*Application Note*

# Analysis of Per- and Polyfluoroalkyl Substances in Wastewater Using EPA Method 1633 with Improved Automated Solid Phase Extraction - Turbo Trace PFC

Per- and polyfluoroalkyl substances (PFAS) constitute a group of compounds characterized by perfluorinated or polyfluorinated carbon chain moieties, typically denoted by structures such as F(CF2)n or F(CF2)n-(C2H4)n. Due to their unique properties, these substances have found extensive application in various industrial and consumer products.

Many industrial and consumer applications utilize perfluorooctane sulfonate (PFOS) and other PFAS compounds. These include but are not limited to, stain-resistant coatings for textiles, leather, and carpets; grease-proof coatings for food-contact paper products; firefighting foams; surfactants for mining and oil-well operations; floor polishes; and insecticide formulations. Their widespread usage has led to their ubiquitous presence in the environment.

In recent years, mounting concerns have emerged regarding the widespread distribution and potential adverse effects of PFAS, particularly notable compounds like PFOS and perfluorooctanoic acid (PFOA). These concerns have prompted intensified scrutiny of these substances' environmental occurrence, fate, and potential impacts.

Recent developments in the United States have led to the introduction of EPA method 1633, which addresses the need for robust methodologies to monitor and analyze PFAS. This method, unveiled in early 2024, enables comprehensive analysis across various matrices, including wastewater, surface water, groundwater, soil, biosolids, sediment, landfill leachate, and fish tissue. EPA Method 1633 represents a significant advancement in the analytical toolkit for assessing PFAS contamination and understanding their distribution and behavior in diverse environmental compartments.

**Instrumentation**

- FMS Turbo Trace PFC™ System The system is modular in nature and can be extended to a total of 4 modules for a total of 8 samples processed in parallel.
- Vacuum pump
- Agilent 6475 TripleQuad LC/MS

**Consumables**

- Agilent Bond Elut PFAS WAX 150mg cartridges (# 5610-2150)
- Ultrapure DI water
- Methanol pesticide grade
- Ammonium hydroxide
- Formic acid
- Relevant PFAS spiking standards

**Method**

- Eight synthetic wastewater samples (500 mL) spiked with native PFAS standards and relevant internals
- Load sample bottles onto system and install cartridges
- Rinse bottles are automatically filled during procedure
- Use positive pressure (nitrogen) for pumping solvents and mixes through the system and use vacuum to load the samples
- Condition cartridges with 15 mL 1% methanolic ammonium hydroxide followed by 5 mL of 0.3M formic acid.
- Load samples across the cartridges at 5-10 mL/min (vacuum ~ 8-inch Hg)
- Sample bottles rinsed with 5 mL reagent water (twice) followed by 5 mL of 1:1 0.1M formic acid/methanol and load rinses across the cartridges
- Dry 10 min
- Rinse sample bottles with 5 mL 1% methanolic ammonium hydroxide
- Load rinses across cartridges and collect in polypropylene tubes
- Cleanup over 10 mg of loose carbon
- As per the method no further concentration is carried out.
- Further relevant standards were added prior to LC/MS analysis.

FMS
Fluid Management Systems

**Analysis**

■ Take aliquot from final 5 mL extract (Method 1633 does not require volume reduction of final extract)
■ Agilent 1290 Infinity II LC System
■ Agilent 6475 Triple quad LC/MS
■ Agilent Zorbax Eclipse Plus C18 column 3.0 x 50 mm, 1.8 um
■ Column temperature 40 °C
■ Injection 5.0 uL
■ Mobile phase 5 mM ammonium acetate in 95% water, 5% acetonitrile (A) and methanol (B)
■ Gradient
  0 min  98% A 2% B
  0.2 min 98% A 2% B
  10 min 5% a 95% B
■ Stop time 12.2 min
■ Dynamic MRM negative electrospray
■ T (gas) = 230 °C
■ T (sheath) = 355 °C


Turbo Trace PFC System

| Compound Name | ECONO-SPE-IDC-1 Final Conc. | ECONO-SPE-IDC-2 Final Conc. | ECONO-SPE-IDC-3 Final Conc. | ECONO-SPE-IDC-4 Final Conc. | Window | RSD(%) |
|---|---|---|---|---|---|---|
| 11Cl-PF3OUdS | 87.1 | 89.2 | 82.3 | 88.9 | 50-150 | 3.7 |
| 3-3 FTCA | 98.1 | 98.6 | 85.9 | 91.2 | 70-130 | 6.5 |
| 4-2 FTS | 90.3 | 93.6 | 94.1 | 91.3 | 70-135 | 2.0 |
| 5-3 FTCA | 99.6 | 105.2 | 92.6 | 95.2 | 70-130 | 5.6 |
| 6-2 FTS | 95.0 | 104.4 | 90.0 | 97.4 | 70-135 | 6.2 |
| 7-3 FTCA | 101.0 | 102.5 | 89.1 | 88.5 | 55-130 | 7.9 |
| 8-2 FTS | 100.2 | 104.3 | 87.6 | 95.2 | 70-140 | 7.4 |
| 9Cl-PF3ONS | 95.2 | 105.0 | 93.2 | 99.5 | 70-145 | 5.3 |
| ADONA | 96.4 | 101.4 | 91.0 | 95.0 | 70-135 | 4.5 |
| EtFOSE | 85.1 | 87.2 | 86.9 | 87.4 | 70-130 | 1.2 |
| HFPO-DA | 106.4 | 100.1 | 83.9 | 96.8 | 70-135 | 9.8 |
| MeFOSE | 84.7 | 86.9 | 89.5 | 84.8 | 70-135 | 2.6 |
| N-EtFOSA | 100.3 | 99.2 | 102.8 | 97.2 | 70-135 | 2.4 |
| N-EtFOSAA | 80.0 | 87.1 | 96.0 | 90.1 | 70-135 | 7.6 |
| NFDHA | 103.3 | 103.8 | 92.9 | 99.0 | 65-140 | 5.0 |
| N-MeFOSA | 91.1 | 112.2 | 97.7 | 85.5 | 70-135 | 11.9 |
| N-MeFOSAA | 91.0 | 82.2 | 86.0 | 94.6 | 65-140 | 6.2 |
| PFBA | 98.9 | 99.1 | 92.9 | 96.6 | 70-135 | 3.0 |
| PFBS | 90.2 | 100.5 | 90.8 | 91.4 | 70-140 | 5.2 |
| PFDA | 90.4 | 101.5 | 94.1 | 88.8 | 65-140 | 6.0 |
| PFDoA | 80.5 | 90.3 | 86.4 | 91.0 | 70-130 | 5.5 |
| PFDoS | 80.3 | 83.7 | 87.0 | 92.5 | 45-135 | 6.1 |
| PFDS | 83.2 | 93.8 | 84.4 | 86.0 | 70-135 | 5.5 |
| PFEESA | 102.2 | 105.7 | 91.9 | 97.2 | 70-135 | 6.1 |
| PFHpA | 95.6 | 105.2 | 89.8 | 91.4 | 70-135 | 7.3 |
| PFHpS | 111.3 | 104.6 | 101.5 | 94.2 | 70-140 | 6.9 |
| PFHxA | 105.0 | 106.6 | 94.7 | 97.4 | 70-135 | 5.7 |
| PFHxS | 91.7 | 89.5 | 91.7 | 89.1 | 70-135 | 1.6 |
| PFMBA | 96.9 | 100.6 | 91.6 | 95.4 | 65-145 | 3.9 |
| PFMPA | 97.9 | 102.4 | 91.8 | 96.1 | 60-140 | 4.5 |
| PFNA | 100.6 | 107.0 | 93.3 | 93.9 | 70-140 | 6.5 |
| PFNS | 96.1 | 105.2 | 101.9 | 87.0 | 70-135 | 8.2 |
| PFOA | 90.2 | 102.4 | 89.9 | 89.9 | 65-155 | 6.6 |
| PFOS | 90.9 | 90.3 | 91.6 | 86.2 | 70-140 | 2.7 |
| PFOSA | 84.8 | 96.9 | 83.0 | 86.8 | 70-135 | 7.1 |
| PFPeA | 99.0 | 102.4 | 94.8 | 97.6 | 70-135 | 3.2 |
| PFPeS | 87.3 | 97.6 | 96.6 | 97.7 | 70-135 | 5.3 |
| PFTDA | 88.6 | 89.2 | 90.3 | 82.5 | 70-145 | 4.0 |
| PFTrDA | 83.2 | 89.0 | 81.1 | 93.0 | 60-145 | 6.3 |
| PFUnA | 94.5 | 102.7 | 95.8 | 86.1 | 70-135 | 7.2 |

**Table 1**. Recoveries (%) and RSDs (%) for 40 native PFAS in synthetic wastewater (1633) using Turbo Trace PFC (spiked with 1-38 ng/L).

| Compound Name | Percent | ECONO-SPE-IDC-1 % Recoveries | ECONO-SPE-IDC-2 % Recoveries | ECONO-SPE-IDC-3 % Recoveries | ECONO-SPE-IDC-4 % Recoveries | Window |
|---|---|---|---|---|---|---|
| **13C2-4-2 FTSA** | | 104.2 | 105.1 | 92.3 | 93.7 | **40-200** |
| **13C2-6-2 FTS** | | 105.1 | 96.7 | 101.1 | 97.7 | **40-200** |
| **13C2-8-2 FTSA** | | 93.7 | 94.8 | 91.5 | 90.2 | **40-300** |
| **13C2-PFDoDA** | | 111.6 | 98.3 | 99.8 | 104.2 | **10-130** |
| **13C2-PFTDA** | | 104.8 | 101.3 | 100.0 | 94.9 | **10-130** |
| **13C3-HFPO-DA** | | 95.4 | 93.8 | 96.6 | 91.8 | **40-130** |
| **13C3-PFBS** | | 101.3 | 96.5 | 93.4 | 91.7 | **40-135** |
| **13C3-PFHxS** | | 110.2 | 108.9 | 100.8 | 101.6 | **40-130** |
| **13C4-PFBA** | | 94.1 | 90.3 | 96.7 | 94.3 | **5-130** |
| **13C4-PFHpA** | | 94.8 | 94.9 | 99.6 | 93.9 | **40-130** |
| **13C5-PFHxA** | | 93.3 | 96.5 | 97.7 | 92.0 | **40-130** |
| **13C5-PFPeA** | | 95.7 | 97.4 | 97.6 | 93.7 | **40-130** |
| **13C6-PFDA** | | 109.1 | 97.1 | 97.5 | 111.9 | **40-130** |
| **13C7-PFUnA** | | 95.7 | 88.5 | 86.5 | 103.1 | **30-130** |
| **13C8-PFOA** | | 88.8 | 87.7 | 90.1 | 90.8 | **50-200** |
| **13C8-PFOS** | | 82.3 | 85.3 | 84.3 | 100.5 | **50-200** |
| **13C8-PFOSA** | | 90.1 | 94.6 | 88.2 | 96.0 | **40-130** |
| **13C9-PFNA** | | 87.9 | 86.1 | 87.3 | 87.3 | **40-130** |
| **2H3-N-MeFOSA** | | 88.0 | 91.5 | 85.0 | 95.5 | **10-130** |
| **2H3-N-MeFOSAA** | | 89.3 | 90.3 | 85.2 | 91.3 | **40-170** |
| **2H5-N-EtFOSA** | | 96.0 | 97.0 | 89.5 | 80.5 | **10-130** |
| **2H5-N-EtFOSAA** | | 89.3 | 84.5 | 83.9 | 98.1 | **25-135** |
| **2H7-MeFOSE** | | 80.0 | 88.4 | 80.5 | 81.8 | **10-130** |
| **2H9-EtFOSE** | | 83.2 | 87.5 | 83.8 | 81.1 | **10-130** |

**Table 2.** Recoveries (%) and acceptance windows (%) for 24 surrogate PFAS in synthetic wastewater (1633) using Turbo Trace PFC.

| Compound Name | In ng/L | ECONO-MDL-1 Final Conc. | ECONO-MDL-2 Final Conc. | ECONO-MDL-3 Final Conc. | ECONO-MDL-4 Final Conc. | ECONO-MDL-5 Final Conc. | ECONO-MDL-6 Final Conc. | ECONO-MDL-7 Final Conc. | STDEV | MDL |
|---|---|---|---|---|---|---|---|---|---|---|
| **11Cl-PF3OUdS** | | 0.35 | 0.36 | 0.41 | 0.43 | 0.43 | 0.37 | 0.45 | 0.04 | 0.13 |
| **3-3 FTCA** | | 0.76 | 0.87 | 1.07 | 0.84 | 0.86 | 0.87 | 1.10 | 0.13 | 0.40 |
| **4-2 FTS** | | 2.21 | 2.16 | 2.40 | 2.14 | 1.99 | 2.33 | 2.31 | 0.14 | 0.44 |
| **5-3 FTCA** | | 4.73 | 5.04 | 4.36 | 4.34 | 4.85 | 4.76 | 5.99 | 0.56 | 1.75 |
| **6-2 FTS** | | 1.07 | 1.07 | 1.41 | 1.39 | 1.24 | 1.44 | 1.29 | 0.16 | 0.49 |
| **7-3 FTCA** | | 3.29 | 3.28 | 4.07 | 3.09 | 3.46 | 3.39 | 4.72 | 0.58 | 1.81 |
| **8-2 FTS** | | 1.86 | 1.72 | 1.91 | 2.01 | 2.04 | 1.94 | 2.98 | 0.42 | 1.31 |
| **9Cl-PF3ONS** | | 0.53 | 0.60 | 0.65 | 0.61 | 0.67 | 0.59 | 0.74 | 0.07 | 0.21 |
| **ADONA** | | 0.70 | 0.69 | 0.78 | 0.73 | 0.74 | 0.72 | 1.08 | 0.14 | 0.42 |
| **EtFOSE** | | 6.34 | 6.29 | 6.58 | 5.77 | 5.24 | 5.40 | 5.88 | 0.50 | 1.58 |
| **HFPO-DA** | | 0.95 | 1.06 | 1.15 | 0.96 | 1.15 | 0.87 | 1.04 | 0.11 | 0.33 |
| **MeFOSE** | | 5.40 | 5.55 | 5.57 | 4.85 | 5.10 | 4.83 | 4.77 | 0.35 | 1.11 |
| **N-EtFOSA** | | 0.53 | 0.47 | 0.54 | 0.45 | 0.53 | 0.57 | 0.47 | 0.05 | 0.15 |
| **N-EtFOSAA** | | 0.26 | 0.27 | 0.33 | 0.32 | 0.28 | 0.23 | 0.37 | 0.05 | 0.15 |
| **NFDHA** | | 0.40 | 0.40 | 0.48 | 0.36 | 0.45 | 0.43 | 0.61 | 0.08 | 0.26 |
| **N-MeFOSA** | | 0.52 | 0.56 | 0.52 | 0.56 | 0.47 | 0.45 | 0.45 | 0.05 | 0.15 |
| **N-MeFOSAA** | | 0.24 | 0.28 | 0.25 | 0.24 | 0.23 | 0.17 | 0.22 | 0.03 | 0.10 |
| **PFBA** | | 0.81 | 0.86 | 0.87 | 0.82 | 0.88 | 0.88 | 1.26 | 0.16 | 0.49 |
| **PFBS** | | 0.22 | 0.24 | 0.28 | 0.24 | 0.28 | 0.24 | 0.32 | 0.03 | 0.11 |
| **PFDA** | | 0.19 | 0.24 | 0.26 | 0.17 | 0.22 | 0.24 | 0.30 | 0.04 | 0.13 |
| **PFDoA** | | 0.31 | 0.38 | 0.44 | 0.43 | 0.31 | 0.33 | 0.46 | 0.06 | 0.20 |
| **PFDoS** | | 0.18 | 0.19 | 0.18 | 0.18 | 0.19 | 0.18 | 0.23 | 0.02 | 0.06 |
| **PFDS** | | 0.16 | 0.20 | 0.26 | 0.16 | 0.23 | 0.23 | 0.28 | 0.05 | 0.15 |
| **PFEESA** | | 0.43 | 0.45 | 0.55 | 0.48 | 0.48 | 0.43 | 0.62 | 0.07 | 0.22 |
| **PFHpA** | | 0.21 | 0.21 | 0.25 | 0.21 | 0.24 | 0.24 | 0.31 | 0.04 | 0.11 |
| **PFHpS** | | 0.19 | 0.27 | 0.29 | 0.22 | 0.25 | 0.26 | 0.24 | 0.03 | 0.10 |
| **PFHxA** | | 0.21 | 0.22 | 0.25 | 0.20 | 0.24 | 0.20 | 0.34 | 0.05 | 0.16 |
| **PFHxS** | | 0.20 | 0.20 | 0.28 | 0.27 | 0.22 | 0.22 | 0.31 | 0.04 | 0.14 |
| **PFMBA** | | 0.30 | 0.31 | 0.38 | 0.31 | 0.33 | 0.34 | 0.50 | 0.07 | 0.22 |
| **PFMPA** | | 0.29 | 0.31 | 0.33 | 0.31 | 0.34 | 0.33 | 0.48 | 0.07 | 0.20 |
| **PFNA** | | 0.22 | 0.20 | 0.30 | 0.24 | 0.20 | 0.22 | 0.29 | 0.04 | 0.13 |
| **PFNS** | | 0.18 | 0.16 | 0.23 | 0.18 | 0.19 | 0.18 | 0.17 | 0.02 | 0.07 |
| **PFOA** | | 0.18 | 0.18 | 0.25 | 0.19 | 0.23 | 0.27 | 0.26 | 0.04 | 0.13 |
| **PFOS** | | 0.21 | 0.25 | 0.24 | 0.25 | 0.28 | 0.26 | 0.34 | 0.04 | 0.13 |
| **PFOSA** | | 0.34 | 0.37 | 0.36 | 0.32 | 0.36 | 0.33 | 0.47 | 0.05 | 0.16 |
| **PFPeA** | | 0.39 | 0.40 | 0.45 | 0.39 | 0.42 | 0.42 | 0.47 | 0.03 | 0.10 |
| **PFPeS** | | 0.22 | 0.21 | 0.28 | 0.19 | 0.24 | 0.18 | 0.31 | 0.05 | 0.14 |
| **PFTDA** | | 0.51 | 0.60 | 0.39 | 0.52 | 0.48 | 0.41 | 0.39 | 0.08 | 0.25 |
| **PFTrDA** | | 0.57 | 0.53 | 0.52 | 0.44 | 0.39 | 0.43 | 0.40 | 0.07 | 0.22 |
| **PFUnA** | | 0.24 | 0.25 | 0.29 | 0.26 | 0.23 | 0.26 | 0.32 | 0.03 | 0.11 |

**Table 3.** Method Detection Limit values for 40 native PFAS in synthetic wastewater (1633) using Turbo Trace PFC (spiked with 0.2-6 ng/L).

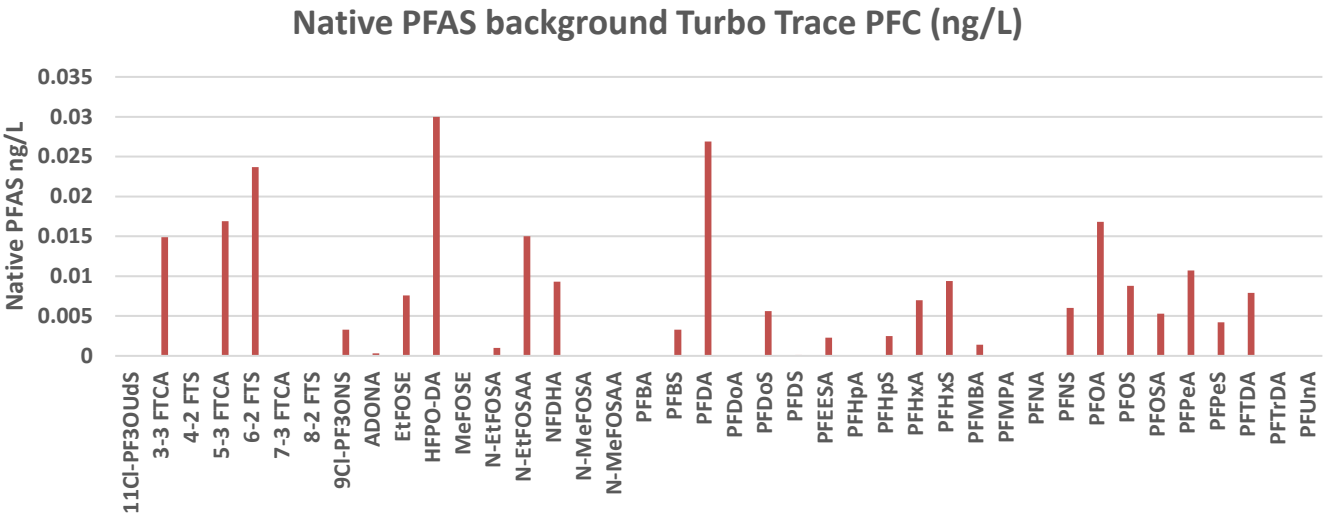


**Table 4.** Native PFAS background with Turbo Trace PFC for method 1633 (in ng/L).

| Compound | Sample-Lake-1 | Sample-Lake-2 | Sample-Lake-3 | Sample-Well-1 | Sample-Well-2 | Sample-Well-3 | Sample-tap-water-1 | Sample-tap-water-2 | Sample-tap-water-3 |
|---|---|---|---|---|---|---|---|---|---|
| Name NATIVES PFAS | Final Conc. | Final Conc. | Final Conc. | Final Conc. | Final Conc. | Final Conc. | Final Conc. | Final Conc. | Final Conc. |
| 11Cl-PF3OUdS | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3-3 FTCA | 0.01 | 0.02 | 0.02 | 0.01 | 0.01 | 0.02 | 0.00 | 0.02 | 0.00 |
| 4-2 FTS | 0.00 | 0.00 | 0.00 | 0.06 | 0.09 | 0.06 | 0.00 | 0.00 | 0.00 |
| 5-3 FTCA | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.05 | 0.00 | 0.03 |
| 6-2 FTS | 0.04 | 0.02 | 0.04 | 0.01 | 0.01 | 0.04 | 0.06 | 0.05 | 0.07 |
| 7-3 FTCA | 0.04 | 0.09 | 0.05 | 0.03 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 8-2 FTS | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 | 0.00 | 0.00 | 0.01 | 0.00 |
| 9Cl-PF3ONS | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| ADONA | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| EtFOSE | 0.11 | 0.07 | 0.09 | 0.15 | 0.17 | 0.10 | 0.00 | 0.00 | 0.00 |
| HFPO-DA | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 | 0.11 | 0.05 |
| MeFOSE | 0.07 | 0.02 | 0.09 | 0.14 | 0.07 | 0.09 | 0.00 | 0.00 | 0.00 |
| N-EtFOSA | 0.01 | 0.00 | 0.02 | 0.00 | 0.00 | 0.00 | 0.01 | 0.02 | 0.00 |
| N-EtFOSAA | 0.00 | 0.00 | 0.00 | 0.03 | 0.02 | 0.00 | 0.02 | 0.00 | 0.00 |
| NFDHA | 0.01 | 0.01 | 0.02 | 0.01 | 0.01 | 0.01 | 0.01 | 0.00 | 0.01 |
| N-MeFOSA | 0.01 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.01 | 0.01 | 0.00 |
| N-MeFOSAA | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 |
| PFBA | 0.23 | 0.32 | 0.39 | 1.50 | 1.59 | 1.79 | 0.54 | 0.65 | 0.65 |
| PFBS | 0.11 | 0.09 | 0.14 | 1.69 | 1.86 | 1.69 | 0.60 | 0.53 | 0.55 |
| PFDA | 0.03 | 0.02 | 0.04 | 0.05 | 0.06 | 0.04 | 0.00 | 0.00 | 0.00 |
| PFDoA | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.04 | 0.00 | 0.00 |
| PFDoS | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PFDS | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 |
| PFEESA | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PFHpA | 0.15 | 0.15 | 0.19 | 0.79 | 0.91 | 0.81 | 0.41 | 0.36 | 0.40 |
| PFHpS | 0.00 | 0.00 | 0.00 | 0.04 | 0.03 | 0.04 | 0.03 | 0.03 | 0.01 |
| PFHxA | 0.17 | 0.19 | 0.16 | 2.01 | 1.95 | 2.10 | 0.67 | 0.71 | 0.76 |
| PFHxS | 0.08 | 0.10 | 0.03 | 0.96 | 1.02 | 1.12 | 0.21 | 0.25 | 0.25 |
| PFMBA | 0.00 | 0.00 | 0.01 | 0.00 | 0.01 | 0.00 | 0.00 | 0.01 | 0.00 |
| PFMPA | 0.00 | 0.02 | 0.01 | 0.00 | 0.01 | 0.01 | 0.00 | 0.01 | 0.01 |
| PFNA | 0.07 | 0.08 | 0.20 | 0.15 | 0.09 | 0.09 | 0.25 | 0.10 | 0.20 |
| PFNS | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 |
| PFOA | 0.40 | 0.47 | 0.49 | 3.08 | 3.07 | 3.30 | 0.72 | 0.54 | 0.79 |
| PFOS | 0.17 | 0.14 | 0.15 | 0.55 | 0.37 | 0.52 | 0.45 | 0.31 | 0.31 |
| PFOSA | 0.01 | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 | 0.02 | 0.01 | 0.00 |
| PFPeA | 0.12 | 0.19 | 0.65 | 1.58 | 1.73 | 1.94 | 0.66 | 0.72 | 0.73 |
| PFPeS | 0.00 | 0.00 | 0.01 | 0.10 | 0.13 | 0.08 | 0.06 | 0.05 | 0.06 |
| PFTDA | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PFTrDA | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| PFUnA | 0.03 | 0.05 | 0.04 | 0.02 | 0.02 | 0.02 | 0.00 | 0.00 | 0.00 |

**Table 5.** Native PFAS with Turbo Trace PFC for method 1633 in lake, well, and tap water (in ng/L).

**Discussion and Conclusions**

40 native PFAS compounds were analyzed using EPA method 1633 (Table 1) with the Turbo Trace PFC and synthetic wastewater. All recoveries were within the acceptance windows of the method with RSDs (%) all < 12%. Run time of the automated system is 70 min. Note that with method 1633 no final concentration step is required. The Turbo Trace PFC produces very good recoveries with low standard deviations.

Surrogate PFAS recoveries (%) and acceptance windows (%) are shown in Table 2. Excellent data were obtained all well within those windows.

Table 3 shows the method detection limits for all 40 native PFAS using synthetic wastewater. Most MDL values are < 0.50 ng/L.

Note that the system has low, non-detect, native background values for PFAS and that the risk of cross-contamination is low (Table 4). Values are < 0.03 ng/L.

Table 5 shows analysis of three different water categories: lake water, well water and tap water. Good reproducibility is seen between the replicates.

The Turbo Trace PFC system produces data that is as good as other more expensive fully automated SPE systems. The system is easy to operate and has fewer valves reducing chance of breakdown and contamination. Cleaning the system between runs is quick and easy.

An important problem with ground and wastewater extraction is the presence of particulate matter which can easily plug up cartridges. Using a vacuum pump to deliver the sample through a minimal pathway to the cartridge prevents clogging. Use of plastic filtration wool in the barrel of the cartridges can eliminate this problem. In this work no clogging of cartridges was observed.

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