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PFAS TECHNICAL WEBINAR SERIES

Webinar Instructions

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Dr. Rula A. Deeb

Webinar Facilitator

Geosyntec PFAS Webinar Series

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#	Webinar Title	Date and Time	Speakers
1	Managing PFAS: Key Technical and Regulatory Issues and PFAS Forensics	Tuesday April 7 9 am PT/12 pm ET ***1 hour***	• Dr. Rula Deeb, Geosyntec Consultants • Dr. Lydia Dorrance, Geosyntec Consultants
2	PFAS Toxicology and Risk Assessment: State of the Science	Tuesday April 14 9 am PT/12 pm ET ***1 hour***	• Dr. Jason Conder, Geosyntec Consultants • Ms. Jennifer Arblaster, Geosyntec Consultants • Dr. Kristin Bridges, Geosyntec Consultants
3	PFAS: Key Takeaways from the ***Emerging Contaminants Summit*** held in March 2020	Tuesday April 21 9 am PT/12 pm ET ***1.5 hours***	• Ms. Ginny Yingling, Minnesota Department of Health (Conference Keynote) • Dr. Helena Solo-Gabriele, University of Miami (Session Keynote) • Mr. James L'Esperance, Northrop Grumman Corporation (Scientific Advisory Board) • Mr. Nick Garson, The Boeing Company (Scientific Advisory Board) • Dr. Rula Deeb, Geosyntec (Conference Co-Chair)

Geosyntec PFAS Webinar Series (Cont'd)

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#	Webinar Title	Date and Time	Speakers
4	PFAS Site Investigation and Management Strategies	Tuesday April 28 9 am PT/12 pm ET ***1 hour***	• Mr. Eric Sager, Geosyntec Consultants • Ms. Seth Kellogg, Geosyntec Consultants
5	PFAS Destruction Technologies and a Lines of Evidence Approach to Evaluate Treatment Efficacy	Tuesday May 5 9 am PT/12 pm ET ***1 hour***	• Dr. David Major, Savron • Mr. John Merrill, Geosyntec Consultants
6	The Evolution of PFAS Litigation and Future Drivers	Wednesday May 13 9 am PT/12 pm ET ***2 hours***	• Tammy Helminski, Barnes & Thornburg LLP • Kim Bick, Bick Law LLP • Peter Gray, Crowell & Moring LLP • Edward (Ned) Witte, Godfrey & Kahn S.C. • Nicole Moshang, Manko, Gold, Katcherand Fox LLP

Geosyntec PFAS Webinar Series (Cont'd)

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#	Webinar Title	Date and Time	Speakers
7	PFAS Inhalation and Vapor Intrusion Potential	Tuesday May 19 9 am PT/12 pm ET ***1 hour***	• Mr. Travis Kline, Geosyntec Consultants • Dr. Helen Dawson, Geosyntec Consultants

- Recordings available
  1. https://vimeo.com/405433845
  2. https://vimeo.com/407719091
  3. https://vimeo.com/410375563
  4. https://vimeo.com/412879660
  5. https://vimeo.com/415255286
  6. https://vimeo.com/418177239

Password: geosyntecPFAS

- Professional Development Hours available by contacting our training coordinator, Mickie Epley (MEpley@Geosyntec.com)

Submitting Questions

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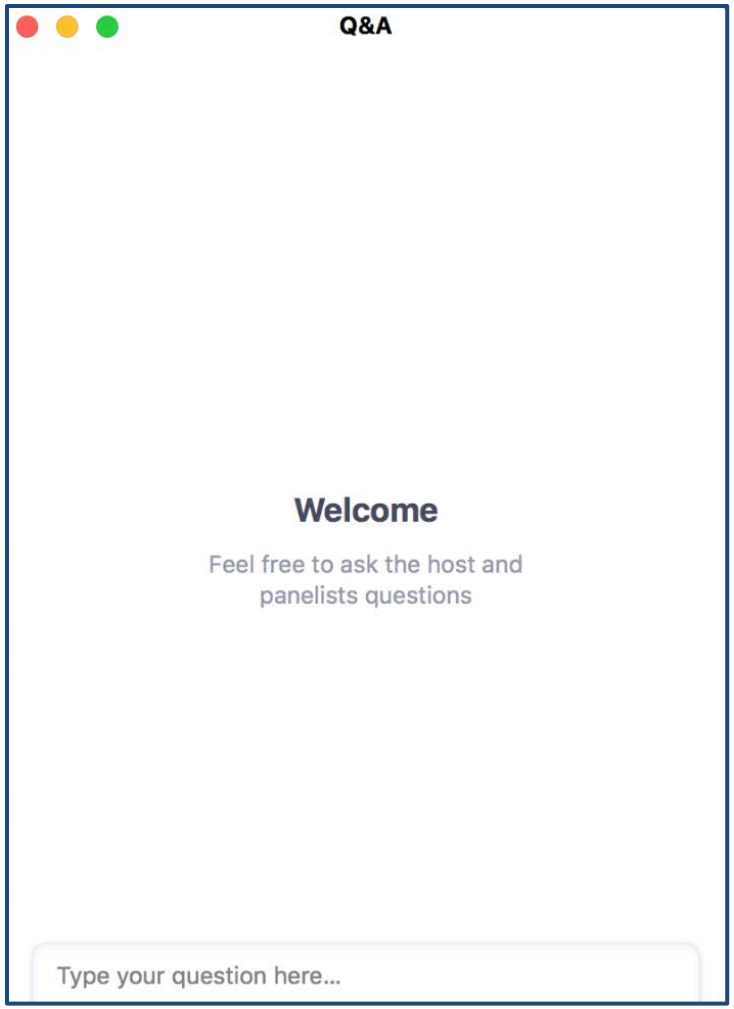
- Find the Q&A button on your control bar and type in your question(s)



Today's Webinar: PFAS Inhalation Exposure

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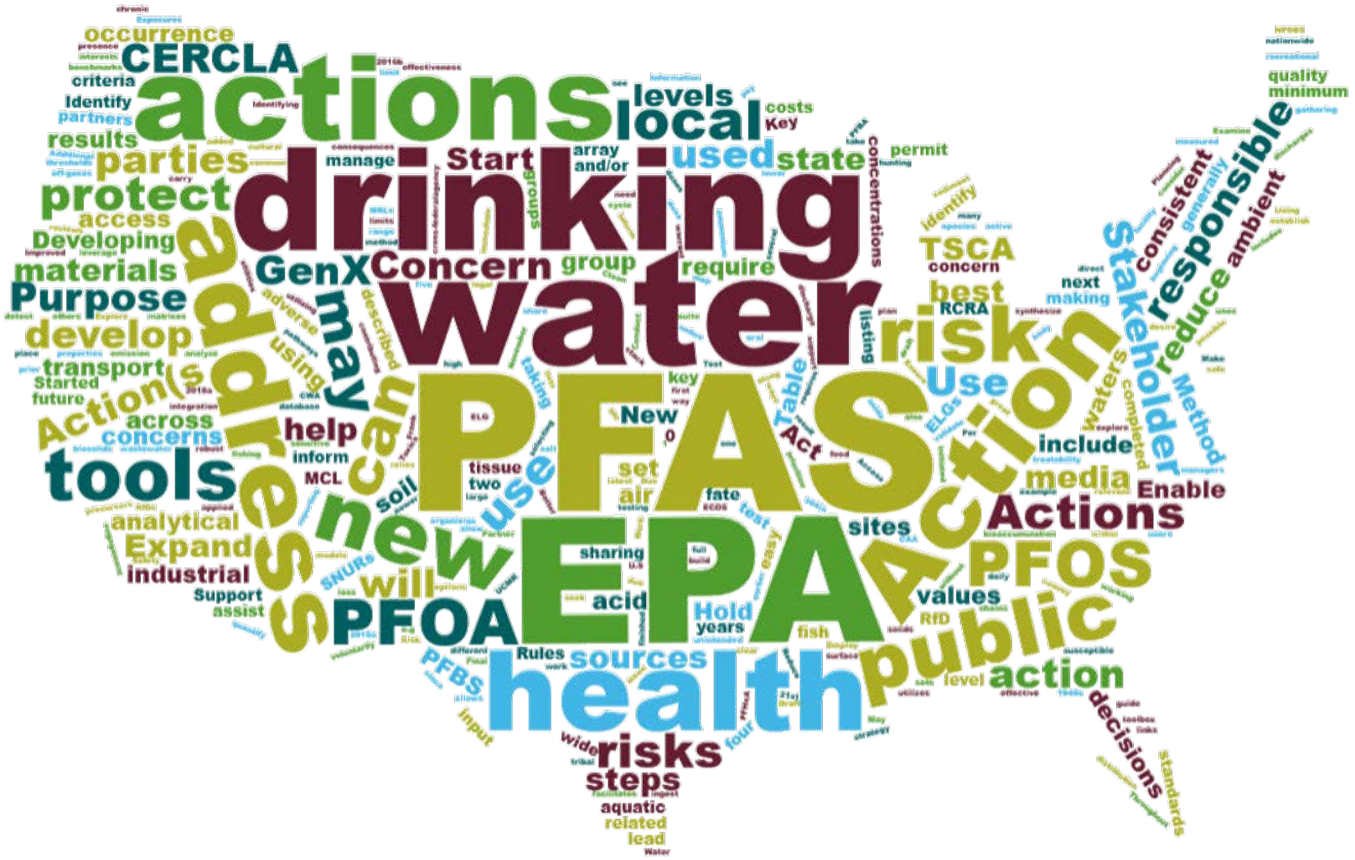
- Webinar overview (5 minutes)
- PFAS Inhalation Exposure and Data Gaps (20 minutes)
  - Travis Kline
- PFAS Vapor Intrusion Potential (20 minutes)
  - Helen Dawson
- Q&A (15 minutes)



Travis Kline

PFAS Inhalation Exposure and Data Gaps

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PFAS: Inhalation Exposure and Data Gaps

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PFAS: Inhalation Exposure and Data Gaps

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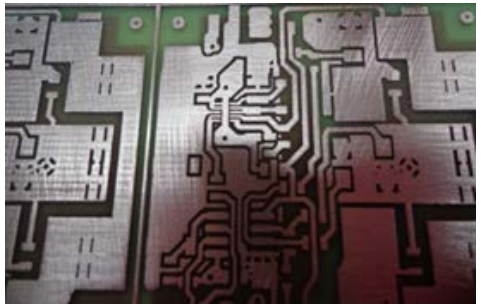

Population Exposures

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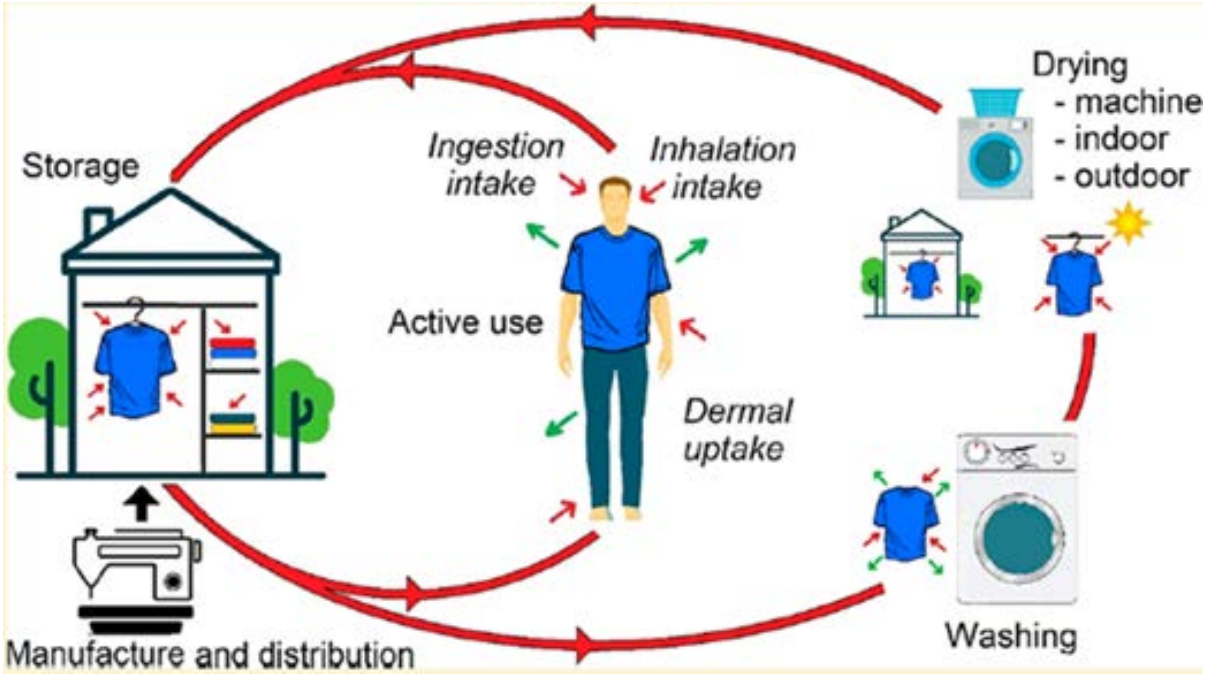
- Pervasive exposure
  - Drinking water (DW)
  - Ubiquitous in the U.S. population
- Target communities – adjacent to industrial production of high-volume use
  - Bioaccumulative potential: blood serum levels > 100x [DW]s



Population Exposures

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- General population – focus on drinking water

ITEM	VALUE
PFOS	
Food (pack/prep)	80%
Drinking water	15%
Hand-to-mouth	5% (consumer products)
PFOA	
Food	60%
Inhalation particles (e.g., performance fabrics)	25%
Drinking water	15%

PFOA Case Example – Southeastern U.S.

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- Driving pathways of concern – RME child
- Initial indications
  - Intake estimates (mg/kg-day) – not risk/hazard

ITEM	VALUE
Produce	1.3E-05* (detections)
Order of magnitude drop	
Fish	1.4E-06* (control technologies)
Drinking water	9.6E-07
Inhalation of ambient air	8.8E-07
Order of magnitude drop	
Incidental ingestion of soil	1.4E-07
Order of magnitude drop +	
Ingestion of surface water, swimming	4.2E-08
Dermal exposure to soil	2E-10
Dermal exposure to surface water	3.5E-12

- Drop produce and fish … → … drinking water … (alternative water supply) … → …
  - Inhalation, no toxicity criteria, data gaps

Highly Exposed Populations

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- Occupationally exposed populations
  - PFAS production and manufacturing (e.g., application of protective coatings)
  - Driven by fugitive emissions and subsequent inhalation
  - Blood serum levels 1000x higher than the general population for PFOA and 50x higher for PFOS
- Notes
  - Fire fighters
  - Ski wax

Basis	PFOA	PFOS	Reference
2000 - Geometric mean	5,200 ng/mL	1,760 ng/mL	ATSDR, 2018

Standards Summary

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- Toxicity criteria
  - Available, limited to ingestion
  - Most highly exposed are workers by inhalation
  - USEPA
    - PFOA/PFOS RfD_o: 2E-05 mg/kg/day (lifetime)
  - ATSDR
    - Oral $MRLs_{INT}$: (364 days)
      - PFOA = 3E-06 mg/kg/day
      - PFOS = 2E-06 mg/kg/day
  - USEPA/ATSDR – Critical effect elicitation

"The only places we're not finding PFAS are places we're not looking"

Heidi Grehter, Director
Michigan Department of Environmental Quality

PFAS Water Standards and Guidance (ng/L)

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	PFOA	PFOS
USEPA: AK, CO, CT, DE, IA, NH, PA, RI	70	70
CA	10	40
MA	20	20
ME	400	400
MI	9	8
MN	35	15
NV	667	667
NJ	10	10
NY	10*	10*
TX	560	290
VT	20	20

* Pending

ITRC, April 2020

Inhalation Data Gaps

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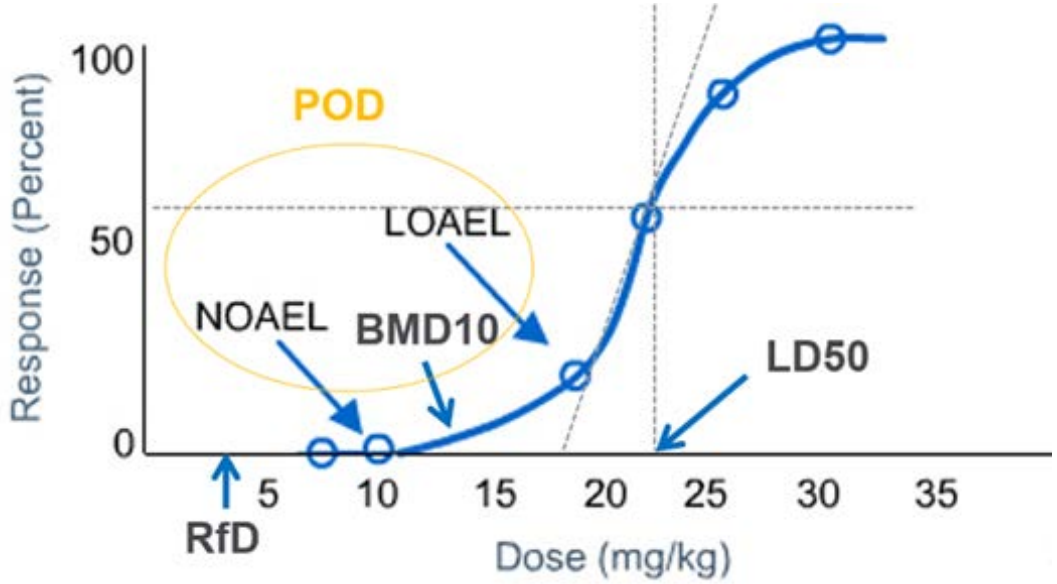
- Inhalation exposures remain a data gap
- All toxicity criteria = ingestion
- Route-to-Route extrapolation convention
- EPA guidance and application



Inhalation Exposure

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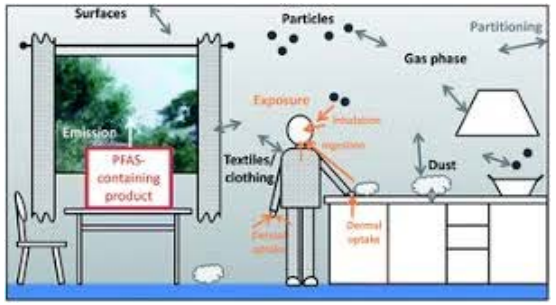
ITEM	COMMENT
GI absorption efficiency	>95% PFOA; respiratory system; no adjustment
Dusts	Impacted upper airways, ciliary action, ultimately swallowed
Distribution	Inhalation/ingestion, same (consistent blood, extravascular tissues, liver)
No metabolism	Toxic metabolites
Portal of entry effects	No evidence; low lung irritation, ingestion/inhalation
Route-to-Route extrapolation (for screening)	No contraindication

- Lots of unknowns, but preliminary understanding
  - Ranking, where to expend effort, additional scrutiny on drivers



Provisional Inhalation Screening Comparisons

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- Example EPA/ATSDR-based provisional values
  - EPA: Continuous exposures (lifetime)
  - ATSDR: Annual exposures

Table 1: Conversion of Ingestion-based Toxicity Criteria

Compound	Adult Body Weight (kg)	USEPA RfD_o (mg/kg/d)	USEPA Target Inhalation Dose (µg/day)	ATSDR MRL_{int} (mg/kg/d)	ATSDR Target Inhalation Dose (µg/day)
PFOA	70	2.00E-05	**1.40E+00**	3.00E-06	**2.10E-01**
PFOS	70	2.00E-05	**1.40E+00**	2.00E-06	**1.40E-01**

Table 2: Derivation of Residential Ambient Air Screening Levels

Compound	Adult Inhalation Rate (m^3/d)	USEPA Target Inhalation Dose (µg/day)	USEPA-Based Air SL (Residential) (µg/m^3)	ATSDR Target Inhalation Dose (µg/day)	ATSDR-Based Air SL (Residential) (µg/m^3)
PFOA	20	1.40E+00	**0.07**	2.10E-01	**0.01**
PFOS	20	1.40E+00	**0.07**	1.40E-01	**0.007**

Contact Information

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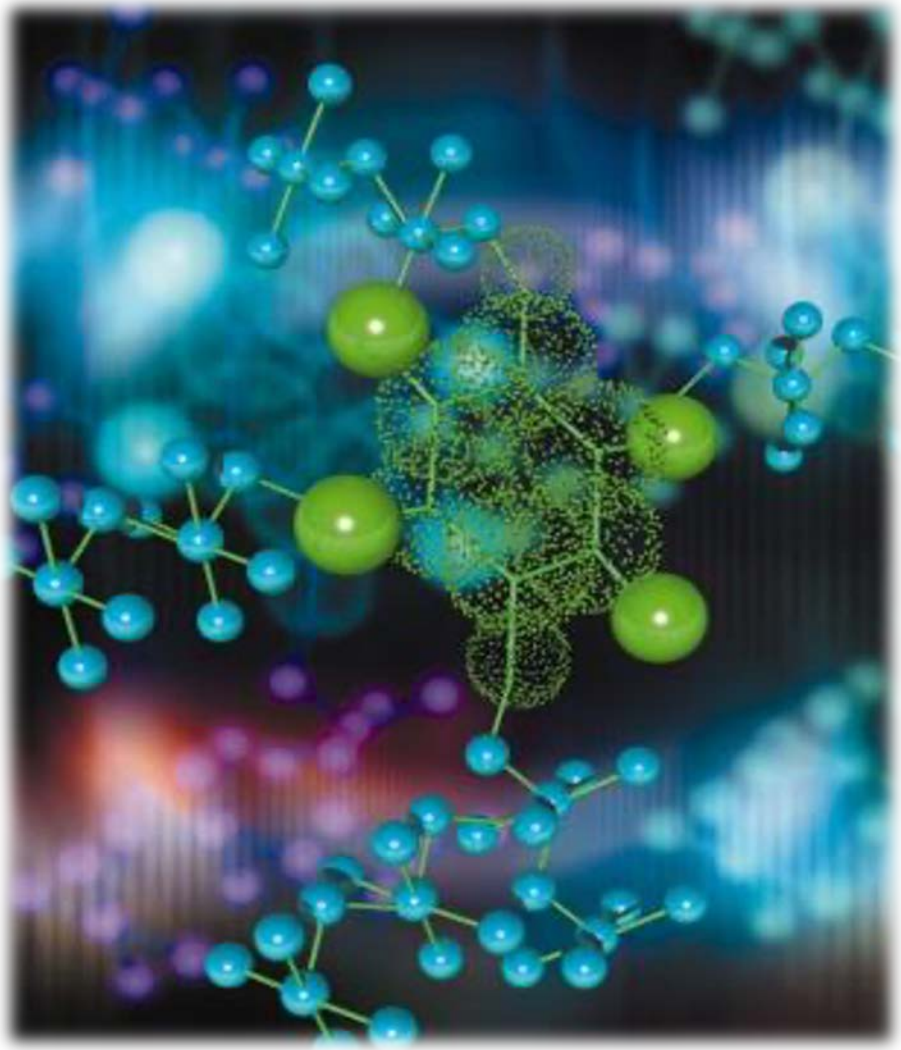

https://www.geosyntec.com/pfas

Helen Dawson

PFAS Vapor Intrusion Potential

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PFAS Vapor Intrusion (VI) Potential

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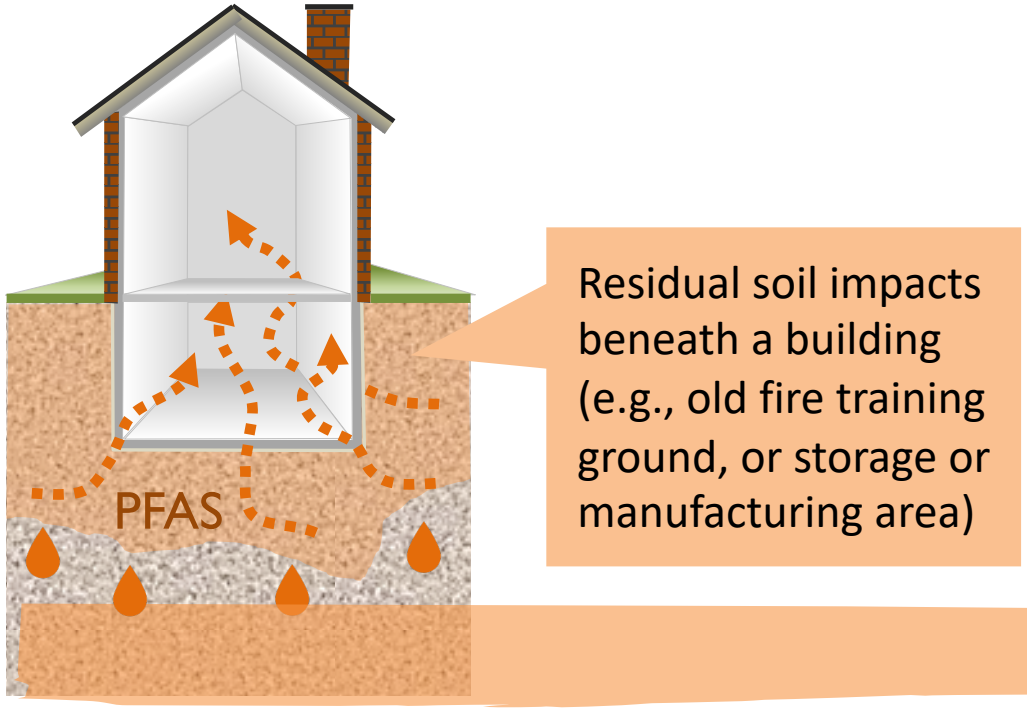
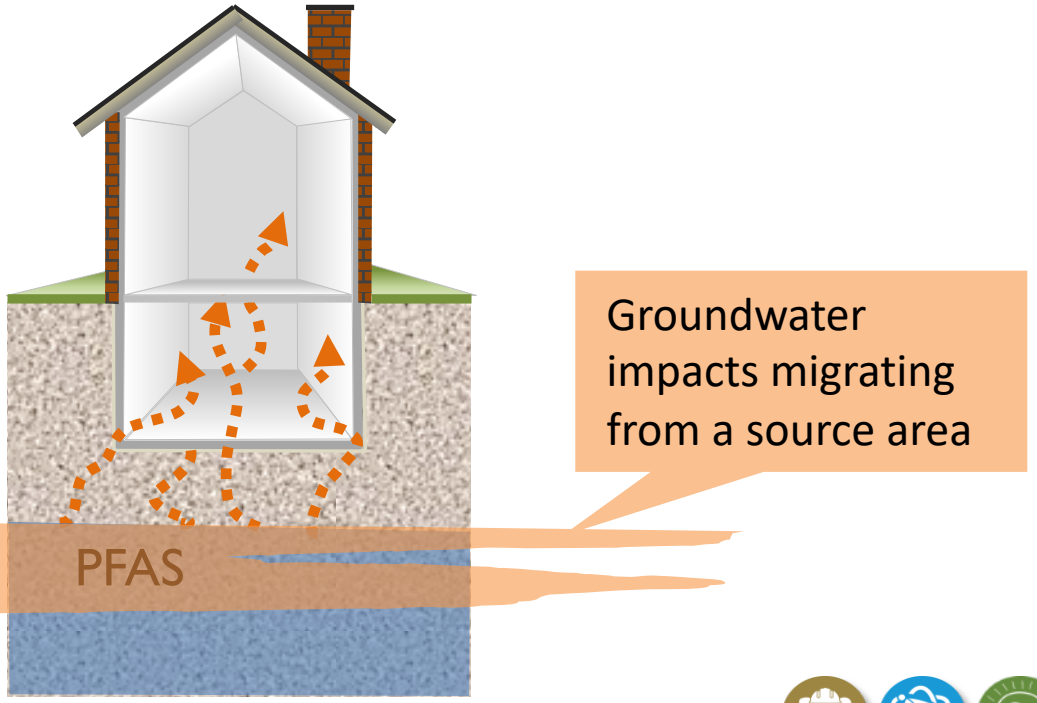
- Are PFAS compounds sufficiently volatile and toxic to pose inhalation risk via vapor intrusion from soil?



- Are PFAS compounds sufficiently volatile and toxic to pose inhalation risk via vapor intrusion from groundwater?



Criteria for Assessing PFAS VI Potential?

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- Possible for a soil source if:
  - Building constructed over PFAS release area (e.g., residual PFAS in soil)
  - Vapor concentration of chemical off-gassing from a soil source is greater than 30X indoor air screening level
    - Note: 30X is EPA's default soil gas vapor intrusion attenuation factor based on the 95th percentile of the distribution of attenuation factors in residences.
  - Vapor concentration at a soil source is a function of the PFAS vapor pressure, release volume and presence of other PFAS compounds
- Possible for a groundwater source if:
  - Groundwater PFAS plume migrates beneath buildings
  - Vapor concentration of chemical off-gassing from a groundwater source is greater than 1000X indoor air screening level
    - Note: 1000X is EPA's default groundwater vapor intrusion attenuation factor based on the 95th percentile of the distribution of attenuation factors in residences.
  - Vapor concentration at the water table is a function of the chemical's Henry Law Constant and groundwater concentration

PFAS Chemical Properties

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APPROACH

- Compiled published chemical property values for PFAS compounds
  - Vapor pressure
  - Water solubility
  - Henry's Law Constant - limited availability
- Calculated theoretical maximum vapor concentrations
  - Vapor Concentration = (Molecular Weight) × Vapor Pressure / (Ideal Gas Constant × Temperature)
- Calculated theoretical Henry's Law Constants
  - Henry's Law Constant = Maximum Vapor Concentration / Water Solubility

PFAS Properties

- Sources
  - Wang et al., 2011. Using COSMOtherm to predict physicochemical properties of poly- and perfluorinated alkyl substances (PFAS)
  - ATSDR, 2018. Draft Toxicological Profile for Perfluoroalkyls
- Notes
  - Black font indicates reported value
  - Underlined black font indicates value used in calculating vapor concentration
  - Italicized grey font indicates values derived by Wang et al., 2011, using COSMOtherm
  - Blue font indicates values calculated from reported or modeled values

Class	Method 533	Method 537.1	Acronym	MW	Water Solubility 20-25°C (µg/l)	Vapor Pressure 20-25°C [Pa]	Calculated Vapor Conc. (µg/m³)	Calculated Henry's Law Constant (-)	Reported Henry's Law Constant (-)
PFCA	●		PFBA	214	2.1E+08	3890	3.4E+08	1.6E-03	2.4E-03
	●		PFPeA	264	*1.1E+08*	*1349*	1.5E+08	1.3E-03	
	●	●	PFHxA	314	2.2E+07	457	5.9E+07	2.7E-03	
	●	●	PFHpA	364	4.2E+06	158, 613	2.4E+07	5.6E-03	1.1E-03
	●	●	PFOA	414	*7.7E+05*	2.3, 4.2	3.9E+05	5.0E-04	7.0E-04
	●	●	PFNA	464	*1.3E+05*	0.65, 1.3	1.2E+05	9.4E-04	
	●	●	PFDA	514	*2.5E+04*	0.1, 0.23	2.1E+04	8.5E-04	
	●	●	PFUnA	564	*4.2E+03*	0.05, 0.1	1.1E+04	2.5E-03	
	●	●	PFDoA	614	*7.1E+02*	*0.0051*	1.3E+03	1.8E-03	
		●	PFTrdA	664	*1.7E+02*	*0.27*	7.3E+04	4.3E-01	
		●	PFTeDA	714	*2.7E+01*	*0.10*	3.0E+04	1.1E+00	
PFSA	●	●	PFBS	300	*3.0E+07*	*631*	7.8E+07	2.6E-03	
			PFHxS	400	*2.3E+06*	*59*	9.7E+06	4.2E-03	
	●	●	PFOS	500	*6.0E+04*	0.0003, 6.8	1.4E+06	2.3E-02	
			PFDS	600	*2.4E+03*	*0.71*	1.7E+05	7.1E-02	
PFPA			PFBPA	350	*1.4E+10*	*0.18*	2.6E+04	1.8E-09	
			PFHxPA	400	*5.2E+08*	*0.040*	6.5E+03	1.3E-08	
			PFOPA	500	*2.4E+07*	*0.0051*	1.1E+03	4.3E-08	
			PFDPA	600	*4.9E+05*	*0.00022*	5.5E+01	1.1E-07	
FOSE			N-MeFOSA	513	*2.3E+02*	*0.30*	6.2E+04	2.7E-01	
		●	N-EtFOSA	527	*5.6E+01*	*0.12*	2.5E+04	4.5E-01	
			N-MeFOSE	557	*3.4E+02*	*0.0066*	1.5E+03	4.5E-03	
			N-EtFOSE	571	*1.1E+02*	*0.0039*	9.1E+02	8.6E-03	
FTS	●		H4-PFHxS (4:2 FTS)	328	*2.8E+07*	*0.33*	4.5E+04	1.6E-06	
	●		H4-PFOS (6:2 FTS)	428	*1.3E+06*	*0.11*	1.9E+04	1.5E-05	
	●		H4-PFDeS (8:2 FTS)	528	*5.8E+04*	*0.008*	1.8E+03	3.1E-05	
			H4-PFUdS (10:2 FTS)	628	*2.1E+03*	*0.001*	2.9E+02	1.4E-04	
			H4-PFTeS (12:2 FTS)	728	*1.6E+02*	*0.001*	2.1E+02	1.3E-03	
FTOH			4:2 FTOH	264	9.8E+05	214	2.3E+07	2.4E-02	
			6:2 FTOH	364	1.9E+04	18	2.7E+06	1.5E-01	
			8:2 FTOH	464	1.4E+02	4.0	7.6E+05	5.5E+00	
			10:2 FTOH	564	1.1E+01	0.200	4.6E+04	4.2E+00	

PFAS VI Potential?

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APPROACH

- Use provisional ambient air screening levels based on oral route to inhalation route extrapolation of USEPA and ATSDR toxicity criteria (Kline, previous slides)
- Compare calculated PFAS vapor concentrations to potential soil gas vapor intrusion screening levels (VISLs)
  - Potential ambient air screening level divided by vapor intrusion soil gas-to-indoor air attenuation factor
- Compare PFAS groundwater concentrations to potential groundwater vapor intrusion screening levels (VISLs)
  - Potential ambient air screening level divided by groundwater-to-indoor air attenuation factor for vapor intrusion

PFAS Provisional Ambient Air Screening Levels?

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Toxicity Basis (Oral Route to Inhalation Route Extrapolation)	Potential Ambient Air Screening Level (µg/m³)	Potential Soil Vapor Screening Level for Soil Source (Air SL x 33) (µg/m³)	Potential Soil Vapor Screening Level for Groundwater * (Air SL x 1000) (µg/m³)
10 x USEPA Level	0.7	20	700
USEPA PFOA/PFOS RfD_o 2E-05 mg/kg/day (Lifetime)	0.07	2	70
ATSDR PFOS Oral MRL 2E-06 mg/kg/day (364 days)	0.007	0.2	7
0.1 x ATSDR Level	0.0007	0.02	0.7

* Divide by Henry's Law Constant to derive groundwater screening level

PFAS VI Potential from Soil Sources

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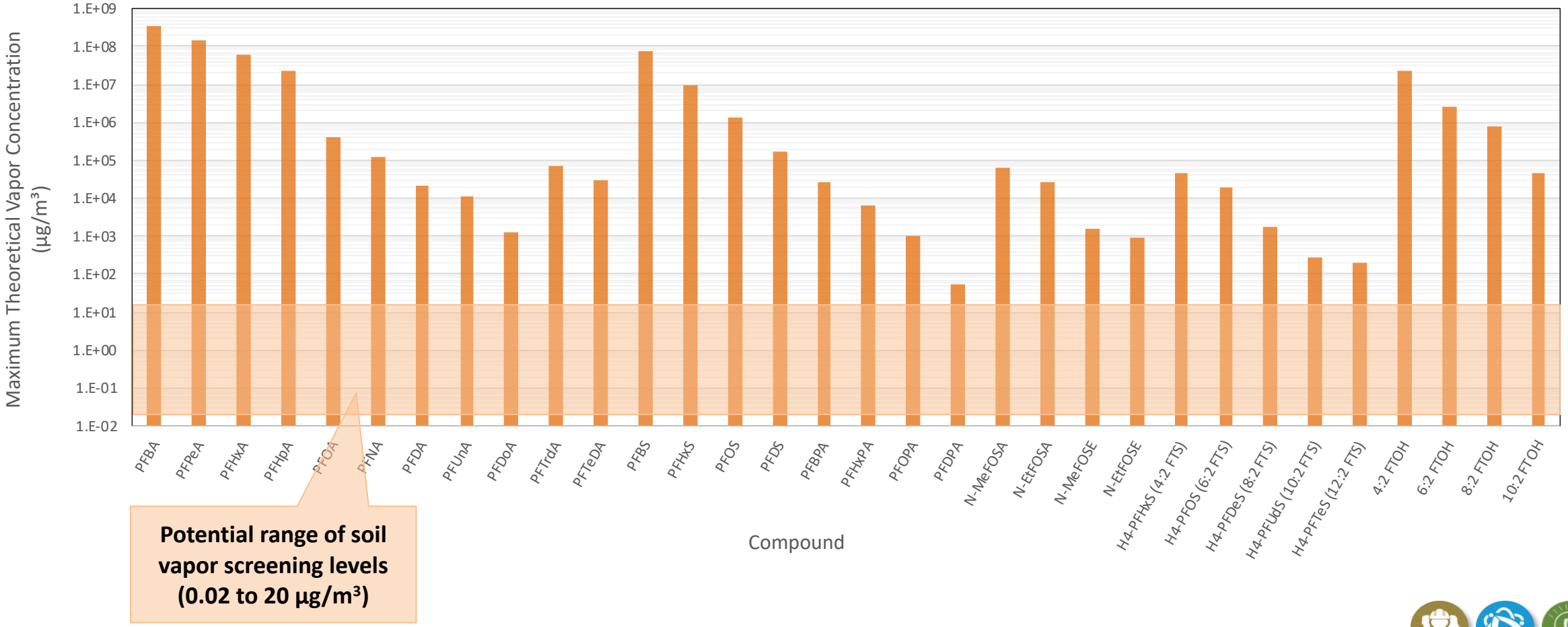
Maximum vapor concentrations for PFAS compounds exceed potential soil vapor screening levels, in some cases by several orders of magnitude



PFAS VI Potential from Groundwater Sources

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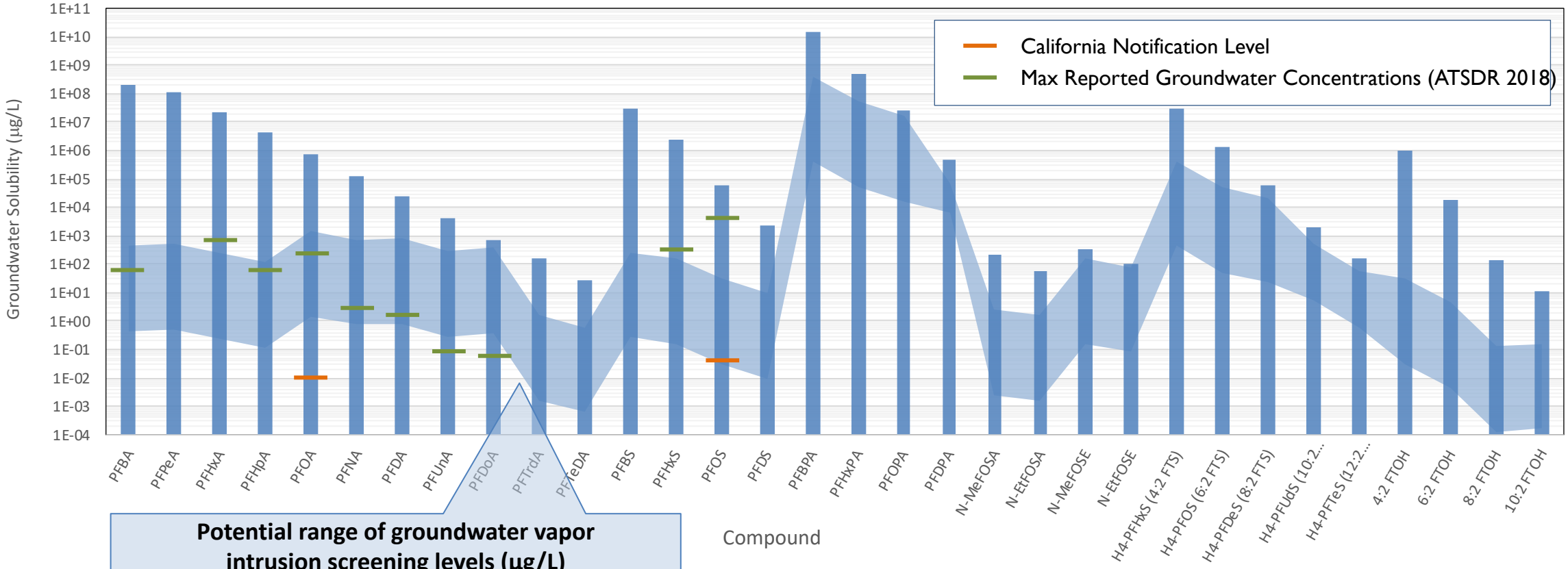
Maximum vapor concentrations for PFAS compounds exceed potential soil vapor screening levels, in some cases by several orders of magnitude



Potential range of groundwater vapor intrusion screening levels (µg/L)
(Variation is due to varying Henry's Law Constants for individual compounds)

Summary and Conclusions

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If indoor air screening levels are derived from provisional toxicity data

- Lighter molecular weight (<500 g/mol) PFAS compounds may present potential for vapor intrusion impacts
- EPA Methods EPA 533 and 537.1 (for water) currently analyze for some but not all of the PFAS compounds identified as having higher potential for vapor intrusion impacts
- Approach presented provides a means of ranking PFAS compounds to develop analytical methods and investigate for vapor intrusion potential

Contact Information

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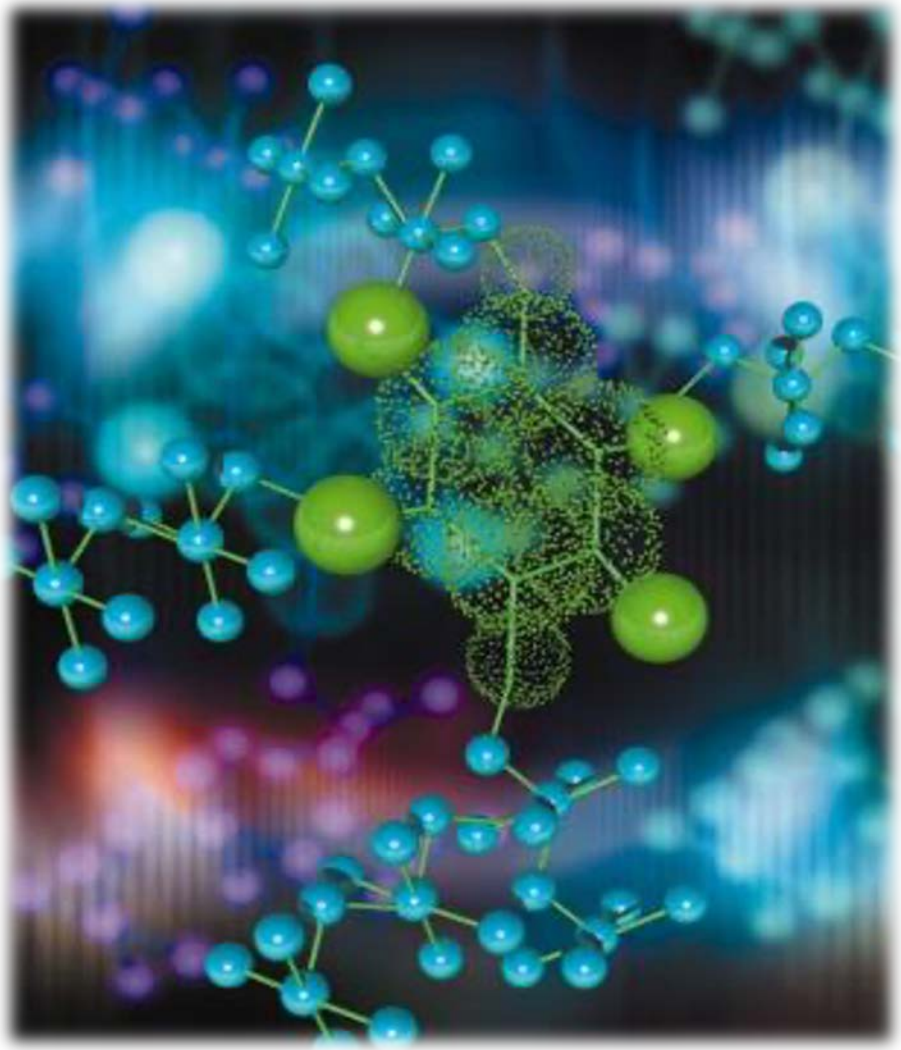

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