Water treatment applications using ozone fractionation systems

Southern Queensland Land Rehabilitation Group (SQLRG)

evocra

WATER SOLUTIONS:EVOLVED

15 June 2021

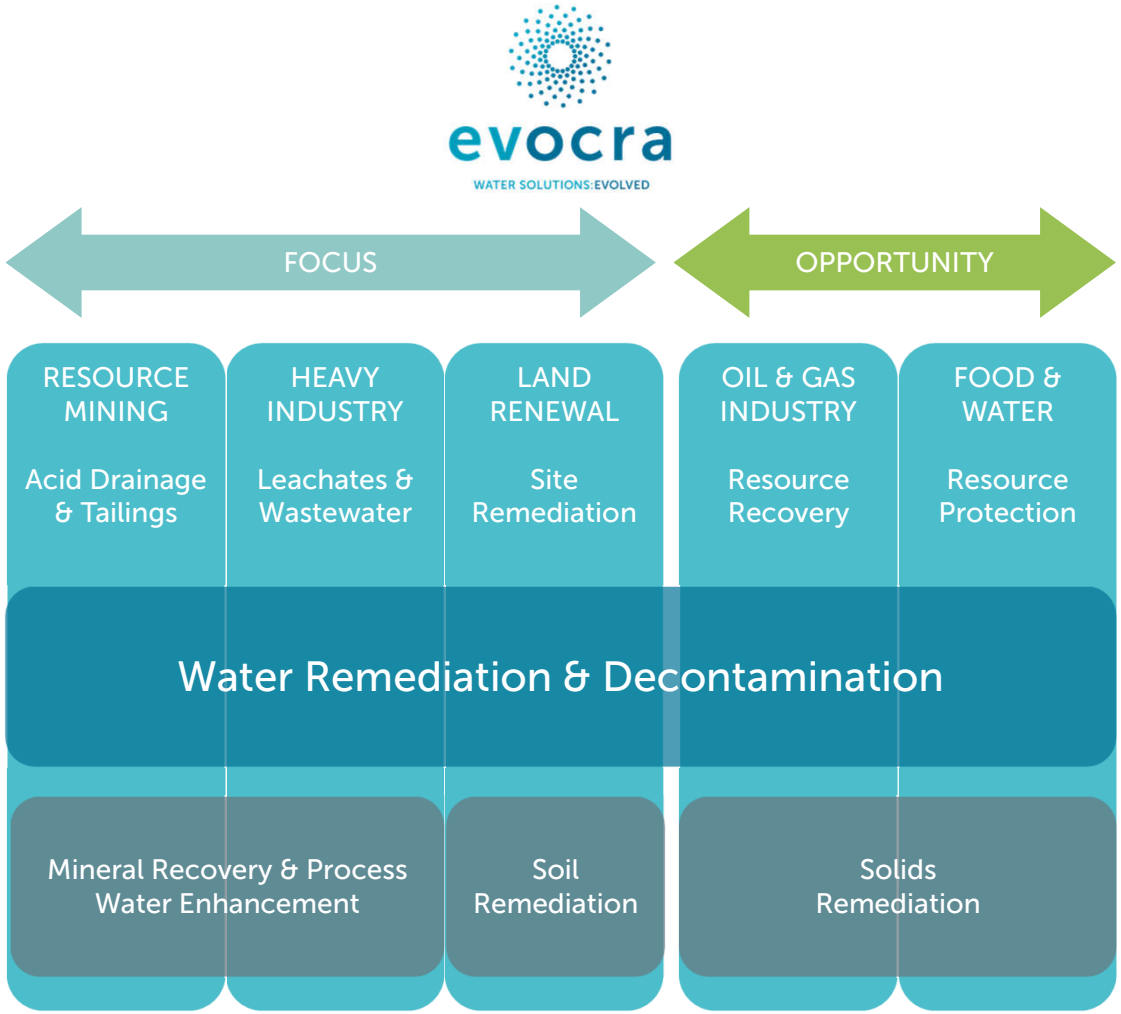
Who is evocra?

EVOCRA is an Australian private company with patented technology, Ozofractionative Catalysed Reagent Addition (OCRA).

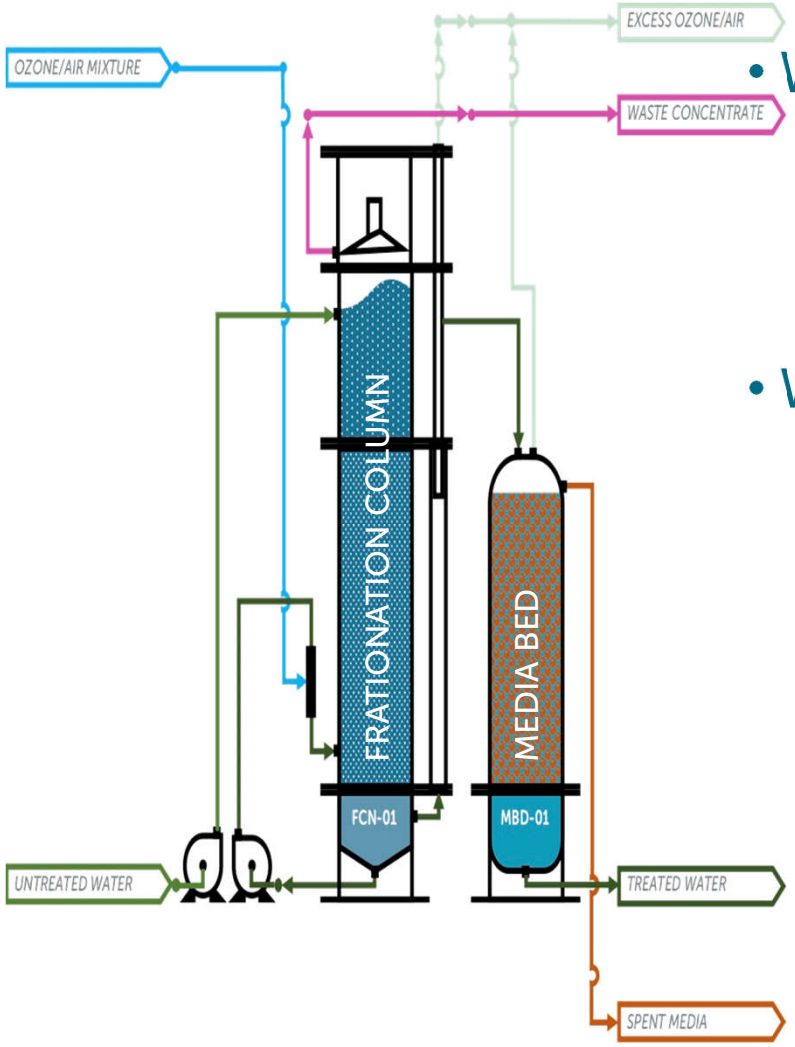
OCRA has wide ranging applications across a broad range of sectors in both primary and secondary industries, providing resource recovery and recycling opportunities.

EVOCRA business model has evolved from technology developer to build-own-operate to technology provider & licensee supporter.

EVOCRA has successfully built and operated two temporary PFAS WTPs and currently negotiating two permanent PFAS WTPs.



What is the OCRA process?

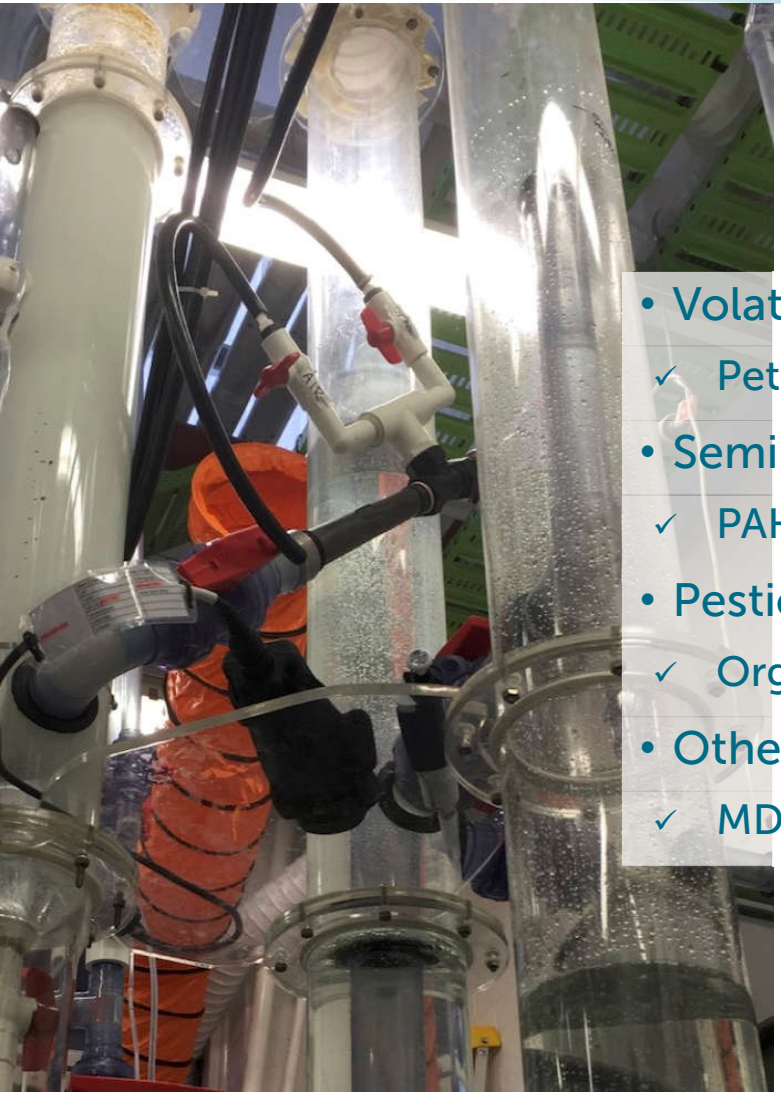


- What does OCRA do?
  - Removes contaminants from dirty water via rapid separation, decomposition or captured with reagents.
- Why does OCRA work?
  - Manipulating the Oxidation-Reduction Potential that leads to Chemical Decomposition, Oxide Formation-Precipitation and Chemical Activation for reagent capture.
  - Fractionation in the bubble column also causes Electrostatic Floatation and Rapid Solid/Liquid Separation.

Applications of OCRA

- Per & Poly Fluoro Alkyl Substances (PFAS)
- Suspended Solids
- Metals
  - ✓ Aluminium
  - ✓ Lead
  - ✓ Cadmium
  - ✓ Chromium
  - ✓ Cobalt
  - ✓ Copper
  - ✓ Manganese
  - ✓ Mercury
  - ✓ Molybdenum
  - ✓ Nickel
  - ✓ Radium
  - ✓ Tin
  - ✓ Uranium
  - ✓ Vanadium
  - ✓ Zinc
- Metalloids & Non - Metals
  - ✓ Arsenic
  - ✓ Antimony
  - ✓ Selenium
- Acid/Alkaline Treatment (pH adjustment)
- Salts (low removal)
  - ✓ Sodium Chloride
  - ✓ Potassium Chloride

Other plausible applications – persistent organic compounds



- Volatile Organic Compounds (VOCs)
  - ✓ Petroleum Based
  - ✓ MAHs
  - ✓ Phenols
- Semi-Volatile Organic Compounds (SVOCs)
  - ✓ PAH
  - ✓ PCBs
  - ✓ PBBs
- Pesticides
  - ✓ Organo-Chloride
  - ✓ Organo-Phosphate
  - ✓ Carbarmates
- Others
  - ✓ MDEA (Amines)

PFAS Removal

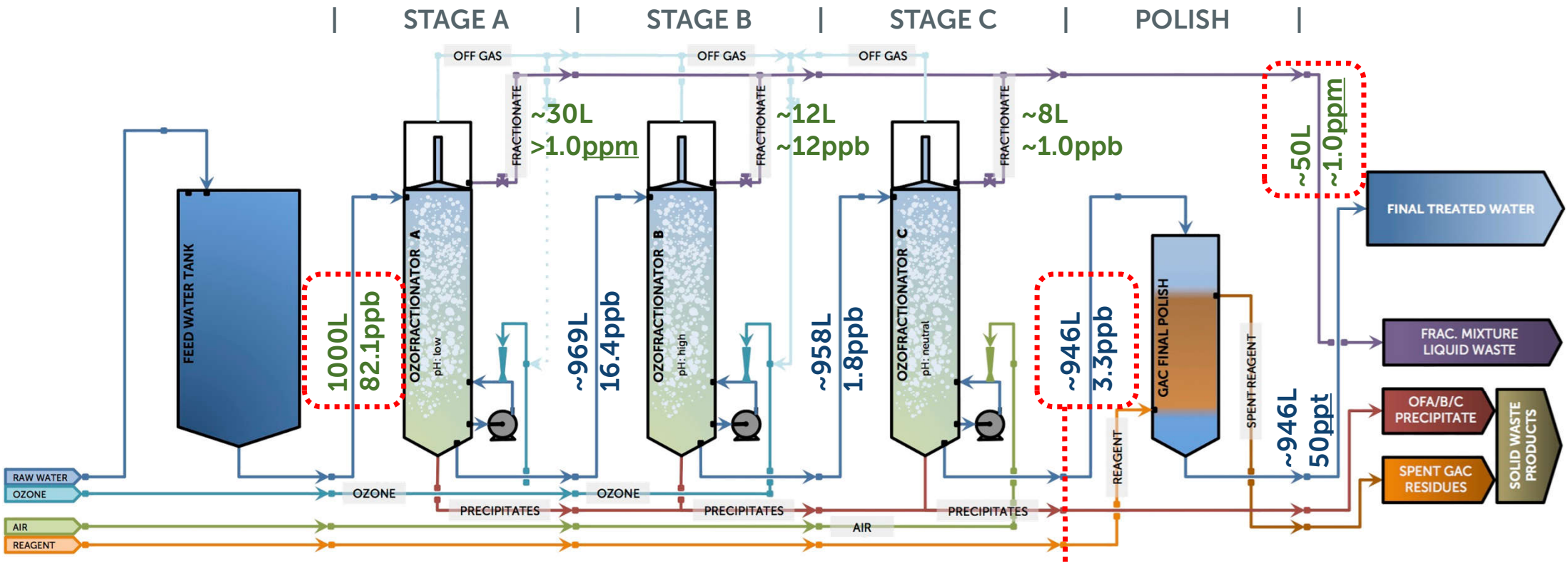
- Highly effective in removing ∑ PFAS.
  - PFOS (below 99% ecology protection & drinking water limits)
  - PFOA (below 99% ecology protection & drinking water limits)
  - PFHxS (below 99% ecology protection & drinking water limits)
  - Moderate Precursor Conversion
  - Short Chain Compounds

- Can remove most co-contaminants

Highly Affective	Less Affective	Least Affective
Metals	Nutrients	Glycols
Biology	Salts	
Organics (most)	Fluorine-Free Foam	
S. Solids		

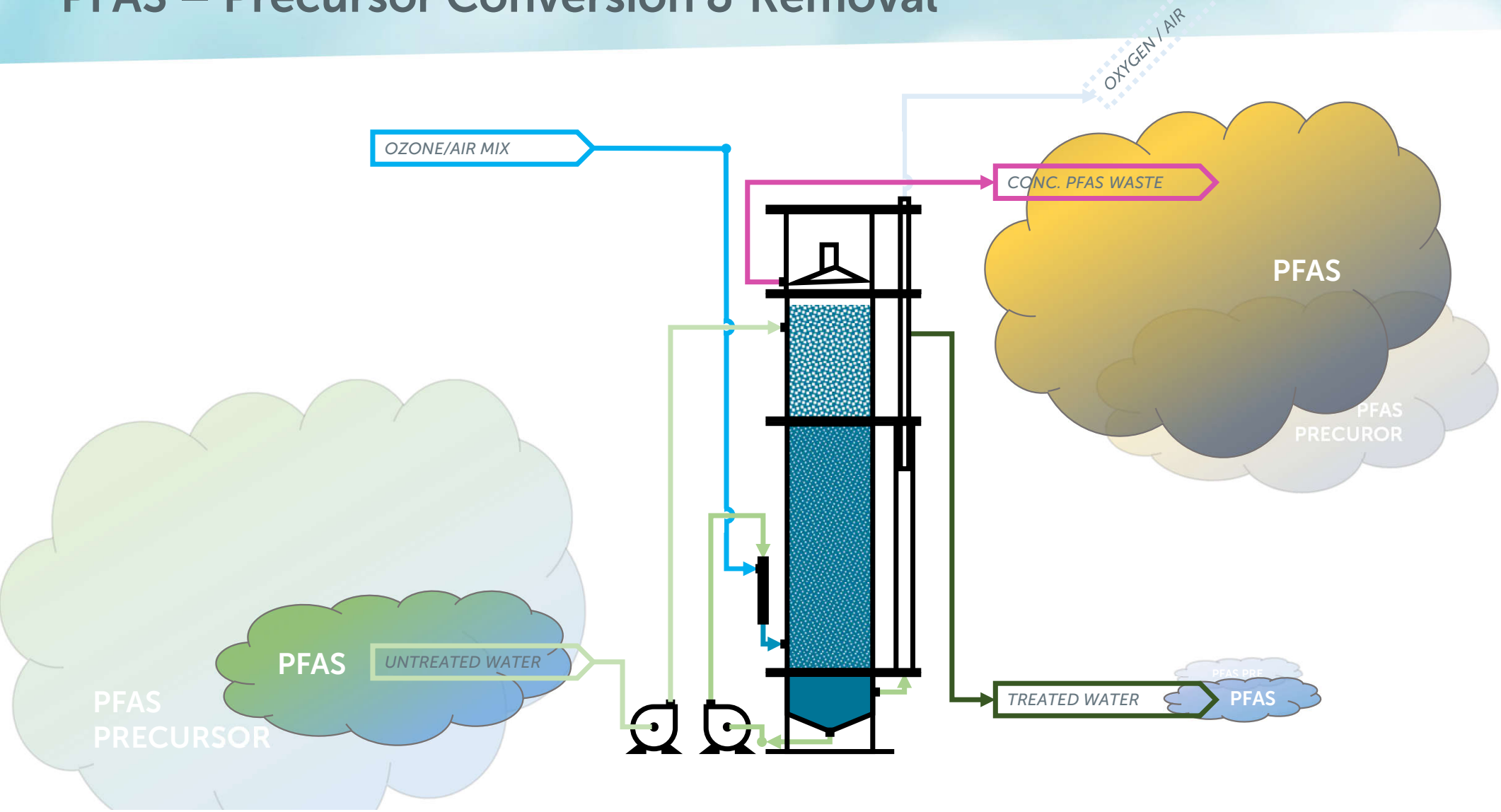
PFAS – Typical Flows & Concentrations

Example: Volume = 1,000L/hr; Inlet Total PFAS = 82ppb; all concentrations are the average values



PFOS <70ppt, *in most cases <0.2ppt*
PFOA <70ppt, *in most cases <1.0ppt*
PFHxS <70ppt, *in most cases <0.1ppt*

PFAS – Precursor Conversion & Removal



PFAS – Applications of Ozone Fractionation

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PFAS Removal

- Ozone Fractionation alone, removes >90% of Total PFAS
  - PFOS removal to < 0.0001 µg/L (ppb)
  - PFOA removal to < 0.001 µg/L (ppb)
  - PFHxS removal to < 0.01 µg/L (ppb)
- Ozone Fractionation with polish system (GAC and/or IX), removes >99% of Total PFAS.
  - PFOS removal to < 0.0002 µg/L (ppb)
  - PFOA removal to < 0.001 µg/L (ppb)
  - PFHxS removal to < 0.001 µg/L (ppb)
  - PFAS removal to < 0.05 µg/L (ppb)
  - $PFAS_{TOP\text{-}A}$ removal to < 0.1 µg/L (ppb)

Benefits

- Volume reduction to a PFAS concentrated (for off/on site destruction)
- Removal of co-contaminants in the same vessel, without pre-treatment
  - Heavy Metals, Metalloids & Non-Metals
  - Suspended Solids
  - Petroleum Hydrocarbons
  - Biological Organics & Chemical Organics
- Improved performance & life-cycle of polishing media.

When high order PFAS removals are required, Ozone Fractionation is the pre-treatment for the polish system. Performance & life-cycle improvements are achieved by:

- Decreases the bulk PFAS load.
- Decreases the co-contaminants

PFAS – Applications of Ozone Fractionation

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PFAS Removal Applications (to date)

- Industrial sewage rehabilitation from an AFFF loss to a sewer main.
- Estuarine water remediation from an AFFF loss to environment.
- Fire training water from a contaminated concrete pad.
- Mine water decontamination related to dewatering underground workings.
- Landfill leachate treatment for off site discharge.
- Contaminated site surface water & groundwater treatment.

Other Removal Applications (to date)

- Metal removal from Acid Mine Drainage (AMD).
- Tailing spoil reprocessing trials.
- Removal of none PFAS organics from an industrial process water.

Technology was developed in Australia by EVOCRA Pty Ltd and is available globally via ARCADIS under a licensing agreement.

Case Study 1 – Landfill Leachate

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SITE:	Queensland Landfill, near Ipswich Landfill Leachate impacted with PFAS from construction & demolition (C&D) waste
TREATMENT:	PFAS Contaminated Leachate (Total PFAS ≈ 10-20ppb)
PRODUCTION:	20,000L per day (10 hours operation)
PLANT CAPACITY:	50,000 Litres/day
CLIENT:	Waste Management Company
DISCHARGE TO:	Sewer (transported via tanker)
TREATMENT CRITERIA:	Total $PFAS_{28}$ <0.2µg/L TOP Assay and/or PFOS <0.00023µg/L (non-digest)
PROCESS:	OCRA + IX polish Secondary polish system (IX) employed to ensure compliance against strict total PFAS criteria

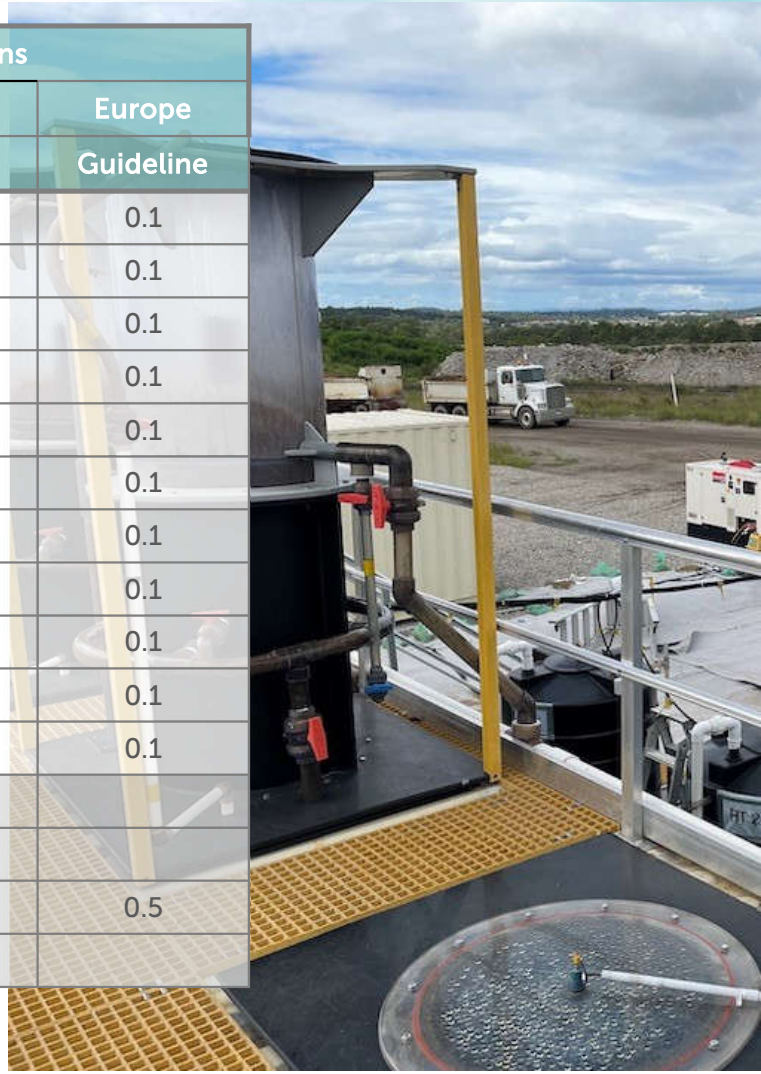
PROJECT PROGRESSING

Case Study 1 – PFAS Results

PFAS Standard Analysis	Raw Water (average)	OCRA Treated (average)	Final Treated (IX)	Drinking Water Specifications			
				Australia	United States	Canada	Europe
	µg/L (ppb)	µg/L (ppb)	µg/L (ppb)	Guideline	Guideline	Guideline	Guideline
PFBS	0.86	1.3	< 0.001				0.1
PFBA	1.6	< 0.005	< 0.005				0.1
PFPeA	< 0.01	< 0.001	< 0.001				0.1
PFHxS	2.0	0.023	< 0.001	0.07			0.1
PFHxA	1.5	0.5	< 0.001				0.1
PFHpA	0.64	0.12	< 0.005				0.1
PFOS	0.7	< 0.0001	< 0.0002	0.07 / 0.00023	0.07 *	0.2	0.1
PFOA	1.3	0.004	0.001	0.56 / 19	0.07 *	0.6 (0.3**)	0.1
PFNA	0.09	< 0.001	< 0.001				0.1
6:2 FTS	0.69	< 0.005	< 0.005				0.1
8:2 FTS	0.03	< 0.001	< 0.001				0.1
PFOS+PFOA	2.0	0.0041	0.0012				
PFOS+PFHxS	2.7	0.0231	< 0.0012				
TOTAL PFAS	9.86	2.27	0.032		0.07 *		0.5
TOTAL $PFAS_{TOPA}$	13.44	5.43	< 0.1	0.2 (Qld)			

** Sum of PFOS + PFOA*

*** British Columbia PFOA Guideline*



Case Study 2 – Fire Training Ground

ARCADIS Design & Consultancy for natural and built assets

SITE:	Hobart International Airport, Tasmania, Australia Treatment of Fire Training Water impacted with legacy PFAS leaching from training structures
TREATMENT:	PFAS Contaminated Surface Water post-Training Exercises (Total PFAS ≈ 50ppb)
PRODUCTION:	≈10,000L per week
PLANT CAPACITY:	25,000 Litres/day
CLIENT:	Emergency Services Provider
DISCHARGE TO:	Sewer (transported via tanker)
TREATMENT CRITERIA:	Total $PFAS_{28}$ <0.02µg/L (<0.02ppb)
PROCESS:	OCRA + NF/RO (or IX) polish Secondary polish system (NF/RO or IX) employed to ensure compliance against strict total PFAS criteria

PROJECT SUCCESSFULLY COMPLETED

Case Study 2 – PFAS Results

PFAS Standard Analysis	Raw Water (average)	OCRA Treated (average)	Final Treated (RO)	Drinking Water Specifications			
				Australia	United States	Canada	Europe
	µg/L (ppb)	µg/L (ppb)	µg/L (ppb)	Guideline	Guideline	Guideline	Guideline
PFBS	1.11	1.04	< 0.02				0.1
PFBA	1.77	1.67	< 0.10				0.1
PFPeA	1.39	1.38	< 0.02				0.1
PFHxS	3.77	0.11	< 0.02	0.07			0.1
PFHxA	4.25	3.22	< 0.02				0.1
PFHpA	0.83	0.11	< 0.02				0.1
PFOS	27.50	0.05	< 0.01	0.07	0.07 *	0.2	0.1
PFOA	1.39	< 0.01	< 0.01	0.56	0.07 *	0.6 (0.3**)	0.1
PFNA	0.53	< 0.02	< 0.02				0.1
6:2 FTS	0.39	< 0.05	< 0.05				0.1
8:2 FTS	4.03	< 0.05	< 0.05				0.1
PFOS+PFOA	28.89	0.06	< 0.02				
TOTAL PFAS	49.66	7.90	< 0.01		0.07 *		0.5

** Sum of PFOS + PFOA*

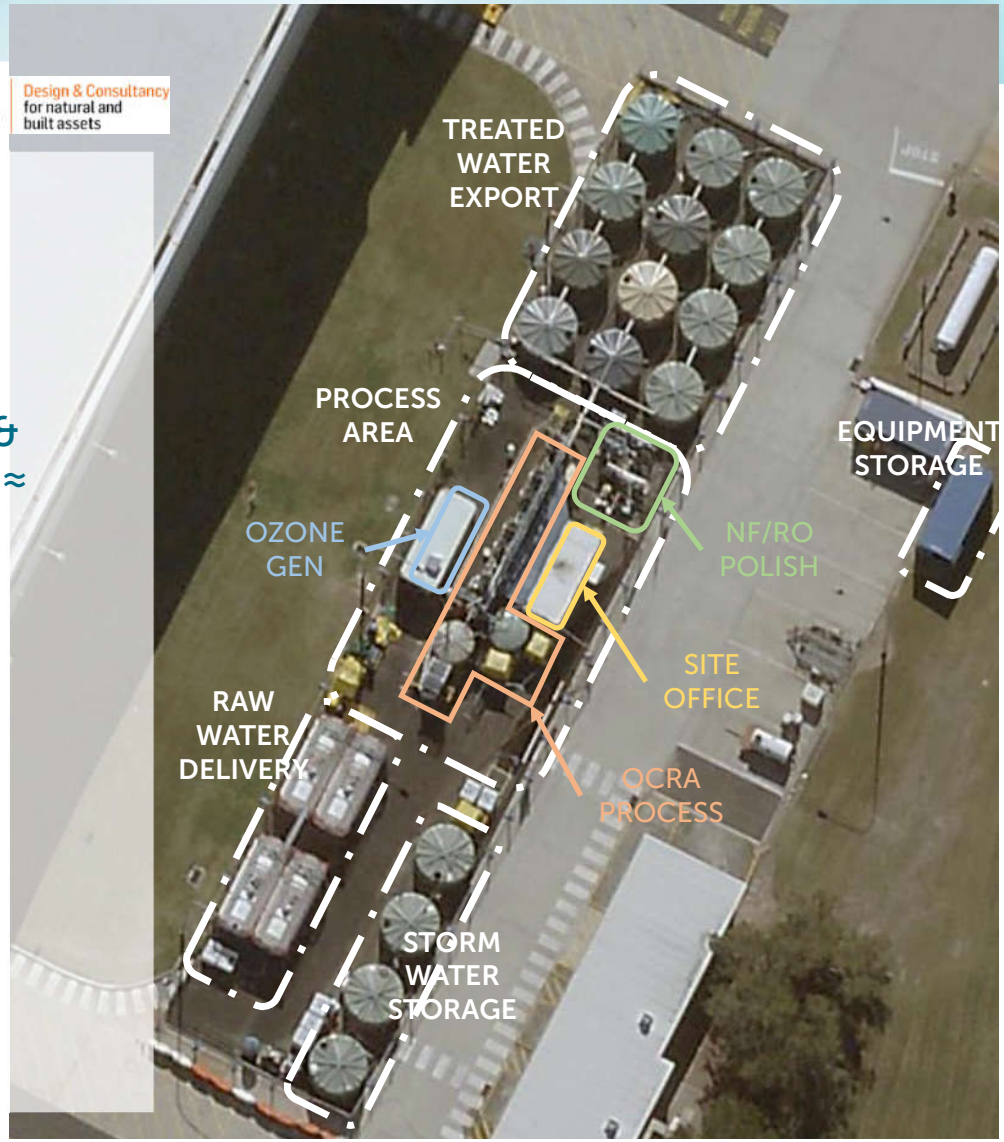
*** British Columbia PFOA Guideline*

Case Study 3 – Brisbane Airport

ARCADIS Design & Consultancy for natural and built assets

SITE:	Brisbane International Airport, Queensland, Australia Accidental Discharge of Aircraft Hangar Fire Suppression System
TREATMENT:	PFAS Contaminated Sewer, Surface Water & Remedial Cleaning Reagents, Sewage, Salts & Solvents co-contaminants (Total PFAS up to ≈ 5,000ppb)
PRODUCTION:	>18ML, in ~15 months
PLANT CAPACITY:	100,000 Litres/day
CLIENT:	Airline Operator
DISCHARGE TO:	Sewer (transported via tanker)
TREATMENT CRITERIA:	T.O.P. Assay $PFAS_{28}$ <0.25µg/L (<0.25ppb)
PROCESS:	OCRA + NF/RO polish Secondary polish system (NF/RO) employed to ensure compliance against strict total PFAS criteria

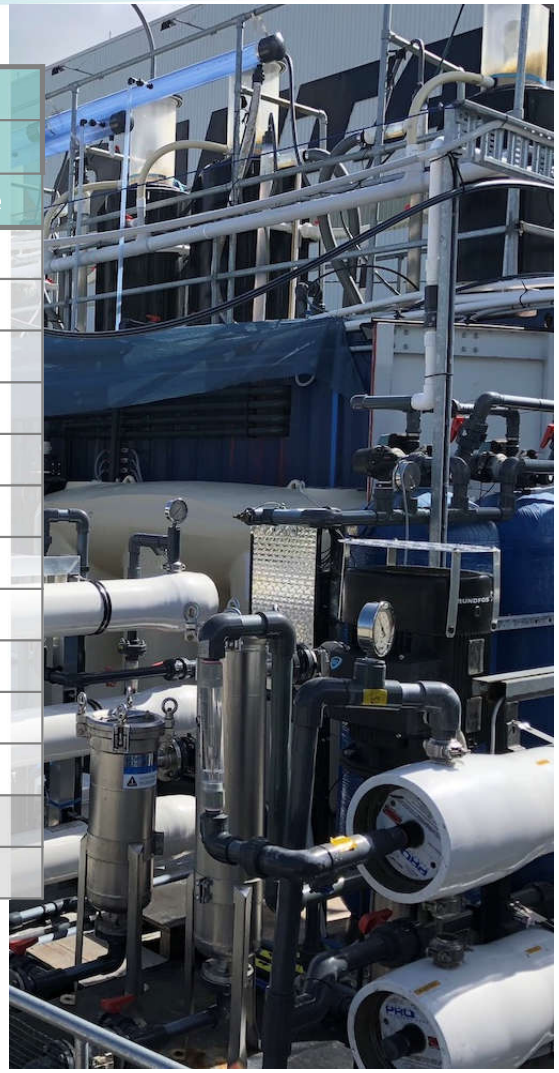
PROJECT SUCCESSFULLY COMPLETED



Case Study 3 – PFAS Results

PFAS Standard Analysis	Raw Water (average)	OCRA Treated (average)	Final Treated (RO)	Drinking Water Specifications			
				Australia	United States	Canada	Europe
	µg/L (ppb)	µg/L (ppb)	µg/L (ppb)	Guideline	Guideline	Guideline	Guideline
PFBS	0.09	0.20	0.03				0.1
PFBA	0.45	3.32	0.66				0.1
PFPeA	1.57	8.40	1.30				0.1
PFHxS	0.34	< 0.01	< 0.01	0.07			0.1
PFHxA	2.86	13.73	2.12				0.1
PFHpA	0.57	0.37	0.04				0.1
PFOS	1.83	< 0.01	< 0.01	0.07	0.07 *	0.2	0.1
PFOA	0.72	< 0.01	< 0.01	0.56	0.07 *	0.6 (0.3**)	0.1
PFNA	0.11	< 0.01	< 0.01				0.1
6:2 FTS	19.78	0.19	0.06				0.1
8:2 FTS	2.58	< 0.05	<0.05				0.1
PFOS+PFOA	2.55	<0.02	<0.02		0.07 *		
TOTAL PFAS	30.7	26.4	4.5				0.5

Data above relates to the sewage treatment phase of the project.
Other fluids successfully treated included estuarine water, solutions of industrial cleaning fluids and sewer caustic wash.
** Sum of PFOS + PFOA* *** British Columbia PFOA Guideline*



Case Study 3 – PFAS TOP Assay & Metals Results

PFAS TOP Assay Analysis	Raw Water (average)	OCRA Treated (average)	Final Treated (RO)
	µg/L (ppb)	µg/L (ppb)	µg/L (ppb)
PFOS	5.45	< 0.01	< 0.01
PFOA	11.30	< 0.02	< 0.01
PFNA	4.64	< 0.01	< 0.01
8:2 FTS	18.72	0.04	< 0.03
6:2 FTS	122.39	0.39	< 0.03
PFHpA	23.01	0.70	< 0.01
PFHxS	4.24	< 0.01	< 0.01
PFHxA	131.28	34.61	0.05
PFPeA	230.23	20.46	< 0.02
PFBS	4.06	0.47	< 0.01
PFBA	106.81	9.19	0.06
TOTAL PFAS	631.08	66.09	0.50

METALS Available Data	Raw Water (average)	OCRA Treated (average)	Final Treated (RO)
	mg/L (ppm)	mg/L (ppm)	mg/L (ppm)
Barium (Ba)	16.0	4.5	0.5
Iron (Fe)	590	58.3	25.0
Manganese (Mn)	218	27.7	0.5
Strontium (Sr)	221	185	7.7

Data above relates to the sewage treatment phase of the project.
Other fluids successfully treated included estuarine water, solutions of industrial cleaning fluids and a sewer caustic wash.

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Thank you

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