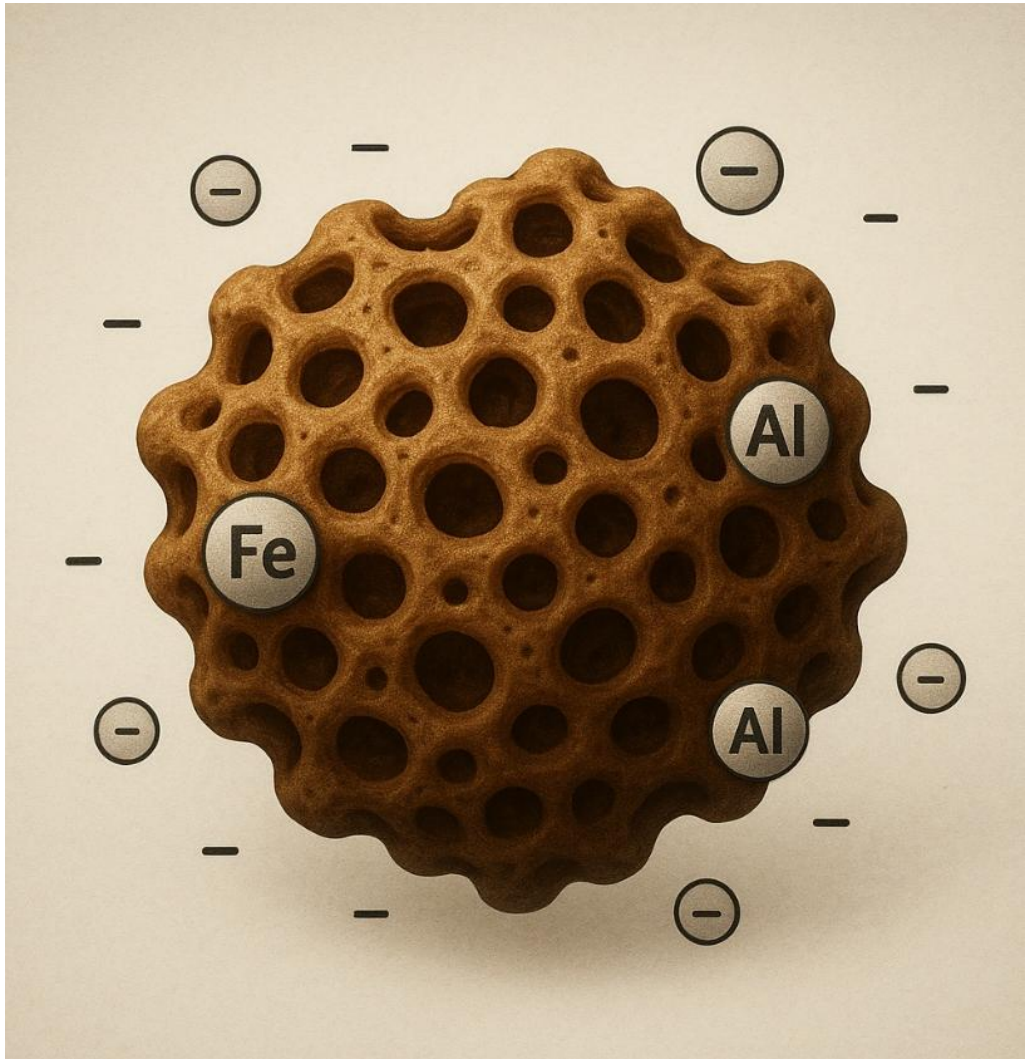
NOM Sense:

Disinfection Challenges Amidst Elevated Organics in Small Systems



Simon Horsley
North American Distribution System Water Quality Leader, Stantec

Agenda

1 How elevated organics complicate disinfection

2 Approaches to managing NOM

3 NOM Tool Kit

4 Case Study

5 Conclusions

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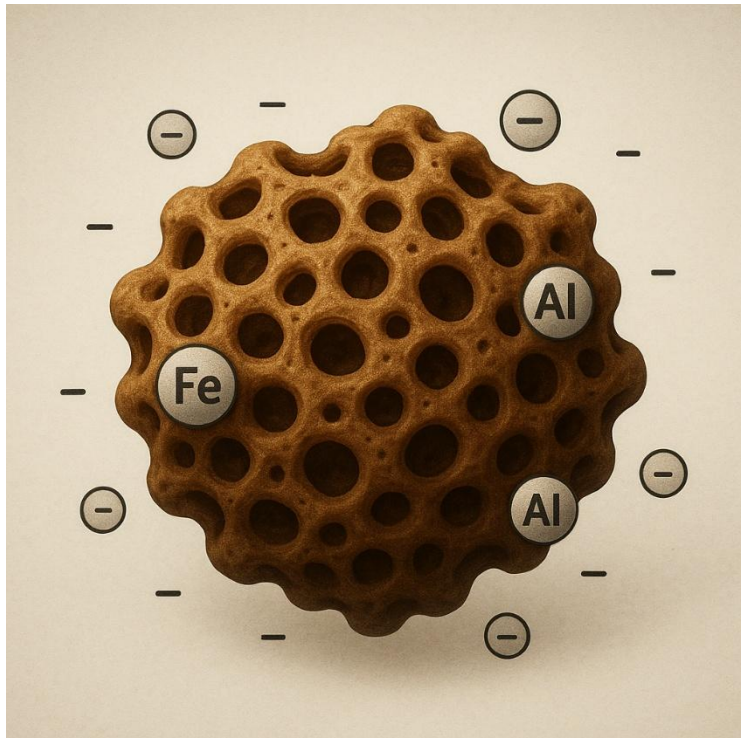
First off…what *is* NOM (exactly)?

https://www.istockphoto.com/photos/brown-water-glass



Large, 3D (sponge-like) carbon molecules

Some big, some small

Like a sponge, NOM will “soak up” metals

Negatively charged

NOM & Disinfection Challenges

1. Coagulant Demand

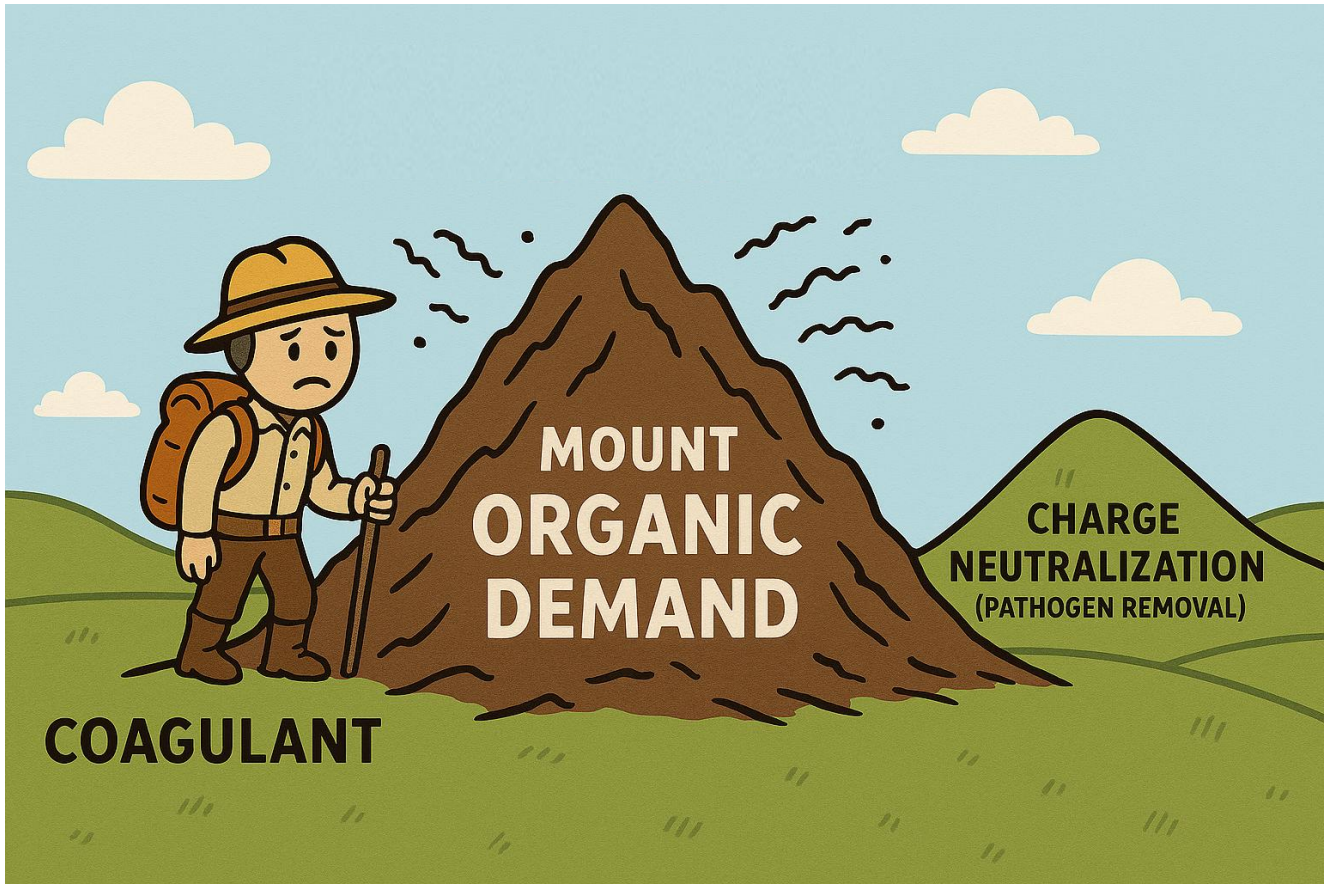
2. Chlorination

3. UV Interference

Coagulant Demand

NOM reacts with coagulants (chemical costs, sludge disposal)

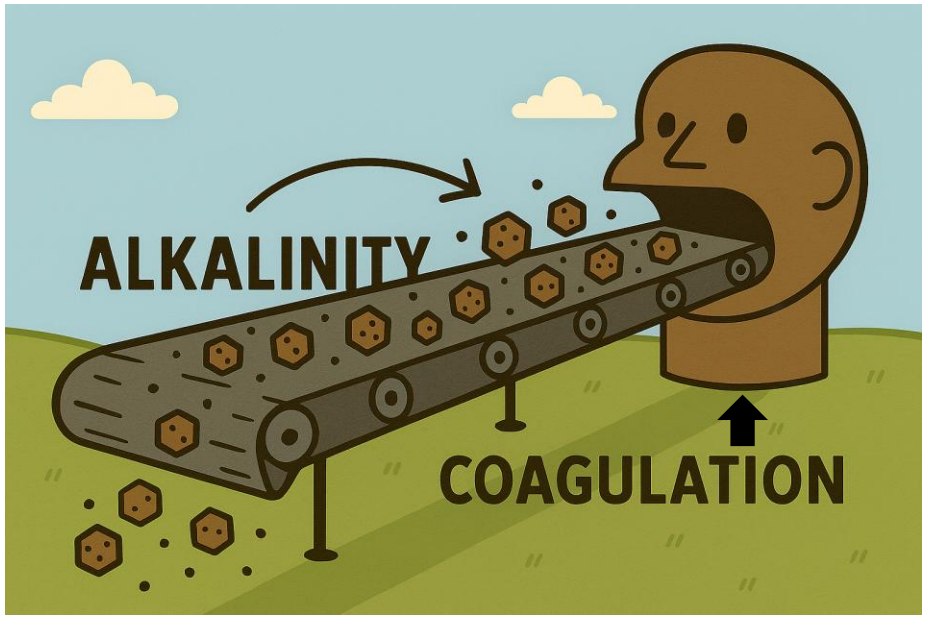
Must overcome NOM demand to achieve turbidity (read: pathogen) removal



Coagulant Demand

Atlantic Canada:

- Surface waters frequently < 15 mg/L alkalinity
- 1 mg/L alum consumes ~0.5 mg alkalinity
- 1 mg TOC consumes ~10 mg alum (very approximate)
- Do the math…negative alkalinity! (unstable)
- Requires more chemicals to boost alkalinity (lime & CO_2, soda ash, etc.)



- Coagulant addition (driven by organics) consumes alkalinity
- For low alkalinity waters (common in Newfoundland and Labrador) need to put back what has been consumed

Chlorination

Direct Decay

NOM is a major contributor to direct disinfectant residual decay

Indirect Decay (Biofilm)

Biodegradable NOM supports microbial growth in distribution systems

Image(s)

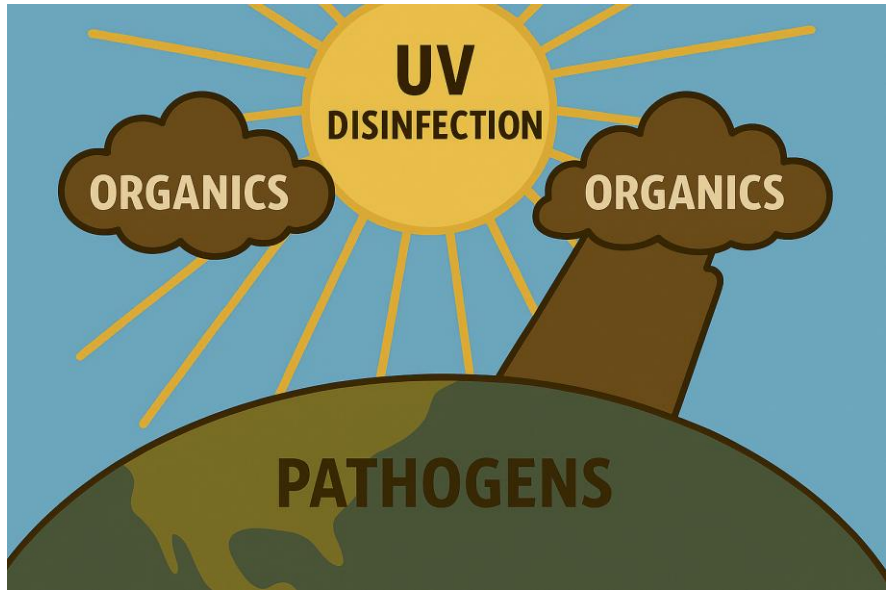
WINNER of award for “least considered but most important factor”

UV Interference

NOM absorbs UV light, especially at 254 nm (germicidal wavelength for UV)

Absorption reduces UV transmittance (UVT)

Lower UVT = reduced disinfection efficiency



- Organics absorb UV254 and so decrease the effectiveness of UV disinfection

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Approaches to managing NOM

Reduction:

- Source water protection
- Clarification (conventional, DAF)
- Membrane filtration (NF, RO)
- Carbon filters (GAC)
- Ion Exchange

Mitigation:

- Chloramines
- Flushing

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IX waste stream (brine) often the limiting factor

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NOM causes high decay rate in chloramines; high nitrification risk

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Achieves water age reduction, but requires high frequency

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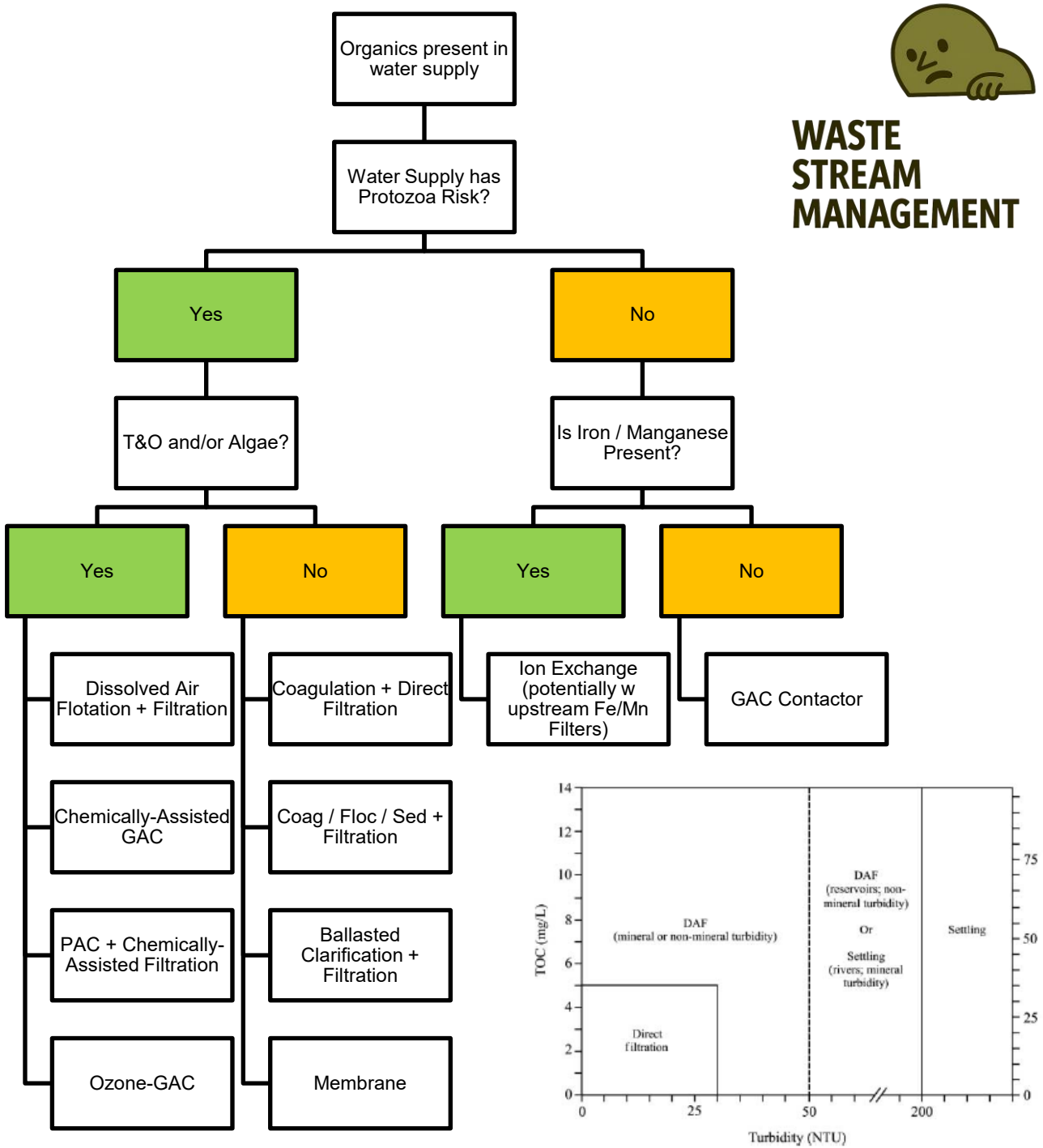
Treatment Tools

Key considerations:

- Are we targeting protozoa removal?
- Any algae issues?
- Fe and / or Mn an issue?

For coagulation considerations, refer to the (famous) diagram by Jim Edzwald



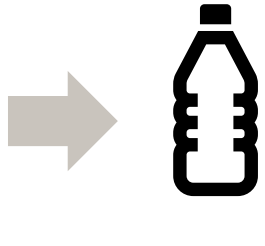
Distribution System Tools

- More NOM = more cleaning
- **Use / install hydrants** for high velocity flushing (consider Unidirectional Flushing approach)
- Frequency? Only the sampling data will tell you
- **Auto-flushers** at strategic dead-ends can save on operator time

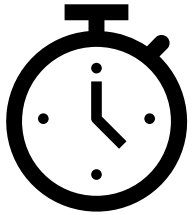
Source: https://www.gov.nl.ca/ecc/files/waterres-training-adww-2013-05-tom-cameron.pdf

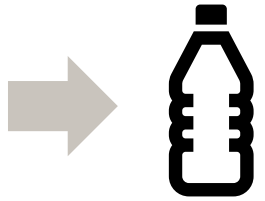
Treatment Vs Pipes?

- Total chlorine decay = bulk + pipes
- How much is bulk, how much pipe?
- Where to focus $$$s and time?
- Consider conducting a (simple) bottle test to find out

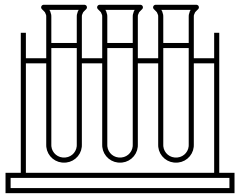


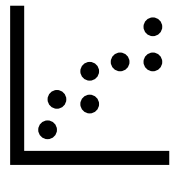
Collect treated water sample





Measure chlorine at regular intervals





Calculate decay rate

A well-established protocol for **Simulated Distribution System (SDS) testing** is provided by the **U.S. EPA** in their ICR Treatment Study Fact Sheet.

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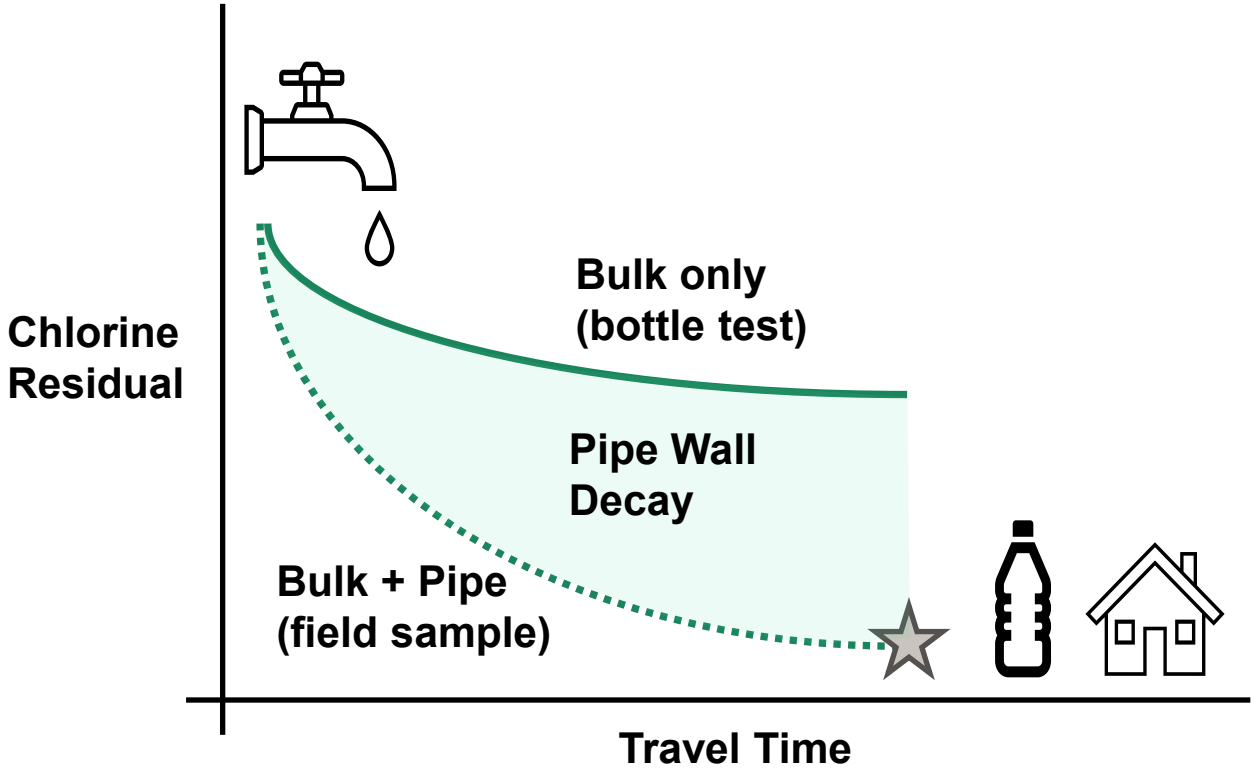
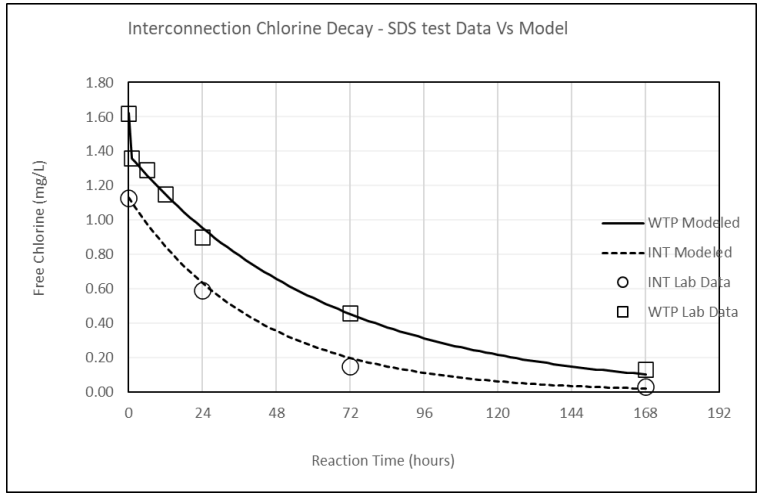


- Bulk decay: treatment
- Pipe wall decay: clean pipes
- Both…treatment + pipes



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Howley Water System – Water System Basics

Parameter	Units	Average
Alkalinity	mg/L as CaCO3	4.9
Colour	TCU	52
Conductivity	uS/cm	32
Hardness	mg/L	4.33
pH	mg/L	6.7
TDS	mg/L	20
Turbidity	NTU	1.47
Boron	mg/L	0
Bromide	mg/L	0
Calcium	mg/L	1.53
Chloride	mg/L	2.67
Flouride	mg/L	0
Potassium	mg/L	0
Sodium	mg/L	2.33
Sulphate	mg/L	0
Ammonia	mg/L	0.02
Iron	mg/L	0.20
Manganese	mg/L	0.02
DOC	mg/L	6.8
Nitrite/nitrate	mg/L	0.02
TKN	mg/L	0.14
Copper	mg/L	0
Magnesium	mg/L	0.17
Aluminum	mg/L	0.11

Above; intake, Sandy Lake

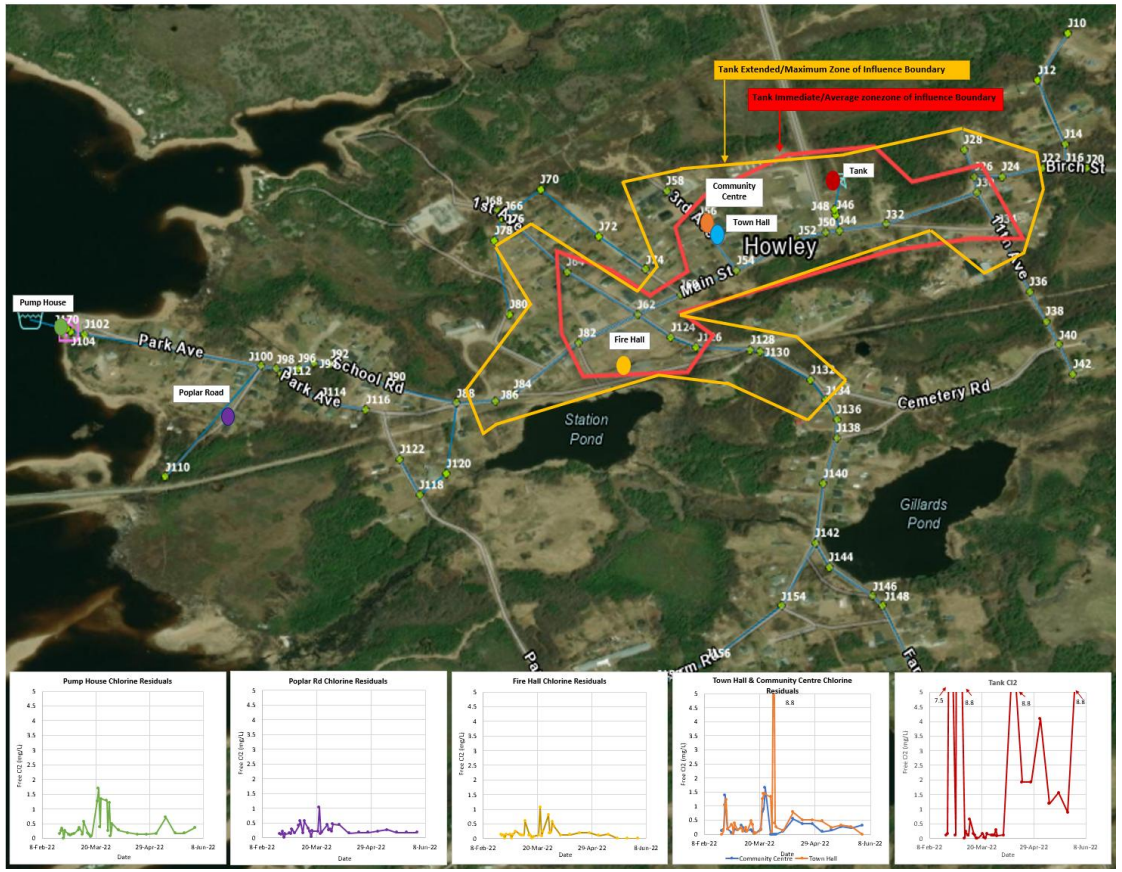
Above; disinfection equipment

Fixed speed pump (~4 L/s) to standpipe

Left; standpipe & chlorine booster station

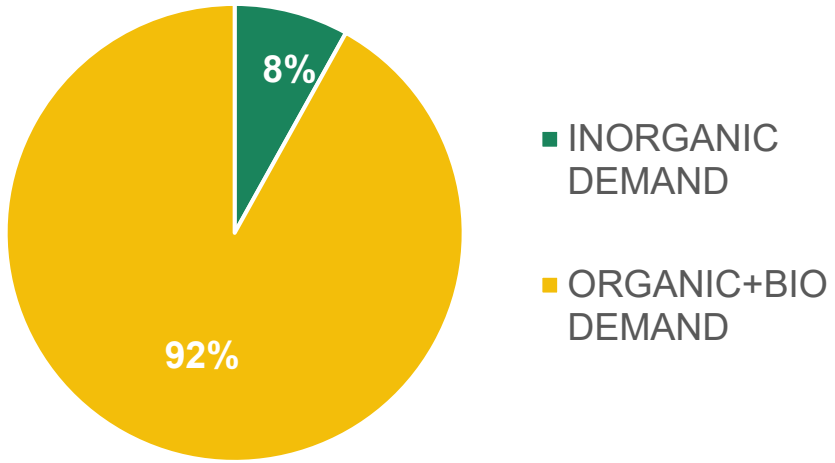
Howley Water System – Chlorine Residuals

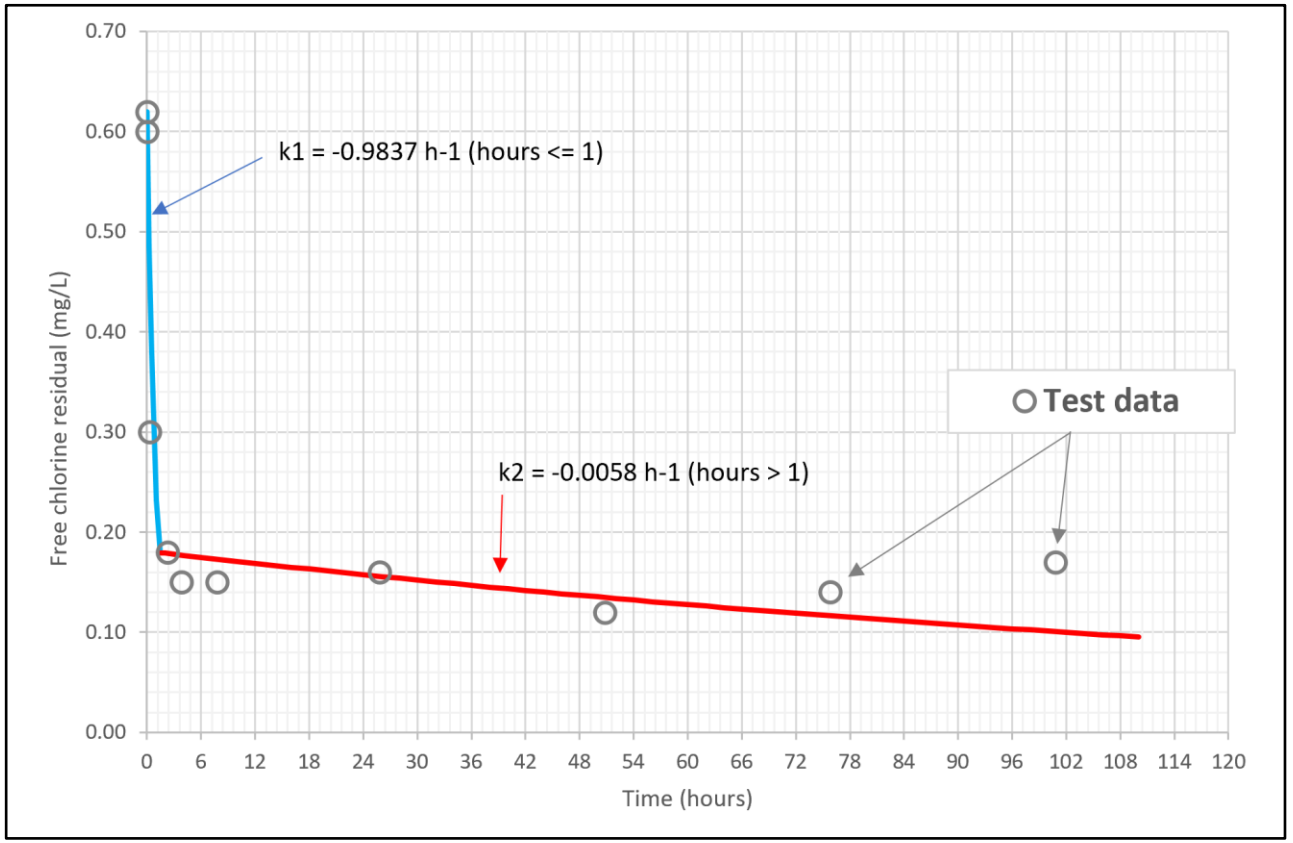
- Hard time maintaining steady free chlorine residuals



Howley Water System – Chlorine Residuals

- Bottle tests show high rate of bulk-driven demand in first 2 hours (common)





Howley Water System – Key Outcomes

- Bulk decay rate identified as primary cause of chlorine loss
- The option to simply increase chlorine dosing to overcome the organics-driven is limited by DBP formation potential
- Conclusion – treated water organics will need to be reduced to allow formation of stable chlorine residual

Equipment
Customized Shipping Container
Pre-Filters (10 micron)
Granular Activated Carbon (GAC) Filters
UVT Analyzer
Ultrafiltration Unit
Sodium Hypochlorite metering pumps
Sodium Hypochlorite panel
Sodium Hypochlorite tank (double walled containment, ultrasonic level sensor)
Free Chlorine Residual Anlayzer (plus pH and temperature analysis)
Sodium Hydroxide metering pumps
Sodium Hydroxide panel
Sodium Hypochlorite tank
Contact Main (1000mm dia., 12m length)
High Lift Pumps

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Conclusions

(1) If your system is struggling to maintain disinfection, consider the role of organics.

(2) Best treatment option depends on your goals (NOM only?), site constraints (waste stream management) and cost.

(3) Consider doing a simple bottle test to evaluate chlorine decay (protocol for **Simulated Distribution System (SDS) testing** is provided by the U.S. EPA in their **ICR Treatment Study Fact Sheet**).

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Thank you