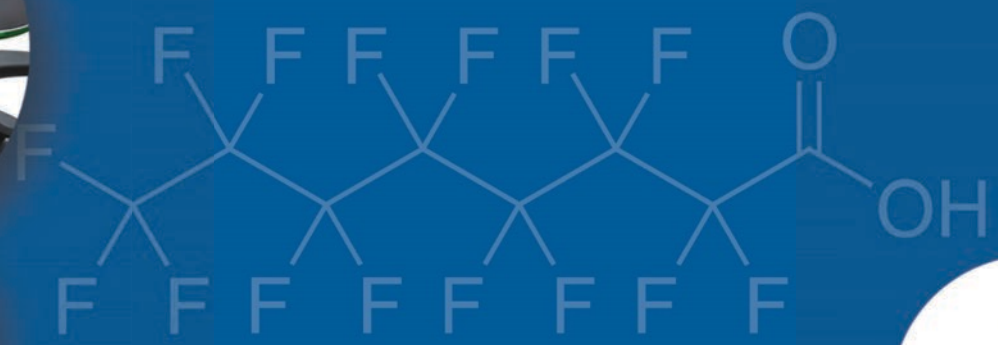
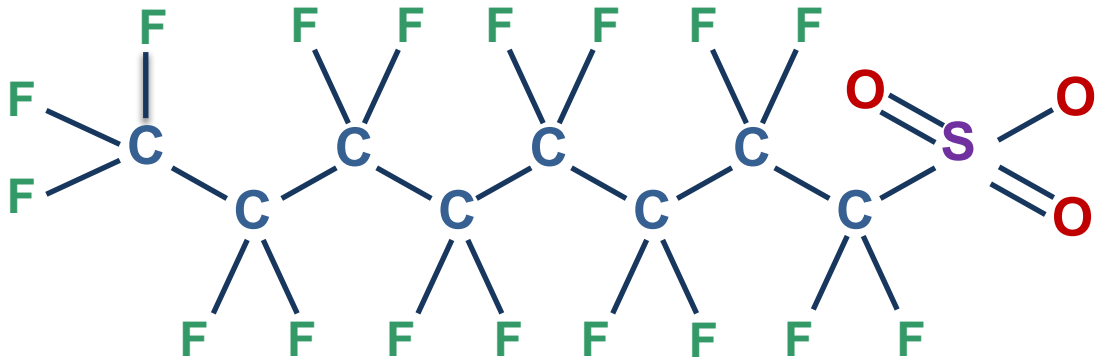


PFAS Analysis of Soils

What to Expect and How to Evaluate the Data

Today's Topics

- PFAS Analytical Methods
- Modifications/variations by laboratories for PFAS soil analyses
- Quality Controls used in PFAS analysis
- What to expect in and how to read a PFAS analytical report
- What the modifications/variations can mean to PFAS data usability



Acronyms

PFAS = Per- and Poly-fluoroalkyl substances

- PFCs – Perfluorinated compounds - Do not use this acronym
  - PFCs do not include polyfluorinated compounds

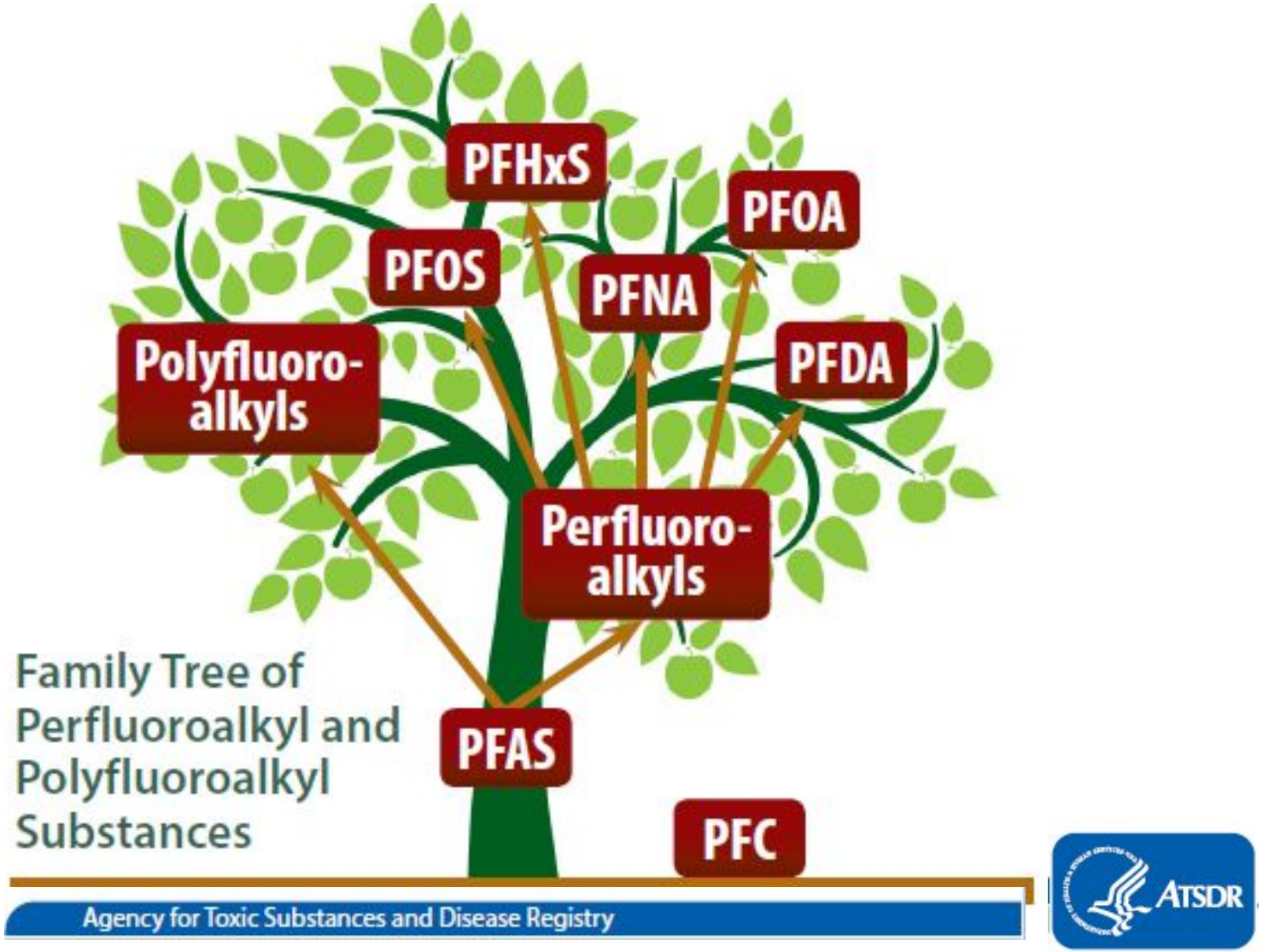
Perfluoroalkyl Substances

- **PFAA** = Perfluoroalkyl acids
  - **PFOA** = Perfluorooctanoic acid (perfluorooctanoate)
  - **PFOS** = Perfluorooctane sulfonic acid (perfluorooctane sulfonate)

Poly-fluoroalkyl substances

- **8:2 FTS** = 8:2 Fluorotelomer sulfonic acid
- **MeFOSAA** = N-methylperfluoro-1-octanesulfonamidoacetic acid

Tree of Perfluoroalkyl and Polyfluoroalkyl Substances



PFAS Drinking Water Method U.S. EPA 537

- Validated by U.S. EPA (accurate and consistent)
- Liquid Chromatography/Tandem Mass Spectrometry (LC/MS/MS)
- 14 PFAS reported (12 perfluoroalkyl acids and 2 polyfluoroalkyl acids)
- Quantitation by three (3) internal standards
- Extraction efficiency monitored by three (3) surrogates
- Quantitates linear isomers for 9 of the 14 reported PFAS
  - Quantitates linear and branched-chain isomers for PFOS, PFHxS, NetFOSAA, NMeFOSAA
  - U.S. EPA Technical Advisory September 2016 – added PFOA to the list of PFAS quantitated for linear and branched-chain isomers for PFOA

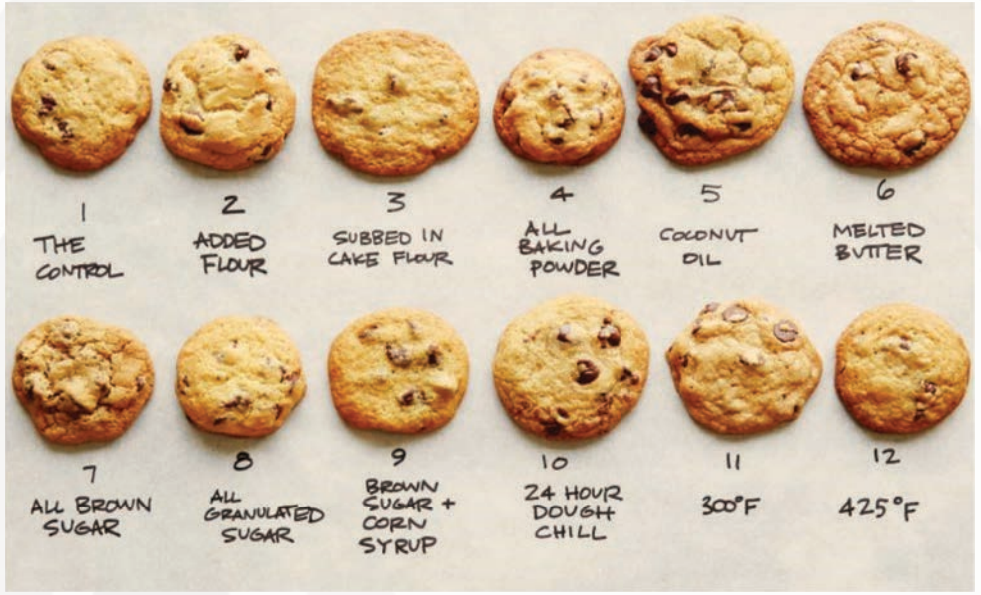
U.S. EPA PFAS Analytical Methods

- Currently no standard U.S. EPA PFAS methods for GW, SW, WW, soils, sediments, or sludge
- September 2018 U.S. EPA Technical Brief (EPA/600/F-17/022d)
  - Ongoing method development and validation of SW-846 methods for matrices other than DW
    - **Phase One**
      - ✓ U.S. EPA laboratories tested direct injection for GW, SW and WW for 24 PFAS
      - ✓ Drafted a solid-phase extraction/isotope dilution method (SPE-ID)
    - **Phase Two**
      - ❑ External laboratories will validate the direct injection method (Draft SW-846 Method 8327)
      - ❑ U.S. EPA laboratory testing of SPE-ID (Draft SW-846 Method 8328)

Laboratory PFAS Analytical Methods

No standard U.S. EPA methods for GW, SW, WW, soils, sediments, or sludge

- U.S. EPA Method 537 used as reference
- What's the same
  - Instrumentation (LC/MS/MS)
- What's different
  - Sample preparation
  - Quantitation
  - Reporting
    - Number of reported PFAS
    - RLs



Many laboratory standard operating procedures (SOPs) are proprietary

Solid Preparation/Extraction

There is no standard preparation/extraction for soil samples

Some laboratory preparation/extraction steps are proprietary

- Steps may include all or some of the following:
  - Homogenized
  - Use 1 to 5 grams of sample
  - Fortify with surrogates and spikes (LCS, MS, as applicable)
  - Extract with solvent mixture
  - Vortex or shake (number of hours)
  - Ultrasonic extraction (number of hours)
  - Centrifuge
  - Solvent filter
  - Solid Phase Extraction

Quantitation

Two Options for Quantitation

- Internal standards
- Isotope dilution

Quantitation – Option 1

Internal standards

- Limited number of internal standards (ex. 3 for 21 PFAS)
- Surrogates verify extraction efficiency
- Results not corrected for analytical bias
- **Not recommended for GW, SW, WW, soil, sediment, sludge**

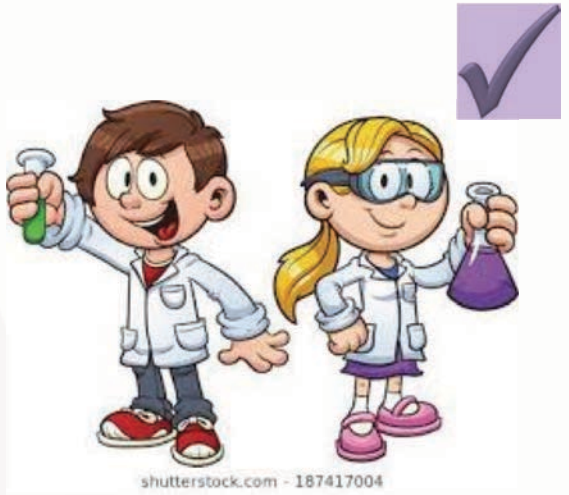
Quantitation – Option 2

Quantitation by isotope dilution (Preferred method)

- Extracted isotopically labeled isomers chemically specific to each PFAS
- Results are corrected for analytical bias

Difference between laboratories

- Extracted isotopically labeled isomers may vary
  For example: PFHpS with $^{13}C_8$-PFOS or $^{13}C_3$-PFHxS
- Additional precursor/product ions for qualitative purposes
- Internal Standard (monitor injection enhancement/suppression)



Reporting

Verify with laboratory prior to sampling the reporting needs of the project

- Number of PFAS reported (ex. 14, 17, 21)
- Is there a specific PFAS list required for the project based on the regulatory agency
- PFAS reported in acid or anion form
- CAS numbers vary depending on if reporting acid or anion form
- Reporting limits (range from 0.2 to 10 ng/g; also know as µg/kg)

Summary of PFAS from Various Laboratories

PFAAs via EPA 537(M)-Isotope Dilution (SOIL)	Lab 1		Lab 2		Lab 3		Lab 4		Lab 5	
	28 PFAS Isotope Dilution		9 PFAS Isotope Dilution		32 PFAS Isotope Dilution		21 PFAS Isotope Dilution		31 PFAS Isotope Dilution	
Sample Container/Preservation	1 - Plastic 8oz /<6°C		1 - glass 4oz/ <6°C		1- polyethylene/ <6°C		1- 8 oz HDPE/ <6°C		1- 8 oz HDPE/ <6°C	
HT	28 d to ext/28 d to analysis		14 days to extraction		28 d to ext/28 d to analysis		14 d to ext/40 d to analysis		60 d to ext/30 d to analysis	
Analyte	RL (ng/g)	MS/MSD LCS/LCSD Criteria	RL (ng/g)	MS/MSD LCS/LCSD Criteria	RL (ng/g)	MS/MSD LCS/LCSD Criteria	RL (ng/g)	MS/MSD LCS/LCSD Criteria	RL (ng/g)	MS/MSD LCS/LCSD Criteria
Perfluorobutanoic Acid (PFBA)	1	50-150%/30 RPD	2	70-130%/30 RPD	0.6	70-130%/30 RPD	0.2	Lab Statistical/30 RPD	2	70-130%/50 RPD
Perfluoropentanoic Acid (PFPeA)	1	50-150%/30 RPD	2	70-130%/30 RPD	0.6	70-130%/30 RPD	0.2	Lab Statistical/30 RPD	2	70-130%/50 RPD
Perfluorobutanesulfonic Acid (PFBS)	1	50-150%/30 RPD	2	70-130%/30 RPD	0.6	70-130%/30 RPD	0.2	Lab Statistical/30 RPD	2	70-130%/50 RPD
Perfluorohexanoic Acid (PFHxA)	1	50-150%/30 RPD	2	70-130%/30 RPD	0.6	70-130%/30 RPD	0.2	Lab Statistical/30 RPD	2	70-130%/50 RPD
Perfluoropentanesulfonic Acid (PFPeS)	1	50-150%/30 RPD	-	-	-		2	Lab Statistical/30 RPD	2	70-130%/50 RPD
Perfluoropentanesulfonate (PFPeS)	-	-	-	-	0.6	70-130%/30 RPD	-	-	-	-
Perfluoroheptanoic Acid (PFHpA)	1	50-150%/30 RPD	2	70-130%/30 RPD	0.6	70-130%/30 RPD	0.2	Lab Statistical/30 RPD	2	70-130%/50 RPD
Perfluorohexanesulfonic Acid (PFHxS)	1	50-150%/30 RPD	2	70-130%/30 RPD	0.6	70-130%/30 RPD	0.2	Lab Statistical/30 RPD	2	70-130%/50 RPD
Perfluorooctanoic Acid (PFOA)	1	50-150%/30 RPD	2	70-130%/30 RPD	0.6	70-130%/30 RPD	0.2	Lab Statistical/30 RPD	2	70-130%/50 RPD
Perfluoroheptanesulfonic Acid (PFHpS)	1	50-150%/30 RPD	-	-	-		0.2	Lab Statistical/30 RPD	2	70-130%/50 RPD
Perfluoroheptanesulfonate (PFHpS)	-	-	-	-	0.6	70-130%/30 RPD	-	-	-	-
Perfluorononanoic Acid (PFNA)	1	50-150%/30 RPD	2	70-130%/30 RPD	0.6	70-130%/30 RPD	0.2	Lab Statistical/30 RPD	2	70-130%/50 RPD
Perfluorooctanesulfonic Acid (PFOS)	1	50-150%/30 RPD	2	70-130%/30 RPD	0.9	70-130%/30 RPD	0.2	Lab Statistical/30 RPD	2	70-130%/50 RPD
Perfluorodecanoic Acid (PFDA)	1	50-150%/30 RPD	-	-	0.6	70-130%/30 RPD	0.2	Lab Statistical/30 RPD	2	70-130%/50 RPD
Perfluorononanesulfonic Acid (PFNS)	1	50-150%/30 RPD	-	-	-		-	-	2	70-130%/50 RPD
Perfluorononanesulfonate (PFNS)	-	-	-	-	0.6	70-130%/30 RPD	-	-	-	-
Perfluoroundecanoic Acid (PFUnA)	1	50-150%/30 RPD	-	-	0.6	70-130%/30 RPD	0.2	Lab Statistical/30 RPD	2	70-130%/50 RPD
Perfluorodecanesulfonic Acid (PFDS)	1	50-150%/30 RPD	-	-			0.2	Lab Statistical/30 RPD	2	70-130%/50 RPD
Perfluorodecanesulfonate (PFDS)	-	-	-	-	1	70-130%/30 RPD	-	-	-	-
Perfluorooctanesulfonamide (FOSA)	1	50-150%/30 RPD	-	-	0.6	70-130%/30 RPD	0.2	Lab Statistical/30 RPD	2	70-130%/50 RPD
Perfluorododecanoic Acid (PFDoA)	1	50-150%/30 RPD	-	-	0.6	70-130%/30 RPD	0.2	Lab Statistical/30 RPD	2	70-130%/50 RPD
Perfluorotridecanoic Acid (PFTrDA)	1	50-150%/30 RPD	-	-	0.6	70-130%/30 RPD	0.2	Lab Statistical/30 RPD	2	70-130%/50 RPD
Perfluorotetradecanoic Acid (PFTA)	1	50-150%/30 RPD	-	-	0.6	70-130%/30 RPD	0.2	Lab Statistical/30 RPD	2	70-130%/50 RPD
Decafluoro-3H-4,8-Dioxanonanoate (ADONA)	1	50-150%/30 RPD	-	-	-		-	-	-	-
Perfluorohexadecanoic Acid (PFHxDA)	1	50-150%/30 RPD	-	-	0.6	70-130%/30 RPD	-	-	2	70-130%/50 RPD
Perfluorooctadecanoic Acid (PFODA)	1	50-150%/30 RPD	-	-	0.6	70-130%/30 RPD	-	-	2	70-130%/50 RPD
Perfluorododecanesulfonate (PFDoS)	-	-	-	-	0.9	70-130%/30 RPD	-	-	-	-
Perfluoroalkane sulfonamido acetic acids/ethanols										
N-Methyl Perfluorooctanesulfonamidoacetic Acid (NMeFOSAA)	1	50-150%/30 RPD	-	-	2	70-130%/30 RPD	2	Lab Statistical/30 RPD	-	-
N-ethyl perfluorooctanesulfonamidoacetic Acid (NEtFOSAA)	1	50-150%/30 RPD	-	-	2	70-130%/30 RPD	2	Lab Statistical/30 RPD	-	-
N-ethylperfluorooctane-1-sulfonamide (NEtPFOSA)	-	-	-	-	2	70-130%/30 RPD	-	-	10	70-130%/50 RPD
N-ethylperfluoro-1-octanesulfonamido ethanol (NEtPFOSAE)	-	-	-	-	2	70-130%/30 RPD	-	-	10	70-130%/50 RPD
N-methylperfluoro-1-octanesulfonamide (NMePFOSA)	-	-	-	-	2	70-130%/30 RPD	-	-	10	70-130%/50 RPD
N-methylperfluoro-1-octanesulfonamido ethanol (NMePFOSAE)	-	-	-	-	2	70-130%/30 RPD	-	-	10	70-130%/50 RPD
N-ethyl perfluorooctanesulfonamidoacetic acid (N-EtFOSAA)	-	-	-	-	-	-	-	-	2	70-130%/50 RPD
N-methyl perfluorooctanesulfonamidoacetic acid (N-MeFOSAA)	-	-	-	-	-	-	-	-	2	70-130%/50 RPD
Hexafluoropropylene oxide dimer acid (HFPO-DA)	10	50-150%/30 RPD	-	-	-	-	-	-	2	70-130%/50 RPD
Fluorotelomers										
4:2 Fluorotelomersulfonate	-	-	-	-	3	70-130%/30 RPD	-	-	-	-
1H,1H,2H,2H-Perfluorohexanesulfonic Acid (4:2FTS)	1	50-150%/30 RPD	-	-	-		-	-	2	70-130%/50 RPD
6:2 fluorotelomersulfonate	-	-	-	-	2	70-130%/30 RPD	-	-	-	-
1H,1H,2H,2H-Perfluorooctanesulfonic Acid (6:2FTS)	1	50-150%/30 RPD	-	-	-		2	Lab Statistical/30 RPD	2	70-130%/50 RPD
8:2 fluorotelomersulfonate	-	-	-	-	2	70-130%/30 RPD	-	-	-	-
1H,1H,2H,2H-Perfluorodecanesulfonic Acid (8:2FTS)	1	50-150%/30 RPD	-	-	-		2	Lab Statistical/30 RPD	2	70-130%/50 RPD
10:2-fluorotelomersulfonate	-	-	-	-	3	70-130%/30 RPD	-	-	-	-
		Criteria		Criteria		Criteria		Criteria		Criteria
Extracted Isotopically Labeled Surrogates	21	50-150%	9	50-150%	23	50-150%	18	25-150%	24	50-150%
Internal Standards	NA	NA	NA	NA	4	50-150%	1	50-150%	5	50-150%

Note: RL information is calculated using a 100% Solids factor.

Types of QC used for PFAS Analysis

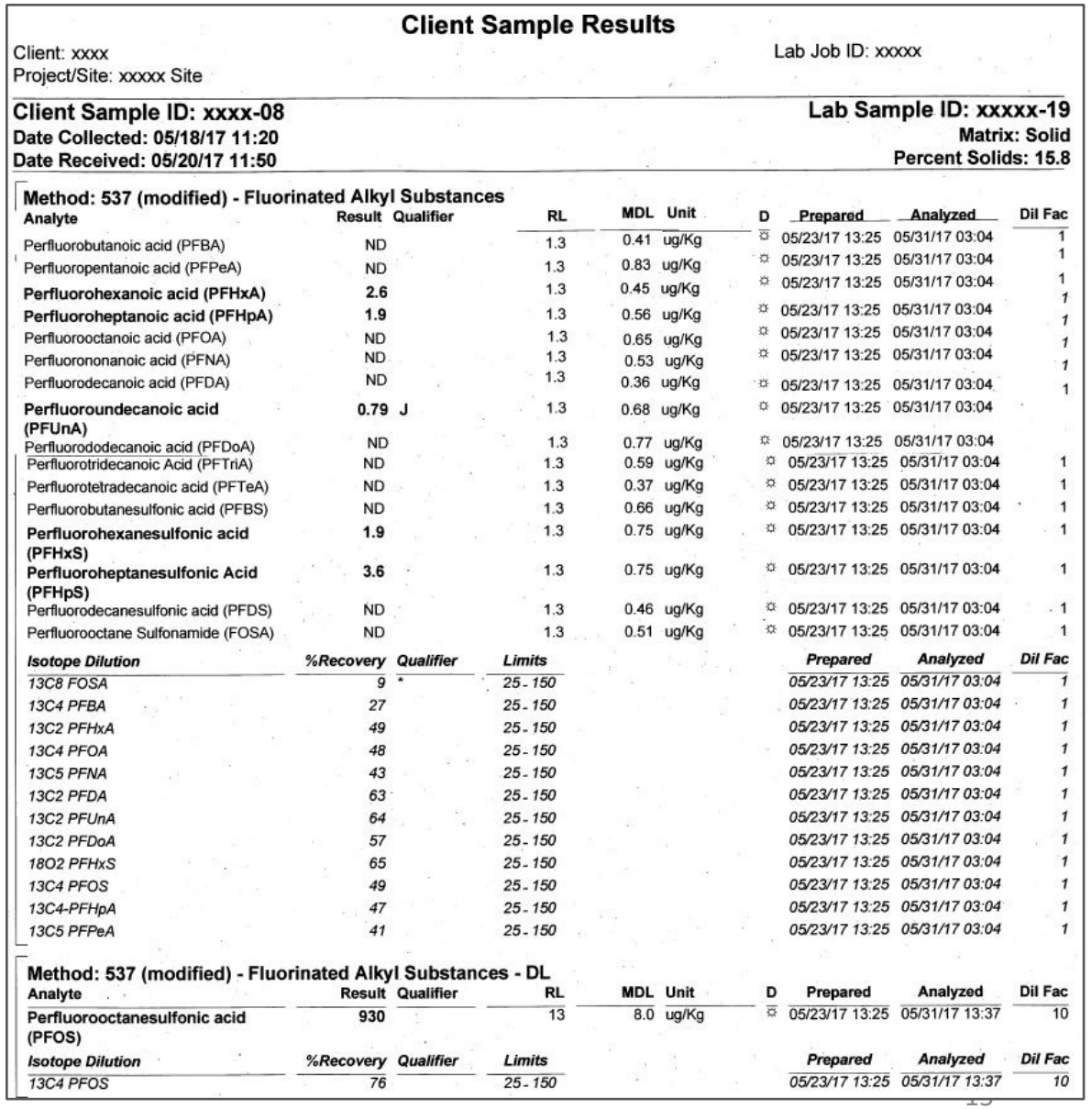
- Field Blanks
- Method Blanks (1/20 samples in a prep batch)
- LCS/LCSD
- MS/MSD (site specific; depends on project objectives)
- Internal Standards (injection efficiency -suppression/enhancement)
- Isotopically Labeled Surrogates (recovery corrected quantitation)
  - Additional precursor/product ion transitions (for qualitative purposes)

Signal	RT	EXP RT	DLT RT	REL RT	Response	Amount ng/ml	Ratio(Limits)	%Rec	S/N
15 Perfluorooctanoic acid									
413.00 > 369.00	3.511	3.528	-0.017	1.000	30746	0.2060	1.27(0.90-1.10)		21.9
413.00 > 169.00	3.511	3.528	-0.017	1.000	24205				
17 Perfluorooctane sulfonic acid									
499.00 > 80.00	3.881	3.847	0.034	1.000	802151	4.05	4.05(0.90-1.10)		121
499.00 > 99.00	3.881	3.847	0.034	1.000	198253				

PFAS Analytical Reports

Typical sample result summary form

- Number of PFAS reported
- Results, RLs, units
- Dilution results
- Collection date, prepared date, analysis date
- Percent solids (dry weight)
- Isotope Dilution recoveries



Client Sample Results

Client: xxxx
Project/Site: xxxxx Site

Lab Job ID: xxxxx

Client Sample ID: xxxx-08
Date Collected: 05/18/17 11:20
Date Received: 05/20/17 11:50

Lab Sample ID: xxxxx-19
Matrix: Solid
Percent Solids: 15.8

Method: 537 (modified) - Fluorinated Alkyl Substances

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Perfluorobutanoic acid (PFBA)	ND		1.3	0.41	ug/Kg	☼	05/23/17 13:25	05/31/17 03:04	1
Perfluoropentanoic acid (PFPeA)	ND		1.3	0.83	ug/Kg	☼	05/23/17 13:25	05/31/17 03:04	1
Perfluorohexanoic acid (PFHxA)	**2.6**		1.3	0.45	ug/Kg	☼	05/23/17 13:25	05/31/17 03:04	1
Perfluoroheptanoic acid (PFHpA)	**1.9**		1.3	0.56	ug/Kg	☼	05/23/17 13:25	05/31/17 03:04	1
Perfluorooctanoic acid (PFOA)	ND		1.3	0.65	ug/Kg	☼	05/23/17 13:25	05/31/17 03:04	1
Perfluorononanoic acid (PFNA)	ND		1.3	0.53	ug/Kg	☼	05/23/17 13:25	05/31/17 03:04	1
Perfluorodecanoic acid (PFDA)	ND		1.3	0.36	ug/Kg	☼	05/23/17 13:25	05/31/17 03:04	1
Perfluoroundecanoic acid (PFUnA)	**0.79**	**J**	1.3	0.68	ug/Kg	☼	05/23/17 13:25	05/31/17 03:04	
Perfluorododecanoic acid (PFDoA)	ND		1.3	0.77	ug/Kg	☼	05/23/17 13:25	05/31/17 03:04	
Perfluorotridecanoic Acid (PFTriA)	ND		1.3	0.59	ug/Kg	☼	05/23/17 13:25	05/31/17 03:04	1
Perfluorotetradecanoic acid (PFTeA)	ND		1.3	0.37	ug/Kg	☼	05/23/17 13:25	05/31/17 03:04	1
Perfluorobutanesulfonic acid (PFBS)	ND		1.3	0.66	ug/Kg	☼	05/23/17 13:25	05/31/17 03:04	1
Perfluorohexanesulfonic acid (PFHxS)	**1.9**		1.3	0.75	ug/Kg	☼	05/23/17 13:25	05/31/17 03:04	1
Perfluoroheptanesulfonic Acid (PFHpS)	**3.6**		1.3	0.75	ug/Kg	☼	05/23/17 13:25	05/31/17 03:04	1
Perfluorodecanesulfonic acid (PFDS)	ND		1.3	0.46	ug/Kg	☼	05/23/17 13:25	05/31/17 03:04	1
Perfluorooctane Sulfonamide (FOSA)	ND		1.3	0.51	ug/Kg	☼	05/23/17 13:25	05/31/17 03:04	1

Isotope Dilution	*%Recovery*	*Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
13C8 FOSA	*9*	*	*25 - 150*	*05/23/17 13:25*	*05/31/17 03:04*	*1*
13C4 PFBA	*27*		*25 - 150*	*05/23/17 13:25*	*05/31/17 03:04*	*1*
13C2 PFHxA	*49*		*25 - 150*	*05/23/17 13:25*	*05/31/17 03:04*	*1*
13C4 PFOA	*48*		*25 - 150*	*05/23/17 13:25*	*05/31/17 03:04*	*1*
13C5 PFNA	*43*		*25 - 150*	*05/23/17 13:25*	*05/31/17 03:04*	*1*
13C2 PFDA	*63*		*25 - 150*	*05/23/17 13:25*	*05/31/17 03:04*	*1*
13C2 PFUnA	*64*		*25 - 150*	*05/23/17 13:25*	*05/31/17 03:04*	*1*
13C2 PFDoA	*57*		*25 - 150*	*05/23/17 13:25*	*05/31/17 03:04*	*1*
18O2 PFHxS	*65*		*25 - 150*	*05/23/17 13:25*	*05/31/17 03:04*	*1*
13C4 PFOS	*49*		*25 - 150*	*05/23/17 13:25*	*05/31/17 03:04*	*1*
13C4-PFHpA	*47*		*25 - 150*	*05/23/17 13:25*	*05/31/17 03:04*	*1*
13C5 PFPeA	*41*		*25 - 150*	*05/23/17 13:25*	*05/31/17 03:04*	*1*

Method: 537 (modified) - Fluorinated Alkyl Substances - DL

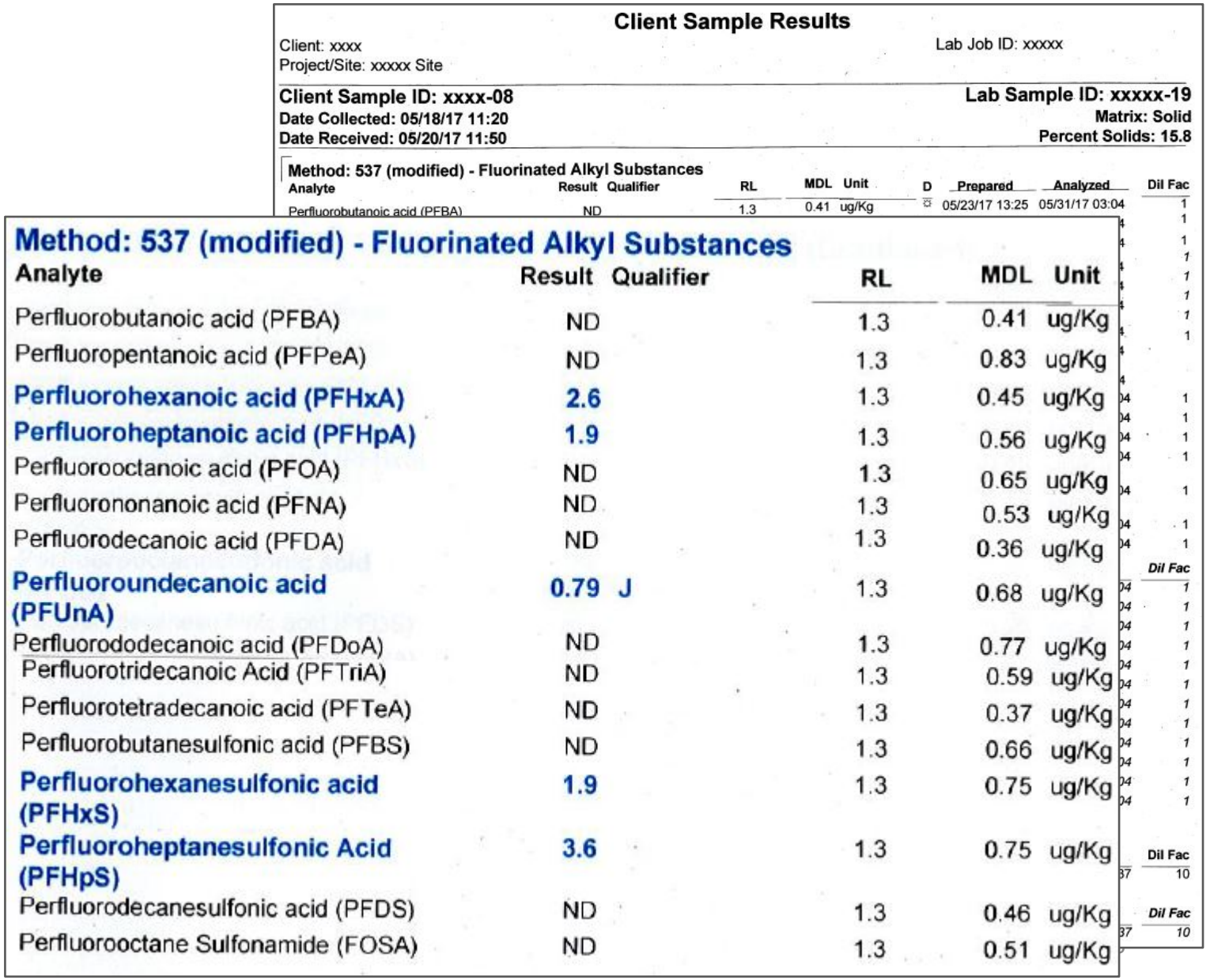
Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Perfluorooctanesulfonic acid (PFOS)	**930**		13	8.0	ug/Kg	☼	05/23/17 13:25	05/31/17 13:37	10

Isotope Dilution	*%Recovery*	*Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
13C4 PFOS	*76*		*25 - 150*	*05/23/17 13:25*	*05/31/17 13:37*	*10*

PFAS Analytical Report

Typical sample result summary form

- PFAS reported
- Results, RLs, units
- Dilution results
- Collection, prepared, analysis date
- Percent solids (dry weight)
- Isotope Dilution recoveries



Client Sample Results

Client: xxxx
Project/Site: xxxxx Site

Lab Job ID: xxxxx

Client Sample ID: xxxx-08
Date Collected: 05/18/17 11:20
Date Received: 05/20/17 11:50

Lab Sample ID: xxxxx-19
Matrix: Solid
Percent Solids: 15.8

Method: 537 (modified) - Fluorinated Alkyl Substances

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Perfluorobutanoic acid (PFBA)	ND		1.3	0.41	ug/Kg	☼	05/23/17 13:25	05/31/17 03:04	1
Perfluoropentanoic acid (PFPeA)	ND		1.3	0.83	ug/Kg				1
Perfluorohexanoic acid (PFHxA)	**2.6**		1.3	0.45	ug/Kg				1
Perfluoroheptanoic acid (PFHpA)	**1.9**		1.3	0.56	ug/Kg				1
Perfluorooctanoic acid (PFOA)	ND		1.3	0.65	ug/Kg				1
Perfluorononanoic acid (PFNA)	ND		1.3	0.53	ug/Kg				1
Perfluorodecanoic acid (PFDA)	ND		1.3	0.36	ug/Kg				1
Perfluoroundecanoic acid (PFUnA)	**0.79**	**J**	1.3	0.68	ug/Kg				1
Perfluorododecanoic acid (PFDoA)	ND		1.3	0.77	ug/Kg				1
Perfluorotridecanoic Acid (PFTriA)	ND		1.3	0.59	ug/Kg				1
Perfluorotetradecanoic acid (PFTeA)	ND		1.3	0.37	ug/Kg				1
Perfluorobutanesulfonic acid (PFBS)	ND		1.3	0.66	ug/Kg				1
Perfluorohexanesulfonic acid (PFHxS)	**1.9**		1.3	0.75	ug/Kg				1
Perfluoroheptanesulfonic Acid (PFHpS)	**3.6**		1.3	0.75	ug/Kg				10
Perfluorodecanesulfonic acid (PFDS)	ND		1.3	0.46	ug/Kg				10
Perfluorooctane Sulfonamide (FOSA)	ND		1.3	0.51	ug/Kg				

PFAS Analytical Report

Typical sample result summary form

- PFAS reported
- Results, RLs, units
- Dilution results
- Collec
- Perce
- Isotop

Client Sample Results

Client: xxxx
Project/Site: xxxxx Site

Lab Job ID: xxxxx

Client Sample ID: xxxx-08
Date Collected: 05/18/17 11:20
Date Received: 05/20/17 11:50

Lab Sample ID: xxxxx-19
Matrix: Solid
Percent Solids: 15.8

Method: 537 (modified) - Fluorinated Alkyl Substances

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Perfluorobutanoic acid (PFBA)	ND		1.3	0.41	ug/Kg	☼	05/23/17 13:25	05/31/17 03:04	1
Perfluoropentanoic acid (PFPeA)	ND		1.3	0.83	ug/Kg	☼	05/23/17 13:25	05/31/17 03:04	1
Perfluorohexanoic acid (PFHxA)	**2.6**		1.3	0.45	ug/Kg	☼	05/23/17 13:25	05/31/17 03:04	1
Perfluoroheptanoic acid (PFHpA)	**1.9**		1.3	0.56	ug/Kg	☼	05/23/17 13:25	05/31/17 03:04	1
Perfluorooctanoic acid (PFOA)	ND		1.3	0.65	ug/Kg	☼	05/23/17 13:25	05/31/17 03:04	1
Perfluorononanoic acid (PFNA)	ND		1.3	0.53	ug/Kg	☼	05/23/17 13:25	05/31/17 03:04	1
Perfluorodecanoic acid (PFDA)	ND		1.3	0.36	ug/Kg	☼	05/23/17 13:25	05/31/17 03:04	1
Perfluoroundecanoic acid (PFUnA)	**0.79**	**J**	1.3	0.68	ug/Kg	☼	05/23/17 13:25	05/31/17 03:04	
Perfluorododecanoic acid (PFDoA)	ND		1.3	0.77	ug/Kg	☼	05/23/17 13:25	05/31/17 03:04	
Perfluorotridecanoic Acid (PFTriA)	ND		1.3	0.59	ug/Kg	☼	05/23/17 13:25	05/31/17 03:04	1

Method: 537 (modified) - Fluorinated Alkyl Substances - DL

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Perfluorooctanesulfonic acid (PFOS)	**930**		13	8.0	ug/Kg	☼	05/23/17 13:25	05/31/17 13:37	10

Isotope Dilution	*%Recovery*	*Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
13C4 PFOS	*76*		*25 - 150*	*05/23/17 13:25*	*05/31/17 13:37*	*10*

13C2 PFDA	*63*	*25 - 150*	*05/23/17 13:25*	*05/31/17 03:04*	*1*
13C2 PFUnA	*64*	*25 - 150*	*05/23/17 13:25*	*05/31/17 03:04*	*1*
13C2 PFDoA	*57*	*25 - 150*	*05/23/17 13:25*	*05/31/17 03:04*	*1*
18O2 PFHxS	*65*	*25 - 150*	*05/23/17 13:25*	*05/31/17 03:04*	*1*
13C4 PFOS	*49*	*25 - 150*	*05/23/17 13:25*	*05/31/17 03:04*	*1*
13C4-PFHpA	*47*	*25 - 150*	*05/23/17 13:25*	*05/31/17 03:04*	*1*
13C5 PFPeA	*41*	*25 - 150*	*05/23/17 13:25*	*05/31/17 03:04*	*1*

Method: 537 (modified) - Fluorinated Alkyl Substances - DL

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Perfluorooctanesulfonic acid (PFOS)	**930**		13	8.0	ug/Kg	☼	05/23/17 13:25	05/31/17 13:37	10

Isotope Dilution	*%Recovery*	*Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
13C4 PFOS	*76*		*25 - 150*	*05/23/17 13:25*	*05/31/17 13:37*	*10*

PFAS Analytical Report

Typical sample result summary form

- PFAS reported
- Results, RLs, units
- Dilution results
- Collection date, prepared date, analysis date
- Percent solids (dry weight)
- Isotop

Client Sample Results

Client: xxxx
Project/Site: xxxxx Site
Lab Job ID: xxxxx

Client Sample ID: xxxx-08
Date Collected: 05/18/17 11:20
Date Received: 05/20/17 11:50

Lab Sample ID: xxxxx-19
Matrix: Solid
Percent Solids: 15.8

Method: 537 (modified) - Fluorinated Alkyl Substances

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Perfluorobutanoic acid (PFBA)	ND		1.3	0.41	ug/Kg	☼	05/23/17 13:25	05/31/17 03:04	1
Perfluoropentanoic acid (PFPeA)	ND		1.3	0.83	ug/Kg	☼	05/23/17 13:25	05/31/17 03:04	1
Perfluo noic acid (PFHxA)	2.6		1.3	0.45	ug/Kg	☼	05/23/17 13:25	05/31/17 03:04	1
Perfluor oic acid (PFHpA)	1.9		1.3	0.56	ug/Kg	☼	05/23/17 13:25	05/31/17 03:04	1
Perfluo ic acid (PFOA)	ND		1.3	0.65	ug/Kg	☼	05/23/17 13:25	05/31/17 03:04	1
Perflu noic acid (PFNA)	ND		1.3	0.53	ug/Kg	☼	05/23/17 13:25	05/31/17 03:04	1
Perfl anoic acid (PFDA)	ND		1.3	0.36	ug/Kg	☼	05/23/17 13:25	05/31/17 03:04	1
Pe undecanoic acid (P	0.79	J	1.3	0.68	ug/Kg	☼	05/23/17 13:25	05/31/17 03:04	
odododecanoic acid (PFDoA)	ND		1.3	0.77	ug/Kg	☼	05/23/17 13:25	05/31/17 03:04	
rotridecanoic Acid (PFTriA)	ND		1.3	0.59	ug/Kg	☼	05/23/17 13:25	05/31/17 03:04	1
orotetradecanoic acid (PFTeA)	ND		1.3	0.37	ug/Kg	☼	05/23/17 13:25	05/31/17 03:04	1
uorobutanesulfonic acid (PFBS)	ND		1.3	0.66	ug/Kg	☼	05/23/17 13:25	05/31/17 03:04	1
rfluorohexanesulfonic acid (PFHxS)	1.9		1.3	0.75	ug/Kg	☼	05/23/17 13:25	05/31/17 03:04	1
Perfluoroheptanesulfonic Acid (PFHpS)	3.6		1.3	0.75	ug/Kg	☼	05/23/17 13:25	05/31/17 03:04	1
Perfluorodecanesulfonic acid (PFDS)	ND		1.3	0.46	ug/Kg	☼	05/23/17 13:25	05/31/17 03:04	1
Perfluorooctane Sulfonamide (FOSA)	ND		1.3	0.51	ug/Kg	☼	05/23/17 13:25	05/31/17 03:04	1

Isotope Dilution	*%Recovery*	*Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
(PFOS)						
13C4 PFOS	*76*		*25 - 150*	*05/23/17 13:25*	*05/31/17 13:37*	*10*

Client Sample ID: xxxx-08
Date Collected: 05/18/17 11:20
Date Received: 05/20/17 11:50

Lab Sample ID: xxxxx-19
Matrix: Solid
Percent Solids: 15.8

Method: 537 (modified) - Fluorinated Alkyl Substances

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Perfluorobutanoic acid (PFBA)	ND		1.3	0.41	ug/Kg	☼	05/23/17 13:25	05/31/17 03:04	1
Perfluoropentanoic acid (PFPeA)	ND		1.3	0.83	ug/Kg	☼	05/23/17 13:25	05/31/17 03:04	1

PFAS Analytical Report

Typical sample result summary form

- PFAS reported
- Results, R
- Dilution r
- Collectio
- Percent solids (dry weight)
- Isotope Dilution recoveries

Isotope Dilution	%Recovery	Qualifier	Limits
13C8 FOSA	9	*	25 - 150
13C4 PFBA	27		25 - 150
13C2 PFHxA	49		25 - 150
13C4 PFOA	48		25 - 150

Client Sample Results

Client: xxxx
Project/Site: xxxxx Site

Lab Job ID: xxxxx

Client Sample ID: xxxx-08
Date Collected: 05/18/17 11:20
Date Received: 05/20/17 11:50

Lab Sample ID: xxxxx-19
Matrix: Solid
Percent Solids: 15.8

Method: 537 (modified) - Fluorinated Alkyl Substances

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Perfluorobutanoic acid (PFBA)	ND		1.3	0.41	ug/Kg	☼	05/23/17 13:25	05/31/17 03:04	1
			.3	0.83	ug/Kg	☼	05/23/17 13:25	05/31/17 03:04	1
			.3	0.45	ug/Kg	☼	05/23/17 13:25	05/31/17 03:04	1
			.3	0.56	ug/Kg	☼	05/23/17 13:25	05/31/17 03:04	1
			.3	0.65	ug/Kg	☼	05/23/17 13:25	05/31/17 03:04	1
			.3	0.53	ug/Kg	☼	05/23/17 13:25	05/31/17 03:04	1
			.3	0.36	ug/Kg	☼	05/23/17 13:25	05/31/17 03:04	1
			.3	0.68	ug/Kg	☼	05/23/17 13:25	05/31/17 03:04	
			.3	0.77	ug/Kg	☼	05/23/17 13:25	05/31/17 03:04	
			3	0.59	ug/Kg	☼	05/23/17 13:25	05/31/17 03:04	1
			3	0.37	ug/Kg	☼	05/23/17 13:25	05/31/17 03:04	1
			3	0.66	ug/Kg	☼	05/23/17 13:25	05/31/17 03:04	1
			3	0.75	ug/Kg	☼	05/23/17 13:25	05/31/17 03:04	1
			3	0.75	ug/Kg	☼	05/23/17 13:25	05/31/17 03:04	1
(PFHpS)									
Perfluorodecanesulfonic acid (PFDS)	ND		1.3	0.46	ug/Kg	☼	05/23/17 13:25	05/31/17 03:04	1
Perfluorooctane Sulfonamide (FOSA)	ND		1.3	0.51	ug/Kg	☼	05/23/17 13:25	05/31/17 03:04	1

Isotope Dilution	%Recovery	Qualifier	Limits	Prepared	Analyzed	Dil Fac
C8 FOSA	9	*	25 - 150	05/23/17 13:25	05/31/17 03:04	1
C4 PFBA	27		25 - 150	05/23/17 13:25	05/31/17 03:04	1
C2 PFHxA	49		25 - 150	05/23/17 13:25	05/31/17 03:04	1
13C4 PFOA	48		25 - 150	05/23/17 13:25	05/31/17 03:04	1
13C5 PFNA	43		25 - 150	05/23/17 13:25	05/31/17 03:04	1
13C2 PFDA	63		25 - 150	05/23/17 13:25	05/31/17 03:04	1
13C2 PFUnA	64		25 - 150	05/23/17 13:25	05/31/17 03:04	1
13C2 PFDoA	57		25 - 150	05/23/17 13:25	05/31/17 03:04	1
18O2 PFHxS	65		25 - 150	05/23/17 13:25	05/31/17 03:04	1
13C4 PFOS	49		25 - 150	05/23/17 13:25	05/31/17 03:04	1
13C4-PFHpA	47		25 - 150	05/23/17 13:25	05/31/17 03:04	1
13C5 PFPeA	41		25 - 150	05/23/17 13:25	05/31/17 03:04	1

Method: 537 (modified) - Fluorinated Alkyl Substances - DL

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Perfluorooctanesulfonic acid (PFOS)	930		13	8.0	ug/Kg	☼	05/23/17 13:25	05/31/17 13:37	10

Isotope Dilution	%Recovery	Qualifier	Limits	Prepared	Analyzed	Dil Fac
13C4 PFOS	76		25 - 150	05/23/17 13:25	05/31/17 13:37	10

PFAS Data Usability

Main impacts of differences and QC non-conformances on data usability

- Sample preparation/extraction
- Number of PFAS reported
- Acid or anion form reported
- Isotope dilution vs IS quantitation
- Isotope recoveries
- Blanks
- Linear and branched isomers

PFAS Data Usability

Main impacts of differences and QC non-conformances on data usability

- Sample preparation/extraction
- Number of PFAS reported
- Acid or anion form reported
- Isotope dilution vs IS quantitation
- Isotope Dilution recoveries
- Blanks
- Linear and branched isomers

Isotope Dilution Summary

Client: xxx
Job ID: xxxx
Project/Site: xxxxxx

Method: 537 (modified) - Fluorinated Alkyl Substances
Matrix: Solid **Pre**

		Percent Isotope Dilution Recovery (Acceptance Li					
		3C8 FOSA	3C4 PFBA	3C2 PFHx	3C4 PFOA	3C5 PFNA	3C2 PFDA
Lab Sample ID	Client Sample ID	(25-150)	(25-150)	(25-150)	(25-150)	(25-150)	(25-150)
lab-12	sample-01	26	46	72	68	72	75
lab-13	sample-02	16 *	28	59	60	71	80
lab-14	sample-03	30	35	62	63	70	69
lab-15	sample-04	23 *	28	52	59	65	73
lab-16	sample-05	35	27	57	59	66	73
lab-17	sample-06	35	28	43	47	51	54
lab-18	sample-07	38	34	60	63	67	69
lab-19	sample-08	9*	27	49	48	43	63
lab-20	sample-09	29	31	61	58	63	71
lab-21	sample-10	41	57	77	80	81	92
lab-22	sample-11	31	35	55	57	62	65
lab-22 MS	sample-11	28	37	58	55	60	64
lab-22 MSD	sample-11	29	33	54	53	57	59
LCS	Lab Control Sample	40	89	84	99	103	101
MB	Method Blank	37	85	82	96	105	102

PFAS Data Usability

Main impacts of differences and QC non-conformances on data usability

- Sample preparation/extraction
- Number of PFAS reported
- Acid or anion form reported
- Isotope dilution vs IS quantitation
- Isotope recoveries
- Blanks
- Linear and branched isomers

Method: 537 (modified) - Fluorinated Alkyl Substances (Continued)

Lab Sample ID: MB 320-165772/1-A
Matrix: Solid
Analysis Batch: 166742

Client Sample ID: Method Blank
Prep Type: Total/NA
Prep Batch: 165772

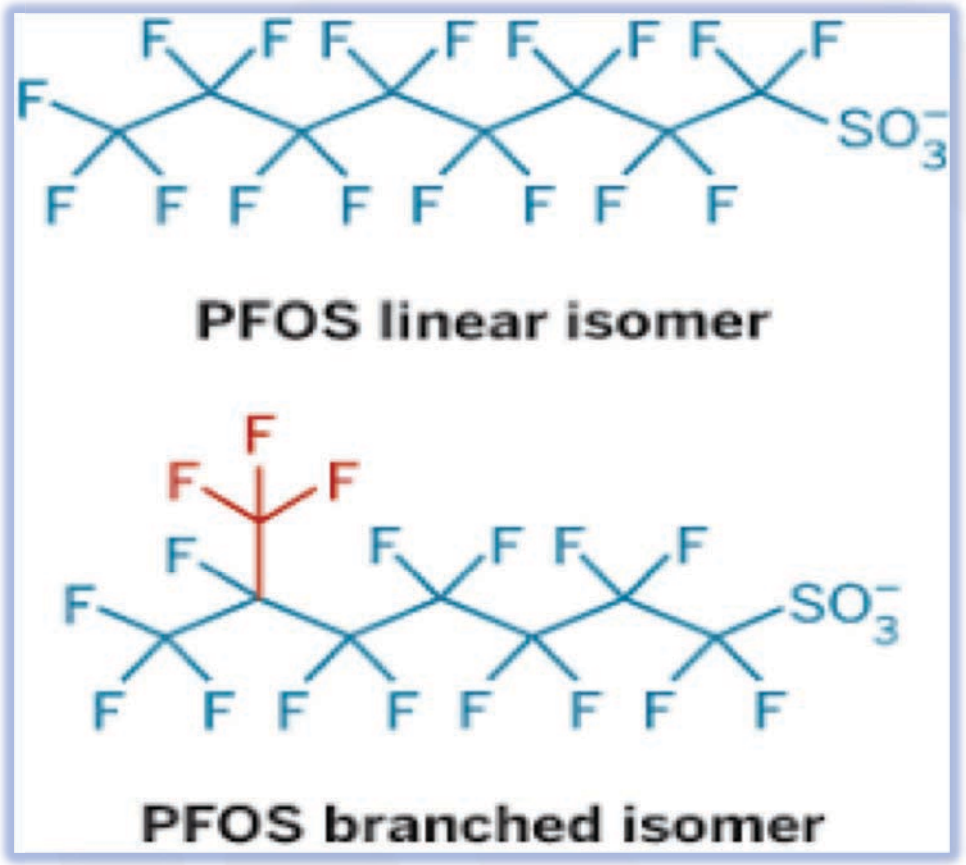
Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Perfluoropentanoic acid (PFPeA)	ND		0.20	0.13	ug/Kg		05/23/17 13:25	05/31/17 01:27	1
Perfluorohexanoic acid (PFHxA)	ND		0.20	0.071	ug/Kg		05/23/17 13:25	05/31/17 01:27	1
Perfluoroheptanoic acid (PFHpA)	ND		0.20	0.088	ug/Kg		05/23/17 13:25	05/31/17 01:27	1
Perfluorooctanoic acid (PFOA)	ND		0.20	0.10	ug/Kg		05/23/17 13:25	05/31/17 01:27	1
Perfluorononanoic acid (PFNA)	ND		0.20	0.083	ug/Kg		05/23/17 13:25	05/31/17 01:27	1
Perfluorodecanoic acid (PFDA)	ND		0.20	0.057	ug/Kg		05/23/17 13:25	05/31/17 01:27	1
Perfluoroundecanoic acid (PFUnA)	ND		0.20	0.11	ug/Kg		05/23/17 13:25	05/31/17 01:27	1
Perfluorododecanoic acid (PFDoA)	ND		0.20	0.12	ug/Kg		05/23/17 13:25	05/31/17 01:27	1
Perfluorotridecanoic Acid (PFTriA)	ND		0.20	0.092	ug/Kg		05/23/17 13:25	05/31/17 01:27	1
Perfluorotetradecanoic acid (PFTeA)	0.0593	J	0.20	0.058	ug/Kg		05/23/17 13:25	05/31/17 01:27	1
Perfluorobutanesulfonic acid (PFBS)	ND		0.20	0.10	ug/Kg		05/23/17 13:25	05/31/17 01:27	1
Perfluorohexanesulfonic acid (PFHxS)	ND		0.20	0.12	ug/Kg		05/23/17 13:25	05/31/17 01:27	1
Perfluoroheptanesulfonic Acid (PFHpS)	ND		0.20	0.12	ug/Kg		05/23/17 13:25	05/31/17 01:27	1
Perfluorooctanesulfonic acid (PFOS)	ND		0.20	0.13	ug/Kg		05/23/17 13:25	05/31/17 01:27	1
Perfluorodecanesulfonic acid (PFDS)	ND		0.20	0.072	ug/Kg		05/23/17 13:25	05/31/17 01:27	1
Perfluorooctane Sulfonamide (FOSA)	ND		0.20	0.080	ug/Kg		05/23/17 13:25	05/31/17 01:27	1

Isotope Dilution	*MB %Recovery*	*MB Qualifier*	*Limits*	*Prepared*	*Analyzed*	*Dil Fac*
13C8 FOSA	*37*		*25 - 150*	*05/23/17 13:25*	*05/31/17 01:27*	*1*
13C4 PFBA	*85*		*25 - 150*	*05/23/17 13:25*	*05/31/17 01:27*	*1*
13C2 PFHxA	*82*		*25 - 150*	*05/23/17 13:25*	*05/31/17 01:27*	*1*
13C4 PFOA	*96*		*25 - 150*	*05/23/17 13:25*	*05/31/17 01:27*	*1*
13C5 PFNA	*105*		*25 - 150*	*05/23/17 13:25*	*05/31/17 01:27*	*1*
13C2 PFDA	*102*		*25 - 150*	*05/23/17 13:25*	*05/31/17 01:27*	*1*
13C2 PFUnA	*98*		*25 - 150*	*05/23/17 13:25*	*05/31/17 01:27*	*1*
13C2 PFDoA	*91*		*25 - 150*	*05/23/17 13:25*	*05/31/17 01:27*	*1*
18O2 PFHxS	*81*		*25 - 150*	*05/23/17 13:25*	*05/31/17 01:27*	*1*
13C4 PFOS	*84*		*25 - 150*	*05/23/17 13:25*	*05/31/17 01:27*	*1*
13C4-PFHpA	*99*		*25 - 150*	*05/23/17 13:25*	*05/31/17 01:27*	*1*
13C5 PFPeA	*87*		*25 - 150*	*05/23/17 13:25*	*05/31/17 01:27*	*1*

PFAS Data Usability

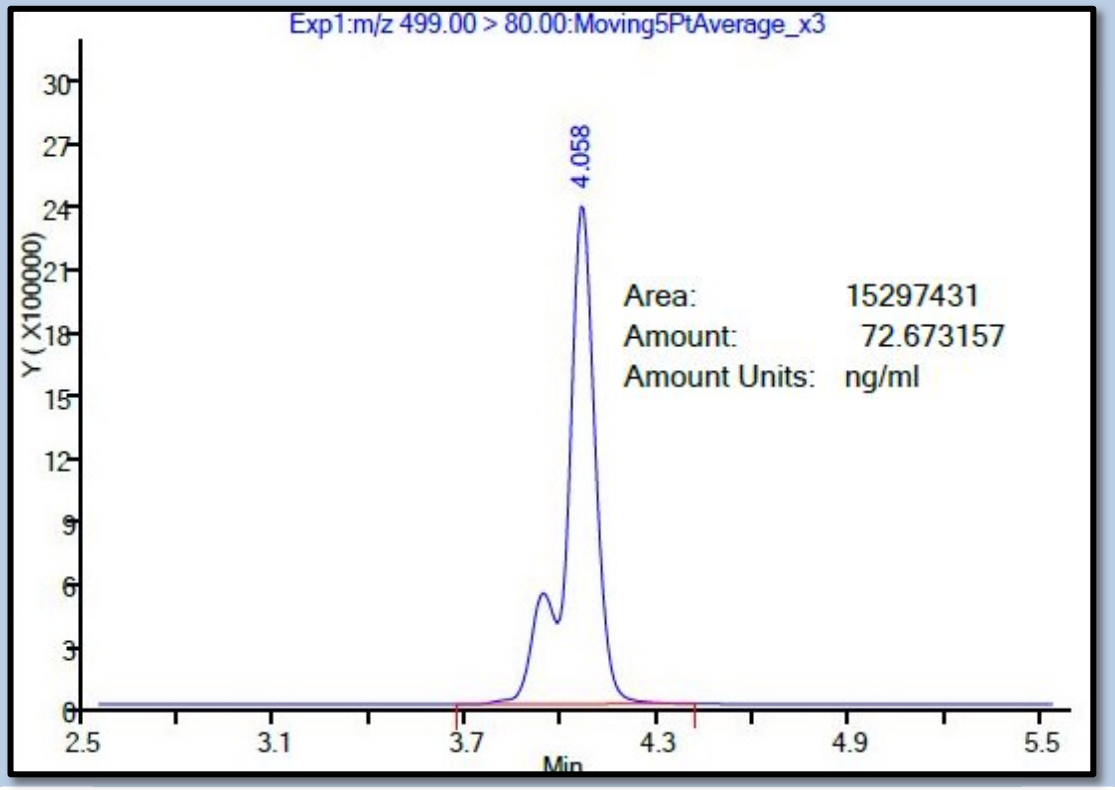
Main impacts of differences and QC non-conformances on data usability

- Sample preparation/extraction
- Number of PFAS reported
- Acid or anion form reported
- Isotope dilution vs IS quantitation
- Isotope recoveries
- Blanks
- Linear and Branched isomers

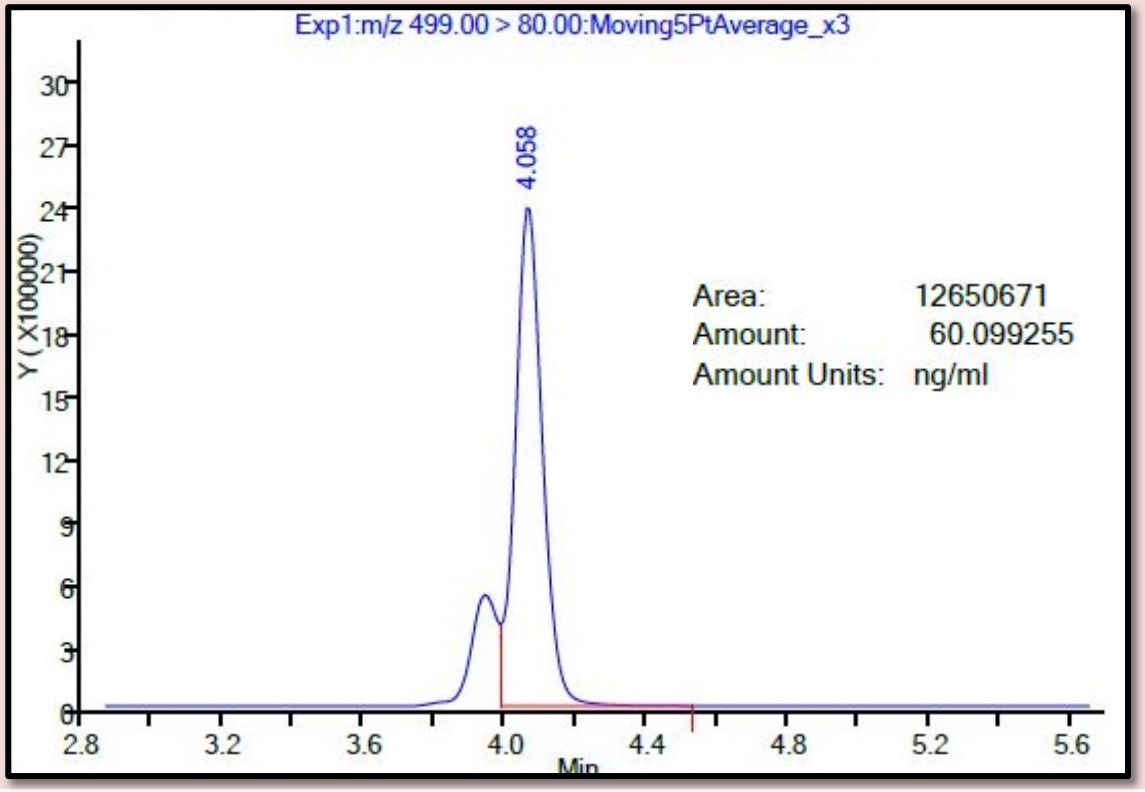


Branched and Linear Isomers: Lab Quantitation

Correct Integration Of PFOS



Incorrect Integration Of PFOS



Summary – Take Aways

- No standard PFAS Analytical Method for non-DW matrix
- SOPs are inconsistent across laboratories and proprietary
- Preferred method of quantitation is Isotope Dilution
- Large variations between laboratory reported PFAS results

Questions?

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