FMS
Fluid Management Systems

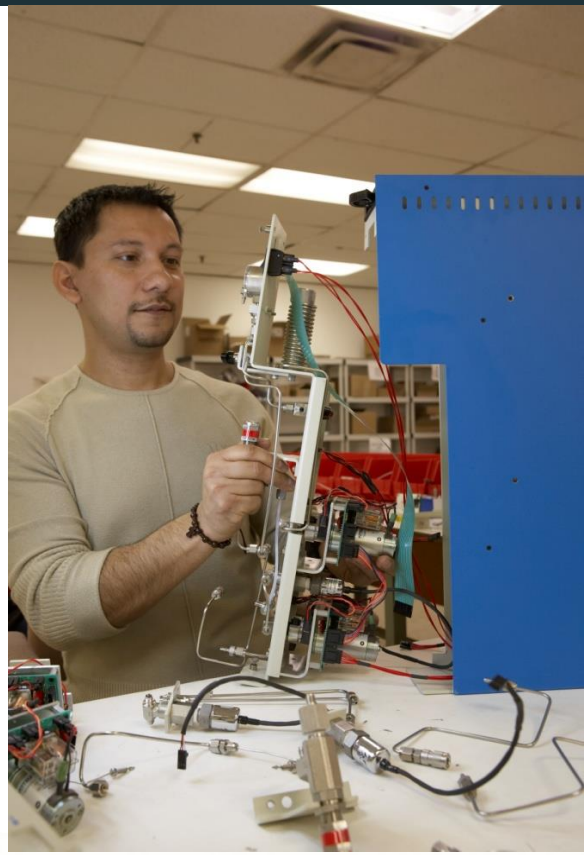
Fast, Easy, Low Cost Sample Prep for the analysis of Semi-Volatiles in Waste Water

FMS

- **FMS - Fluid Management Systems**
  - **Founded in 1986**
  - **Manufactures Total Solution Sample Preparation and Consumables for GC, GC/MS, LC and LC/MS**

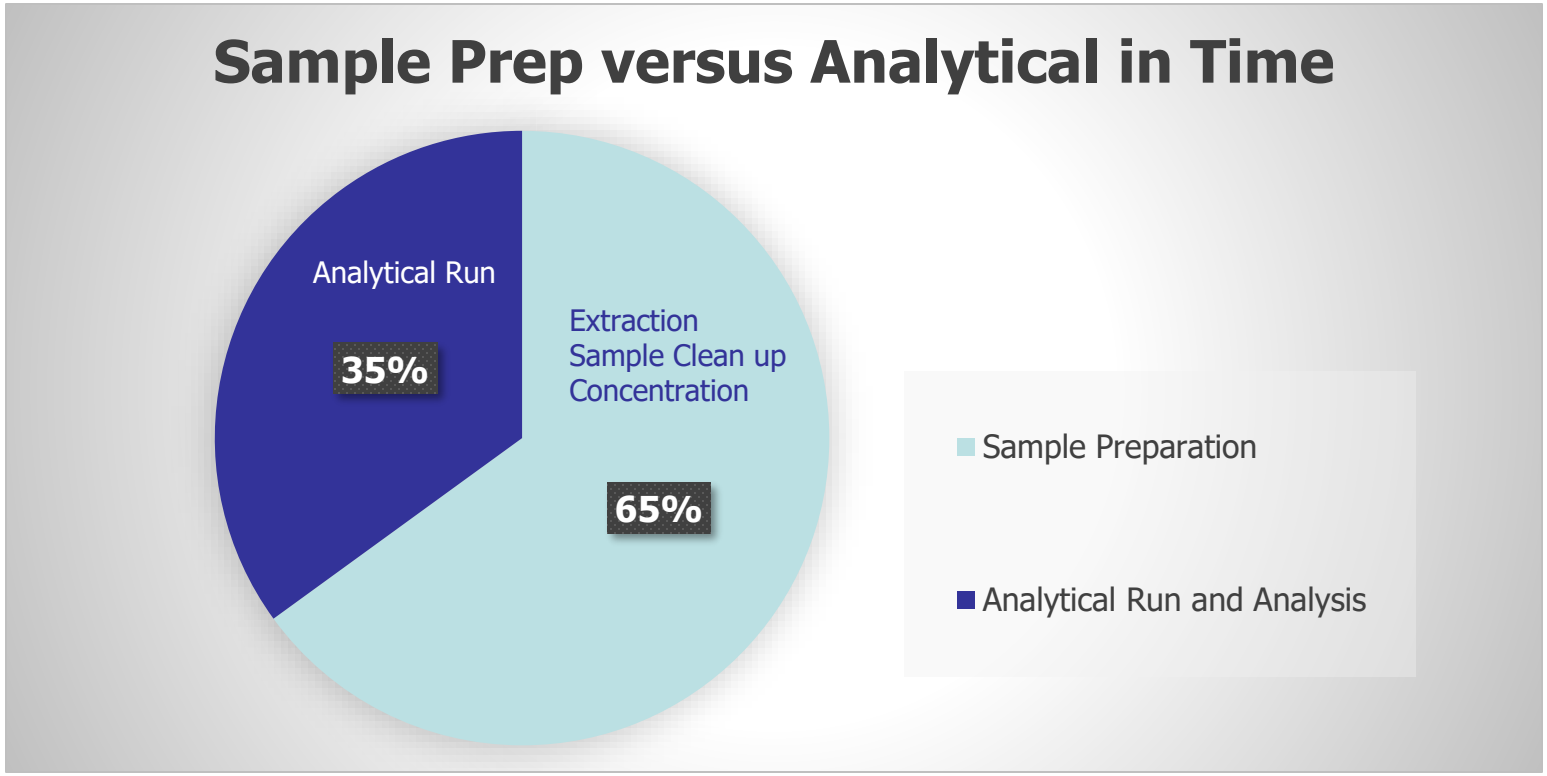
FMS
Fluid Management Systems

Made in the USA



Class 1000 Cleanroom for Consumables Manufacturing

Laboratory Workflow Breakdown



Solid Phase Extraction

Automated

EconoTrace®
Drinking Water

TurboTrace®
Drinking &
Waste Water

TurboTrace® ABN
EPA Methods 625
& 8270

TurboTrace® PFC
Drinking & Waste
Water

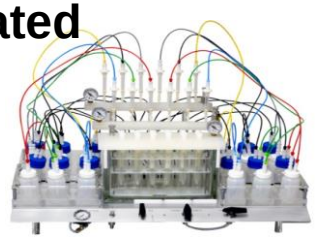
Concentration

SuperVap®
Concentration and
Evaporation

Direct to Vial

Semi-Automated

12 Position EZSPE®
Drinking Water &
Waste Water
Analysis



12 Position EZPFC
Drinking Water & Waste
Water
PFAS/PFOS/PFOA
Analysis

Pressurized Liquid Extraction

PLE®

Solids and Semi-Solids

Concentration

SuperVap®
Concentration and Evaporation

Direct to Vial

Sample Cleanup

Automated

PowerPrep® NG
Dioxin & PCB
Sample Cleanup

EconoPrep®
Dioxin & PCB Sample
Cleanup

EP110®
Zero DCM Dioxin
& PCB Sample
Prep

Concentration

SuperVap®
Concentration and
Evaporation

Direct to Vial

Semi-Automated

Ezprep 123®
Dioxin & PCB
Analysis

Overview

- **Development of a fully automated extraction system for EPA 8270/625**
  - **Full Validation package available reviewed by the US EPA**
- **Establishment of an extraction procedure capable of implementation of various aqueous matrices**
  - **Implementation of platform across other EPA methodologies**
- **Participation in ILI SPE Demonstration project for method suitability**
- **Performed Independent Validation Study of Many Waste Water Matrices**
- **Most recently developed a Semi-Automated extraction system for EPA 8270/625 (Semi Volatiles in Water)**

Matrices

- DI and Tap
- ASTM 5909 synthetic Wastewater
- TCLP Fluid
- Pond, River and Reservoir surface water
- Real world industrial effluents and influents
- Groundwater

Comparison of LLE/CLE vs. Automated SPE Methods

LLE/CLE	Automated SPE
Open to laboratory background	Closed system
Uses >360mls solvent	Uses <60mls solvent
Shaking / Continuous process	Filtration process
Forms emulsions requiring centrifuging	No emulsions formed
Little Selectivity	Wide Selectivity (adsorbent)
Requires water removal	In-line water removal
	Fast and Unattended

Comparison of LLE/CLE vs. Automated SPE Methods

LLE/CLE	Automated SPE
No Separation of waste	Separates Aqueous and Organic Waste
More volume to evaporate	<60mls solvent to evaporate
Massive solvent emission	6 times less solvent emission
CLE uses a lot of power	Easily Capture Solvent
Requires lots of solvent for cleaning	Lower solvent costs
	Lower Disposal Costs

FMS TurboTrace® ABN

Real Time Graphical Display of Extraction Steps

Touch Screen Control

Automatic Liquid Level Sensor

SD Card for Storing and Transferring Methods

Six Elution and Wash Solvents

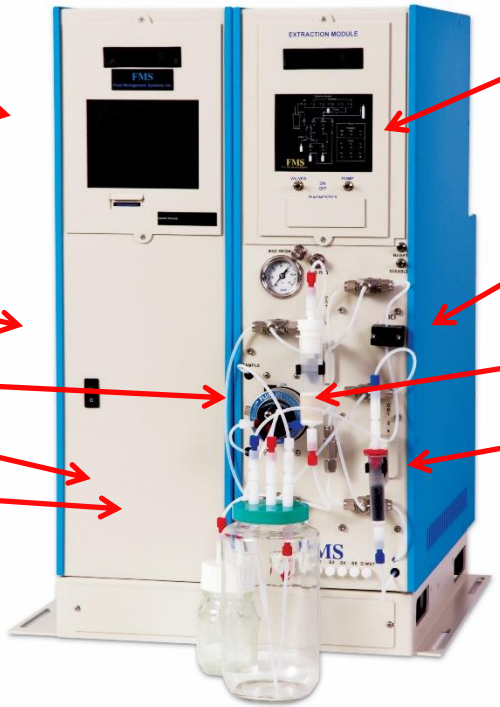
Positive Pressure Pump for precise, consistent delivery of Sample and Solvent

ABN Cartridge

Carbon Cartridge

Sample Size 2 ml to unlimited

Automatic Bottle Rinse



TurboTrace ABN

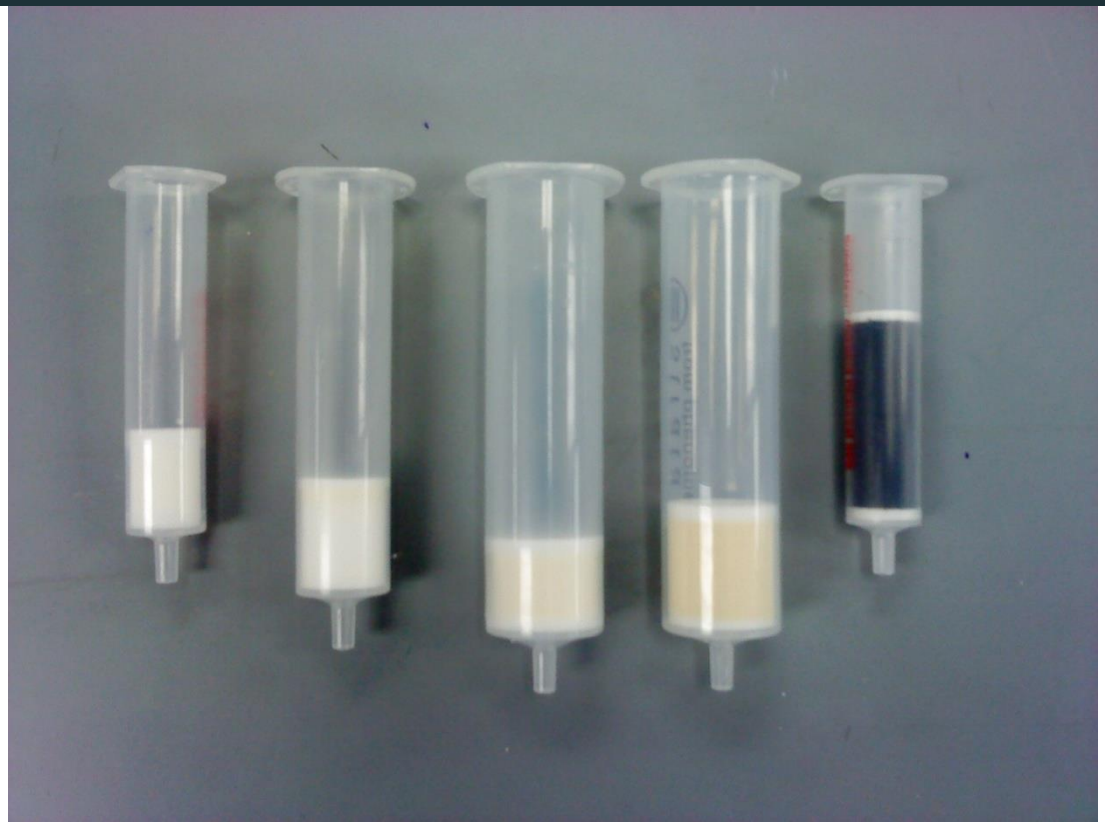
- **Fully automates all processes, not manual steps**
- **Capable of delivering up to to 3 independent fractions (or combine as 1)**
- **Can elute direct to FMS SuperVap evaporator**
- **Automated organic solvent rinse of sample bottle**
- **Can elute either cartridge independently or in parallel**
- **Modular and Expandable**
- **Direct to GC Vial extracts**

Automated Fast Flow Sample Processing

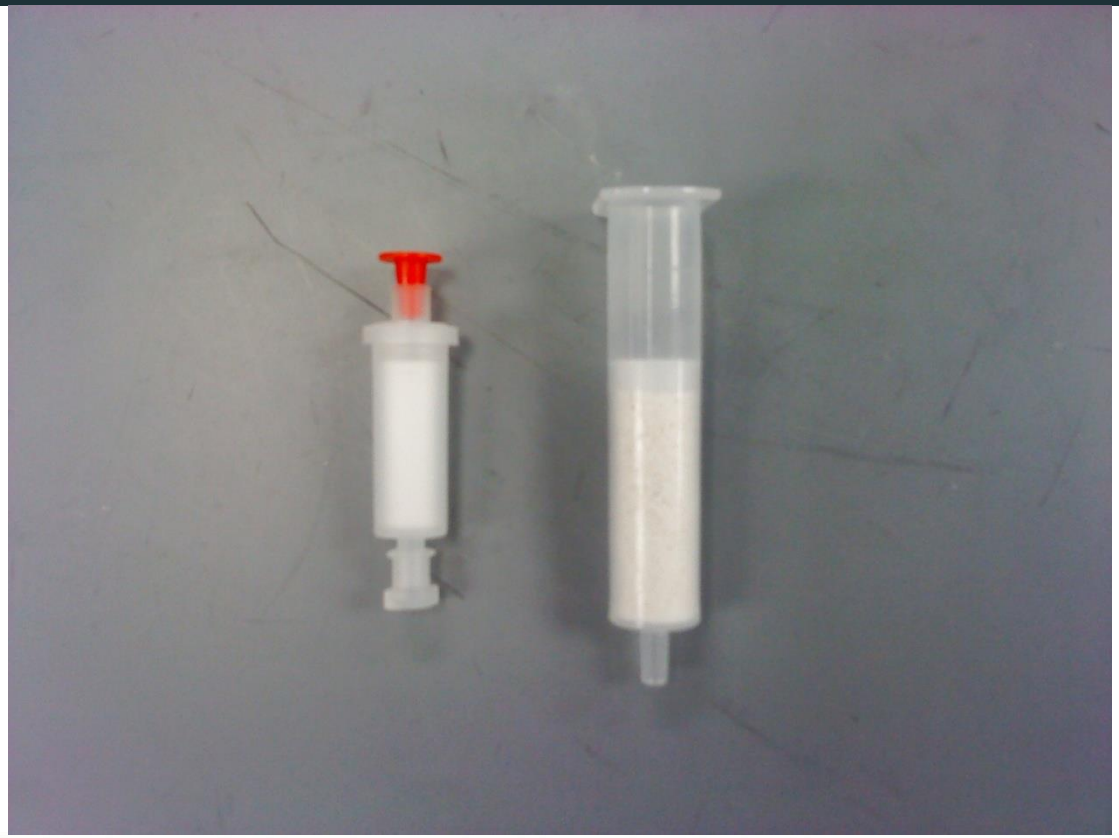
Sample Sizes Unlimited

FMS
Fluid Management Systems

SPE Cartridges



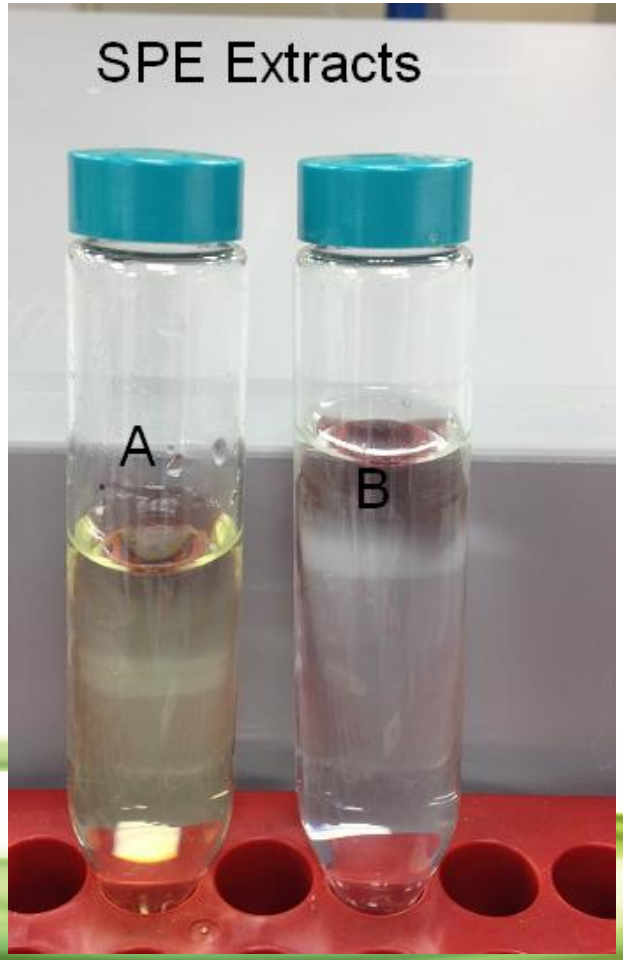
Drying Cartridges



Vacuum and Nitrogen Drying

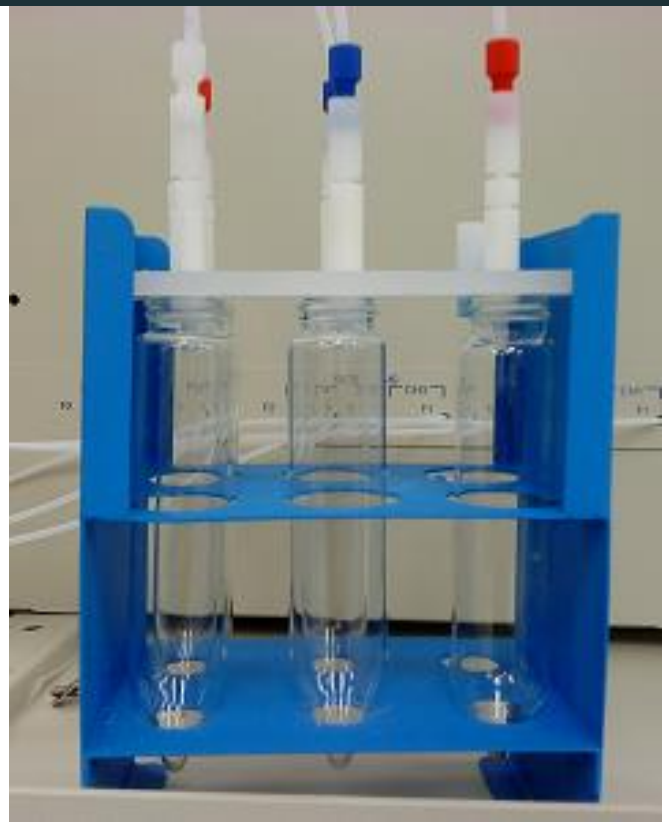
No Formation of Emulsions

No subsequent Emulsions in Extracts to deal with

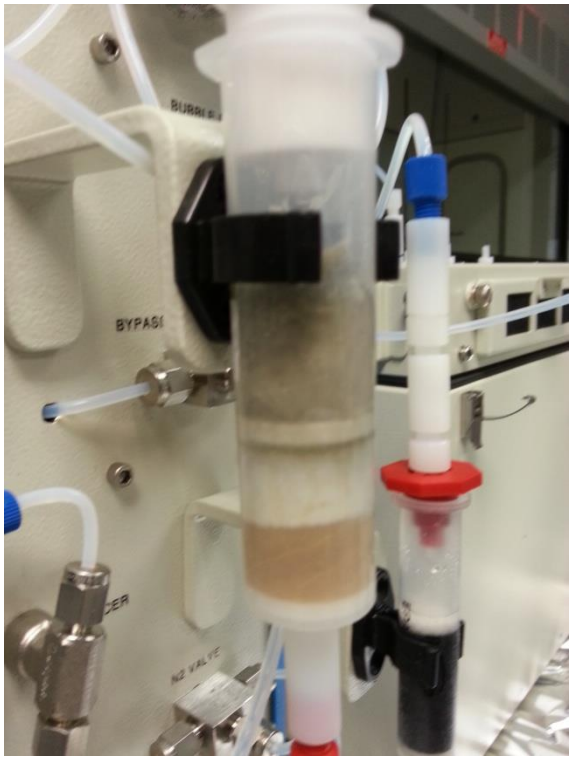


Reduced Solvent Usage

Reduced Exposure to Laboratory Background



Dual SPE Cartridge Extraction



Direct to Vial Concentration

FMS
Fluid Management Systems

Direct to Vial Concentration

SuperVap Concentrator

- 12 position
- 50ml vessel

SuperVap Features

- **6 (250ml) and 12 (50ml) position models for extractions.**
- **Dry bath heating element**
- **Independent secondary heater for extract nipple (Can be disabled).**
- **Sensor controlled**
- **Savable temperature log capability.**

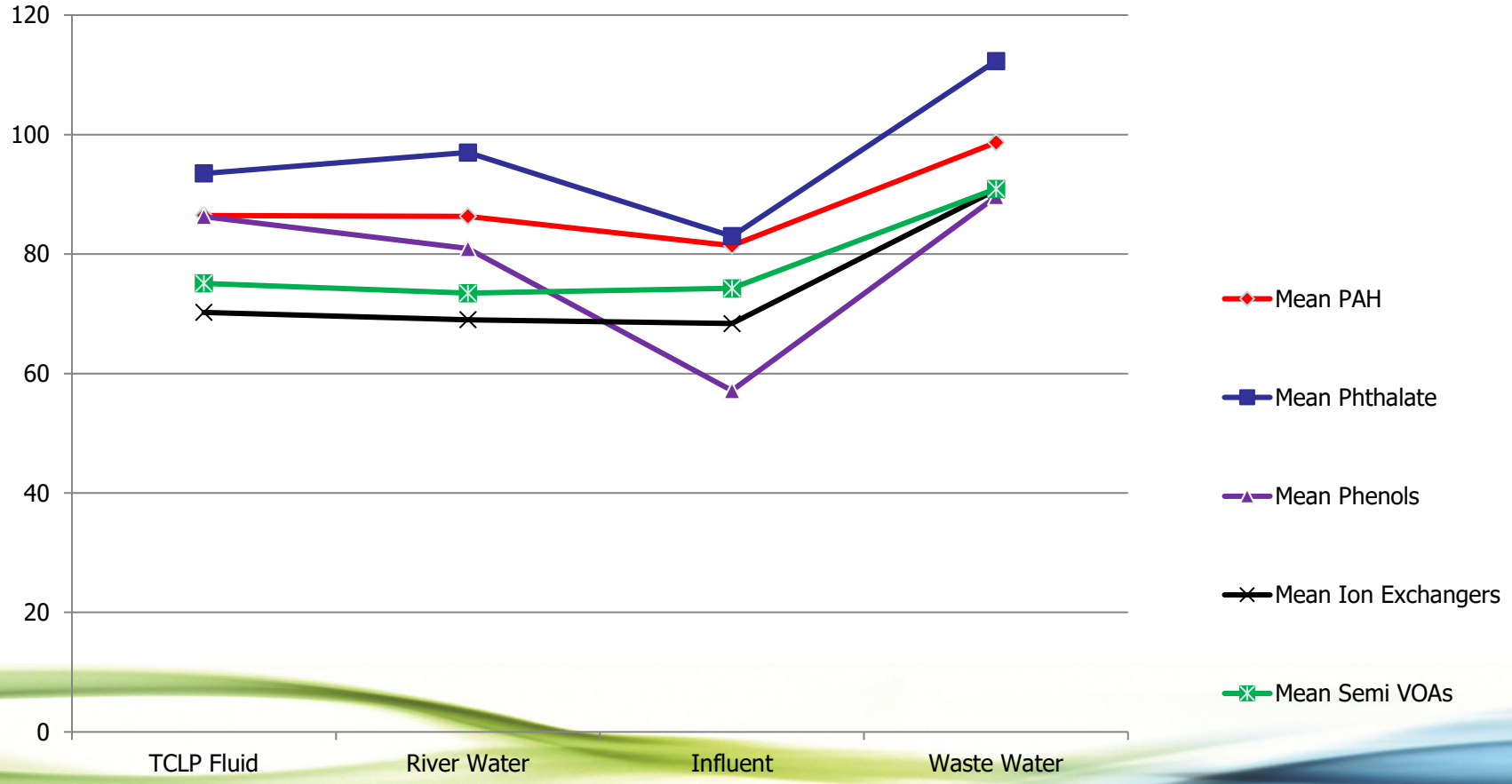
SPE Procedure (1)

- 1 L water samples, pH < 2, spike with standards
- Condition with DCM, MeOH, water
- Cartridges: mixed bed and coconut charcoal
- Load samples across cartridges under vacuum and dry
- Bottle rinse, elute DCM across mixed bed and collect (Fraction # 1)
- Recondition mixed bed (MeOH); 1% NaOH across both cartridges

SPE Procedure (2)

- **Dry, elute both cartridges sequentially with DCM (Fraction # 2)**
- **Purge system with nitrogen to collect any analytes**
- **Dry Fraction with sodium sulfate**
- **Evaporation and low res GC/MS**

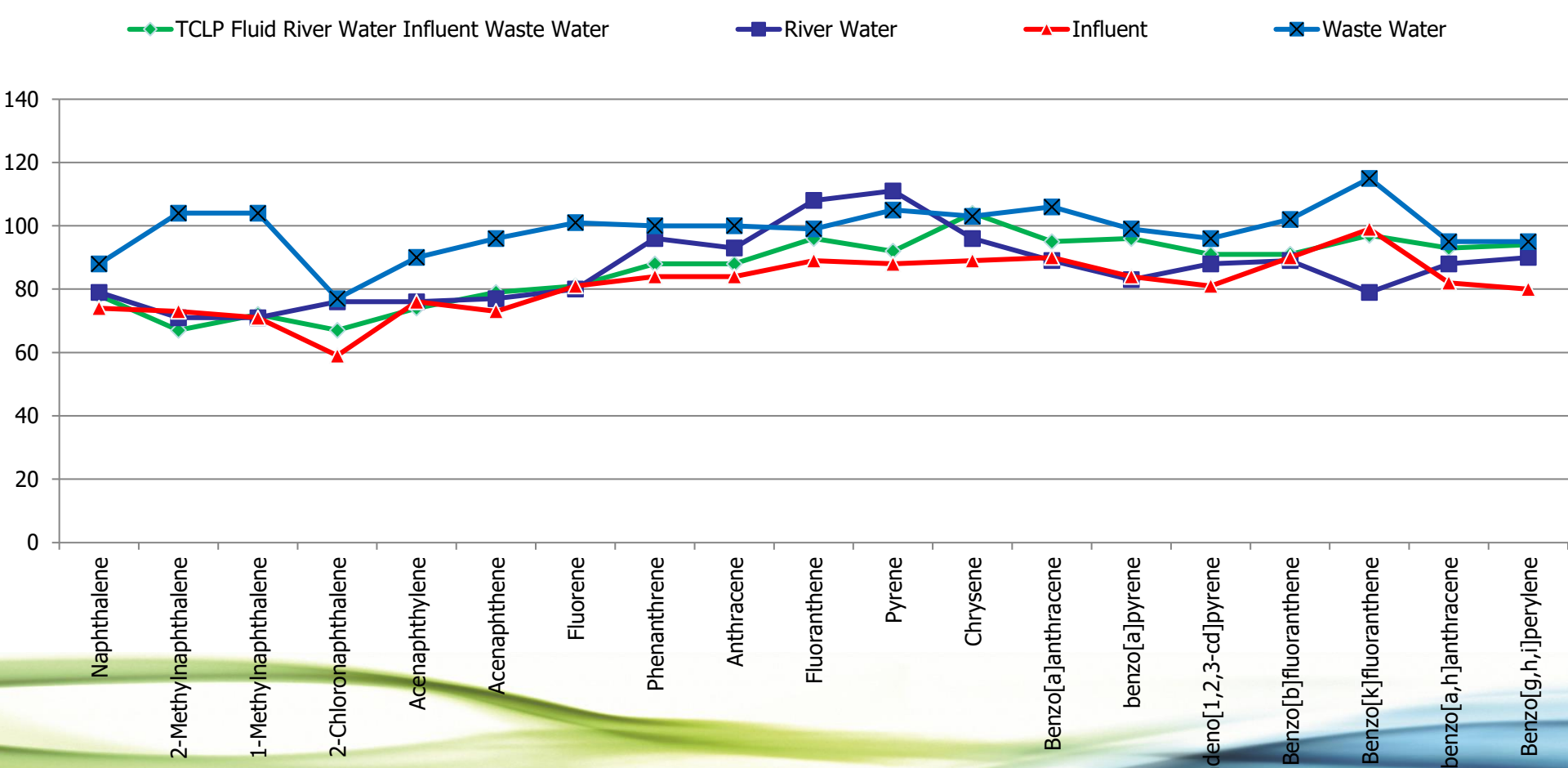
Recoveries by Analyte Class



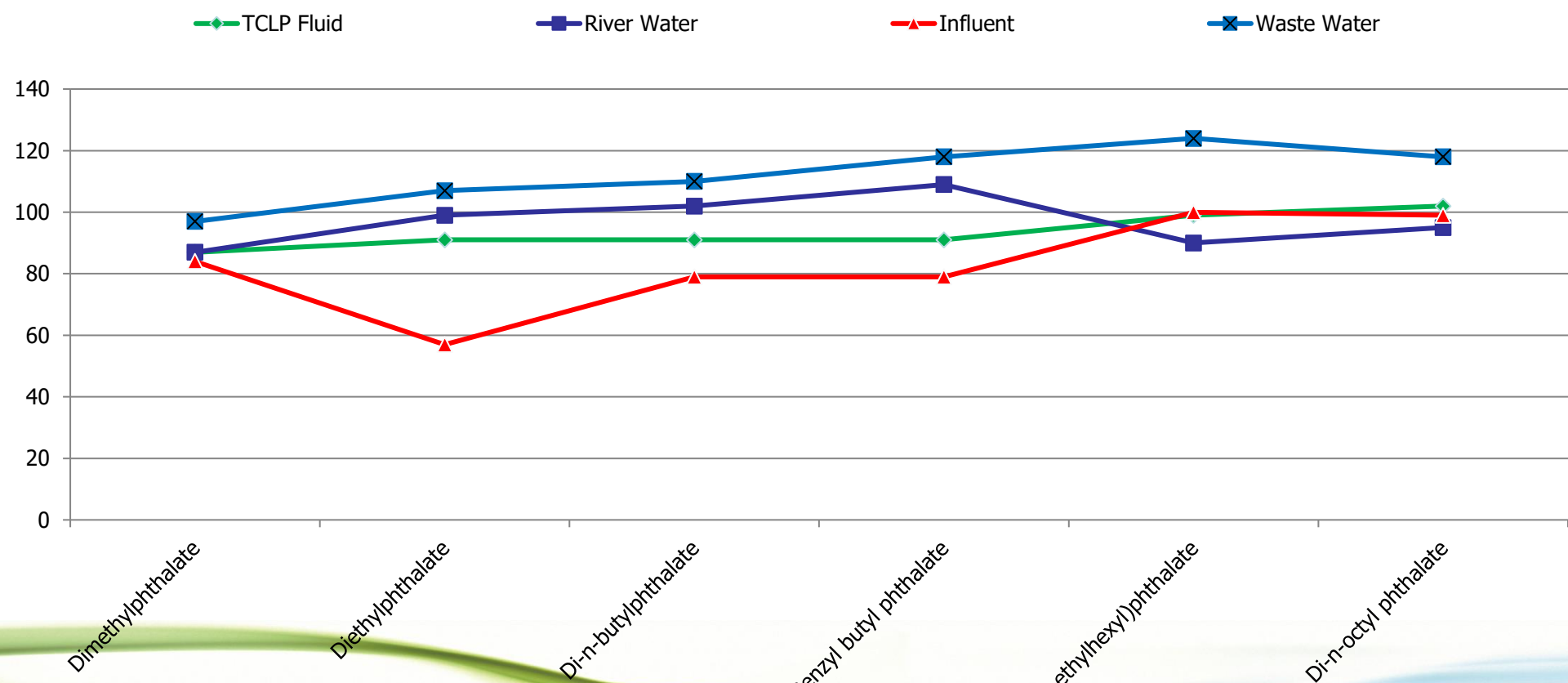
Data

Recoveries for Individual Compounds with specific Analyte Classes

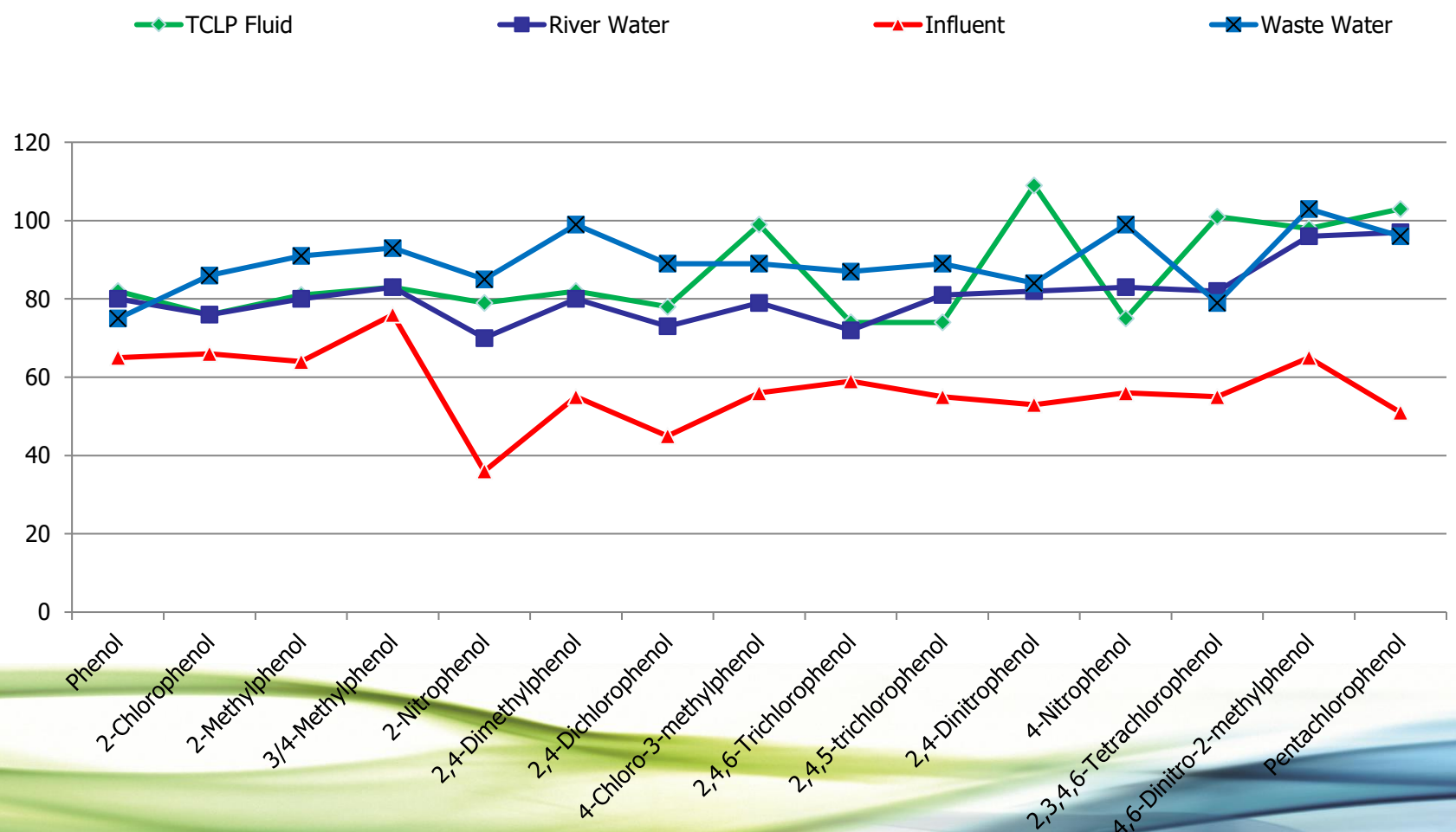
PAHs


TCLP Fluid River Water Influent Waste Water
River Water
Influent
Waste Water
140
120
100
80
60
40
20
0
Naphthalene
2-Methylnaphthalene
1-Methylnaphthalene
2-Chloronaphthalene
Acenaphthylene
Acenaphthene
Fluorene
Phenanthrene
Anthracene
Fluoranthene
Pyrene
Chrysene
Benzo[a]anthracene
benzo[a]pyrene
Indeno[1,2,3-cd]pyrene
Benzo[b]fluoranthene
Benzo[k]fluoranthene
Dibenzo[a,h]anthracene
Benzo[g,h,i]perylene

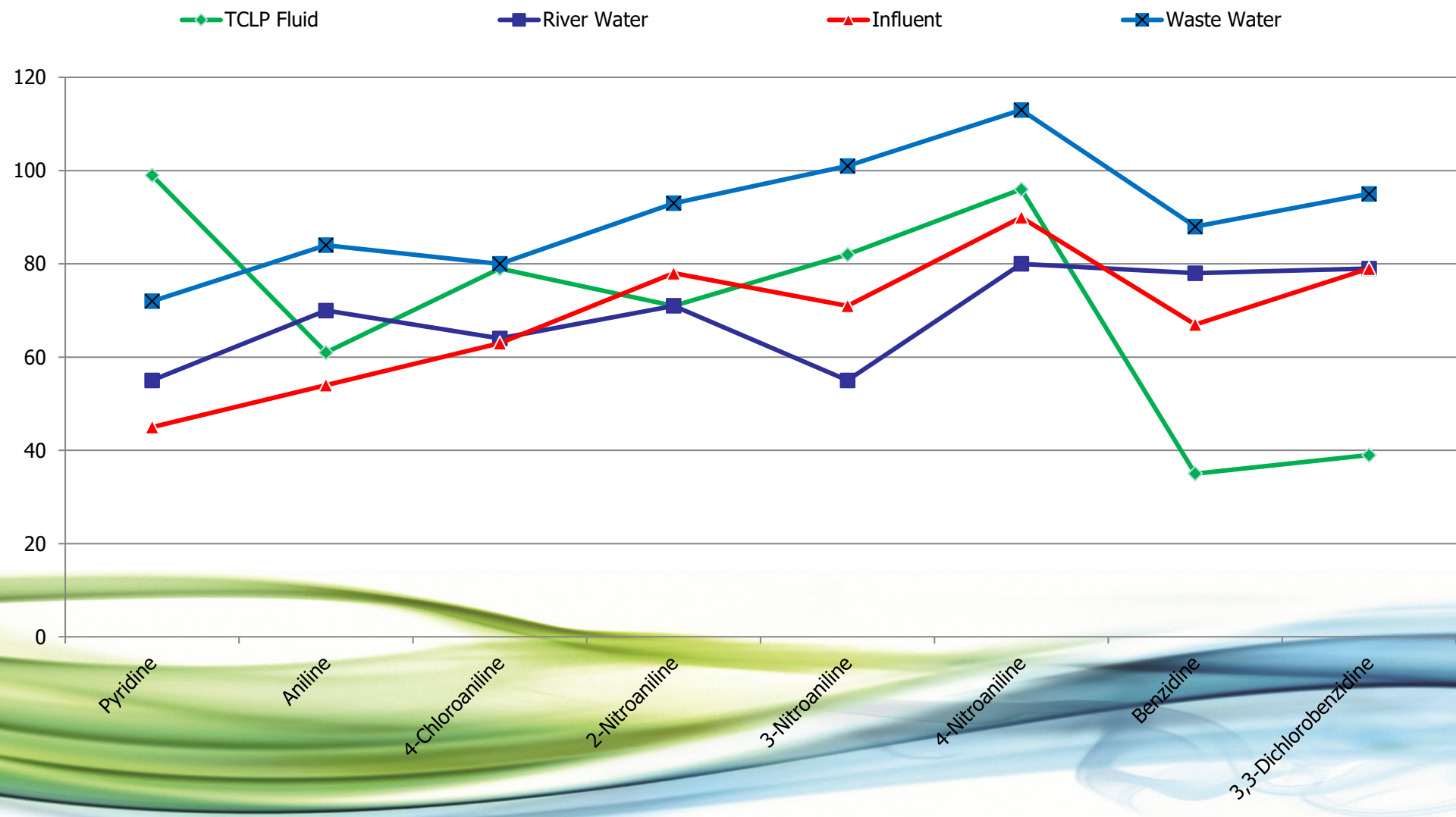
Phthalates


TCLP Fluid
River Water
Influent
Waste Water
140
120
100
80
60
40
20
0
Dimethylphthalate
Diethylphthalate
Di-n-butylphthalate
Benzyl butyl phthalate
Bis(2-ethylhexyl)phthalate
Di-n-octyl phthalate

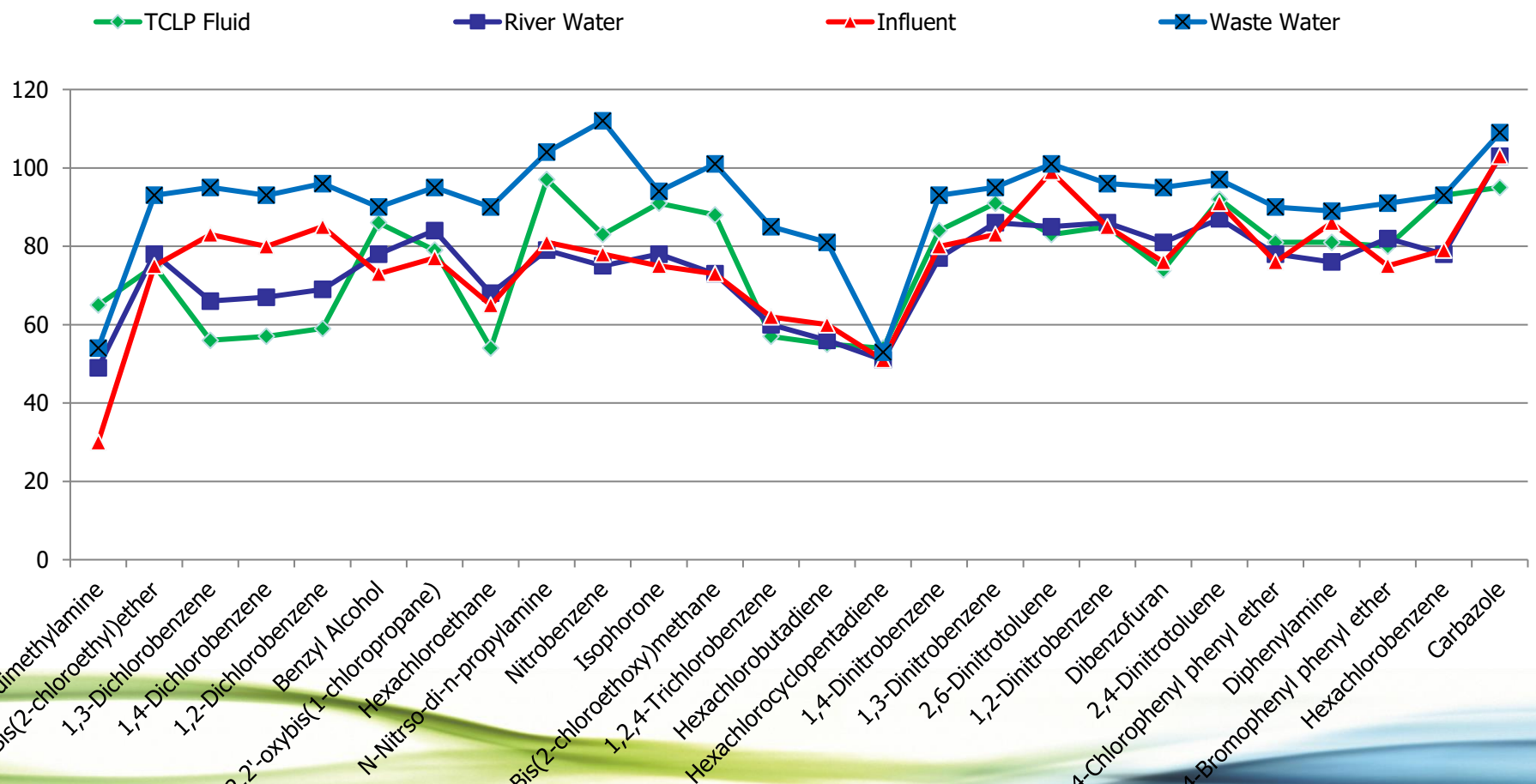
Phenols


TCLP Fluid
River Water
Influent
Waste Water
120
100
80
60
40
20
0
Phenol
2-Chlorophenol
2-Methylphenol
3/4-Methylphenol
2-Nitrophenol
2,4-Dimethylphenol
2,4-Dichlorophenol
4-Chloro-3-methylphenol
2,4,6-Trichlorophenol
2,4,5-trichlorophenol
2,4-Dinitrophenol
4-Nitrophenol
2,3,4,6-Tetrachlorophenol
4,6-Dinitro-2-methylphenol
Pentachlorophenol

Ion Exchangers



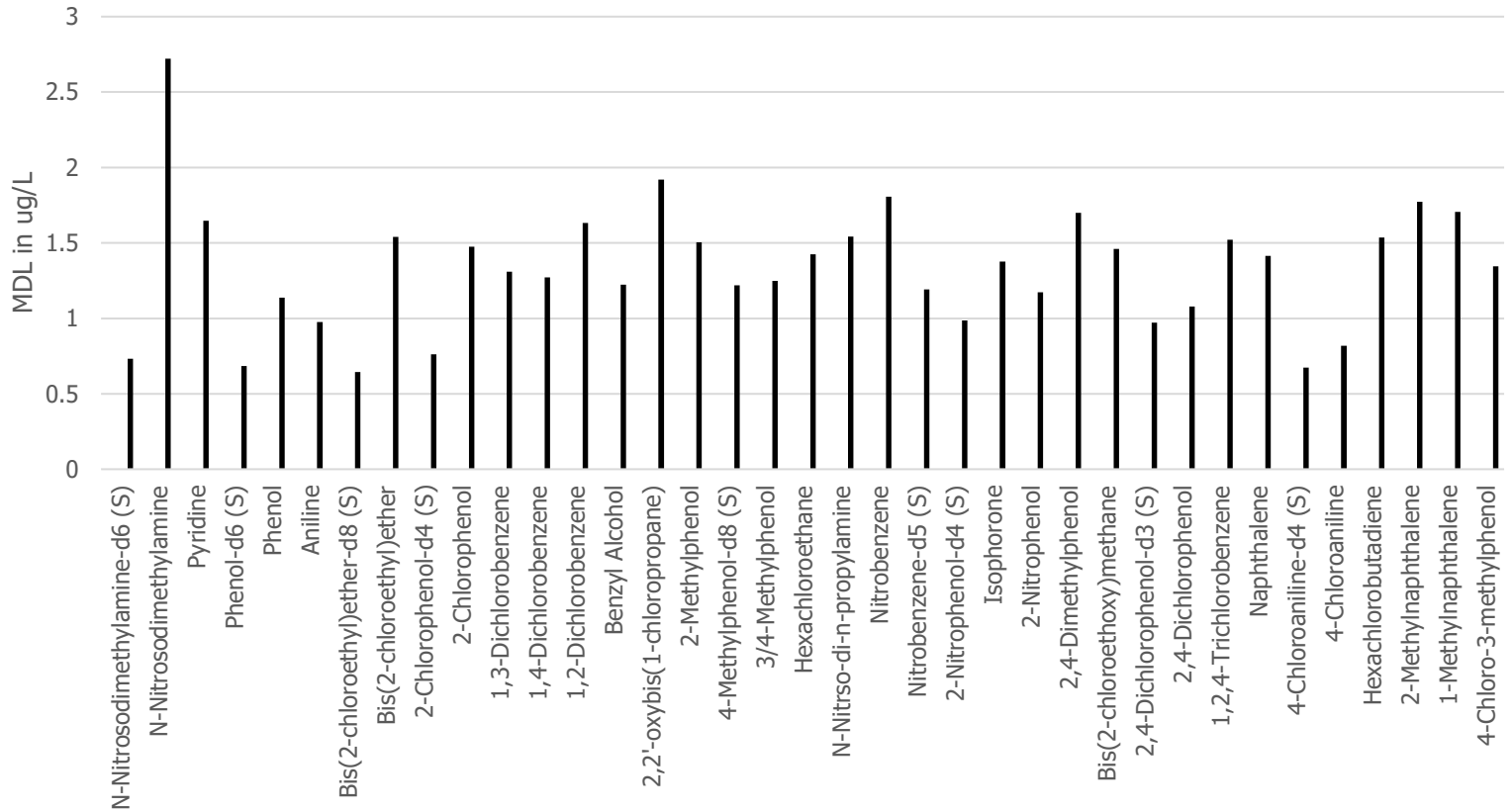
Semi-Volatiles



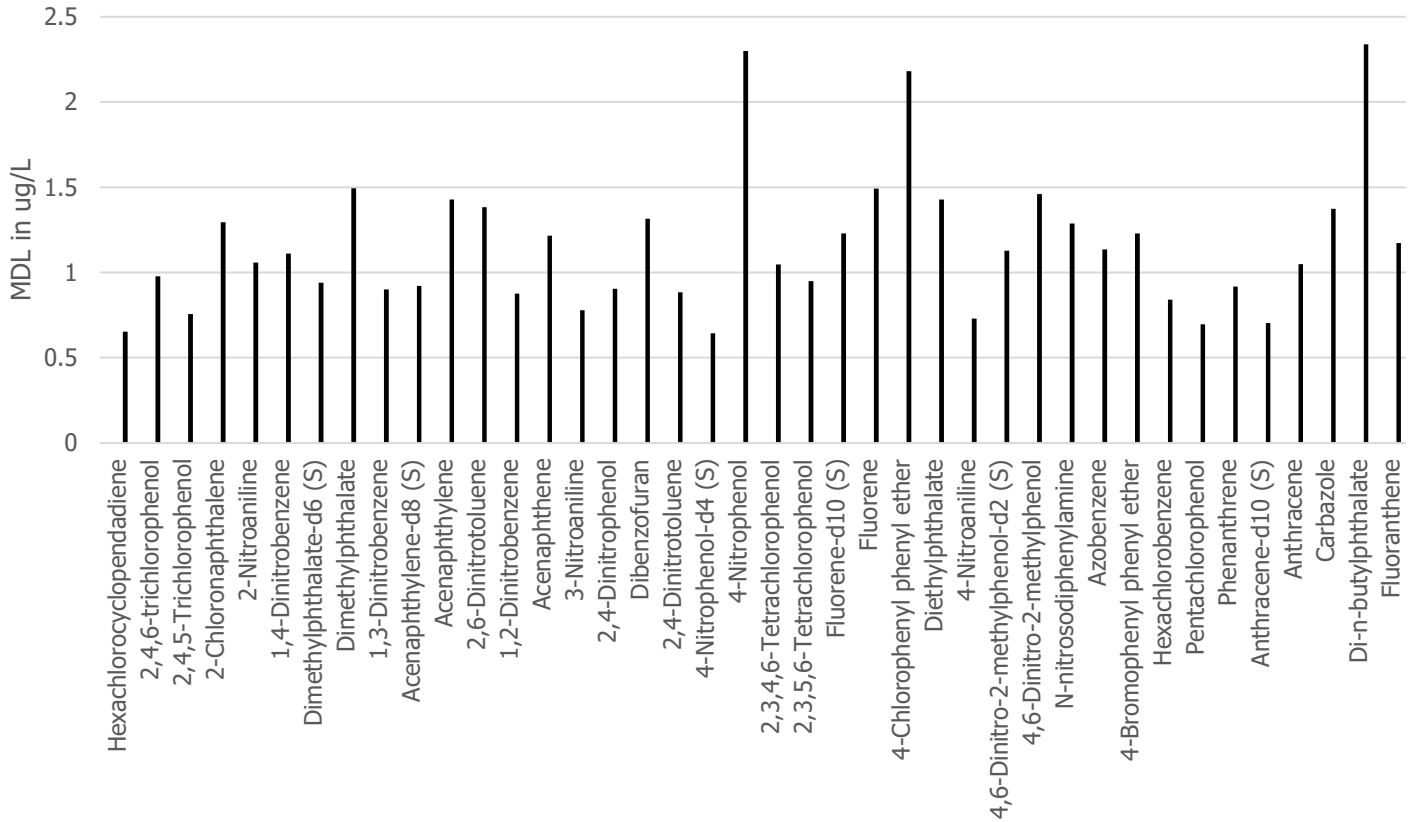
Method Validation

Method Detection Limit

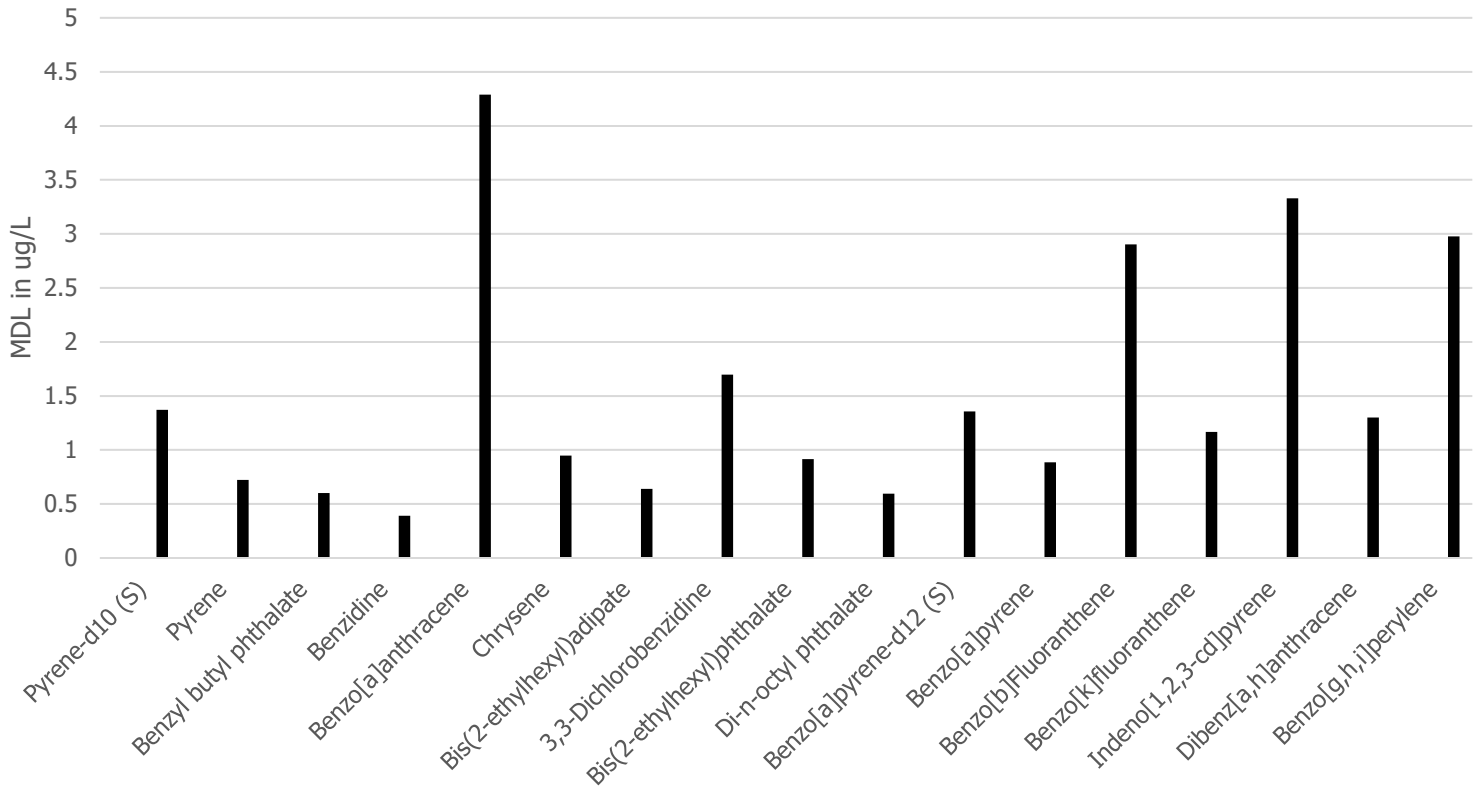
MDL (1)


MDL in ug/L
3
2.5
2
1.5
1
0.5
0
N-Nitrosodimethylamine-d6 (S)
N-Nitrosodimethylamine
Pyridine
Phenol-d6 (S)
Phenol
Aniline
Bis(2-chloroethyl)ether-d8 (S)
Bis(2-chloroethyl)ether
2-Chlorophenol-d4 (S)
2-Chlorophenol
1,3-Dichlorobenzene
1,4-Dichlorobenzene
1,2-Dichlorobenzene
Benzyl Alcohol
2,2'-oxybis(1-chloropropane)
2-Methylphenol
4-Methylphenol-d8 (S)
3/4-Methylphenol
Hexachloroethane
N-Nitrso-di-n-propylamine
Nitrobenzene
Nitrobenzene-d5 (S)
2-Nitrophenol-d4 (S)
Isophorone
2-Nitrophenol
2,4-Dimethylphenol
Bis(2-chloroethoxy)methane
2,4-Dichlorophenol-d3 (S)
2,4-Dichlorophenol
1,2,4-Trichlorobenzene
Naphthalene
4-Chloroaniline-d4 (S)
4-Chloroaniline
Hexachlorobutadiene
2-Methylnaphthalene
1-Methylnaphthalene
4-Chloro-3-methylphenol

MDL (2)


MDL in ug/L
2.5
2
1.5
1
0.5
0
Hexachlorocyclopendadiene
2,4,6-trichlorophenol
2,4,5-Trichlorophenol
2-Chloronaphthalene
2-Nitroaniline
1,4-Dinitrobenzene
Dimethylphthalate-d6 (S)
Dimethylphthalate
1,3-Dinitrobenzene
Acenaphthylene-d8 (S)
Acenaphthylene
2,6-Dinitrotoluene
1,2-Dinitrobenzene
Acenaphthene
3-Nitroaniline
2,4-Dinitrophenol
Dibenzofuran
2,4-Dinitrotoluene
4-Nitrophenol-d4 (S)
4-Nitrophenol
2,3,4,6-Tetrachlorophenol
2,3,5,6-Tetrachlorophenol
Fluorene-d10 (S)
Fluorene
4-Chlorophenyl phenyl ether
Diethylphthalate
4-Nitroaniline
4,6-Dinitro-2-methylphenol-d2 (S)
4,6-Dinitro-2-methylphenol
N-nitrosodiphenylamine
Azobenzene
4-Bromophenyl phenyl ether
Hexachlorobenzene
Pentachlorophenol
Phenanthrene
Anthracene-d10 (S)
Anthracene
Carbazole
Di-n-butylphthalate
Fluoranthene

MDL (3)


MDL in ug/L
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Pyrene-d10 (S)
Pyrene
Benzyl butyl phthalate
Benzidine
Benzo[a]anthracene
Chrysene
Bis(2-ethylhexyl)adipate
3,3-Dichlorobenzidine
Bis(2-ethylhexyl)phthalate
Di-n-octyl phthalate
Benzo[a]pyrene-d12 (S)
Benzo[a]pyrene
Benzo[b]Fluoranthene
Benzo[k]fluoranthene
Indeno[1,2,3-cd]pyrene
Dibenz[a,h]anthracene
Benzo[g,h,i]perylene

Sample Analysis Work Flow

Automated Sample Prep Time

= 80 Minutes

Solid Phase Extraction

35 Minutes

Concentration

45 Minutes

Semi Automated Sample Prep Time

= 80 Minutes

Solid Phase Extraction

35 Minutes

Concentration

45 Minutes

Objective for Semi Automation

- **Use as many features from the FMS Automated systems and implement them into a Semi automated platform**
- **Develop as many SPE procedures for the testing lab using a single extraction platform.**
- **Minimize manual steps to lessen error and maximize limited man hours**

Goal

- **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 Optional Direct to GC Vial Concentration
- **Fast**
  - The fastest sample processing available for SPE
  - Run up to six samples simultaneously
  - Vacuum for fast loading of large volume samples
  - Unattended Sample loading walkaway time
- **Closed system**
  - Eliminate potential outside contamination

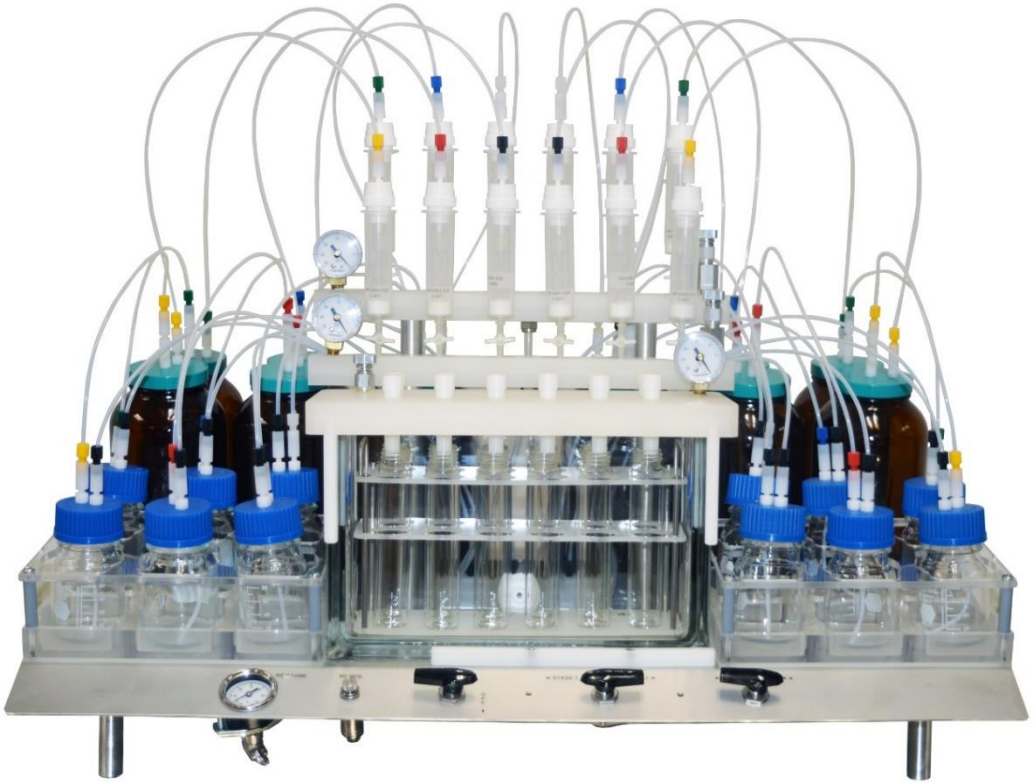
Goal

- **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 to No Capital Expense**
  - Purchase an FMS Cartridge Contract
  - receive an EZSpe at No Charge

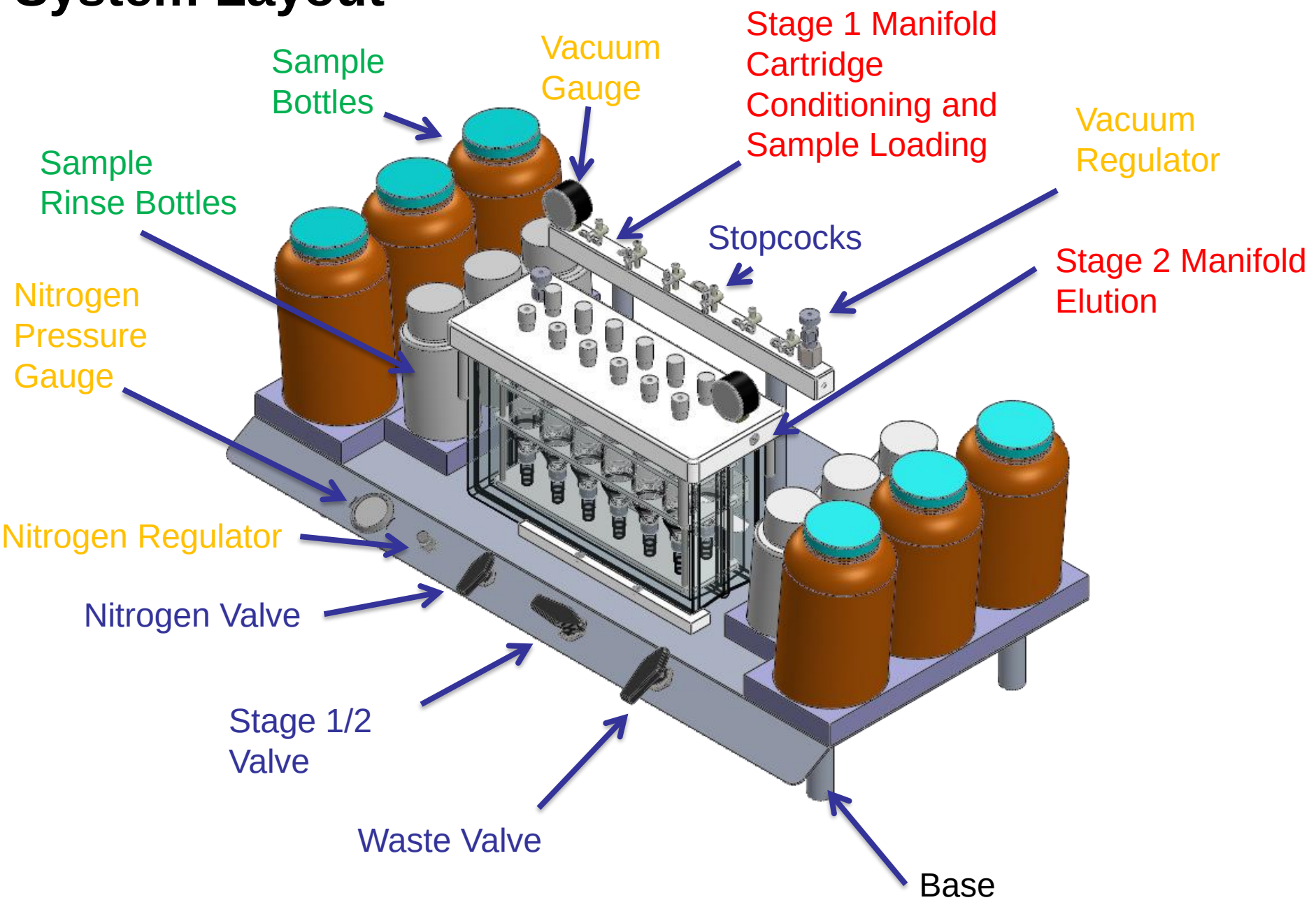
FMS
Fluid Management Systems

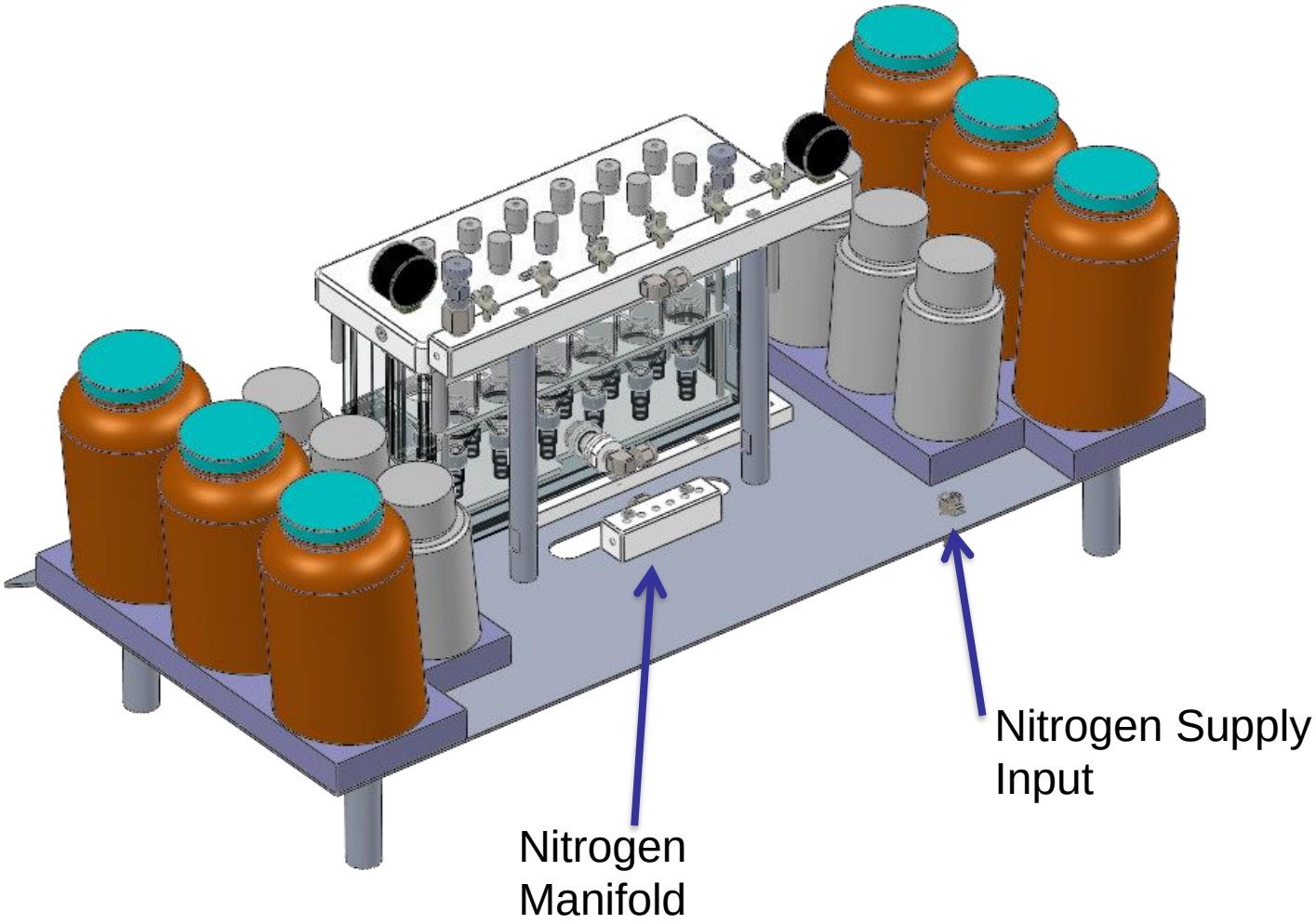
EZSpe®



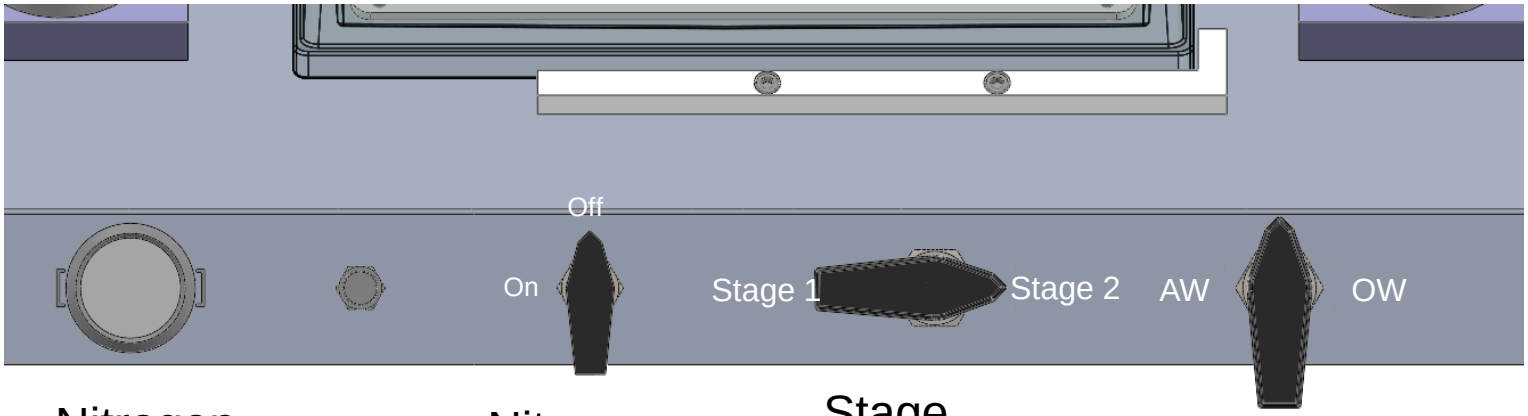
EZSpe 12 sample

System Layout




Nitrogen Supply Input
Nitrogen Manifold

Control Valve Layout



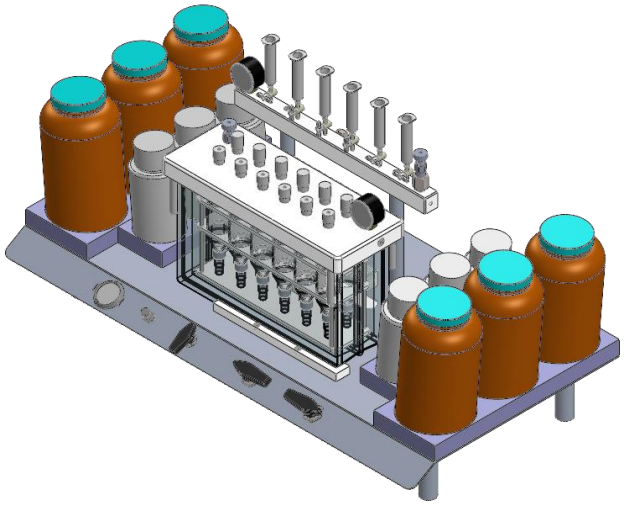
Nitrogen Gauge

Nitrogen Valve

Stage 1/2 Valve

Waste Valve

Cartridge Conditioning (Stage 1, Organic Waste)

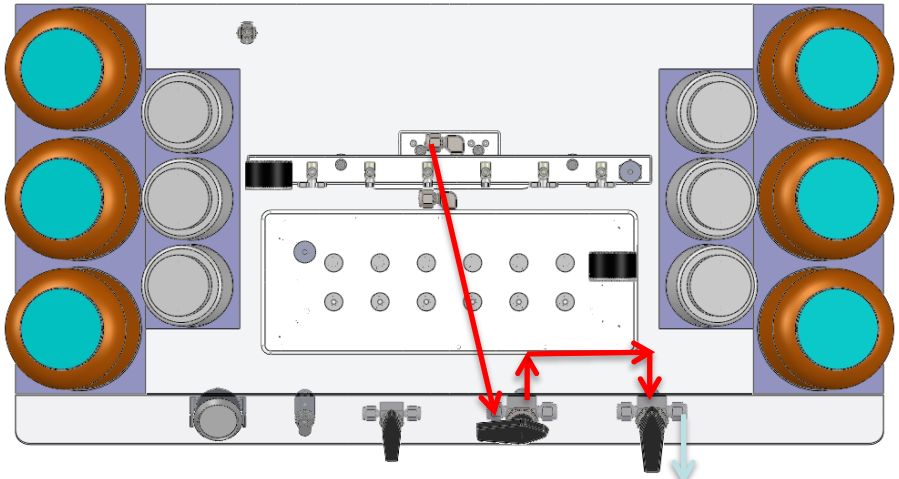


Nitrogen Valve

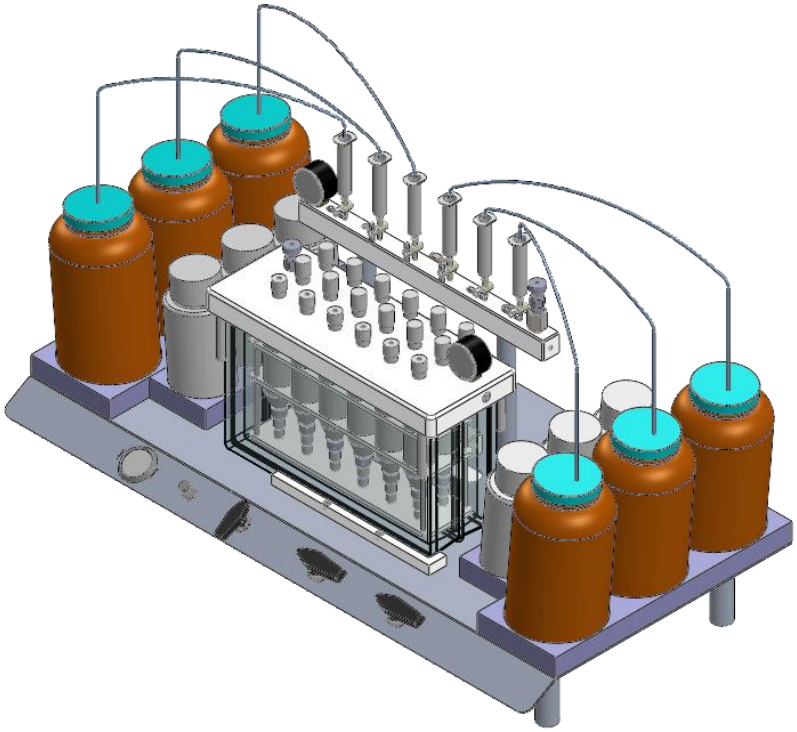
Stage 1/2 Valve

Waste Valve

Flow Path



Sample Loading (Stage 1, Aqueous Waste)

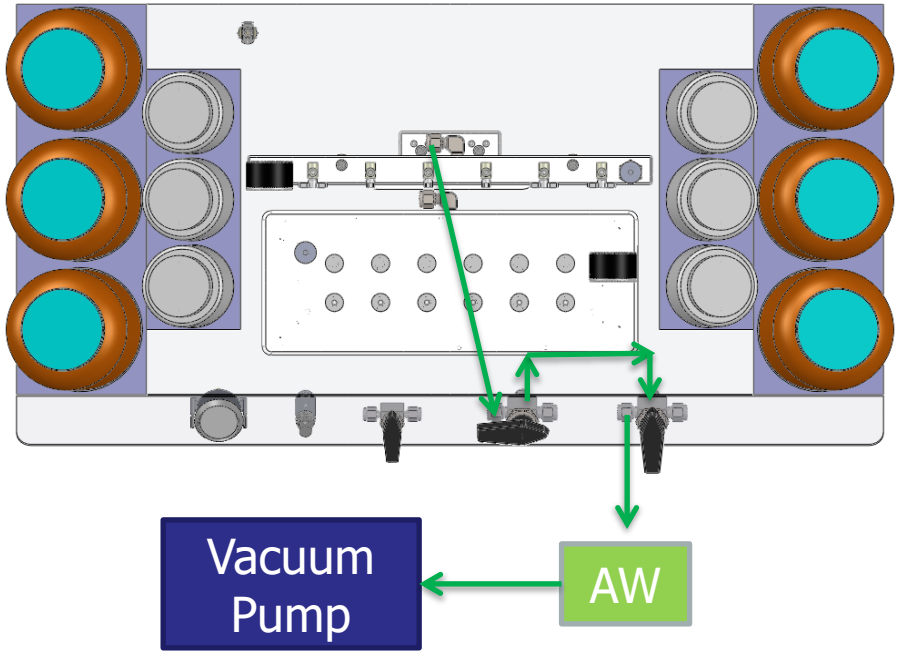


Flow Path

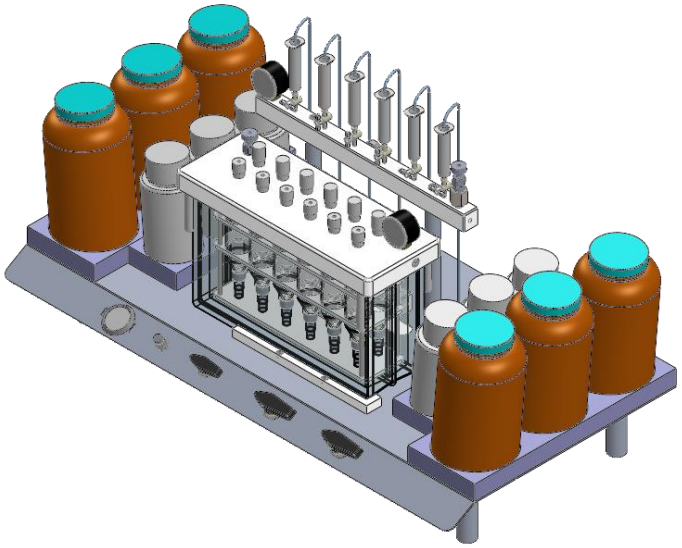
Nitrogen Valve

Stage 1/2 Valve

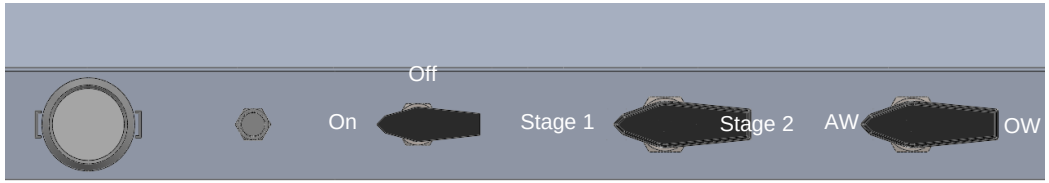
Waste Valve



Cartridge Drying- Nitrogen/Vacuum



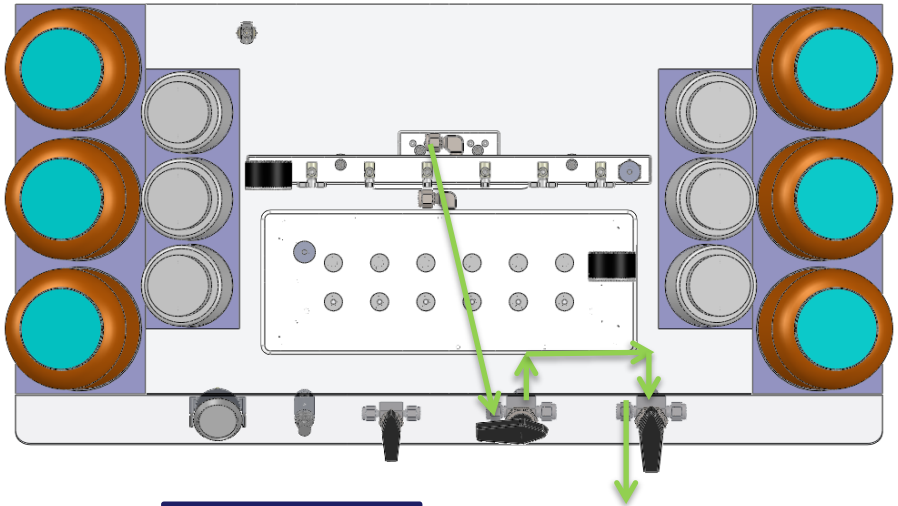
Flow Path



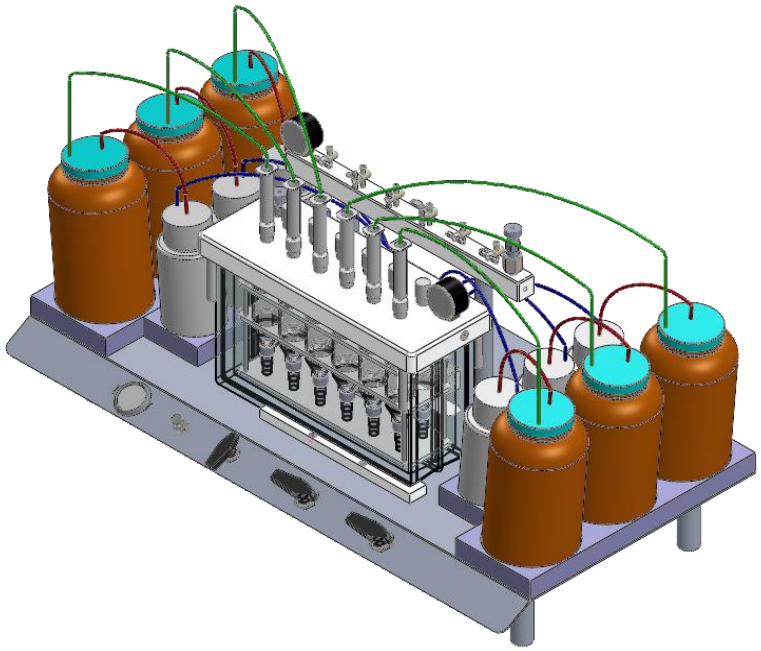
Nitrogen Valve

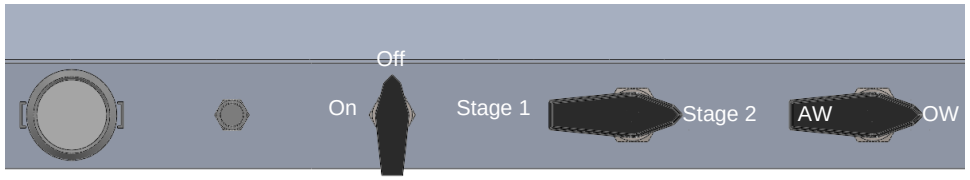
Stage 1/2 Valve

Waste Valve



Sample Elution (Stage 2)

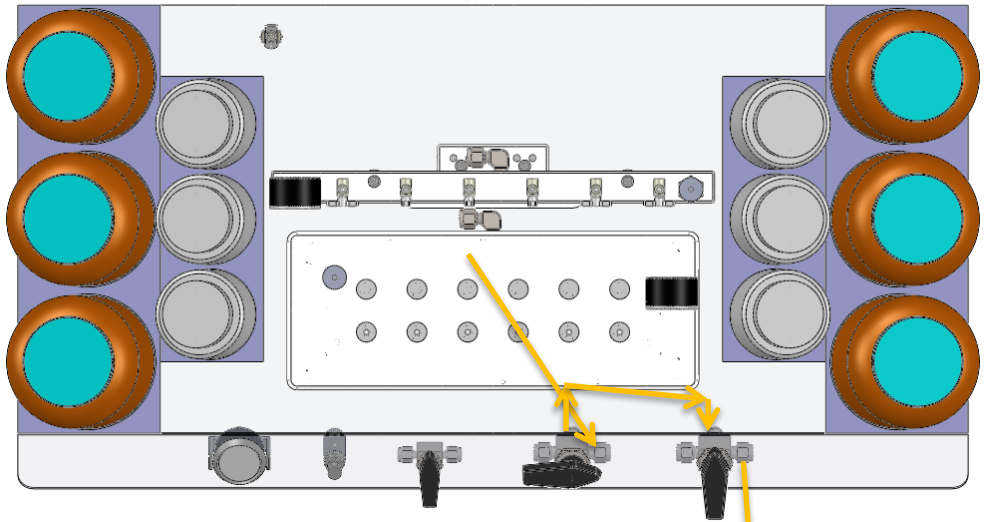




Nitrogen Valve

Stage 1/2 Valve

Waste Valve



Flow Path

Vacuum Pump

OW

Summary

- **Fully Automated Semi-Volatile extractions for various compound classes**
- **Excellent recoveries**
- **Method validated (five year US-based study), can be used internationally**
- **Can use many brands of cartridges**
- **Excellent MDL results**

Summary

- **Solid Phase Extraction is a well accepted technology**
- **New Solid Phase Extraction Chemistries and Sorbents are being developed**
- **Drinking Water and Waste Water Extractions**
  - **625/8270**
  - **608**
  - **Validation data package is available**
- **Capable of performing in line extract drying and/or Cartridge extract clean-ups**
- **Reduce Solvent, Labor and Time**

Semi-Automated SPE in Summary

- **EZSpe and SuperVap systems are easy to use and install**
  - **Complete Water Sample Prep Workflow**
- **Low cost, High throughput, Low maintenance solution**
- **EZSpe Extractions and Concentration is a very green technique**
  - **Reduces Solvent Use**
  - **Reduces Solvent Disposal Costs**
  - **Reduces Solvent emissions**

Semi-Automated 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 and Column sizes**
- **Comply with existing methods that require vacuum, positive pressure and precise delivery of sample and solvents**