Analysis of Per- and Polyfluoroalkyl Substances in Water and Soil Samples Using Draft EPA Method 1633 with Automated and Semi-Automated Solid Phase Extraction

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Purpose

- Sample Preparation Workflows and tools for EPA method 1633 (draft)
- Comparison of Automated and Semi-Automated Solid Phase Extraction for PFAS applications
- EPA Method 1633 results

Target Analytes

Method	533	537.1	1633	ISO21675
PFBA	x		x	x
PFPeA	x		x	x
PFHxA	x	x	x	x
PFHpA	x	x	x	x
PFOA	x	x	x	x
PFNA	x	x	x	x
PFDA	x	x	x	x
PFUnA	x	x	x	x
PFDoA	x	x	x	x
PFTrDA		x	x	x
PFTeDA		x	x	x
PFBS	x	x	x	x
PFPeS	x		x	
PFHxS	x	x	x	x

Target Analytes

Method	533	537.1	1633	ISO21675
PFHpS	x		x	x
PFOS	x	x	x	x
PFNS			x	
PFDS			x	x
PFDoS			x	
4:2FTS	x		x	
6:2FTS	x		x	x
8:2FTS	x		x	x
PFOSA			x	x
NMeFOSA			x	x
NEtFOSA			x	x
NMeFOSAA		x	x	x
NEtFOSAA		x	x	x
NMeFOSE			x	

Target Analytes

Method	533	537.1	1633	ISO21675
NEtFOSE			x	
HFPO-DA	x	x	x	x
ADONA	x	x	x	x
PFMPA	x		x	
PFMBA	x		x	
NFDHA	x		x	
9Cl-PF3ONS	x	x	x	x
11Cl-PF3OUdS	x	x	x	
PFEESA	x		x	
3:3 FTCA			x	
5:3 FTCA			x	
7:3 FTCA			x	
PFOcDA				x
PFHxDA				x
8:2 FTUCA				x
8:2 diPAP				x

Optimizing the PFAS Analysis Workflow

- **Automate the Sample Prep Workflow**
  - **Automate the Solid Phase Extraction Step**
  - **Automate the Concentration/Evaporation Step**

- **Automated, Semi-Automated SPE extractions and Concentration**
  - **Reduces Human Error**
  - **Reduces Outside contamination and background**
  - **Reduces Solvent Usage**
  - **Reduces Labor**

- **Use SPE solutions to deliver consistent, reproducible results**
- **Different configurations to handle Matrix type and Budget**
- **No Teflon Components**

Comparison of Manual SPE vs. Automated SPE Methods

Manual SPE	Automated/Semi-Auto SPE
Manually Separate Waste	Separates Aqueous and Organic Waste
<10 mls solvent evaporate	<10 mls solvent to evaporate
Run times are ~ 30 to 90 minutes	Run times are ~20 to 50 minutes or less
Technician Time 25 minutes	Technician time 5 minutes
Physical transfer and Concentration steps	Automatic and Direct to Concentration delivery and completion
Concentration steps 70 to 200 minutes	Concentration step 70 minutes ready for injection

FMS
Fluid Management Systems

Determining Factors

- **Closed System**
- **Ability to load samples by vacuum or positive pressure consistently.**
- **Handle difficult Matrices**
- **Ability to dry cartridges by vacuum and positive Nitrogen gas pressure.**
- **Easily handle various cartridge designs and sizes without cumbersome modifications.**
- **Easy, Simple Sample delivery**
- **Bottle Rinse**

Automated Solid Phase Extraction front end for LC/MS

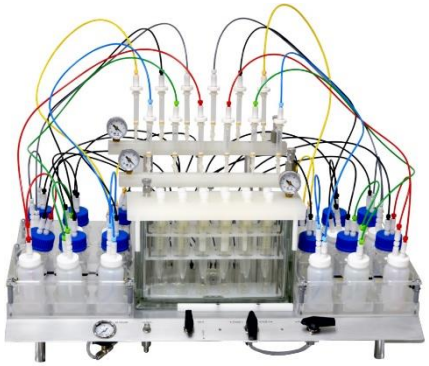
EconoTrace® PFC

TurboTrace® PFC

TurboTrace®
Parallel
Sequential

LC/MS

Semi-Automated Solid Phase Extraction front end LC/MS



EZPFC

LC/MS

Can this Handle Dirty Samples?

Typical Cartridge can have problems!

- **6ml cartridge**
  - **Doesn't do well**
  - **Frit Surface Area is to small**

Yes, A Cartridge will work

- **25ml cartridge**
  - **Does well**
  - **3X the Frit Surface Area**

FMS, Inc. Plastic Filtration Wool

Glass/Plastic Wool

- Irregular random stranding
- Slows Particles to the Uniform Frit
- Prevents Clogging

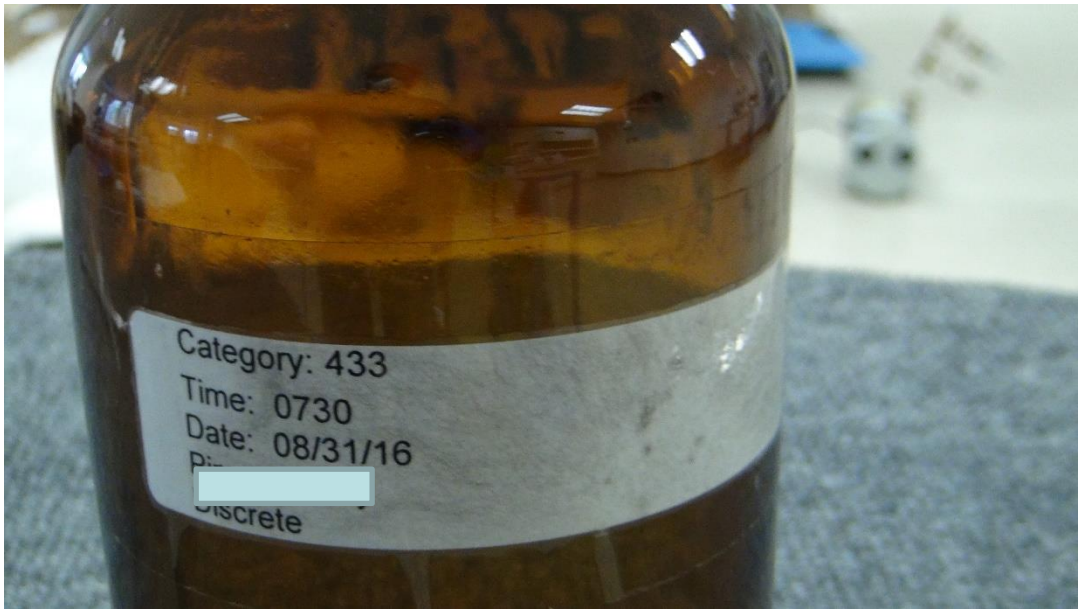
Prepping the 6ml Cartridge with Plastic Filtration Wool

6ml cartridge with Plastic wool

- Take a little and push it into the barrel of the syringe until it touches the cartridge Frit

- The Sample will not clog, it will take longer to process

Dirty Sample from a Customer



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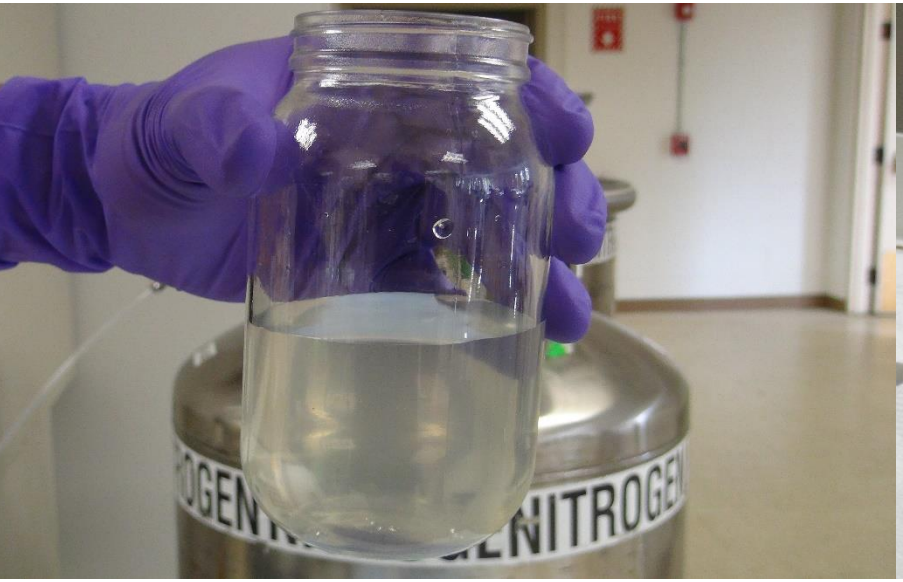
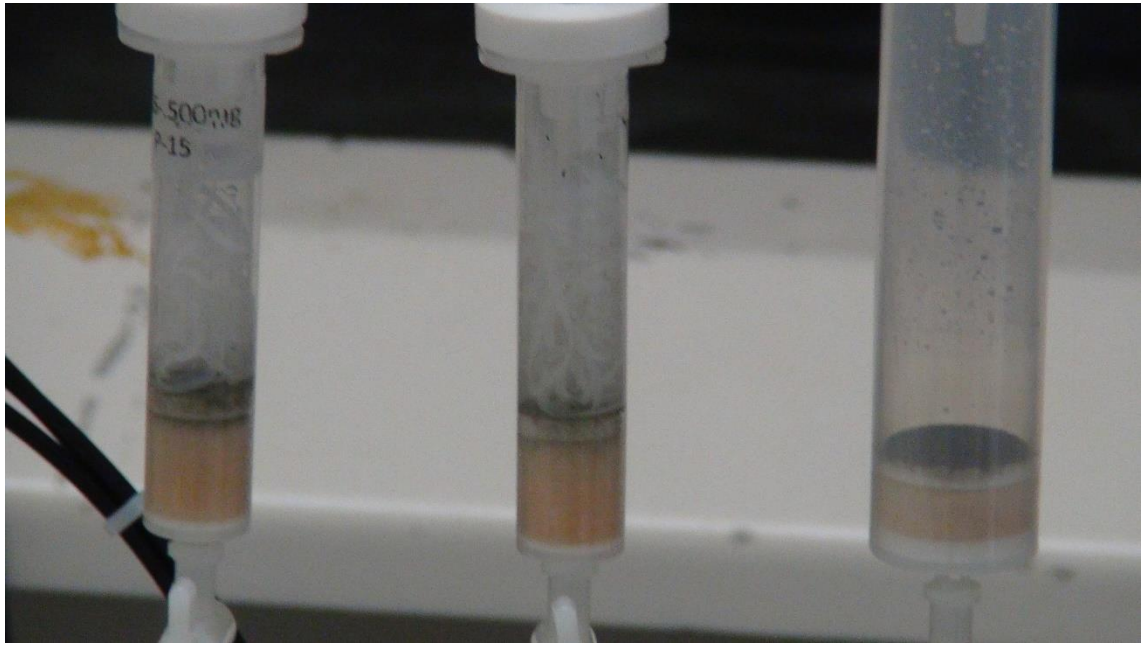
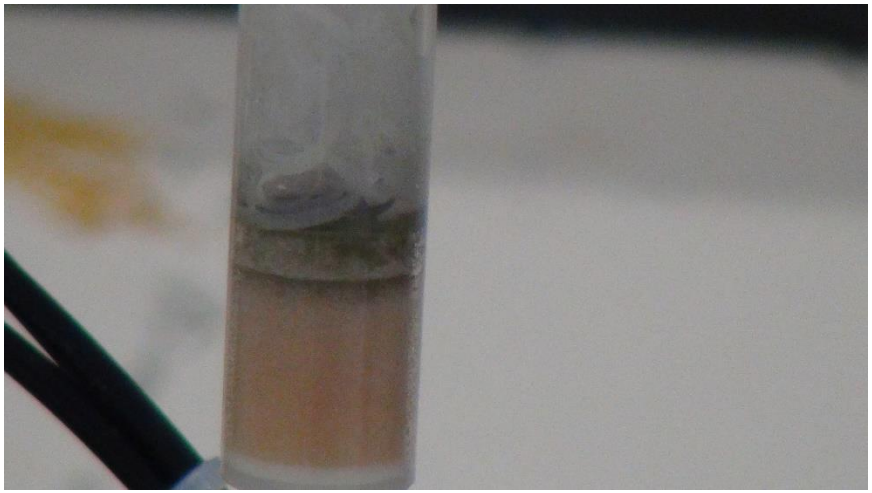
Industrial 433 Matrix 250ml

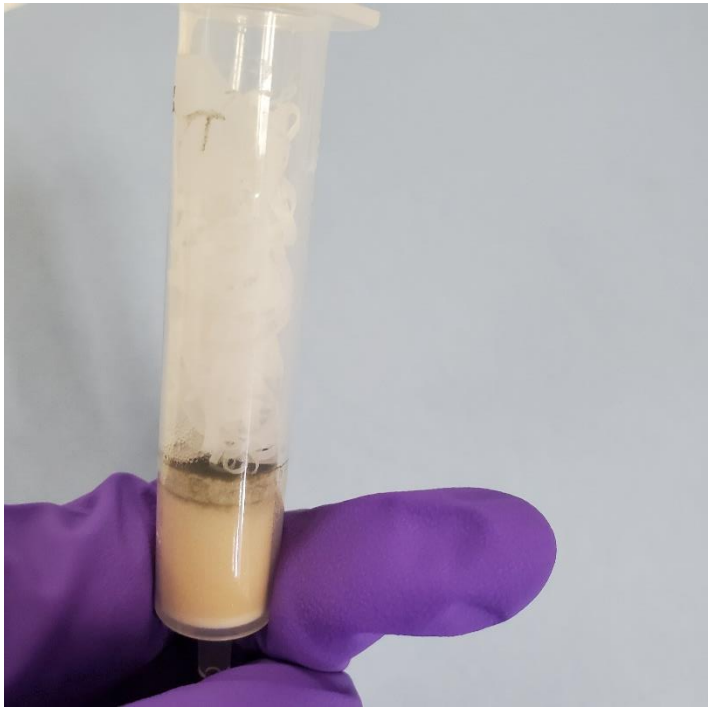


6ml and 25ml Cartridges

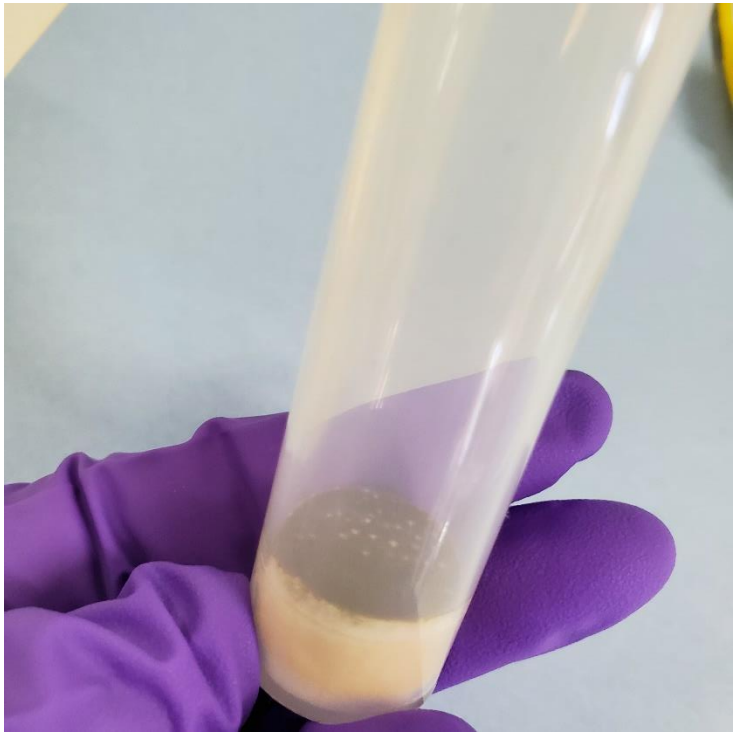


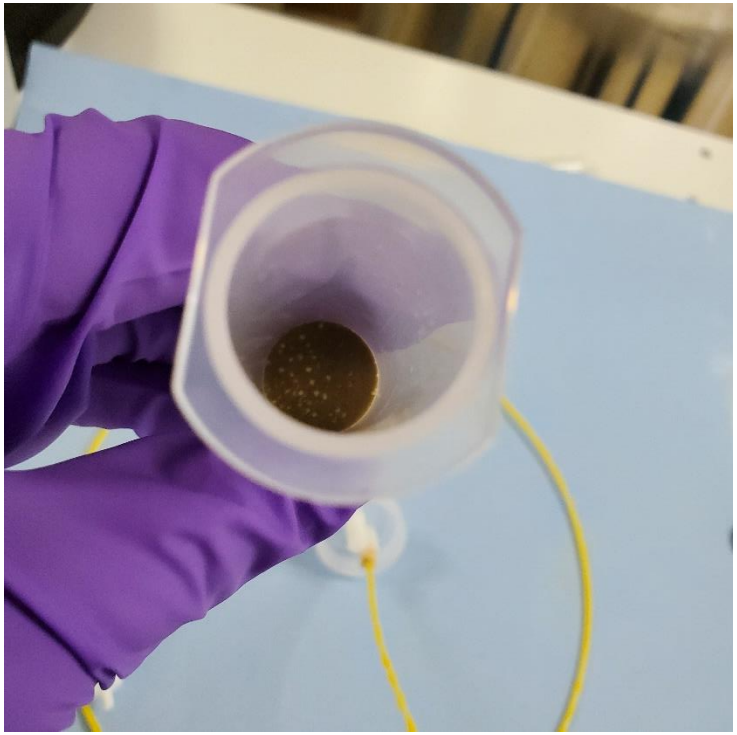
250 ml run to completion on 6 ml cartridge with Plastic Wool





250ml run to completion
25ml cartridge





TurboTrace Parallel Sequential PFC Automated Extraction and Concentration for PFAS/PFOS in Drinking Water and WasteWater

LC/MS

TurboTrace® PFC Parallel Sequential

Wastewater, Particulate Laden Samples
Drinking water Samples
Vacuum Pump or Positive Pressure for loading samples
Positive Pressure Pumping for conditioning, rinsing and elution
Direct to SuperVap Concentrator

TurboTrace for Extraction and Concentration of PFAS/PFOS in Drinking/WasteWater

Fluid Management Systems

Fully Automated

Modular and Scalable expandable from 1 to 6 Modules

Run 1 to 6 samples simultaneously, up to 30 sequentially

Each Module can Run 5 Samples in a Sequence

Uses Positive Pressure Pumping for Precise delivery of Elution and Wash Solvent

Uses Vacuum with liquid sensor to Load Dirty Samples

Direct Extract delivery to Concentrator for Evaporation

Automated Concentration for PFAs

- SuperVap PFC
  - 24 positions
  - 15ml Conical vials
  - Dry Bath

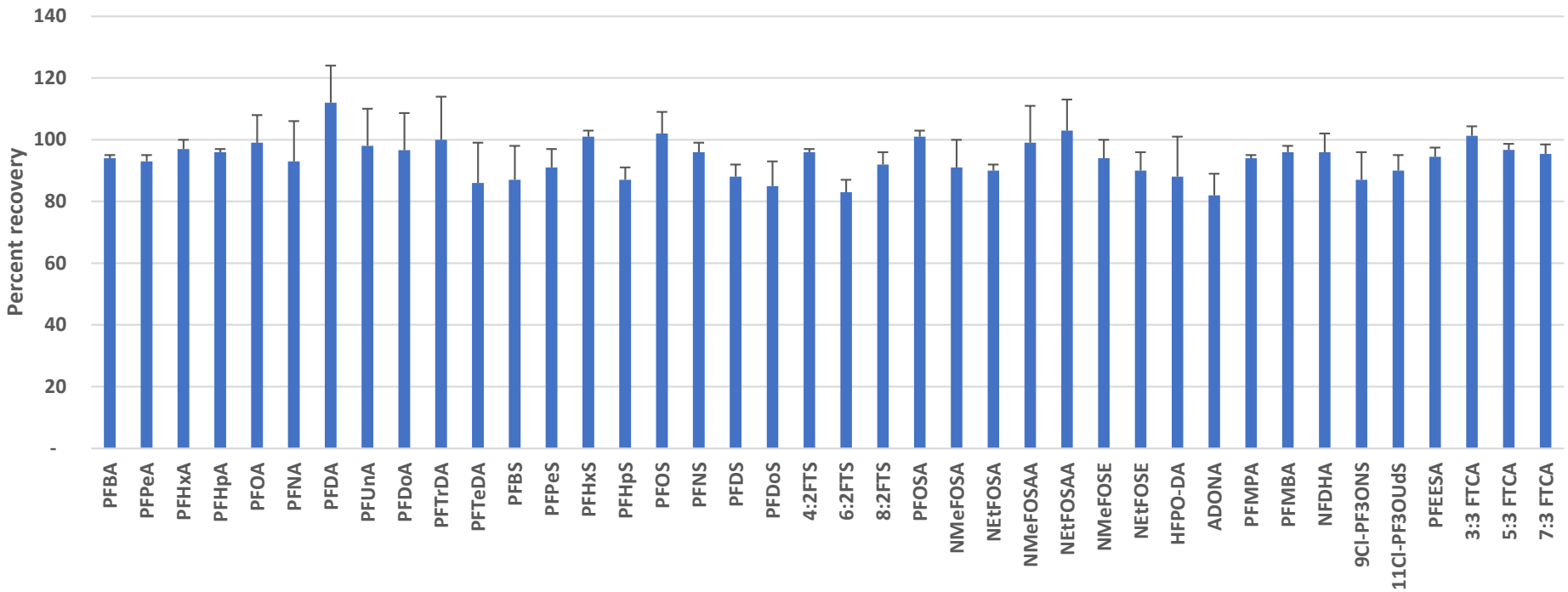
Automated Concentration for PFAs

- SuperVap PFC
  - 12 positions
  - 50 ml Conical vials
  - Dry Bath

Concentration Functionality

- **Self Installable**
  - **Video unpacking, installation and training video**
- **Preprogrammed with most common temperature settings**
- **Direct to 15ml Centrifuge Tubes**
- **Dry bath heating element**
- **Time based endpoint**
- **Savable temperature log**
- **No Teflon Components**

EPA 1633
Turbo Trace Parallel/Sequential



Various Blanks EPA 1633

		ch.1	ch.2	ch.3	ch.4	ch.5	stopcock	sample bottle
Name		Calc. Conc.	Calc. Conc.	Calc. Conc.	Calc. Conc.	Calc. Conc.	Calc. Conc.	Calc. Conc.
3-3 FTCA		0.00	0.00	0.00	0.00	0.00	0.00	0.00
PFBA		0.00	0.00	0.00	0.00	0.02	0.00	0.91
PFMPA		0.00	0.00	0.00	0.00	0.00	0.00	0.00
PFPeA		0.00	0.04	0.03	0.00	0.00	0.13	0.01
PFMBA		0.00	0.00	0.00	0.00	0.00	0.00	0.00
HFPO-DA		0.01	0.00	0.00	0.00	0.00	0.00	0.12
4-2 FTS		0.00	0.00	0.00	0.00	0.00	0.00	0.00
NFDHA		0.00	0.00	0.00	0.00	0.00	0.00	0.01
PFHxA		0.03	0.04	0.02	0.00	0.00	0.00	0.00
PFBS		0.00	0.00	0.00	0.00	0.00	0.00	0.00
5-3 FTCA		0.03	0.00	0.00	0.00	0.00	0.00	0.00
PFHpA		0.00	0.02	0.00	0.02	0.01	0.00	0.00
PFEESA		0.00	0.00	0.00	0.00	0.00	0.00	0.00

Various Blanks EPA 1633

		ch.1	ch.2	ch.3	ch.4	ch.5	stopcock	sample bottle
Name		Calc. Conc.	Calc. Conc.	Calc. Conc.	Calc. Conc.	Calc. Conc.	Calc. Conc.	Calc. Conc.
ADONA		0.00	0.00	0.00	0.00	0.00	0.00	0.00
PFPeS		0.00	0.00	0.00	0.00	0.00	0.00	0.00
PFOA		0.03	0.01	0.02	0.02	0.00	0.28	0.01
PFNA		0.02	0.03	0.01	0.03	0.05	0.00	0.01
8-2 FTS		0.01	0.00	0.00	0.02	0.01	0.00	0.00
PFDA		0.02	0.02	0.03	0.01	0.02	0.04	0.00
PFDoS		0.00	0.00	0.00	0.00	0.00	0.00	0.00
PFOS		0.03	0.02	0.04	0.02	0.01	0.03	0.05
6-2 FTS		0.01	0.00	0.00	0.00	0.00	0.00	0.02
PFHxS		0.00	0.00	0.01	0.03	0.03	0.05	0.06
PFTrDA		0.01	0.00	0.00	0.04	0.04	0.00	0.03
N-EtFOSAA		0.00	0.00	0.00	0.00	0.00	0.00	0.00
PFHpS		0.00	0.00	0.02	0.03	0.03	0.00	0.00

Various Blanks EPA 1633

	ch.1	ch.2	ch.3	ch.4	ch.5	stopcock	sample bottle
Name	Calc. Conc.	Calc. Conc.	Calc. Conc.	Calc. Conc.	Calc. Conc.	Calc. Conc.	Calc. Conc.
N-MeFOSAA	0.00	0.00	0.00	0.02	0.00	0.00	0.00
PFNS	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7-3 FTCA	0.00	0.00	0.00	0.00	0.01	0.00	0.01
9Cl-PF3ONS	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11Cl-PF3OUdS	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PFDoA	0.01	0.00	0.00	0.03	0.02	0.03	0.00
PFUnA	0.00	0.00	0.00	0.00	0.04	0.00	0.04
PFTDA	0.00	0.01	0.00	0.01	0.00	0.04	0.00
PFDS	0.00	0.00	0.00	0.00	0.00	0.00	0.01
PFOSA	0.02	0.00	0.00	0.02	0.03	0.01	0.00
MeFOSE	0.00	0.00	0.00	0.00	0.00	0.01	0.00
EtFOSE	0.00	0.00	0.00	0.00	0.00	0.00	0.00
N-MeFOSA	0.00	0.00	0.00	0.00	0.00	0.00	0.00
N-EtFOSA	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Sample Analysis Work Flow

Automated Sample Prep Time = 80 Minutes

Solid Phase Extraction

35 Minutes

Concentration

45 Minutes

Solid Phase Extraction

35 Minutes

Semi Automated Sample Prep Time = 80 Minutes

Reasons for Semi-Automated SPE

- **Closed System**
- **12 samples in parallel**
- **Reduced Actions / Easy to Use**
- **Simplified procedures**
- **Semi-Automated versus Manual protocols = Reproducibility**
- **Increased Sample Throughput**
- **Low cost compared to Automated solutions**

Objective for Semi Automation

- **Incorporate automated system capabilities to the semi-automated platform.**
- **Our goal is to establish several Standard Operating Procedures (SOPs) for the testing lab through the utilization of a solitary extraction platform.**
- **In order to optimize time and minimize mistakes, it is crucial to decrease the amount of manual steps involved.**

FMS
Fluid Management Systems

Goal

- **Low Cost**
  - Extract and Concentrate a batch of 24 samples 2 to 3 hours
- **Self Installable**
  - Unpacking and Installation/training video
- **Easy to Operate**
  - No Computers or Electronics to fail or maintain
- **Semi - Automated**
  - Hyphenates the entire Solid Phase Extraction Process – Extraction, Bottle Rinse, Inline Drying and Direct to 15ml Centrifuge tube for easy Concentration
- **Fast**
  - The fastest sample processing available for SPE
  - Run up to 12 samples simultaneously
  - Vacuum for fast loading of large volume samples
  - Unattended Sample loading walkaway time
- **Closed system**
  - Eliminate potential outside contamination

FMS
Fluid Management Systems

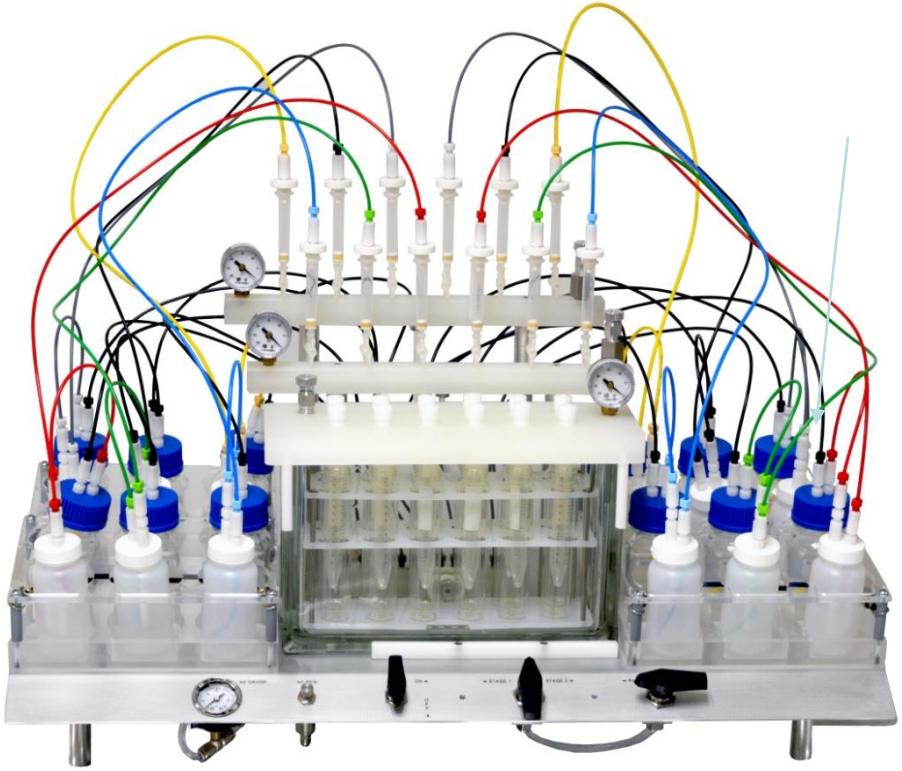
Goal

- **Efficient**
  - Uses all SPE cartridge sizes
  - Dedicated manifold for cartridge conditioning and sample loading
  - Dedicated manifold for extraction and extracts
  - Separates Organic from Aqueous waste
  - Vacuum cartridge drying, Nitrogen cartridge drying or combined
  - Automated Bottle Rinse and Elution
  - Inline Extract Drying
  - Small number of components to clean

- **Low Capital Expense**

EZPFC®

Drinking Water,
Wastewater,
Particulate laden samples



EZPFC 12 sample

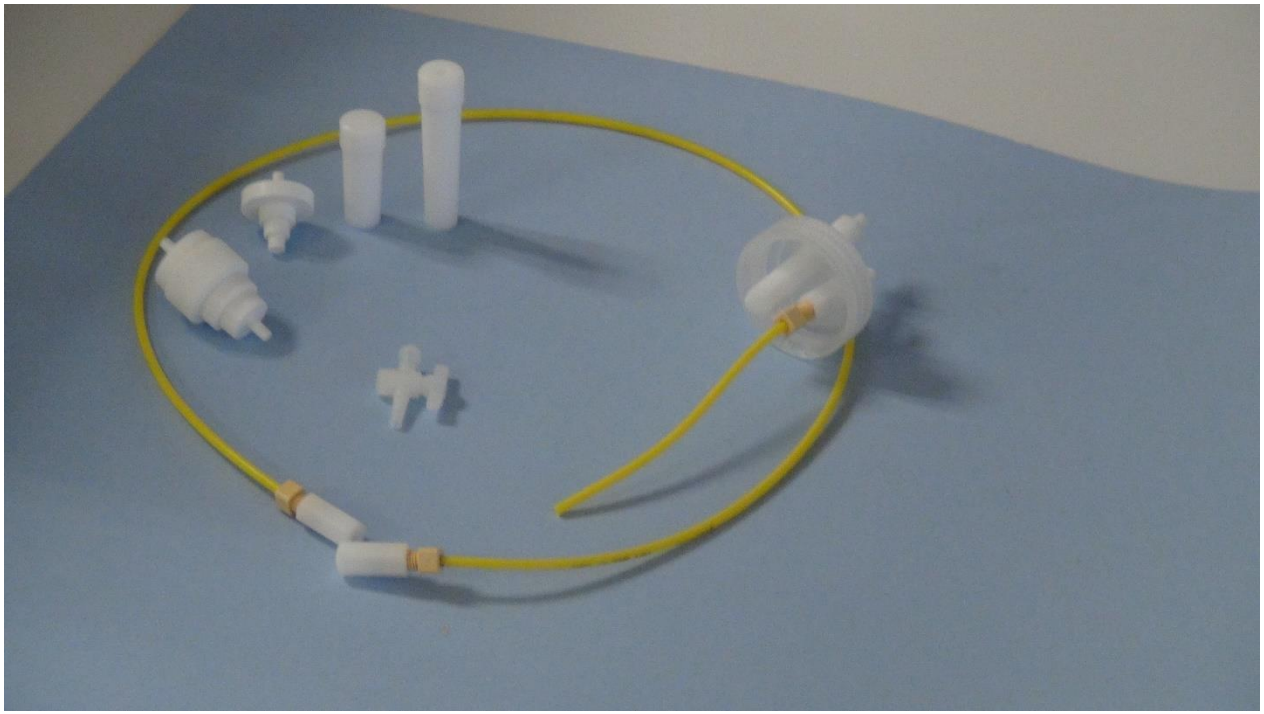
System Components

No Teflon

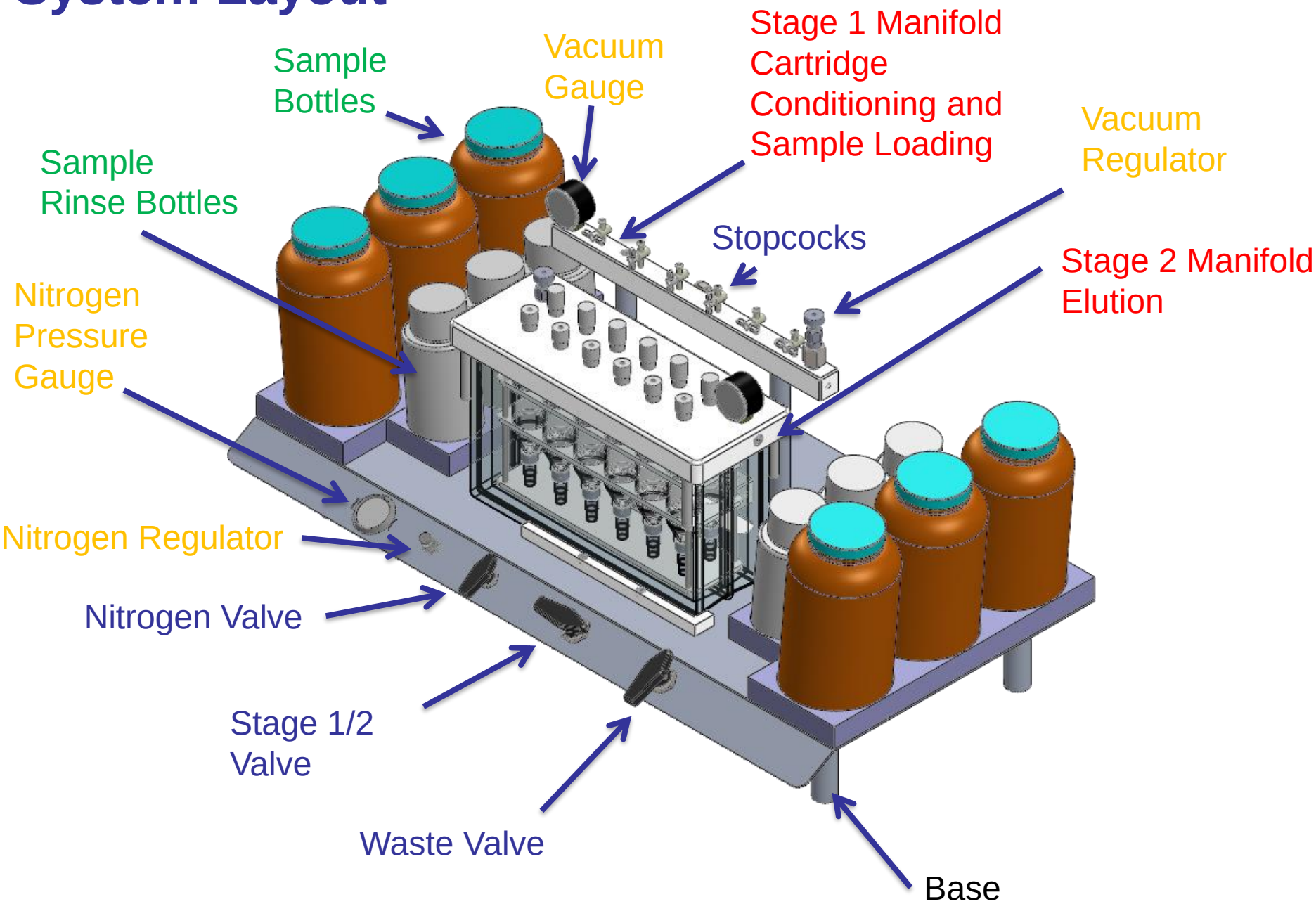
Tubing - High Density Polyethylene

Fittings – Delrin

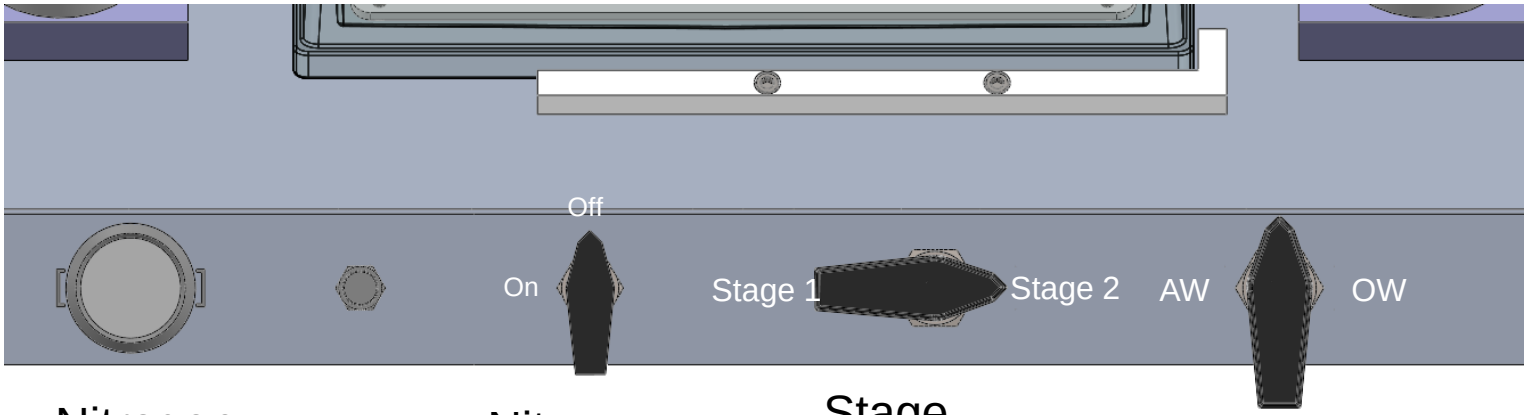
Cartridge Adapters – Medical Grade Polypropylene



System Layout



Control Valve Layout



Nitrogen Gauge

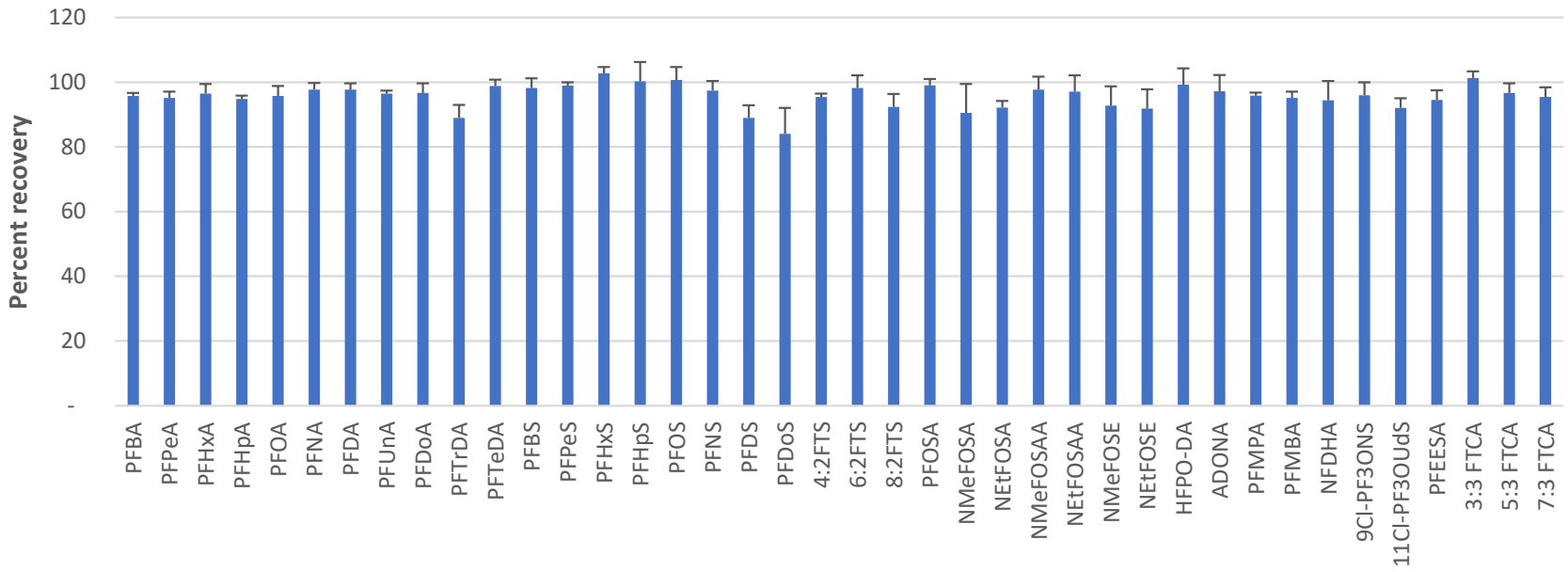
Nitrogen Valve

Stage 1/2 Valve

Waste Valve

EPA 1633

EZPFC



Automated Concentration for PFAs

- SuperVap PFC
  - 24 positions
  - 15ml Conical vials
  - Timed Endpoint

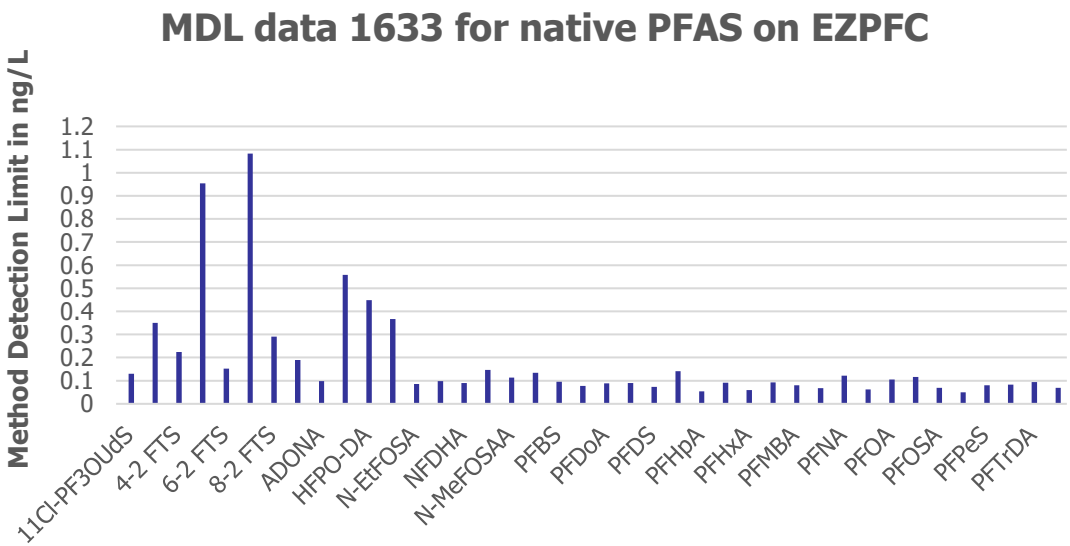
1633 EZPFC labeled surrogate recoveries

Surrogate Recovery with EZPFC				
1633 order	230131 RT Order	Surrogate	EZPFC Avg Recovery	EZPFC %RSD
1	1	13C4-PFBA	111	6%
2	2	13C5-PFPeA	116	6%
3	4	13C5-PFHxA	110	6%
4	7	13C4-PFHpA	110	7%
5	9	13C8-PFOA	107	6%
6	11	13C9-PFNA	109	8%
7	13	13C6-PFDA	106	9%
8	17	13C7-PFUnA	104	10%
9	18	13C2-PFDoA	93	10%
10	19	13C2-PFTeDA	83	12%
11	5	13C3-PFBS	106	6%
12	10	13C3-PFHxS	105	11%
13	16	13C8-PFOS	110	8%
14	3	13C2-4:2FTS	99	15%
15	8	13C2-6:2FTS	97	16%
16	12	13C2-8:2FTS	105	19%
17	20	13C8-PFOSA	142	15%
18	22	D3-NMeFOSA	114	12%
19	24	D5-NEtFOSA	70	16%
20	14	D3-NMeFOSAA	103	9%
21	15	D5-NEtFOSAA	111	14%
22	21	D7-NMeFOSE	87	6%
23	23	D9-NEtFOSE	76	10%
24	6	13C3-HFPO-DA	111	7%

1633 natives IDC spikes concentrations and recoveries

		In ng/L				Native spike recovered (%)						
Name	Target Amount ng/L	IDC-1	IDC-2	IDC-3	IDC-4	IDC-1	IDC-2	IDC-3	IDC-4	Average	STDEV	RSD(%)
11Cl-PF3OUdS	8.7	8.69	8.39	8.78	9.04	100	97	101	104	100	3.1	3.1
3-3 FTCA	9.7	8.21	9.66	9.45	9.26	84	99	97	95	94	6.6	7.0
4-2 FTS	9.6	9.53	9.39	8.96	8.84	99	98	93	92	96	3.4	3.6
5-3 FTCA	52.0	48.65	52.44	52.01	52.74	94	101	100	101	99	3.7	3.7
6-2 FTS	9.7	9.20	9.53	9.38	9.48	95	98	97	98	97	1.5	1.5
7-3 FTCA	49.6	45.57	48.85	50.91	50.80	92	98	103	102	99	5.0	5.1
8-2 FTS	10.0	8.65	9.39	10.08	9.85	86	93	100	98	94	6.3	6.7
9Cl-PF3ONS	9.4	9.60	9.00	9.35	9.30	103	96	100	99	100	2.6	2.6
ADONA	8.0	8.25	7.73	8.26	8.03	103	96	103	100	100	3.1	3.1
EtFOSE	23.9	22.60	22.30	25.24	24.09	95	93	106	101	99	5.7	5.8
HFPO-DA	9.3	9.31	9.34	9.24	9.34	100	100	99	100	100	0.5	0.5
MeFOSE	21.6	21.94	22.76	23.26	22.26	102	106	108	103	105	2.7	2.6
N-EtFOSA	2.0	2.25	1.84	2.04	2.19	113	92	102	110	104	9.2	8.8
N-EtFOSAA	2.3	2.04	1.99	2.19	2.33	91	89	97	103	95	6.6	7.0
NFDHA	5.2	4.51	4.76	4.97	4.86	87	92	96	94	92	3.8	4.1
N-MeFOSA	2.4	2.26	1.95	2.33	2.27	95	82	98	96	93	7.2	7.8
N-MeFOSAA	2.3	2.09	2.21	2.23	2.45	93	98	99	109	100	6.7	6.7
PFBA	8.6	8.07	10.17	9.14	9.09	94	118	106	106	106	10.0	9.4
PFBS	2.2	2.08	2.06	2.18	2.21	93	91	97	98	95	3.4	3.6
PFDA	1.9	2.13	2.01	2.05	2.17	109	103	105	111	107	3.7	3.5
PFDoA	2.3	2.11	2.30	2.20	2.45	92	100	96	106	98	6.2	6.3
PFDoS	2.0	1.32	1.55	1.50	1.52	68	79	77	77	75	5.1	6.8
PFDS	1.9	2.15	1.90	1.81	2.14	112	99	94	111	104	8.8	8.5
PFEESA	5.2	4.91	5.12	5.39	5.41	94	97	103	103	99	4.6	4.6
PFHpA	2.1	1.91	2.26	2.00	2.19	91	107	95	104	99	7.8	7.8
PFHpS	2.0	2.24	2.19	2.08	2.24	110	108	102	110	108	3.7	3.5
PFHxA	2.2	2.01	2.12	2.22	2.17	94	99	103	101	99	4.1	4.2
PFHxS	2.2	1.94	1.93	2.11	2.13	90	89	98	99	94	5.0	5.3
PFMBA	4.5	4.51	4.55	4.60	5.21	100	100	101	115	104	7.2	6.9
PFMPA	4.2	3.56	4.01	4.10	3.62	85	96	98	87	92	6.6	7.2
PFNA	2.2	1.78	2.07	2.03	2.41	80	93	91	108	93	11.6	12.4
PFNS	2.0	1.93	2.00	1.83	2.24	98	101	93	114	101	8.8	8.7
PFOA	2.3	1.99	2.21	2.25	2.31	85	95	96	99	94	6.0	6.4
PFOS	1.8	2.10	1.94	2.09	2.16	116	108	116	120	115	5.1	4.4
PFOSA	2.2	2.09	2.22	2.11	2.17	97	103	98	101	100	2.7	2.7
PFPeA	4.3	4.05	4.23	4.37	4.52	95	99	103	106	101	4.7	4.6
PFPeS	2.1	1.97	2.07	2.11	1.97	94	98	100	94	97	3.3	3.5
PFTDA	2.3	1.97	1.93	2.00	2.27	86	84	87	99	89	6.9	7.7
PFTrDA	2.2	2.48	2.41	2.85	2.57	113	110	130	117	118	8.8	7.5
PFUnA	2.2	1.99	2.11	2.07	2.14	92	97	95	98	96	2.9	3.1

MDL data for native PFAS 1633



Method Detection Limit data for 1633

Compound Method		In ng/L														
Name	Tareget Amount ng/L	MDL-1	MDL-2	MDL-3	MDL-4	MDL-5	MDL-6	MDL-7	MDL-8	MDL-9	MDL-10	MDL-11	MDL-12		STDEV		MDL
11Cl-PF3OUdS	1.00	0.9757	0.8461	0.8848	0.8676	0.903	0.9562	0.9295	1.001	0.9269	0.8606	0.8928	0.8952		0.05		0.13
3-3 FTCA	1.16	1.1076	1.0061	1.0523	0.7624	1.008	1.0535	0.8077	1.1272	0.8627	0.8681	1.1234	1.0782		0.13		0.35
4-2 FTS	1.31	1.2138	1.2403	1.2292	1.12	1.1484	1.3895	1.2266	1.3185	1.1732	1.1413	1.3365	1.2441		0.08		0.22
5-3 FTCA	6.26	6.4841	5.9048	5.5367	5.5774	6.0513	5.9923	5.4599	5.3063	5.4973	6.0996	5.6657	6.1143		0.35		0.95
6-2 FTS	1.21	1.2059	1.1808	1.1303	1.1957	1.203	1.2985	1.2592	1.1853	1.2621	1.1807	1.1687	1.3155		0.06		0.15
7-3 FTCA	6.34	6.367	6.1878	5.4119	5.3315	6.0653	6.2616	6.213	5.8661	5.2776	6.2892	6.0647	6.234		0.40		1.08
8-2 FTS	1.33	1.2039	1.299	1.2643	1.389	1.317	1.1943	1.5686	1.2324	1.2724	1.2325	1.3068	1.4187		0.11		0.29
9Cl-PF3ONS	1.09	1.1451	0.9936	1.0535	0.9826	1.0667	1.0434	0.9971	1.0751	1.1198	1.0277	0.9342	1.1701		0.07		0.19
ADONA	0.89	0.9331	0.8955	0.9211	0.8563	0.8665	0.9005	0.8241	0.8555	0.8582	0.8953	0.8385	0.9277		0.04		0.10
EtFOSE	3.06	3.1171	2.9492	2.8939	2.8205	2.7337	2.9667	3.0383	2.9994	3.5478	2.9956	3.1121	3.1652		0.21		0.56
HFPO-DA	1.16	1.1641	1.3673	1.5113	1.0828	1.0109	1.0609	1.1359	1.3796	1.1205	1.2871	0.9968	1.0701		0.17		0.45
MeFOSE	3.00	2.5702	2.7387	2.6963	2.6539	2.8431	2.9566	2.7913	2.9272	2.8156	2.5827	2.5617	2.8164		0.14		0.37
N-EtFOSA	0.27	0.3248	0.2129	0.2622	0.2651	0.2489	0.2446	0.2385	0.2225	0.2738	0.2605	0.2469	0.3043		0.03		0.09
N-EtFOSAA	0.30	0.2845	0.2739	0.2375	0.2527	0.2837	0.2303	0.2095	0.2888	0.3021	0.2625	0.2115	0.3256		0.04		0.10
NFDHA	0.64	0.6186	0.619	0.5583	0.6562	0.6746	0.5904	0.5982	0.6066	0.574	0.5886	0.5884	0.625		0.03		0.09
N-MeFOSA	0.31	0.2471	0.3268	0.2514	0.2368	0.2816	0.3739	0.2901	0.3545	0.3193	0.232	0.3859	0.3278		0.05		0.15
N-MeFOSAA	0.28	0.3117	0.2472	0.2321	0.2977	0.2384	0.2612	0.2864	0.2534	0.2638	0.3746	0.2339	0.3021		0.04		0.11
PFBA	1.08	1.0962	1.159	1.1025	1.0075	1.1083	1.1955	1.173	1.1283	1.1204	1.1415	1.172	1.1056		0.05		0.13
PFBS	0.28	0.3285	0.2689	0.2388	0.2611	0.2751	0.3131	0.221	0.3002	0.2619	0.319	0.2321	0.2757		0.03		0.09
PFDA	0.27	0.2506	0.2909	0.2361	0.2176	0.2595	0.2759	0.2616	0.3261	0.2425	0.2495	0.2792	0.2476		0.03		0.08
PFDoA	0.29	0.3323	0.2606	0.2292	0.2169	0.2683	0.2693	0.2342	0.209	0.2512	0.2323	0.2593	0.2436		0.03		0.09
PFDoS	0.29	0.2192	0.256	0.2896	0.2259	0.2232	0.267	0.2175	0.2738	0.2151	0.2079	0.2143	0.3014		0.03		0.09
PFDS	0.25	0.2301	0.1757	0.1765	0.2025	0.2176	0.2154	0.2466	0.2313	0.1801	0.2055	0.2559	0.2347		0.03		0.07
PFEESA	0.69	0.7128	0.6682	0.6493	0.5944	0.6329	0.7684	0.6109	0.6574	0.5812	0.6736	0.622	0.6703		0.05		0.14
PFHpA	0.26	0.2297	0.2846	0.2933	0.2427	0.2696	0.251	0.2392	0.2503	0.2656	0.28	0.2552	0.2479		0.02		0.05
PFHpS	0.28	0.2574	0.2908	0.326	0.2877	0.2886	0.3607	0.2466	0.2722	0.2683	0.3081	0.3061	0.2464		0.03		0.09
PFHxA	0.28	0.2897	0.2576	0.2562	0.2579	0.2552	0.2902	0.2793	0.3301	0.2716	0.2875	0.2799	0.2912		0.02		0.06
PFHxS	0.28	0.2227	0.3127	0.2622	0.246	0.2643	0.2726	0.3009	0.2923	0.2666	0.1995	0.2697	0.3092		0.03		0.09
PFMBA	0.54	0.539	0.5606	0.5443	0.5149	0.5315	0.574	0.5406	0.6259	0.5466	0.5749	0.5672	0.5869		0.03		0.08
PFMPA	0.50	0.4847	0.4793	0.4858	0.4529	0.4525	0.5001	0.4696	0.4255	0.4639	0.4289	0.4308	0.4424		0.02		0.07
PFNA	0.27	0.2852	0.3358	0.2602	0.2634	0.238	0.3386	0.3071	0.3041	0.1958	0.2127	0.2647	0.2618		0.04		0.12
PFNS	0.26	0.2396	0.2515	0.2648	0.2273	0.2186	0.2847	0.2626	0.2727	0.2753	0.2247	0.2501	0.2831		0.02		0.06
PFOA	0.30	0.261	0.2558	0.1974	0.2901	0.2698	0.2128	0.2429	0.2625	0.2844	0.3486	0.2896	0.2675		0.04		0.11
PFOS	0.26	0.3029	0.2816	0.2597	0.2627	0.2448	0.3093	0.2937	0.2765	0.2633	0.2575	0.4074	0.2837		0.04		0.12
PFOSA	0.28	0.2943	0.2071	0.2477	0.2558	0.2722	0.2591	0.274	0.2944	0.2621	0.2323	0.2797	0.2812		0.03		0.07
PFPeA	0.53	0.5197	0.5177	0.5318	0.4851	0.5124	0.5336	0.5397	0.5596	0.5282	0.5379	0.5188	0.5156		0.02		0.05
PFPeS	0.25	0.3187	0.3015	0.2294	0.2379	0.2541	0.2346	0.2725	0.2498	0.3018	0.2523	0.2528	0.2857		0.03		0.08
PFTDA	0.30	0.2558	0.2445	0.2144	0.2632	0.2519	0.2855	0.3153	0.3078	0.3042	0.2542	0.2394	0.2742		0.03		0.08
PFTrDA	0.26	0.2658	0.2708	0.2303	0.2448	0.3257	0.2801	0.2462	0.2674	0.3147	0.2731	0.3081	0.3411		0.03		0.09
PFUnA	0.29	0.2569	0.2504	0.2495	0.2524	0.2639	0.2939	0.2639	0.2902	0.2471	0.1995	0.2852	0.2803		0.03		0.07

Native PFAS 1633 in tap water from two locations

Compound Method	Tap Water location 1	Tap Water location 1	Tap Water location 1	Tap Water location 1	Tap Water location 1	Tap water location 2	Tap water location 2	Tap water location 2
Name	Final Conc.-01 ng/L	Final Conc.-02 ng/L	Final Conc.-03 ng/L	Final Conc.-04 ng/L	Final Conc.-05 ng/L	Final Conc.-01 ng/L	Final Conc.-02 ng/L	Final Conc.-03 ng/L
11Cl-PF3OUdS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3-3 FTCA	0.0000	0.0000	0.0000	0.0000	0.0000	0.0234	0.0000	0.0000
4-2 FTS	0.0146	0.0446	0.0330	0.0268	0.0156	0.0908	0.1206	0.2044
5-3 FTCA	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
6-2 FTS	0.1434	0.1154	0.0282	0.0950	0.0798	24.7672	17.3236	86.8058
7-3 FTCA	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
8-2 FTS	0.0000	0.0000	0.0000	0.0000	0.0202	0.0000	0.0000	0.0000
9Cl-PF3ONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ADONA	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
EtFOSE	0.0882	0.2222	0.1464	0.0848	0.1984	0.1234	0.0928	0.0736
HFPO-DA	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
MeFOSE	0.1272	0.1502	0.0666	0.1212	0.0862	0.0642	0.0994	0.0412
N-EtFOSA	0.0000	0.0000	0.0000	0.0134	0.0000	0.0000	0.0000	0.0000
N-EtFOSAA	0.0000	0.0000	0.0000	0.0000	0.0000	0.0236	0.0152	0.0000
NFDHA	0.0070	0.0192	0.0152	0.0182	0.0078	0.0072	0.0234	0.0196
N-MeFOSA	0.0294	0.0036	0.0094	0.0000	0.0356	0.0000	0.0090	0.0154
N-MeFOSAA	0.0000	0.0000	0.0000	0.0064	0.0116	0.0000	0.0000	0.0000
PFBA	1.5770	1.3316	1.3872	1.4132	1.4016	1.1606	1.3030	1.4006
PFBS	1.6218	1.2796	1.2782	1.4984	1.4660	1.4100	1.1902	1.4956
PFDA	0.0718	0.0974	0.0890	0.0626	0.0706	0.0000	0.0000	0.0000
PFDoA	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PFDoS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PFDS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PFEESA	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PFHpA	1.0702	0.9342	0.9920	0.9988	0.8530	0.8032	0.8514	0.8058
PFHpS	0.0212	0.0272	0.0342	0.0116	0.0000	0.0292	0.0414	0.0332
PFHxA	1.8204	1.7654	1.7784	1.8550	1.7464	1.0906	1.2070	1.2286
PFHxS	0.7156	0.6920	0.6024	0.9908	0.8098	1.1624	1.2360	1.0748
PFMBA	0.0054	0.0022	0.0064	0.0056	0.0000	0.0022	0.0036	0.0040
PFMPA	0.0014	0.0058	0.0046	0.0052	0.0010	0.0038	0.0044	0.0060
PFNA	0.4840	0.2624	0.2900	0.3934	0.4108	0.2682	0.2684	0.0964
PFNS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PFOA	2.1128	1.7522	1.7848	1.6276	1.8030	1.5536	1.9654	1.8556
PFOS	0.9254	0.8520	0.8944	0.8462	1.0024	0.9536	0.9838	1.2636
PFOSA	0.0348	0.0130	0.0268	0.0188	0.0030	0.0256	0.0304	0.0560
PFPeA	1.9106	1.6546	1.7258	1.7332	1.6934	1.3638	1.3744	1.4148
PFPeS	0.1314	0.1322	0.0982	0.1312	0.1380	0.3302	0.1154	0.3052
PFTDA	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PFTrDA	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PFUnA	0.0416	0.0584	0.0396	0.0244	0.0352	0.0000	0.0000	0.0000

Native PFAS 1633 in River Water

Compound Method Name	River Water Final Conc. ng/L	River Water Final Conc. ng/L	River Water Final Conc. ng/L
11Cl-PF3OUdS	0.0000	0.0000	0.0000
3-3 FTCA	0.0000	0.0000	0.0000
4-2 FTS	0.1414	0.5982	0.1840
5-3 FTCA	0.0000	0.0000	0.0000
6-2 FTS	49.0880	143.2002	54.1156
7-3 FTCA	0.0000	0.0000	0.0000
8-2 FTS	0.0000	0.0000	0.0000
9Cl-PF3ONS	0.0000	0.0000	0.0000
ADONA	0.0000	0.0000	0.0000
EtFOSE	0.0484	0.0254	0.0000
HFPO-DA	0.0000	0.0000	0.0000
MeFOSE	0.0368	0.0388	0.0358
N-EtFOSA	0.0000	0.0000	0.0000
N-EtFOSAA	0.1178	0.0052	0.1104
NFDHA	0.0046	0.0194	0.0124
N-MeFOSA	0.0116	0.0000	0.0030
N-MeFOSAA	0.0752	0.0482	0.0472
PFBA	1.2922	1.3166	1.5178
PFBS	2.4348	2.3022	3.0300
PFDA	0.2762	0.0490	0.2702
PFDoA	0.0000	0.0000	0.0000
PFDoS	0.0000	0.0000	0.0000
PFDS	0.0000	0.0000	0.0000
PFEESA	0.0000	0.0000	0.0000
PFHpA	1.0380	1.2252	1.2282
PFHpS	0.0738	0.0352	0.0638
PFHxA	1.9908	2.1192	2.4204
PFHxS	1.6712	1.6714	2.2346
PFMBA	0.0000	0.0000	0.0000
PFMPA	0.0000	0.0000	0.0048
PFNA	0.3328	0.3946	0.4566
PFNS	0.0000	0.0000	0.0000
PFOA	2.8638	2.7774	3.2582
PFOS	6.0952	3.3096	8.5638
PFOSA	0.0226	0.0262	0.0490
PFPeA	1.8224	1.9592	2.1968
PFPeS	0.2370	0.1780	0.2588
PFTDA	0.0000	0.0000	0.0000
PFTrDA	0.0000	0.0000	0.0000
PFUnA	0.0402	0.0278	0.0496

Native PFAS 1633 in Well Water

Compound Method	Well water-1	Well water-2	Well water-3
Name ng/L	Final Conc. ng/L	Final Conc. ng/L	Final Conc. ng/L
11Cl-PF3OUdS	0.00	0.00	0.00
3-3 FTCA	0.04	0.00	0.00
4-2 FTS	0.19	0.15	0.12
5-3 FTCA	0.00	0.00	0.00
6-2 FTS	38.72	26.24	7.79
7-3 FTCA	0.00	0.00	0.00
8-2 FTS	0.00	0.00	0.00
9Cl-PF3ONS	0.00	0.00	0.00
ADONA	0.00	0.00	0.00
EtFOSE	0.02	0.00	0.00
HFPO-DA	0.05	0.03	0.02
MeFOSE	0.02	0.02	0.02
N-EtFOSA	0.00	0.00	0.01
N-EtFOSAA	0.00	0.00	0.01
NFDHA	0.00	0.01	0.00
N-MeFOSA	0.00	0.00	0.00
N-MeFOSAA	0.00	0.00	0.00
PFBA	1.55	1.70	1.54
PFBS	1.32	1.41	1.32
PFDA	0.04	0.06	0.05
PFDoA	0.00	0.00	0.00
PFDoS	0.00	0.00	0.00
PFDS	0.00	0.00	0.00
PFEESA	0.00	0.00	0.00
PFHpA	0.81	0.88	0.92
PFHpS	0.03	0.05	0.02
PFHxA	1.97	1.92	1.96
PFHxS	0.93	1.14	1.11
PFMBA	0.00	0.00	0.00
PFMPA	0.00	0.00	0.00
PFNA	0.16	0.10	0.18
PFNS	0.00	0.00	0.00
PFOA	3.93	3.41	3.93
PFOS	0.40	0.46	0.41
PFOSA	0.00	0.00	0.02
PFPeA	1.70	1.76	1.77
PFPeS	0.12	0.11	0.12
PFTDA	0.00	0.00	0.00
PFTrDA	0.00	0.00	0.00
PFUnA	0.00	0.00	0.00

Semi-Automated SPE in Summary

- **EZPFC and SuperVap systems are easy to use and install**
  - **Complete Water Sample Prep Workflow**
- **Low cost, High throughput, Low maintenance solution**
- **EZPFC Extractions and Concentration**
  - **Closed System Reduces Contamination**
  - **Reduces Human error**

FMS
Fluid Management Systems

Summary

- **FMS semi-automated SPE and SuperVap systems deliver consistent, reproducible results**
- **Handles a wide range of Sample sizes and matrix types**
- **Uses all SPE Cartridge sizes**
- **Comply with existing methods that require vacuum, positive pressure and precise delivery of sample and solvents**

Summary

Automated SPE for PFAS

- **TurboTrace**
  - Fully automated, Vacuum pump for loading "dirty samples", automated bottle rinse,
  - Direct delivery to SuperVap Concentrator

Semi Automated SPE for PFAS

- **EZPFC**
  - 2 EZPFC 12 position systems and the SuperVap PFC Concentrator for 24 samples
  - Run a batch of 24 in 2 hours

Questions

Come see us at booth # 3233

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