



PFAS Guidance – BC's Third Best Export

EnviroTech

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Third-Best?

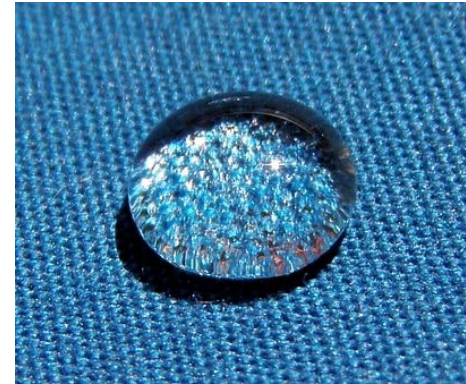


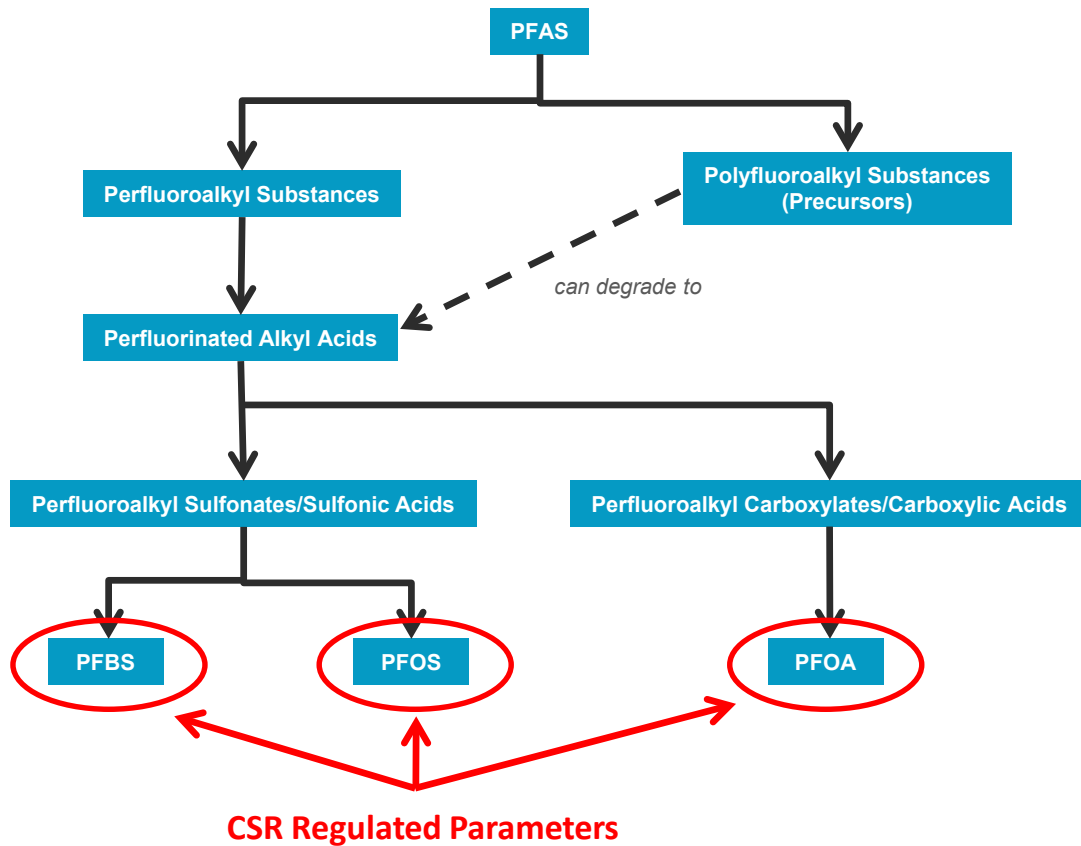
Overview

- Introduction - PFAS of focus in BC
- Regulatory Framework
- Potential Sources
- Laboratory Analysis
- Site Investigation Considerations
- Remediation Considerations

What are PFAS?

They are a family of man-made chemicals that have been used in a wide variety of industrial and consumer products and in specialized applications.





Naming reflects number of carbons and end groups on molecules

Number of carbons	Carboxylate End Group	Sulfonate End Group
C4	PFBA	PFBS
C5	PFPeA	PFPeS
C6	PFHxA	PFHxS
C7	PFHpA	PFHpS
C8	PFOA	PFOS
C9	PFNA	PFNS

Perfluoroalkyl Acids (PFAAs)

- Persistent – fully fluorinated part doesn't break down in nature (no biodegradation, no volatilization)
- Bioaccumulative – some PFAS accumulate in tissues of higher trophic level biota
- Toxic – known human and ecological health effects
- Mobile – generally in anion form, contaminant plumes can be large

Provincial Regulatory Framework

BC Contaminated Sites Regulation – November 2017

- PFBS: soil (human soil ingestion), groundwater (drinking water)
- PFOA: groundwater (drinking water)
- PFOS: soil (full matrix), groundwater (aquatic life and drinking water)

SCHEDULE 3.2
GENERIC NUMERICAL WATER STANDARDS¹

COLUMN 1	COLUMN 2	COLUMN 3	COLUMN 4	COLUMN 5	COLUMN 6
Substance	Chemical Abstract Service # (CAS)	Aquatic Life ² (AW)	Irrigation ² (IW)	Livestock ² (LW)	Drinking Water ³ (DW)
pentaerythritol tetranitrate [PETN]	78-11-5				8 ⁴
perchlorate	14797-73-0				3 ⁴
perfluorobutane sulfonate [PFBS] ⁵⁷	375-73-5				80 ⁴
perfluorooctane sulfonate [PFOS] ⁵⁷	1763-23-1	60			0.3 ¹²
perfluorooctanoic acid [PFOA] ⁵⁷	335-67-1				0.2 ¹²

- 4 Standard is based on the 2015 United States (US) Environmental Protection Agency (EPA) “Regional Screening Levels” for tapwater. The EPA Regional Screening Levels for both non-carcinogenic and carcinogenic substances reflect the 1996 “Overview of CSST Procedures for the Derivation of Soil Quality Matrix Standards for Contaminated Sites” 20% (i.e., 0.2) Toxicity Reference Value (TRV) apportionment for drinking water exposure. For carcinogenic substances, the EPA Regional Screening Level is also adjusted to reflect section 18 (3) (a) of this regulation, with a human lifetime cancer risk of less than or equal to one in 100 000.
- 12 Standard is specific to protection of human health. Standard is derived with TRV protective of adults. Standard may not adequately protect other age groups.
- 57 Standards apply to a site used for an industrial or commercial purpose or activity set out in Schedule 2 as
- (a) item A4,
 - (b) item C3,
 - (c) item E10, or
 - (d) item G1.

← ???

Schedule 2

[am. B.C. Regs. 17/2002, s. 16; 239/2007, s. 5; 343/2008, s. 12; 62/2013, s. 1; 253/2016, s. 16.]

Industrial and Commercial Purposes and Activities

COLUMN 1 Item	COLUMN 2 Purpose or Activity
A	Chemical industries and activities <ol style="list-style-type: none"> adhesives manufacturing or wholesale bulk storage chemical manufacturing or wholesale bulk storage explosives or ammunition manufacturing or wholesale bulk storage fire retardant manufacturing or wholesale bulk storage
C	Metal smelting, processing or finishing industries and activities <ol style="list-style-type: none"> foundries or scrap metal smelting galvanizing metal plating or finishing metal salvage operations nonferrous metal smelting or refining welding or machine shops (repair or fabrication)

E	Miscellaneous industries, operations or activities <ol style="list-style-type: none"> appliance, equipment or engine repair, reconditioning, cleaning or salvage ash deposit from boilers, incinerators, or other thermal facilities asphalt tar manufacture, wholesale storage and distribution coal gasification (manufactured gas production) medical, chemical, radiological or biological laboratories rifle or pistol firing ranges road salt storage facilities measuring instruments (containing mercury) manufacture, repair or wholesale bulk storage dry cleaning facilities or operations and dry cleaning chemical storage sites which have been or likely have been contaminated by substances migrating from other properties
G	Transportation industries, operations and related activities <ol style="list-style-type: none"> aircraft maintenance, cleaning or salvage automotive, truck, bus, subway or other motor vehicle repair, salvage or wrecking

Fire Retardants (Schedule 2 – A4)



PFAS-Containing Firefighting Foams

- Firefighting Training Areas
- Crash sites
- Fuel spills and fires
- Equipment test locations
- Emergency vehicle filling
- Emergency vehicle maintenance areas
- Fire halls/stations
- Firefighting foam bulk storage
- Foam-charged fire suppression systems



Photo: Global News

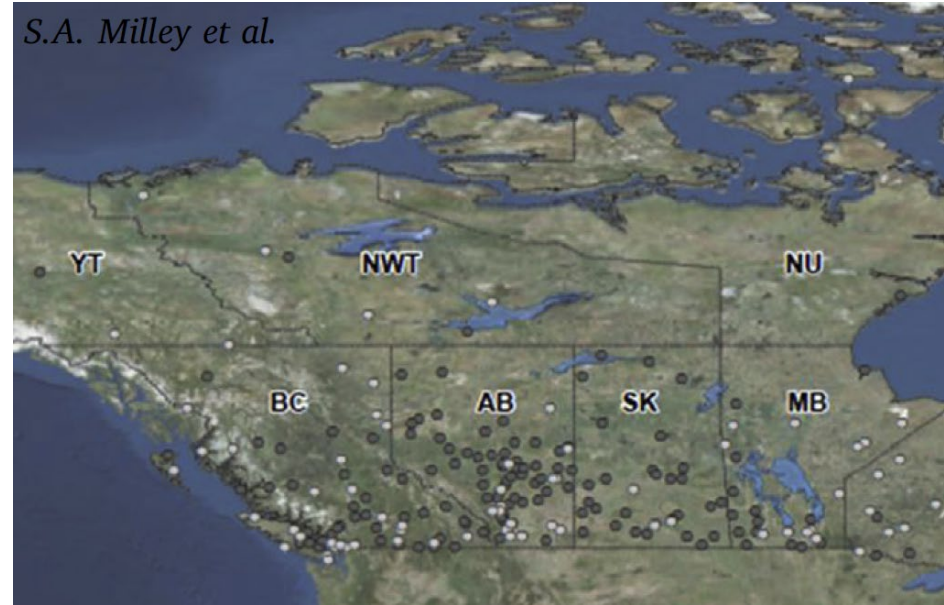
Metal Plating (Schedule 2 - C3)

- PFAS in products used to suppress volatilization of hexavalent chromium (e.g. Fumetrol), added to plating baths

PERFLUOROALKYL SUBSTANCES IN GROUNDWATER (ug/L)												
PFBA	PFPeA	PFHxA	PFHpA	PFOA	PFNA	PFDA	PFUnA	PFDaA	PFBS	PFHxS	PFOS	PFOSA
0.12	0.33	0.38	0.15	ND	ND	ND	ND	ND	0.54	0.03	1.7	ND
0.06	0.36	0.39	0.10	ND	ND	ND	ND	ND	5.7	0.04	8.1	ND
ND	0.51	0.41	0.14	0.06	ND	ND	ND	ND	0.71	0.02	5.4	ND
0.09	0.28	0.14	ND	ND	ND	ND	ND	ND	0.17	ND	1.3	ND
0.10	0.48	0.35	0.19	ND	ND	ND	ND	ND	0.34	ND	2.1	ND

Aircraft Maintenance/Cleaning/Salvage (Schedule 2 – G1)

- Milley et al. (2018) identified approximately 175 airports in Western Canada that were considered to be likely or potentially contaminated with PFAS from use of firefighting foams.
- PFAS also used in aviation hydraulic fluids to prevent corrosion and fires (limited data available)



Sources not listed under the CSR

- Landfills
- Wastewater treatment facilities
- Wastewater lagoons
- Biosolids application areas

Western Canadian Landfill Leachate

- PFHxA, PFPeA, PFOA, PFOS predominant PFAS in landfill leachates ^{1,2}

	Analyte	Mean (ppb)	Range (ppb)
C4-C12 Perfluoro Carboxylates	PFBA	0.227	<MDL-3.260
	PFPeA	0.359	<MDL-3.920
	PFHxA	0.695	<MDL-7.090
	PFHpA	0.278	<MDL-2.310
	PFOA	0.439	0.006-3.450
	PFNA	0.022	<MDL-0.117
	PFDA	0.015	<MDL-0.190
	PFUnA	0.002	<MDL-0.011
	PFDoA	0.003	<MDL-0.032
C4-C8 Perfluoro Sulfonates	PFBS	0.114	<MDL-1.370
	PFHxS	0.300	<MDL-3.010
	PFOS	0.2' limit	<MDL-4.840
	PFOSA	0.008	<MDL-0.063

^a MDL: Method detection limit

¹ Belinda Li (2011) *Perfluorinated Compounds in Landfill Leachate and their Effect on the Performance of Sodium Bentonite Landfill Liners*, MAsc thesis UBC/UNBC

² Benskin et al (2012) *Per- and Polyfluoroalkyl Substances in Landfill Leachate: Patterns, Time Trends, and Sources*, ES&T (46): 11532-11540

Wastewater

Environment Canada Study (Guerra et al, 2014)

- PFOA, PFOS and PFHxA most frequently detected
- Median final effluent levels of 0.012, 0.005 and 0.009 ug/L, respectively

Wastewater treatment plants may transform PFAS precursors into “dead-end” PFAS which then do not degrade further in the environment.

Biosolids

- > 80,000 dry tonnes biosolids produced annually in BC & AB
- Significant proportion applied to agricultural land, subject to provincial regulations and guidelines
- Median Canadian biosolid concentration of ~ 0.013 ug/g PFOS¹ (similar to data from one BC WWTP of 0.015 ug/g PFOS)

¹ Guerra et al (2014) *Parameters affecting the formation of perfluoroalkyl acids during wastewater treatment*, J.Haz.Mat. 272: 148-154.

BC Environmental Laboratory Manual

Organics

Revision Date: Sept 15, 2017

Perfluoroalkyl Substances (PFAS) in Soils by LC/MS/MS - PBM

Parameter	Perfluoroalkyl Substances (Perfluorobutane Sulfonate (PFBS), Perfluorooctane Sulfonate (PFOS), Perfluorooctanoic Acid (PFOA)) in Soils
Analytical Method	Methanol Extraction, Solid Phase Extraction (SPE) Clean-up, LC/MS/MS
Introduction	This method is applicable to the quantitative determination of perfluorinated alkyl substances in soils and solids.

Organics

Revision Date: Sept 15, 2017

Perfluoroalkyl Substances (PFAS) in Water by LC/MS/MS - PBM

Parameter	Perfluoroalkyl Substances (Perfluorobutane Sulfonate (PFBS), Perfluorooctane Sulfonate (PFOS), Perfluorooctanoic Acid (PFOA)) in Waters
Analytical Method	Solid Phase Extraction (SPE), LC/MS/MS
Introduction	This method is applicable to the quantitative determination of perfluorinated alkyl substances in waters.

Site Investigation Considerations

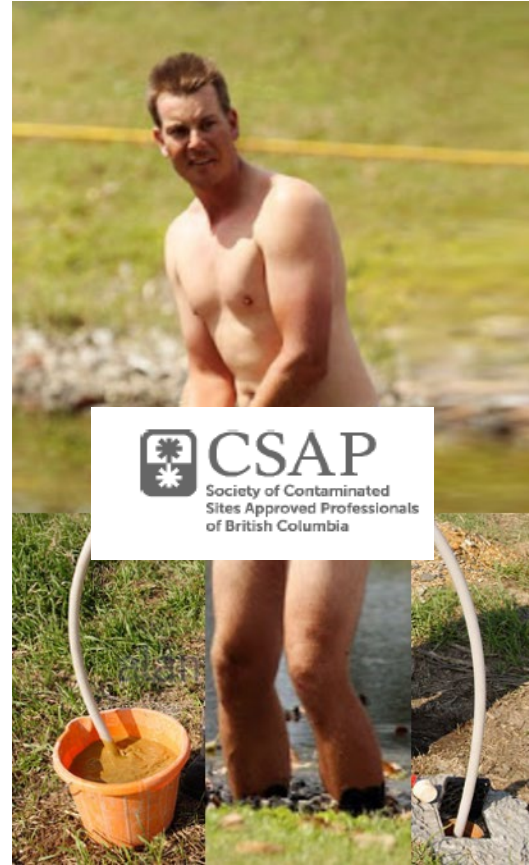
- Site-Specific Considerations
 - Surface runoff and stormwater transport
 - Groundwater-surface water interactions
 - Proximity of water supply wells
- Receptor Identification
 - Consider persistence and mobility (transport distances can be significant)
 - Expedite investigations where potential for DW consumption (“Outside-In approach”)

Site Investigation Considerations

- Media of interest:
 - Regulated media: soil, groundwater
 - Media to be considered with risk-based approach: sediment, surface water, drinking water, dust, biota tissues (human and eco food items)



Field Precautions or The Birthday Suit Well Development and Sampling Protocols



Field Precautions

- Materials to avoid
- Acceptable materials
- Water sources for investigation programs
- Equipment Decontamination
- Other Field Considerations

QA/QC

- Blanks
- Blanks
- And more blanks

Remediation

- Resists biodegradation
- Resists photolysis, hydrolysis
- Destroyed at $\sim 1000^{\circ}\text{C}$
- Non-volatile
- Large dissolved phase groundwater plumes
- Sorption, solubility differences

Remediation



Remediation Considerations



Sample ID	PFBA	PFPeA	PFHxA	PFHpA	PFOA	PFBS	PFHxS	PFOS
INFLUENT	1.6	3.8	9.8	1.4	1.8	4.3	19	< 0.22
EFFLUENT	0.41	0.14	0.044	0.0019	< 0.0010	0.0049	0.0038	< 0.0020

Notes:

ug/L - micrograms per litre

Contaminated Soil Handling and Disposal

- PFAS not currently regulated under the BC Hazardous Waste Regulations
- BC CSR standards applicable at landfill facility would apply (varies with facility)
- Basel Convention:
 - Guidelines for management of PFOS-containing wastes
 - 50 mg/kg threshold
- Environmental Management Act
 - Cannot introduce waste into environment in manner/quantity as to cause pollution

Thank You!

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