

Assessing Airborne PFAS

ESAA PFAS Symposium - EDMONTON

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Imad Touahar, Eng., M.A.Sc., M.Sc.

Outline

- Airborne PFAS – sources, fate & transport and exposure
- Measuring PFAS in Air - sampling and analysis, case study
- Modelling Air Dispersion and Deposition - available tools
- Regulatory Status - indicators and needs

Airborne PFAS

What are airborne PFAS?

- PFAS released into the atmosphere, exist as
 - ❖ Gases (volatile fluorinated compounds)
 - ❖ Aerosols
 - ❖ Particulates

Where do airborne PFAS originate?

- Industrial Emissions
 - ❖ Fluoropolymer and chemical manufacturing
 - ❖ Metal plating, coating, and finishing
- Waste Treatment & Disposal
 - ❖ Incineration of PFAS-containing waste
 - ❖ Landfill gas emissions
- Consumer Product Manufacture and Use
 - ❖ Sprays, coatings, and cleaners
 - ❖ Textiles, carpets, and upholstery off-gassing
 - ❖ Refrigerant gases
- Aqueous Film-Forming Foams (AFFF)
 - ❖ Fire training facilities
 - ❖ Emergency fire suppression events

What are some concerns around airborne PFAS

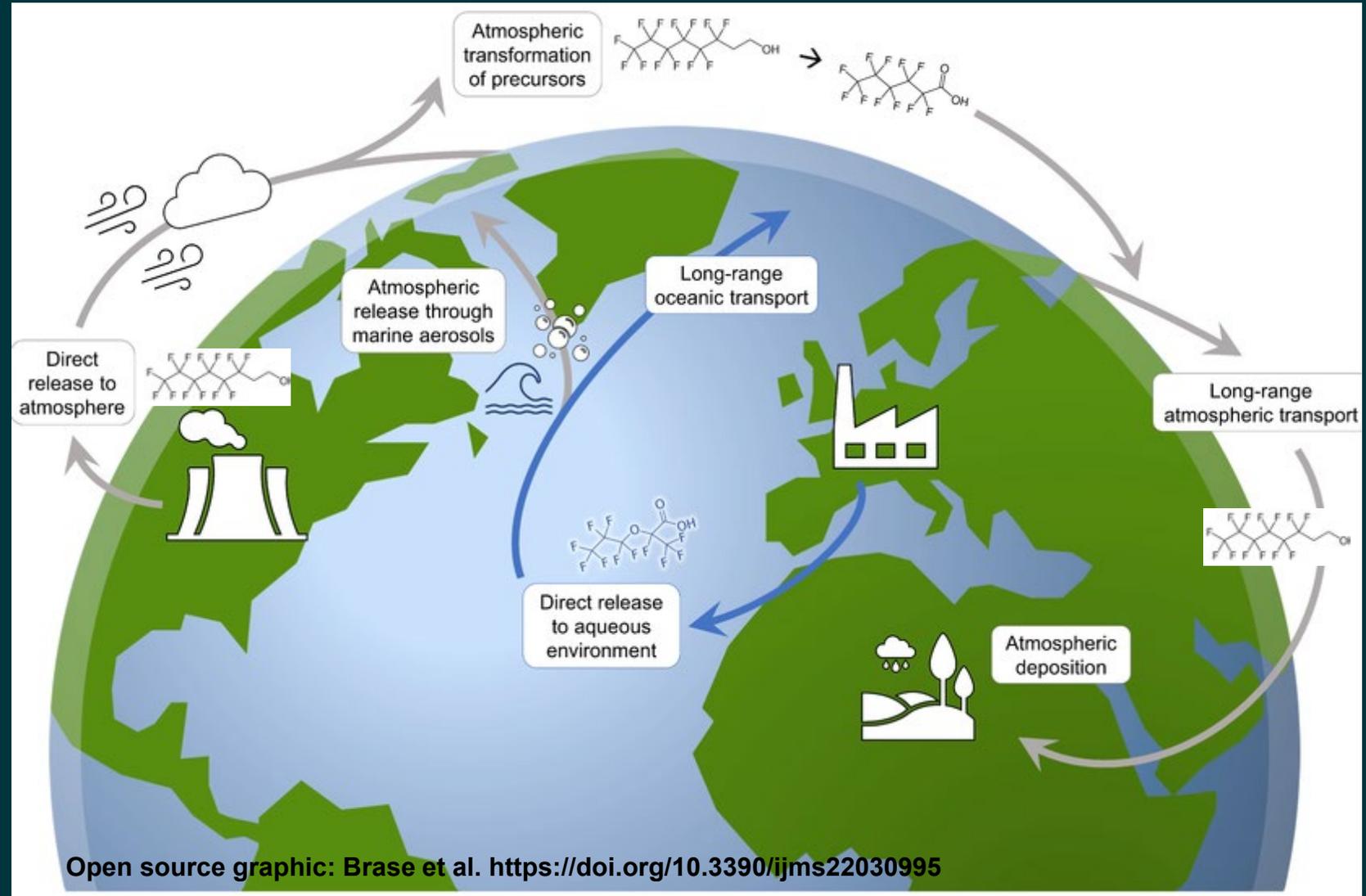
Emissions result in long range transport in air and water

Relatively more volatile FTOHs, FOSAs, FOSE transform to PFAAs

Non-polar volatile fluorocarbons (e.g., refrigerant gases) transform to ultra-short-chain (e.g., trifluoroacetic acid TFA)

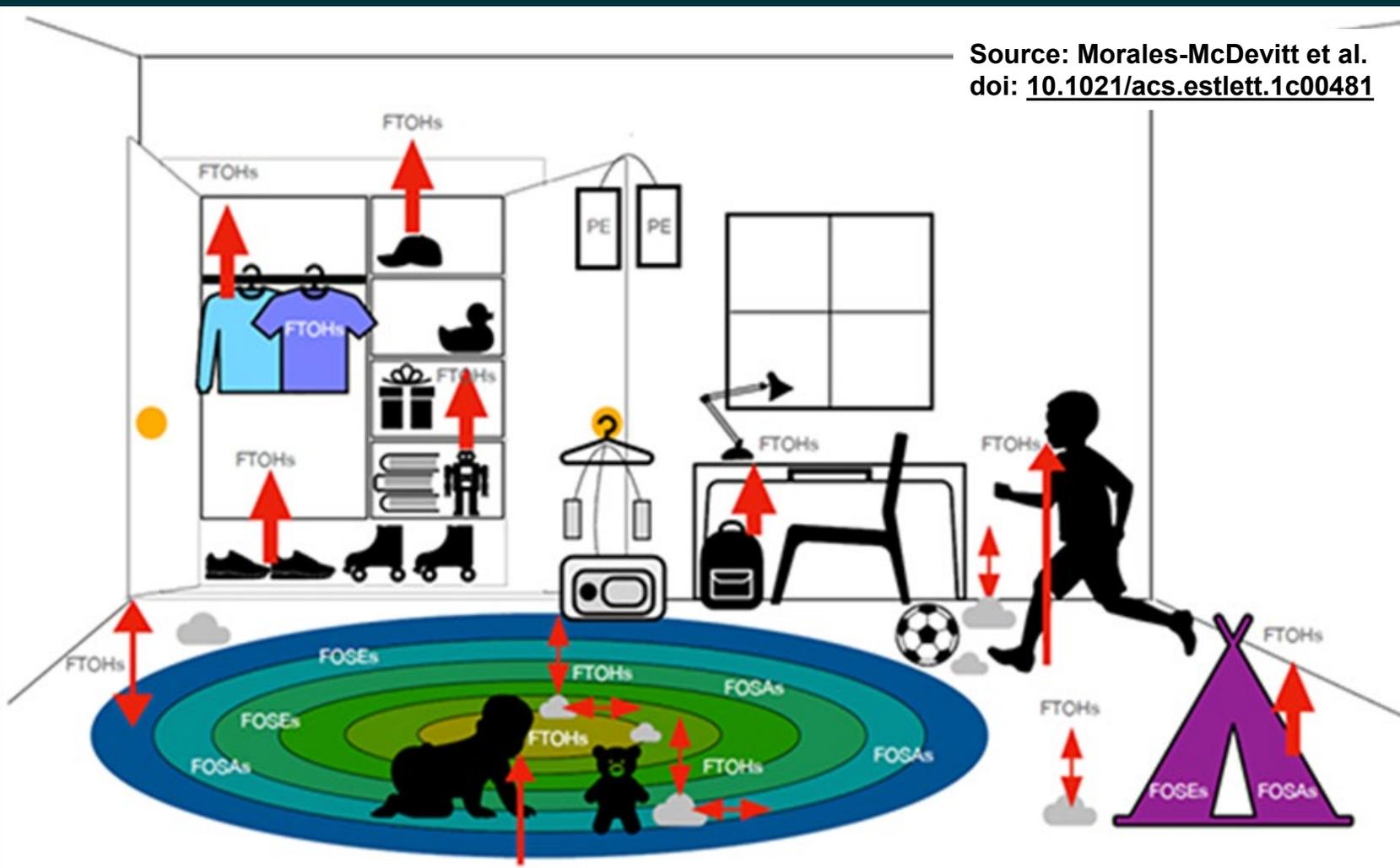
Global distribution creates ambient or background PFAS exposure

FTOHs - fluorotelomer alcohols
FOSAs - perfluorooctane sulfonamides
FOSEs - perfluorooctane sulfonamidoethanols
PFAAs – perfluoroalkyl acids



What are some concerns around airborne PFAS

Source: Morales-McDevitt et al.
doi: [10.1021/acs.estlett.1c00481](https://doi.org/10.1021/acs.estlett.1c00481)



Consumer and industrial products lead to household exposures

Inhalation pathways not yet quantified for exposure risk evaluation

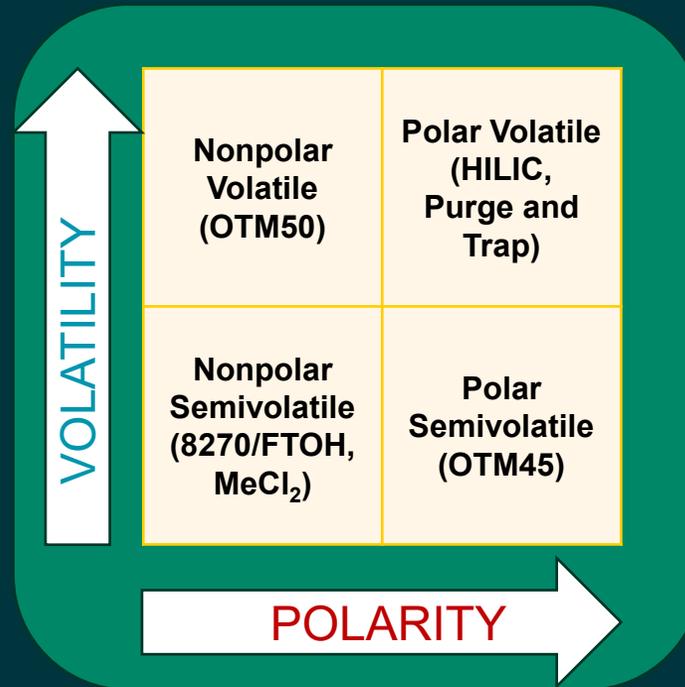
PFAS Sampling in Air (Gaseous Phase)

Canister sampling OTM-50 with GC-MS analysis

- 30 targeted volatile fluorocarbons
- Products of incomplete combustion (PICs)
- Some industrial PFAS

Method 0010 sampling with select 8270 GC-MS analysis (future OTM-55)

- Targeted for fluorotelomer alcohols (FTOHs) and PICs
- Includes potential compounds of concern



OTM = Other Test Method

Not a current focus

- Impinger sampling?
- LC analysis?
- Hydrophilic interaction chromatography (HILIC)
- Short- and ultra-short chain PFAS

OTM-45 sampling with LC-MS/MS analysis

- Includes 49 targeted PFAS typical to drinking water test methods
- C4 and longer
- GenX and PFOA

PFAS Sampling in Air (Gaseous Phase)

Same info as prior slide, but with US EPA method names and references

Get 'em while you still can!

- Modified Method 5/0010 for PFAS <https://www.epa.gov/hw-sw846/sw-846-test-method-0010-modified-method-5-sampling-train>
- Other Test Method-45: Measurement of Selected Per- and Polyfluorinated Alkyl Substances from Stationary Sources <https://www.epa.gov/system/files/documents/2025-01/other-test-method-45-rev1-final-1-14-25.pdf>
- Other Test Method-50: Sampling and Analysis of Volatile Fluorinated Compounds (VFCs) from Stationary Sources Using Passivated Stainless-Steel Canisters <https://www.epa.gov/system/files/documents/2025-01/otm-50-release-1-r1.pdf>

Additional methods to consider

- Other Test Method-55 (Under development): Detect semivolatile PFAS such as PICs and FTOHs
- Fourier Transform Infrared (FTIR) spectroscopy: Select volatile PFAS in real-time

OTM-45 Sampling System

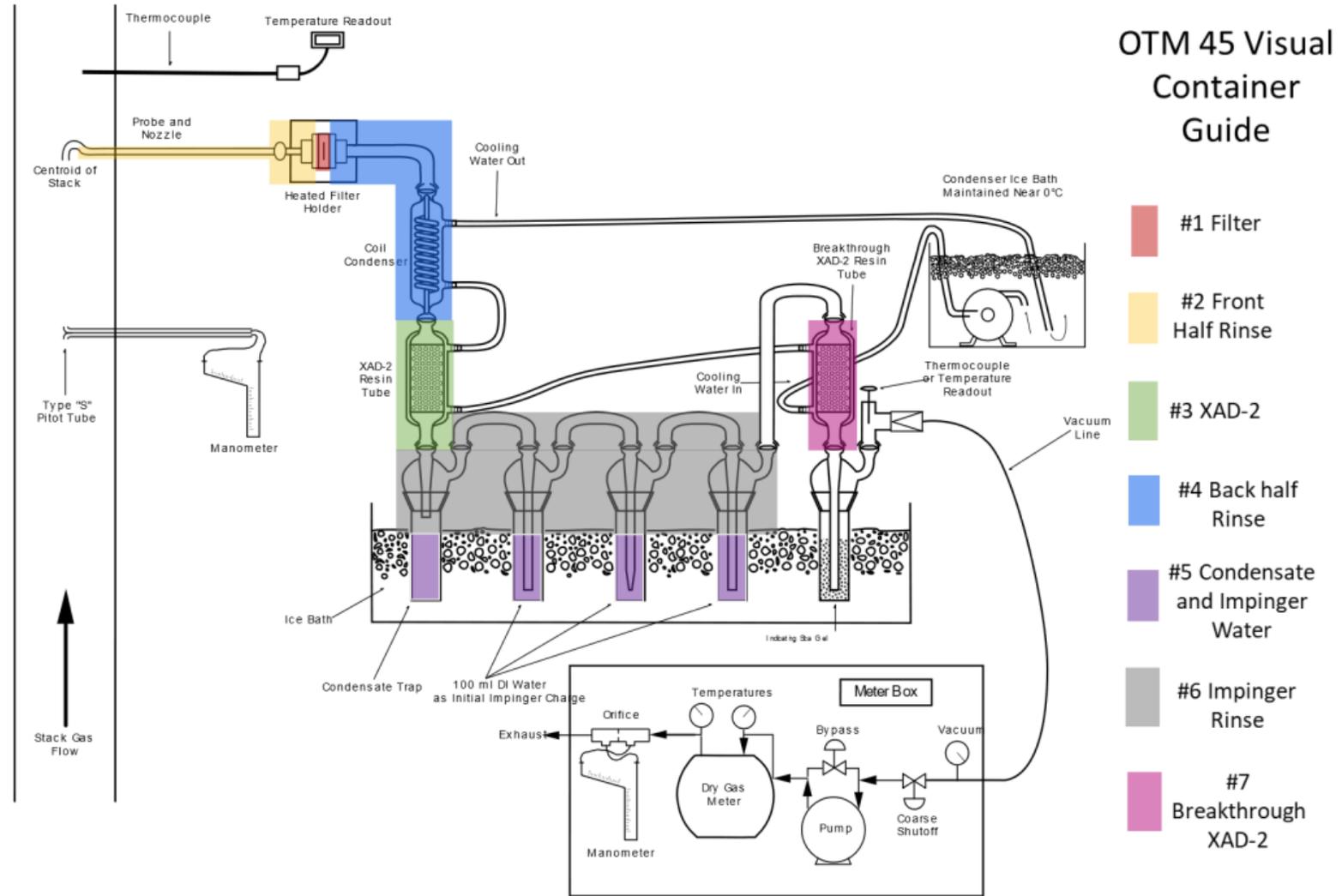
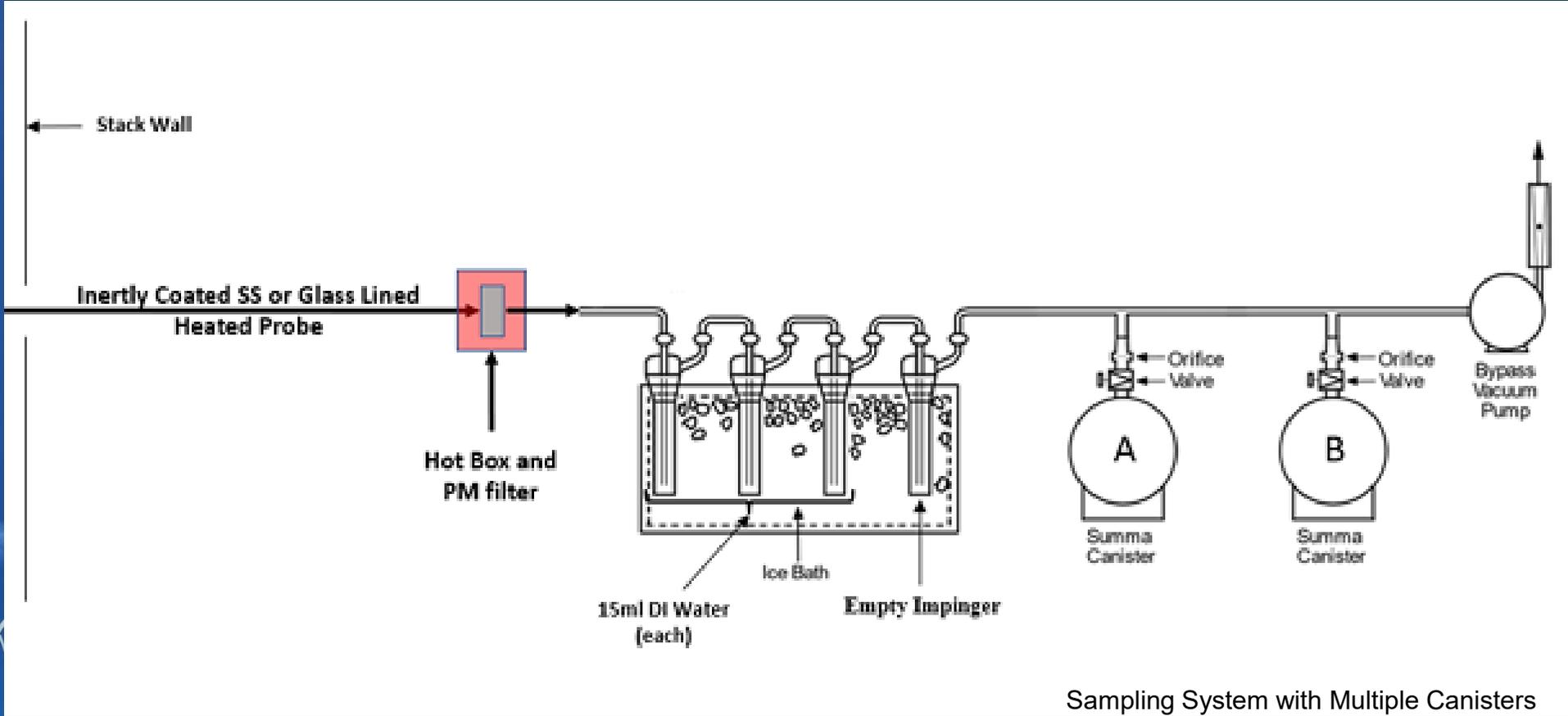


Figure OTM-45-1. Sampling Train

OTM-50 Sampling System



Image property of AECOM



Sampling System with Multiple Canisters

PFAS Air Sampling Case Study - Waste Incineration Facility, US

- Evaluated several waste streams and conditions over 2 campaigns
- Waste streams tested
 - ❖ AFFF Concentrate
 - ❖ AFFF-Contaminated Soil
 - ❖ AFFF with Lime Injection (to capture free fluoride)
 - ❖ General PFAS-contaminated soil
 - ❖ Spent activated carbon
 - ❖ Carbon Tetrafluoride waste

Tested stack emissions using OTM-45, OTM-50 & Method 26A (for HF)

PFAS Air Sampling Case Study - Waste Incineration Facility, US

Closing the fluorine mass balance

Stream	Location	Parameter	Sampling Method	Analytical Method
Waste Feeds	Prior to incineration	PFAS	Grab	EPA Method 537 (mod) EPA Method 1622
Stack Gas	Stack	HF	EPA Method 26A	IC-EPA Method 26A
		PFAS	OTM-45	EPA Method 537 (mod)
		VFC	OTM-50	GC/MS – ASTM D5466-21
		O ₂ , CO ₂	EPA Method 3A	Instrument Analyzer
Process Water	Tap	PFAS	S004	EPA Method 537 (mod)
Liquid Residues	Blowdown - end of treatment line repeated 24 hours later	PFAS	S004	LC-MS EPA Method 537 (modified)
Solid Residues (Ashes, Slag, Filtercake)	Ash from kiln Slag from secondary combustion chamber Filtercake from water treatment	PFAS	S007	LC-MS EPA Method 537 (modified)

U.S. EPA Method S004, "Sampling and Analysis Methods for Hazardous Waste Combustion.

U.S. EPA Method S007, "Sampling and Analysis Methods for Hazardous Waste Combustion"

PFAS Air Sampling Case Study - Waste Incineration Facility, US

- **Emissions:** HF stack emissions remained within regulatory limits
 - ❖ PFAS were either non-detect or emitted at extremely low levels (<9 mg/hr)
 - ❖ Achieving up to 99.9999% destruction removal efficiency (DRE) for PFAS at high concentration feeds
- **Difficult Compounds:**
 - ❖ Tetrafluoromethane (CF₄) incineration achieved less than 50% DRE, consistent with modeling predictions requiring >1,400 °C for effective destruction.
- **Byproducts:**
 - ❖ Products of incomplete combustion (PICs) were generally non-detect or near detection limits; only CF₄ was quantified above Limit of Quantitation (LoQ)
- **Residues:**
 - ❖ Solid residues showed PFAS in only 7 of 69 samples near the method detection limit
 - ❖ Liquid residues contained trace-level (ppt) PFAS indistinguishable from tap water

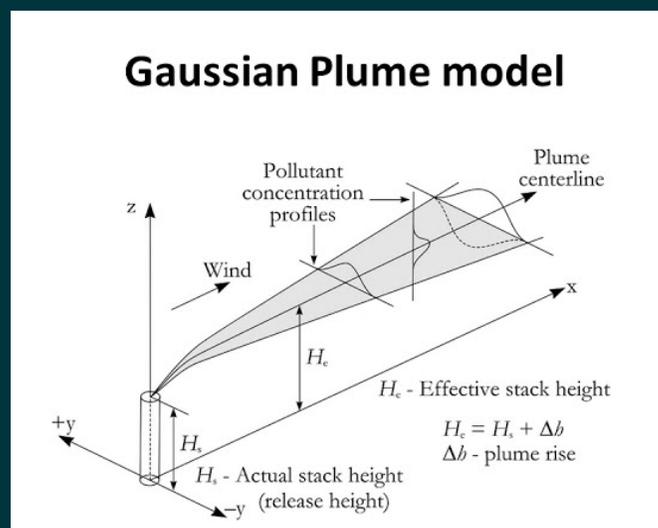
Modelling PFAS Air Dispersion and Deposition

Gaussian models:

American Meteorological Society-EPA Regulatory Model (AERMOD) steady-state model used for short-range or localized impacts

Used to predict PFAS air transport

Assume horizontal plume travel plume and vertical and lateral (crosswind) expansion follow Gaussian distribution



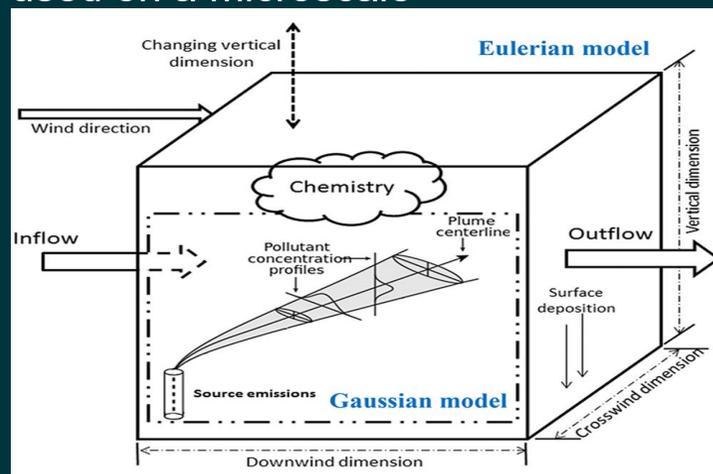
Eulerian models:

Dynamic with a fixed reference grid system

Each pollutant concentration is calculated at each time step for each point in the grid

CMAQ and CAMx used on mesoscale to predict regional or continental transport photochemical grid transport

Computational Fluid Dynamics (CFD) used on a microscale



Lagrangian models:

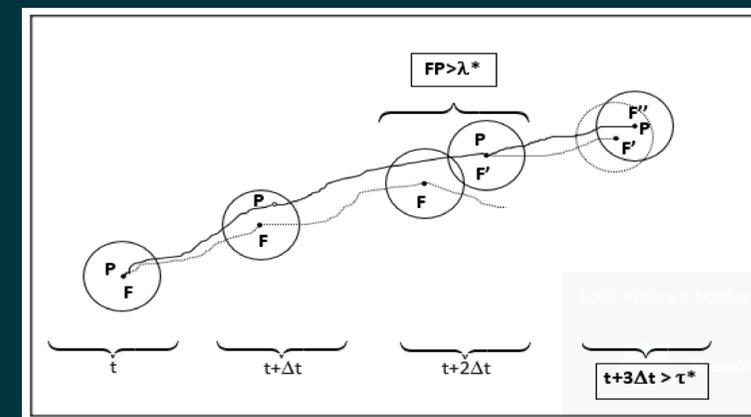
Dynamic models with shifting reference

Dispersion simulated by tracking paths of individual particles or parcels of air (air masses) as they move with the wind

Effective for following pollutants from source to understand transport, dispersion, and concentration over time

Suited for long-range atmospheric transport and deposition

CALPUFF and HYSPLIT



Modelling PFAS Air Dispersion and Deposition - Headwinds



Chemical diversity: many PFAS compounds with varying physical properties

Data gaps: lack physicochemical property data and emissions inventories are limited



Atmospheric processes: the fate of PFAS in the atmosphere is complex -- both transport and dispersion

Measurement: low concentrations PFAS in the environment are hard to measure and confound model validation



Model complexity: running models requires significant expertise and resources

Model uncertainty: gas-particle partitioning and hydrolysis of PFAS precursors introduce additional

Regulatory Status

A general lack of regulations for PFAS in air globally

Canadian regulatory considerations for airborne PFAS

Emissions data are sparse but should increase: National Pollutant Release Inventory (NPRI, 2025)

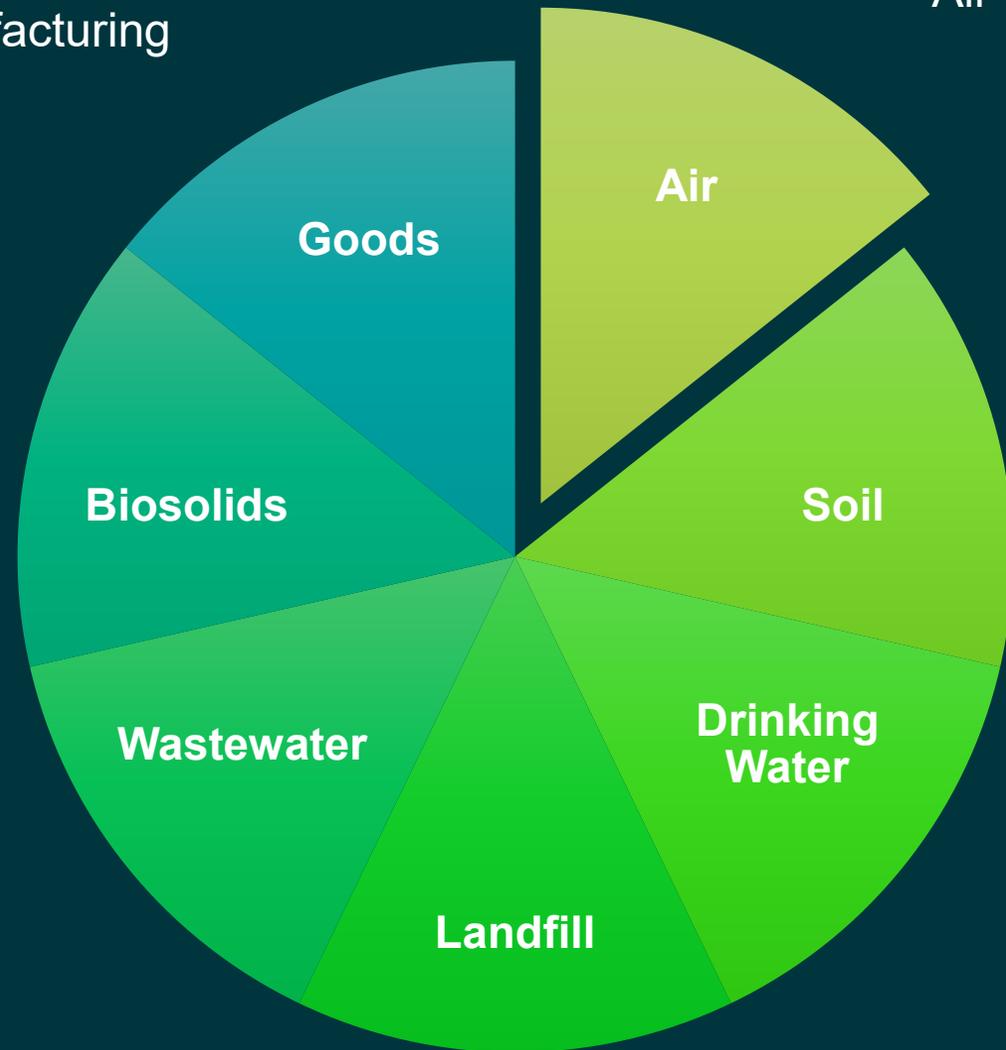
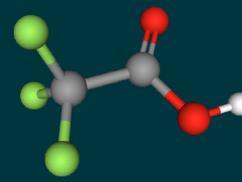
PFAS restrictions in goods (Canadian risk management approach, 2025)

Risk-based air screening levels

- Lack exposure information
- Inhalation toxicity values unavailable

Background ambient levels in soil and water

Regulating throughout the PFAS cycle



Volatile sources in goods
Air monitoring

Airborne deposition creates ambient background
Soil limits for protection of groundwater

Infiltration from soil to groundwater
Groundwater discharge to surface water
Drinking water restriction

Disposal releases PFAS into leachate

Biosolids reuse under scrutiny

Restrictions in manufacturing

Monitoring wastewater



Contributors

AECOM Canada

Randy Rudolph
Mary Ellen Starodub

AECOM US

Phaneendra Uppalapati
Ignacio Gallardo
Rosa Gwinn

University of Calgary

Olufemi Oluseun Akintunde
Gopal Achari
Vita Martez