

EVALUATING THE VAPOR INTRUSION PATHWAY FOR PFAS AT ONTARIO INDUSTRIAL LEGACY SITES

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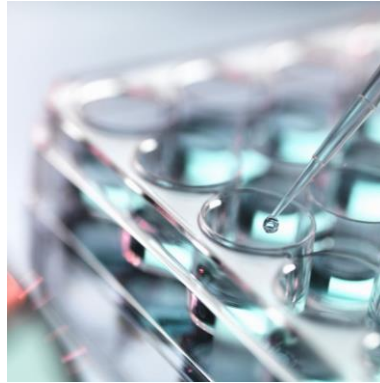


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Key Learning Objectives



Assess Technical Challenges

Assess PFAS vapor intrusion (VI) pathway challenges, the complexities of Henry's Law constants for fluorotelomer alcohols (FTOHs) and the challenges of thermal degradation during laboratory analysis.



Differentiate PFAS Sources

Identify methods to distinguish subsurface PFAS from indoor background using multiple lines of evidence for accurate source tracking.



Analyze Regulatory Trends

Review emerging regulations to design site-specific Conceptual Site Models for legacy sites in Ontario.

Introduction to PFAS and VI

Persistence of PFAS

PFAS are **highly persistent** in the environment, remaining for long periods and resisting natural breakdown processes.

Groundwater and Exposure

PFAS are **water soluble**, making ingestion of contaminated groundwater a primary exposure pathway for humans.

Vapor Intrusion Risks

Vapor intrusion involves **subsurface chemical vapors entering buildings**, potentially affecting indoor air quality if concentrations are significant.

Ontario Legacy Site Challenges

At Ontario legacy sites, PFAS vapor intrusion is **an emerging issue** needing phased and adaptive investigation strategies.



PFAS VI Fundamentals

Vapor-Forming PFAS

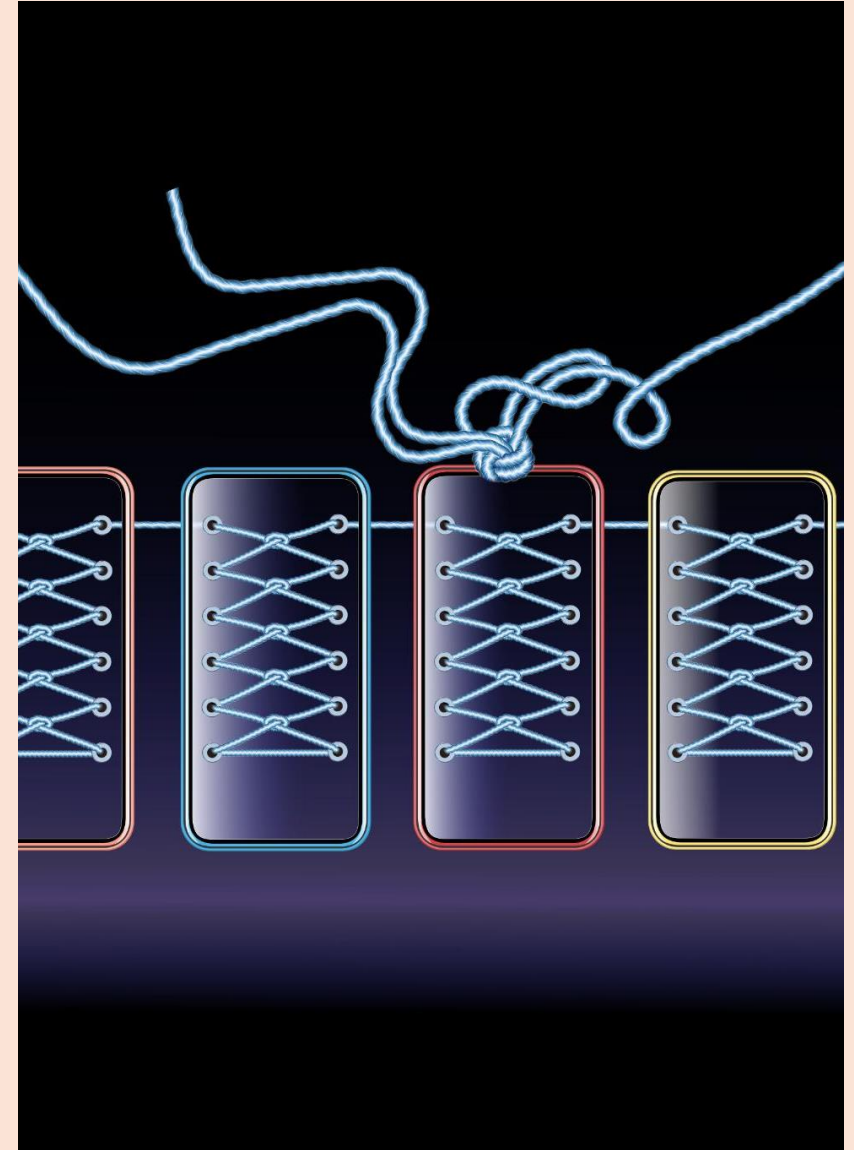
Certain PFAS, including FTOHs, FASAs, and ultrashort-chain compounds, are highly volatile and contribute to vapor intrusion.

Nonvolatile PFAS

Less volatile PFAS like PFCAs and PFSAAs remain mainly nonvolatile in the vadose zone and seldom cause vapor intrusion.

Subsurface Transport Pathways

Volatilized PFAS travel through soil pores and preferential pathways, such as utility conduits and ground cracks, to reach indoor air.



PFAS VI vs. Traditional VOCs

Traditional VOC Characteristics

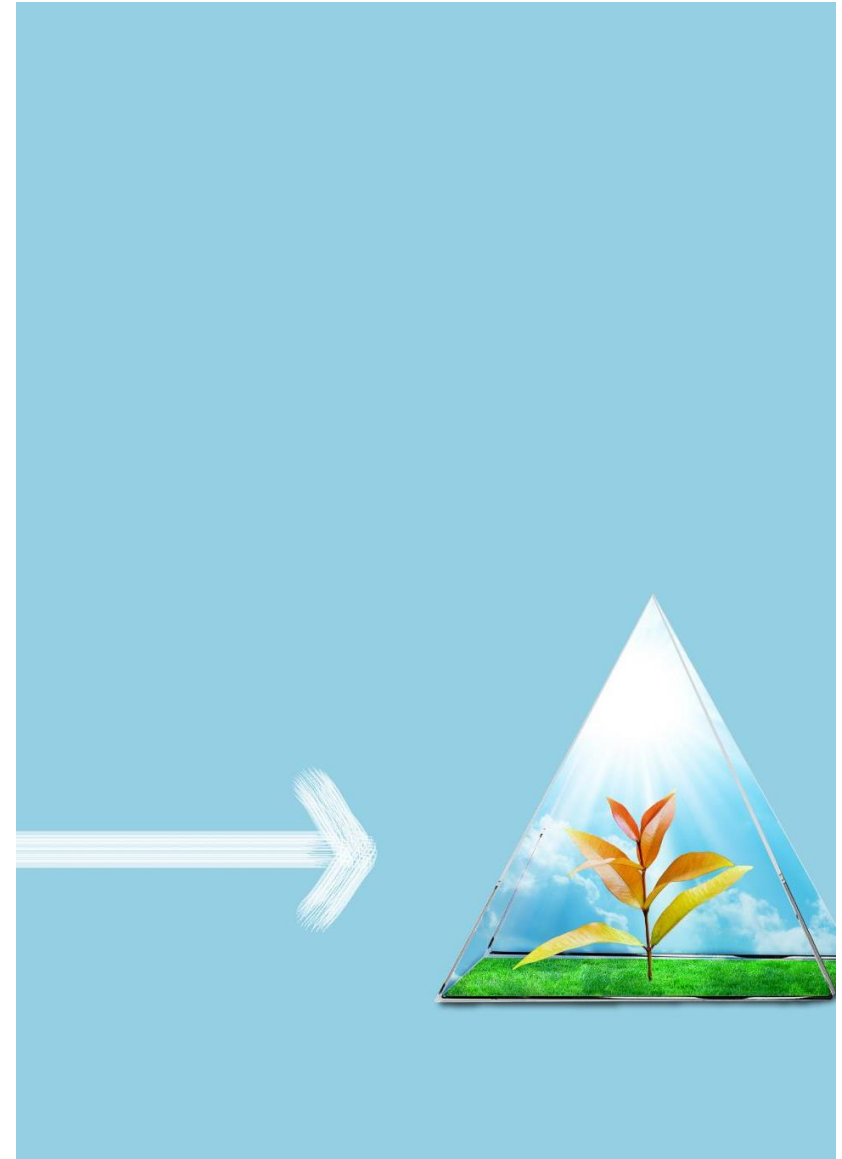
Traditional VOCs follow **predictable partitioning** with clear toxicity values and mature protocols for sampling and mitigation.

Complex PFAS Partitioning

PFAS compounds show **complex behavior** with volatile FTOHs in vapor and others dissolved or sorbed in water or soil.

PFAS VI Investigation Challenges

Investigating PFAS VI requires understanding precursor transformation, sorption at air–water interfaces, and mixed-phase (vapor vs. particulate/aerosol) transport.



Current Science and Evidence

Laboratory Vapor Partitioning

Studies show FTOH can enter vapor phase above AFFF solutions, with concentrations measured up to $38 \mu\text{g}/\text{m}^3$.

Field Detection in Soil Gas

USEPA fieldwork found FTOHs and PFCAs in shallow soil vapor and sub slab gas, indicating environmental presence.

Indoor Air Considerations

Indoor air often contains FTOHs, but these are mostly from indoor sources rather than vapor intrusion from the subsurface.



PFAS Vapor Intrusion Gaps

Unproven Vapor Intrusion Pathway

There is **no conclusive evidence** linking vapor-forming PFAS movement from subsurface sources to indoor air through a documented pathway.

Knowledge Gaps in Vadose Zone

Limited understanding exists about PFAS behavior in the vadose zone and their interactions at the air–water interface.

Field Data Scarcity

There is **little physical–chemical data** on PFAS under real field conditions, making risk evaluation difficult.

Ongoing Method Development

Active research aims to improve PFAS detection (TD-GC/MS/MS) methods and enhance risk assessment for vapor intrusion.



Challenges of Indoor PFAS Sources



PFAS Prevalence Indoors

Stain-resistant fabrics, carpets, paints, and cookware release PFAS, heavily influencing indoor air and dust composition.



VI Source Identification Difficulties

High PFAS concentrations from indoor items make it challenging to identify vapor intrusion sources using only indoor air data.



Need for Multiple Evidence Lines

Clarifying vapor intrusion pathways requires soil gas gradients and building diagnostics, not just indoor air analysis.

Health and Toxicity Risks

Limited Toxicity Data

Most vapor-forming PFAS **lack inhalation toxicity values**, making standardized risk screening challenging for regulators and scientists.

Health Concerns from FTOH

FTOH metabolites have been linked to liver effects and possible carcinogenicity, raising concerns about chronic exposure to these chemicals.

Interim Risk Evaluation Methods

Without robust toxicity data, PFAS vapor intrusion risks rely on interim or surrogate evaluation methods until further research is completed.



PFAS Regulatory Landscape Update



Missing Federal Toxicity Values

The USEPA has not established federal inhalation toxicity values or VI screening levels for vapor-forming PFAS compounds.



CERCLA Hazardous Substance Listing

PFOA and PFOS are now listed as hazardous substances under CERCLA, leading to more thorough PFAS reviews at legacy sites.



Vapor Intrusion Assessments

USEPA recommends VI assessments at sites with high PFAS concentrations near buildings, but quantitative thresholds are not yet defined.

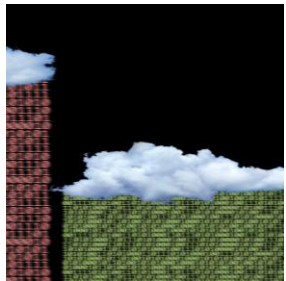


PFAS Regulatory Insights



Site-Specific PFAS Evaluation

The ITRC urges **careful, site-specific evaluation** for vapor-forming PFAS, avoiding assumptions unsupported by data.



Vapor Intrusion Models

PFAS-specific vapor intrusion conceptual site models are needed to distinguish vapor-phase processes from other transport routes.



Comprehensive Monitoring Initiatives

ECCC promotes ongoing **comprehensive PFAS monitoring** but has not yet established specific vapor intrusion screening criteria.



PFAS Regulation: State Variations

State-Specific Approaches

Some states, such as New Jersey, develop air benchmarks for PFAS using route-to-route extrapolation from ingestion toxicity values, though not specific to vapor intrusion.

Interim Guidance in Hawaii

Hawaii DOH provides interim risk-based screening levels for certain volatile PFAS, but does not require vapor intrusion assessment.

Regulatory Uncertainty

These efforts show proactive state actions but also highlight regulatory uncertainty due to the lack of federal guidelines.

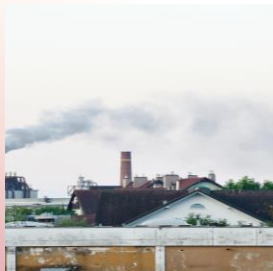


Ontario's Industrial PFAS Legacy



PFAS Contamination from Industrial Sites

Historic use and disposal of AFFF at industrial sites in Ontario have led to widespread PFAS contamination in soil and groundwater.



Managing Vapor Intrusion Risks

Site owners and regulators must consider PFAS vapor intrusion in liability and remediation strategies, responding to evolving regulations.



Role of Conceptual Site Models

CSMs should evaluate volatile PFAS, nearby buildings, and possible vapor migration pathways to guide remediation decisions.

PFAS VI Conceptual Models

Essential Pathway Elements

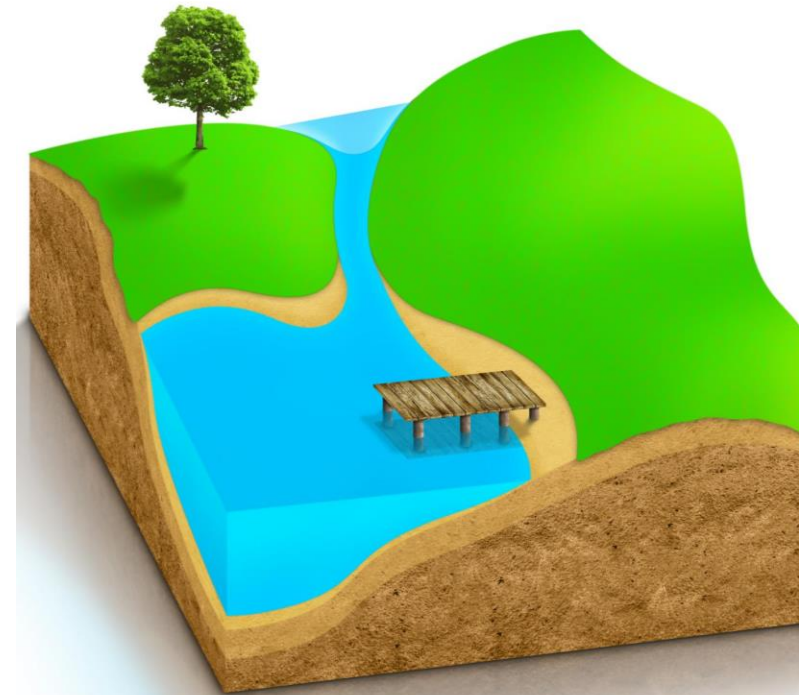
CSMs should show AFFF-impacted **soil** and **groundwater**, **building** locations, **vadose-zone conditions**, and **conduits** like utilities or drains.

PFAS-Specific Processes

Unlike VOC models, **PFAS CSMs must address air–water interface sorption and precursor transformation** in the conceptualization.

Uncertainties and Data Gaps

AVIP-style guidance emphasizes documenting uncertainties and data gaps throughout the exposure pathway in CSMs.



Sampling PFAS: Current Challenges

Lack of Standard Methods

No standardized USEPA methods exist for vapor-phase PFAS in soil gas, sewer gas, or indoor air, making sampling difficult.

Promise of Thermal Desorption

Thermal desorption GC/MS/MS methods adapted from TO-17 show promise for FTOHs and volatile PFAS with low-level validation.

Thermal Degradation Issues

PFCAs may degrade thermally during analysis, potentially causing underestimation and complicating data interpretation.



Tackling PFAS Sampling Hurdles

Minimizing Cross Contamination

Contamination from equipment and field blanks is a major challenge due to the widespread presence and low detection targets of PFAS.

Differentiating PFAS Forms

Accurately distinguishing vapor-phase PFAS from particulate or aerosol forms requires careful selection of sampling media and flow rates.

Guidance for Best Practices

ASTM and ITRC recommend **integrating PFAS-specific protocols with vapor intrusion toolkits** for reliable sample handling and quality assurance.



Multiple Lines of Evidence

Soil Gas and Vapor Gradients

Analyzing soil gas and sub-slab vapor gradients helps reveal attenuation between PFAS sources and building interiors, clarifying vapor movement.

Compound Profiles and Diagnostics

Combining compound profiles with building use, ventilation, and diagnostic tests distinguishes PFAS vapor intrusion from indoor sources.

Integrated Site Modeling

Integrating groundwater, soil, and vapor data into the conceptual site model provides a comprehensive understanding beyond indoor air sampling alone.

PFAS Mitigation & Gaps

Current Mitigation Methods

PFAS vapor intrusion is addressed using strategies similar to VOCs, such as **sub slab depressurization, improved ventilation, and vapor barriers.**

Effectiveness and Uncertainty

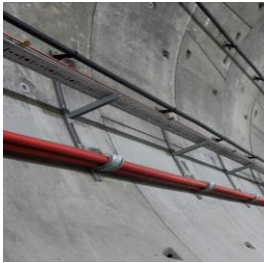
The effectiveness of these mitigation approaches for PFAS, especially semi volatile compounds, remains uncertain and needs further evaluation.

Emerging Treatment Technologies

Granular activated carbon and other adsorptive media are being studied for PFAS remediation, but standardized design criteria are still in development.



Key System Design Factors



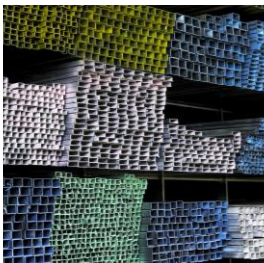
Active System Requirements

Active systems demand **sufficient sub slab permeability, sealed penetrations, and vapor barriers** that surpass ASTM E1745 Class A standards.



Passive Barrier Installation

Passive barriers, such as **geomembranes**, must be installed carefully to avoid leaks at cracks or joints.



Material Selection Criteria

Designers should choose **PFAS-free or low-PFAS materials**, emphasizing durability and ease of maintenance for long-term performance.

Stakeholder Best Practices

Thorough Documentation

Consultants and lawyers should record physical–chemical data, note analytical limitations, and highlight toxicity gaps for PFAS VI liability.

System Verification

Designers and installers must check system seals, pressure field extension, and maintain comprehensive installation records.

Adaptive Investigation

Regulators and site owners should use a phased investigation, starting with CSM refinement and screening data, then targeted VI sampling.



PFAS VI: Key Takeaways

High Uncertainty in PFAS VI

PFAS VI exposure **pathway is highly uncertain** due to low volatility, widespread indoor sources, and limited toxicity information.

Site-Specific Models Are Essential

Industrial legacy sites in Ontario require **robust, site-specific conceptual site models** and strict adherence to evolving guidance.

Need for Valid Data

Validated **screening levels and inhalation toxicity data** are urgently needed to make informed decisions about PFAS VI risks.

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Thank You
for
listening

