Background PFAS Concentrations in Soil – An Overview with a Focus on the Northeast

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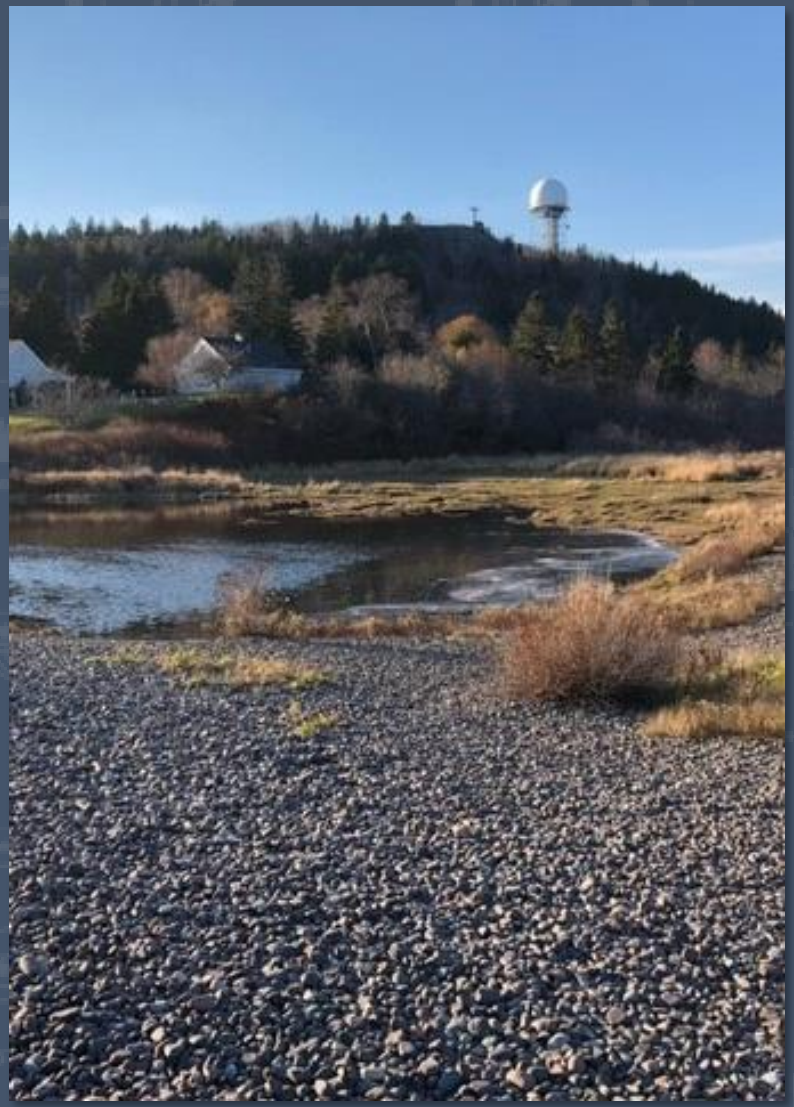

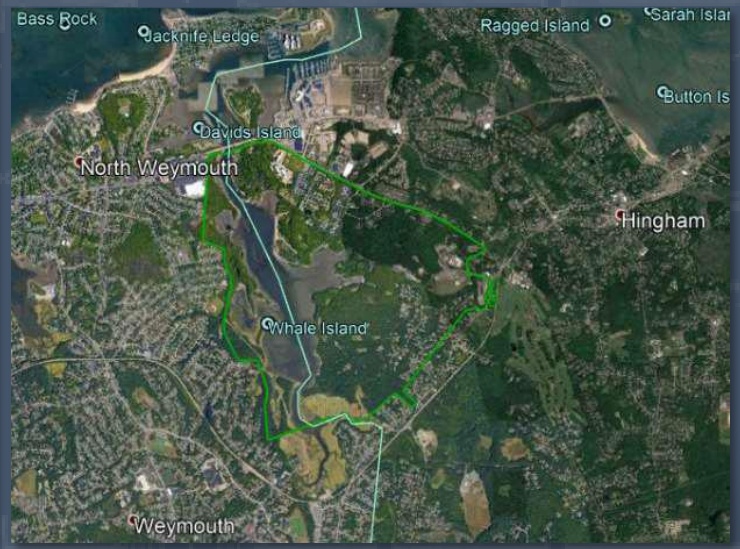

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NE REGION PFAS SOIL BACKGROUND DATA

This presentation will provide an overview of available PFAS soil background data for the Northeast region of the United States.

Objectives:

- To summarize available PFAS soil background data from NE Region states.
- To evaluate the extent to which states have incorporated available soil background data sets into regulatory programs.
- To discuss the limitations of these data.

My goals:

- Risk assessor for the US Army Corps of Engineers New England as part of project teams doing site investigation and remediation.
- Important to have background data to ensure we are focusing on the DoD sources of the most concern.
- Not speaking on behalf of the states, just compiled available data.

NE REGION BACKGROUND DATA

Soil:

- All NE Region states have some soil background data.
- Some states have incorporated into regulatory programs.

Sediment:

- Limited background data available.
- NE Region states do not have specific regulatory guidance regarding sediment background.

Some states also have data available for background in:

- **Surface water**
- **Groundwater**
- **Drinking water**
- **Fish/shellfish tissue**

MAINE SOIL BACKGROUND STUDY

Maine shallow soils study conducted by Sanborn, Head & Associates, April 2022, and posted by the Maine DEP, July 2022:

- **Sample Locations**:
  - 31 urban and 32 non-urban locations in 16 counties in Maine.
  - Away from suspected sources.
- **Soil Depth:** Shallow soil, 0-6”
- **PFAS Compounds Analyzed:** 28
- **Analytical Method:** Method 537.1

ME SOIL BACKGROUND STUDY RESULTS (CONTINUED)

Summary of Results:

- Recommended BTV and UCLM values for 9 PFAS, after screening for outliers.
- Measured 19 other PFAS but did not recommend background values (detected in <10% of samples or in fewer than 4 samples).
- PFOS most frequently detected (in 81% of samples) followed by PFCAs.
- Urban and non-urban data were different for PFOS and PFDA; therefore, background calculated separately for the urban and non-urban datasets.

Study Limitations:

- One sample from each location.
- Reliance on urban/rural designations based on information developed by others.
- Results not normalized for physical parameters (i.e., percent organic matter, total organic carbon, grain size, total solids, pH) that may impact PFAS concentrations.
- Did not consider location-specific environmental conditions (weather, topography, hydrogeologic settings that can impact atmospheric deposition) and habitat (different land cover and surrounding development, topography and vegetation) that could impact PFAS concentrations.

ME BACKGROUND VS. STATE REGULATORY LEVELS

Maine DEP, 2023 Regulations:

- Remediation to established background concentrations only if background is higher than the applicable Remedial Action Guideline (RAG).
- Incorporated BTVs for 5 PFAS from this study into regulations; can be used in the absence of better, representative site-specific background data:
  - BTVs – to be used when comparing individual, discrete samples.
  - UCLs – to be used when comparing to samples that represent a mean or average conc in soil in a specific area (such as incremental samples).

- **Given that the BTVs are orders of magnitude lower than the RAGs protective of human health, in general:**
  - Comparison to background will not help eliminate PFAS as COPCs.
  - Cleanup standards will not likely be set to background concentrations.

PFAS	Soil BTV (ng/g)	Soil UCLM (ng/g)	Maine Soil RAGs (ng/g)					
			Protection of Groundwater	Residential	Commercial Worker	Park User	Recreator Sediment	Construction Worker
PFBA	0.43	0.14	360	110,000	1,600,000	300,000	350,000	2,000,000
PFHxA	1.5	0.22	130	43,000	560,000	120,000	140,000	130,000
PFOA	2.2	0.39	17	260	3,400	740	850	770
PFNA	1.9	0.15	4.6	260	3,400	740	850	770
PFOS - urban	3.0	1.2	1	170	2,200	490	570	510
PFOS - non-urban	0.55	0.28						

NEW HAMPSHIRE SOIL BACKGROUND STUDY

USGS New England Water Science Center in cooperation with NHDES:

- **Sample Locations**:
  - Lands classified as forested, shrubland, herbaceous, barren, or wetlands, with a 500-meter buffer around parcels with known or potential PFAS contamination or releases.
  - State gridded into 100 equal-area grid cells; sites were randomly generated within the grid cells; one sample taken from each grid cell.
- **Soil Depth:** All locations, shallow soil, 0-6”; 50 locations, 6-12”; 6 locations, profiles in 6” increments to 36”.
- **PFAS Compounds Analyzed:** 36
- **Analytical Methods:** Liquid chromatography tandem mass spectrometry (LC-MS/MS) and isotope dilution quantitation.

NH SOIL BACKGROUND STUDY RESULTS (CONTINUED)

Summary of Results - All Soil Depths:

- 28 PFAS compounds detected.
- 15 PFAS detected in greater than 20% of samples.
- PFAS concentrations typically decrease with depth below land surface.

Study Limitations:

- NHDES analysis did not exclude outliers.
- NHDES notes that samples were included that may be located within the area of air deposition from local PFOA air emission sources which may skew the PFOA BTV high.

NHDES: Proposed Background Threshold Screening Values

Data Subset		BTV PFOS (ng/g)	BTV PFOA (ng/g)	BTV PFHxS (ng/g)	BTV PFNA (ng/g)
Full State 0-6" (100 samples)	**-**	**3**	**3**	**0.1**	**1**
Full State 6-12" (50 samples)	**-**	**2**	**3**	**-**	**1**
Region split	**Southern 6**	**4**	**4**	**-**	**-**
	Northern 4	**3**	**2**	**-**	**-**

Table Note: BTVs shown represent 95% UTLs with 95% coverage calculated by NHDES using ProUCL 5.1/5.2.

NH BACKGROUND VS. STATE REGULATORY LEVELS

	Proposed SRS (ng/g)	Direct Contact (ng/g)			Leaching (ng/g)	EQL (ng/g)	Full State 0-6' Proposed BTV (ng/g)
	S-1/S-2/S-3	S-1	S-2	S-3	S-1/S-2/S-3	S-1/S-2/S-3	S-1/S-2/S-3
PFOA	0.2	200	1400	1400	0.1	0.2	3
PFNA	0.4	100	1000	1000	0.4	0.2	1
PFHxS	0.2	100	900	900	0.2	0.2	0.1
PFOS	0.5	100	700	700	0.5	0.2	3

Table Notes: SRS=soil remediation standards; EQL=estimated quantitation limit; BTV=background threshold value

- **For these 4 compounds, the NHDES proposed BTVs are orders of magnitude lower than the SRS values for Direct Contact (protective of human health), thus:**
  - Comparison to background will not help eliminate PFAS based on human health.
- **However, applying the NHDES Proposed SRS values, which are primarily based on leaching to groundwater:**
  - 3 of the 4 proposed SRS values are less than background, so applying these background values may help differentiate site from background in site investigations.

VERMONT SOIL BACKGROUND STUDIES

Zhu et al. **2019** and **2022;** and **Schroeder** et al. **2021:**

- **Zhu** et al. **2019** and **2022:**
  - Study conducted by University of Vermont and Sanborn Head with partial funding and support provided by VTDEC.
  - Soil samples collected June - August 2018 to determine the background concentrations of PFAS in VT shallow soils.
- **Schroeder** et al. **2021:**
  - PFAS soil and groundwater contamination via industrial airborne emissions and land deposition in Bennington VT area in conjunction with Hoosick Falls, NY air emissions.
  - Samples collected to characterize soils impacted by Norlite (lightweight aggregate plant that incinerated received PFAS materials).

VT SOIL BACKGROUND STUDY – ZHU ET AL. 2019 AND 2022

- **Sample Locations:**
  - Same 66 locations as a previous VTDEC background study for PAHs, arsenic, and lead.
  - Properties selected by overlaying a 100-square mile grid across the state, identifying the largest municipality in each grid, and sampling therein at state or municipal parks, forests, greens, or building or school lawns.
- **Number and Soil Depth:** 68 surface soil samples, 0-6“
- **PFAS Compounds Analyzed:** 17 perfluoroalkyl acids (PFAA)
- **Analytical Method:** Liquid chromatography-tandem mass spectrometry (LC-MS/MS) with internal standardization quantitation

VT SOIL BACKGROUND STUDY – ZHU ET AL. 2019 AND 2022 (CONTINUED)

Summary of Results:

- Total PFAA concentrations ranged from 0.54 to 36 ng/g dry soil weight.
- PFOS most common, followed by PFNA and PFOA, with seven other PFAA identified at more than 50% of the locations.
- Higher total PFAA levels in northern Vermont.
- BTVs were not calculated for PFAS with quantitative detection frequencies less than 10%.

Study Limitations:

- One sample collected at each location (two locations had duplicates).
- One location determined to be an outlier and removed from the data set.

VT SOIL BACKGROUND VS. STATE REGULATORY LEVELS

VT DEC Current Regulations:

- VT Rule: "Investigation and Remediation of Contaminated Properties Rule July 6, 2019“, Appendix B.
- Current preferred approach is to use site-specific data.
- These soil background studies may be used to attempt to discern background from a new release, as allowed by the Rule, but are not formally incorporated into the Rule.

- **Given that the BTVs are orders of magnitude lower than the RAGs protective of human health, in general:**
  - Comparison to background will not help eliminate PFAS as COPCs.
  - Cleanup standards will not likely be set to background concentrations.

		VT DEC Soil Standards (TR=1E-06, HQ=1.0)	
Analyte	**Zhu et al. 2019 Proposed UTL** (ng/g)	**Residential Soil** (ng/g)	**Non-Residential Soil** (ng/g)
PFHpA	0.84	1,220	14,360
PFHxS	0.38		
PFNA	0.44		
PFOS	3.4		
PFOA	1.6		
Sum of 5 regulated PFAS in background=	6.7		

Table Notes: Used Zhu 2019 study data presented without outliers (Tables 5.2 and 6.2); and the results of the ProUCL 5.1 analysis (Table 7).
VT Regulations for PFAS are for the sum of 5 - PFHpA, PFHxS, PFNA, PFOS and PFOA.

MASSACHUSETTS SOIL BACKGROUND STUDY

Woodard & Curran conducted a PFAS soil background study in 2022:

- **Sample Locations:** Undisturbed soils in MA; 25 open spaces in West, Central, Northeast and Southeast Massachusetts
    - Locations selected with --
        - no suspected historical sources onsite
        - no known sources nearby
        - good geographic coverage across the State
        - public accessibility
        - owners allowed access/approval to sample
- **Number and Soil Depth:** 100 samples, 0-6”
- **PFAS Compounds Analyzed:** 36
- **Analytical Method:** Isotope dilution LCMS/MS

MA SOIL BACKGROUND STUDY RESULTS (CONTINUED)

Summary of Results:

- Of the 36 PFAS analytes, nine were detected in one or more samples.
- One or more PFAS analytes were detected in 88% of samples.
- PFAS6 concentrations were > the lowest Mass DEP risk-based standard S-1/GW-1 in 58% of samples.
- Reporting limits for non-detect results exceeded S-1/GW-1 standards in numerous samples for all PFAS6 compounds except for PFOS.

Study Limitations:

- Focused only on surface soil.
- Soil characteristics may influence the nature and concentration of PFAS; study collected the following but was unable to determine any association between these factors and PFAS concentrations:
  - Qualitative information on soil type and location, and
  - Quantitative data for soil organic carbon content.

MA BACKGROUND VS. STATE REGULATORY LEVELS

MassDEP derives MCP soil standards considering:

1. Direct contact exposure routes;
2. Leaching potential to underlying groundwater; and
3. Feasibility of achievement, which includes achievable reporting limits as well as background concentrations, when available.

MCP 40.091(3): The characterization of risk of harm to health, safety, public welfare, and the environment is not required for a disposal site, environmental medium, or chemical for which response actions have successfully reduced concentrations to background levels, as described in 310 CMR 40.1020.

- **Since the UTLs are orders of magnitude lower than the human risk-based criteria:**
  - Comparison to background will not help eliminate PFAS as chemicals of potential concern for human health risks.
- **However, applying the S-1/GW-1 criteria, based on leaching to groundwater:**
  - Applying PFAS background values may help differentiate background in site investigations.

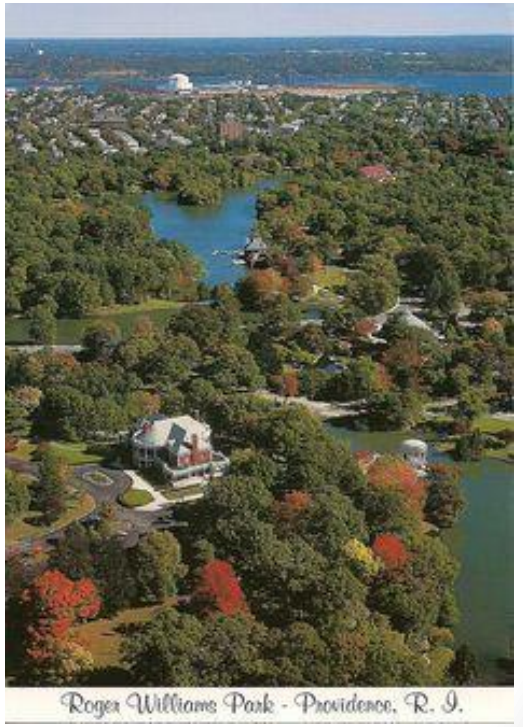
Analyte	95% Upper Tolerance Limit (W&C MA Background Study) (ng/g)	MCP Criteria			
		Direct Contact Exposure S-1 (ng/g)	Direct Contact Exposure S-2 (ng/g)	S-1/GW-1 (ng/g)	S-2/GW-2 (ng/g)
PFOS	3.1	300	400	2	300
PFOA	2.0	300	400	0.72	300
PFNA	0.72	300	400	0.32	300
PFDA	0.46	300	400	0.3	300
PFHpA	0.63	300	400	0.5	300

Table Notes: MA also regulates PFHxS; but in this MA Background study, PFHxS was not detected in any sample.

RHODE ISLAND SOIL BACKGROUND STUDY

RIDEM Statewide PFAS Investigation Report, November 2023

- **Sample Locations**:
  - 50 locations chosen from within 5 RI counties using available historic aerial imagery to target locations that showed no disturbance since the 1940s.
  - Locations on state lands that overlay GA/GAA aquifers.
  - Selected a representative number of samples from each county based on land area.
- **Soil Depth:** 0-2 feet
- **PFAS Compounds Analyzed:** 24
- **Analytical Method:** Isotope dilution via LC/MS/MS for non-drinking water matrices



RI SOIL BACKGROUND STUDY RESULTS

Summary of Results:

- Recommended Interim BTVs and UTLs for PFAS6 only.
  - BTVs not presented for: PFBA, PFPeA, PFHxA, and PFUnA (detected in 100%, 88%, 78% and 18% of samples, respectively).
  - No other individual PFAS were detected in more than one sample.
- One outlier removed (contained several PFCAs maximum detections).

Study Limitations:

- No identification of potential source areas
  - Rather, used aerial imagery to identify landscape changes since the 1940s.

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RI BACKGROUND VS. STATE REGULATORY LEVELS

- **RI passed legislation June 2022 to add PFAS6 to the definition of a hazardous substance:** *Industrial Property Remediation and Reuse Act (RIGL 23-19.14-3)*.
  - Allowed for the adoption of standards of PFAS in environmental media, including soil: *Rules and Regulations for the Investigation and Remediation of Hazardous Material Releases (250-RICR140-30-1)*.
- **Forthcoming Rules:**
  - In 2024, State will promulgate soil standards for PFAS6.
  - Criteria will include *Residential Direct Exposure Criteria, Industrial/Commercial Direct Exposure Criteria, and GA Leachability Criteria* for each of the individual PFAS6.
- **Draft RIDEM Statewide PFAS Investigation Report, November 2023 states that:**
  - In instances where the derived leachability criteria for an individual PFAS is below the BTV determined by RIDEM, the leachability criteria will default to the BTV, and
  - This is not anticipated to be true for Direct Exposure Criteria, which are orders of magnitude higher than the associated GA Leachability Criteria.

CONNECTICUT SOIL BACKGROUND STUDY

CT Department of Energy and Environmental Protection (CTDEEP) supported a UConn student study in 2022:

- Students collected and analyzed soil data from 16 state forests.
- Students' *Final Design Report* – not peer-reviewed outside of UConn
- Data available upon request from CTDEEP.

CT SOIL BACKGROUND STUDY RESULTS

- **Sample Locations**:
  - 110 samples taken at 16 locations in Connecticut parks and forests.
  - Sites were evaluated for possible PFAS contamination by identifying layers in GIS that indicated potential sources such as fire stations, airports, and sewage treatment plants.
  - Considerations for sampling locations included: easily accessible from roads or trails, in a sunny area, and land access approval.
- **Soil Depth:** 0-6” and 18-24”
- **PFAS Compounds Analyzed:** 18
- **Analytical Method:** EPA Method 8327

CT SOIL BACKGROUND STUDY RESULTS (CONTINUED)

Summary of Results:

- Samples collected at 0-6” showed higher concentrations than deeper samples, in general, by an order of magnitude of about 2.
- Samples collected within each property had inconsistent results.
- Range of Concentrations:
  - 0-6”: 0-11,730 ppt
  - 18-24”: 0-967 ppt

Study Limitations:

- Not peer-reviewed.
- Time constraints; adjusted sampling plan; increased number of soil samples in each sampled area.
- Number of samples analyzed by the lab.
- Accessibility: sampling only done on CT DEEP owned property.

CT BACKGROUND VS. STATE REGULATORY LEVELS

CT PFAS Remediation Criteria: The Remediation Standard Regulations do not contain numeric cleanup standards for emerging contaminants including PFAS, but do require remediation using the procedures for Additional Polluting Substances (APS). APS Criteria for PFAS are available for use upon request using the APS Fast Track Form for the PFAS listed in the table below. APS criteria for PFAS are in the process of being updated to reflect changes to DPH's Drinking Water Action Levels for PFAS in June 2022 and June 2023.CT DEEP soil remediation criteria apply to the sum of 5: PFOA, PFOS, PFNA, PFHxS & PFHpA (https://portal.ct.gov/DEEP/Remediation--Site-Clean-Up/Contaminants-of-Emerging-Concern/PFAS-Information-for-Environmental-Professionals#criteria)

- Regulations state: Soil must be remediated so that the concentration of a substance in soil is equal to or less than:

  (1) The direct exposure criteria (residential or industrial/ commercial, as applicable) and the pollutant mobility criteria; or

  (2) The background concentration for soil.

		Upon request, not promulgated CT PFAS Remediation Criteria (ng/g)			
Analyte - Shallow Soil	Preliminary 95% UTL with 95% coverage - CT Background Study (ng/g)	Residential Direct Exposure	Industrial/ Commercial Direct Exposure	GA Pollutant Mobility	GB Pollutant Mobility
Sum of PFOA, PFOS, PFNA, PFHxS, PFHpA	3.8	1,350	41,000	1.4	14

Table notes: Presenter compiled data and conducted BTV calculations in ProUCL 5.2. These are preliminary calculations using certain assumptions and should not be used in any site investigations.

Potential site investigation impacts:

- Comparison to background may not help eliminate PFAS as COPCs, except for GA Pollutant Mobility.

NEW YORK SOIL BACKGROUND STUDIES

NYSDEC 2021 and **SCHROEDER** et al. **2019**

- **NYSDEC, 2021:**
  - Sampling of soil possibly impacted by Norlite Corporation (lightweight aggregate plant incinerated PFAS materials received from DoD collection programs).
  - Results showed that soil unlikely impacted by kiln emissions (upwind of kilns was considered background in the study).
- **Schroeder** et al.**, 2019:**
  - Academic study to evaluate the extent to which airborne PFAS emissions can impact soil and groundwater.
  - Collected samples upgradient and downgradient of known industrial PFAS emission sources, including far field samples from NYSDEC forest preserve or stand forest land not impacted by air emissions to represent background conditions.

Future NYSDEC background PFAS study:

- NYSDEC is conducting a background PFAS study (rural) expected to be finished later this year (2024) *(as per Jan 2024 correspondence)*.
- Once completed, Soil Cleanup Objectives in Part 375-6 will be updated.

NYSDEC UPWIND/SCHROEDER vs. NYSDEC GUIDANCE VALUES

PFOA and PFOS guidance values are listed in NYSDEC April 2023 Document: *Sampling, Analysis, and Assessment of Per- and Polyfluoroalkyl Substances (PFAS) Under NYSDEC's Part 375 Remedial Programs.*

- To be used in determining whether PFOA and PFOS are contaminants of concern for the site and for determining remedial action objectives and cleanup requirements.

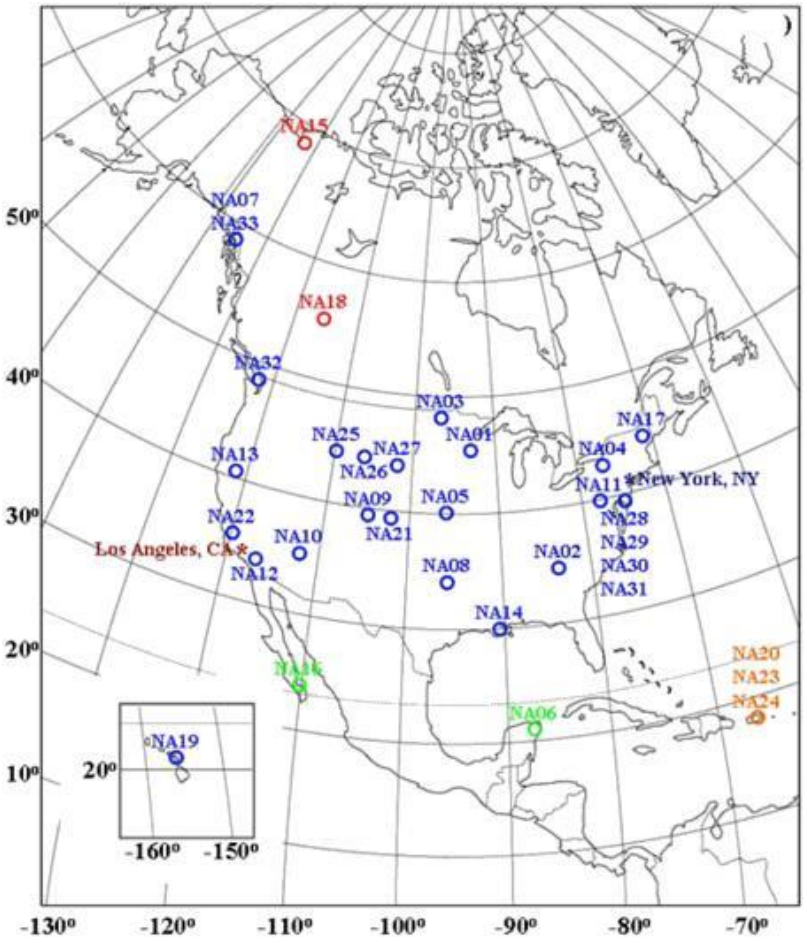
- Schroeder average background values are lower than NYSDEC guidance values protective of human health, except for unrestricted use.
- Therefore, using these data for comparison to background may not help eliminate PFAS as COPCs for anticipated site uses, other than unrestricted use.

	Mean Soil Background* (ng/g)	**NYSDEC Soil Guidance Values** (ng/g)					
		Protection of Groundwater	Unrestricted Use	Residential	Restricted Residential	Commercial	Industrial
PFOA	1.16	0.8	0.66	6.6	33	500	600
PFOS	0.55	1.0	0.88	8.8	44	440	440

*Table Notes: *Schroeder et al., 2019*

US SOIL BACKGROUND - OVERVIEW

- Predominant analytes often include PFOS, PFOA, PFNA, and PFDA:
  - PFOS concentrations typically > PFOA
- Rankin et al. (2016) collected and analyzed ~30 samples across the US from sites removed from known contamination sources.
  - Total PFCAs ranged from 0.145-6.080 ng/g (mean = 1.820).
  - Total PFSAs ranged from 0.035 - 1.990 ng/g (mean = 0.410).
  - Concentrations of individual analytes were typically <1 ng/g.



From: Rankin et al. (2016)
https://doi.org/10.1016/j.chemosphere.2016.06.109

CONCLUSIONS

Several Northeast area states have:

- Well-developed PFAS soil background data, and
- Incorporated PFAS soil background into their regulatory programs.

Several Northeast area states have:

- Plans in place to incorporate existing or new soil PFAS background data sets into regulations.

Other Northeast area states are:

- Still in the process of developing data and figuring out how to incorporate PFAS soil background into regulations.

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