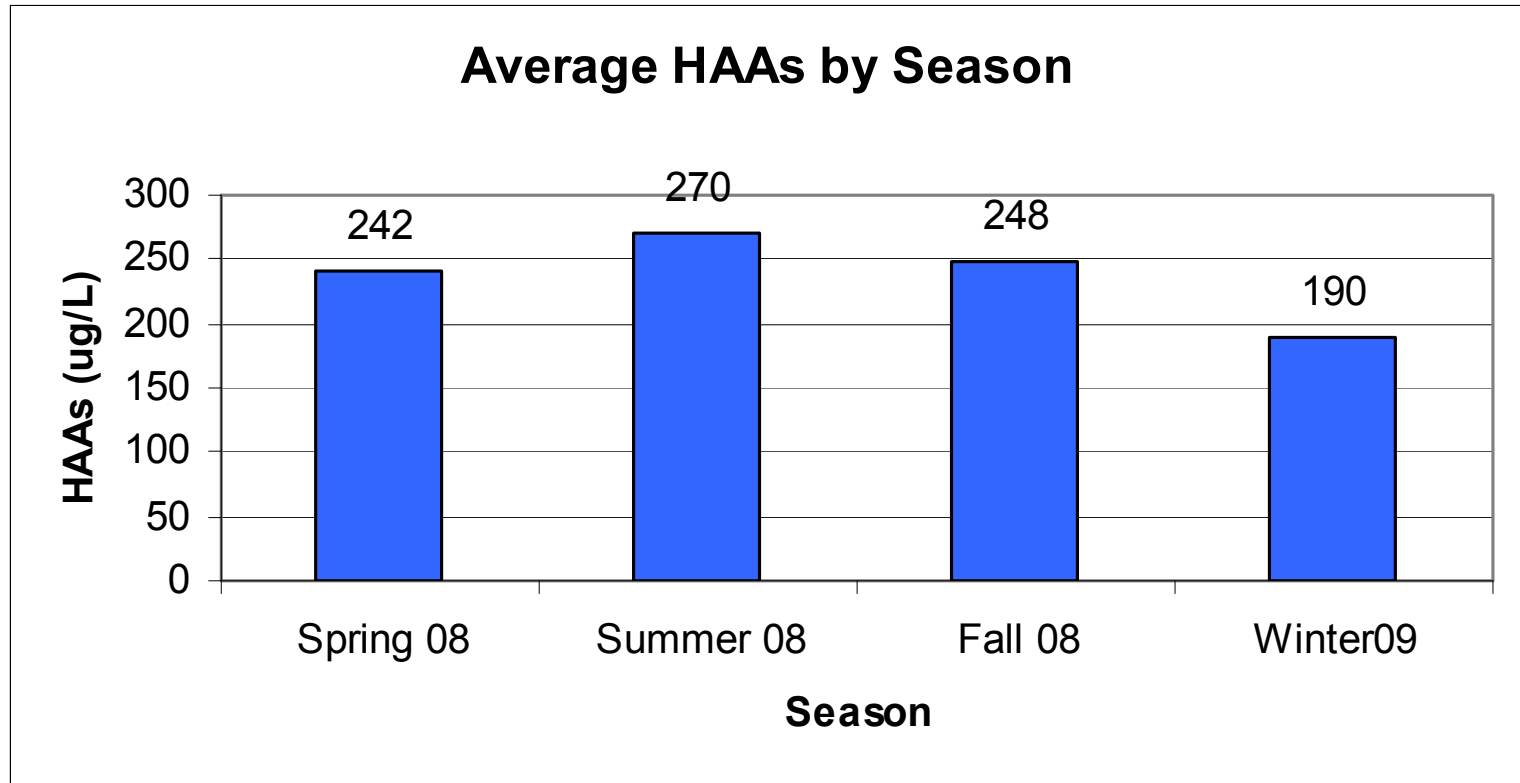


HAA Study Results



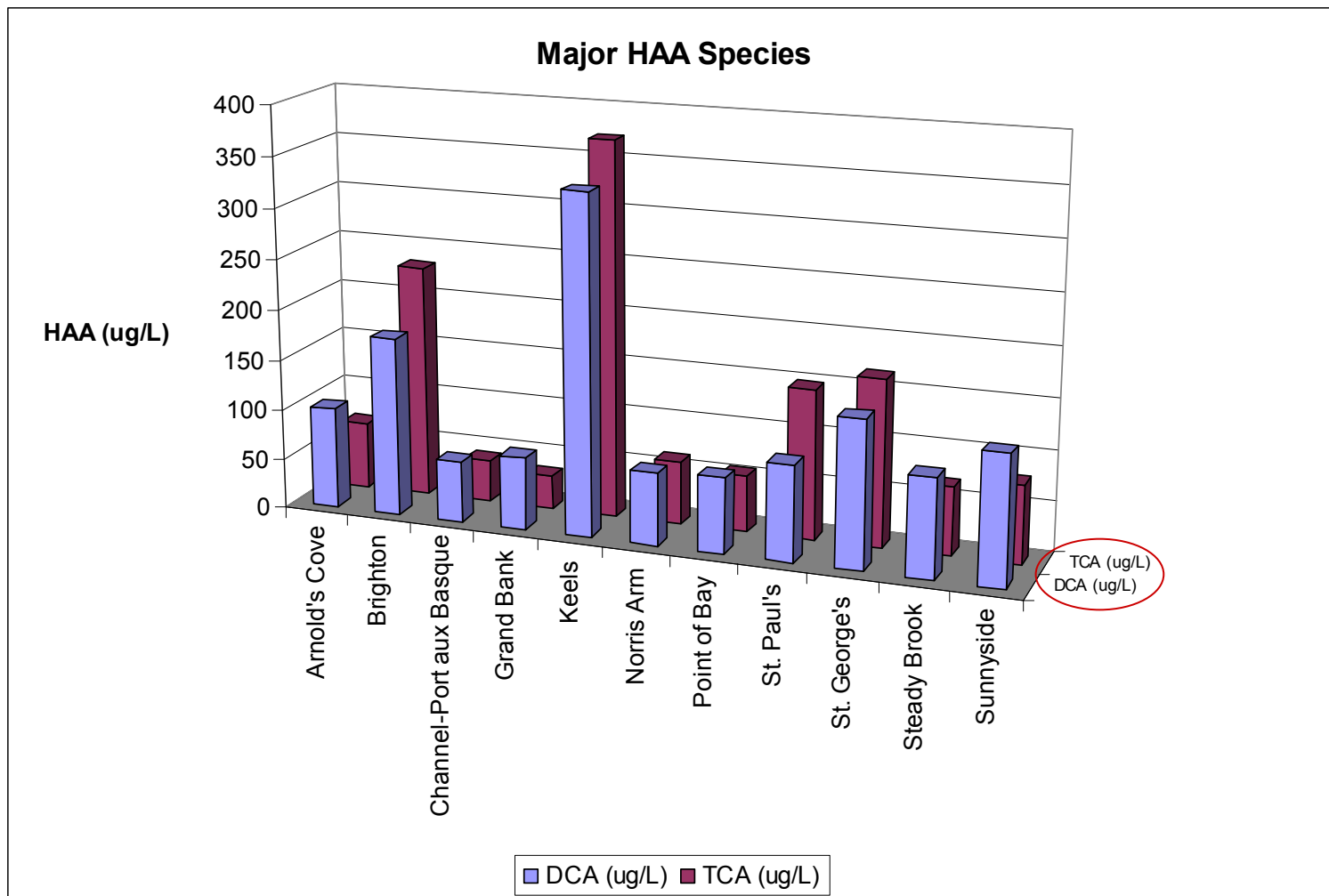
- HAAs tend to decrease towards the end of the distribution system
- Highest HAA levels were observed at site 3- three quarters of the length of the distribution system
- Lowest HAA levels observed at site 4- end of the distribution system

HAA Study Results



- HAAs peak in the summer and are lowest in the winter
- Peak HAA levels in the distribution system occur earlier in the distribution system in summer and fall and later in the system in winter and spring

HAA Study Results



- DCA was predominant HAA species in 7 out of 11 communities
- Brominated HAAs barely present in most communities
- DCA tends to peak earlier in the distribution system and then decay
- DCA (50%) and TCA (48%) make up 98% of HAAs in NL

Trends in Precursors: 1985-2010

Town	DOC	pH
Arnolds Cove	↑	↓
Brighton	↑	↑
Port aux Basques	↑	↑
Grand Bank	↑	↓
Keels	↑	↓
Norris Arm	↓	↑
Point of Bay	↑	↑
St. Paul's	↑	↑
St. George's	↑	-
Steady Brook	↑	↑
Sunnyside	↓	↑

- Higher levels of DOC in source water may be causing higher HAA formation potential

HAA Study Results Summary

- DOC is significantly and positively correlated with HAAs
- More drinking water systems in NL with HAA exceedances than THM exceedances
- DCA and TCA are the primary HAA species observed in the province
- Higher HAAs observed in systems:
 - With water storage tanks
 - Without fishplants
 - With branched distribution systems (more dead ends)
 - Smaller systems (population and flow)
- ENVC should sample for HAAs at a location 3-quarters the length of the distribution system to capture maximum HAA formation

Path Forward

- Examine effectiveness of WTPs at removing NOM precursors and controlling HAAs
- Study on the species of NOM that are most likely to form HAAs and how best to remove them
- Treatability studies for new WTPs to examine HAA formation potential
- Examine how climate trends are affecting water quality, DBP formation, and water treatment
- Optimizing WTPs
- Operator training
- Focus on precursor removal to address HAA issues as a preferred corrective measure
- Chlorine Demand Management

Thank You

