

Treating Boggy Canadian Waters with Magnetic Ion Exchange:

Mitigating the Formation of Disinfection By-Products by Removing Organic Carbon

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Overview

- Background
- Process Overview
- Water #1, Alberta
- Water #2, Alberta
- Water #3, Nova Scotia
- Summary
- Acknowledgements



Background

Dissolved Organic Carbon

- Dissolved organic carbon (DOC) contributes to colour and can impact aesthetics (T&O)
- DOC is indirectly responsible for the formation of disinfection by-products when oxidized by free chlorine:
 - Trihalomethane species (THM)
 - Haloacetic acid species (HAA₅)
- DOC can be present at higher levels (> 5 mg/L) in boggy surface waters:
 - Atlantic Canada
 - Quebec and Northern Ontario
 - Western Provinces



Background

Dissolved Organic Carbon Removal

- Dissolved organic carbon (DOC) can be removed in a number of ways through a water treatment plant process:
 - Coagulation and Enhanced Coagulation
 - Aluminum based: alum, polyaluminum chloride (PACl), aluminum chlorohydrate (ACH)
 - Iron based: ferric chloride or ferric sulphate
 - pH optimized chemistry
 - Biological Processes
 - Ozone + biologically active carbon/filters (BAC/BAF)
 - Membrane Processes
 - NF or RO
 - Ion Exchange
 - Magnetic ion exchange

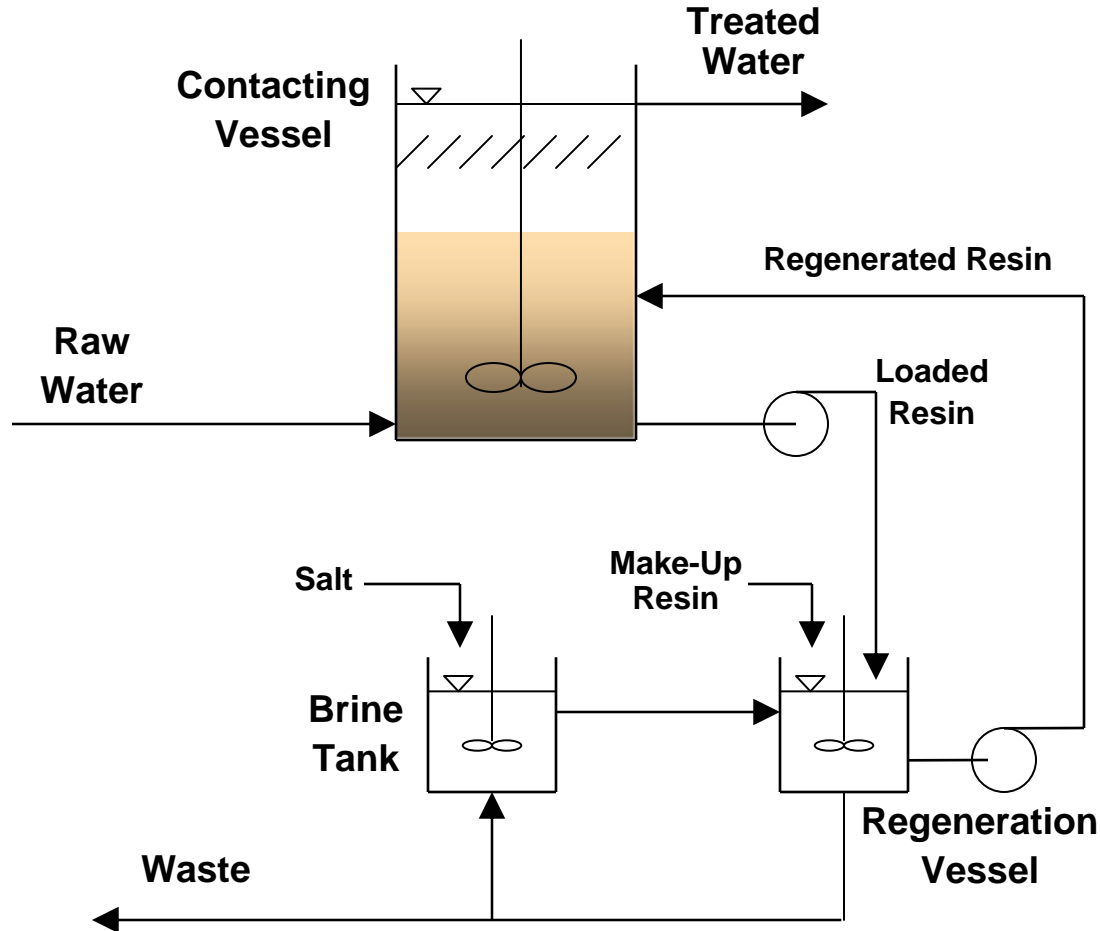
Process Overview

Magnetic Ion Exchange

- Magnetic ion exchange (MIEX[®]) utilizes continuous ion exchange resin contacting in a mixed or fluidized bed for removal of DOC through anion exchange
- Regenerated using sodium chloride or sodium bicarbonate
- Produces liquid residuals

Process Overview

Magnetic Ion Exchange Process Flow



$$\text{Bed Volume (BV)} = \frac{V_T}{V_R}$$

V_T = Treated Water Volume

V_R = Resin Volume

Source: Orica Watercare

Water #1, Alberta

Raw Water Quality

- Suncor Voyager WTP (north of Fort McMurray)
- Raw water is from a large raw water storage “pond” fed from the Athabasca River
- Source characteristics:
 - High DOC concentration up to 14 mg/L with high colour
 - High turbidity with periodic events up to 200 NTU
 - Elevated iron
- Plant Flows:
 - Average Day: 518 m³/day
 - Design Flow: 2,045 m³/day

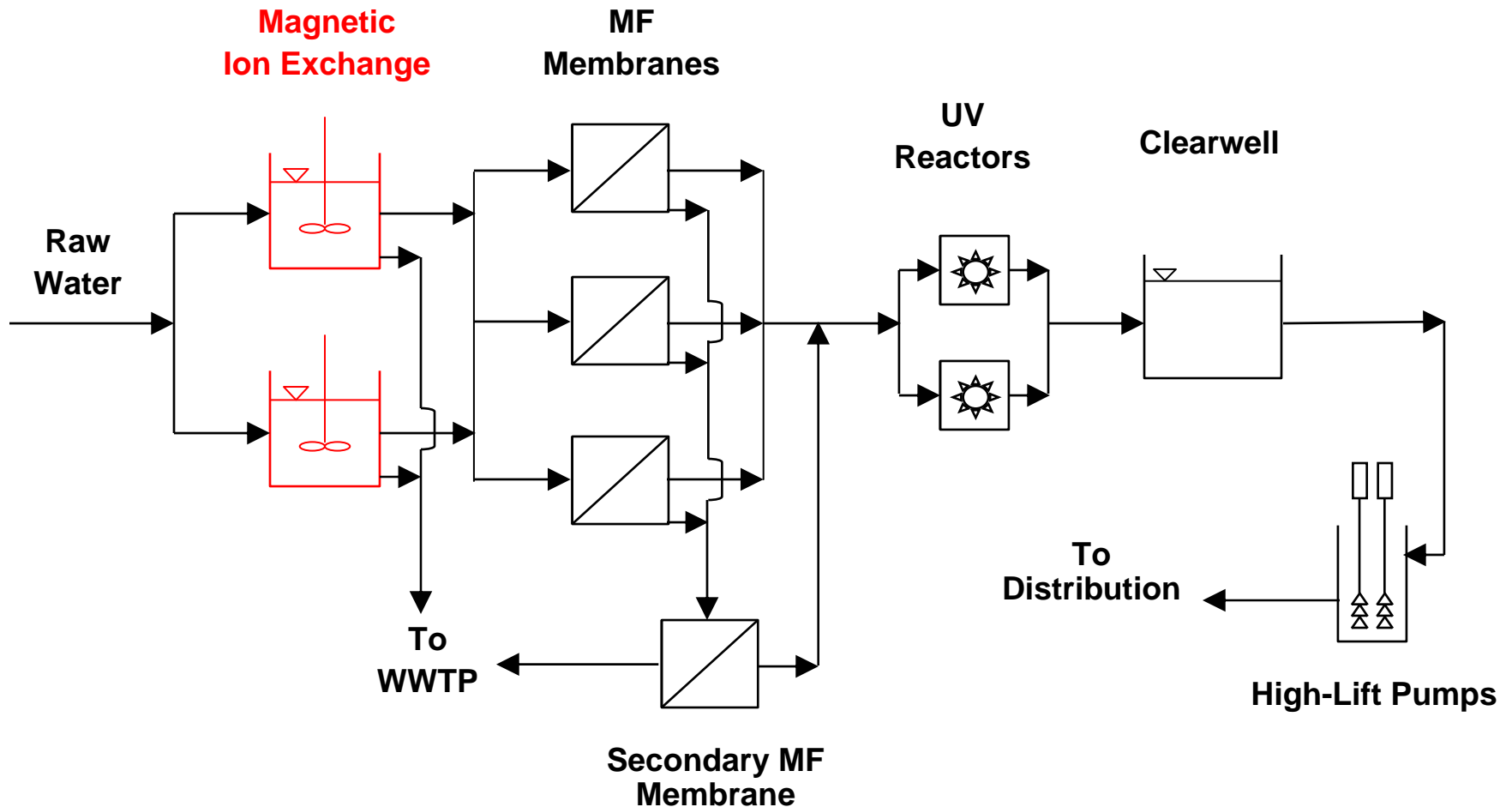


Water #1, Alberta

Raw Water Quality and Objectives

Parameter	Raw Water	Treatment Objective
Total Organic Carbon, mg/L	2.6 – 14	<i>DBPs/Colour</i>
UV Transmittance, %	60 - 85	> 80
Colour, TCU	> 25	< 15
Total Iron, mg/L	0 – 1.2	< 0.3
Turbidity, NTU	1.7 – 300	0.1
<i>Disinfection By-products (µg/L):</i>		
Trihalomethanes (four species; THM)	-	100
Haloacetic acids (five species; HAA ₅)	-	80

Water #1, Alberta Process Design



Water #1, Alberta

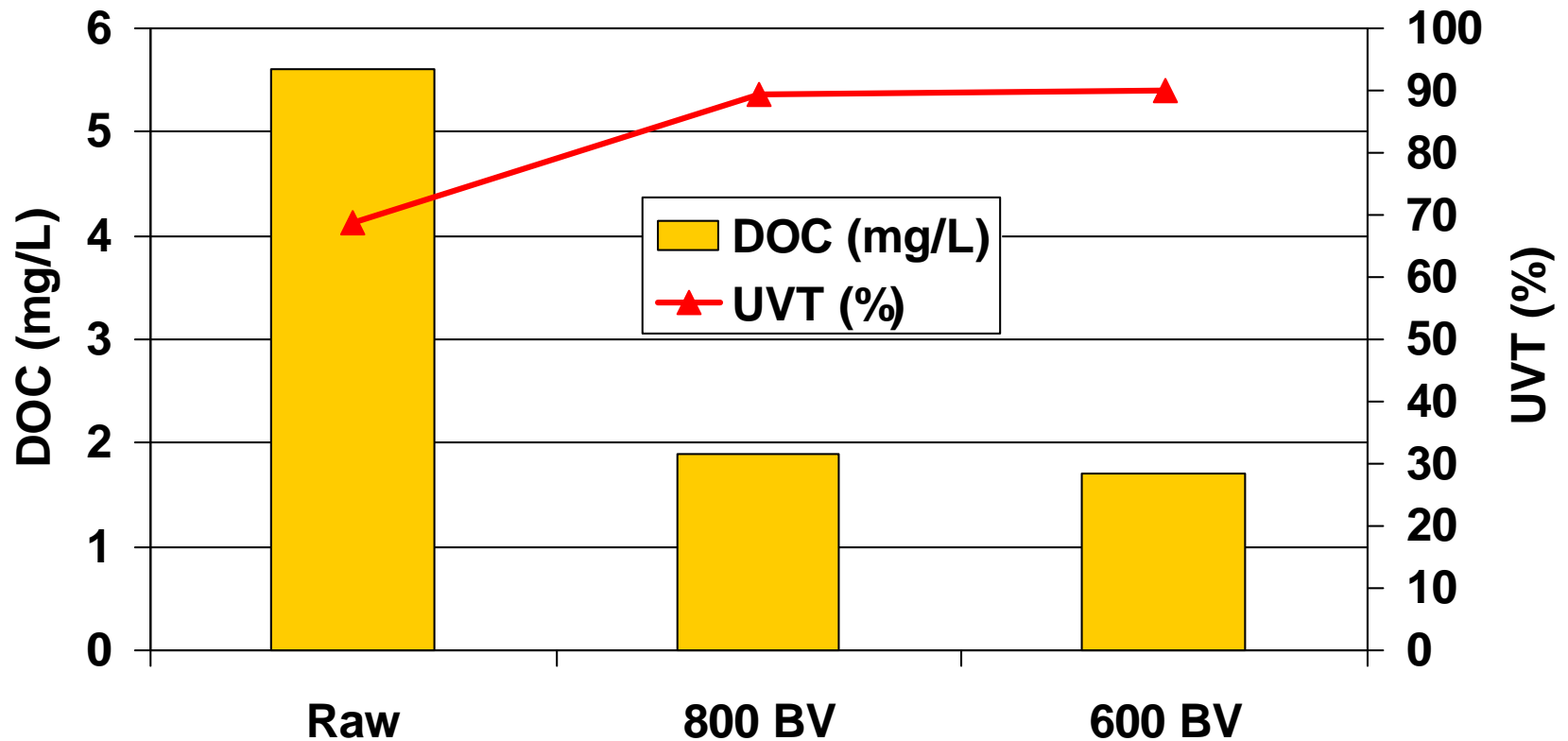
MIEX[®] Testing – DOC Removal

- Orica Watercare tested the source water for organics removal at two temperatures: 5°C and 20°C
- DOC removal performance:
 - 66% removal @ 5°C
 - 70% removal @ 20°C
 - No significant pH change

Parameter	Raw Water	Treated Water	
		600 BV	800 BV
pH	8.2	7.8	8.0
Temp, °C	NA	5	5
UV Abs. 254nm, cm ⁻¹	0.163	0.043	0.049
UV Transmittance, %	68.7	90.1	89.3
DOC, mg/L	5.59	1.7	1.9
Turbidity, NTU	82.6	-	-
True Colour, Pt-Co	29	25	22
Alkalinity, mgCaCO ₃ /L	100	80	-
Sulfate, mg/L	29.8	12	-
Chloride, mg/L	5	55	-

Water #1, Alberta

MIEX[®] Testing – DOC and UVT Performance



Water #1, Alberta

MIEX[®] Testing – DBP Mitigation Performance

- Simulated distribution system (SDS) tests were performed
- A sample was collected from an equivalent 800 bed volume (BV) test and SDS tests were carried out under the following conditions:
 - Incubation temperature: 20°C for 3 days
 - Incubation pH: approximately 8
 - Target chlorine residual: 0.5 – 1.0 mg/L

Sample	DOC (mg/L)	Chlorine Dose (mg/L)	Chlorine Res. (mg/L)	SDS-TTHM (µg/L)	SDS-HAA ₅ (µg/L)
Objective	-	-	-	100	80
Raw	5.6	7.0	0.8	283	190
Treated	1.9	3.5	1.1	51	28

Design

Magnetic Ion Exchange Equipment

Inlet side of
contactors



Pre-engineered
skid design

Regeneration
skid

Water #2, Alberta

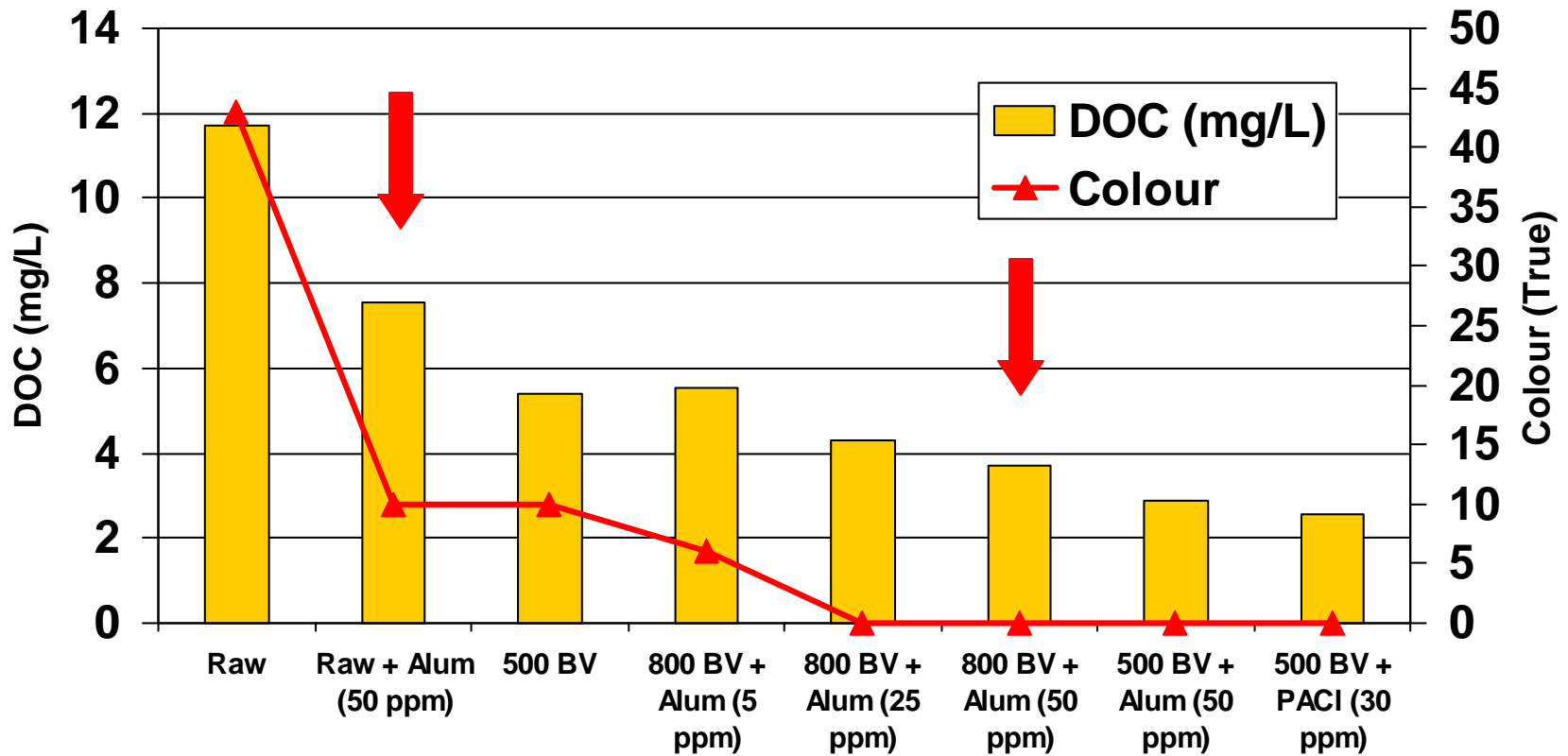
Raw Water Quality

- Potable WTP (north of Fort McMurray)
- Raw water is from the Athabasca River
- Source characteristics:
 - High DOC concentration of up to 14 mg/L
 - High turbidity and elevated iron



Water #2, Alberta

MIEX[®] Testing – DOC and Colour Performance



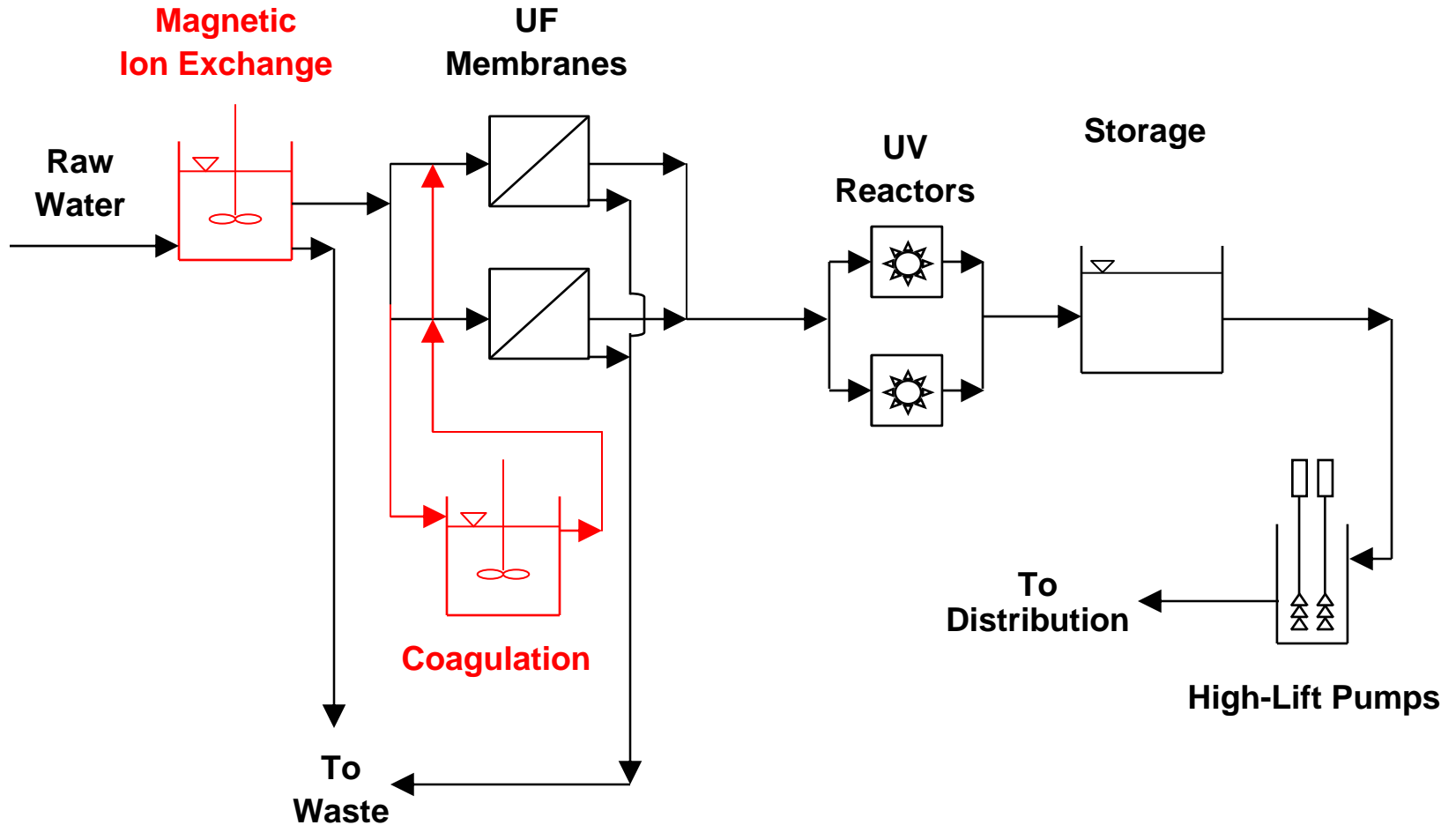
Water #2, Alberta

MIEX[®] Testing – DBP Mitigation Performance

- Simulated distribution system (SDS) tests were performed
- Samples were collected for the alum control and 800 BV test and SDS tests were carried out under the following conditions:
 - Incubation temperature: 20°C for 3 days
 - Incubation pH: approximately 8
 - Target chlorine residual: 0.5 – 1.0 mg/L

Sample	DOC (mg/L)	Chlorine Dose (mg/L)	Chlorine Res. (mg/L)	SDS-TTHM (µg/L)	SDS-HAA ₅ (µg/L)
Objective	-	-	-	100	80
Alum (50 ppm)	11.7	8.0	0.1	227	258
MIEX (800 BV) + Alum (50 ppm)	1.9	3.7	0.4	79.4	57.2

Water #2, Alberta Process Design



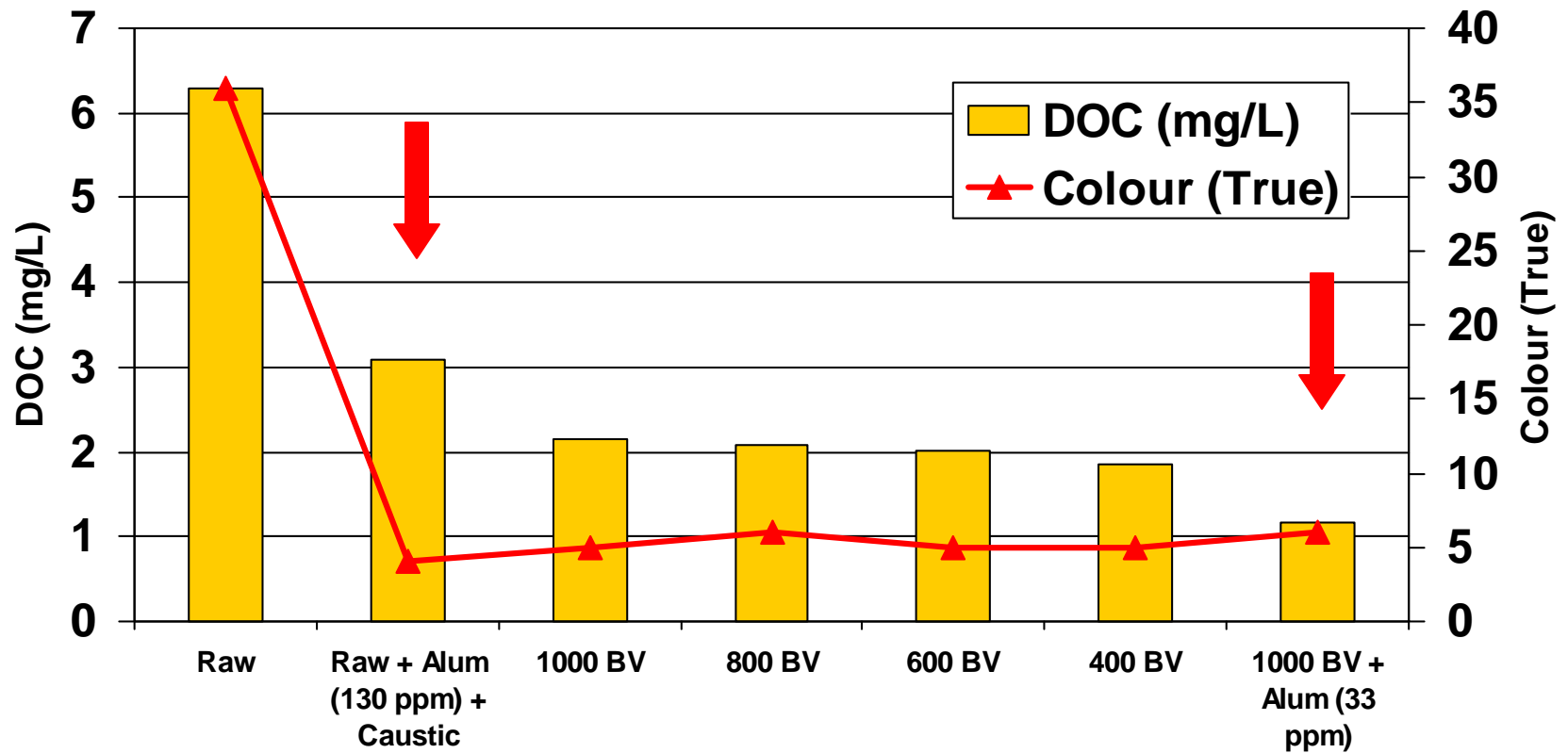
Water #3, Nova Scotia

Raw Water Quality

- Louisbourg WTP, Cape Breton Regional Municipality (CBRM)
 - Recently upgraded to DAF + Filtration
- Raw water is from Kelly Lake
- Water sample taken in summer '09 to examine efficacy of magnetic ion exchange

Water #3, Nova Scotia

MIEX[®] Testing – DOC and Colour Performance



Water #3, Nova Scotia

MIEX[®] Testing – DBP Mitigation Performance

- Simulated distribution system (SDS) tests were performed
- Samples were collected for the alum control and 1000 BV test and SDS tests were carried out under the following conditions:
 - Incubation temperature: 20°C for 25 hours
 - Incubation pH: approximately 7.35
 - Target chlorine residual: 0.5 – 1.0 mg/L

Sample	DOC (mg/L)	Chlorine Dose (mg/L)	Chlorine Res. (mg/L)	SDS-TTHM (µg/L)	SDS-HAA ₅ (µg/L)
Objective	-	-	-	100	80
Alum (130 ppm) + Caustic	3.09	3.9	1.22	28	74*
MIEX (1000 BV) + Alum (33 ppm)	1.17	2.4	1.14	10	15

Summary

Magnetic Ion Exchange Performance

- Athabasca River Water, Alberta
 - 55 - 66% reduction of DOC with MIEX[®] alone at 5°C
 - Compares to 36% reduction using coagulation
 - 78% reduction of DOC with MIEX[®] + low level coagulation
 - DBP formation well below regulated levels and improved performance versus control (coagulation)
- Kelly Lake, Nova Scotia
 - 66% Reduction of DOC with MIEX[®] alone
 - Compares to 50% reduction using enhanced coagulation
 - 81% reduction of DOC with MIEX[®] + low level coagulation
 - Improved DBP formation versus control (enhanced coagulation)

Summary

Process Design Drivers

- Fewer chemical inputs required
 - Bags of salt (solid) required for filling of regeneration skid
- No solid sludge production
 - Decrease in load for WWTPs
- Compact footprint and pre-engineered skid design
 - Larger facilities use cast in place concrete contactors
- Turbidity passes through the contactors

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questions and answers