Evaluation of Emerging Contaminant Data at Solid Waste Facilities

Prepared for

Minnesota Pollution Control Agency – Closed Landfill Program

May 2020

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Abbreviations

AHC	Agglomerative Hierarchical Cluster analysis
CLP	Closed Landfill Program
EC	Emerging Contaminants
HBV	Minnesota Health-Based Value
HRL	Minnesota Health Risk Limit
μg/L	microgram per liter, typical reporting units for various analytes in water, equivalent to ppb for water samples with a density of 1 gram per centiliter (i.e., low total dissolved solids)
MPCA	Minnesota Pollution Control Agency
PFAS	Per- and polyfluoroalkyl substances
PFBS	Perfluorobutanesulfonic acid
PFDA	Perfluorodecanoic acid
PFDoA/PFDoDA	Perfluorododecanoic acid
PFDS	Perfluorodecane sulfonate
PFHpA	Perfluoroheptanoic acid
PFHxA	Perfluorohexanoic acid
PFHpA	Perfluoroheptanoic acid
PFHxS	Perfluorohexanesulfonic acid
PFNA	Perfluorononanoic acid
PFOA	Perfluorooctanoic acid
PFOS	Perfluorooctanesulfonic acid
PFOSA/FOSA	Perfluorooctane-sulfonamide
PFPeA	Perfluoropentanoic acid
PFUnA/PFUnDA	Perfluoroundecanoic acid

Disclaimers

The purpose of this study was to access the distribution and range of available emerging contaminant data for waste disposal sites in Minnesota. Data provided by MPCA were assumed to be accurate and minimal QA/QC of the raw data was conducted. Where referenced, regulatory guidance/values were used to provide a point of reference and are not intended to indicate the need for specific additional actions at specific facilities, which is beyond the scope of this study and should involve a wider consideration of each facility's unique conditions and setting. No attempt was made to evaluate sample locations in relation to groundwater flow at a site or potential neighboring sources of groundwater contamination. It is assumed that concentrations in groundwater are associated with the waste disposal site. However, it is possible that concentrations observed in groundwater at some locations may also be affected by other nearby release sites and/or represent background conditions for a larger area.

Certifications

I hereby certify that this plan, document, or report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Geologist under the laws of the state of Minnesota.

Evan Christianson

Evan G Christianson

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Date: 2020.06.02 21:24:59 -05'00'

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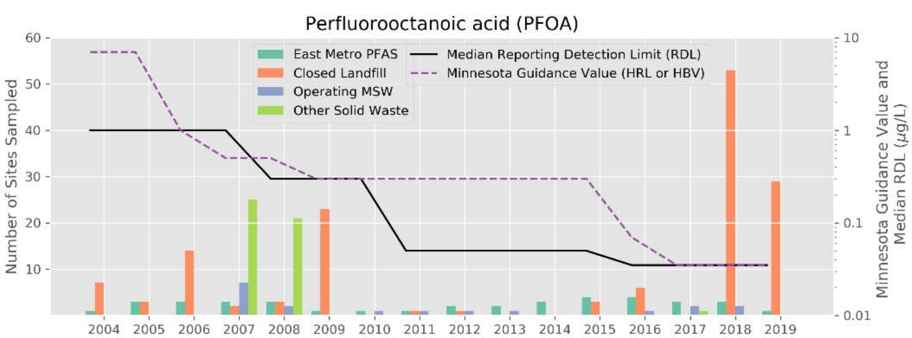
Evaluation of Emerging Contaminant Data at Solid Waste Facilities

Executive Summary

SUMMARY

Emerging contaminants (ECs) are those contaminants for which there is new awareness regarding how they move in the environment or affect public health. The emerging contaminants Per- and polyfluoroalkyl substances (PFAS) and 1,4-dioxane may be associated with many landfills and other solid waste facilities. This study compiles available data from the MPCA for these ECs in the closed landfill program (CLP), other operating solid waste facilities across Minnesota, and similar sites known to be sources of PFAS in the eastern Twin Cities Metropolitan Area. These data were then summarized and analyzed to evaluate trends, correlations, and summary statistics to better understand the potential distribution of these ECs present at CLP sites and similar facilities.

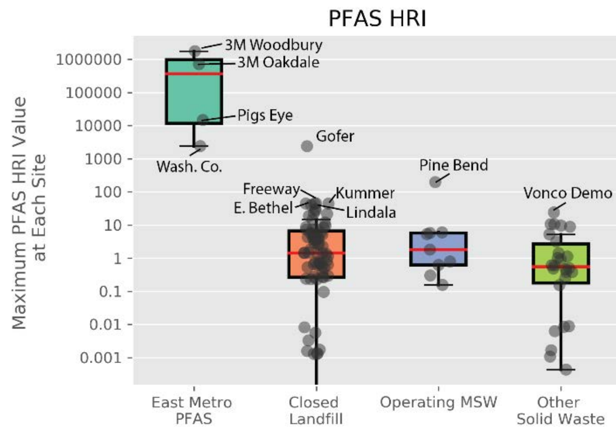


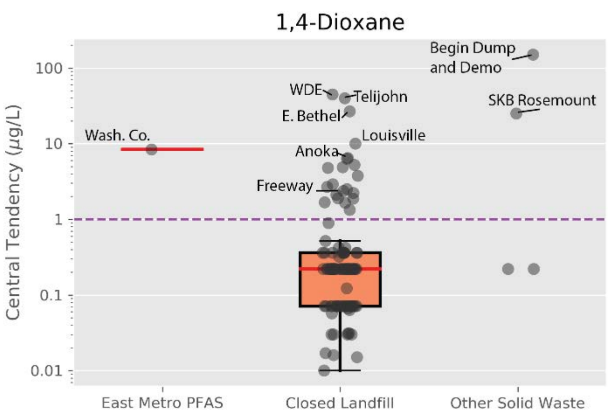
DATA AVAILABILITY

Over the past fifteen years, both the laboratory detection limits and the regulatory standards for PFAS have decreased significantly. Much of the available PFAS data was collected in the past two years at CLP sites, or is from 2006-2009 when regulatory guidance values and laboratory reporting limits were up to an order of magnitude greater than today. With the exception of closed landfills, there are very little data available for 1,4-dioxane at solid waste facilities.

PFAS

The distribution of PFAS in groundwater near the known sources in the east metro (including the Washington County Landfill) are distinct and typically much higher than most other solid waste facilities. However, near many facilities the composite Health Risk Index (HRI) values for PFAS are greater than 1.0 indicating possible exceedance of regulatory guidance. For sites within the CLP, 56 percent of sites had a maximum HRI for PFAS greater than 1.0. PFOA, PFOS and PFHxS are the most common PFAS detected at solid waste facilities above drinking water guidance values. PFBS and PFBA are typically not detected above the drinking water guidance values.





1,4-Dioxane

With the exception of the CLP sites, very little data are available for 1,4-dioxane in groundwater near solid waste facilities. Within the CLP sites, 25 percent of the facilities with data for 1,4-dioxane had an average concentration greater than the Minnesota drinking water guidance value of 1 µg/L. 1,4-dioxane was found to be correlated with many volatile organic compounds, indicating facilities with historically high groundwater concentrations for some VOCs may have concentrations of 1,4-dioxane at levels of concern.

1 Introduction

A study was conducted of available public data provided by the Minnesota Pollution Control Agency (MPCA) to better understand the range of emerging contaminants (ECs) at waste disposal sites in Minnesota. In recent years, MPCA has increased sampling for ECs at waste disposal sites, particularly in water samples related to groundwater monitoring, waste leachate, or related groundwater remediation systems.

Emerging contaminants are those contaminants for which there is new awareness regarding how they move in the environment or affect public health. Often these contaminants have been in the environment for some time but have typically not been tested for, either because laboratory techniques did not exist to test at low concentrations or there was lack of awareness that they may be present and of concern for public health or the environment.

Per- and polyfluoroalkyl substances (PFAS) and 1,4-dioxane are emerging contaminants of concern that may be associated with many landfills and other solid waste facilities. While in some contexts these contaminants are no longer emerging, as awareness of their presence has been growing for over a decade, the regulatory standards for these contaminants have been lowered over the last several years as new research is conducted and new analytical methods have reduced laboratory detection limits. Today's regulatory standards for PFAS are well below what were the laboratory detection limits less than 10 years ago.

It was only recently that these contaminants have been tested for at and near closed landfills within the Closed Landfill Program (CLP). This study compiles all available data for these emerging contaminants at facilities within the CLP and other solid waste facilities outside of the CLP across Minnesota. Data were also compiled for similar sites that the MPCA determined to be sources of PFAS in the eastern Twin Cities Metropolitan Area. These data were then summarized and analyzed to evaluate trends, correlations, and summary statistics to better understand the potential prevalence and risk of these emerging contaminants at closed landfill and similar facilities.

1.1 PFAS

PFAS were used in the manufacture of a wide range of products, including Teflon™, breathable water-proof fabrics, carpet and textile coatings, treated food wrappers, wire coatings, non-stick cookware, aqueous fire-fighting foam (AFFF), concrete and rock sealants, electrical capacitors, dyes, paints and coatings, batteries, photographic films, printing inks, herbicide and pesticide formulations, car wash surfactants, and as a vapor suppressor in metal plating processes (Kissa, 2001; 3M, 1999; Knepper and Langue, 2012). They are a ubiquitous presence in most households and consequently are found in municipal waste streams and in most landfills (Busch et al., 2009; MPCA, 2009).

The fluorine-carbon bond is one of the strongest chemical bonds and gives products made with PFAS the highly desirable properties of chemical, heat, and oil resistance; physical durability; and low electrical conductivity. Most PFAS are highly soluble in water and are resistant to degradation. They adsorb poorly to material with low organic material content, and when they bond, it is typically to surfaces of organic material. In saturated, unconsolidated deposits and fractured rock media, they are mobile and migrate similar to an unattenuated solute in flowing groundwater.

The most commonly studied PFAS are perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS). These are the eight-carbon chained molecules that were historically used in the majority of PFAS containing products. PFOA (perfluorooctanoic acid) is one of a class of fluorinated hydrocarbon compounds associated with fluoropolymers – most commonly recognized as Teflon®. PFOA and PFOS are no longer produced in North America.

Minnesota has established drinking water guidance values for five different PFAS (Table 1). The guidance values for these PFAS compounds have changed relatively frequently over the last decade as more studies and additional information have become available. These five PFAS are also the most common PFAS that are sampled for at solid waste facilities in Minnesota.

Table 1 Minnesota Guidance Values for PFAS in Drinking Water

PFAS	Minnesota Drinking Water Guidance Value (micrograms per liter (µg/L))
Perfluorobutane Sulfonate (PFBS)[2]	2
Perfluorohexane Sulfonate (PFHxS)[2]	0.047
Perfluorooctane Sulfonate (PFOS)[2]	0.015
Perfluorobutanoic Acid (PFBA)[1]	7
Perfluorooctanoic Acid (PFOA)[1]	0.035

(1) Values are Minnesota Health Risk Limit (HRL)

(2) Values are Minnesota Health-Based Value (HBV)

According to the Minnesota Department of Health (MDH), an HBV or HRL is the level of a contaminant that can be present in water and pose little or no health risk to a person drinking that water. HBVs and HRLs were developed to protect sensitive or highly exposed populations (MDH, 2020).

1.2 1,4-Dioxane

1,4-dioxane is most often associated with chlorinated solvents as it was commonly used as a stabilizer/preservative for solvent products. As a result, 1,4-dioxane can be present at chlorinated solvent release sites. 1,4-dioxane is very miscible in water, does not volatilize easily, adsorbs poorly to soil, and is resistant to degradation. Therefore, 1,4-dioxane is highly mobile in groundwater. Additionally, water impacted with 1,4-dioxane presents additional challenges as it cannot be treated with carbon-based treatment technologies that are often used for the remediation of chlorinated solvents sites. The current Minnesota HRL for 1,4-Dioxane is 1 μg/L.

2 Data Availability

Analytical data were provided from the MPCA's EQuIS™ database, including data from 109 CLP sites, 124 permitted solid waste facilities, and three former disposal areas within the eastern Twin Cities metropolitan area that are known sources of PFAS and have been part of the MPCA superfund program (east metro PFAS sites). These include Pigs Eye Dump, 3M Oakdale Disposal Site, and 3M Woodbury Disposal Site. The data provided included all analytical results in the database, including both emerging contaminants and data for analytes and parameters that have traditionally been monitored at waste facilities for decades such as: volatile organic compounds (VOCs), metals, and polychlorinated biphenyls (PCBs). For the east metro sites, data were available from the MPCA's EQuIS™ database for the 3M Woodbury Disposal Site and the Pigs Eye Dump. PFAS data for the 3M Oakdale Disposal Site were obtained from the 2018 annual PFAS monitoring report (Weston, 2019), provided by MPCA. In total, 5,956,217 records from 236 waste disposal sites were included in the dataset used for this study.

Data provided by MPCA were assumed to be accurate and minimal QA/QC of the raw data was conducted. Much of the data was processed to allow for consistent units and was converted to units of μg/L when possible. During the process of unit conversion some samples were noted to have units that were not consistent with the media being evaluated (e.g. units of μg/kg for a water concentration). These data were excluded and not considered for further analysis. Also, data from laboratory blanks, duplicates, gas extraction, soil gas, finished water, and storm water were not included in the analysis.

Many samples from closed landfills include locations within the footprint of the waste. When comparing to groundwater from other facilities these samples were excluded as they often represent results from targeted investigations and are not applicable when comparing to compliance monitoring from other facilities.

2.1 Grouping of Facility Types

For comparative purposes, four groups were established based on the type of site: closed landfills, sites in the east metro that are known sources of PFAS, operating solid waste facilities that accept mixed municipal solid waste (MSW), and all other permitted solid waste facilities. The Washington County landfill, which is part of the closed landfill program, has also been identified by MPCA as a source of PFAS in the east metro, in part due to the former legal disposal by 3M of industrial wastes from the manufacture of PFAS-containing materials. Waste from the Washington County Landfill was excavated and placed on a liner system in 2011. Due to the unique history of Washington County Landfill, it is more similar to other east metro PFAS sites than typical closed landfills. For the purpose of this study, Washington County Landfill is typically grouped with the east metro PFAS sites rather than the closed landfill sites. Additional discussion of the unique characteristics of Washington County Landfill compared to other closed landfills is presented throughout this report.

The Pigs Eye dump is located in the east metro and is a known source of PFAS in groundwater and surface water. This site is administered under the superfund program and for the purpose of the study is grouped with the east metro PFAS sites. Sites that do not fit the categories of CLP, East Metro PFAS sites, or operating MSW sites are grouped together as "other solid waste" facilities. This group primarily consists of demolition landfills but also includes specialty facilities that accept industrial waste.

The geographic extent and number of monitoring locations for data associated with the 3M Woodbury Disposal Site and the Washington County Landfill is much more expansive than all other locations evaluated as part of this study. These sites are known sources of PFAS in southern Washington County and large scale regional groundwater sampling has been conducted surrounding these sites to an extent that is not typical of most sites. To allow for better comparison of Washington County Landfill and 3M Woodbury Disposal Site to the others sites evaluated for this study, and to prevent the large regional nature of the sampling from skewing summary statistics, only monitoring locations within approximately two miles of each of the these sites were used. Figure 1 shows the monitoring locations associated with these two sites and which monitoring locations were included for this study.

Table 2 presents the availability of groundwater data for PFAS and 1,4-dioxane amongst the different facility groups reviewed for this study and the percent of samples that had detections for each analyte. The dataset available for the CLP sites is much more comprehensive than the operating MSW and other solid waste facilities. MPCA has very limited data for 1,4-dioxane for facilities outside of the CLP. There are no available results of 1,4-dioxane in groundwater for currently operating landfills that accept mixed municipal solid waste. As would be expected, there are significantly more data for the five regulated PFAS (PFOA, PFOS, PFBS, PFBA, and PFHxS) compared to the non-regulated PFAS. The most commonly detected emerging contaminant for the closed landfill facilities was PFBA, which was detected at 88.0 percent of the closed landfill facilities and 60.4 percent of closed landfill monitoring locations.

PFOA, PFHpA, and 1,4-dioxane were detected at similar frequencies at closed landfill facilities. PFOA was detected at 80.0 percent of closed landfills and at 36.5 percent of closed landfill monitoring locations. PFHpA, which is not regulated, was detected at 84.0 percent of closed landfills and at 44.0 percent of monitoring locations. 1,4-dioxane was detected at 83.2 percent of closed landfills and at 38.6 percent of monitoring locations. Regulated PFAS were detected with greater frequency at operating landfills that currently accept MSW when compared to closed landfills, though the sample size from the operating MSW group is much smaller than what is available for the closed landfill group. Due to the lack of available data for non-regulated PFAS, the majority of the analyses conducted did not include non-regulated PFAS.

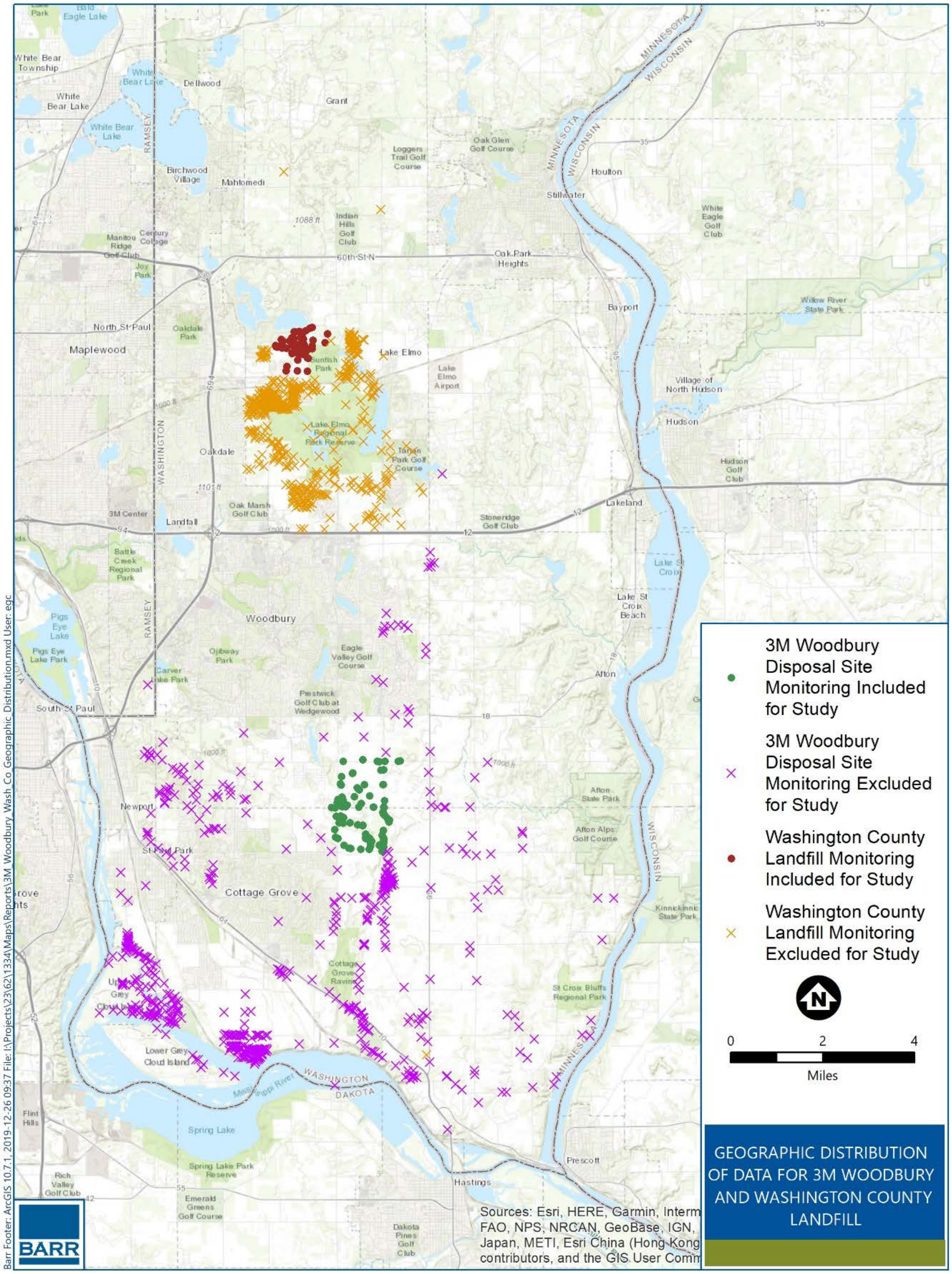


Figure 1 Geographic Distribution of Data for 3M Woodbury Disposal Site and Washington County Landfill

Table 2 Availability of Data for PFAS and 1,4-Dioxane

Analyte	Facility Type	Number of Samples	Percent of Samples with Detections	Number of Wells Sampled	Percent of Wells with Detections	Number of Facilities	Percent of Facilities with Detections
1,4-Dioxane	Closed Landfill	3624	40.0%	1485	38.6%	101	83.2%
	Operating MSW	0	--	0	--	0	--
	Other Solid Waste	34	2.9%	27	3.7%	4	25.0%
	East Metro PFAS	117	60.7%	33	60.6%	1	100.0%
Perfluorooctanoic acid (PFOA)	Closed Landfill	994	35.3%	616	36.5%	75	80.0%
	Operating MSW	117	53.0%	58	63.8%	9	100.0%
	Other Solid Waste	147	34.0%	81	39.5%	26	73.1%
	East Metro PFAS	1743	67.7%	253	64.8%	4	100.0%
Perfluorooctane sulfonic acid (PFOS)	Closed Landfill	991	18.4%	613	20.2%	75	48.0%
	Operating MSW	117	36.8%	58	37.9%	9	55.6%
	Other Solid Waste	147	8.8%	81	12.3%	26	34.6%
	East Metro PFAS	1760	50.0%	253	56.1%	4	100.0%
Perfluorobutane-sulfonate (PFBS)	Closed Landfill	942	19.5%	608	21.2%	75	46.7%
	Operating MSW	117	43.6%	58	44.8%	9	66.7%
	Other Solid Waste	147	17.7%	81	22.2%	26	50.0%
	East Metro PFAS	1816	40.7%	253	57.3%	4	100.0%
Perfluorobutanoic acid (PFBA)	Closed Landfill	942	59.7%	608	60.4%	75	88.0%
	Operating MSW	117	80.3%	58	81.0%	9	100.0%
	Other Solid Waste	147	70.1%	81	76.5%	26	100.0%
	East Metro PFAS	1606	85.9%	249	89.2%	4	100.0%
Perfluorohexane sulfonate (PFHxS)	Closed Landfill	942	19.4%	608	19.9%	75	42.7%
	Operating MSW	117	36.8%	58	39.7%	9	66.7%
	Other Solid Waste	147	24.5%	81	27.2%	26	50.0%
	East Metro PFAS	1329	50.9%	232	58.2%	4	100.0%
Perfluorodecane sulfonate (PFDS)	Closed Landfill	5	0.0%	5	0.0%	1	0.0%
	Operating MSW	60	6.7%	24	8.3%	2	50.0%
	Other Solid Waste	0	--	0	--	0	--
	East Metro PFAS	0	--	0	--	0	--

Table 2 (continued)

Analyte	Facility Type	Number of Samples	Percent of Samples with Detections	Number of Wells Sampled	Percent of Wells with Detections	Number of Facilities	Percent of Facilities with Detections
Perfluorodecanoic acid (PFDA)	Closed Landfill	246	10.2%	125	12.8%	25	16.0%
	Operating MSW	117	2.6%	58	3.4%	9	11.1%
	Other Solid Waste	145	4.8%	79	6.3%	25	12.0%
	East Metro PFAS	362	45.6%	64	71.9%	3	100.0%
Perfluorododecanoic acid (PFDoA / PFDoDA)	Closed Landfill	246	10.2%	125	12.8%	25	16.0%
	Operating MSW	117	0.9%	58	1.7%	9	11.1%
	Other Solid Waste	145	0.0%	79	0.0%	25	0.0%
	East Metro PFAS	370	15.9%	64	48.4%	3	100.0%
Perfluoroheptanoic acid (PFHpA)	Closed Landfill	246	37.4%	125	44.0%	25	84.0%
	Operating MSW	117	48.7%	58	58.6%	9	77.8%
	Other Solid Waste	145	30.3%	79	32.9%	25	64.0%
	East Metro PFAS	198	84.3%	30	86.7%	2	100.0%
Perfluorohexanoic acid (PFHxA)	Closed Landfill	942	31.7%	608	31.7%	75	66.7%
	Operating MSW	117	70.9%	58	75.9%	9	100.0%
	Other Solid Waste	147	42.9%	81	45.7%	26	80.8%
	East Metro PFAS	1496	61.2%	247	63.2%	4	100.0%
Perfluorononanoic acid (PFNA)	Closed Landfill	246	13.4%	125	16.8%	25	32.0%
	Operating MSW	117	4.3%	58	6.9%	9	22.2%
	Other Solid Waste	145	5.5%	79	7.6%	25	12.0%
	East Metro PFAS	368	51.9%	64	75.0%	3	100.0%
Perfluorooctane-sulfonamide (PFOSA / FOSA)	Closed Landfill	246	11.0%	125	14.4%	25	16.0%
	Operating MSW	117	8.5%	58	13.8%	9	22.2%
	Other Solid Waste	145	0.0%	79	0.0%	25	0.0%
	East Metro PFAS	0	--	0	--	0	--
Perfluoropentanoic acid (PFPeA)	Closed Landfill	942	34.7%	608	37.2%	75	72.0%
	Operating MSW	117	65.0%	58	69.0%	9	77.8%
	Other Solid Waste	0	--	0	--	0	--
	East Metro PFAS	1497	63.7%	247	70.4%	4	100.0%
Perfluoroundecanoic acid (PFUnA / PFUnDA)	Closed Landfill	246	10.6%	125	13.6%	25	20.0%
	Operating MSW	117	0.9%	58	1.7%	9	11.1%
	Other Solid Waste	0	--	0	--	0	--
	East Metro PFAS	367	18.5%	64	46.9%	3	66.7%

2.2 Temporal Availability of Data and Reporting Detection Limits

Over the last fifteen years, the laboratory detection limits for PFAS have decreased significantly. In parallel, the regulatory standards for PFAS in drinking water have also fallen. For several PFAS the median reporting detection limit for samples from 2007 and 2008 is an order of magnitude greater than the median reporting detection limits from samples collected in 2018 and 2019 (Table 3). In many cases the reported detection limits from 2007 and 2008 are over an order of magnitude greater than the current Minnesota drinking water guidance values.

Figure 2 shows the number of sites sampled for PFAS and 1,4-dioxane through time and how the median reporting detection limits (RDL) and Minnesota drinking water guidance values have changed. The majority of PFAS data in the closed landfill group are from 2018 and 2019 while the majority of PFAS data for the other groups is from 2006 and 2009. The data collected in 2007-2009 is primarily associated with an MPCA study of PFAS at solid waste facilities in Minnesota (MPCA, 2010). Since the time of that study significantly more data have been collected at closed landfills and the regulatory guidance values for PFAS have changed significantly.

For 1,4-dioxane, nearly all the data available are from the last five years. The majority of 1,4-dioxane data available for the closed landfill program is from 2016-2019 and for the other groups the data are from 2017-2018. A Health-Based Guidance Value (HBV) for 1,4-dioxane was first established in 2002 at 30 µg/L. In 2011 the HBV was revised to 1 µg/L and adopted as a Health Risk Limit (HRL) in 2013.

Table 3. PFAS Reporting Detection Limits and Minnesota Drinking Water Guidance Values in 2007-2008 Compared to 2018-2019

Chemical	Median Reporting Detection Limit from 2007-2008 (µg/L)	Median Reporting Detection Limit from 2018-2019 (µg/L)	Minnesota Drinking Water Guidance in 2007 (µg/L)	Minnesota Drinking Water Guidance 2019 (µg/L)
PFOA	0.3	0.035	0.5	0.035
PFBA	0.3	0.05	7	7
PFHxS	0.3	0.025	--	0.047
PFOS	0.3	0.025	0.3	0.015
PFBS	0.3	0.05	7	2

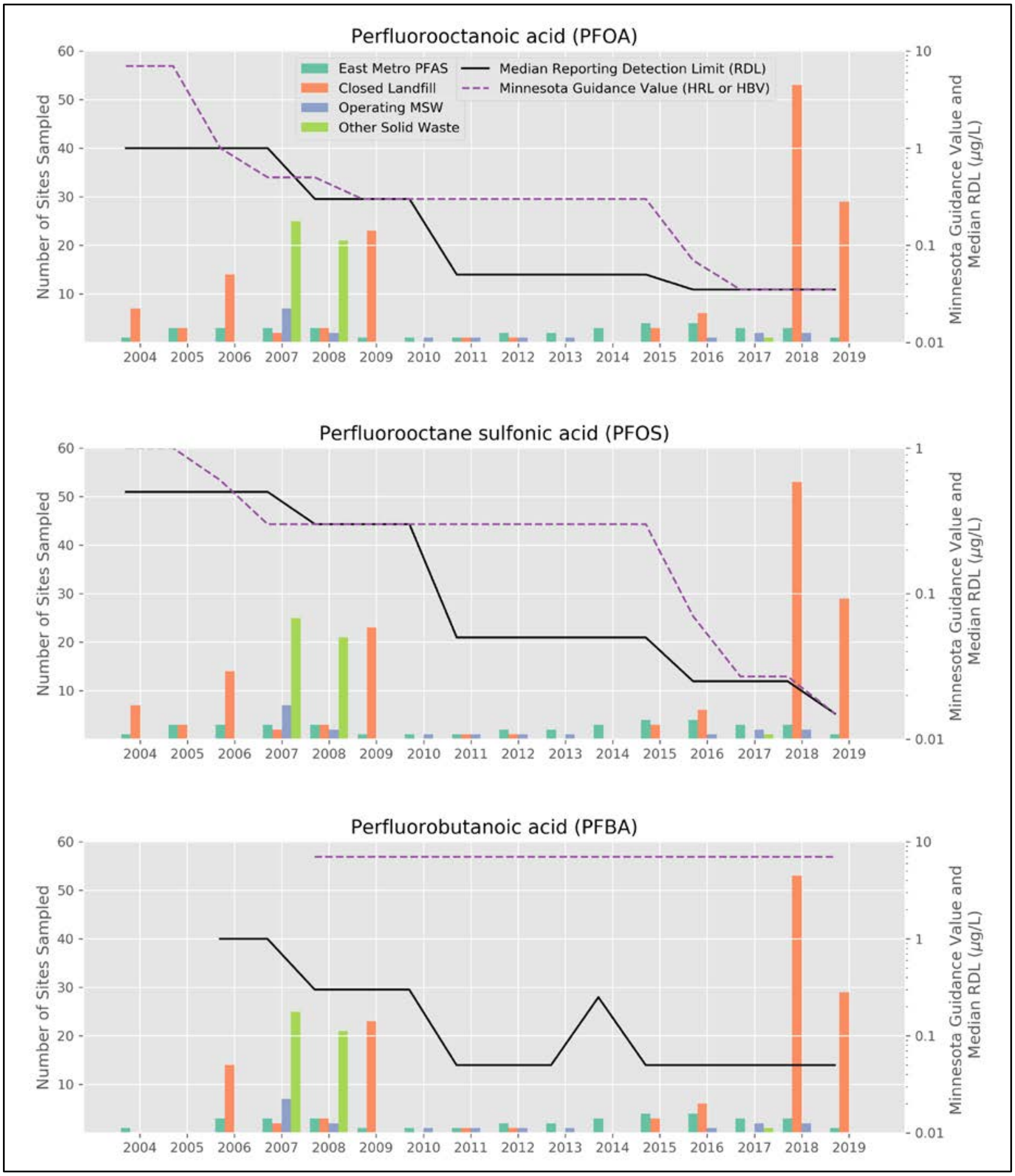


Figure 2 Number of Sites Sampled Minnesota Drinking Water Guidance Values, and Reporting Detection Limits though time for PFAS and 1,4-Dioxane

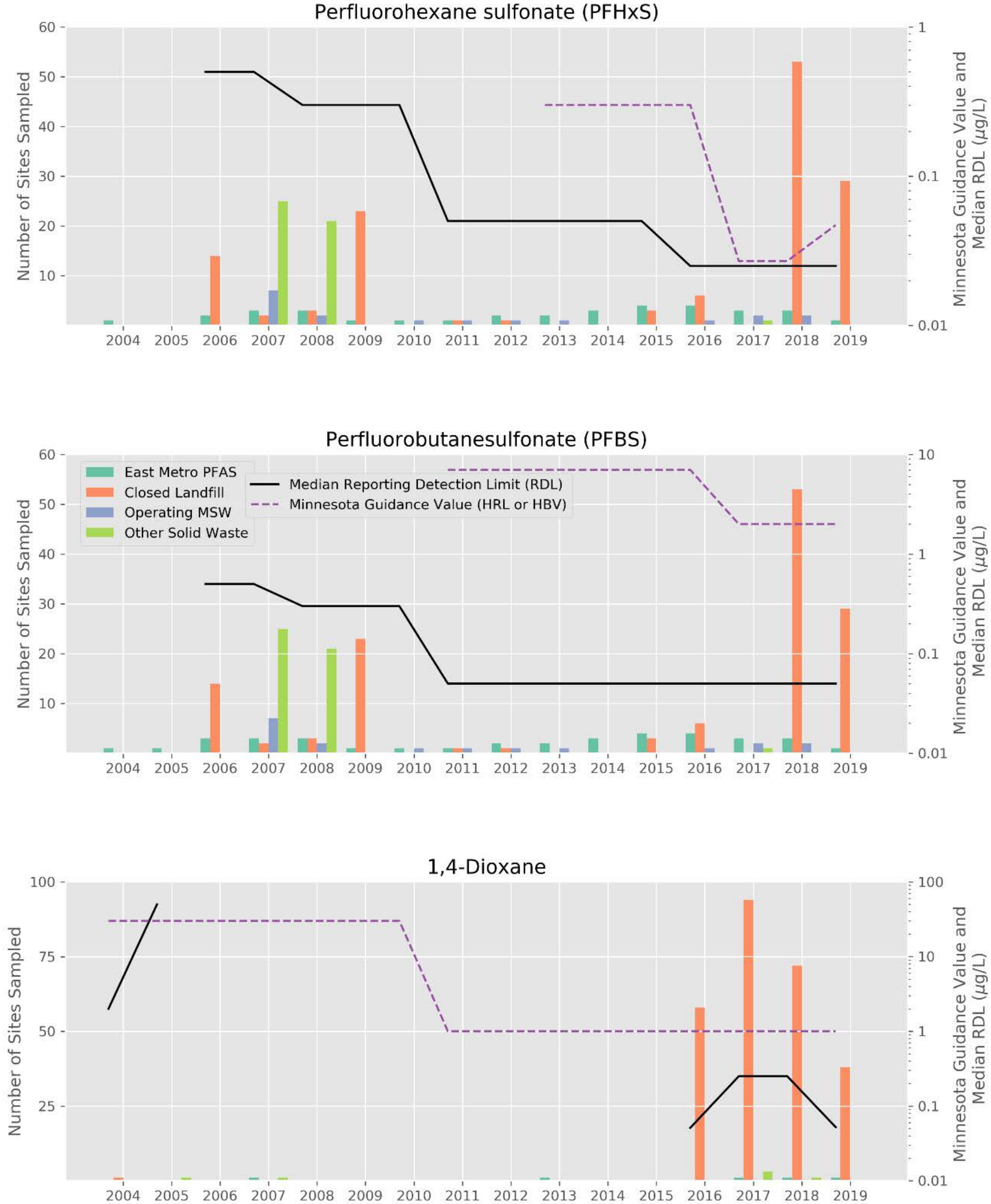


Figure 2 (continued) Number of Sites Sampled Drinking Water Guidance Values, and Reporting Detection Limits though time for PFAS and 1,4-Dioxane

3 PFAS and 1,4-Dioxane Summary Statistics

Summary statistics for regulated PFAS and 1,4-dioxane were determined for each site for comparison purposes. These include minimum and maximum concentrations, a measure of central tendency (an average or alternate measure for datasets for which there may be limitations affecting calculations of averages), the total number of samples collected, and the percentage of values with reported detections. All summary statistics are presented in Table A1 in Appendix A. The selection of the summary statistic used to compute the measure of central tendency was dictated by the percentage of detections. The decision process implemented is outlined in Table 4 below. These decisions are based on regulatory technical documents, including the EPA's Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities (Unified Guidance; U.S. EPA, 2009), the Statistical Software for Environmental Applications for Data Sets with and without Non-detect Observations (ProUCL Technical Guide; U.S. EPA, 2015), the ITRC Guidance Document: Groundwater Statistics and Monitoring Compliance (ITRC Guidance; ITRC, 2013), and project specific considerations.

Table 4 Process to Determine Measure of Central Tendency for Data Containing Non-Detects with Variable Detection Limits

Non-Detect Frequency	Measure of Central Tendency	Citations
0%	Arithmetic mean	For datasets with no non-detects, the Kaplan-Meier mean is equal to the arithmetic mean (Helsel, 2012).
≤50%	Kaplan-Meier (KM) mean	• Kaplan Meier recommended (U.S. EPA 2009, pg. 15-3) *"The guidance generally favors the use of the …Kaplan-Meier or Robust ROS* [regression on order statistics] *methods which can address the problem of multiple detection limits"* • Robust ROS ruled out (U.S. EPA 2009, pg. 8-24) Robust ROS underlying assumptions: *"Data must be normal or normalized…"* • Limit at 50% non-detects (U.S. EPA 2009, pg. 8-23) *"Kaplan-Meier should not be used when more than 50% of the data are non-detects."*
>51%	Median value. If median is a non-detect, report as a less-than value	• Project-specific method (U.S. EPA 2015, sec. 1.12): *"For data sets with low detection frequencies, other measures such as the median or mode represent better estimates (with lesser uncertainty) of the population measure of central tendency."*
100%	Not reported (n/a)	For the purposes of this study the measure of central tendency for datasets consisting of 100% non-detect will be reported as the lowest detection limit associated with the non-detects.

In addition to the quantitative summary statistics in Table A1, box-and-whisker plots of all data for many of the analytes were created to visually illustrate the distribution of the data and used as an initial screening to discern group differences. Box-and-whisker plots presented in Appendix B consist of a central box, with the lower limit of the box indicating the first quartile (25th percentile of the data) and the upper limit of the box indicating the third quartile (75th percentile of the data). The height of the box (the difference between the first and third quartiles) is called the interquartile range. Within the box is a heavy line indicating the median (50th percentile of the data). Extending in each direction from the box are "whiskers," which extend to values within one and a half times the interquartile range from each end of the box. Values beyond the whiskers are potential outliers. For each box-and-whisker plot in Appendix B individual measured values are plotted as points over lying the box-and-whiskers; non-detect values are plotted as blue points at their reporting detection limit and all measurements above the detection limit are plotted as green points.

Summary statistics from Table A1 are presented visually on as box-and-whisker plots of the measures of central tendency (Figure 3) and maximum value (Figure 4) for each of the PFAS with Minnesota drinking water guidance values and also for 1,4-dioxane. The dots overlying each box are the values for an individual site. The red lines on each box indicates the median and the horizontal purple dashed line shows the Minnesota drinking water guidance value. Values which are non-detects are included at the detection limit.

Based on review of Figure 3 and Figure 4, and the summary statistics presented in Table A1, the following are noted for PFAS and 1,4-dioxane amongst the different groups:

PFOA

With the exception of Washington County Landfill, the east metro PFAS sites have measures of central tendency for PFOA that are one to two orders of magnitude greater than most other facilities. Washington County Landfill does have a maximum measured concentration of 82 µg/L which is greater than all other closed landfill facilities. Gofer Landfill, which is in the Closed Landfill Program, is an apparent outlier with a central tendency for PFOA of 5.5 µg/L and a maximum measured value of 47 µg/L. Pine Bend Sanitary Landfill is an apparent outlier within the operating MSW group for both the measure of central tendency and maximum value, 0.34 µg/L and 2.7 µg/L respectively. A total of 17 facilities within the closed landfill group have a measure of central tendency for PFOA greater than the Minnesota drinking water guidance value of 0.035 µg/L. An additional five facilities within the closed landfill group had a measure of central tendency of <0.087 µg/L, indicating non-detects but with a detection limits above the current guidance value.

PFOS

The east metro PFAS sites have a large range for the measures of central tendency, with 3M Woodbury Disposal Site (<0.04 µg/L) and Washington County Landfill (<0.1 µg/L) on the low end of the range. However, maximum measured values for all the east metro PFAS sites are higher than other facilities with the exception of Gofer Landfill (1.49 µg/L) which is an apparent outlier within the closed landfill group. Pine Bend Sanitary Landfill is an apparent outlier within the operating MSW group for both the measure of central tendency (0.18 µg/L) and maximum measured value (1.4 µg/L). Eight facilities within the closed landfill group have measures of central tendency greater than the

Minnesota drinking water guidance of 0.015 µg/L. One facility within the other solid waste group, Begin Dump and Demolition Landfill, and two facilities within the operating MSW group, Pine Bend Sanitary Landfill and Burnsville Sanitary Landfill, had a measure of central tendency greater than the drinking water guidance. It is noted that only one sample (of two total) at Begin Dump and Demolition Landfill exceeded the drinking water guidance.

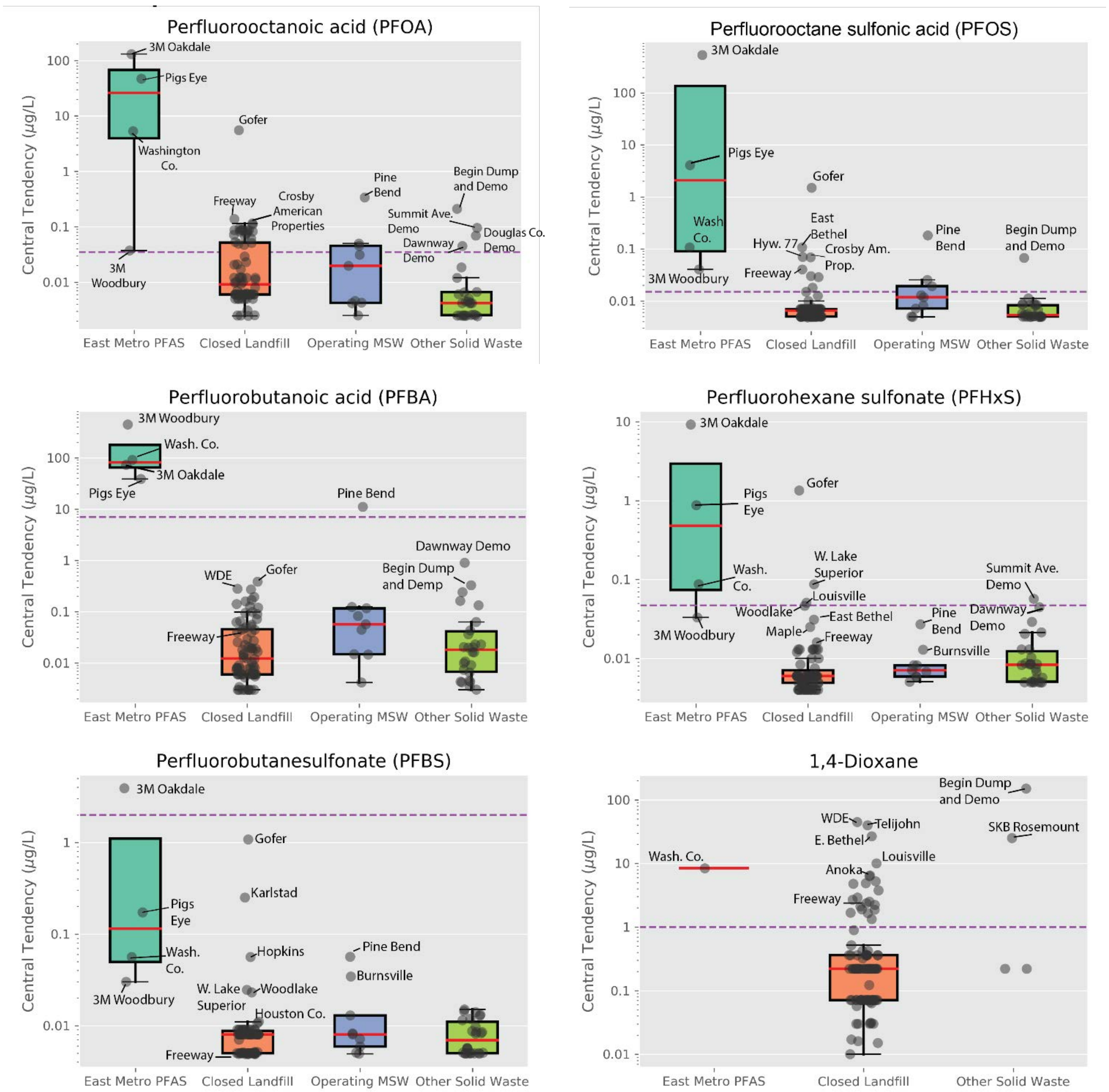


Figure 3 Box-and-Whisker Plots of the Measure of Central Tendency for PFAS and 1,4-Dioxane

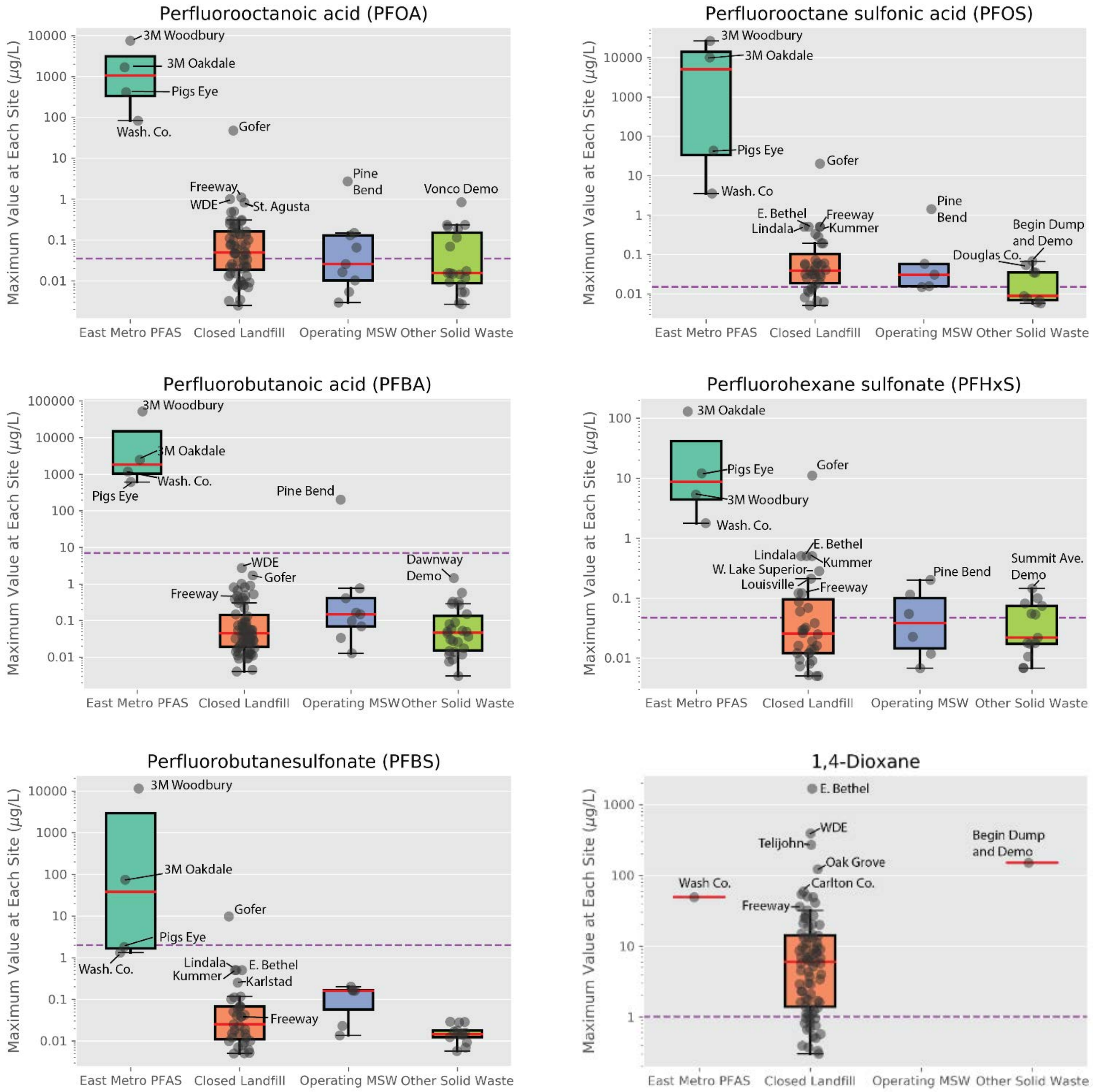


Figure 4 Box-and-Whisker Plots of the Maximum Value for PFAS and 1,4-Dioxane

PFBA

The east metro PFAS sites and Pine Bend Sanitary Landfill are the only facilities with measures of central tendency and maximum measured values greater than the Minnesota drinking water guidance of 7 µg/L. The measure of central tendency for all the facilities within the closed landfill group are at least an order of magnitude below the drinking water guidance.

PFHxS

The east metro PFAS sites have a large range for measures of central tendency for PFHxS, with Washington County Landfill (0.03 µg/L) and the 3M Woodbury Disposal Site (0.08 µg/L) falling on the low end. This is similar to the distribution observed for PFOS. Gofer Landfill is a significant outlier within the closed landfill group having a central tendency of 1.34 µg/L and maximum measured value of 11.0 µg/L.

Two facilities within the closed landfill group, Gofer Landfill and Western Lake Superior Sanitary District Landfill, had measures of central tendency greater than the Minnesota drinking water guidance of 0.047 µg/L. No facilities from the operating MSW group had measures of central tendency greater than the drinking water guidance. One facility from the other solid waste group, Summit Avenue Demolition Landfill, had a measure of central tendency greater than the drinking water guidance.

PFBS

Only one facility, 3M Oakdale Disposal Site, had a central tendency greater than the Minnesota drinking water guidance for PFBS of 2 µg/L. Three facilities had maximum measured values greater than the drinking water guidance; 3M Oakdale Disposal Site, 3M Woodbury Disposal Site, and Gofer Sanitary Landfill. For most facilities the measure of central tendency is one to two orders of magnitude less than the drinking water guidance value.

1,4-Dioxane

Limited data for 1,4-dioxane are available outside the closed landfill group to allow for meaningful comparisons. Within the closed landfill group, the central tendency for 20 facilities is greater than the Minnesota drinking water guidance value of 1 µg/L. The maximum value from 69 facilities was greater than the drinking water guidance value.

3.1 Composite Heath Risk Index for PFAS

Due to the ubiquitous presence of potential PFAS containing materials in landfills, there are often multiple PFAS compounds that may be present in groundwater near these sites. The MDH uses an additive model to determine a Health Risk Index (HRI) associated with exposure to multiple chemicals. Using this approach is useful for this study to better understand the distribution and potential risk associated with multiple PFAS at the different landfills.

The HRI for PFAS was determined as:

$$HRI = \frac{C_{PFBS}}{HBV_{PFBS}} + \frac{C_{PFHxS}}{HBV_{PFHxS}} + \frac{C_{PFOS}}{HBV_{PFOS}} + \frac{C_{PFBA}}{HRL_{PFBA}} + \frac{C_{PFOA}}{HRL_{PFOA}}$$

Where:

C_{PXXX} is the concentration of a PFAS
HBV_{PXXX} is the Health Base Value for a PFAS, where applicable
HRL_{PXXX} is the Health Risk Limit for a PFAS, where applicable.

HRI values greater than 1.0 indicates possible exceedance of regulatory guidance (MDH, 2020).

To determine the HRI for PFAS, all non-detect values were assumed to be zero. HRI values for PFAS were determined for individual wells using results from individual sampling events. Samples from locations within the footprint of the waste were not included. A total of 5,426 HRI values were determined for 114 sites. The maximum HRI value at each site was compiled and used to compare different sites. Figure 5 and Table 5 summarize the maximum HRI for PFAS observed at each site grouped into different categories. The east metro PFAS sites show substantially higher maximum HRI values than other groups. The closed landfill group had a median HRI for PFAS of 1.4. A total of 42 closed landfills (56%) had a maximum HRI above 1.0 and 33 had a maximum HRI below 1.0.

The four east metro PFAS sites had the highest PFAS HRI of all the sites. Within the closed landfill group Gofer Sanitary Landfill is distinct and has a maximum PFAS HRI nearly two orders of magnitude greater than other landfills in the closed landfill program (with the exception of Washington County Landfill which is in the east metro PFAS group). Among the east metro PFAS sites the 3M Woodbury Disposal Site and 3M Oakdale Disposal Site had the highest maximum PFAS HRI.

There were six sites where the PFAS HRI was 0.0, meaning all samples for PFAS were below the detection limit. There were an additional nine closed landfills and seven solid waste facilities where the HRI for PFAS was below 0.1. At most of the sites where the HRI was below 0.1 only a few samples (typically just one) were available.

Figure 6 shows the maximum PFAS HRI values for each facility at its mapped geographic location. These data are also presented in Appendix E. Many of the facilities with higher PFAS HRI tend to be located within or near the Twin Cities Metropolitan Area. This may be partially explained by two factors associated with site operation and monitoring: 1) the facilities in the Twin Cities Metropolitan Area tend to be larger facilities (based on data from the CLP) and 2) facilities within the Twin Cities Metropolitan Area have larger data sets (more sampling locations) than many of the outstate facilities, due in part to their size. Figure 7 shows a plot of the maximum PFAS HRI value for each facility within the closed landfill group compared to the volume of waste at each facility. The volume of waste and the maximum PFAS HRI show a statistically significant positive correlation with an R^2 of 0.37 and a p-value of 0.002. This suggests that sites with greater volume of waste are more likely to have higher maximum PFAS HRIs.

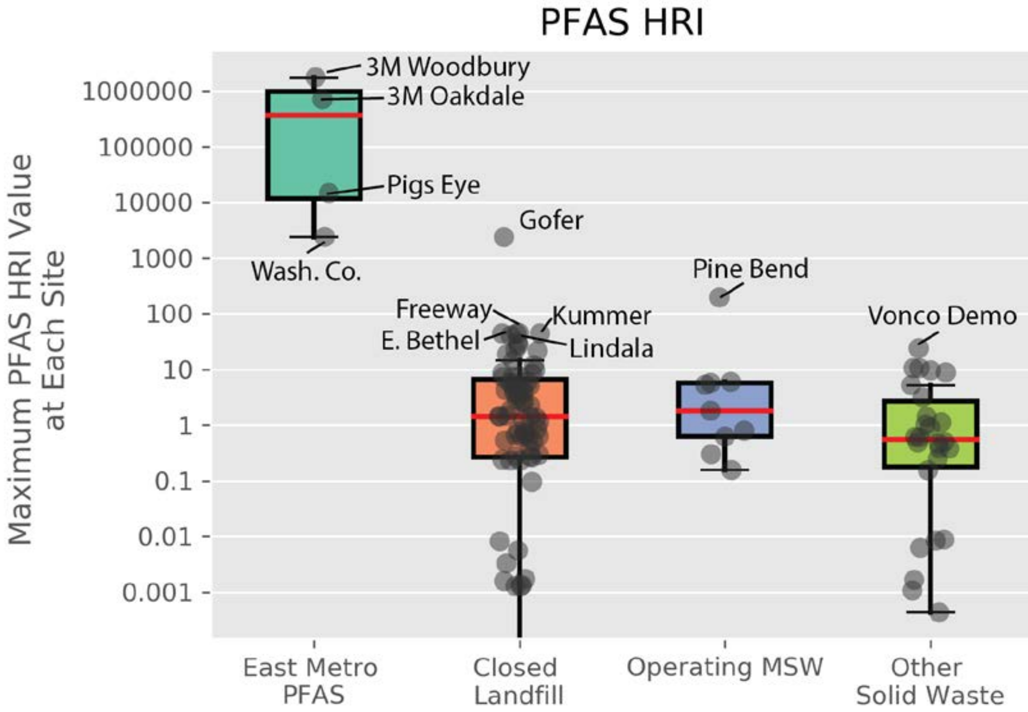


Figure 5 Box-and-Whisker Plots of the Maximum PFAS Health Risk Index (HRI) for Groundwater

Table 5 Summary of PFAS Health Risk Index

Landfill Group	Median HRI	Number of Sites with HRI > 1	Number of Sites with HRI < 1	Min HRI	Max HRI
Closed Landfills	1.4	42	33	0.0	2381
MSW	1.8	5	4	0.16	197
Other Solid Waste	0.6	10	16	0.0004	239
East Metro PFAS Sites	8565	4	0	14.8	1763998

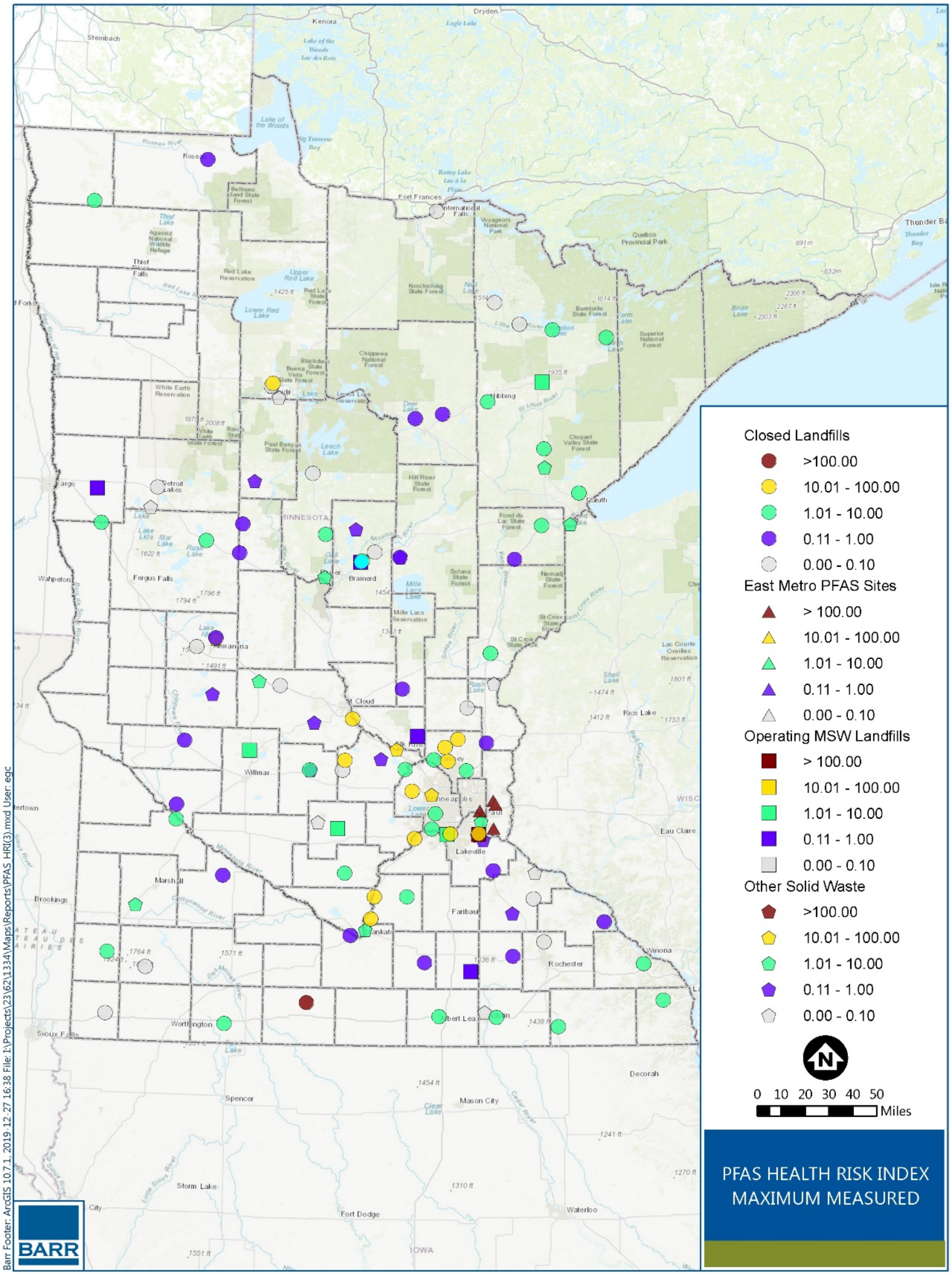


Figure 6. Spatial Distribution of PFAS Health Risk Index

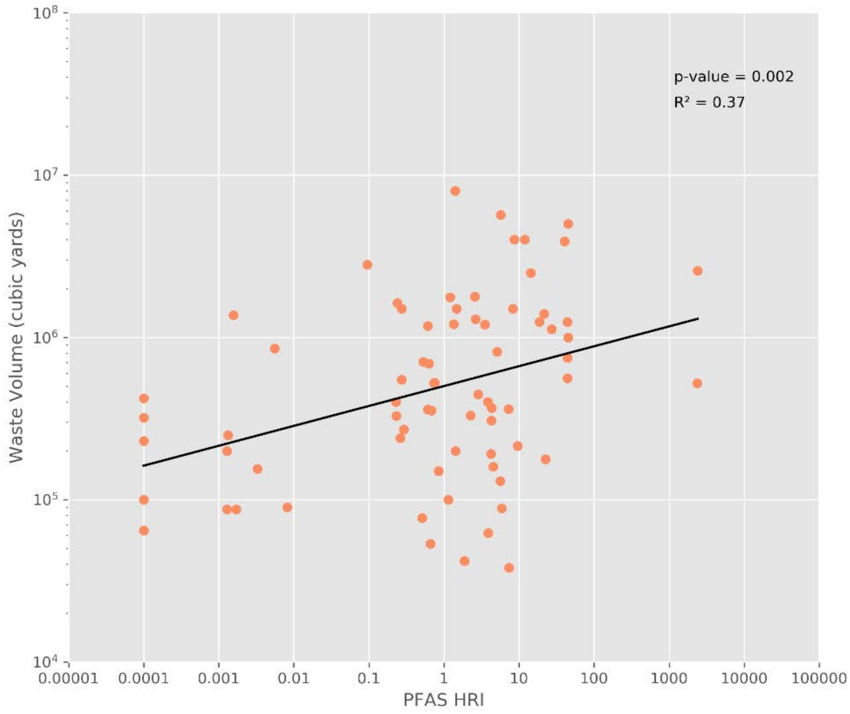


Figure 7 PFAS Health Risk Index (HRI) vs Volume of Waste, CLP Sites Only

3.2 Comparison of PFAS and 1,4-dioxane distributions amongst different sites

Review of the summary statistics and box plots suggest there are differences in the distributions of PFAS and 1,4-dioxane between sites. The generalized Wilcoxon Test was used to compare distributions of PFAS and 1,4-dioxane amongst different sites as it is suited for datasets that are not normally distributed and contain non-detects (Helsel, 2012). The results of the Wilcoxon Test were used to determine if the observed differences in the distribution at different sites are statistically significant. The results of the test were used to calculate a p-value. A p-value less than 0.01 was taken to indicate distributions which are different at a statistically significant level.

Heat-maps of the Wilcoxon Test p-values are presented on Figures C1 to C6 in Appendix C. Review of the results indicates that the four east metro PFAS sites in addition to the Gofer Landfill have PFAS distributions that tend to be significantly different from other sites. Tellijohn Landfill (SW-67), Louisville Landfill (SW-32), and Anoka Municipal Landfill (SW-94) have distributions of 1,4-dioxane that are different at a statistically significant level from most sites.

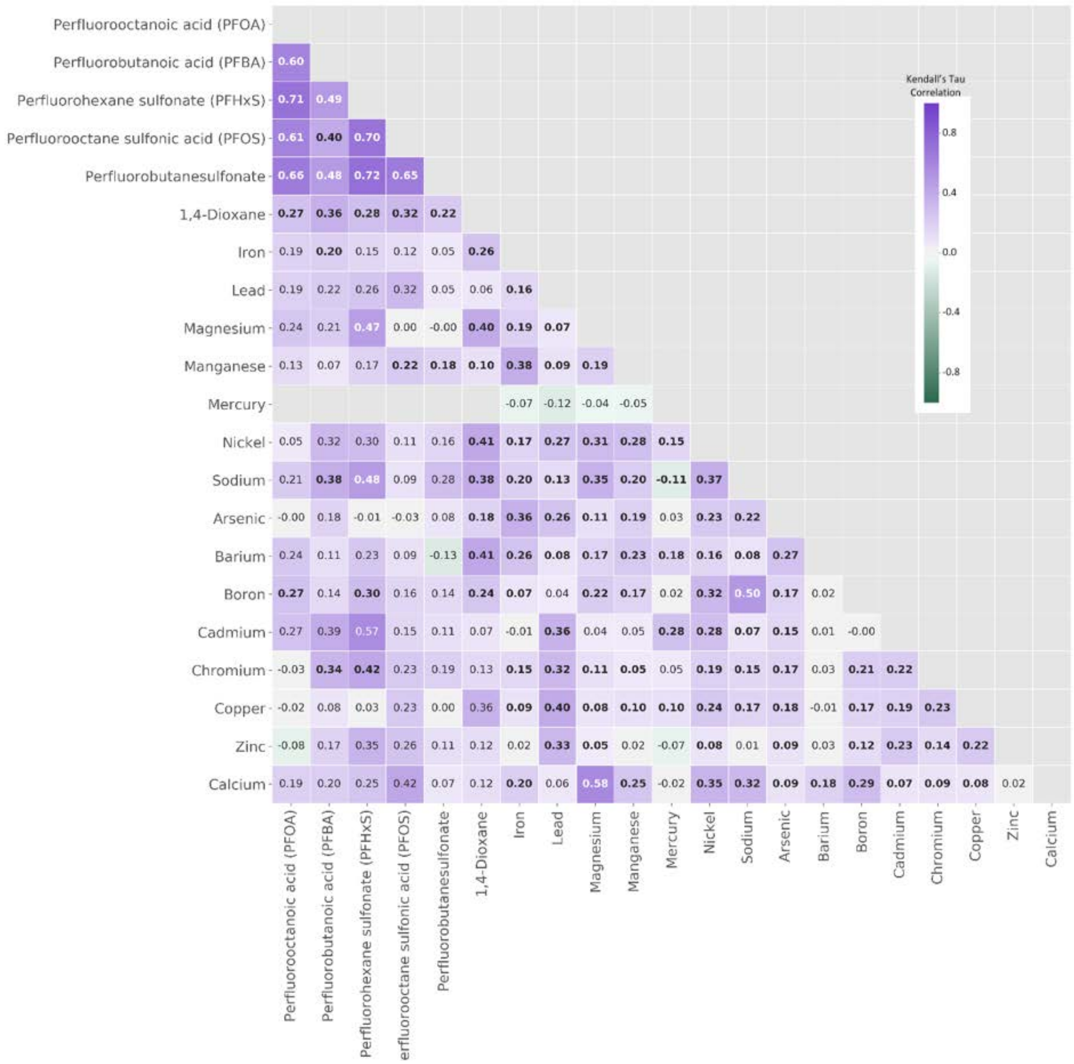
3.3 Correlation Analysis

Correlations between different analytes were evaluated by calculating Kendall's tau correlation coefficients. Kendall's tau correlation is a non-parametric statistical test used to assess whether the concentration of two parameters systematically increase (positive correlation) or decrease (negative correlation) together. A Kendall's tau correlation coefficient of 0 indicates that the data are perfectly uncorrelated, a Kendall's tau correlation coefficient of -1 indicates that the data are perfectly negatively correlated, and Kendall's tau correlation coefficient of 1 indicates that the data are perfectly positively correlated. For this analysis, two sample results were considered comparable only if from the same monitoring location and sampled for on the same day. All non-detects were excluded. If fewer than 10 sample pairs were available, a correlation coefficient was not calculated.

Results showing the Kendall's tau correlations for PFAS, 1,4-dioxane and metals is shown on Figure 8. All of the PFAS are positively correlated with each other. 1,4-dioxane is weakly correlated with PFAS; meaning they are likely not predictors of the other's presence. Some metals had a weak correlation with PFAS. However, overall metals are likely not a good predictor of the presence of PFAS. The strongest significant correlations of metals with 1,4-dioxane were barium, nickel, and magnesium. However, like PFAS, metals are likely not a good predictor of the presence of 1,4-dioxane.

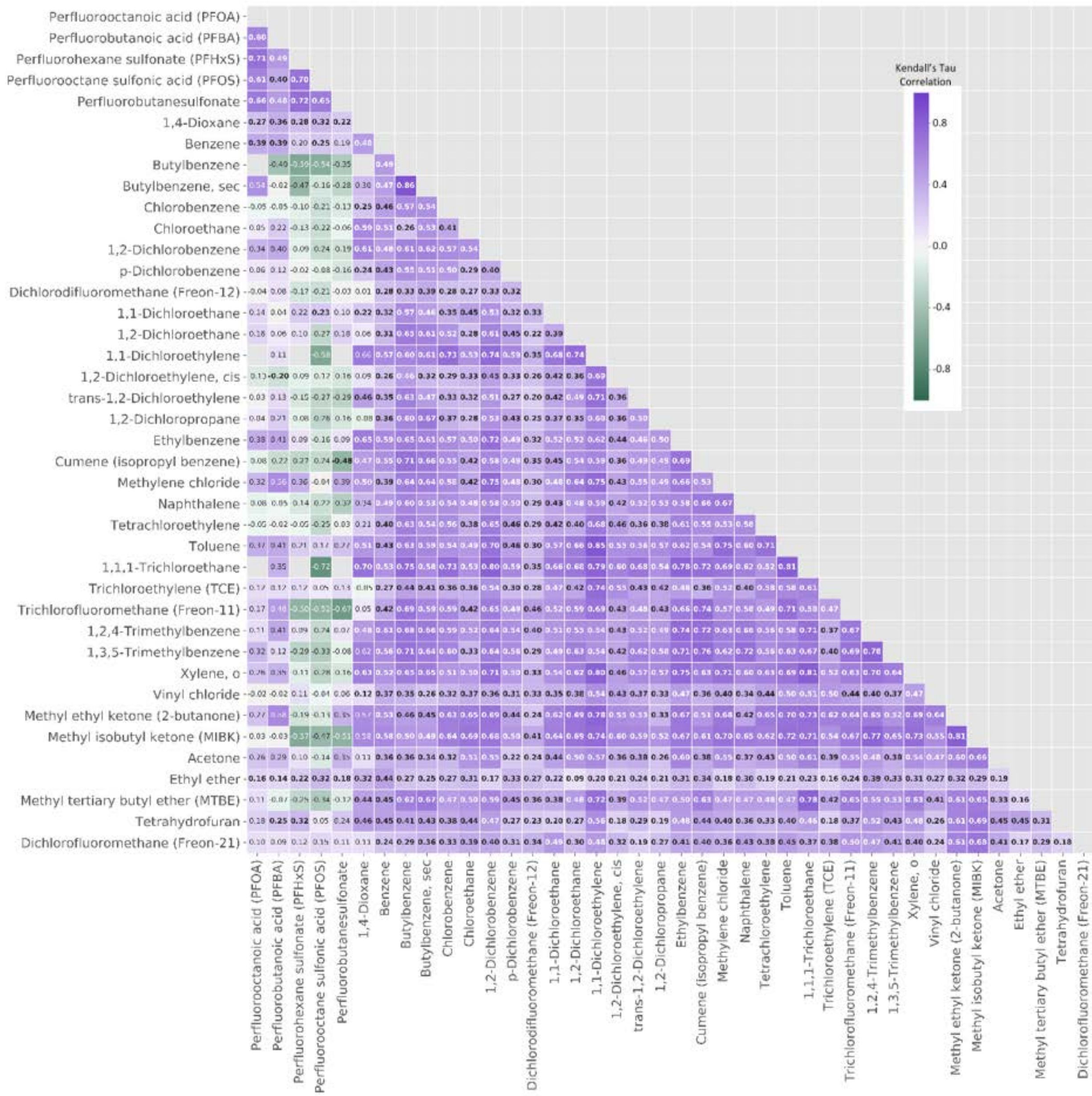
Figure 9 shows the Kendall tau correlation for PFAS, 1,4-dioxane, and volatile organic compounds (VOCs). Only four of the VOCs tested were found to have significant positive correlations with any of the PFAS compounds. These include: benzene, 1,1-dichlorobenzene, ethyl ether, and tetrahydrofuran. Of these benzene had the strongest correlation with a tau of 0.39 for both PFOA and PFBA.

1,4-dioxane was positively correlated with many VOCs. The strongest significant correlations for 1,4-dioxane were with 1,1,1-Trichloroethane (TCA), ethylbenzene, xylene, 1,2-dichlorobenzene, and chloroethane. 1,4-dioxane is commonly associated with TCA because it was often used as a stabilizer for chlorinated solvents. Some of these VOCs may be a good predictor of the presence of 1,4-dioxane.



Purple indicate positive correlations and green indicates negative correlations. Darker shading indicates stronger correlation. Values in **bold** indicate statistically significant correlations

Figure 8 Kendall's Tau Correlation Coefficients, PFAS, 1,4-Dioxane, and Metals



Purple indicate positive correlations and green indicates negative correlations. Darker shading indicates stronger correlation.
Values in **bold** indicate statistically significant correlations

Figure 9. Kendall's Tau Correlation Coefficients, PFAS, 1,4-Dioxane, and VOCs

4 Leachate Data

There were limited data available for PFAS and 1,4-dioxane in waste leachate compared to the available EC data for groundwater. This lack of data is in part because only seven closed landfills have bottom liner systems where leachate can be contained and monitored. Figure 10 shows box-and-whisker plots of maximum PFAS HRI for each site calculated using leachate concentrations. Comparison of Figure 10 to Figure 5 indicates that PFAS HRI values calculated using leachate are typically higher than groundwater. However, on a site-by-site basis this relationship was not always true. Figure 11 shows maximum PFAS HRI for leachate vs maximum PFAS HRI for groundwater. If groundwater and leachate PFAS HRI values were identical for a site it would plot on the diagonal line (one-to-one line) on Figure 11. Most points plot above/left of the one-to-one line indicating the leachate PFAS HRI values are typically higher than HRI values calculated using groundwater. However, for two sites the highest groundwater HRI was greater than leachate HRI: Spruce Ridge Landfill, and Mille Lacs Landfill. The data were not sufficient to indicate why the leachate were less than groundwater but it may be due to timing of samples, sampling protocol, or misidentification of leachate or groundwater in the database.

The data were not sufficient to indicate trends regarding performance of different liner types for effectively mitigating the transport of PFAS from leachate to groundwater. No trends or clusters of facilities that indicated better or worse relative differences in PFAS leachate vs groundwater were observed. To better assess the effectiveness of different liner types on PFAS mitigation a specifically designed study with carefully chosen sampling locations would be necessary.

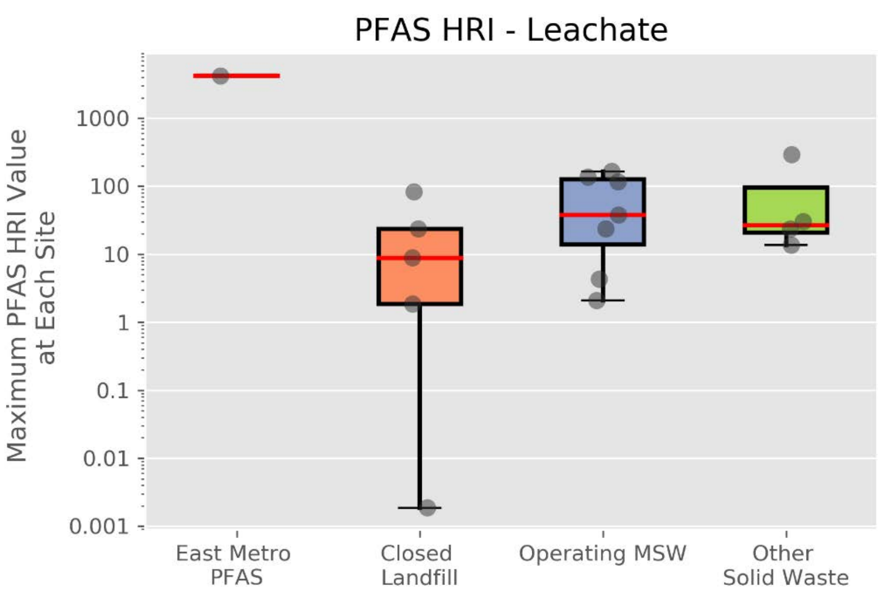


Figure 10 Box-and-Whisker Plots of the Maximum PFAS Health Risk Index (HRI) for Leachate

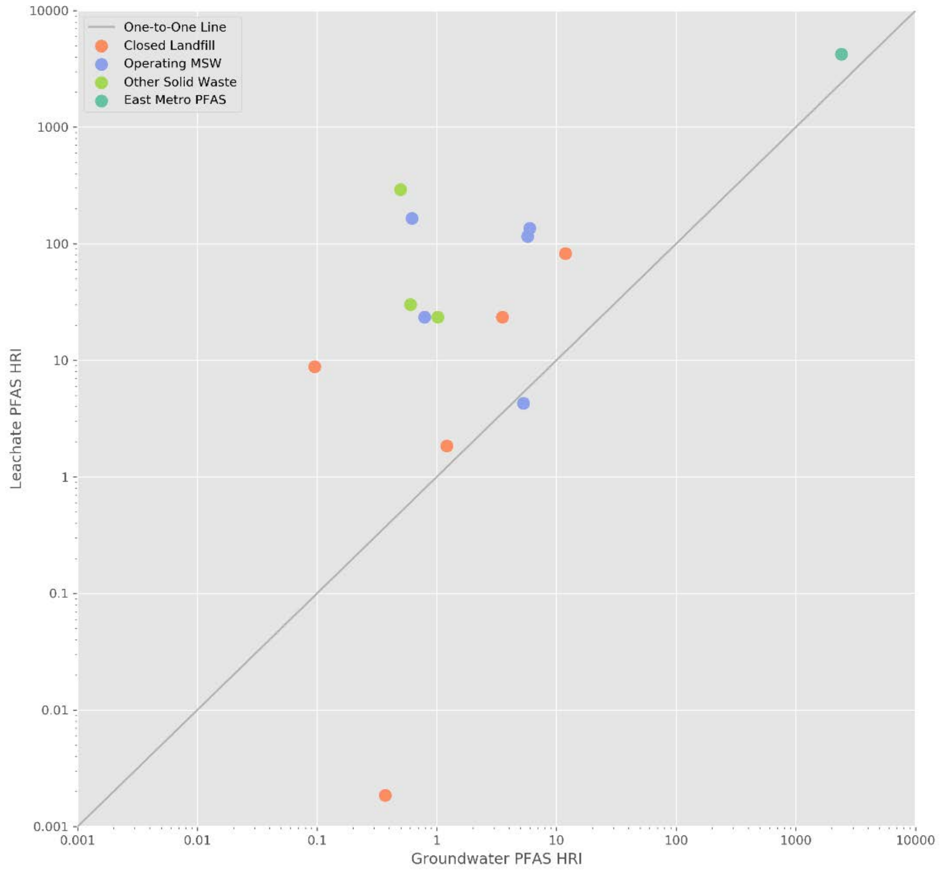


Figure 11 Groundwater PFAS HRI vs. Leachate PFAS HRI

5 Agglomerative Hierarchical Cluster Analysis

Agglomerative Hierarchical Cluster (AHC) analysis involves evaluating data for multiple analytes at once to try and identify which locations are similar to other locations based on the characteristics and distributions of the analytes. AHC analysis is a statistical iterative classification method that groups, or clusters, like-data based on statistical thresholds. The output from AHC analysis is commonly presented using a dendrogram (clustering tree) representing a hierarchy of similarities and dissimilarities. For this study AHC analysis was conducted using Scikit-learn (Pedregosa et. al., 2011) with Ward method linkage criteria. For all analytes evaluated, concentrations less than the reporting detection limit were set at a value of zero, as other methods of treating non-detect data can obfuscate clustering results due to varying reporting limits.

Several different cluster analyses were conducted with different groups of analytes: regulated PFAS; 1,4-Dioxane; and VOCs with 1,4-Dioxane. Dendrograms for these analyses are presented on Figures 12 to

14. The horizontal axis of the dendrograms represents the dissimilarity between clusters. For example, to compare how similar (or dissimilar) two sites are, determine where along the horizontal axis the two sites join. The further along the horizontal axis where two sites, or groups of sites, join the more dissimilar those sites or groups are.

Results of the AHC analysis suggest that for regulated PFAS six major groups could be identified based on similarities in PFAS. These are: 1) Washington County Landfill, 2) Pigs Eye Landfill and 3M Oakdale Disposal Site, 3) Pine Bend Landfill and Dawnway Demolition Landfill, 4) 3M Woodbury, 5) Gofer Landfill, and 6) all other sites. Comparing the AHC results and the measures of central tendency in Figure 3 shows that for many PFAS Pigs Eye Landfill and 3M Oakdale have central tendencies greater than other sites. However, when comparing maximum values the East Metro PFAS sites are more similar to each other. As described in Section 2.1 the geographic distribution of available data for 3M Woodbury and Washington County Landfill were much greater than other sites. Data collected approximately two miles from these sites were excluded from the analysis. However, this difference in data density and geographic distribution may still be skewing the AHC results to some degree.

For 1,4-dioxane four groups were identified: 1) Tellijohn Landfill and Begin Dump and Demolition Landfill, 2) Louisville Landfill and Anoka Municipal Landfill, 3) Jackson County Landfill and WDE Landfill, and 4) all other sites. The classification of Begin Dump is suspect due to only two sample results available and only one of these being a detection.

The AHC analysis for 1,4-dioxane and VOC identified four groups: 1) Tellijohn Landfill and Begin Dump and Demolition Landfill, 2) Dodge County Landfill Salol Landfill, and Mankato Landfill 3) Anoka Municipal Landfill and Louisville Landfill, 4) Land Investors Landfill, and 5) all other sites. The results of this analysis were similar to the results for 1,4-dioxane by itself.

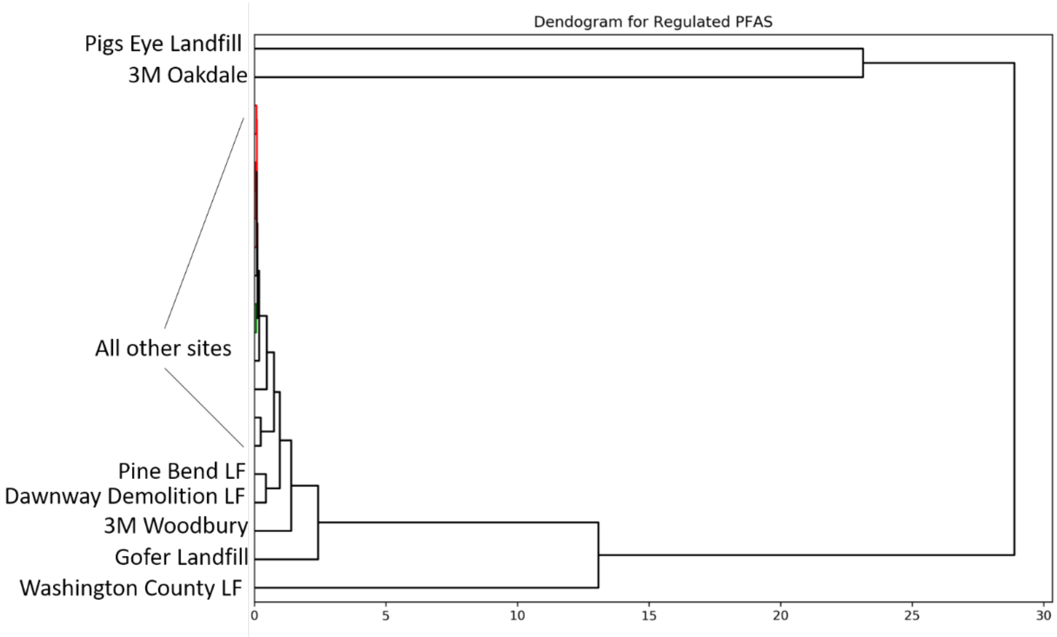


Figure 12. Dendrogram Showing Results of AHC Analysis for PFAS

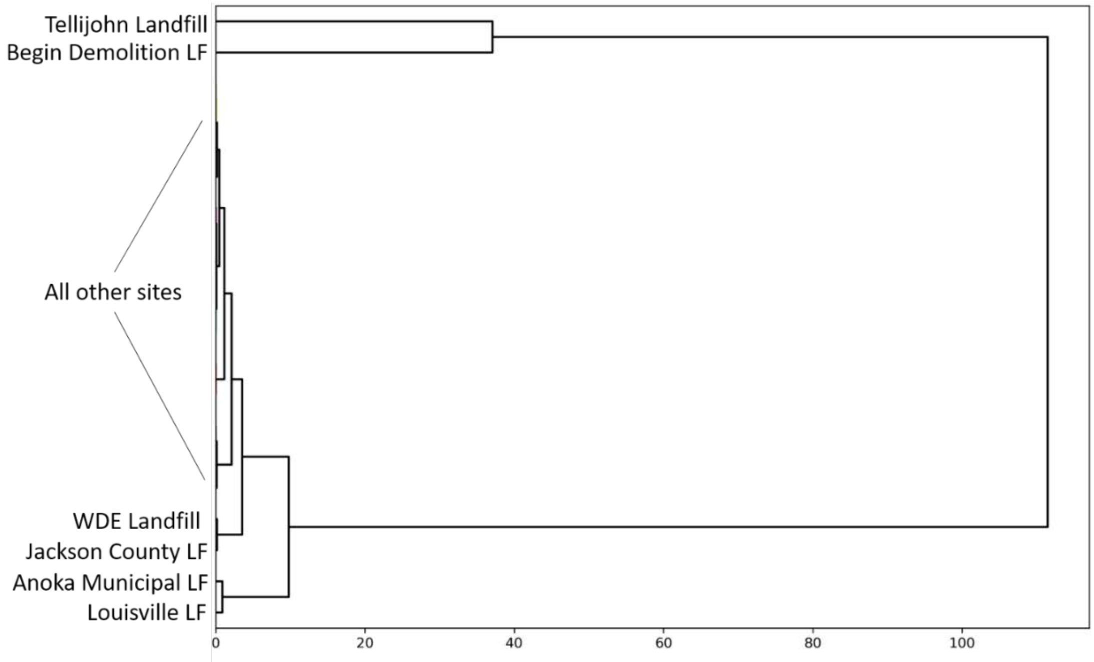


Figure 13 Dendrogram Showing Results of AHC Analysis for 1,4-Dioxane

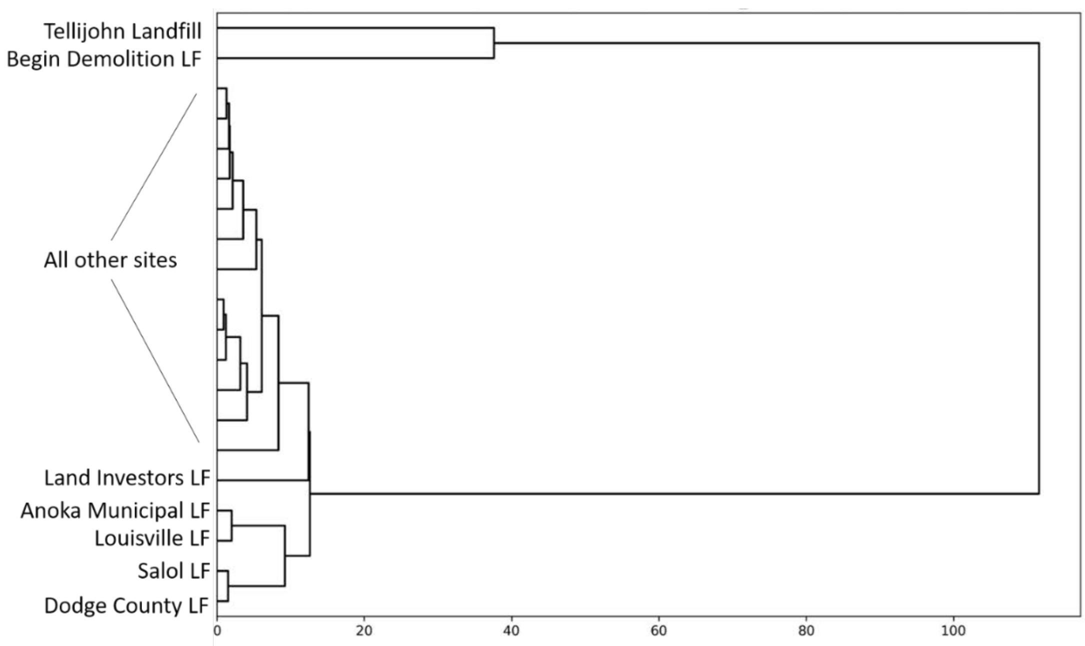


Figure 14 Dendrogram Showing Results of AHC Analysis for 1,4-Dioxane and VOCs

6 Conclusions

The results from this study indicate that, based on available public data provided by the MPCA, the presence of emerging contaminants at waste disposal sites is variable. In regard to PFAS and 1,4-dioxane the following conclusions are provided:

PFAS

- Much of the PFAS data for sites outside of the CLP is from 2007-2009 and had reporting detection limits an order of magnitude greater than current reporting detection limits. These data limitations likely resulted in more non-detect values than would be observed with current detection limits.
- Sites in the east metro PFAS group are significantly different than most other sites. These sites typically have average PFAS concentrations that are one to two orders of magnitude greater than most other sites. When comparing maximum measured concentration the difference between the east metro PFAS sites and other sites is even more pronounced. Gofer Landfill, Pine Bend Landfill, and Dawnway Demolition Landfill are also more distinct than most other sites.
- The closed landfill group had a median HRI for PFAS of 1.4 (as determined based on a maximum from each site). A total of 42 closed landfills (56%) had a maximum HRI above 1.0 and 33 had a maximum HRI below 1.0.
- Very few facilities had concentrations above drinking water guidance for PFBA and PFBS. For PFBA, the east metro PFAS sites and Pine Bend Sanitary Landfill were the only facilities with measures of central tendency and maximum measured values greater than the drinking water guidance. Only one facility, 3M Oakdale Disposal Site, had a central tendency greater than the Minnesota drinking water guidance for PFBS. Three facilities had maximum measured values greater than the drinking water guidance; 3M Oakdale Disposal Site, 3M Woodbury Disposal Site, and Gofer Sanitary Landfill.
- PFAS concentrations show a strong correlation with other PFAS but weak correlation with all other constituents evaluated in this study.
- PFAS in groundwater appear to be correlated with the size of the waste disposal area. Sites with larger waste volumes tend to have higher PFAS HRI values.
- No trends or clusters of facilities that indicated better or worse relative differences in PFAS leachate vs groundwater were observed. However, the data to evaluate these relationships were limited. To better assess the effectiveness of different liner types on PFAS mitigation a specifically designed study with carefully chosen sampling locations would be necessary.

1,4-Dioxane

- Very little data for 1,4-dioxane are available for sites outside of the CLP.
- Within the closed landfill group, the average concentration in groundwater at 20 facilities is greater than the Minnesota drinking water guidance value of 1 µg/L. The maximum concentration from 69 facilities was greater than the drinking water guidance value.
- 1,4-Dioxane is positively correlated with several VOCs. The strongest correlation observed was with 1,1,1-Trichloroethane (TCA). 1,4-dioxane is commonly associated with TCA because it was often used as a stabilizer for chlorinated solvents.
- Tellijohn Landfill, Begin Demolition Landfill, WDE Landfill, Jackson County Landfill, Anoka Municipal Landfill and Louisville Landfill have different 1,4-dioxane distributions than most other landfills and tend to have higher groundwater concentrations.

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Appendix A

Summary Statistics for PFAS and 1,4-Dioxane

Table A-1
Summary Statistics Regulated PFAS and 1,4-Dioxane

Facility Code	Facility Type	Facility Name	CAS RN	Chemical Name	Total Sample Count	% Detect	Number of Sampled Wells	% Well Detect	Arthmetic Mean of Detects	Minimum Detect	Maximum Detect	Kaplan Meier Mean	Median of Detects and Non-Detects	Measure of Central Tendency
SR0000055	East Metro PFAS	Oakdale Dump Sites	108427-53-8	Perfluorohexane sulfonate (PFHxS)	196	84.2%	28	89.3%	10.9136	0.0250	129.0000	9.1915	1.8500	**9.1915**
			335-67-1	Perfluorooctanoic acid (PFOA)	301	97.7%	30	100.0%	133.1964	0.0300	1660.0000	130.0995	19.4000	**130.0995**
			375-22-4	Perfluorobutanoic acid (PFBA)	301	95.0%	30	100.0%	95.4780	0.0400	2460.0000	90.7222	12.0000	**90.7222**
			45187-15-3	Perfluorobutanesulfonate (PFBS)	301	69.4%	30	90.0%	5.6116	0.0270	73.7000	3.9047	0.5430	**3.9047**
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	301	100.0%	30	100.0%	533.7031	0.0470	9980.0000	533.7031	23.7000	**533.7031**
SR0000117	East Metro PFAS	Pigs Eye Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	170	78.8%	47	87.2%	1.0784	0.0160	12.0000	0.8735	0.5000	**0.8735**
			335-67-1	Perfluorooctanoic acid (PFOA)	168	92.3%	47	95.7%	50.8555	0.0510	410.0000	46.9315	20.0000	**46.9315**
			375-22-4	Perfluorobutanoic acid (PFBA)	170	97.6%	47	97.9%	39.5131	0.0410	610.0000	38.5887	14.0000	**38.5887**
			45187-15-3	Perfluorobutanesulfonate (PFBS)	169	72.2%	47	85.1%	0.2034	0.0110	1.8000	0.1720	0.1200	0.172
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	179	69.3%	47	85.1%	5.8411	0.0125	43.0000	4.0680	<0.5	**4.068**
SR0000365	East Metro PFAS	3M Woodbury	108427-53-8	Perfluorohexane sulfonate (PFHxS)	139	38.1%	90	46.7%	0.1540	0.0050	5.3000	0.0709	0.0330	0.033
			335-67-1	Perfluorooctanoic acid (PFOA)	301	35.2%	108	46.3%	172.6906	0.0110	7400.0000	60.8305	0.0372	**0.0372**
			375-22-4	Perfluorobutanoic acid (PFBA)	292	58.6%	102	86.3%	759.0486	0.0080	51700.0000	444.5297	0.3900	**444.5297**
			45187-15-3	Perfluorobutanesulfonate (PFBS)	489	29.4%	108	50.9%	314.9668	0.0090	11400.0000	92.7817	<0.03	<0.03
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	308	29.9%	108	38.9%	638.4778	0.0200	26300.0000	190.7342	<0.0403	**<0.0403**
SW-1	East Metro PFAS	Washington County Sanitary Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	824	39.4%	67	40.3%	0.1678	0.0080	1.7700	0.0772	0.0870	**0.087**
			123-91-1	1,4-Dioxane	117	60.7%	33	60.6%	13.7865	0.0550	49.0000	8.3901	0.6600	**8.3901**
			335-67-1	Perfluorooctanoic acid (PFOA)	958	65.2%	67	58.2%	8.1145	0.0110	82.0000	5.3021	0.5150	**5.3021**
			375-22-4	Perfluorobutanoic acid (PFBA)	825	91.6%	67	86.6%	79.3481	0.0090	1170.0000	72.7193	3.4000	**72.7193**
			45187-15-3	Perfluorobutanesulfonate (PFBS)	824	32.2%	67	34.3%	0.0994	0.0090	1.3100	0.0416	<0.056	<0.056
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	956	38.0%	67	44.8%	0.3285	0.0070	2.6900	0.1398	<0.107	**<0.107**
SW-100	Closed Landfill	Waseca County Sanitary Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	17	0.0%	15	0.0%				0.0000	<0.006	<0.004
			123-91-1	1,4-Dioxane	33	36.4%	19	31.6%	1.3900	0.1500	6.8000	0.6009	<0.071	<0.071
			335-67-1	Perfluorooctanoic acid (PFOA)	23	4.3%	15	6.7%	0.0080	0.0080	0.0080	0.0080	<0.087	**<0.087**
			375-22-4	Perfluorobutanoic acid (PFBA)	17	23.5%	15	26.7%	0.0185	0.0030	0.0530	0.0086	0.0080	0.008
			45187-15-3	Perfluorobutanesulfonate (PFBS)	17	0.0%	15	0.0%				0.0000	<0.008	<0.005
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	23	0.0%	15	0.0%				0.0000	<0.107	<0.005
SW-101	Closed Landfill	Jackson County Sanitary Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	14	0.0%	8	0.0%				0.0000	<0.006	<0.004
			123-91-1	1,4-Dioxane	30	60.0%	8	62.5%	8.0167	1.0400	25.1400	5.2260	1.9600	**5.226**
			335-67-1	Perfluorooctanoic acid (PFOA)	14	57.1%	8	50.0%	0.1079	0.0460	0.2900	0.0814	0.0520	**0.0814**
			375-22-4	Perfluorobutanoic acid (PFBA)	14	85.7%	8	87.5%	0.0303	0.0070	0.0640	0.0270	0.0255	0.027
			45187-15-3	Perfluorobutanesulfonate (PFBS)	14	14.3%	8	25.0%	0.0100	0.0100	0.0100	0.0100	<0.008	<0.008
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	14	7.1%	8	12.5%	0.0190	0.0190	0.0190	0.0190	<0.007	<0.007
SW-102	Closed Landfill	Carlton County 2 Sanitary Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	15	13.3%	8	12.5%	0.0066	0.0059	0.0072	0.0060	<0.0052	<0.0052
			123-91-1	1,4-Dioxane	84	33.3%	25	28.0%	19.1015	0.0730	59.0000	6.4192	<0.36	<0.36
			335-67-1	Perfluorooctanoic acid (PFOA)	15	60.0%	8	62.5%	0.0460	0.0037	0.1340	0.0291	0.0059	0.0291
			375-22-4	Perfluorobutanoic acid (PFBA)	15	66.7%	8	75.0%	0.0165	0.0037	0.0307	0.0123	0.0049	0.0123
			45187-15-3	Perfluorobutanesulfonate (PFBS)	15	6.7%	8	12.5%	0.0148	0.0148	0.0148	0.0148	<0.0052	<0.0052
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	15	13.3%	8	12.5%	0.0127	0.0086	0.0169	0.0091	<0.0052	<0.0052
SW-104	Closed Landfill	Murray County Sanitary Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	2	0.0%	2	0.0%				0.0000	<0.004	<0.004
			123-91-1	1,4-Dioxane	16	18.8%	11	18.2%	0.5257	0.0570	0.8300	0.1449	<0.071	<0.071
			335-67-1	Perfluorooctanoic acid (PFOA)	2	0.0%	2	0.0%				0.0000	<0.005	<0.005
			375-22-4	Perfluorobutanoic acid (PFBA)	2	0.0%	2	0.0%				0.0000	<0.003	<0.003
			45187-15-3	Perfluorobutanesulfonate (PFBS)	2	0.0%	2	0.0%				0.0000	<0.005	<0.005
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	2	0.0%	2	0.0%				0.0000	<0.007	<0.007
SW-111	Closed Landfill	Crow Wing County Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	49	6.1%	32	9.4%	0.0081	0.0070	0.0094	0.0071	<0.006	<0.006
			123-91-1	1,4-Dioxane	76	76.3%	36	72.2%	3.0724	0.0820	28.0000	2.3644	1.0000	**2.3644**
			335-67-1	Perfluorooctanoic acid (PFOA)	49	18.4%	32	25.0%	0.0192	0.0070	0.0419	0.0092	<0.006	<0.006
			375-22-4	Perfluorobutanoic acid (PFBA)	49	53.1%	32	59.4%	0.0434	0.0130	0.1460	0.0291	0.0160	0.0291
			45187-15-3	Perfluorobutanesulfonate (PFBS)	49	30.6%	32	40.6%	0.0236	0.0053	0.0650	0.0109	<0.008	<0.008
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	49	0.0%	32	0.0%				0.0000	<0.005	<0.0008

all concentrations in µg/L
pink shading indicates method used to determine measure of central tendency
bold indicates measure of central tendenncy above MN drinking water guidance

Table A-1 (continued)
Summary Statistics Regulated PFAS and 1,4-Dioxane

Facility Code	Facility Type	Facility Name	CAS RN	Chemical Name	Total Sample Count	% Detect	Number of Sampled Wells	% Well Detect	Arthmetic Mean of Detects	Minimum Detect	Maximum Detect	Kaplan Meier Mean	Median of Detects and Non-Detects	Measure of Central Tendency
SW-113	Closed Landfill	Hansen Sanitary Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	7	0.0%	6	0.0%				0.0000	<0.0052	<0.0049
			123-91-1	1,4-Dioxane	13	15.4%	7	14.3%	0.2800	0.1700	0.3900	0.1869	<0.071	<0.071
			335-67-1	Perfluorooctanoic acid (PFOA)	7	14.3%	6	16.7%	0.0092	0.0092	0.0092	0.0092	0.0092	0.0092
			375-22-4	Perfluorobutanoic acid (PFBA)	7	57.1%	6	66.7%	0.0097	0.0039	0.0130	0.0072	<0.008	0.0072
			45187-15-3	Perfluorobutanesulfonate (PFBS)	7	0.0%	6	0.0%				0.0000	<0.0052	<0.0049
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	7	0.0%	6	0.0%				0.0000	<0.0052	<0.0049
SW-114	Closed Landfill	Anderson Sanitary Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	1	0.0%	1	0.0%				0.0000	<0.006	<0.006
			123-91-1	1,4-Dioxane	15	26.7%	8	37.5%	3.3250	1.1000	8.2000	2.0889	2.9000	**2.9**
			335-67-1	Perfluorooctanoic acid (PFOA)	1	100.0%	1	100.0%	0.0230	0.0230	0.0230	0.0230	0.0230	0.023
			375-22-4	Perfluorobutanoic acid (PFBA)	1	0.0%	1	0.0%				0.0000	<0.006	<0.006
			45187-15-3	Perfluorobutanesulfonate (PFBS)	1	0.0%	1	0.0%				0.0000	<0.008	<0.008
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	1	0.0%	1	0.0%				0.0000	<0.005	<0.005
SW-115	Closed Landfill	Karlstad Sanitary Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	2	0.0%	2	0.0%				0.0000	<0.013	<0.013
			123-91-1	1,4-Dioxane	6	33.3%	5	20.0%	11.2000	8.4000	14.0000	9.3333	<0.36	<0.36
			335-67-1	Perfluorooctanoic acid (PFOA)	2	50.0%	2	50.0%	0.0610	0.0610	0.0610	0.0610	0.0610	**0.061**
			375-22-4	Perfluorobutanoic acid (PFBA)	2	100.0%	2	100.0%	0.0205	0.0130	0.0280	0.0205	0.0205	0.0205
			45187-15-3	Perfluorobutanesulfonate (PFBS)	2	50.0%	2	50.0%	0.2500	0.2500	0.2500	0.2500	0.2500	0.25
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	2	0.0%	2	0.0%				0.0000	<0.007	<0.007
SW-117	Closed Landfill	Lindala Sanitary Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	74	9.5%	21	33.3%	0.5000	0.5000	0.5000	0.5000	<0.0051	<0.0051
			123-91-1	1,4-Dioxane	62	12.9%	23	13.0%	5.1000	0.4000	9.2000	1.2174	<0.22	<0.22
			335-67-1	Perfluorooctanoic acid (PFOA)	81	17.3%	21	19.0%	0.0079	0.0032	0.0153	0.0043	<0.0031	<0.0031
			375-22-4	Perfluorobutanoic acid (PFBA)	74	45.9%	21	52.4%	0.0182	0.0031	0.0516	0.0111	0.0074	0.0074
			45187-15-3	Perfluorobutanesulfonate (PFBS)	74	9.5%	21	33.3%	0.5000	0.5000	0.5000	0.5000	<0.0051	<0.0051
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	81	17.3%	21	33.3%	0.5000	0.5000	0.5000	0.5000	<0.0051	<0.0051
SW-120	Closed Landfill	Pipestone County Sanitary Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	3	0.0%	3	0.0%				0.0000	<0.006	<0.006
			123-91-1	1,4-Dioxane	9	22.2%	9	22.2%	1.0700	0.8200	1.3200	0.8756	<0.071	<0.071
			335-67-1	Perfluorooctanoic acid (PFOA)	3	33.3%	3	33.3%	0.1900	0.1900	0.1900	0.1900	<0.006	<0.006
			375-22-4	Perfluorobutanoic acid (PFBA)	3	100.0%	3	100.0%	0.0190	0.0100	0.0360	0.0190	0.0110	0.019
			45187-15-3	Perfluorobutanesulfonate (PFBS)	3	33.3%	3	33.3%	0.0120	0.0120	0.0120	0.0120	<0.008	<0.008
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	3	33.3%	3	33.3%	0.0270	0.0270	0.0270	0.0270	<0.005	<0.005
SW-121	Closed Landfill	Dodge County Sanitary Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	5	0.0%	5	0.0%				0.0000	<0.006	<0.006
			123-91-1	1,4-Dioxane	31	58.1%	14	50.0%	2.6889	0.2700	13.1200	1.6745	0.2900	**1.6745**
			335-67-1	Perfluorooctanoic acid (PFOA)	5	20.0%	5	20.0%	0.0080	0.0080	0.0080	0.0080	<0.006	<0.006
			375-22-4	Perfluorobutanoic acid (PFBA)	5	60.0%	5	60.0%	0.0170	0.0120	0.0250	0.0150	0.0120	0.015
			45187-15-3	Perfluorobutanesulfonate (PFBS)	5	0.0%	5	0.0%				0.0000	<0.008	<0.008
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	5	0.0%	5	0.0%				0.0000	<0.005	<0.005
SW-126	Closed Landfill	Houston County Sanitary Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	11	63.6%	7	57.1%	0.0128	0.0049	0.0596	0.0100	0.0051	0.01
			123-91-1	1,4-Dioxane	55	40.0%	18	61.1%	0.9779	0.0520	8.6000	0.4228	0.0660	0.066
			335-67-1	Perfluorooctanoic acid (PFOA)	11	72.7%	7	57.1%	0.0144	0.0025	0.0763	0.0112	0.0025	0.0112
			375-22-4	Perfluorobutanoic acid (PFBA)	11	72.7%	7	57.1%	0.0594	0.0025	0.4140	0.0441	0.0051	0.0441
			45187-15-3	Perfluorobutanesulfonate (PFBS)	11	63.6%	7	57.1%	0.0138	0.0049	0.0665	0.0106	0.0051	0.0106
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	11	63.6%	7	57.1%	0.0128	0.0049	0.0596	0.0100	0.0050	0.01
SW-129	Closed Landfill	Isanti-Chisago County Sanitary Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	1	0.0%	1	0.0%				0.0000	<0.087	**<0.087**
			123-91-1	1,4-Dioxane	48	54.2%	19	47.4%	0.5497	0.0510	2.9000	0.3211	0.0555	0.3211
			335-67-1	Perfluorooctanoic acid (PFOA)	1	0.0%	1	0.0%				0.0000	<0.087	**<0.087**
			375-22-4	Perfluorobutanoic acid (PFBA)	1	0.0%	1	0.0%				0.0000	<0.271	<0.271
			45187-15-3	Perfluorobutanesulfonate (PFBS)	1	0.0%	1	0.0%				0.0000	<0.056	<0.056
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	1	0.0%	1	0.0%				0.0000	<0.107	**<0.107**
SW-131	Operating MSW	Steele County Sanitary Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	5	0.0%	5	0.0%				0.0000	<0.0085	<0.0071
			335-67-1	Perfluorooctanoic acid (PFOA)	5	20.0%	5	20.0%	0.0103	0.0103	0.0103	0.0103	<0.0043	<0.0043
			375-22-4	Perfluorobutanoic acid (PFBA)	5	60.0%	5	60.0%	0.0182	0.0098	0.0332	0.0148	0.0098	0.0148
			45187-15-3	Perfluorobutanesulfonate (PFBS)	5	0.0%	5	0.0%				0.0000	<0.0085	<0.0071
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	5	0.0%	5	0.0%				0.0000	<0.0085	<0.0071

all concentrations in µg/L
pink shading indicates method used to determine measure of central tendency
bold indicates measure of central tendenncy above MN drinking water guidance

Table A-1 (continued)
Summary Statistics Regulated PFAS and 1,4-Dioxane

Facility Code	Facility Type	Facility Name	CAS RN	Chemical Name	Total Sample Count	% Detect	Number of Sampled Wells	% Well Detect	Arthmetic Mean of Detects	Minimum Detect	Maximum Detect	Kaplan Meier Mean	Median of Detects and Non-Detects	Measure of Central Tendency
SW-134	Other Solid Waste	Begin Dump and Demolition Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	2	0.0%	2	0.0%				0.0000	<0.013	<0.013
			123-91-1	1,4-Dioxane	2	50.0%	2	50.0%	150.0000	150.0000	150.0000	150.0000	150.0000	**150**
			335-67-1	Perfluorooctanoic acid (PFOA)	2	50.0%	2	50.0%	0.2100	0.2100	0.2100	0.2100	0.2100	**0.21**
			375-22-4	Perfluorobutanoic acid (PFBA)	2	100.0%	2	100.0%	0.3275	0.0850	0.5700	0.3275	0.3275	0.3275
			45187-15-3	Perfluorobutanesulfonate (PFBS)	2	50.0%	2	50.0%	0.0140	0.0140	0.0140	0.0140	0.0140	0.014
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	2	50.0%	2	50.0%	0.0670	0.0670	0.0670	0.0670	0.0670	**0.067**
SW-135	Closed Landfill	Grand Rapids Area Sanitary Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	10	0.0%	10	0.0%				0.0000	<0.013	<0.013
			123-91-1	1,4-Dioxane	71	33.8%	29	34.5%	3.2450	0.2200	9.8000	1.2425	<0.42	<0.42
			335-67-1	Perfluorooctanoic acid (PFOA)	10	10.0%	10	10.0%	0.0210	0.0210	0.0210	0.0210	<0.012	<0.012
			375-22-4	Perfluorobutanoic acid (PFBA)	10	80.0%	10	80.0%	0.0195	0.0090	0.0550	0.0174	0.0110	0.0174
			45187-15-3	Perfluorobutanesulfonate (PFBS)	10	10.0%	10	10.0%	0.0090	0.0090	0.0090	0.0090	0.0090	0.009
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	10	0.0%	10	0.0%				0.0000	<0.007	<0.007
SW-137	Closed Landfill	Salol Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	5	0.0%	5	0.0%				0.0000	<0.005	<0.0049
			123-91-1	1,4-Dioxane	100	55.0%	39	64.1%	2.3536	0.0680	9.6000	1.3298	0.3950	**1.3298**
			335-67-1	Perfluorooctanoic acid (PFOA)	5	40.0%	5	40.0%	0.0033	0.0032	0.0035	0.0033	<0.0025	<0.0025
			375-22-4	Perfluorobutanoic acid (PFBA)	5	60.0%	5	60.0%	0.0038	0.0028	0.0045	0.0034	0.0028	0.0034
			45187-15-3	Perfluorobutanesulfonate (PFBS)	5	0.0%	5	0.0%				0.0000	<0.005	<0.0049
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	5	20.0%	5	20.0%	0.0065	0.0065	0.0065	0.0065	<0.005	<0.005
SW-14	Closed Landfill	Flying Cloud Sanitary Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	7	0.0%	7	0.0%				0.0000	<0.0049	<0.0048
			123-91-1	1,4-Dioxane	32	53.1%	19	52.6%	8.9331	0.0620	21.0000	4.7748	0.2310	**4.7748**
			335-67-1	Perfluorooctanoic acid (PFOA)	11	18.2%	8	25.0%	0.0290	0.0111	0.0468	0.0182	<0.087	**<0.087**
			375-22-4	Perfluorobutanoic acid (PFBA)	7	57.1%	7	57.1%	0.1574	0.0045	0.5180	0.0989	0.0941	0.0989
			45187-15-3	Perfluorobutanesulfonate (PFBS)	7	14.3%	7	14.3%	0.0098	0.0098	0.0098	0.0098	<0.0049	<0.0049
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	11	0.0%	8	0.0%				0.0000	<0.107	<0.0048
SW-141	Closed Landfill	La Grand Sanitary Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	3	0.0%	3	0.0%				0.0000	<0.006	<0.006
			123-91-1	1,4-Dioxane	20	10.0%	9	22.2%	0.2750	0.1800	0.3700	0.1895	<0.22	<0.22
			335-67-1	Perfluorooctanoic acid (PFOA)	3	0.0%	3	0.0%				0.0000	<0.006	<0.006
			375-22-4	Perfluorobutanoic acid (PFBA)	3	33.3%	3	33.3%	0.0230	0.0230	0.0230	0.0230	<0.006	<0.006
			45187-15-3	Perfluorobutanesulfonate (PFBS)	3	0.0%	3	0.0%				0.0000	<0.008	<0.008
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	3	0.0%	3	0.0%				0.0000	<0.005	<0.005
SW-145	Closed Landfill	Aitkin County Sanitary Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	2	0.0%	2	0.0%				0.0000	<0.006	<0.006
			123-91-1	1,4-Dioxane	32	31.3%	11	36.4%	2.5420	0.2800	4.5000	0.9869	<0.22	<0.22
			335-67-1	Perfluorooctanoic acid (PFOA)	2	50.0%	2	50.0%	0.0100	0.0100	0.0100	0.0100	0.0100	0.01
			375-22-4	Perfluorobutanoic acid (PFBA)	2	50.0%	2	50.0%	0.0470	0.0470	0.0470	0.0470	0.0470	0.047
			45187-15-3	Perfluorobutanesulfonate (PFBS)	2	0.0%	2	0.0%				0.0000	<0.008	<0.008
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	2	0.0%	2	0.0%				0.0000	<0.005	<0.005
SW-154	Closed Landfill	Wabasha County Sanitary Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	4	25.0%	4	25.0%	0.0320	0.0320	0.0320	0.0320	<0.006	<0.006
			123-91-1	1,4-Dioxane	38	26.3%	13	23.1%	1.0803	0.0630	3.0000	0.3307	0.0630	0.063
			335-67-1	Perfluorooctanoic acid (PFOA)	4	0.0%	4	0.0%				0.0000	<0.006	<0.006
			375-22-4	Perfluorobutanoic acid (PFBA)	4	25.0%	4	25.0%	0.0280	0.0280	0.0280	0.0280	<0.006	<0.006
			45187-15-3	Perfluorobutanesulfonate (PFBS)	4	0.0%	4	0.0%				0.0000	<0.008	<0.008
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	4	0.0%	4	0.0%				0.0000	<0.005	<0.005
SW-157	Closed Landfill	Goodhue Cooperative Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	2	0.0%	2	0.0%				0.0000	<0.006	<0.006
			123-91-1	1,4-Dioxane	16	50.0%	5	60.0%	0.1491	0.0950	0.3000	0.1221	0.0950	0.1221
			335-67-1	Perfluorooctanoic acid (PFOA)	2	0.0%	2	0.0%				0.0000	<0.006	<0.006
			375-22-4	Perfluorobutanoic acid (PFBA)	2	100.0%	2	100.0%	0.0445	0.0320	0.0570	0.0445	0.0445	0.0445
			45187-15-3	Perfluorobutanesulfonate (PFBS)	2	0.0%	2	0.0%				0.0000	<0.008	<0.008
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	2	0.0%	2	0.0%				0.0000	<0.005	<0.005
SW-16	Closed Landfill	Crosby American Properties Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	5	40.0%	5	40.0%	0.0090	0.0060	0.0120	0.0072	<0.004	<0.004
			123-91-1	1,4-Dioxane	38	31.6%	11	36.4%	10.4828	0.0620	54.0000	3.3528	<0.03	<0.03
			335-67-1	Perfluorooctanoic acid (PFOA)	5	80.0%	5	80.0%	0.1335	0.0410	0.3000	0.1150	0.0930	**0.115**
			375-22-4	Perfluorobutanoic acid (PFBA)	5	100.0%	5	100.0%	0.1940	0.0600	0.4800	0.1940	0.1600	0.194
			45187-15-3	Perfluorobutanesulfonate (PFBS)	5	20.0%	5	20.0%	0.0150	0.0150	0.0150	0.0150	<0.005	<0.005
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	5	80.0%	5	80.0%	0.0833	0.0110	0.1900	0.0688	0.0620	**0.0688**

all concentrations in µg/L
pink shading indicates method used to determine measure of central tendency
bold indicates measure of central tendenncy above MN drinking water guidance

Table A-1 (continued)
Summary Statistics Regulated PFAS and 1,4-Dioxane

Facility Code	Facility Type	Facility Name	CAS RN	Chemical Name	Total Sample Count	% Detect	Number of Sampled Wells	% Well Detect	Arthmetic Mean of Detects	Minimum Detect	Maximum Detect	Kaplan Meier Mean	Median of Detects and Non-Detects	Measure of Central Tendency
SW-161	Closed Landfill	Hibbing Sanitary Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	2	0.0%	2	0.0%				0.0000	<0.013	<0.013
			123-91-1	1,4-Dioxane	23	13.0%	15	20.0%	0.7800	0.3100	1.1000	0.3713	<0.36	<0.36
			335-67-1	Perfluorooctanoic acid (PFOA)	2	50.0%	2	50.0%	0.0470	0.0470	0.0470	0.0470	0.0470	**0.047**
			375-22-4	Perfluorobutanoic acid (PFBA)	2	100.0%	2	100.0%	0.0255	0.0120	0.0390	0.0255	0.0255	0.0255
			45187-15-3	Perfluorobutanesulfonate (PFBS)	2	0.0%	2	0.0%				0.0000	<0.009	<0.009
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	2	0.0%	2	0.0%				0.0000	<0.007	<0.007
SW-174	Other Solid Waste	Red Wing Land Disposal Facility	108427-53-8	Perfluorohexane sulfonate (PFHxS)	3	0.0%	3	0.0%				0.0000	<0.0085	<0.0085
			335-67-1	Perfluorooctanoic acid (PFOA)	3	0.0%	3	0.0%				0.0000	<0.0043	<0.0042
			375-22-4	Perfluorobutanoic acid (PFBA)	3	100.0%	3	100.0%	0.0362	0.0318	0.0437	0.0362	0.0330	0.0362
			45187-15-3	Perfluorobutanesulfonate (PFBS)	3	0.0%	3	0.0%				0.0000	<0.0085	<0.0085
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	3	0.0%	3	0.0%				0.0000	<0.0085	<0.0085
SW-175	Closed Landfill	Cotton Area Sanitary Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	5	20.0%	4	25.0%	0.0050	0.0050	0.0050	0.0050	0.0050	0.005
			123-91-1	1,4-Dioxane	9	44.4%	8	37.5%	4.5500	2.0000	7.0000	3.1333	<0.36	<0.36
			335-67-1	Perfluorooctanoic acid (PFOA)	5	40.0%	4	25.0%	0.1365	0.1100	0.1630	0.1206	<0.006	<0.006
			375-22-4	Perfluorobutanoic acid (PFBA)	5	60.0%	4	50.0%	0.0227	0.0141	0.0319	0.0192	0.0141	0.0192
			45187-15-3	Perfluorobutanesulfonate (PFBS)	5	20.0%	4	25.0%	0.0387	0.0387	0.0387	0.0387	<0.008	<0.008
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	5	40.0%	4	25.0%	0.0486	0.0381	0.0590	0.0423	<0.005	<0.005
SW-178	Closed Landfill	Northeast Otter Tail Co. Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	3	33.3%	3	33.3%	0.0300	0.0300	0.0300	0.0300	<0.006	<0.006
			123-91-1	1,4-Dioxane	44	36.4%	14	50.0%	2.2067	0.0770	5.7000	1.2128	1.6500	**1.65**
			335-67-1	Perfluorooctanoic acid (PFOA)	3	100.0%	3	100.0%	0.0717	0.0300	0.1300	0.0717	0.0550	**0.0717**
			375-22-4	Perfluorobutanoic acid (PFBA)	3	100.0%	3	100.0%	0.0193	0.0100	0.0290	0.0193	0.0190	0.0193
			45187-15-3	Perfluorobutanesulfonate (PFBS)	3	33.3%	3	33.3%	0.0590	0.0590	0.0590	0.0590	<0.008	<0.008
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	3	0.0%	3	0.0%				0.0000	<0.005	<0.005
SW-179	Closed Landfill	Walker-Hackensack Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	1	0.0%	1	0.0%				0.0000	<0.006	<0.006
			123-91-1	1,4-Dioxane	10	10.0%	9	11.1%	0.5300	0.5300	0.5300	0.5300	<10	**<10**
			335-67-1	Perfluorooctanoic acid (PFOA)	1	0.0%	1	0.0%				0.0000	<0.006	<0.006
			375-22-4	Perfluorobutanoic acid (PFBA)	1	0.0%	1	0.0%				0.0000	<0.006	<0.006
			45187-15-3	Perfluorobutanesulfonate (PFBS)	1	0.0%	1	0.0%				0.0000	<0.008	<0.008
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	1	0.0%	1	0.0%				0.0000	<0.005	<0.005
SW-18	Closed Landfill	Bueckers #1 Sanitary Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	1	0.0%	1	0.0%				0.0000	<0.006	<0.006
			123-91-1	1,4-Dioxane	16	31.3%	7	42.9%	0.7956	0.0880	1.3400	0.3091	<0.071	<0.071
			335-67-1	Perfluorooctanoic acid (PFOA)	1	0.0%	1	0.0%				0.0000	<0.006	<0.006
			375-22-4	Perfluorobutanoic acid (PFBA)	1	0.0%	1	0.0%				0.0000	<0.006	<0.006
			45187-15-3	Perfluorobutanesulfonate (PFBS)	1	0.0%	1	0.0%				0.0000	<0.008	<0.008
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	1	0.0%	1	0.0%				0.0000	<0.005	<0.005
SW-181	Closed Landfill	Crosby Sanitary Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	6	0.0%	4	0.0%				0.0000	<0.013	<0.006
			123-91-1	1,4-Dioxane	36	8.3%	12	25.0%	0.7767	0.1100	1.6000	0.1900	<0.22	<0.22
			335-67-1	Perfluorooctanoic acid (PFOA)	6	0.0%	4	0.0%				0.0000	<0.012	<0.006
			375-22-4	Perfluorobutanoic acid (PFBA)	6	33.3%	4	50.0%	0.0085	0.0080	0.0090	0.0082	<0.008	<0.008
			45187-15-3	Perfluorobutanesulfonate (PFBS)	6	0.0%	4	0.0%				0.0000	<0.009	<0.008
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	6	0.0%	4	0.0%				0.0000	<0.007	<0.005
SW-19	Closed Landfill	Korf Brothers Sanitary Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	5	0.0%	4	0.0%				0.0000	<0.004	<0.004
			123-91-1	1,4-Dioxane	51	49.0%	13	69.2%	1.6971	0.0840	7.0000	0.8791	<0.22	<0.22
			335-67-1	Perfluorooctanoic acid (PFOA)	5	40.0%	4	50.0%	0.0685	0.0370	0.1000	0.0496	<0.005	<0.005
			375-22-4	Perfluorobutanoic acid (PFBA)	5	40.0%	4	50.0%	0.0125	0.0110	0.0140	0.0116	<0.003	<0.003
			45187-15-3	Perfluorobutanesulfonate (PFBS)	5	0.0%	4	0.0%				0.0000	<0.005	<0.005
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	5	0.0%	4	0.0%				0.0000	<0.007	<0.007
SW-191	Closed Landfill	Koochiching County Sanitary Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	1	0.0%	1	0.0%				0.0000	<0.013	<0.013
			123-91-1	1,4-Dioxane	7	0.0%	7	0.0%				0.0000	<0.22	<0.22
			335-67-1	Perfluorooctanoic acid (PFOA)	1	0.0%	1	0.0%				0.0000	<0.012	<0.012
			375-22-4	Perfluorobutanoic acid (PFBA)	1	100.0%	1	100.0%	0.0390	0.0390	0.0390	0.0390	0.0390	0.039
			45187-15-3	Perfluorobutanesulfonate (PFBS)	1	0.0%	1	0.0%				0.0000	<0.009	<0.009
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	1	0.0%	1	0.0%				0.0000	<0.007	<0.007

all concentrations in µg/L
pink shading indicates method used to determine measure of central tendency
bold indicates measure of central tendenncy above MN drinking water guidance

Summary Statistics Regulated PFAS and 1,4-Dioxane

Facility Code	Facility Type	Facility Name	CAS RN	Chemical Name	Total Sample Count	% Detect	Number of Sampled Wells	% Well Detect	Arthmetic Mean of Detects	Minimum Detect	Maximum Detect	Kaplan Meier Mean	Median of Detects and Non-Detects	Measure of Central Tendency
SW-2	Closed Landfill	Sibley County Sanitary Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	11	27.3%	7	14.3%	0.0233	0.0210	0.0260	0.0216	<0.004	<0.004
			123-91-1	1,4-Dioxane	12	50.0%	8	25.0%	3.2100	1.0000	6.3800	2.1050	1.0000	**2.105**
			335-67-1	Perfluorooctanoic acid (PFOA)	11	27.3%	7	14.3%	0.0993	0.0650	0.1400	0.0744	<0.005	<0.005
			375-22-4	Perfluorobutanoic acid (PFBA)	11	27.3%	7	14.3%	0.0517	0.0390	0.0700	0.0425	<0.003	<0.003
			45187-15-3	Perfluorobutanesulfonate (PFBS)	11	27.3%	7	14.3%	0.0170	0.0110	0.0250	0.0126	<0.005	<0.005
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	11	9.1%	7	14.3%	0.0120	0.0120	0.0120	0.0120	<0.007	<0.007
SW-204	Closed Landfill	Orr Sanitary Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	1	0.0%	1	0.0%				0.0000	<0.005	<0.005
			335-67-1	Perfluorooctanoic acid (PFOA)	1	0.0%	1	0.0%				0.0000	<0.01	<0.01
			375-22-4	Perfluorobutanoic acid (PFBA)	1	0.0%	1	0.0%				0.0000	<0.008	<0.008
			45187-15-3	Perfluorobutanesulfonate (PFBS)	1	0.0%	1	0.0%				0.0000	<0.009	<0.009
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	1	0.0%	1	0.0%				0.0000	<0.007	<0.007
SW-22	Closed Landfill	Barnesville Sanitary Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	5	20.0%	3	33.3%	0.0080	0.0080	0.0080	0.0080	<0.006	<0.006
			123-91-1	1,4-Dioxane	18	38.9%	7	42.9%	1.1443	0.3400	2.1000	0.6528	<0.22	<0.22
			335-67-1	Perfluorooctanoic acid (PFOA)	5	40.0%	3	33.3%	0.0740	0.0730	0.0750	0.0734	<0.006	<0.006
			375-22-4	Perfluorobutanoic acid (PFBA)	5	60.0%	3	66.7%	0.0127	0.0070	0.0170	0.0104	0.0070	0.0104
			45187-15-3	Perfluorobutanesulfonate (PFBS)	5	0.0%	3	0.0%				0.0000	<0.005	<0.005
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	5	40.0%	3	33.3%	0.0225	0.0180	0.0270	0.0198	<0.007	<0.007
SW-232	Closed Landfill	Western Lake Superior Sanitary District Lf	108427-53-8	Perfluorohexane sulfonate (PFHxS)	17	58.8%	10	80.0%	0.0702	0.0130	0.2800	0.0508	0.0350	**0.0508**
			123-91-1	1,4-Dioxane	39	48.7%	24	45.8%	15.1484	0.3200	50.0000	7.5441	<0.22	<0.22
			335-67-1	Perfluorooctanoic acid (PFOA)	18	55.6%	10	80.0%	0.0597	0.0280	0.1100	0.0492	0.0620	**0.0492**
			375-22-4	Perfluorobutanoic acid (PFBA)	17	64.7%	10	90.0%	0.2364	0.0060	0.6600	0.1700	0.1600	0.17
			45187-15-3	Perfluorobutanesulfonate (PFBS)	17	47.1%	10	60.0%	0.0148	0.0090	0.0230	0.0123	0.0110	0.011
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	18	44.4%	10	70.0%	0.0211	0.0100	0.0310	0.0164	0.0180	**0.018**
SW-237	Closed Landfill	Cook Area Sanitary Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	1	0.0%	1	0.0%				0.0000	<0.006	<0.006
			123-91-1	1,4-Dioxane	9	0.0%	7	0.0%				0.0000	<0.22	<0.01
			335-67-1	Perfluorooctanoic acid (PFOA)	1	0.0%	1	0.0%				0.0000	<0.006	<0.006
			375-22-4	Perfluorobutanoic acid (PFBA)	1	0.0%	1	0.0%				0.0000	<0.006	<0.006
			45187-15-3	Perfluorobutanesulfonate (PFBS)	1	0.0%	1	0.0%				0.0000	<0.008	<0.008
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	1	0.0%	1	0.0%				0.0000	<0.005	<0.005
SW-25	Closed Landfill	Winona County Sanitary Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	12	0.0%	12	0.0%				0.0000	<0.006	<0.006
			123-91-1	1,4-Dioxane	17	35.3%	13	46.2%	0.5733	0.1100	1.2000	0.2735	<0.071	<0.071
			335-67-1	Perfluorooctanoic acid (PFOA)	12	8.3%	12	8.3%	0.0510	0.0510	0.0510	0.0510	<0.006	<0.006
			375-22-4	Perfluorobutanoic acid (PFBA)	12	16.7%	12	16.7%	0.0715	0.0330	0.1100	0.0394	<0.006	<0.006
			45187-15-3	Perfluorobutanesulfonate (PFBS)	12	8.3%	12	8.3%	0.0190	0.0190	0.0190	0.0190	<0.008	<0.008
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	12	16.7%	12	16.7%	0.0265	0.0220	0.0310	0.0228	<0.005	<0.005
SW-253	Closed Landfill	Carlton South Sanitary Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	12	33.3%	4	100.0%	0.0049	0.0049	0.0050	0.0049	0.0050	0.005
			123-91-1	1,4-Dioxane	7	0.0%	7	0.0%				0.0000	<0.22	<0.22
			335-67-1	Perfluorooctanoic acid (PFOA)	12	33.3%	4	100.0%	0.0025	0.0024	0.0025	0.0025	<0.0025	<0.0025
			375-22-4	Perfluorobutanoic acid (PFBA)	12	58.3%	4	100.0%	0.0087	0.0025	0.0205	0.0061	<0.0025	0.0061
			45187-15-3	Perfluorobutanesulfonate (PFBS)	12	33.3%	4	100.0%	0.0049	0.0049	0.0050	0.0049	0.0050	0.005
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	12	33.3%	4	100.0%	0.0049	0.0049	0.0050	0.0049	0.0050	0.005
SW-262	Closed Landfill	Hwy 77 Sanitary Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	4	50.0%	4	50.0%	0.0090	0.0060	0.0120	0.0075	0.0060	0.0075
			123-91-1	1,4-Dioxane	14	57.1%	7	57.1%	3.1938	0.1500	6.1000	1.8918	0.4000	**1.8918**
			335-67-1	Perfluorooctanoic acid (PFOA)	4	50.0%	4	50.0%	0.0870	0.0740	0.1000	0.0805	0.0740	**0.0805**
			375-22-4	Perfluorobutanoic acid (PFBA)	4	0.0%	4	0.0%				0.0000	<0.003	<0.003
			45187-15-3	Perfluorobutanesulfonate (PFBS)	4	0.0%	4	0.0%				0.0000	<0.005	<0.005
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	4	50.0%	4	50.0%	0.0445	0.0360	0.0530	0.0403	0.0360	**0.0403**
SW-263	Solid Waste	Wanamingo Demolition Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	6	16.7%	3	33.3%	0.0218	0.0218	0.0218	0.0218	<0.0084	<0.0084
			335-67-1	Perfluorooctanoic acid (PFOA)	6	50.0%	3	66.7%	0.0081	0.0040	0.0155	0.0061	<0.0042	0.0061
			375-22-4	Perfluorobutanoic acid (PFBA)	6	83.3%	3	100.0%	0.0185	0.0043	0.0272	0.0161	0.0193	0.0161
			45187-15-3	Perfluorobutanesulfonate (PFBS)	6	0.0%	3	0.0%				0.0000	<0.0084	<0.0049
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	6	0.0%	3	0.0%				0.0000	<0.0084	<0.0049

all concentrations in µg/L

pink shading indicates method used to determine measure of central tendency

bold indicates measure of central tendenncy above MN drinking water guidance

Table A-1 (continued)
Summary Statistics Regulated PFAS and 1,4-Dioxane

Facility Code	Facility Type	Facility Name	CAS RN	Chemical Name	Total Sample Count	% Detect	Number of Sampled Wells	% Well Detect	Arthmetic Mean of Detects	Minimum Detect	Maximum Detect	Kaplan Meier Mean	Median of Detects and Non-Detects	Measure of Central Tendency
SW-28	Closed Landfill	Waste Disposal Engineering Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	66	36.4%	44	34.1%	0.0240	0.0050	0.0870	0.0121	0.0100	0.01
			123-91-1	1,4-Dioxane	162	66.7%	59	64.4%	66.9585	0.0510	390.0000	44.6560	1.7500	**44.656**
			335-67-1	Perfluorooctanoic acid (PFOA)	66	51.5%	44	47.7%	0.2066	0.0080	1.0000	0.1103	<0.012	**0.1103**
			375-22-4	Perfluorobutanoic acid (PFBA)	66	83.3%	44	86.4%	0.3337	0.0080	2.7000	0.2794	0.0375	0.2794
			45187-15-3	Perfluorobutanesulfonate (PFBS)	66	34.8%	44	34.1%	0.0182	0.0050	0.0400	0.0096	<0.009	<0.009
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	66	10.6%	44	13.6%	0.0214	0.0110	0.0710	0.0121	<0.007	<0.007
SW-29	Closed Landfill	Kluver Sanitary Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	5	0.0%	4	0.0%				0.0000	<0.006	<0.006
			123-91-1	1,4-Dioxane	90	46.7%	24	58.3%	2.0243	0.1100	9.2000	1.0120	<0.22	<0.22
			335-67-1	Perfluorooctanoic acid (PFOA)	5	40.0%	4	50.0%	0.0205	0.0150	0.0260	0.0172	<0.006	<0.006
			375-22-4	Perfluorobutanoic acid (PFBA)	5	80.0%	4	75.0%	0.0523	0.0400	0.0830	0.0498	0.0430	0.0498
			45187-15-3	Perfluorobutanesulfonate (PFBS)	5	0.0%	4	0.0%				0.0000	<0.008	<0.008
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	5	0.0%	4	0.0%				0.0000	<0.005	<0.005
SW-291	Other Solid Waste	Hengel Demolition Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	6	66.7%	3	66.7%	0.0119	0.0071	0.0172	0.0103	0.0078	0.0103
			335-67-1	Perfluorooctanoic acid (PFOA)	6	50.0%	3	66.7%	0.0101	0.0031	0.0148	0.0066	0.0031	0.0066
			375-22-4	Perfluorobutanoic acid (PFBA)	6	66.7%	3	66.7%	0.0098	0.0079	0.0145	0.0091	0.0079	0.0091
			45187-15-3	Perfluorobutanesulfonate (PFBS)	6	33.3%	3	66.7%	0.0073	0.0054	0.0093	0.0061	<0.0057	<0.0057
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	6	16.7%	3	33.3%	0.0060	0.0060	0.0060	0.0060	<0.0056	<0.0056
SW-303	Other Solid Waste	Dawnway Demolition Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	8	50.0%	3	66.7%	0.0617	0.0275	0.0808	0.0446	0.0275	0.0446
			123-91-1	1,4-Dioxane	7	0.0%	7	0.0%				0.0000	<0.22	<0.22
			335-67-1	Perfluorooctanoic acid (PFOA)	8	62.5%	3	66.7%	0.0666	0.0087	0.1150	0.0449	0.0116	**0.0449**
			375-22-4	Perfluorobutanoic acid (PFBA)	8	100.0%	3	100.0%	0.8969	0.3740	1.4400	0.8969	0.8185	0.8969
			45187-15-3	Perfluorobutanesulfonate (PFBS)	8	50.0%	3	66.7%	0.0120	0.0108	0.0143	0.0114	0.0108	0.0114
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	8	12.5%	3	33.3%	0.0087	0.0087	0.0087	0.0087	0.0087	0.0087
SW-306	Other Solid Waste	Beltrami County Demolition Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	6	0.0%	3	0.0%				0.0000	<0.0085	<0.0051
			335-67-1	Perfluorooctanoic acid (PFOA)	6	0.0%	3	0.0%				0.0000	<0.0042	<0.0026
			375-22-4	Perfluorobutanoic acid (PFBA)	6	50.0%	3	66.7%	0.0090	0.0058	0.0117	0.0074	0.0058	0.0074
			45187-15-3	Perfluorobutanesulfonate (PFBS)	6	16.7%	3	33.3%	0.0159	0.0159	0.0159	0.0159	<0.0085	<0.0085
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	6	0.0%	3	0.0%				0.0000	<0.0083	<0.0051
SW-31	Closed Landfill	Kummer Sanitary Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	19	31.6%	14	35.7%	0.2592	0.0150	0.5000	0.0921	<0.006	<0.006
			123-91-1	1,4-Dioxane	94	28.7%	31	45.2%	0.7304	0.2500	2.3000	0.3880	<0.22	<0.22
			335-67-1	Perfluorooctanoic acid (PFOA)	23	30.4%	16	31.3%	0.0317	0.0150	0.0720	0.0223	0.0170	0.017
			375-22-4	Perfluorobutanoic acid (PFBA)	19	57.9%	14	64.3%	0.1513	0.0090	0.8100	0.0946	0.0150	0.0946
			45187-15-3	Perfluorobutanesulfonate (PFBS)	19	15.8%	14	14.3%	0.5000	0.5000	0.5000	0.5000	<0.009	<0.009
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	23	30.4%	16	25.0%	0.5000	0.5000	0.5000	0.5000	<0.007	<0.007
SW-318	Solid Waste	Hubbard Co So Transfer & Demo Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	6	0.0%	3	0.0%				0.0000	<0.0084	<0.005
			335-67-1	Perfluorooctanoic acid (PFOA)	6	0.0%	3	0.0%				0.0000	<0.0042	<0.0025
			375-22-4	Perfluorobutanoic acid (PFBA)	6	50.0%	3	66.7%	0.0055	0.0032	0.0085	0.0043	<0.0044	0.0043
			45187-15-3	Perfluorobutanesulfonate (PFBS)	6	0.0%	3	0.0%				0.0000	<0.0084	<0.005
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	6	16.7%	3	33.3%	0.0057	0.0057	0.0057	0.0057	0.0057	0.0057
SW-32	Closed Landfill	Louisville Landfill Inc.	108427-53-8	Perfluorohexane sulfonate (PFHxS)	16	75.0%	11	90.9%	0.0548	0.0070	0.2100	0.0464	0.0450	0.0464
			123-91-1	1,4-Dioxane	37	91.9%	10	100.0%	7.0015	0.0820	19.0000	6.4405	5.5000	**6.4405**
			335-67-1	Perfluorooctanoic acid (PFOA)	16	81.3%	11	81.8%	0.0947	0.0140	0.4800	0.0819	0.0560	**0.0819**
			375-22-4	Perfluorobutanoic acid (PFBA)	16	87.5%	11	90.9%	0.1686	0.0150	0.8900	0.1590	0.0920	0.159
			45187-15-3	Perfluorobutanesulfonate (PFBS)	16	37.5%	11	54.5%	0.0245	0.0070	0.0680	0.0140	0.0070	0.007
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	16	43.8%	11	63.6%	0.0853	0.0100	0.3300	0.0449	0.0125	0.0125
SW-33	Closed Landfill	Maple Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	8	12.5%	6	16.7%	0.0160	0.0160	0.0160	0.0160	0.0160	0.016
			123-91-1	1,4-Dioxane	93	34.4%	15	33.3%	4.4527	0.0860	20.0000	1.7280	0.4200	0.42
			335-67-1	Perfluorooctanoic acid (PFOA)	13	15.4%	7	28.6%	0.0985	0.0470	0.1500	0.0599	<0.087	**<0.087**
			375-22-4	Perfluorobutanoic acid (PFBA)	8	37.5%	6	33.3%	0.0287	0.0070	0.0650	0.0200	0.0395	0.0395
			45187-15-3	Perfluorobutanesulfonate (PFBS)	8	0.0%	6	0.0%				0.0000	<0.009	<0.008
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	13	0.0%	7	0.0%				0.0000	<0.107	<0.005
SW-333	Other Solid Waste	TK Demolition Disposal LLC	108427-53-8	Perfluorohexane sulfonate (PFHxS)	6	33.3%	3	33.3%	0.0090	0.0074	0.0105	0.0079	0.0074	0.0074
			335-67-1	Perfluorooctanoic acid (PFOA)	6	33.3%	3	66.7%	0.0039	0.0026	0.0053	0.0030	0.0026	0.0026
			375-22-4	Perfluorobutanoic acid (PFBA)	6	66.7%	3	66.7%	0.0258	0.0097	0.0363	0.0204	0.0173	0.0204
			45187-15-3	Perfluorobutanesulfonate (PFBS)	6	33.3%	3	33.3%	0.0135	0.0125	0.0144	0.0128	<0.0097	<0.0097
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	6	0.0%	3	0.0%				0.0000	<0.0057	<0.005

all concentrations in µg/L
pink shading indicates method used to determine measure of central tendency
bold indicates measure of central tendenncy above MN drinking water guidance

Table A-1 (continued)
Summary Statistics Regulated PFAS and 1,4-Dioxane

Facility Code	Facility Type	Facility Name	CAS RN	Chemical Name	Total Sample Count	% Detect	Number of Sampled Wells	% Well Detect	Arthmetic Mean of Detects	Minimum Detect	Maximum Detect	Kaplan Meier Mean	Median of Detects and Non-Detects	Measure of Central Tendency
SW-335	Solid Waste	Bueckers City Sanitation Services	108427-53-8	Perfluorohexane sulfonate (PFHxS)	6	66.7%	3	66.7%	0.0261	0.0094	0.0546	0.0205	0.0135	0.0205
			335-67-1	Perfluorooctanoic acid (PFOA)	6	66.7%	3	66.7%	0.0238	0.0079	0.0693	0.0185	0.0080	0.0185
			375-22-4	Perfluorobutanoic acid (PFBA)	6	83.3%	3	100.0%	0.0264	0.0050	0.0790	0.0230	0.0164	0.023
			45187-15-3	Perfluorobutanesulfonate (PFBS)	6	0.0%	3	0.0%				0.0000	<0.0083	<0.005
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	6	0.0%	3	0.0%				0.0000	<0.0057	<0.005
SW-34	Operating MSW	Clay County Sanitary Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	3	0.0%	3	0.0%				0.0000	<0.0083	<0.0082
			335-67-1	Perfluorooctanoic acid (PFOA)	3	33.3%	3	33.3%	0.0054	0.0054	0.0054	0.0054	<0.0042	<0.0042
			375-22-4	Perfluorobutanoic acid (PFBA)	3	33.3%	3	33.3%	0.0126	0.0126	0.0126	0.0126	<0.0042	<0.0042
			45187-15-3	Perfluorobutanesulfonate (PFBS)	3	0.0%	3	0.0%				0.0000	<0.0083	<0.0082
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	3	0.0%	3	0.0%				0.0000	<0.0083	<0.0082
SW-343	Other Solid Waste	SKB Rich Valley Demolition Waste Mgmt Facility	108427-53-8	Perfluorohexane sulfonate (PFHxS)	6	0.0%	3	0.0%				0.0000	<0.0056	<0.005
			335-67-1	Perfluorooctanoic acid (PFOA)	6	16.7%	3	33.3%	0.0027	0.0027	0.0027	0.0027	<0.0025	<0.0025
			375-22-4	Perfluorobutanoic acid (PFBA)	6	100.0%	3	100.0%	0.1624	0.0996	0.2620	0.1624	0.1435	0.1624
			45187-15-3	Perfluorobutanesulfonate (PFBS)	6	0.0%	3	0.0%				0.0000	<0.0056	<0.005
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	6	33.3%	3	33.3%	0.0071	0.0067	0.0076	0.0069	0.0067	0.0067
SW-35	Closed Landfill	St. Augusta Sanitary Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	11	9.1%	7	14.3%	0.0160	0.0160	0.0160	0.0160	<0.006	<0.006
			123-91-1	1,4-Dioxane	22	18.2%	10	40.0%	5.3425	0.9700	13.0000	1.7650	<0.22	<0.22
			335-67-1	Perfluorooctanoic acid (PFOA)	11	54.5%	7	71.4%	0.1533	0.0070	0.8210	0.0883	0.0120	**0.0883**
			375-22-4	Perfluorobutanoic acid (PFBA)	11	81.8%	7	100.0%	0.0180	0.0056	0.0535	0.0180	0.0150	0.018
			45187-15-3	Perfluorobutanesulfonate (PFBS)	11	36.4%	7	57.1%	0.0288	0.0080	0.0501	0.0172	<0.008	<0.008
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	11	9.1%	7	14.3%	0.0505	0.0505	0.0505	0.0505	<0.005	<0.005
SW-353	Solid Waste	Vonco Demolition Debris Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	6	16.7%	3	33.3%	0.0068	0.0068	0.0068	0.0068	0.0068	0.0068
			335-67-1	Perfluorooctanoic acid (PFOA)	6	33.3%	3	33.3%	0.4242	0.0113	0.8370	0.1489	<0.0042	<0.0042
			375-22-4	Perfluorobutanoic acid (PFBA)	6	83.3%	3	100.0%	0.0511	0.0031	0.0882	0.0431	0.0460	0.0431
			45187-15-3	Perfluorobutanesulfonate (PFBS)	6	16.7%	3	33.3%	0.0057	0.0057	0.0057	0.0057	<0.0081	<0.0081
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	6	0.0%	3	0.0%				0.0000	<0.0081	<0.005
SW-376	Operating MSW	Crow Wing County MMSW Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	20	0.0%	5	0.0%				0.0000	<0.0096	<0.0096
			335-67-1	Perfluorooctanoic acid (PFOA)	20	5.0%	5	20.0%	0.0258	0.0258	0.0258	0.0350	<0.0197	<0.0197
			375-22-4	Perfluorobutanoic acid (PFBA)	20	60.0%	5	60.0%	0.0794	0.0371	0.1470	0.0569	0.0511	0.0569
			45187-15-3	Perfluorobutanesulfonate (PFBS)	20	60.0%	5	60.0%	0.0789	0.0354	0.1610	0.0563	0.0485	0.0563
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	20	0.0%	5	0.0%				0.0000	<0.0295	<0.0295
SW-383	Other Solid Waste	SKB Rosemount Industrial Waste Facility	108427-53-8	Perfluorohexane sulfonate (PFHxS)	4	0.0%	4	0.0%				0.0000	<0.0085	<0.0085
			123-91-1	1,4-Dioxane	19	0.0%	15	0.0%				0.0000	<25	**<25**
			335-67-1	Perfluorooctanoic acid (PFOA)	4	75.0%	4	75.0%	0.0129	0.0091	0.0156	0.0119	0.0115	0.0119
			375-22-4	Perfluorobutanoic acid (PFBA)	4	100.0%	4	100.0%	0.2400	0.1970	0.2850	0.2400	0.2390	0.24
			45187-15-3	Perfluorobutanesulfonate (PFBS)	4	50.0%	4	50.0%	0.0195	0.0105	0.0284	0.0150	0.0105	0.015
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	4	0.0%	4	0.0%				0.0000	<0.0085	<0.0085
SW-387	Other Solid Waste	Summit Avenue Demolition Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	7	85.7%	3	100.0%	0.0646	0.0110	0.1440	0.0569	0.0130	**0.0569**
			335-67-1	Perfluorooctanoic acid (PFOA)	7	71.4%	3	100.0%	0.1320	0.0042	0.2340	0.0955	0.0247	**0.0955**
			375-22-4	Perfluorobutanoic acid (PFBA)	7	100.0%	3	100.0%	0.1330	0.0044	0.3250	0.1330	0.0457	0.133
			45187-15-3	Perfluorobutanesulfonate (PFBS)	7	0.0%	3	0.0%				0.0000	<0.0083	<0.005
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	7	42.9%	3	66.7%	0.0236	0.0112	0.0344	0.0165	0.0112	0.0112
SW-405	Operating MSW	St Louis County Regional Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	11	36.4%	10	30.0%	0.0549	0.0103	0.1140	0.0265	<0.0068	<0.0068
			335-67-1	Perfluorooctanoic acid (PFOA)	11	54.5%	10	50.0%	0.0742	0.0205	0.1490	0.0498	0.0205	**0.0498**
			375-22-4	Perfluorobutanoic acid (PFBA)	11	72.7%	10	70.0%	0.1589	0.0031	0.7540	0.1166	0.0177	0.1166
			45187-15-3	Perfluorobutanesulfonate (PFBS)	11	45.5%	10	50.0%	0.0978	0.0324	0.2010	0.0621	<0.008	<0.008
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	11	18.2%	10	10.0%	0.0201	0.0097	0.0304	0.0116	<0.0118	<0.0118
SW-406	Other Solid Waste	Douglas County Demolition Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	6	83.3%	3	100.0%	0.0337	0.0055	0.0737	0.0290	0.0114	0.029
			335-67-1	Perfluorooctanoic acid (PFOA)	6	100.0%	3	100.0%	0.0692	0.0105	0.1890	0.0692	0.0632	**0.0692**
			375-22-4	Perfluorobutanoic acid (PFBA)	6	100.0%	3	100.0%	0.0630	0.0140	0.1480	0.0630	0.0494	0.063
			45187-15-3	Perfluorobutanesulfonate (PFBS)	6	66.7%	3	66.7%	0.0175	0.0081	0.0278	0.0143	0.0087	0.0143
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	6	33.3%	3	33.3%	0.0365	0.0197	0.0532	0.0253	<0.0056	<0.0056

all concentrations in µg/L
pink shading indicates method used to determine measure of central tendency
bold indicates measure of central tendenncy above MN drinking water guidance

Table A-1 (continued)
Summary Statistics Regulated PFAS and 1,4-Dioxane

Facility Code	Facility Type	Facility Name	CAS RN	Chemical Name	Total Sample Count	% Detect	Number of Sampled Wells	% Well Detect	Arthmetic Mean of Detects	Minimum Detect	Maximum Detect	Kaplan Meier Mean	Median of Detects and Non-Detects	Measure of Central Tendency
SW-407	Other Solid Waste	Lakes Area Demolition Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	3	0.0%	3	0.0%				0.0000	<0.0084	<0.0082
			335-67-1	Perfluorooctanoic acid (PFOA)	3	0.0%	3	0.0%				0.0000	<0.0042	<0.0041
			375-22-4	Perfluorobutanoic acid (PFBA)	3	33.3%	3	33.3%	0.0116	0.0116	0.0116	0.0116	<0.0042	<0.0042
			45187-15-3	Perfluorobutanesulfonate (PFBS)	3	0.0%	3	0.0%				0.0000	<0.0084	<0.0082
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	3	0.0%	3	0.0%				0.0000	<0.0084	<0.0082
SW-408	Solid Waste	Glenwood Demolition Disposal LLC	108427-53-8	Perfluorohexane sulfonate (PFHxS)	6	16.7%	3	33.3%	0.0177	0.0177	0.0177	0.0177	<0.0057	<0.0057
			335-67-1	Perfluorooctanoic acid (PFOA)	6	16.7%	3	33.3%	0.0029	0.0029	0.0029	0.0029	<0.0025	<0.0025
			375-22-4	Perfluorobutanoic acid (PFBA)	6	83.3%	3	100.0%	0.0109	0.0049	0.0300	0.0099	0.0060	0.0099
			45187-15-3	Perfluorobutanesulfonate (PFBS)	6	16.7%	3	33.3%	0.0123	0.0123	0.0123	0.0123	<0.0056	<0.0056
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	6	0.0%	3	0.0%				0.0000	<0.0057	<0.0049
SW-412	Other Solid Waste	Crosslake Construction Demolition Debris	108427-53-8	Perfluorohexane sulfonate (PFHxS)	4	0.0%	2	0.0%				0.0000	<0.0057	<0.005
			335-67-1	Perfluorooctanoic acid (PFOA)	4	50.0%	2	50.0%	0.0052	0.0050	0.0053	0.0051	0.0050	0.0051
			375-22-4	Perfluorobutanoic acid (PFBA)	4	50.0%	2	50.0%	0.0129	0.0085	0.0173	0.0107	0.0085	0.0107
			45187-15-3	Perfluorobutanesulfonate (PFBS)	4	0.0%	2	0.0%				0.0000	<0.0056	<0.005
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	4	0.0%	2	0.0%				0.0000	<0.0057	<0.005
SW-42	Closed Landfill	Yellow Medicine County Sanitary Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	5	0.0%	5	0.0%				0.0000	<0.006	<0.006
			123-91-1	1,4-Dioxane	17	35.3%	11	36.4%	3.9883	0.3000	11.1500	1.6018	<0.071	<0.071
			335-67-1	Perfluorooctanoic acid (PFOA)	5	20.0%	5	20.0%	0.0790	0.0790	0.0790	0.0790	<0.006	<0.006
			375-22-4	Perfluorobutanoic acid (PFBA)	5	20.0%	5	20.0%	0.0880	0.0880	0.0880	0.0880	<0.006	<0.006
			45187-15-3	Perfluorobutanesulfonate (PFBS)	5	0.0%	5	0.0%				0.0000	<0.008	<0.008
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	5	0.0%	5	0.0%				0.0000	<0.005	<0.005
SW-428	Other Solid Waste	Voyageur Disposal & Processing Inc	108427-53-8	Perfluorohexane sulfonate (PFHxS)	8	12.5%	4	25.0%	0.0068	0.0068	0.0068	0.0068	<0.0056	<0.0056
			335-67-1	Perfluorooctanoic acid (PFOA)	8	25.0%	4	25.0%	0.0112	0.0081	0.0144	0.0088	<0.0026	<0.0026
			375-22-4	Perfluorobutanoic acid (PFBA)	8	87.5%	4	100.0%	0.0182	0.0031	0.0520	0.0163	0.0060	0.0163
			45187-15-3	Perfluorobutanesulfonate (PFBS)	8	25.0%	4	25.0%	0.0063	0.0056	0.0069	0.0058	<0.0056	<0.0056
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	8	12.5%	4	25.0%	0.0068	0.0068	0.0068	0.0068	<0.0056	<0.0056
SW-429	Other Solid Waste	DKV Demolition Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	6	0.0%	3	0.0%				0.0000	<0.0056	<0.005
			335-67-1	Perfluorooctanoic acid (PFOA)	6	0.0%	3	0.0%				0.0000	<0.0025	<0.0024
			375-22-4	Perfluorobutanoic acid (PFBA)	6	100.0%	3	100.0%	0.0200	0.0074	0.0588	0.0200	0.0135	0.02
			45187-15-3	Perfluorobutanesulfonate (PFBS)	6	0.0%	3	0.0%				0.0000	<0.0055	<0.005
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	6	0.0%	3	0.0%				0.0000	<0.0056	<0.005
SW-43	Closed Landfill	Oak Grove Sanitary Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	39	2.6%	23	4.3%	0.0190	0.0190	0.0190	0.0190	<0.004	<0.004
			123-91-1	1,4-Dioxane	73	37.0%	28	28.6%	41.2886	0.0790	270.0000	15.3209	<0.031	<0.031
			335-67-1	Perfluorooctanoic acid (PFOA)	39	10.3%	23	8.7%	0.1655	0.0080	0.5000	0.0242	<0.006	<0.006
			375-22-4	Perfluorobutanoic acid (PFBA)	39	41.0%	23	47.8%	0.0982	0.0060	0.8000	0.0438	<0.006	<0.006
			45187-15-3	Perfluorobutanesulfonate (PFBS)	39	2.6%	23	4.3%	0.0060	0.0060	0.0060	0.0060	<0.005	<0.005
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	39	5.1%	23	4.3%	0.0415	0.0300	0.0530	0.0306	<0.007	<0.007
SW-44	Closed Landfill	Lindenfelser Demolition Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	12	0.0%	8	0.0%				0.0000	<0.006	<0.0049
			123-91-1	1,4-Dioxane	51	49.0%	17	47.1%	3.2338	0.0550	25.0000	1.6132	<0.017	<0.017
			335-67-1	Perfluorooctanoic acid (PFOA)	12	25.0%	8	37.5%	0.0130	0.0090	0.0200	0.0100	<0.006	<0.006
			375-22-4	Perfluorobutanoic acid (PFBA)	12	75.0%	8	75.0%	0.0208	0.0040	0.0459	0.0166	0.0100	0.0166
			45187-15-3	Perfluorobutanesulfonate (PFBS)	12	0.0%	8	0.0%				0.0000	<0.008	<0.0049
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	12	8.3%	8	12.5%	0.0310	0.0310	0.0310	0.0310	<0.005	<0.005
SW-45	Operating MSW	Pine Bend Sanitary Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	43	69.8%	19	73.7%	0.0354	0.0077	0.2000	0.0270	0.0190	0.027
			335-67-1	Perfluorooctanoic acid (PFOA)	43	79.1%	19	84.2%	0.4205	0.0234	2.7000	0.3374	0.2400	**0.3374**
			375-22-4	Perfluorobutanoic acid (PFBA)	43	95.3%	19	94.7%	11.5880	0.0290	200.0000	11.0504	1.1000	**11.0504**
			45187-15-3	Perfluorobutanesulfonate (PFBS)	43	62.8%	19	68.4%	0.0501	0.0076	0.1600	0.0343	0.0260	0.0343
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	43	72.1%	19	78.9%	0.2464	0.0140	1.4000	0.1816	0.0890	**0.1816**
SW-47	Closed Landfill	East Bethel Demolition/Sanitary Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	24	37.5%	17	41.2%	0.1304	0.0190	0.5000	0.0614	0.0250	0.025
			123-91-1	1,4-Dioxane	182	63.2%	59	61.0%	42.2174	0.0490	1680.0000	26.6939	0.5600	**26.6939**
			335-67-1	Perfluorooctanoic acid (PFOA)	33	36.4%	21	38.1%	0.1285	0.0540	0.2500	0.0872	<0.087	**<0.087**
			375-22-4	Perfluorobutanoic acid (PFBA)	24	70.8%	17	64.7%	0.1345	0.0120	0.3600	0.1258	0.1750	0.1258
			45187-15-3	Perfluorobutanesulfonate (PFBS)	24	29.2%	17	35.3%	0.1501	0.0090	0.5000	0.0503	0.0090	0.009
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	33	45.5%	21	61.9%	0.3771	0.0100	0.5000	0.1779	0.0700	**0.07**

all concentrations in µg/L
pink shading indicates method used to determine measure of central tendency
bold indicates measure of central tendenncy above MN drinking water guidance

Table A-1 (continued)
Summary Statistics Regulated PFAS and 1,4-Dioxane

Facility Code	Facility Type	Facility Name	CAS RN	Chemical Name	Total Sample Count	% Detect	Number of Sampled Wells	% Well Detect	Arthmetic Mean of Detects	Minimum Detect	Maximum Detect	Kaplan Meier Mean	Median of Detects and Non-Detects	Measure of Central Tendency
SW-486	Other Solid Waste	Meeker County Demolition Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	6	33.3%	3	33.3%	0.0154	0.0130	0.0178	0.0138	0.0130	0.013
			335-67-1	Perfluorooctanoic acid (PFOA)	6	33.3%	3	33.3%	0.0085	0.0077	0.0094	0.0079	<0.0066	<0.0066
			375-22-4	Perfluorobutanoic acid (PFBA)	6	33.3%	3	33.3%	0.0247	0.0236	0.0257	0.0240	<0.0066	<0.0066
			45187-15-3	Perfluorobutanesulfonate (PFBS)	6	33.3%	3	33.3%	0.0172	0.0167	0.0177	0.0169	<0.0131	<0.0131
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	6	0.0%	3	0.0%				0.0000	<0.0126	<0.005
SW-49	Closed Landfill	Ironwood Sanitary Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	24	0.0%	24	0.0%				0.0000	<0.004	<0.004
			123-91-1	1,4-Dioxane	75	49.3%	36	50.0%	2.9053	0.0680	13.0000	1.4677	<0.071	<0.071
			335-67-1	Perfluorooctanoic acid (PFOA)	24	12.5%	24	12.5%	0.0210	0.0050	0.0310	0.0070	<0.005	<0.005
			375-22-4	Perfluorobutanoic acid (PFBA)	24	12.5%	24	12.5%	0.0083	0.0040	0.0120	0.0045	<0.003	<0.003
			45187-15-3	Perfluorobutanesulfonate (PFBS)	24	0.0%	24	0.0%				0.0000	<0.005	<0.005
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	24	4.2%	24	4.2%	0.0080	0.0080	0.0080	0.0080	<0.007	<0.007
SW-5	Closed Landfill	Olmsted County - Oronoco Sanitary Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	18	0.0%	10	0.0%				0.0000	<0.005	<0.004
			123-91-1	1,4-Dioxane	97	35.1%	22	45.5%	0.1977	0.0510	0.5700	0.1025	0.0570	0.057
			335-67-1	Perfluorooctanoic acid (PFOA)	18	5.6%	10	10.0%	0.0032	0.0032	0.0032	0.0032	<0.005	<0.005
			375-22-4	Perfluorobutanoic acid (PFBA)	22	77.3%	10	80.0%	0.0157	0.0030	0.0251	0.0128	0.0125	0.0128
			45187-15-3	Perfluorobutanesulfonate (PFBS)	18	0.0%	10	0.0%				0.0000	<0.005	<0.005
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	18	0.0%	10	0.0%				0.0000	<0.005	<0.005
SW-50	Closed Landfill	Dakhue Sanitary Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	10	0.0%	8	0.0%				0.0000	<0.004	<0.004
			123-91-1	1,4-Dioxane	52	26.9%	18	27.8%	1.0907	0.0530	5.7000	0.3324	<0.03	<0.03
			335-67-1	Perfluorooctanoic acid (PFOA)	10	10.0%	8	12.5%	0.0070	0.0070	0.0070	0.0070	0.0070	0.007
			375-22-4	Perfluorobutanoic acid (PFBA)	10	80.0%	8	87.5%	0.1293	0.0570	0.4600	0.1198	0.0945	0.1198
			45187-15-3	Perfluorobutanesulfonate (PFBS)	10	10.0%	8	12.5%	0.0150	0.0150	0.0150	0.0150	<0.009	<0.009
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	10	0.0%	8	0.0%				0.0000	<0.007	<0.007
SW-501	Other Solid Waste	Lyon County Demolition Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	9	22.2%	6	33.3%	0.0551	0.0110	0.0991	0.0208	<0.0086	<0.0086
			335-67-1	Perfluorooctanoic acid (PFOA)	9	22.2%	6	33.3%	0.1191	0.0042	0.2340	0.0297	<0.0042	<0.0042
			375-22-4	Perfluorobutanoic acid (PFBA)	9	33.3%	6	50.0%	0.1250	0.0044	0.3250	0.0446	<0.0043	<0.0043
			45187-15-3	Perfluorobutanesulfonate (PFBS)	9	0.0%	6	0.0%				0.0000	<0.0083	<0.0051
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	9	11.1%	6	16.7%	0.0344	0.0344	0.0344	0.0344	<0.0083	<0.0083
SW-51	Closed Landfill	Eighty Acres Sanitary Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	1	0.0%	1	0.0%				0.0000	<0.006	<0.006
			123-91-1	1,4-Dioxane	12	0.0%	9	0.0%				0.0000	<0.36	<0.015
			335-67-1	Perfluorooctanoic acid (PFOA)	1	0.0%	1	0.0%				0.0000	<0.006	<0.006
			375-22-4	Perfluorobutanoic acid (PFBA)	1	100.0%	1	100.0%	0.0120	0.0120	0.0120	0.0120	0.0120	0.012
			45187-15-3	Perfluorobutanesulfonate (PFBS)	1	0.0%	1	0.0%				0.0000	<0.008	<0.008
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	1	0.0%	1	0.0%				0.0000	<0.005	<0.005
SW-52	Closed Landfill	Chippewa County Sanitary Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	3	0.0%	3	0.0%				0.0000	<0.006	<0.006
			123-91-1	1,4-Dioxane	13	15.4%	13	15.4%	3.3250	3.2600	3.3900	3.2700	<0.071	<0.071
			335-67-1	Perfluorooctanoic acid (PFOA)	3	66.7%	3	66.7%	0.0210	0.0200	0.0220	0.0207	0.0200	0.0207
			375-22-4	Perfluorobutanoic acid (PFBA)	3	0.0%	3	0.0%				0.0000	<0.006	<0.006
			45187-15-3	Perfluorobutanesulfonate (PFBS)	3	0.0%	3	0.0%				0.0000	<0.008	<0.008
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	3	0.0%	3	0.0%				0.0000	<0.005	<0.005
SW-536	Solid Waste	Vonco V - Duluth	108427-53-8	Perfluorohexane sulfonate (PFHxS)	6	50.0%	3	66.7%	0.0365	0.0063	0.0531	0.0214	0.0063	0.0214
			335-67-1	Perfluorooctanoic acid (PFOA)	6	33.3%	3	33.3%	0.0091	0.0065	0.0118	0.0074	<0.0025	<0.0025
			375-22-4	Perfluorobutanoic acid (PFBA)	6	83.3%	3	100.0%	0.0266	0.0055	0.0491	0.0231	0.0197	0.0231
			45187-15-3	Perfluorobutanesulfonate (PFBS)	6	16.7%	3	33.3%	0.0168	0.0168	0.0168	0.0168	<0.0128	<0.0128
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	6	0.0%	3	0.0%				0.0000	<0.0057	<0.0049
SW-541	Other Solid Waste	Oak Ridge Demolition Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	6	0.0%	3	0.0%				0.0000	<0.0057	<0.0051
			335-67-1	Perfluorooctanoic acid (PFOA)	6	50.0%	3	66.7%	0.0057	0.0033	0.0080	0.0045	0.0033	0.0045
			375-22-4	Perfluorobutanoic acid (PFBA)	6	66.7%	3	66.7%	0.0271	0.0063	0.0498	0.0202	0.0162	0.0202
			45187-15-3	Perfluorobutanesulfonate (PFBS)	6	50.0%	3	66.7%	0.0182	0.0055	0.0288	0.0118	<0.0092	0.0118
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	6	0.0%	3	0.0%				0.0000	<0.0057	<0.0051
SW-542	Other Solid Waste	Vonco 4 - Austin Demolition Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	6	0.0%	3	0.0%				0.0000	<0.0086	<0.005
			335-67-1	Perfluorooctanoic acid (PFOA)	6	0.0%	3	0.0%				0.0000	<0.0043	<0.0025
			375-22-4	Perfluorobutanoic acid (PFBA)	6	16.7%	3	33.3%	0.0030	0.0030	0.0030	0.0030	0.0030	0.003
			45187-15-3	Perfluorobutanesulfonate (PFBS)	6	0.0%	3	0.0%				0.0000	<0.0086	<0.005
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	6	0.0%	3	0.0%				0.0000	<0.0086	<0.005

all concentrations in µg/L
pink shading indicates method used to determine measure of central tendency
bold indicates measure of central tendenncy above MN drinking water guidance

Table A-1 (continued)
Summary Statistics Regulated PFAS and 1,4-Dioxane

Facility Code	Facility Type	Facility Name	CAS RN	Chemical Name	Total Sample Count	% Detect	Number of Sampled Wells	% Well Detect	Arthmetic Mean of Detects	Minimum Detect	Maximum Detect	Kaplan Meier Mean	Median of Detects and Non-Detects	Measure of Central Tendency
SW-548	Other Solid Waste	Waste Management Demolition Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	6	0.0%	3	0.0%				0.0000	<0.007	<0.0049
			335-67-1	Perfluorooctanoic acid (PFOA)	6	0.0%	3	0.0%				0.0000	<0.0035	<0.0025
			375-22-4	Perfluorobutanoic acid (PFBA)	6	16.7%	3	33.3%	0.0075	0.0075	0.0075	0.0075	<0.0035	<0.0035
			45187-15-3	Perfluorobutanesulfonate (PFBS)	6	0.0%	3	0.0%				0.0000	<0.007	<0.0049
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	6	0.0%	3	0.0%				0.0000	<0.007	<0.0049
SW-56	Operating MSW	Burnsville Sanitary Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	9	44.4%	4	75.0%	0.0079	0.0052	0.0117	0.0068	0.0059	0.0059
			335-67-1	Perfluorooctanoic acid (PFOA)	9	100.0%	4	100.0%	0.0311	0.0072	0.0655	0.0311	0.0230	0.0311
			375-22-4	Perfluorobutanoic acid (PFBA)	9	88.9%	4	100.0%	0.0900	0.0214	0.1630	0.0824	0.0755	0.0824
			45187-15-3	Perfluorobutanesulfonate (PFBS)	9	22.2%	4	50.0%	0.0097	0.0059	0.0135	0.0067	0.0059	0.0059
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	9	66.7%	4	100.0%	0.0260	0.0053	0.0572	0.0192	<0.0124	**0.0192**
SW-57	Closed Landfill	Freeway Sanitary Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	36	36.1%	30	36.7%	0.0323	0.0060	0.1200	0.0157	0.0120	0.012
			123-91-1	1,4-Dioxane	34	55.9%	28	57.1%	4.7151	0.0970	36.0000	2.6777	0.2650	**2.6777**
			335-67-1	Perfluorooctanoic acid (PFOA)	41	56.1%	30	60.0%	0.2260	0.0160	1.1000	0.1379	0.0770	**0.1379**
			375-22-4	Perfluorobutanoic acid (PFBA)	36	94.4%	30	93.3%	0.0584	0.0140	0.3800	0.0559	0.0275	0.0559
			45187-15-3	Perfluorobutanesulfonate (PFBS)	36	38.9%	30	40.0%	0.0124	0.0060	0.0380	0.0087	<0.009	<0.009
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	41	48.8%	30	50.0%	0.1019	0.0130	0.5000	0.0592	0.0300	**0.03**
SW-58	Closed Landfill	Hopkins Sanitary Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	26	50.0%	16	50.0%	0.0095	0.0058	0.0248	0.0084	0.0075	0.0084
			123-91-1	1,4-Dioxane	82	80.5%	24	83.3%	6.0358	0.0560	41.0000	4.8690	0.1850	**4.869**
			335-67-1	Perfluorooctanoic acid (PFOA)	26	69.2%	16	62.5%	0.0660	0.0070	0.2900	0.0509	0.0533	**0.0509**
			375-22-4	Perfluorobutanoic acid (PFBA)	26	84.6%	16	81.3%	0.0930	0.0120	0.2230	0.0895	0.1050	0.0895
			45187-15-3	Perfluorobutanesulfonate (PFBS)	26	50.0%	16	50.0%	0.0378	0.0080	0.1110	0.0245	0.0298	0.0245
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	26	50.0%	16	43.8%	0.0173	0.0090	0.0372	0.0150	0.0178	**0.015**
SW-59	Closed Landfill	French Lake Sanitary Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	2	0.0%	2	0.0%				0.0000	<0.006	<0.006
			123-91-1	1,4-Dioxane	21	0.0%	7	0.0%				0.0000	<0.22	<0.22
			335-67-1	Perfluorooctanoic acid (PFOA)	2	0.0%	2	0.0%				0.0000	<0.006	<0.006
			375-22-4	Perfluorobutanoic acid (PFBA)	2	50.0%	2	50.0%	0.0090	0.0090	0.0090	0.0090	0.0090	0.009
			45187-15-3	Perfluorobutanesulfonate (PFBS)	2	0.0%	2	0.0%				0.0000	<0.008	<0.008
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	2	0.0%	2	0.0%				0.0000	<0.005	<0.005
SW-6	Operating MSW	Spruce Ridge Resource Management	108427-53-8	Perfluorohexane sulfonate (PFHxS)	6	16.7%	6	16.7%	0.0225	0.0225	0.0225	0.0225	<0.0129	<0.0129
			335-67-1	Perfluorooctanoic acid (PFOA)	6	100.0%	6	100.0%	0.0450	0.0078	0.1300	0.0450	0.0312	**0.045**
			375-22-4	Perfluorobutanoic acid (PFBA)	6	83.3%	6	83.3%	0.1392	0.0233	0.4040	0.1235	0.0576	0.1235
			45187-15-3	Perfluorobutanesulfonate (PFBS)	6	33.3%	6	33.3%	0.0210	0.0191	0.0229	0.0197	<0.0129	<0.0129
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	6	16.7%	6	16.7%	0.0155	0.0155	0.0155	0.0155	<0.0129	<0.0129
SW-60	Other Solid Waste	Advanced Disposal Services - Rolling Hills Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	3	0.0%	3	0.0%				0.0000	<0.0088	<0.0087
			335-67-1	Perfluorooctanoic acid (PFOA)	3	33.3%	3	33.3%	0.0174	0.0174	0.0174	0.0174	<0.0045	<0.0045
			375-22-4	Perfluorobutanoic acid (PFBA)	3	33.3%	3	33.3%	0.0139	0.0139	0.0139	0.0139	<0.0045	<0.0045
			45187-15-3	Perfluorobutanesulfonate (PFBS)	3	0.0%	3	0.0%				0.0000	<0.0088	<0.0087
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	3	0.0%	3	0.0%				0.0000	<0.0088	<0.0087
SW-61	Closed Landfill	Woodlake Sanitary Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	44	18.2%	22	9.1%	0.0848	0.0310	0.1200	0.0424	0.0310	0.031
			123-91-1	1,4-Dioxane	66	22.7%	37	21.6%	3.0109	0.0780	27.0000	0.7446	<0.03	<0.03
			335-67-1	Perfluorooctanoic acid (PFOA)	44	27.3%	22	18.2%	0.1008	0.0043	0.2300	0.0318	0.0750	**0.075**
			375-22-4	Perfluorobutanoic acid (PFBA)	44	40.9%	22	31.8%	0.3642	0.0029	1.0000	0.1541	0.0655	0.0655
			45187-15-3	Perfluorobutanesulfonate (PFBS)	44	11.4%	22	9.1%	0.0489	0.0230	0.1000	0.0262	0.0230	0.023
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	44	6.8%	22	9.1%	0.0185	0.0062	0.0400	0.0076	<0.007	<0.007
SW-62	Closed Landfill	Red Rock Sanitary Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	21	0.0%	15	0.0%				0.0000	<0.006	<0.004
			123-91-1	1,4-Dioxane	35	51.4%	20	45.0%	0.9475	0.0590	4.2800	0.5161	<0.071	0.5161
			335-67-1	Perfluorooctanoic acid (PFOA)	21	42.9%	15	33.3%	0.0270	0.0090	0.0480	0.0167	<0.012	<0.012
			375-22-4	Perfluorobutanoic acid (PFBA)	21	42.9%	15	40.0%	0.0217	0.0090	0.0910	0.0144	<0.008	<0.008
			45187-15-3	Perfluorobutanesulfonate (PFBS)	21	0.0%	15	0.0%				0.0000	<0.008	<0.005
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	18	5.6%	12	8.3%	0.0250	0.0250	0.0250	0.0250	<0.007	<0.007
SW-63	Closed Landfill	Minnesota Sanitation Services Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	8	37.5%	5	40.0%	0.0210	0.0080	0.0290	0.0129	<0.006	<0.006
			123-91-1	1,4-Dioxane	8	100.0%	4	100.0%	1.8688	0.2900	5.1300	1.8688	0.9700	**1.8688**
			335-67-1	Perfluorooctanoic acid (PFOA)	8	100.0%	5	100.0%	0.0678	0.0150	0.3100	0.0678	0.0190	**0.0678**
			375-22-4	Perfluorobutanoic acid (PFBA)	8	37.5%	5	60.0%	0.0150	0.0050	0.0230	0.0088	<0.006	<0.006
			45187-15-3	Perfluorobutanesulfonate (PFBS)	8	37.5%	5	40.0%	0.0207	0.0090	0.0420	0.0134	<0.008	<0.008
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	8	37.5%	5	40.0%	0.1350	0.0250	0.2800	0.0663	<0.007	<0.007

all concentrations in µg/L
pink shading indicates method used to determine measure of central tendency
bold indicates measure of central tendenncy above MN drinking water guidance

Table A-1 (continued)
Summary Statistics Regulated PFAS and 1,4-Dioxane

Facility Code	Facility Type	Facility Name	CAS RN	Chemical Name	Total Sample Count	% Detect	Number of Sampled Wells	% Well Detect	Arthmetic Mean of Detects	Minimum Detect	Maximum Detect	Kaplan Meier Mean	Median of Detects and Non-Detects	Measure of Central Tendency
SW-64	Closed Landfill	Mankato Sanitary Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	8	0.0%	8	0.0%				0.0000	<0.0051	<0.0049
			123-91-1	1,4-Dioxane	29	41.4%	10	40.0%	1.0133	0.1300	2.9000	0.4955	<0.071	<0.071
			335-67-1	Perfluorooctanoic acid (PFOA)	8	62.5%	8	62.5%	0.0076	0.0043	0.0150	0.0063	0.0045	0.0063
			375-22-4	Perfluorobutanoic acid (PFBA)	8	50.0%	8	50.0%	0.0073	0.0037	0.0148	0.0055	0.0037	0.0055
			45187-15-3	Perfluorobutanesulfonate (PFBS)	8	12.5%	8	12.5%	0.0051	0.0051	0.0051	0.0051	0.0051	0.0051
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	8	50.0%	8	50.0%	0.0090	0.0056	0.0148	0.0073	0.0056	0.0073
SW-67	Closed Landfill	Tellijohn Sanitary Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	6	33.3%	6	33.3%	0.0350	0.0320	0.0380	0.0330	<0.013	<0.013
			123-91-1	1,4-Dioxane	23	78.3%	10	50.0%	50.4222	1.2900	121.8000	39.7413	37.9000	**39.7413**
			335-67-1	Perfluorooctanoic acid (PFOA)	6	66.7%	6	66.7%	0.1263	0.0280	0.2100	0.0935	0.0525	**0.0935**
			375-22-4	Perfluorobutanoic acid (PFBA)	6	83.3%	6	83.3%	0.0826	0.0160	0.1300	0.0715	0.0785	0.0715
			45187-15-3	Perfluorobutanesulfonate (PFBS)	6	33.3%	6	33.3%	0.0150	0.0120	0.0180	0.0130	<0.009	<0.009
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	6	16.7%	6	16.7%	0.1900	0.1900	0.1900	0.1900	<0.007	<0.007
SW-68	Closed Landfill	Northwoods Sanitary Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	3	33.3%	3	33.3%	0.0140	0.0140	0.0140	0.0140	<0.004	<0.004
			123-91-1	1,4-Dioxane	27	51.9%	16	50.0%	4.5814	0.2600	14.7000	2.5007	<0.46	**2.5007**
			335-67-1	Perfluorooctanoic acid (PFOA)	3	66.7%	3	66.7%	0.0270	0.0090	0.0450	0.0210	0.0090	0.021
			375-22-4	Perfluorobutanoic acid (PFBA)	3	33.3%	3	33.3%	0.0130	0.0130	0.0130	0.0130	<0.003	<0.003
			45187-15-3	Perfluorobutanesulfonate (PFBS)	3	33.3%	3	33.3%	0.0070	0.0070	0.0070	0.0070	<0.005	<0.005
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	3	66.7%	3	66.7%	0.0315	0.0230	0.0400	0.0287	0.0230	**0.0287**
SW-7	Closed Landfill	Wadena Sanitary Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	5	0.0%	5	0.0%				0.0000	<0.004	<0.004
			123-91-1	1,4-Dioxane	45	11.1%	12	25.0%	0.1886	0.0640	0.5000	0.0846	<0.22	<0.22
			335-67-1	Perfluorooctanoic acid (PFOA)	5	20.0%	5	20.0%	0.0070	0.0070	0.0070	0.0070	<0.005	<0.005
			375-22-4	Perfluorobutanoic acid (PFBA)	5	20.0%	5	20.0%	0.0040	0.0040	0.0040	0.0040	<0.003	<0.003
			45187-15-3	Perfluorobutanesulfonate (PFBS)	5	0.0%	5	0.0%				0.0000	<0.005	<0.005
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	5	40.0%	5	40.0%	0.0105	0.0100	0.0110	0.0102	<0.007	<0.007
SW-70	Closed Landfill	Meeker County Sanitary Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	14	0.0%	10	0.0%				0.0000	<0.0051	<0.004
			123-91-1	1,4-Dioxane	14	0.0%	14	0.0%				0.0000	<0.071	<0.071
			335-67-1	Perfluorooctanoic acid (PFOA)	15	20.0%	10	10.0%	0.0102	0.0060	0.0131	0.0068	<0.006	<0.006
			375-22-4	Perfluorobutanoic acid (PFBA)	15	20.0%	10	20.0%	0.0152	0.0110	0.0176	0.0118	<0.003	<0.003
			45187-15-3	Perfluorobutanesulfonate (PFBS)	14	0.0%	10	0.0%				0.0000	<0.0051	<0.0049
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	15	26.7%	10	10.0%	0.0394	0.0178	0.0570	0.0236	<0.007	<0.007
SW-72	Closed Landfill	Pine Lane Sanitary Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	2	0.0%	2	0.0%				0.0000	<0.006	<0.006
			123-91-1	1,4-Dioxane	18	50.0%	8	50.0%	1.7030	0.0770	8.0000	0.8900	0.0770	0.89
			335-67-1	Perfluorooctanoic acid (PFOA)	2	50.0%	2	50.0%	0.0080	0.0080	0.0080	0.0080	0.0080	0.008
			375-22-4	Perfluorobutanoic acid (PFBA)	2	100.0%	2	100.0%	0.0515	0.0300	0.0730	0.0515	0.0515	0.0515
			45187-15-3	Perfluorobutanesulfonate (PFBS)	2	0.0%	2	0.0%				0.0000	<0.008	<0.008
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	2	0.0%	2	0.0%				0.0000	<0.005	<0.005
SW-73	Closed Landfill	Iron Range Sanitary Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	3	33.3%	3	33.3%	0.0090	0.0090	0.0090	0.0090	<0.004	<0.004
			123-91-1	1,4-Dioxane	10	30.0%	6	16.7%	5.4000	4.4000	7.0000	4.7000	<0.36	<0.36
			335-67-1	Perfluorooctanoic acid (PFOA)	3	33.3%	3	33.3%	0.0230	0.0230	0.0230	0.0230	<0.005	<0.005
			375-22-4	Perfluorobutanoic acid (PFBA)	3	33.3%	3	33.3%	0.0110	0.0110	0.0110	0.0110	<0.003	<0.003
			45187-15-3	Perfluorobutanesulfonate (PFBS)	3	0.0%	3	0.0%				0.0000	<0.005	<0.005
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	3	0.0%	3	0.0%				0.0000	<0.007	<0.007
SW-74	Operating MSW	Elk River Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	8	12.5%	4	25.0%	0.0067	0.0067	0.0067	0.0067	<0.0082	<0.0082
			335-67-1	Perfluorooctanoic acid (PFOA)	8	37.5%	4	50.0%	0.0089	0.0046	0.0164	0.0062	0.0046	0.0046
			375-22-4	Perfluorobutanoic acid (PFBA)	8	87.5%	4	100.0%	0.0504	0.0033	0.0958	0.0445	0.0390	0.0445
			45187-15-3	Perfluorobutanesulfonate (PFBS)	8	0.0%	4	0.0%				0.0000	<0.0082	<0.0049
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	8	0.0%	4	0.0%				0.0000	<0.0082	<0.0049
SW-76	Closed Landfill	Gofer Sanitary Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	33	72.7%	12	50.0%	1.8434	0.0073	11.0000	1.3427	0.0490	**1.3427**
			123-91-1	1,4-Dioxane	14	57.1%	9	44.4%	3.6150	0.3700	7.6200	2.2243	0.4000	**2.2243**
			335-67-1	Perfluorooctanoic acid (PFOA)	33	75.8%	12	58.3%	7.2646	0.0158	47.0000	5.5073	0.8800	**5.5073**
			375-22-4	Perfluorobutanoic acid (PFBA)	33	66.7%	12	50.0%	0.5740	0.0047	1.7000	0.3842	0.1900	0.3842
			45187-15-3	Perfluorobutanesulfonate (PFBS)	33	69.7%	12	50.0%	1.5413	0.0090	9.7000	1.0769	0.1700	1.0769
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	31	58.1%	12	41.7%	2.5705	0.0053	20.0000	1.4949	<0.051	**1.4949**

all concentrations in µg/L
pink shading indicates method used to determine measure of central tendency
bold indicates measure of central tendenncy above MN drinking water guidance

Table A-1 (continued)
Summary Statistics Regulated PFAS and 1,4-Dioxane

Facility Code	Facility Type	Facility Name	CAS RN	Chemical Name	Total Sample Count	% Detect	Number of Sampled Wells	% Well Detect	Arthmetic Mean of Detects	Minimum Detect	Maximum Detect	Kaplan Meier Mean	Median of Detects and Non-Detects	Measure of Central Tendency
SW-77	Closed Landfill	Rock County Sanitary Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	4	0.0%	4	0.0%				0.0000	<0.0049	<0.0049
			123-91-1	1,4-Dioxane	10	10.0%	10	10.0%	0.9500	0.9500	0.9500	0.9500	<0.071	<0.071
			335-67-1	Perfluorooctanoic acid (PFOA)	4	0.0%	4	0.0%				0.0000	<0.0025	<0.0025
			375-22-4	Perfluorobutanoic acid (PFBA)	6	66.7%	4	50.0%	0.0061	0.0036	0.0093	0.0053	0.0039	0.0053
			45187-15-3	Perfluorobutanesulfonate (PFBS)	4	0.0%	4	0.0%				0.0000	<0.0049	<0.0049
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	4	0.0%	4	0.0%				0.0000	<0.0049	<0.0049
SW-79	Operating MSW	Kandiyohi County Sanitary Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	12	25.0%	2	50.0%	0.0379	0.0228	0.0542	0.0266	<0.0051	<0.0051
			335-67-1	Perfluorooctanoic acid (PFOA)	12	8.3%	2	50.0%	0.0030	0.0030	0.0030	0.0030	<0.0025	<0.0025
			375-22-4	Perfluorobutanoic acid (PFBA)	12	75.0%	2	100.0%	0.0182	0.0038	0.0689	0.0146	0.0072	0.0146
			45187-15-3	Perfluorobutanesulfonate (PFBS)	12	25.0%	2	50.0%	0.0840	0.0175	0.1670	0.0341	<0.0051	<0.0051
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	12	25.0%	2	50.0%	0.0112	0.0084	0.0147	0.0091	<0.005	<0.005
SW-8	Closed Landfill	Johnson Bros./Lochness Park Sanitary Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	45	28.9%	14	50.0%	0.0051	0.0049	0.0052	0.0050	0.0051	0.0051
			123-91-1	1,4-Dioxane	40	22.5%	14	21.4%	0.5737	0.0630	1.1000	0.1779	<0.03	<0.03
			335-67-1	Perfluorooctanoic acid (PFOA)	52	36.5%	14	57.1%	0.0133	0.0025	0.0330	0.0083	0.0098	0.0098
			375-22-4	Perfluorobutanoic acid (PFBA)	45	77.8%	14	85.7%	0.0699	0.0044	0.3000	0.0624	0.0717	0.0624
			45187-15-3	Perfluorobutanesulfonate (PFBS)	45	28.9%	14	50.0%	0.0051	0.0049	0.0052	0.0050	<0.0051	<0.0051
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	52	26.9%	14	50.0%	0.0052	0.0049	0.0061	0.0051	0.0061	0.0061
SW-82	Closed Landfill	Mille Lacs Sanitary Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	13	0.0%	8	0.0%				0.0000	<0.006	<0.004
			123-91-1	1,4-Dioxane	76	21.1%	21	33.3%	1.7226	0.0620	3.7000	0.4116	<0.22	<0.22
			335-67-1	Perfluorooctanoic acid (PFOA)	13	15.4%	8	25.0%	0.0079	0.0028	0.0130	0.0036	<0.006	<0.006
			375-22-4	Perfluorobutanoic acid (PFBA)	13	69.2%	8	75.0%	0.0101	0.0030	0.0185	0.0080	0.0080	0.008
			45187-15-3	Perfluorobutanesulfonate (PFBS)	13	0.0%	8	0.0%				0.0000	<0.008	<0.005
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	13	0.0%	8	0.0%				0.0000	<0.005	<0.005
SW-83	Closed Landfill	Redwood County Sanitary Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	4	0.0%	4	0.0%				0.0000	<0.005	<0.0049
			123-91-1	1,4-Dioxane	8	25.0%	7	14.3%	0.7850	0.6100	0.9600	0.6538	<0.071	<0.071
			335-67-1	Perfluorooctanoic acid (PFOA)	5	40.0%	4	25.0%	0.0086	0.0077	0.0095	0.0081	<0.0025	<0.0025
			375-22-4	Perfluorobutanoic acid (PFBA)	6	66.7%	4	50.0%	0.0086	0.0057	0.0122	0.0076	0.0069	0.0076
			45187-15-3	Perfluorobutanesulfonate (PFBS)	4	0.0%	4	0.0%				0.0000	<0.005	<0.0049
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	4	0.0%	4	0.0%				0.0000	<0.005	<0.0049
SW-85	Closed Landfill	Albert Lea Sanitary Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	7	14.3%	6	16.7%	0.0120	0.0120	0.0120	0.0120	<0.006	<0.006
			123-91-1	1,4-Dioxane	33	63.6%	15	60.0%	5.7595	0.2500	20.1200	3.7561	0.5200	**3.7561**
			335-67-1	Perfluorooctanoic acid (PFOA)	7	14.3%	6	16.7%	0.0330	0.0330	0.0330	0.0330	<0.006	<0.006
			375-22-4	Perfluorobutanoic acid (PFBA)	7	85.7%	6	100.0%	0.0243	0.0110	0.0430	0.0224	0.0180	0.0224
			45187-15-3	Perfluorobutanesulfonate (PFBS)	7	14.3%	6	16.7%	0.0120	0.0120	0.0120	0.0120	<0.008	<0.008
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	7	0.0%	6	0.0%				0.0000	<0.005	<0.005
SW-91	Closed Landfill	Sun Prairie Sanitary Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	9	22.2%	7	14.3%	0.0542	0.0399	0.0684	0.0431	<0.013	<0.013
			123-91-1	1,4-Dioxane	8	25.0%	6	16.7%	1.4650	1.2500	1.6800	1.3038	<0.071	<0.071
			335-67-1	Perfluorooctanoic acid (PFOA)	9	33.3%	7	14.3%	0.0690	0.0606	0.0750	0.0634	<0.012	<0.012
			375-22-4	Perfluorobutanoic acid (PFBA)	9	33.3%	7	14.3%	0.0347	0.0306	0.0380	0.0320	<0.008	<0.008
			45187-15-3	Perfluorobutanesulfonate (PFBS)	9	33.3%	7	14.3%	0.0960	0.0660	0.1160	0.0760	<0.009	<0.009
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	9	22.2%	7	14.3%	0.0197	0.0081	0.0312	0.0107	<0.007	<0.007
SW-94	Closed Landfill	Anoka Municipal Regional Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	36	11.1%	21	14.3%	0.0106	0.0053	0.0140	0.0062	<0.006	<0.006
			123-91-1	1,4-Dioxane	170	82.9%	44	75.0%	7.5943	0.0620	49.0000	6.3094	4.6000	**6.3094**
			335-67-1	Perfluorooctanoic acid (PFOA)	40	62.5%	21	76.2%	0.0591	0.0220	0.1600	0.0531	0.0585	**0.0531**
			375-22-4	Perfluorobutanoic acid (PFBA)	36	88.9%	21	85.7%	0.1458	0.0170	0.3500	0.1408	0.1370	0.1408
			45187-15-3	Perfluorobutanesulfonate (PFBS)	36	13.9%	21	23.8%	0.0065	0.0050	0.0080	0.0053	<0.008	<0.008
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	40	7.5%	21	14.3%	0.0089	0.0068	0.0130	0.0071	<0.007	<0.007
SW-99	Closed Landfill	Becker County Sanitary Landfill	108427-53-8	Perfluorohexane sulfonate (PFHxS)	5	0.0%	5	0.0%				0.0000	<0.013	<0.013
			123-91-1	1,4-Dioxane	167	7.8%	49	20.4%	0.1853	0.0470	0.6600	0.0721	<0.22	<0.22
			335-67-1	Perfluorooctanoic acid (PFOA)	5	0.0%	5	0.0%				0.0000	<0.012	<0.012
			375-22-4	Perfluorobutanoic acid (PFBA)	5	60.0%	5	60.0%	0.0093	0.0080	0.0110	0.0088	0.0080	0.0088
			45187-15-3	Perfluorobutanesulfonate (PFBS)	5	0.0%	5	0.0%				0.0000	<0.009	<0.009
			45298-90-6	Perfluorooctane sulfonic acid (PFOS)	5	0.0%	5	0.0%				0.0000	<0.007	<0.007
SW-108	Closed Landfill	Benson Sanitary Landfill	123-91-1	1,4-Dioxane	11	9.1%	6	16.7%	0.3300	0.3300	0.3300	0.3300	<0.071	<0.071
			335-67-1	Perfluorooctanoic acid (PFOA)	2	100.0%	2	100.0%	0.0123	0.0033	0.0212	0.0123	0.0123	0.0123
			375-22-4	Perfluorobutanoic acid (PFBA)	2	100.0%	2	100.0%	0.0145	0.0031	0.0258	0.0145	0.0145	0.0145

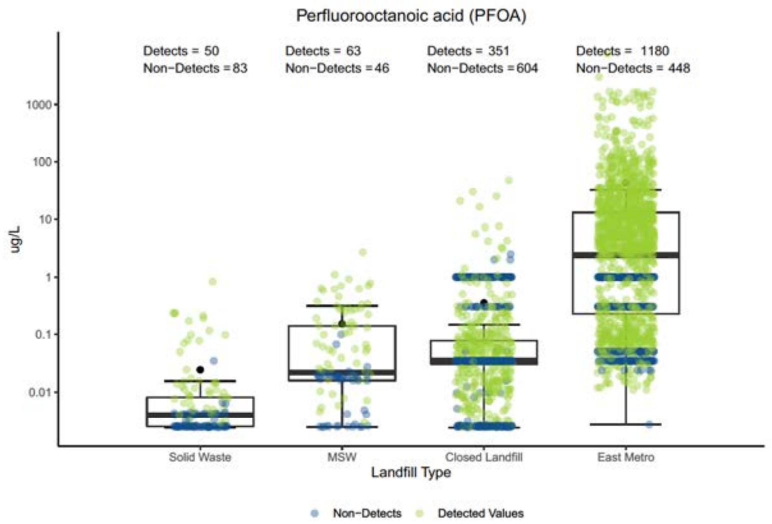
all concentrations in µg/L
pink shading indicates method used to determine measure of central tendency
bold indicates measure of central tendenncy above MN drinking water guidance

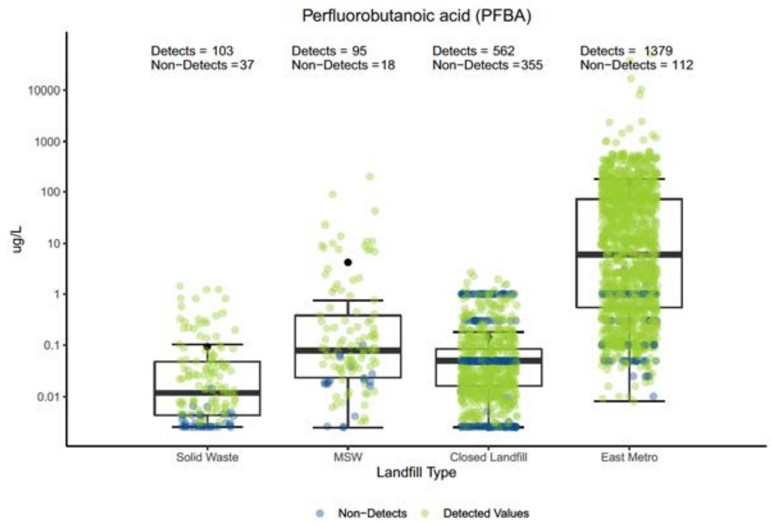
Facility Code	Facility Type	Facility Name	CAS RN	Chemical Name	Total Sample Count	% Detect	Number of Sampled Wells	% Well Detect	Arthmetic Mean of Detects	Minimum Detect	Maximum Detect	Kaplan Meier Mean	Median of Detects and Non-Detects	Measure of Central Tendency
SW-116	Closed Landfill	Sauk Centre Sanitary Landfill	123-91-1	1,4-Dioxane	34	26.5%	11	36.4%	0.6411	0.1100	1.6000	0.2506	<0.071	<0.071
SW-122	Closed Landfill	Mahnomen Sanitary Landfill	123-91-1	1,4-Dioxane	12	0.0%	6	0.0%				0.0000	<0.22	<0.031
SW-128	Closed Landfill	Hudson Sanitary Landfill	123-91-1	1,4-Dioxane	23	39.1%	12	25.0%	3.6889	1.1000	11.0000	2.1130	<0.22	<0.22
SW-130	Closed Landfill	Pickett Sanitary Landfill	123-91-1	1,4-Dioxane	47	12.8%	26	15.4%	0.5627	0.0960	1.1000	0.1556	<0.22	<0.22
SW-140	Closed Landfill	Lake County Sanitary Landfill	123-91-1	1,4-Dioxane	11	0.0%	11	0.0%				0.0000	<0.22	<0.22
SW-146	Closed Landfill	Leech Lake Sanitary Landfill	123-91-1	1,4-Dioxane	8	37.5%	6	16.7%	1.7667	1.7000	1.8000	1.7250	<0.36	<0.36
SW-150	Closed Landfill	Hickory Grove Sanitary Landfill	123-91-1	1,4-Dioxane	16	37.5%	7	71.4%	8.8750	0.2500	15.0000	3.4844	<0.22	<0.22
SW-163	Closed Landfill	Brookston Sanitary Landfill	123-91-1	1,4-Dioxane	7	14.3%	7	14.3%	0.7500	0.7500	0.7500	0.7500	<0.22	<0.22
SW-164	Closed Landfill	Floodwood Sanitary Landfill	123-91-1	1,4-Dioxane	9	0.0%	9	0.0%				0.0000	<0.22	<0.22
SW-169	Closed Landfill	Longville Remer Landfill	123-91-1	1,4-Dioxane	8	0.0%	8	0.0%				0.0000	<0.22	<0.22
SW-171	Closed Landfill	Lake Of The Woods Sanitary Landfill	123-91-1	1,4-Dioxane	19	26.3%	10	40.0%	1.8250	0.0950	5.9000	0.5503	<0.22	<0.22
SW-172	Closed Landfill	Paynesville Sanitary Landfill	123-91-1	1,4-Dioxane	33	33.3%	18	27.8%	2.2100	0.4400	3.9900	1.0300	<0.071	<0.071
SW-177	Closed Landfill	Vermillion Modified Sanitary Landfill	123-91-1	1,4-Dioxane	10	0.0%	5	0.0%				0.0000	<0.46	<0.36
SW-225	Closed Landfill	Northome Sanitary Landfill	123-91-1	1,4-Dioxane	6	0.0%	6	0.0%				0.0000	<0.36	<0.36
SW-236	Closed Landfill	Northwest Angle Modified Sanitary LF	123-91-1	1,4-Dioxane	3	0.0%	3	0.0%				0.0000	<0.22	<0.22
SW-243	Closed Landfill	Fifty Lakes Modified Landfill	123-91-1	1,4-Dioxane	6	0.0%	6	0.0%				0.0000	<0.22	<0.016
SW-294	Closed Landfill	Cook County Sanitary Landfill	123-91-1	1,4-Dioxane	19	0.0%	10	0.0%				0.0000	<0.46	<0.22
SW-311	Other Solid Waste	Becker County Demolition Landfill	123-91-1	1,4-Dioxane	6	0.0%	3	0.0%				0.0000	<0.22	<0.22
SW-38	Closed Landfill	Hoyt Lakes Sanitary Landfill	123-91-1	1,4-Dioxane	7	0.0%	5	0.0%				0.0000	<0.36	<0.36
SW-39	Closed Landfill	Long Prairie Sanitary Landfill	123-91-1	1,4-Dioxane	30	20.0%	11	18.2%	0.6900	0.1700	1.4000	0.2740	<0.22	<0.22
SW-575	Closed Landfill	Land Investors Landfill	123-91-1	1,4-Dioxane	10	30.0%	4	25.0%	0.6167	0.4500	0.8100	0.5000	<0.22	<0.22
SW-66	Closed Landfill	Stevens County Sanitary Landfill	123-91-1	1,4-Dioxane	39	38.5%	11	36.4%	0.5880	0.2000	1.7500	0.3492	<0.071	<0.071
SW-69	Closed Landfill	Faribault County Sanitary Landfill	123-91-1	1,4-Dioxane	9	33.3%	7	14.3%	21.5700	14.5700	32.1000	16.9033	<0.071	<0.071
SW-78	Closed Landfill	Killian Sanitary Landfill	123-91-1	1,4-Dioxane	30	16.7%	13	15.4%	5.2660	0.6300	9.0000	1.4027	<0.22	<0.22
SW-81	Closed Landfill	Watonwan County Sanitary Landfill	123-91-1	1,4-Dioxane	3	0.0%	3	0.0%				0.0000	<0.071	<0.071
SW-86	Closed Landfill	Battle Lake Sanitary Landfill	123-91-1	1,4-Dioxane	30	16.7%	13	23.1%	0.4188	0.0640	0.9200	0.1231	<0.22	<0.22
SW-96	Closed Landfill	Big Stone County Sanitary Landfill	123-91-1	1,4-Dioxane	12	41.7%	10	30.0%	0.5360	0.3200	0.6900	0.4100	<0.071	<0.071
SW-97	Closed Landfill	East Mesaba Sanitary Landfill	123-91-1	1,4-Dioxane	27	18.5%	13	23.1%	1.1380	0.2900	2.3000	0.4470	<0.36	<0.36

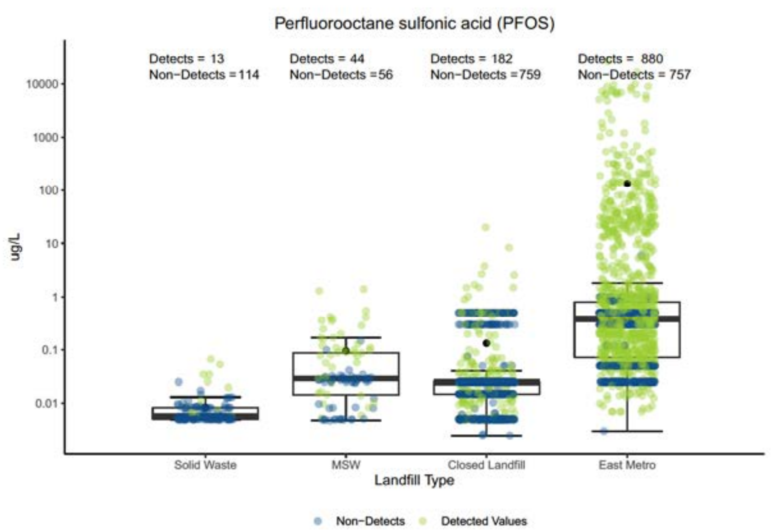
all concentrations in µg/L
pink shading indicates method used to determine measure of central tendency
bold indicates measure of central tendenncy above MN drinking water guidance

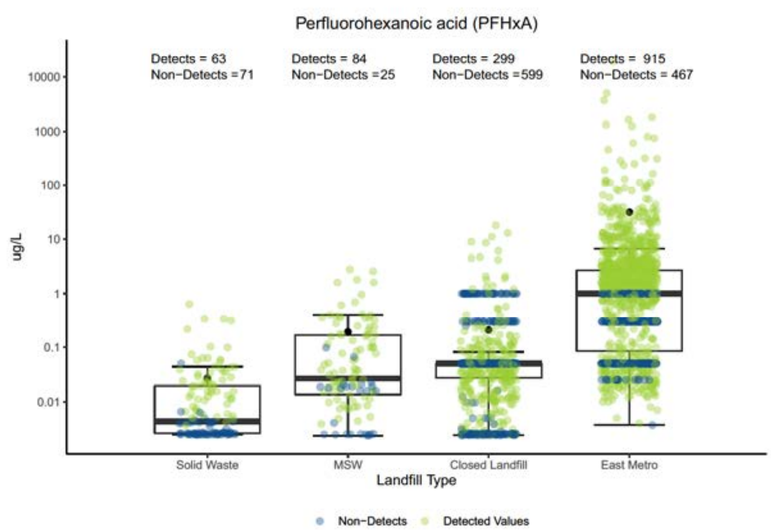
Appendix B

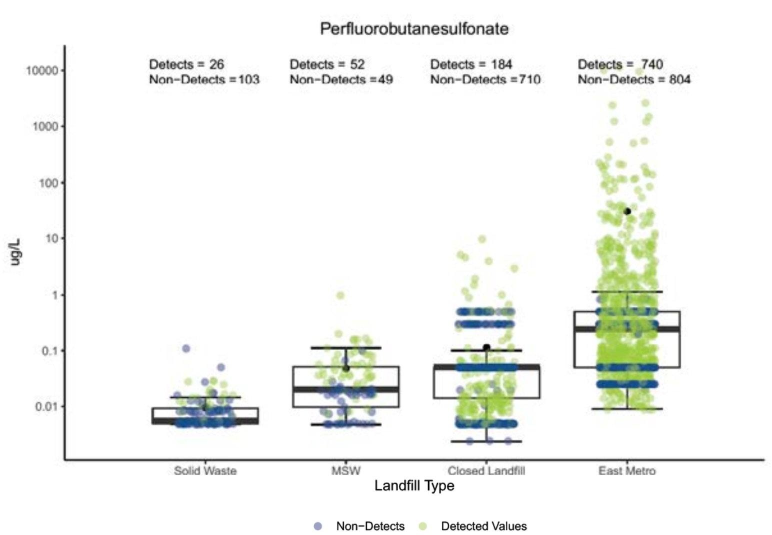
Box-and-Whiskers Plots of Raw Data

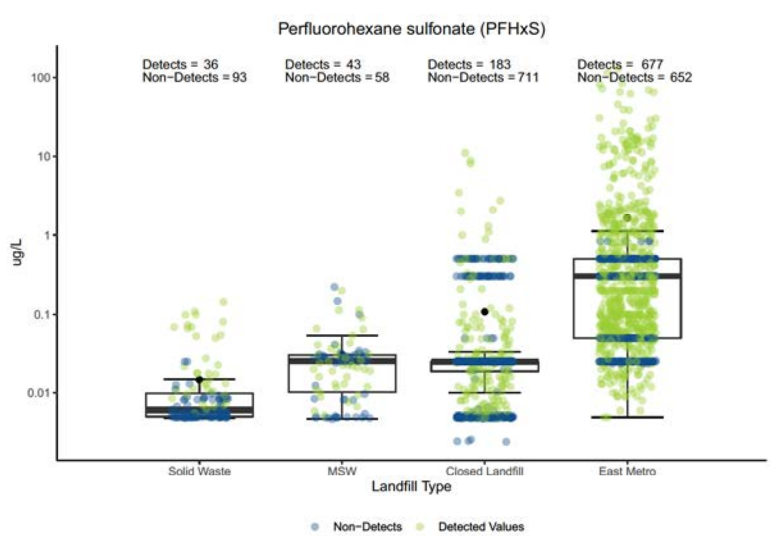

Perfluorooctanoic acid (PFOA)
Detects = 50
Non-Detects = 83
Detects = 63
Non-Detects = 46
Detects = 351
Non-Detects = 604
Detects = 1180
Non-Detects = 448
ug/L
1000
100
10
1
0.1
0.01
Solid Waste
MSW
Closed Landfill
East Metro
Landfill Type
Non-Detects
Detected Values

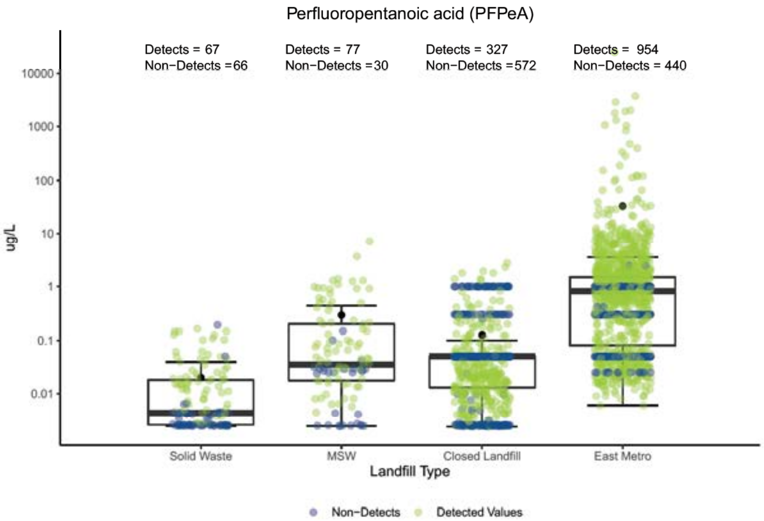

Perfluorobutanoic acid (PFBA)
Detects = 103
Non-Detects = 37
Detects = 95
Non-Detects = 18
Detects = 562
Non-Detects = 355
Detects = 1379
Non-Detects = 112
ug/L
10000
1000
100
10
1
0.1
0.01
Solid Waste
MSW
Closed Landfill
East Metro
Landfill Type
Non-Detects
Detected Values

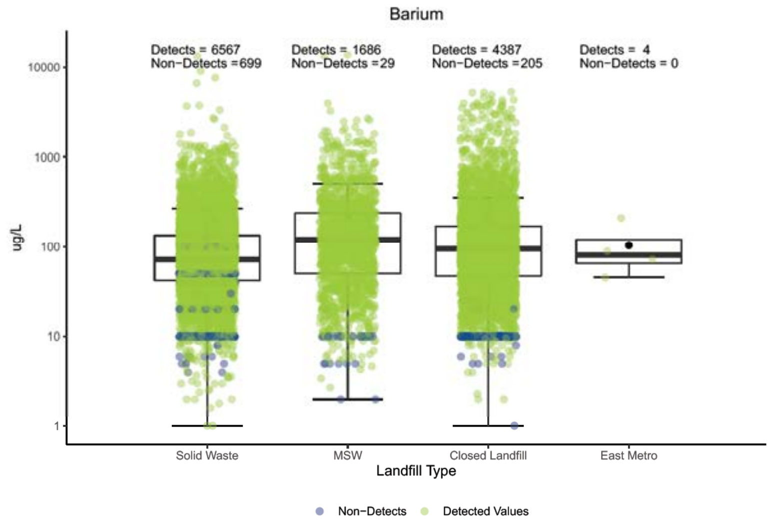

Perfluorooctane sulfonic acid (PFOS)
Detects = 13
Non-Detects = 114
Detects = 44
Non-Detects = 56
Detects = 182
Non-Detects = 759
Detects = 880
Non-Detects = 757
ug/L
10000
1000
100
10
1
0.1
0.01
Solid Waste
MSW
Closed Landfill
East Metro
Landfill Type
Non-Detects
Detected Values

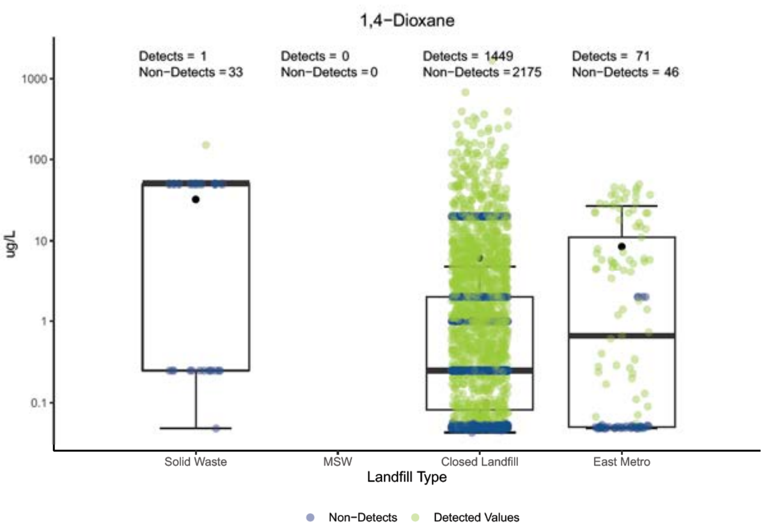

Perfluorohexanoic acid (PFHxA)
Detects = 63
Non-Detects = 71
Detects = 84
Non-Detects = 25
Detects = 299
Non-Detects = 599
Detects = 915
Non-Detects = 467
ug/L
10000
1000
100
10
1
0.1
0.01
Solid Waste
MSW
Closed Landfill
East Metro
Landfill Type
Non-Detects
Detected Values

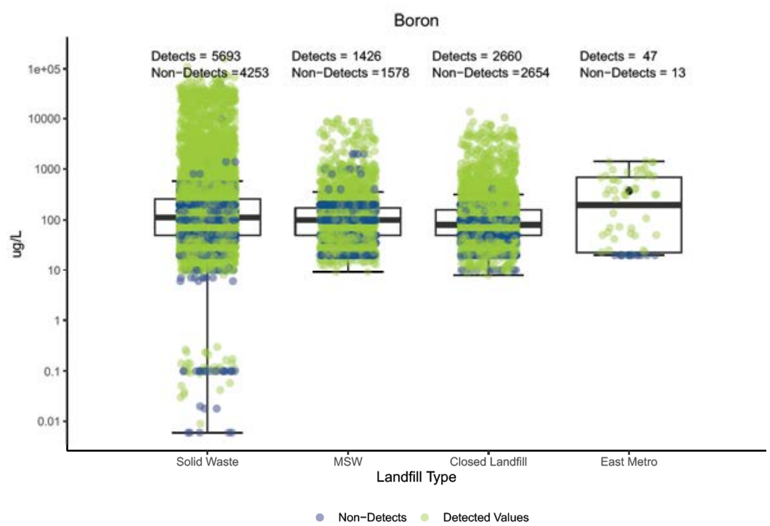

Perfluorobutanesulfonate
Detects = 26
Non-Detects = 103
Detects = 52
Non-Detects = 49
Detects = 184
Non-Detects = 710
Detects = 740
Non-Detects = 804
ug/L
10000
1000
100
10
1
0.1
0.01
Solid Waste
MSW
Closed Landfill
East Metro
Landfill Type
Non-Detects
Detected Values

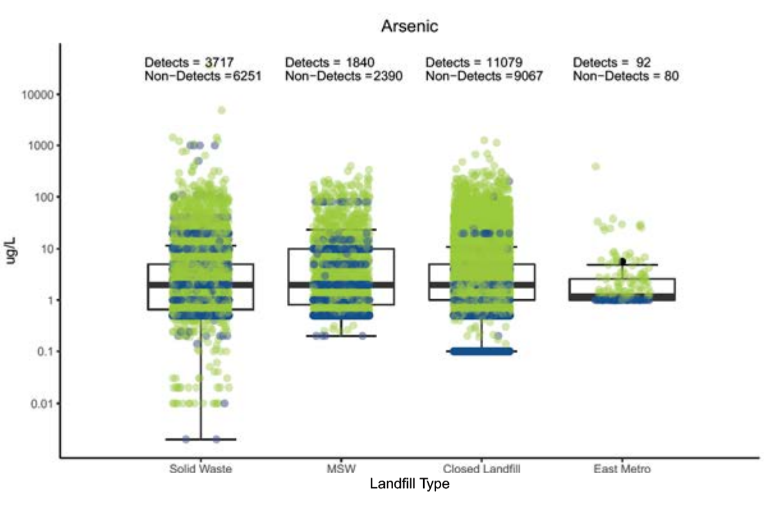

Perfluorohexane sulfonate (PFHxS)
Detects = 36
Non-Detects = 93
Detects = 43
Non-Detects = 58
Detects = 183
Non-Detects = 711
Detects = 677
Non-Detects = 652
ug/L
100
10
1
0.1
0.01
Solid Waste
MSW
Closed Landfill
East Metro
Landfill Type
Non-Detects
Detected Values

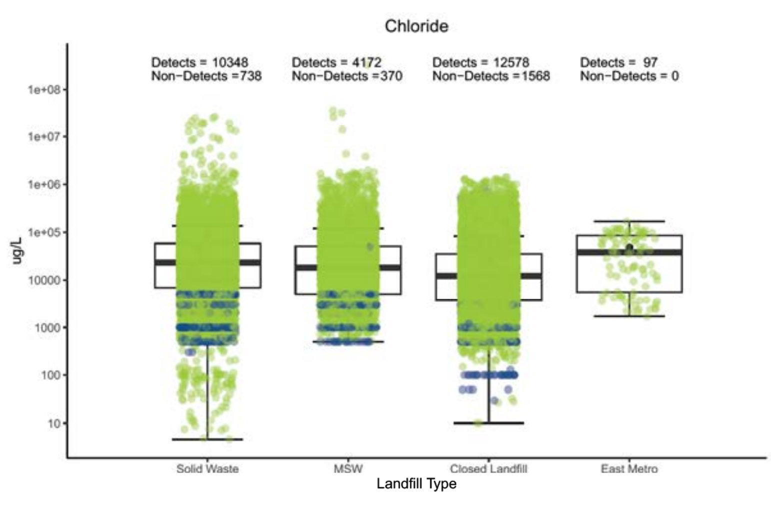

Perfluoropentanoic acid (PFPeA)
Detects = 67
Non-Detects =66
Detects = 77
Non-Detects =30
Detects = 327
Non-Detects =572
Detects = 954
Non-Detects = 440
ug/L
10000
1000
100
10
1
0.1
0.01
Solid Waste
MSW
Closed Landfill
East Metro
Landfill Type
Non-Detects
Detected Values

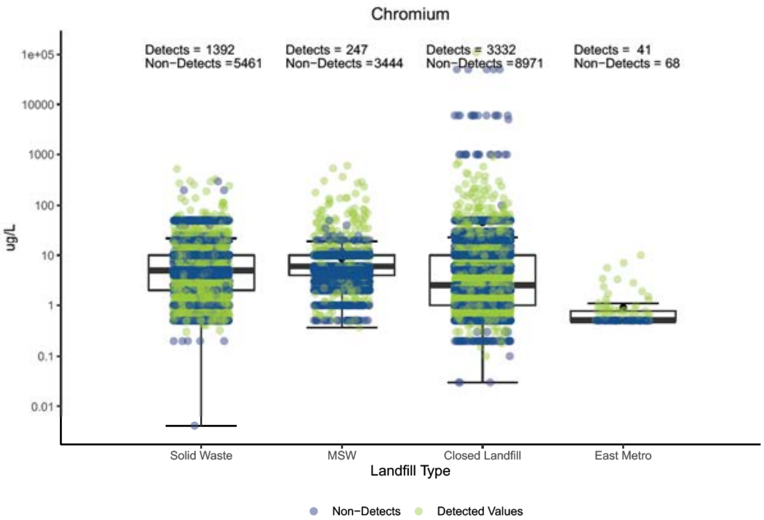

Barium
Detects = 6567
Non-Detects =699
Detects = 1686
Non-Detects =29
Detects = 4387
Non-Detects =205
Detects = 4
Non-Detects = 0
ug/L
10000
1000
100
10
1
Solid Waste
MSW
Closed Landfill
East Metro
Landfill Type
Non-Detects
Detected Values

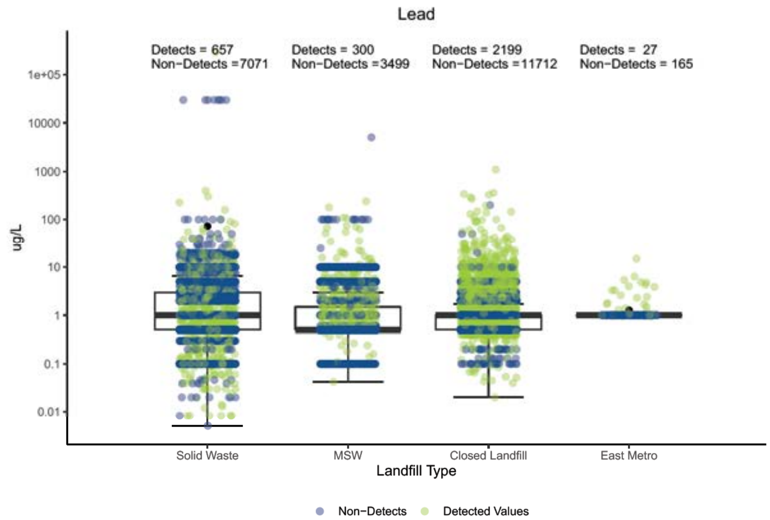

1,4-Dioxane
Detects = 1
Non-Detects = 33
Detects = 0
Non-Detects = 0
Detects = 1449
Non-Detects = 2175
Detects = 71
Non-Detects = 46
ug/L
1000
100
10
1
0.1
Solid Waste
MSW
Closed Landfill
East Metro
Landfill Type
Non-Detects
Detected Values

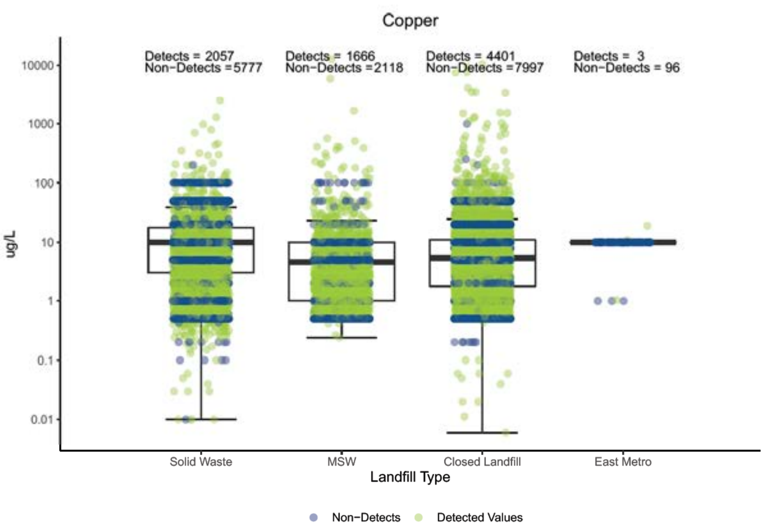

Boron
Detects = 5693
Non-Detects =4253
Detects = 1426
Non-Detects =1578
Detects = 2660
Non-Detects =2654
Detects = 47
Non-Detects = 13
ug/L
1e+05
10000
1000
100
10
1
0.1
0.01
Solid Waste
MSW
Closed Landfill
East Metro
Landfill Type
Non-Detects
Detected Values

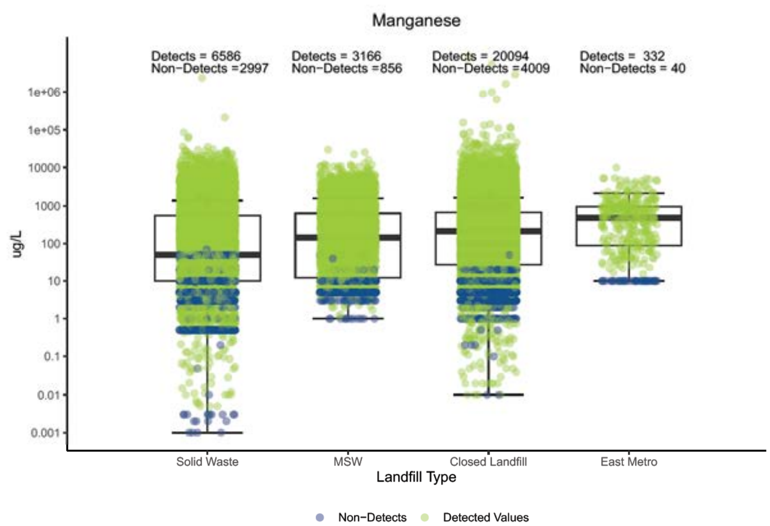

Arsenic
Detects = 3717
Non-Detects =6251
Detects = 1840
Non-Detects =2390
Detects = 11079
Non-Detects =9067
Detects = 92
Non-Detects = 80
ug/L
10000
1000
100
10
1
0.1
0.01
Solid Waste
MSW
Closed Landfill
East Metro
Landfill Type
Non-Detects
Detected Values

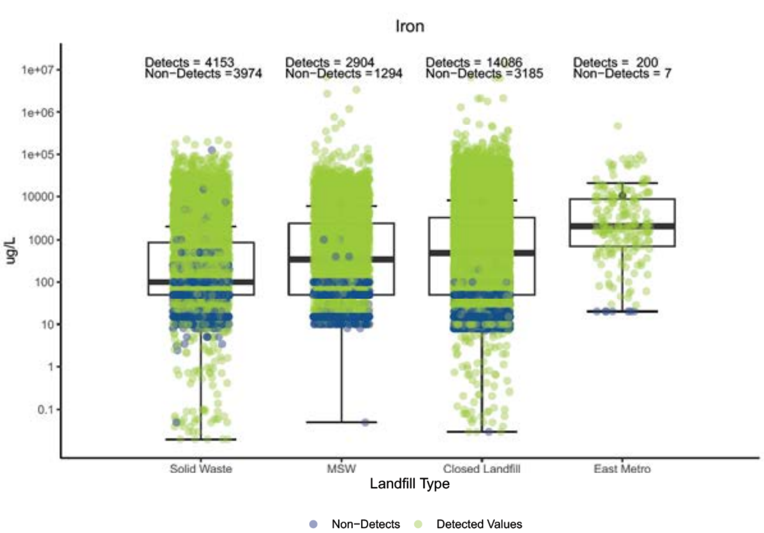

Chloride
Detects = 10348
Non-Detects =738
Detects = 4172
Non-Detects =370
Detects = 12578
Non-Detects =1568
Detects = 97
Non-Detects = 0
ug/L
1e+08
1e+07
1e+06
1e+05
10000
1000
100
10
Solid Waste
MSW
Closed Landfill
East Metro
Landfill Type
Non-Detects
Detected Values

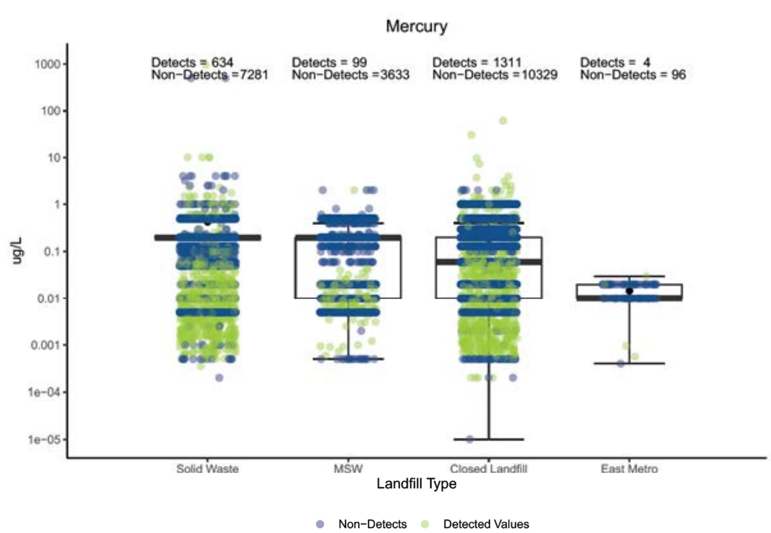

Chromium
Detects = 1392
Non-Detects =5461
Detects = 247
Non-Detects =3444
Detects = 3332
Non-Detects =8971
Detects = 41
Non-Detects = 68
ug/L
Solid Waste
MSW
Closed Landfill
East Metro
Landfill Type
Non−Detects
Detected Values

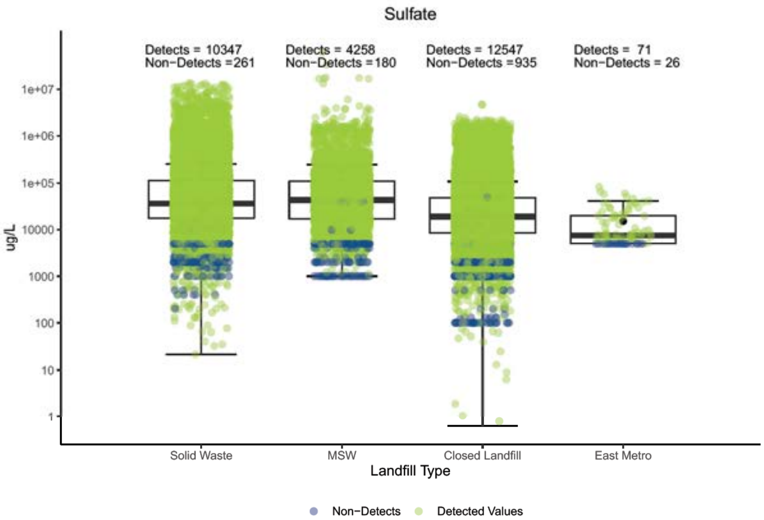

Lead
Detects = 657
Non-Detects =7071
Detects = 300
Non-Detects =3499
Detects = 2199
Non-Detects =11712
Detects = 27
Non-Detects = 165
ug/L
Solid Waste
MSW
Closed Landfill
East Metro
Landfill Type
Non−Detects
Detected Values

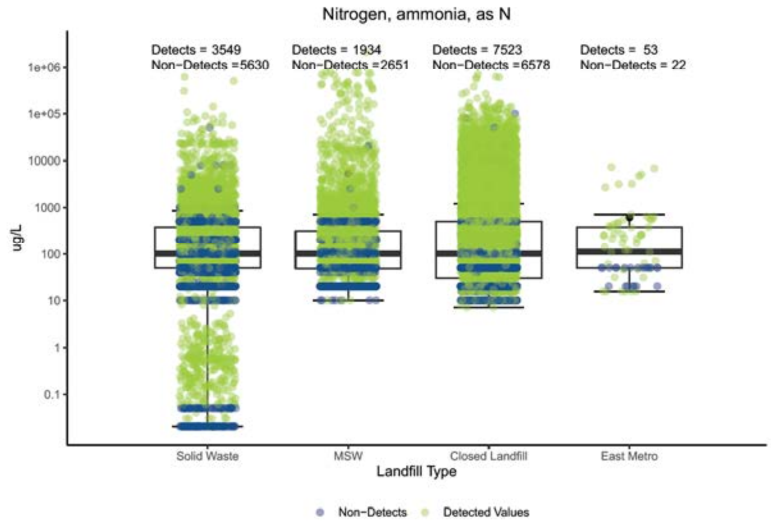

Copper
Detects = 2057
Non-Detects =5777
Detects = 1666
Non-Detects =2118
Detects = 4401
Non-Detects =7997
Detects = 3
Non-Detects = 96
ug/L
Solid Waste
MSW
Closed Landfill
East Metro
Landfill Type
Non−Detects
Detected Values

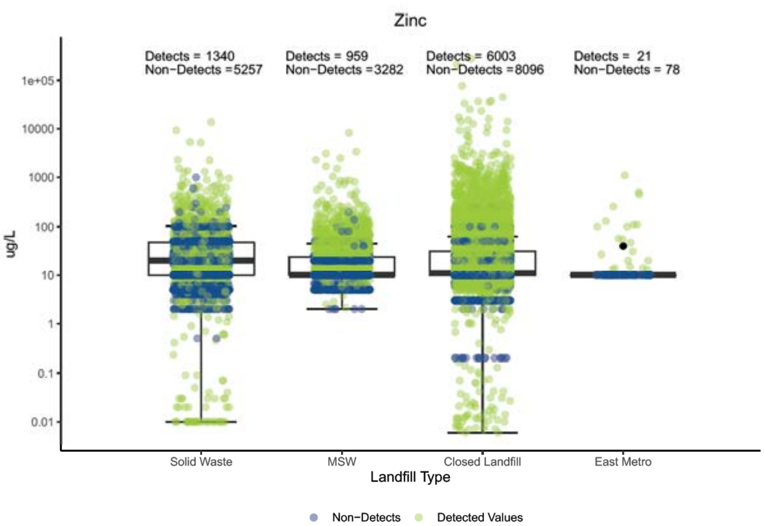

Manganese
Detects = 6586
Non-Detects =2997
Detects = 3166
Non-Detects =856
Detects = 20094
Non-Detects =4009
Detects = 332
Non-Detects = 40
ug/L
Solid Waste
MSW
Closed Landfill
East Metro
Landfill Type
Non−Detects
Detected Values

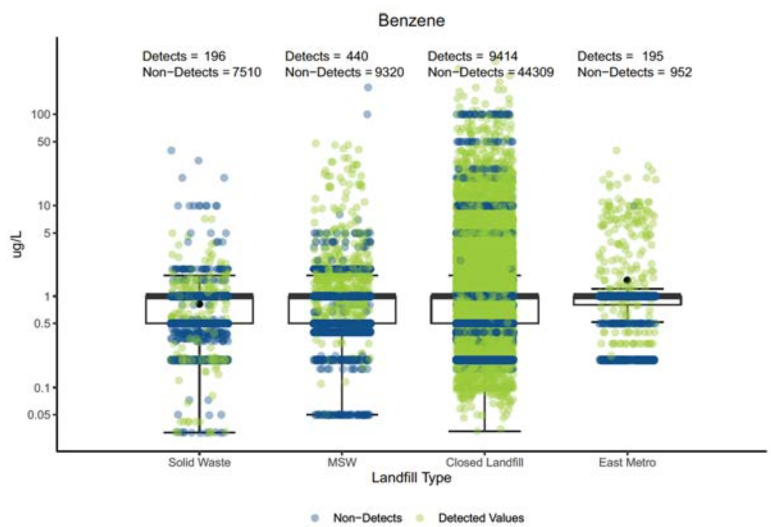

Iron
Detects = 4153
Non-Detects =3974
Detects = 2904
Non-Detects =1294
Detects = 14086
Non-Detects =3185
Detects = 200
Non-Detects = 7
ug/L
Solid Waste
MSW
Closed Landfill
East Metro
Landfill Type
Non−Detects
Detected Values

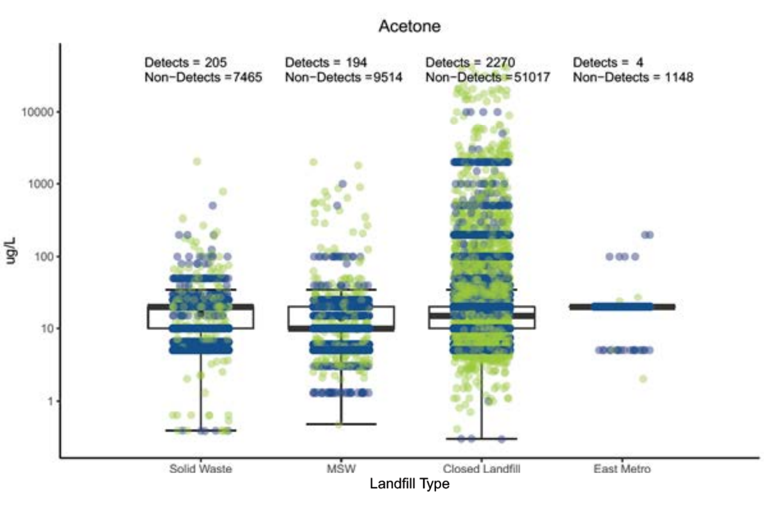

Mercury
Detects = 634
Non-Detects =7281
Detects = 99
Non-Detects =3633
Detects = 1311
Non-Detects =10329
Detects = 4
Non-Detects = 96
ug/L
Solid Waste
MSW
Closed Landfill
East Metro
Landfill Type
Non−Detects
Detected Values

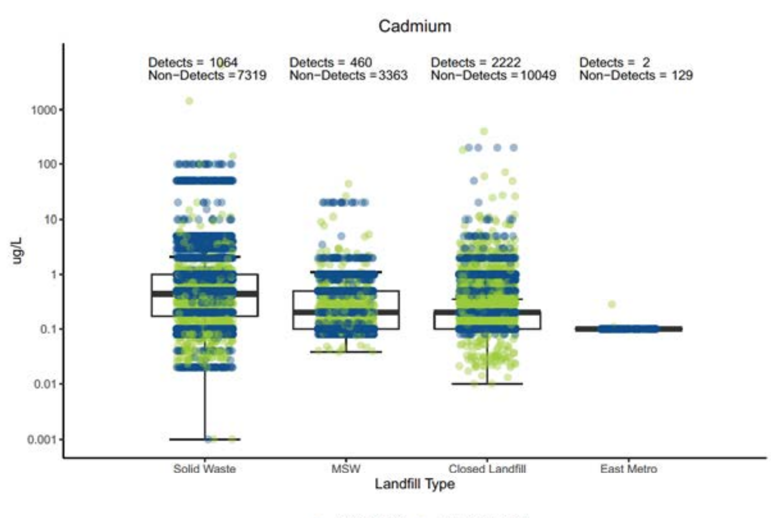

Sulfate
Detects = 10347
Non-Detects =261
Detects = 4258
Non-Detects =180
Detects = 12547
Non-Detects =935
Detects = 71
Non-Detects = 26
ug/L
Solid Waste
MSW
Closed Landfill
East Metro
Landfill Type
Non−Detects
Detected Values

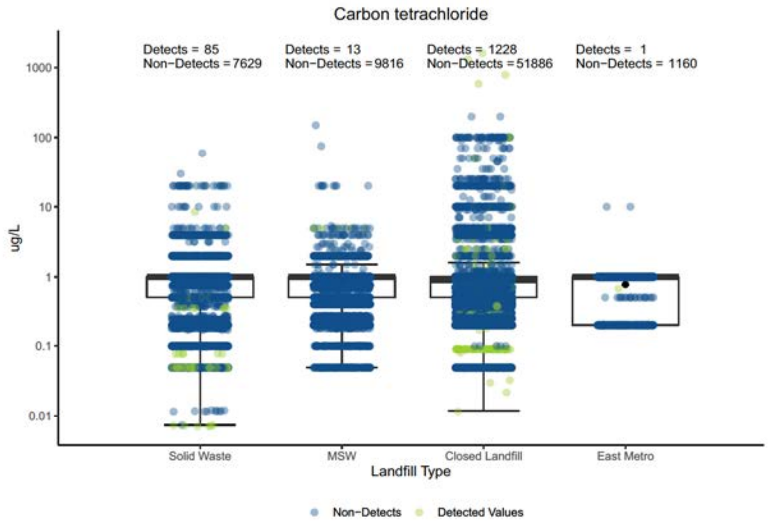

Nitrogen, ammonia, as N
Detects = 3549
Non-Detects =5630
Detects = 1934
Non-Detects =2651
Detects = 7523
Non-Detects =6578
Detects = 53
Non-Detects = 22
ug/L
Solid Waste
MSW
Closed Landfill
East Metro
Landfill Type
Non−Detects
Detected Values

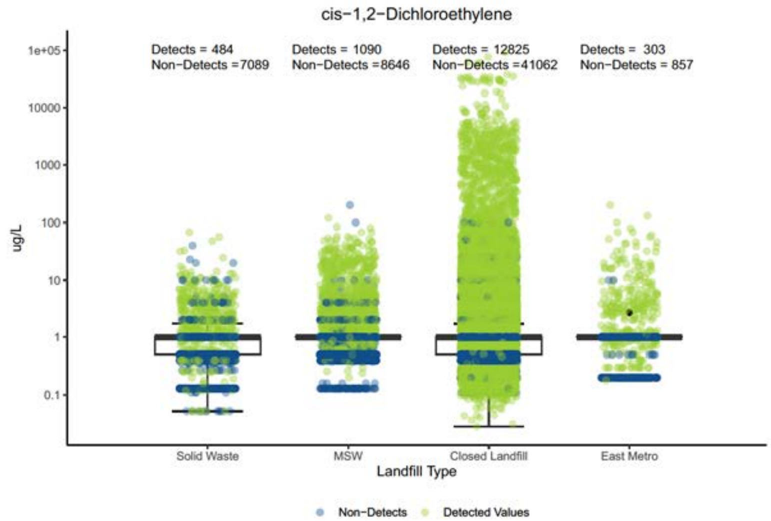

Zinc
Detects = 1340
Non-Detects =5257
Detects = 959
Non-Detects =3282
Detects = 6003
Non-Detects =8096
Detects = 21
Non-Detects = 78
ug/L
Solid Waste
MSW
Closed Landfill
East Metro
Landfill Type
Non−Detects
Detected Values

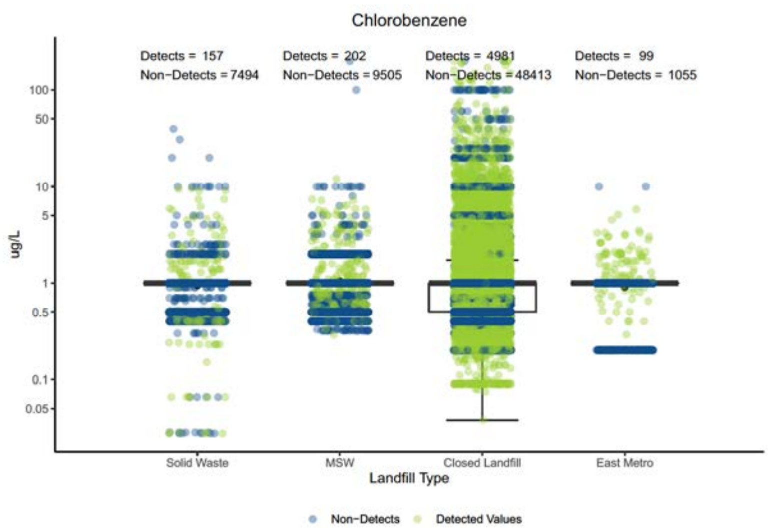

Benzene
Detects = 196
Non-Detects = 7510
Detects = 440
Non-Detects = 9320
Detects = 9414
Non-Detects = 44309
Detects = 195
Non-Detects = 952
ug/L
Solid Waste
MSW
Closed Landfill
East Metro
Landfill Type
Non−Detects
Detected Values

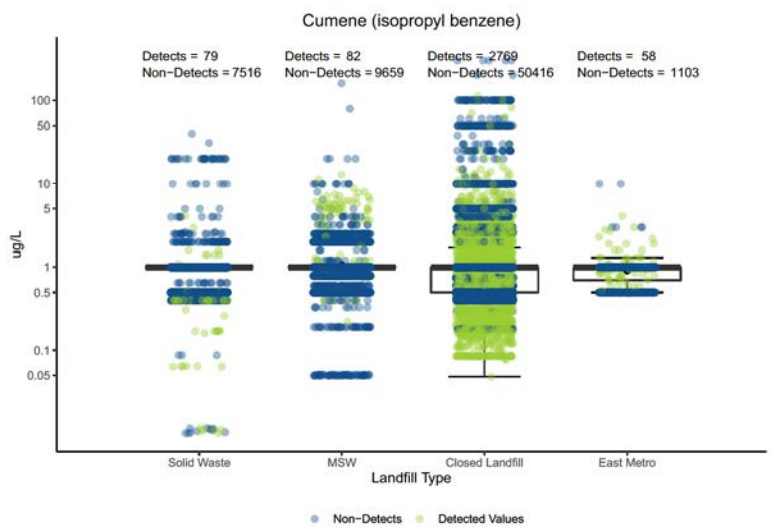

Acetone
Detects = 205
Non-Detects =7465
Detects = 194
Non-Detects =9514
Detects = 2270
Non-Detects =51017
Detects = 4
Non-Detects = 1148
ug/L
Solid Waste
MSW
Closed Landfill
East Metro
Landfill Type
Non−Detects
Detected Values

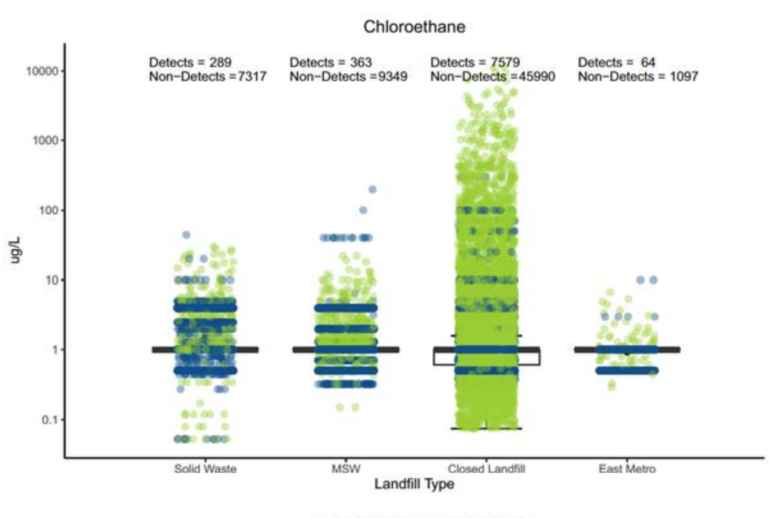

Cadmium
Detects = 1064
Non-Detects = 7319
Detects = 460
Non-Detects = 3363
Detects = 2222
Non-Detects = 10049
Detects = 2
Non-Detects = 129
ug/L
Solid Waste
MSW
Closed Landfill
East Metro
Landfill Type
Non−Detects
Detected Values

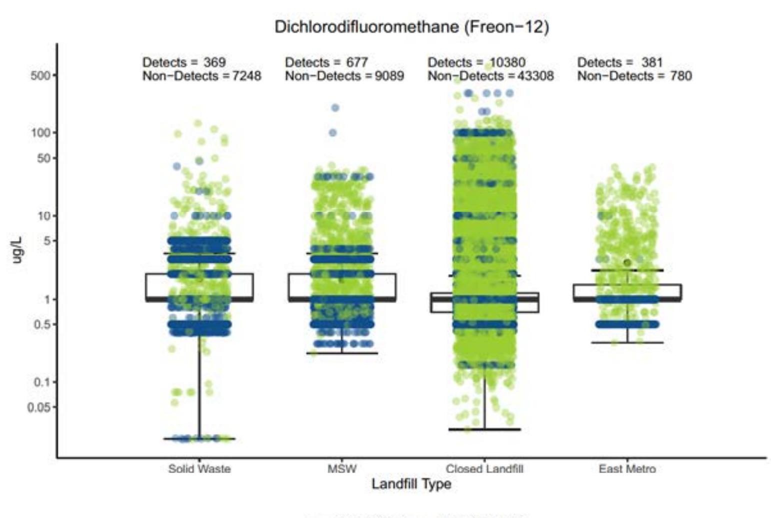

Carbon tetrachloride
Detects = 85
Non−Detects = 7629
Detects = 13
Non−Detects = 9816
Detects = 1228
Non−Detects = 51886
Detects = 1
Non−Detects = 1160
ug/L
Solid Waste
MSW
Closed Landfill
East Metro
Landfill Type
Non−Detects
Detected Values

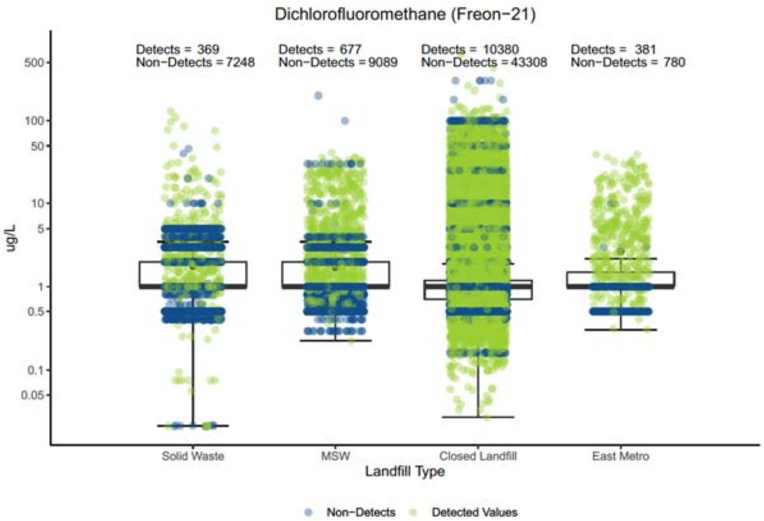

cis−1,2−Dichloroethylene
Detects = 484
Non−Detects = 7089
Detects = 1090
Non−Detects = 8646
Detects = 12825
Non−Detects = 41062
Detects = 303
Non−Detects = 857
ug/L
Solid Waste
MSW
Closed Landfill
East Metro
Landfill Type
Non−Detects
Detected Values

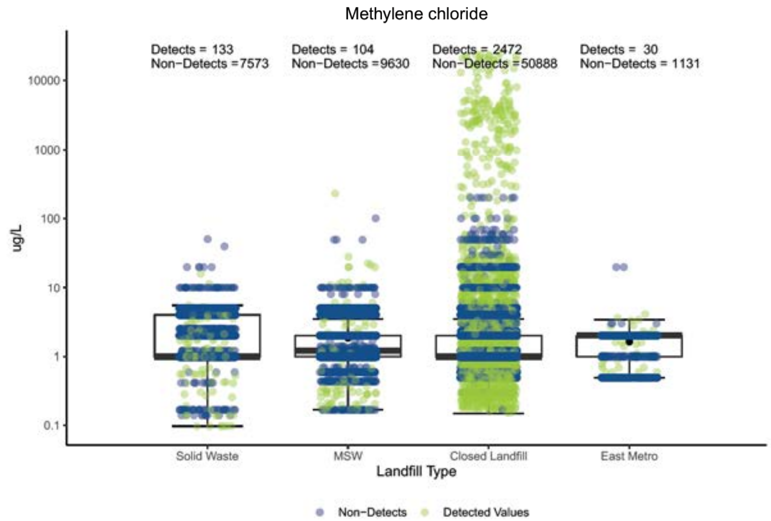

Chlorobenzene
Detects = 157
Non−Detects = 7494
Detects = 202
Non−Detects = 9505
Detects = 4981
Non−Detects = 48413
Detects = 99
Non−Detects = 1055
ug/L
Solid Waste
MSW
Closed Landfill
East Metro
Landfill Type
Non−Detects
Detected Values

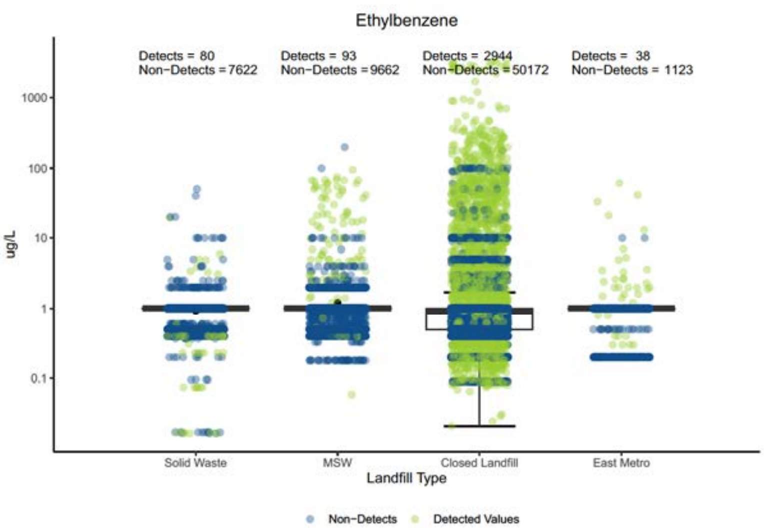

Cumene (isopropyl benzene)
Detects = 79
Non−Detects = 7516
Detects = 82
Non−Detects = 9659
Detects = 2769
Non−Detects = 50416
Detects = 58
Non−Detects = 1103
ug/L
Solid Waste
MSW
Closed Landfill
East Metro
Landfill Type
Non−Detects
Detected Values

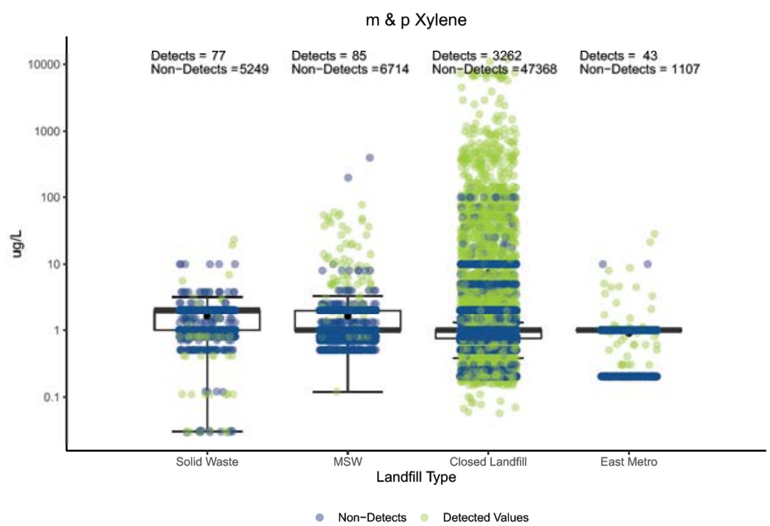

Chloroethane
Detects = 289
Non−Detects = 7317
Detects = 363
Non−Detects = 9349
Detects = 7579
Non−Detects = 45990
Detects = 64
Non−Detects = 1097
ug/L
Solid Waste
MSW
Closed Landfill
East Metro
Landfill Type
Non−Detects
Detected Values

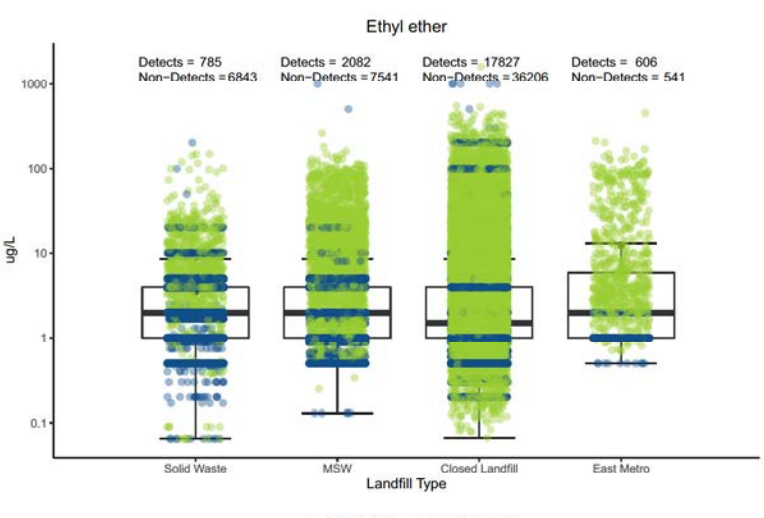

Dichlorodifluoromethane (Freon−12)
Detects = 369
Non−Detects = 7248
Detects = 677
Non−Detects = 9089
Detects = 10380
Non−Detects = 43308
Detects = 381
Non−Detects = 780
ug/L
Solid Waste
MSW
Closed Landfill
East Metro
Landfill Type
Non−Detects
Detected Values

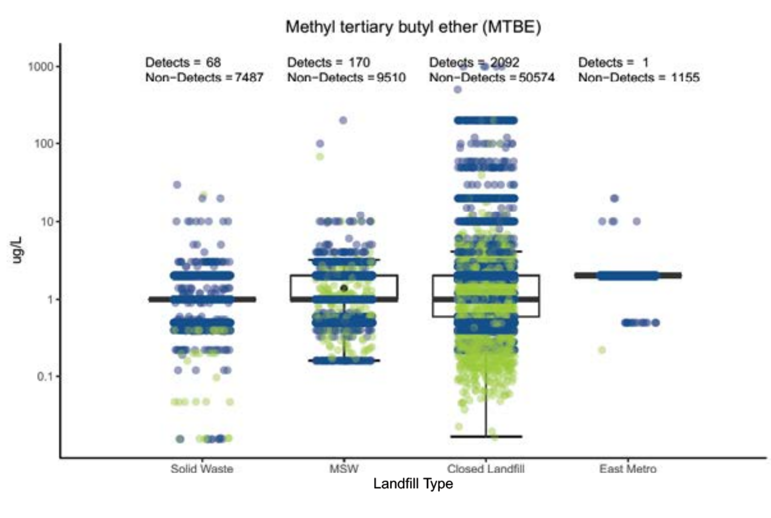

Dichlorofluoromethane (Freon−21)
Detects = 369
Non−Detects = 7248
Detects = 677
Non−Detects = 9089
Detects = 10380
Non−Detects = 43308
Detects = 381
Non−Detects = 780
ug/L
Solid Waste
MSW
Closed Landfill
East Metro
Landfill Type
Non−Detects
Detected Values

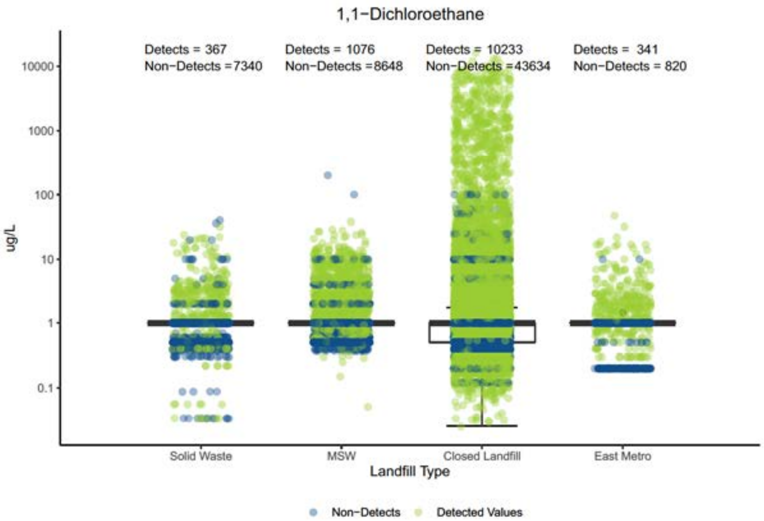

Methylene chloride
Detects = 133
Non−Detects = 7573
Detects = 104
Non−Detects = 9630
Detects = 2472
Non−Detects = 50888
Detects = 30
Non−Detects = 1131
ug/L
Solid Waste
MSW
Closed Landfill
East Metro
Landfill Type
Non−Detects
Detected Values

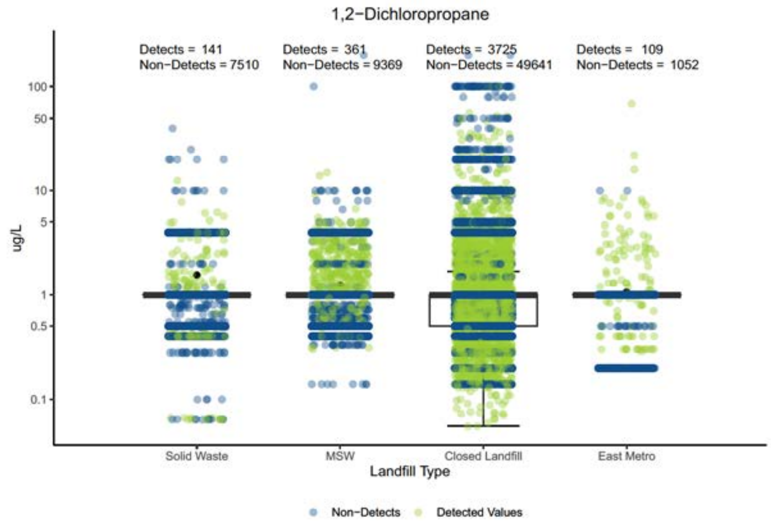

Ethylbenzene
Detects = 80
Non−Detects = 7622
Detects = 93
Non−Detects = 9662
Detects = 2944
Non−Detects = 50172
Detects = 38
Non−Detects = 1123
ug/L
Solid Waste
MSW
Closed Landfill
East Metro
Landfill Type
Non−Detects
Detected Values

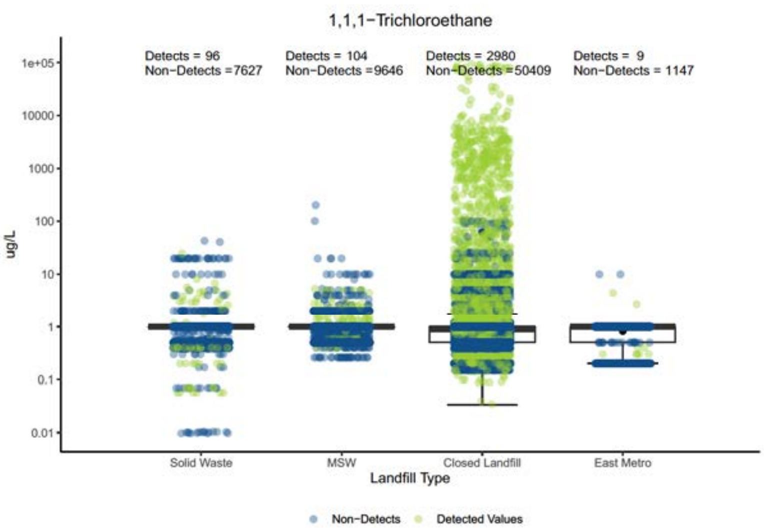

m & p Xylene
Detects = 77
Non−Detects = 5249
Detects = 85
Non−Detects = 6714
Detects = 3262
Non−Detects = 47368
Detects = 43
Non−Detects = 1107
ug/L
Solid Waste
MSW
Closed Landfill
East Metro
Landfill Type
Non−Detects
Detected Values

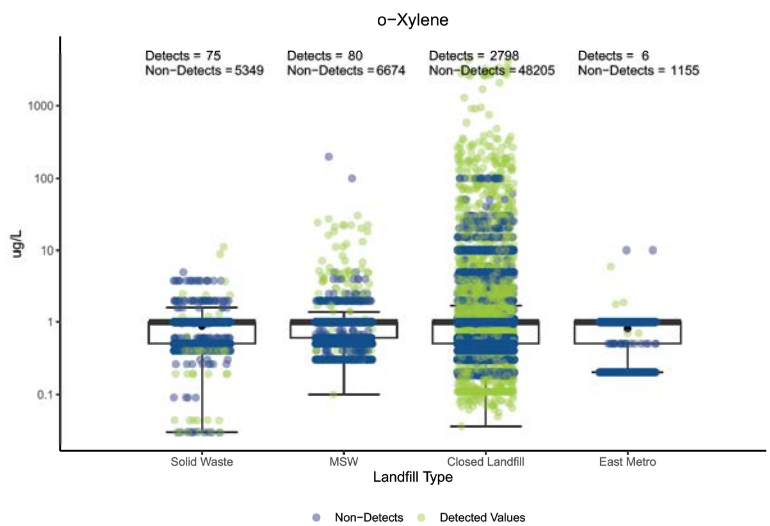

Ethyl ether
Detects = 785
Non−Detects = 6843
Detects = 2082
Non−Detects = 7541
Detects = 17827
Non−Detects = 36206
Detects = 606
Non−Detects = 541
ug/L
Solid Waste
MSW
Closed Landfill
East Metro
Landfill Type
Non−Detects
Detected Values

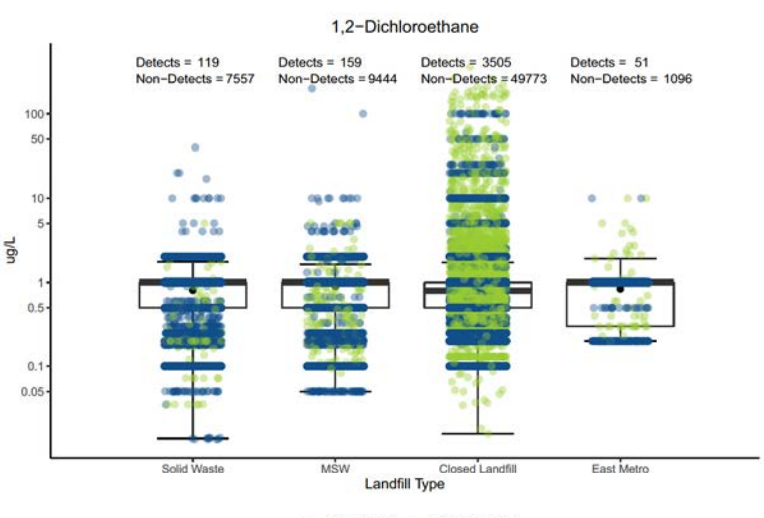

Methyl tertiary butyl ether (MTBE)
Detects = 68
Non−Detects = 7487
Detects = 170
Non−Detects = 9510
Detects = 2092
Non−Detects = 50574
Detects = 1
Non−Detects = 1155
ug/L
Solid Waste
MSW
Closed Landfill
East Metro
Landfill Type
Non−Detects
Detected Values

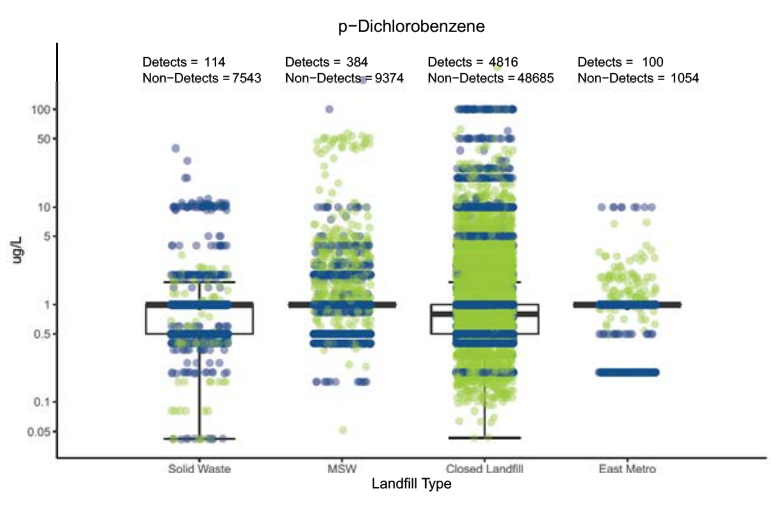

1,1−Dichloroethane
Detects = 367
Non−Detects =7340
Detects = 1076
Non−Detects =8648
Detects = 10233
Non−Detects =43634
Detects = 341
Non−Detects = 820
ug/L
Solid Waste
MSW
Closed Landfill
East Metro
Landfill Type
Non−Detects
Detected Values

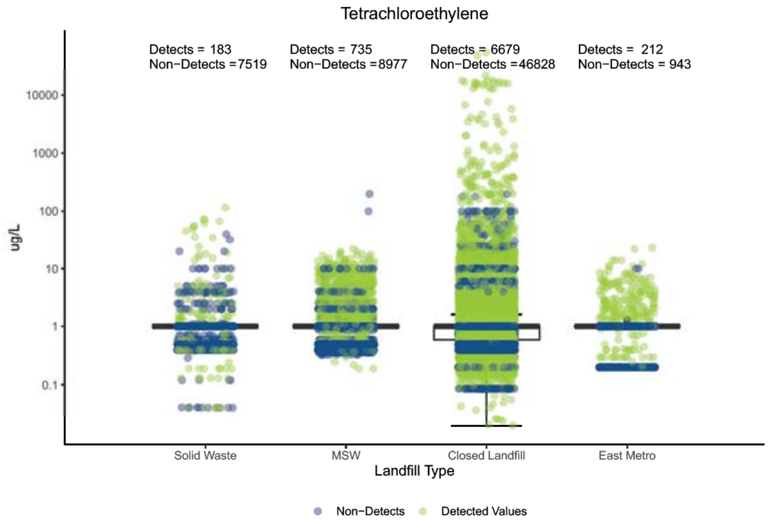

1,2−Dichloropropane
Detects = 141
Non−Detects = 7510
Detects = 361
Non−Detects = 9369
Detects = 3725
Non−Detects = 49641
Detects = 109
Non−Detects = 1052
ug/L
Solid Waste
MSW
Closed Landfill
East Metro
Landfill Type
Non−Detects
Detected Values

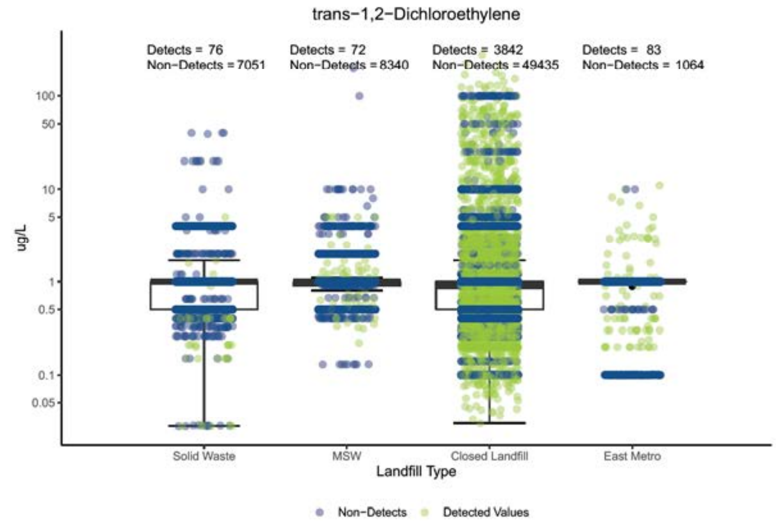

1,1,1−Trichloroethane
Detects = 96
Non−Detects =7627
Detects = 104
Non−Detects =9646
Detects = 2980
Non−Detects =50409
Detects = 9
Non−Detects = 1147
ug/L
Solid Waste
MSW
Closed Landfill
East Metro
Landfill Type
Non−Detects
Detected Values

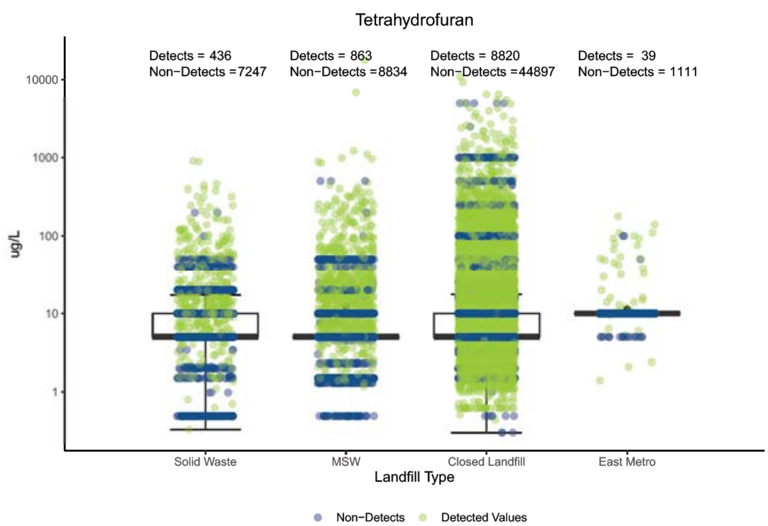

o−Xylene
Detects = 75
Non−Detects = 5349
Detects = 80
Non−Detects = 6674
Detects = 2798
Non−Detects = 48205
Detects = 6
Non−Detects = 1155
ug/L
Solid Waste
MSW
Closed Landfill
East Metro
Landfill Type
Non−Detects
Detected Values

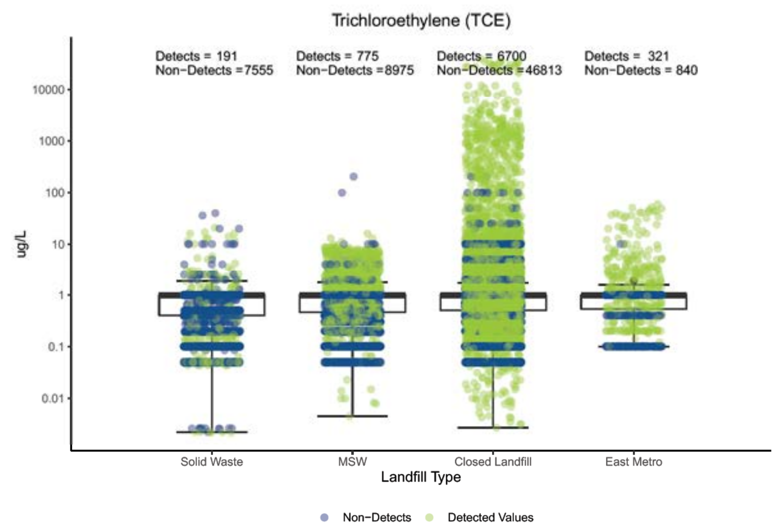

1,2−Dichloroethane
Detects = 119
Non−Detects = 7557
Detects = 159
Non−Detects = 9444
Detects = 3505
Non−Detects = 49773
Detects = 51
Non−Detects = 1096
ug/L
Solid Waste
MSW
Closed Landfill
East Metro
Landfill Type
Non−Detects
Detected Values

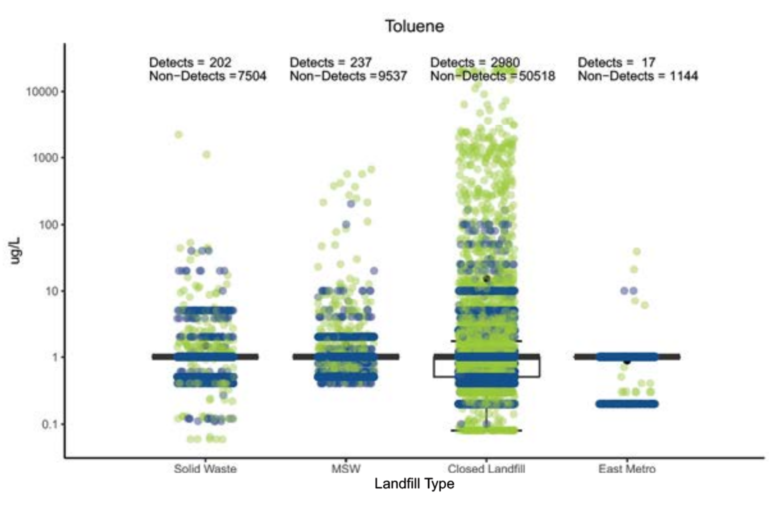

p−Dichlorobenzene
Detects = 114
Non−Detects = 7543
Detects = 384
Non−Detects = 9374
Detects = 4816
Non−Detects = 48685
Detects = 100
Non−Detects = 1054
ug/L
Solid Waste
MSW
Closed Landfill
East Metro
Landfill Type
Non−Detects
Detected Values

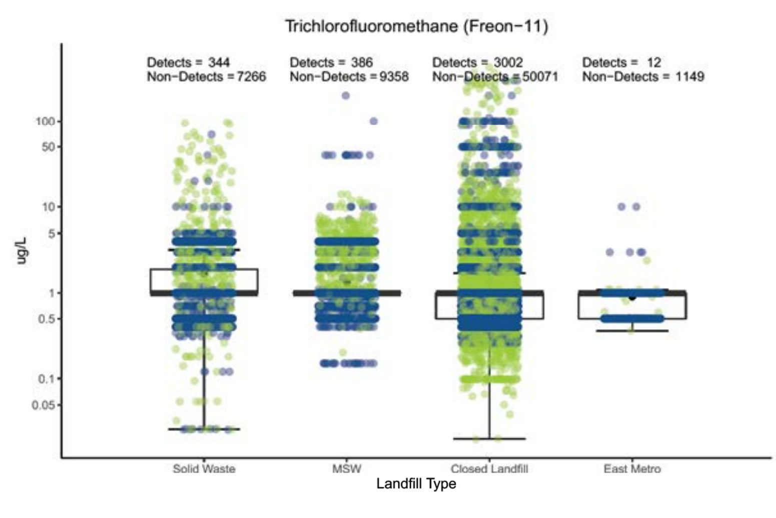

Tetrachloroethylene
Detects = 183
Non-Detects =7519
Detects = 735
Non-Detects =8977
Detects = 6679
Non-Detects =46828
Detects = 212
Non-Detects = 943
ug/L
10000
1000
100
10
1
0.1
Solid Waste
MSW
Closed Landfill
East Metro
Landfill Type
Non−Detects
Detected Values

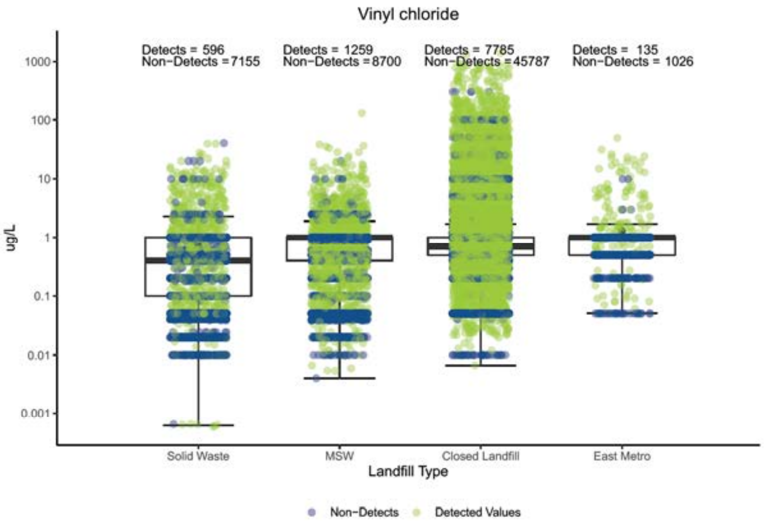

trans−1,2−Dichloroethylene
Detects = 76
Non-Detects =7051
Detects = 72
Non-Detects =8340
Detects = 3842
Non-Detects = 49435
Detects = 83
Non-Detects = 1064
ug/L
100
50
10
5
1
0.5
0.1
0.05
Solid Waste
MSW
Closed Landfill
East Metro
Landfill Type
Non−Detects
Detected Values


Tetrahydrofuran
Detects = 436
Non-Detects =7247
Detects = 863
Non-Detects =8834
Detects = 8820
Non-Detects =44897
Detects = 39
Non-Detects = 1111
ug/L
10000
1000
100
10
1
Solid Waste
MSW
Closed Landfill
East Metro
Landfill Type
Non−Detects
Detected Values


Trichloroethylene (TCE)
Detects = 191
Non-Detects =7555
Detects = 775
Non-Detects =8975
Detects = 6700
Non-Detects =46813
Detects = 321
Non-Detects = 840
ug/L
10000
1000
100
10
1
0.1
0.01
Solid Waste
MSW
Closed Landfill
East Metro
Landfill Type
Non−Detects
Detected Values


Toluene
Detects = 202
Non-Detects =7504
Detects = 237
Non-Detects =9537
Detects = 2980
Non-Detects =50518
Detects = 17
Non-Detects = 1144
ug/L
10000
1000
100
10
1
0.1
Solid Waste
MSW
Closed Landfill
East Metro
Landfill Type
Non−Detects
Detected Values

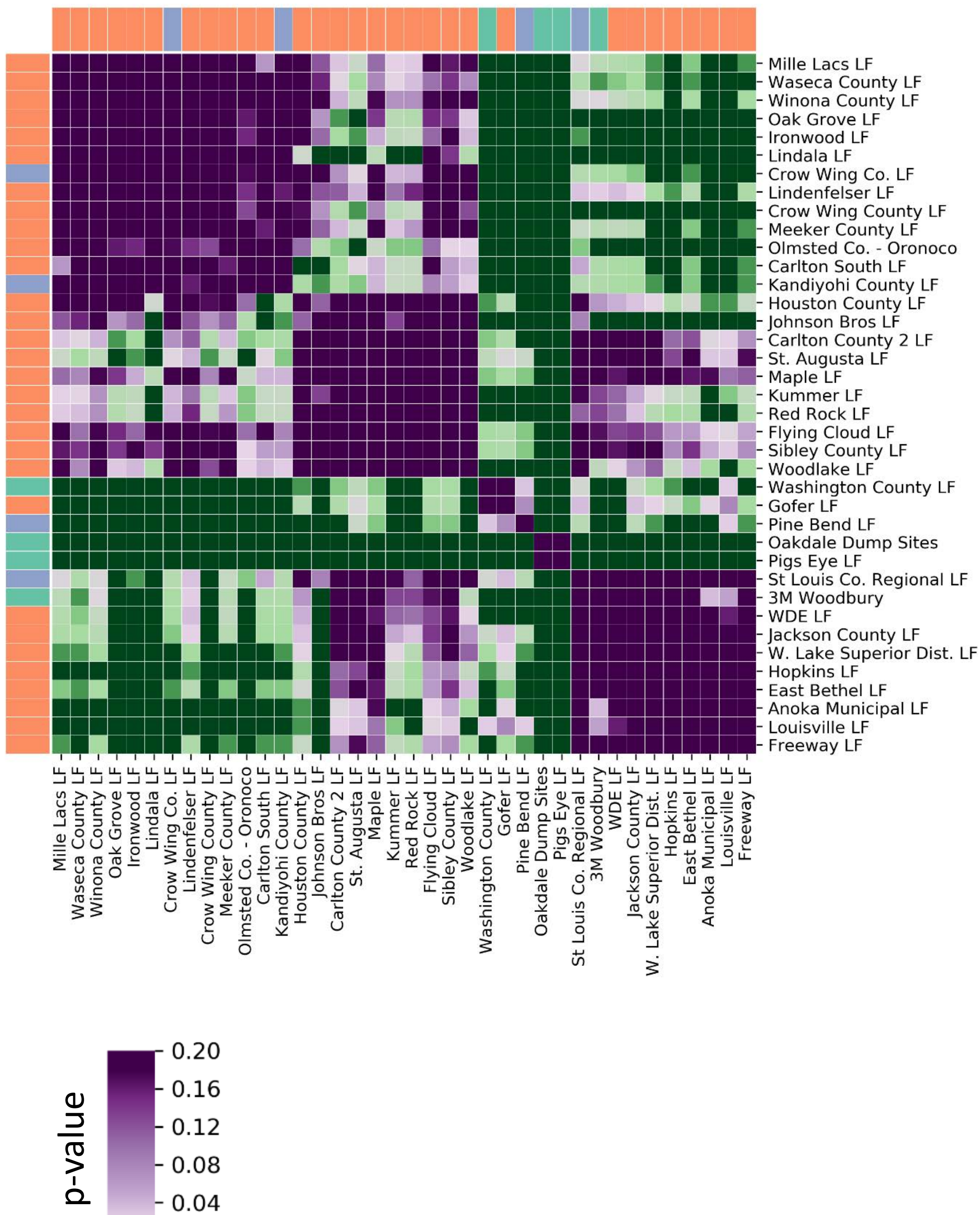

Trichlorofluoromethane (Freon−11)
Detects = 344
Non-Detects =7266
Detects = 386
Non-Detects =9358
Detects = 3002
Non-Detects =50071
Detects = 12
Non-Detects = 1149
ug/L
100
50
10
5
1
0.5
0.1
0.05
Solid Waste
MSW
Closed Landfill
East Metro
Landfill Type
Non−Detects
Detected Values



Vinyl chloride
Detects = 596
Non−Detects =7155
Detects = 1259
Non−Detects =8700
Detects = 7785
Non−Detects =45787
Detects = 135
Non−Detects = 1026
1000
100
10
1
0.1
0.01
0.001
ug/L
Solid Waste
MSW
Closed Landfill
East Metro
Landfill Type
Non−Detects
Detected Values

Appendix C

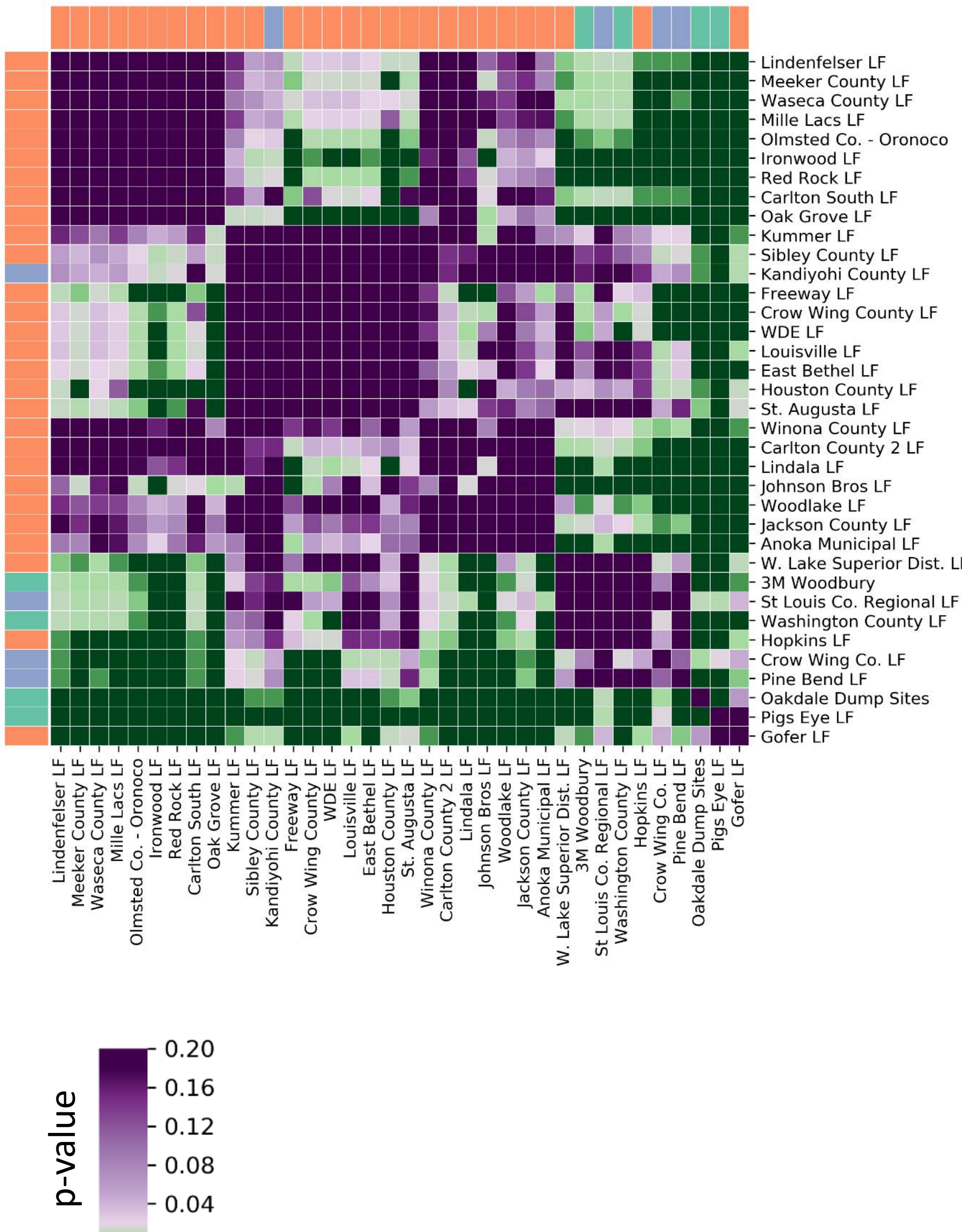
Wilcoxon Test Results



p-values < 0.01 (green) are statistically significant

Wilcoxon Test p-values
PFOA

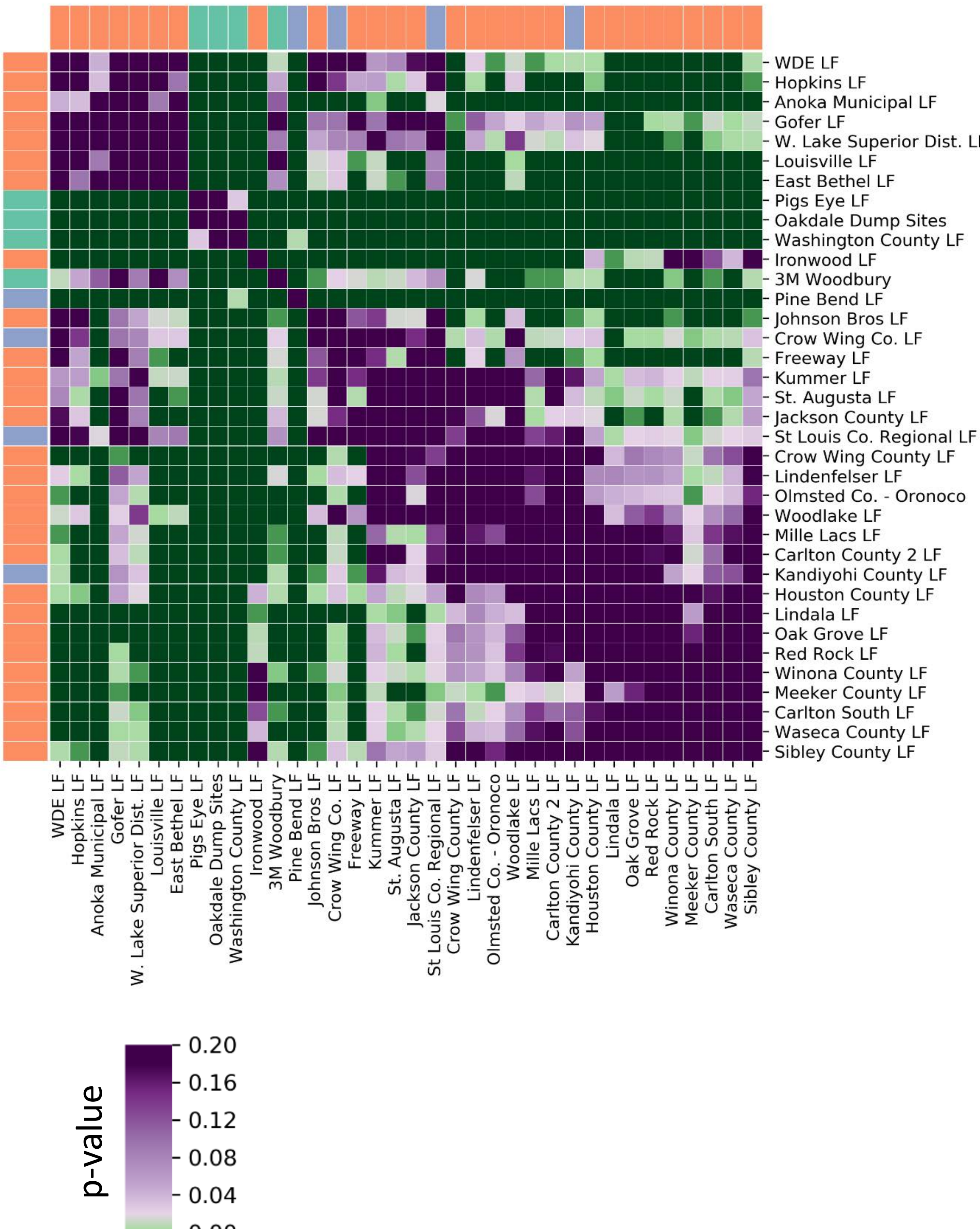
FIGURE C1



p-values < 0.01 (green) are statistically significant

Wilcoxon Test p-values
PFOS

FIGURE C2

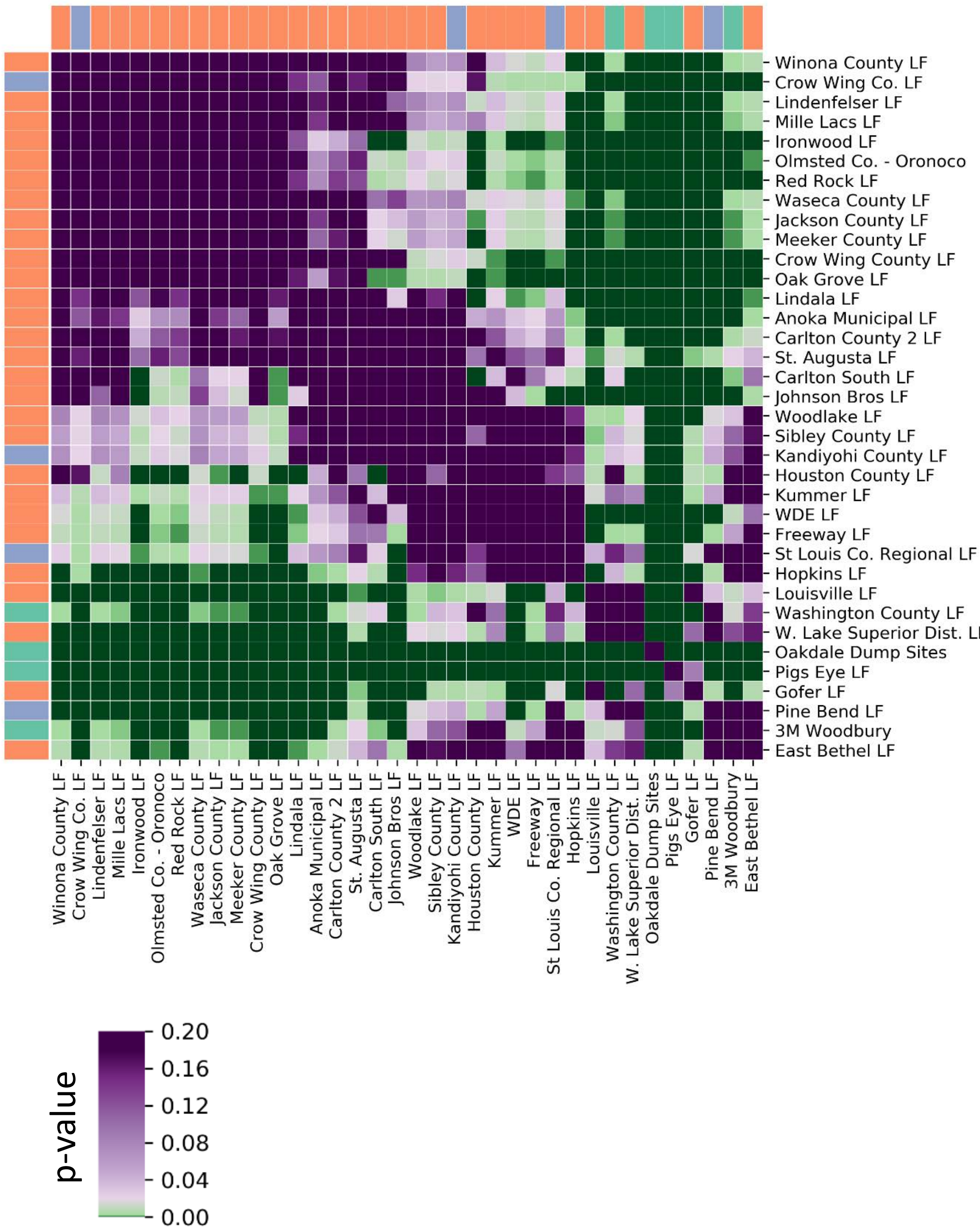


p-values < 0.01 (green) are statistically significant

Wilcoxon Test p-values
PFBA

FIGURE C3

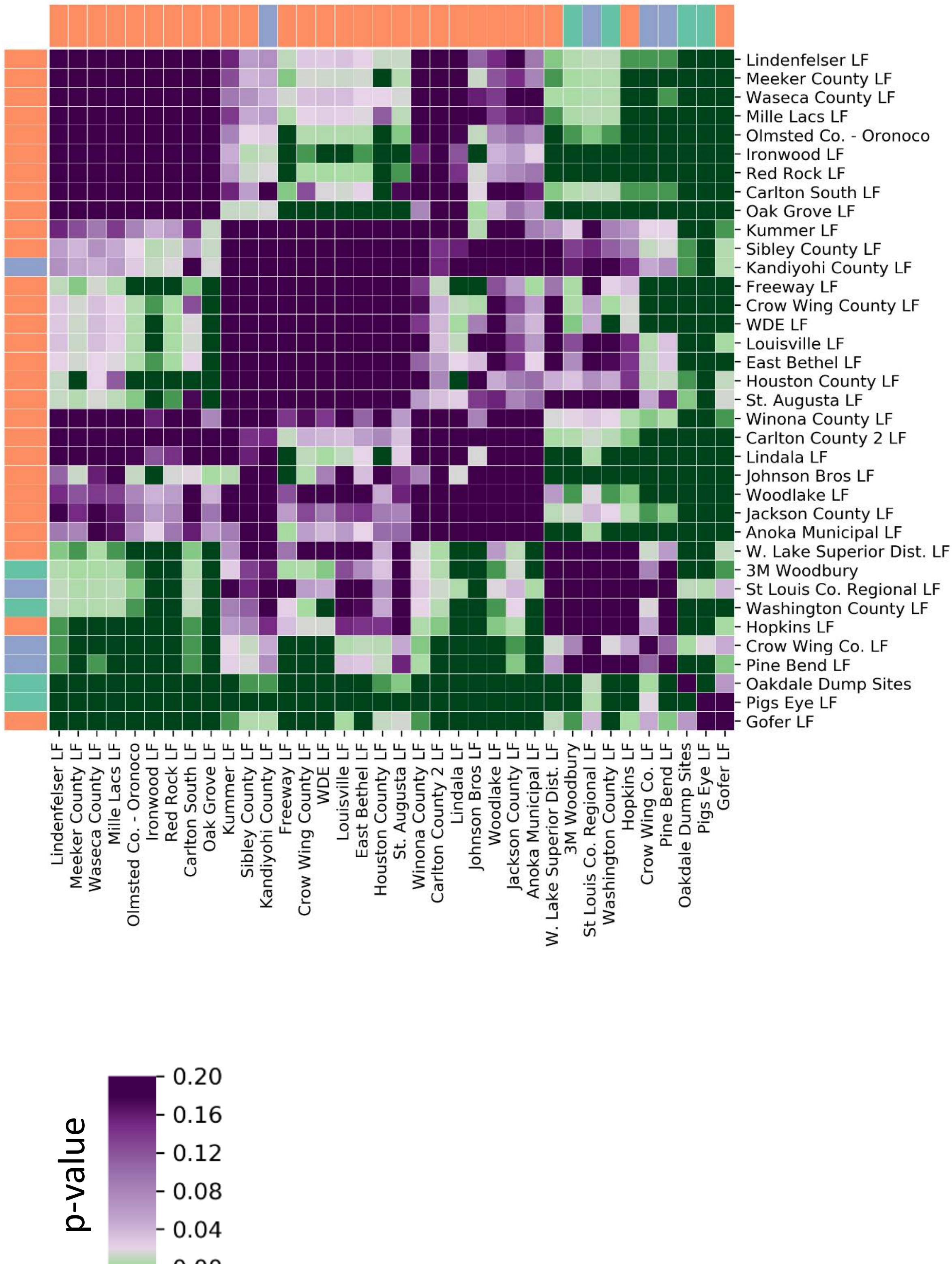
BARR



p-values < 0.01 (green) are statistically significant

Wilcoxon Test p-values
PFHsX

FIGURE C4



p-values < 0.01 (green) are statistically significant

Wilcoxon Test p-values
PFBS

FIGURE C5

p-values < 0.01 (green) are statistically significant

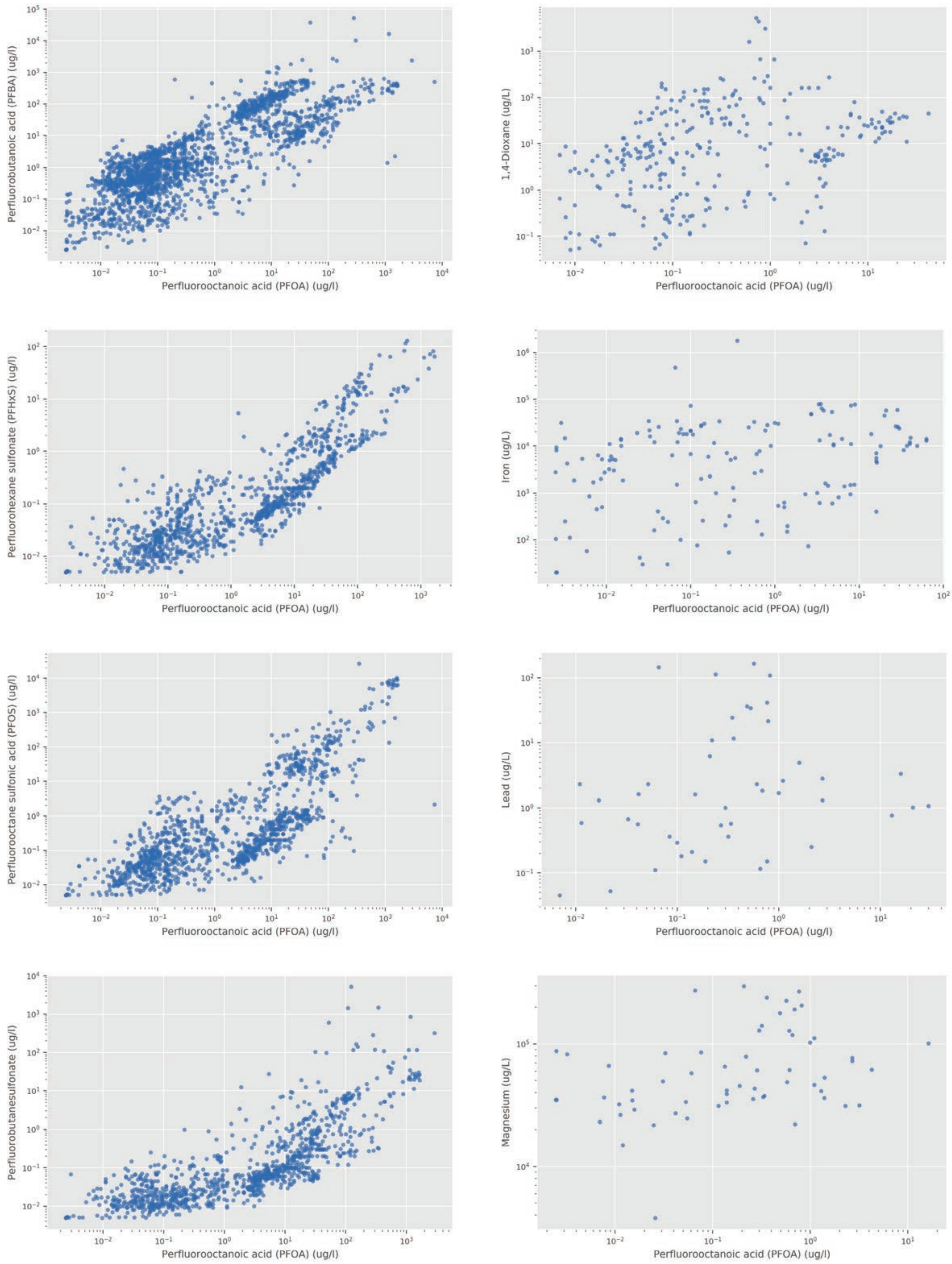
Wilcoxon Test p-values
1,4-Dioxane

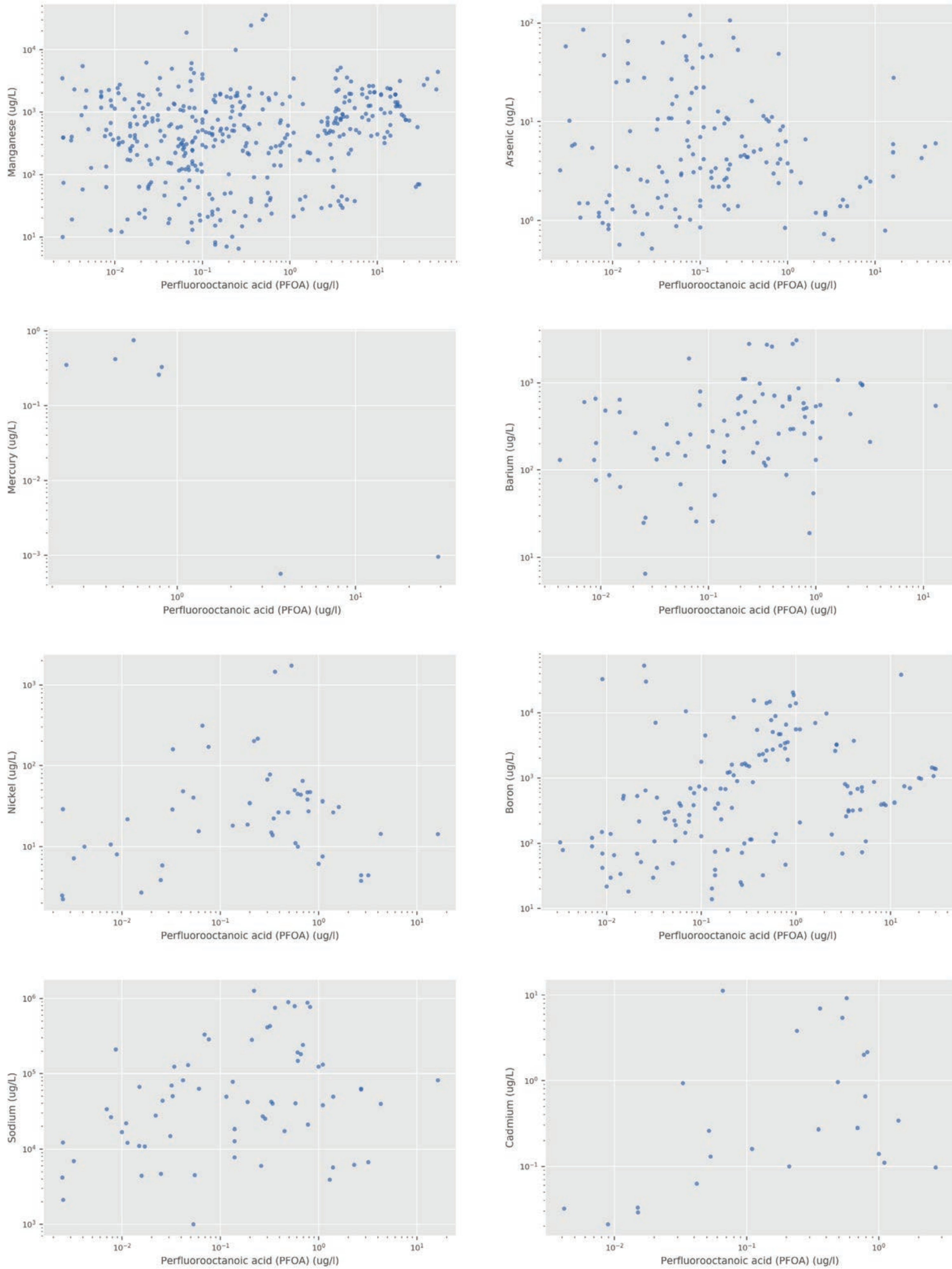
FIGURE C6

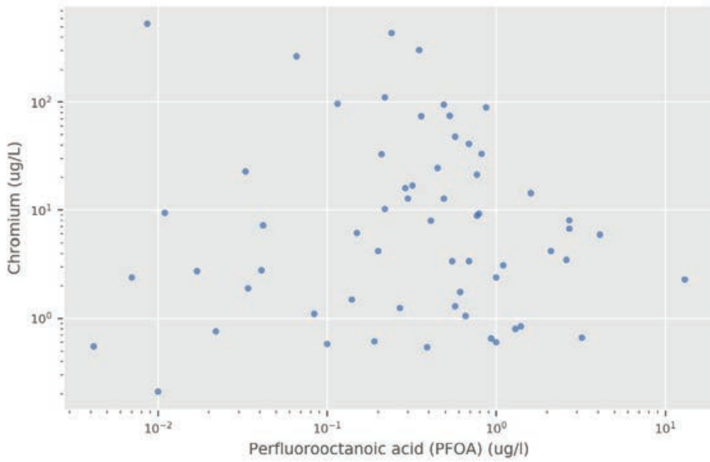
BARR

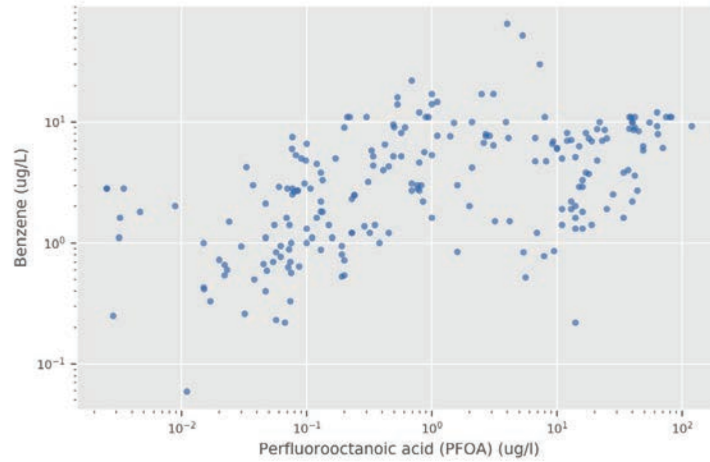
Appendix D

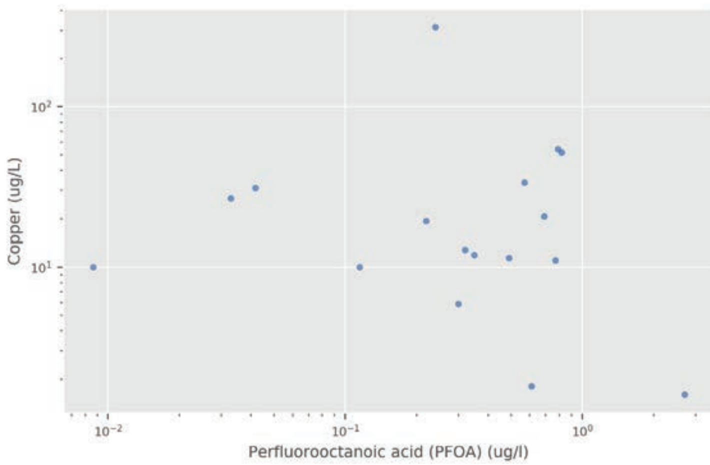
Scatter Plots Illustrating Relationships Between PFAS, 1-4-Dioxane, and Other Constituents

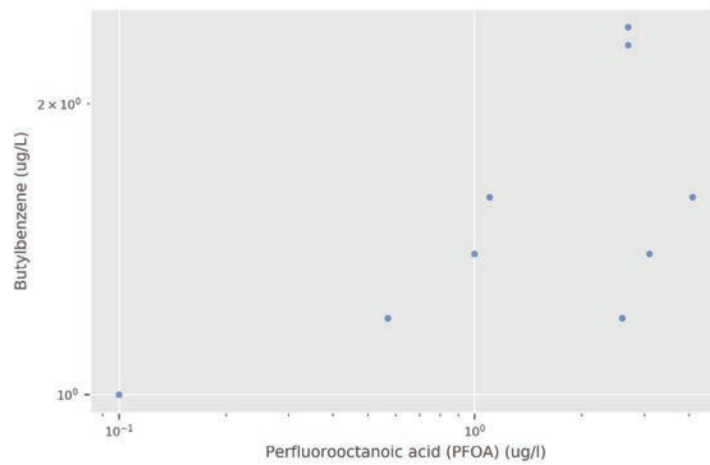

Perfluorobutanoic acid (PFBA) (ug/l)
Perfluorooctanoic acid (PFOA) (ug/l)
1,4-Dioxane (ug/L)
Perfluorooctanoic acid (PFOA) (ug/l)
Perfluorohexane sulfonate (PFHxS) (ug/l)
Perfluorooctanoic acid (PFOA) (ug/l)
Iron (ug/L)
Perfluorooctanoic acid (PFOA) (ug/l)
Perfluorooctane sulfonic acid (PFOS) (ug/l)
Perfluorooctanoic acid (PFOA) (ug/l)
Lead (ug/L)
Perfluorooctanoic acid (PFOA) (ug/l)
Perfluorobutanesulfonate (ug/l)
Perfluorooctanoic acid (PFOA) (ug/l)
Magnesium (ug/L)
Perfluorooctanoic acid (PFOA) (ug/l)

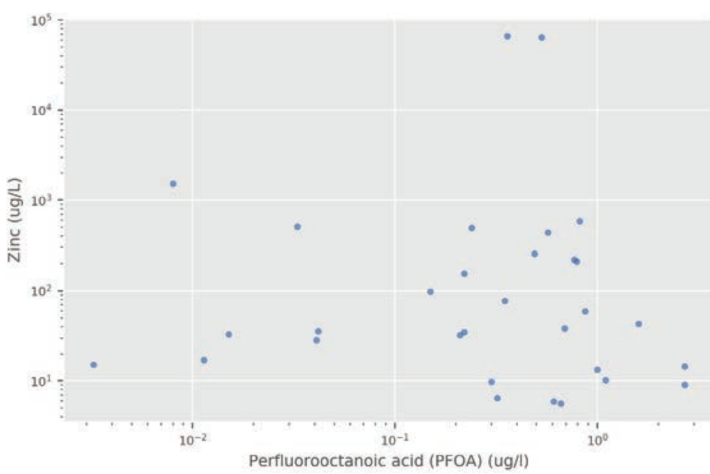

Manganese (ug/L)
Perfluorooctanoic acid (PFOA) (ug/l)
Arsenic (ug/L)
Perfluorooctanoic acid (PFOA) (ug/l)
Mercury (ug/L)
Perfluorooctanoic acid (PFOA) (ug/l)
Barium (ug/L)
Perfluorooctanoic acid (PFOA) (ug/l)
Nickel (ug/L)
Perfluorooctanoic acid (PFOA) (ug/l)
Boron (ug/L)
Perfluorooctanoic acid (PFOA) (ug/l)
Sodium (ug/L)
Perfluorooctanoic acid (PFOA) (ug/l)
Cadmium (ug/L)
Perfluorooctanoic acid (PFOA) (ug/l)

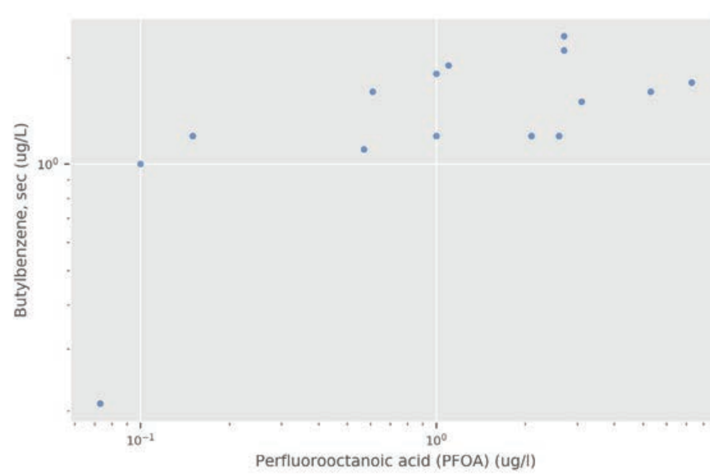

Chromium (ug/L)
Perfluorooctanoic acid (PFOA) (ug/l)

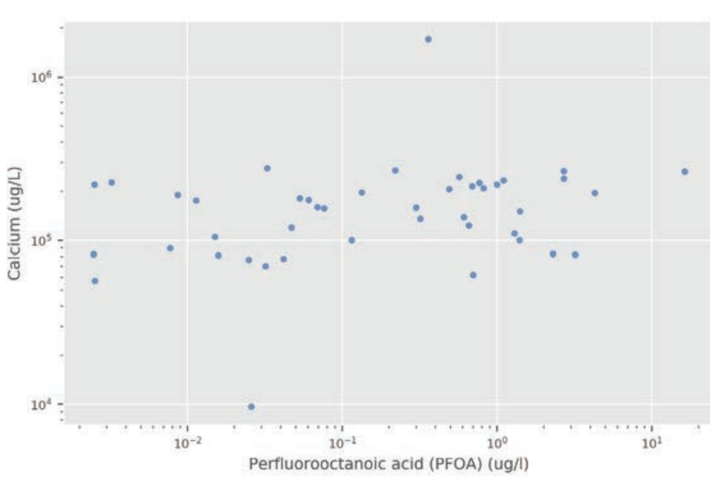

Benzene (ug/L)
Perfluorooctanoic acid (PFOA) (ug/l)

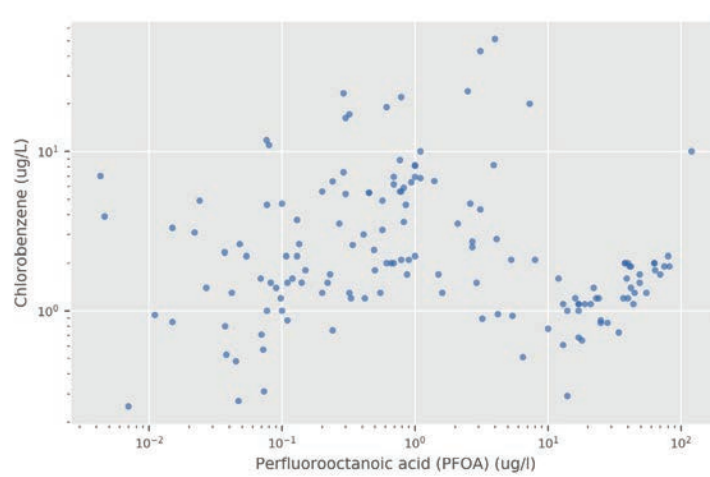

Copper (ug/L)
Perfluorooctanoic acid (PFOA) (ug/l)

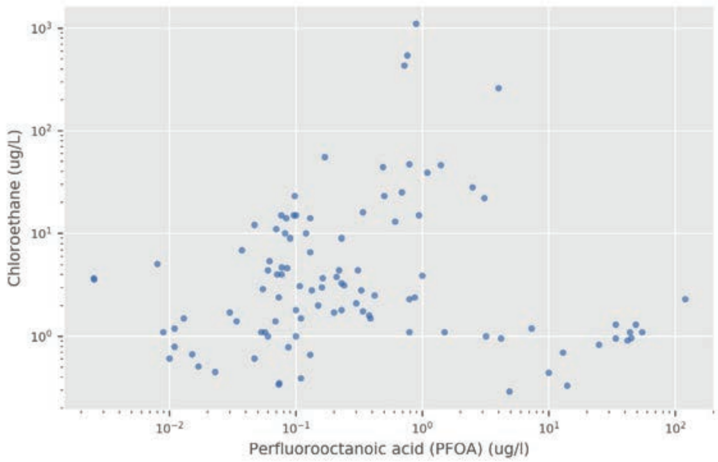

Butylbenzene (ug/L)
Perfluorooctanoic acid (PFOA) (ug/l)

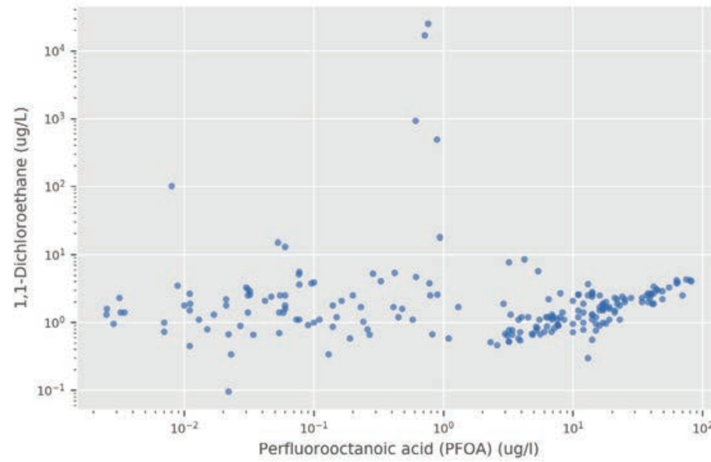

Zinc (ug/L)
Perfluorooctanoic acid (PFOA) (ug/l)

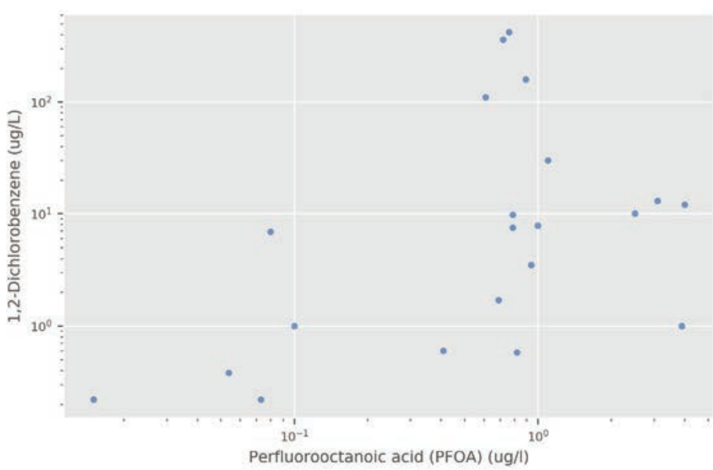

Butylbenzene, sec (ug/L)
Perfluorooctanoic acid (PFOA) (ug/l)

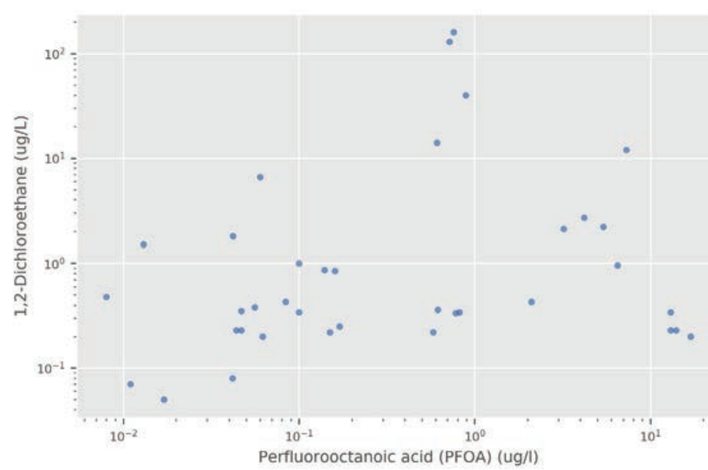

Calcium (ug/L)
Perfluorooctanoic acid (PFOA) (ug/l)

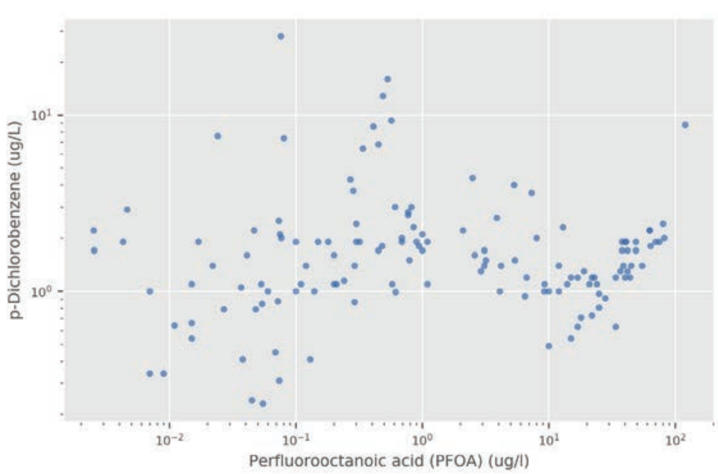

Chlorobenzene (ug/L)
Perfluorooctanoic acid (PFOA) (ug/l)

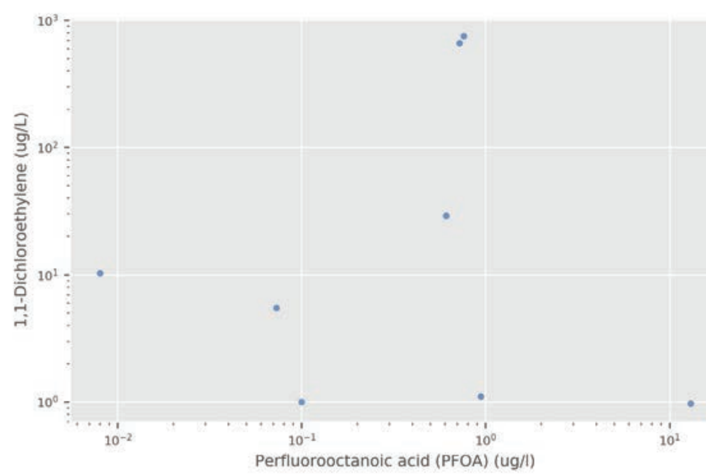

Chloroethane (ug/L)
Perfluorooctanoic acid (PFOA) (ug/l)

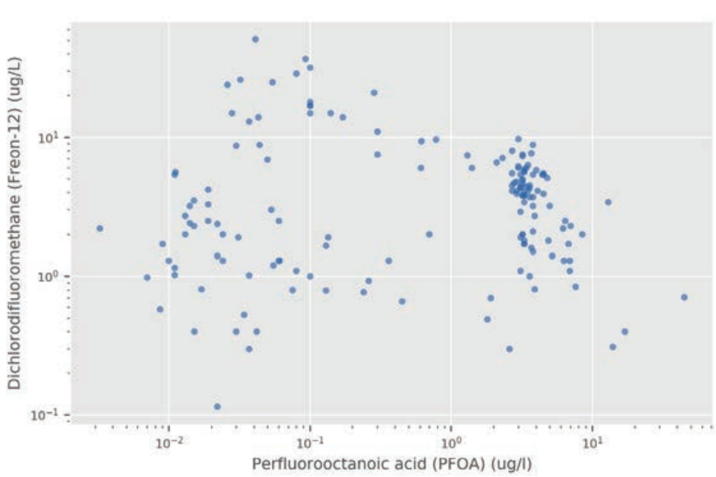

1,1-Dichloroethane (ug/L)
Perfluorooctanoic acid (PFOA) (ug/l)

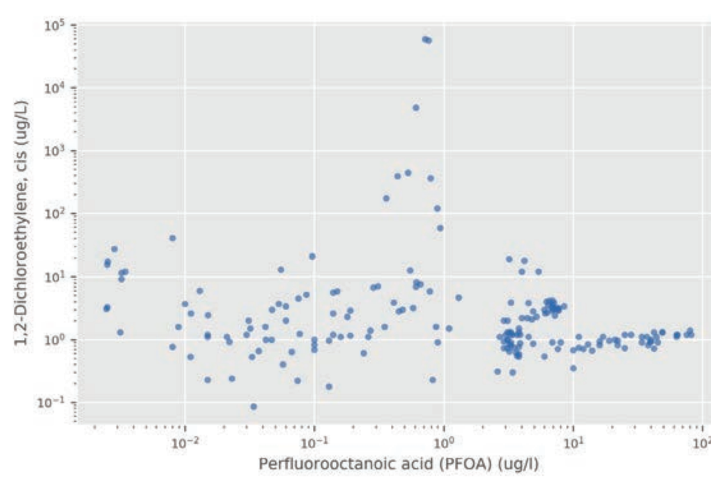

1,2-Dichlorobenzene (ug/L)
Perfluorooctanoic acid (PFOA) (ug/l)

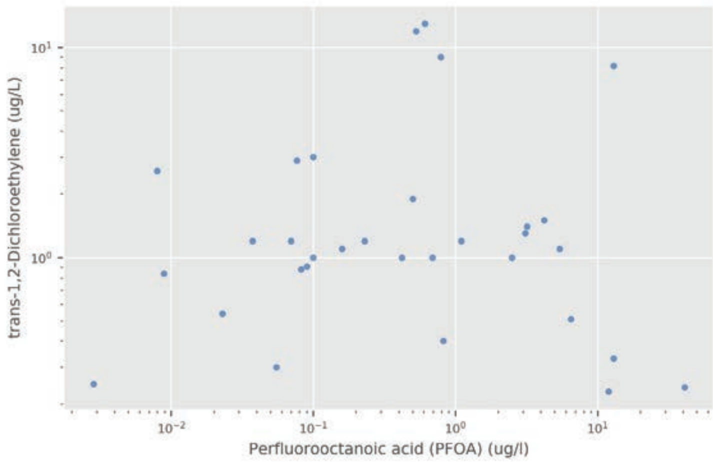

1,2-Dichloroethane (ug/L)
Perfluorooctanoic acid (PFOA) (ug/l)

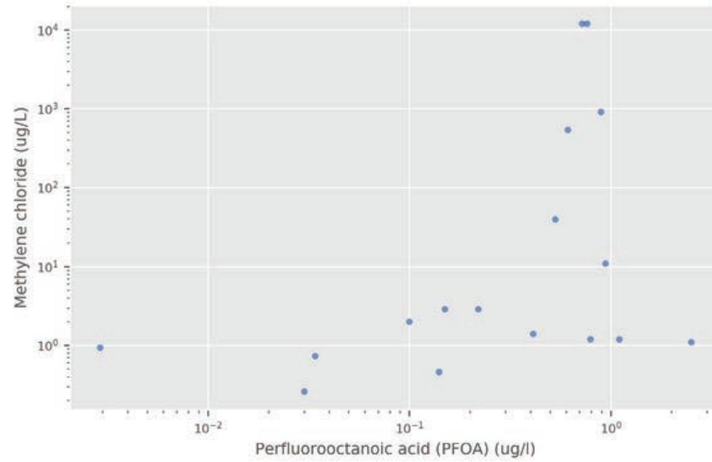

p-Dichlorobenzene (ug/L)
Perfluorooctanoic acid (PFOA) (ug/l)

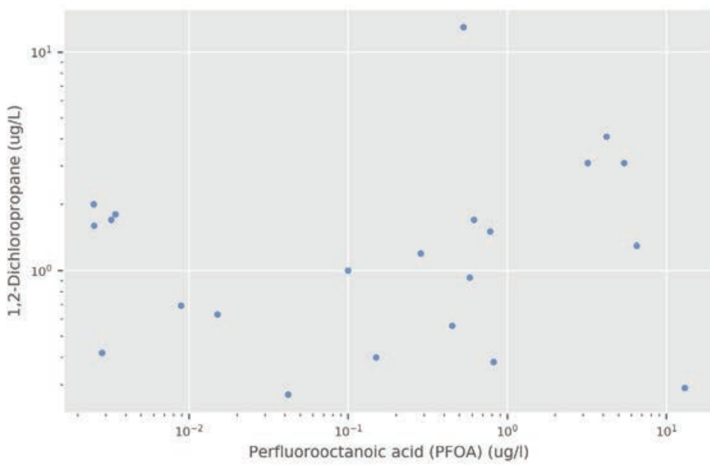

1,1-Dichloroethylene (ug/L)
Perfluorooctanoic acid (PFOA) (ug/l)

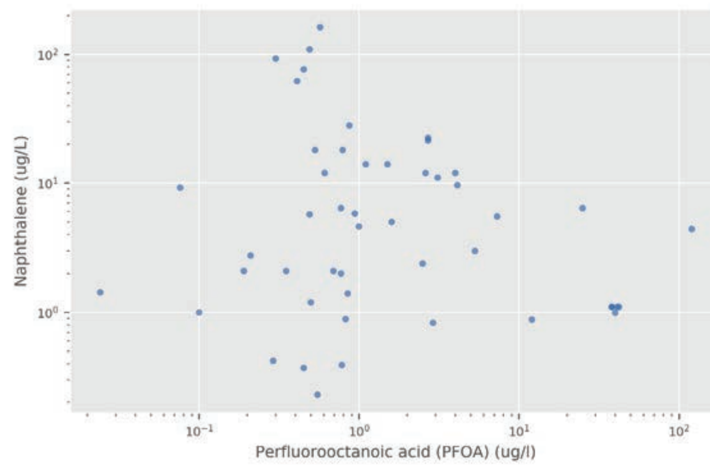

Dichlorodifluoromethane (Freon-12) (ug/L)
Perfluorooctanoic acid (PFOA) (ug/l)

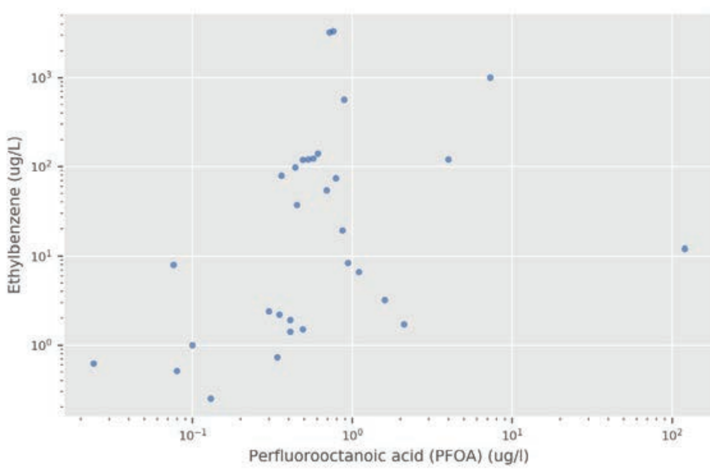

1,2-Dichloroethylene, cis (ug/L)
Perfluorooctanoic acid (PFOA) (ug/l)

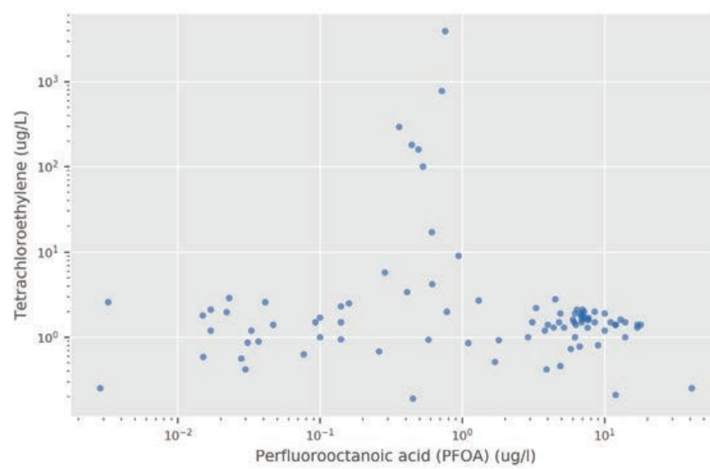

trans-1,2-Dichloroethylene (ug/L)
Perfluorooctanoic acid (PFOA) (ug/l)

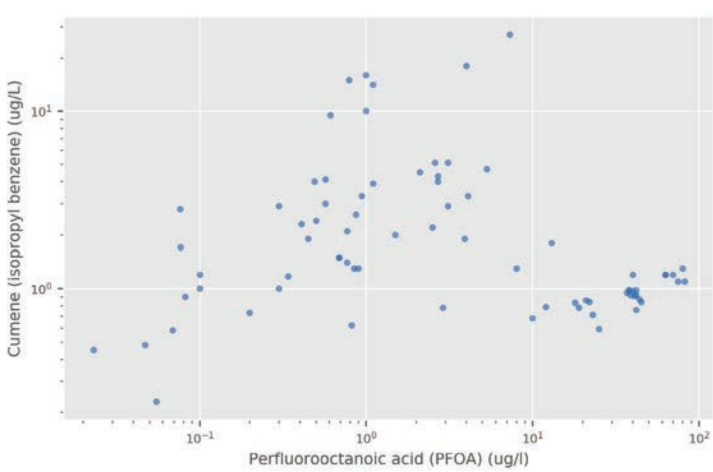

Methylene chloride (ug/L)
Perfluorooctanoic acid (PFOA) (ug/l)

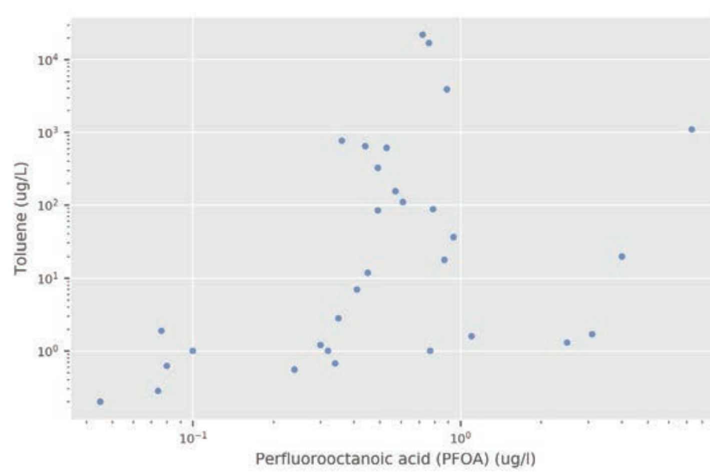

1,2-Dichloropropane (ug/L)
Perfluorooctanoic acid (PFOA) (ug/l)

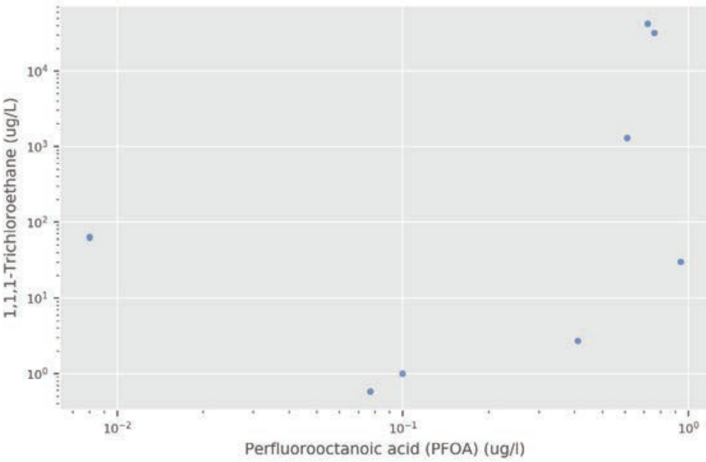

Naphthalene (ug/L)
Perfluorooctanoic acid (PFOA) (ug/l)

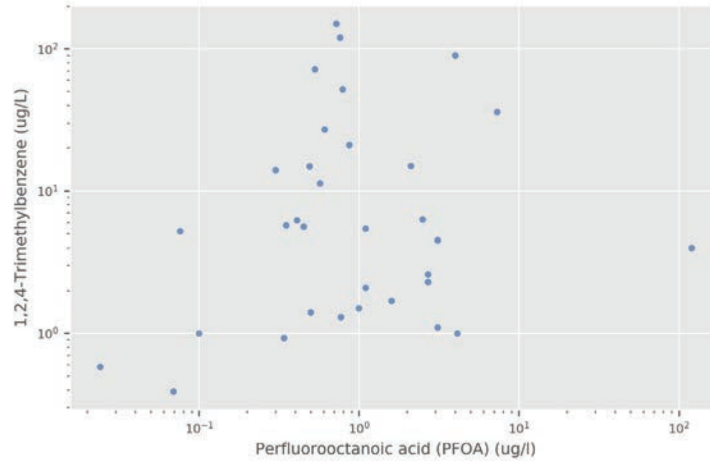

Ethylbenzene (ug/L)
Perfluorooctanoic acid (PFOA) (ug/l)

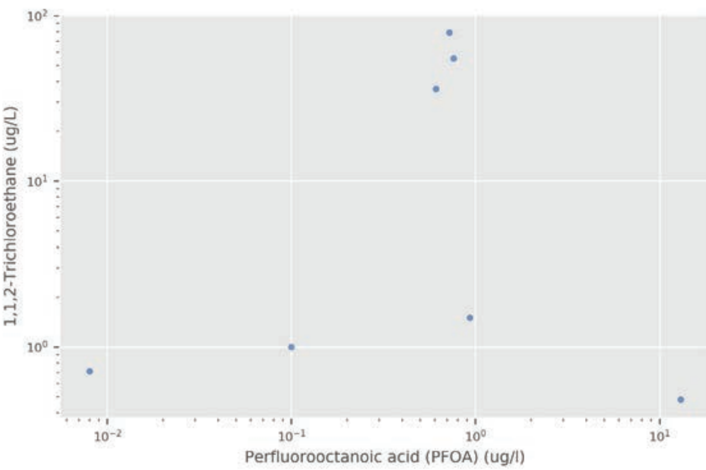

Tetrachloroethylene (ug/L)
Perfluorooctanoic acid (PFOA) (ug/l)

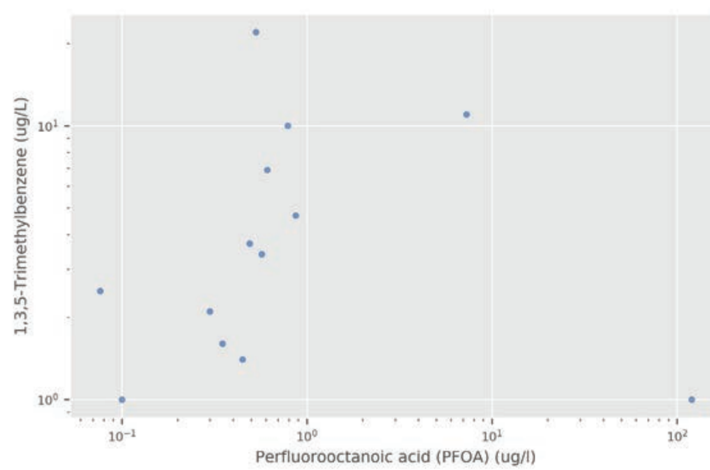

Cumene (isopropyl benzene) (ug/L)
Perfluorooctanoic acid (PFOA) (ug/l)

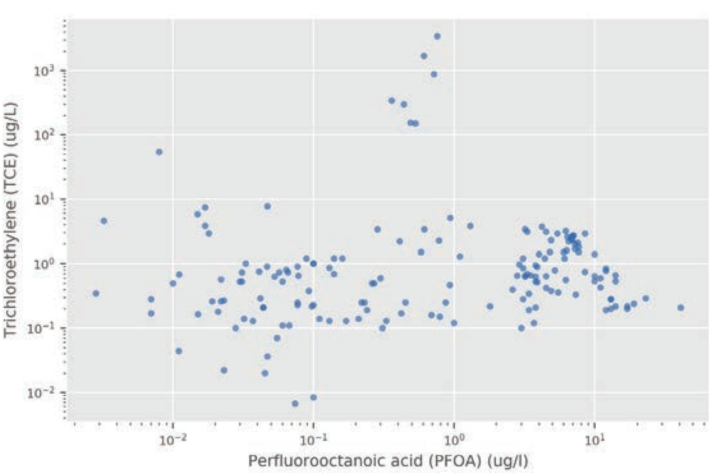

Toluene (ug/L)
Perfluorooctanoic acid (PFOA) (ug/l)

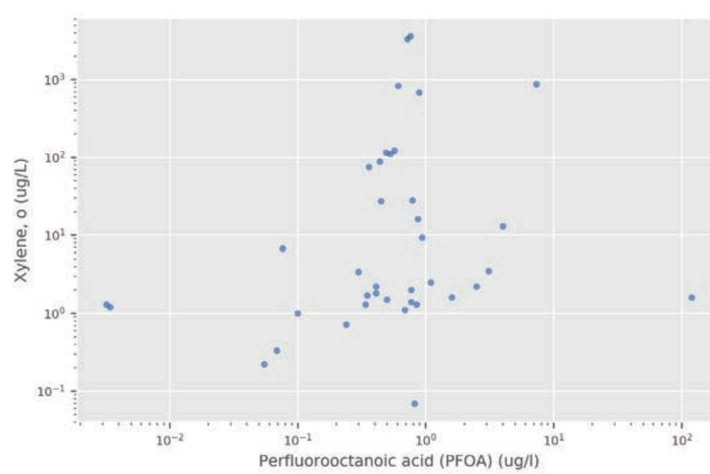

1,1,1-Trichloroethane (ug/L)
Perfluorooctanoic acid (PFOA) (ug/l)
10^{-2}
10^{-1}
10^{0}
10^{0}
10^{1}
10^{2}
10^{3}
10^{4}

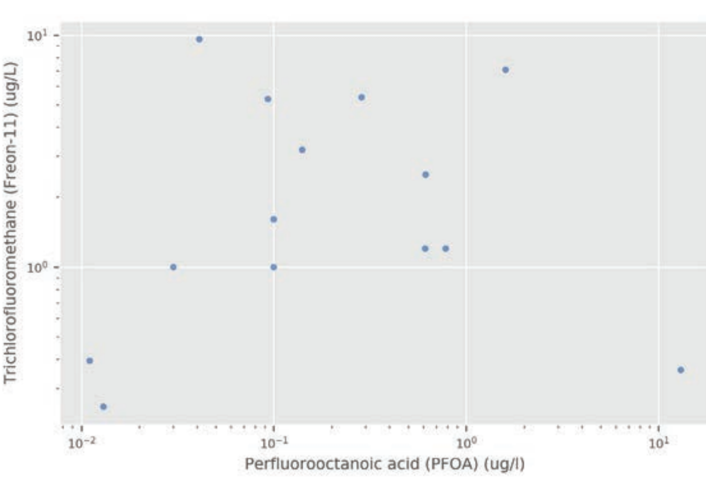

1,2,4-Trimethylbenzene (ug/L)
Perfluorooctanoic acid (PFOA) (ug/l)
10^{-1}
10^{0}
10^{1}
10^{2}
10^{0}
10^{1}
10^{2}

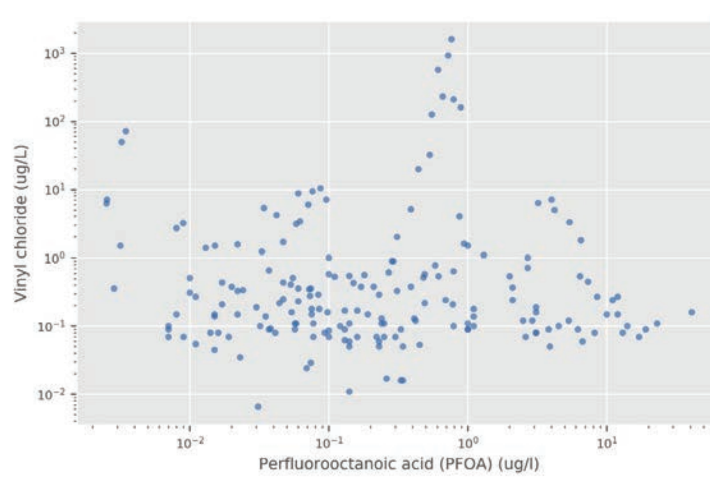

1,1,2-Trichloroethane (ug/L)
Perfluorooctanoic acid (PFOA) (ug/l)
10^{-2}
10^{-1}
10^{0}
10^{1}
10^{0}
10^{1}
10^{2}

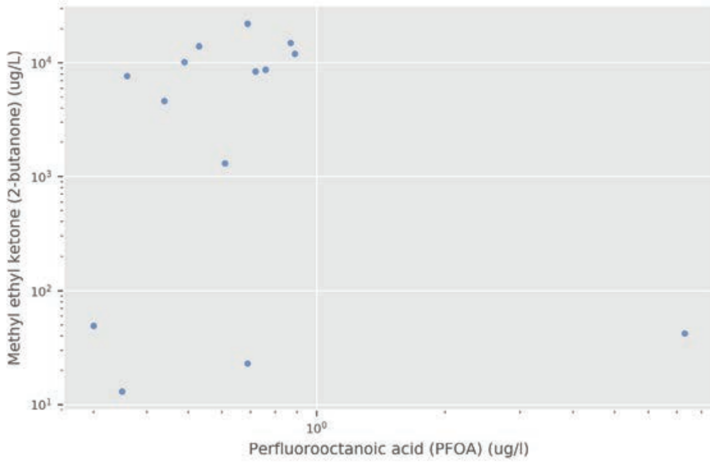

1,3,5-Trimethylbenzene (ug/L)
Perfluorooctanoic acid (PFOA) (ug/l)
10^{-1}
10^{0}
10^{1}
10^{2}
10^{0}
10^{1}

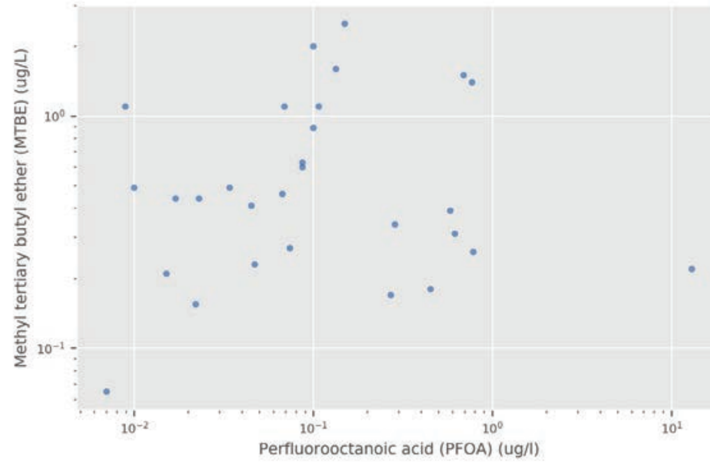

Trichloroethylene (TCE) (ug/L)
Perfluorooctanoic acid (PFOA) (ug/l)
10^{-2}
10^{-1}
10^{0}
10^{1}
10^{-2}
10^{-1}
10^{0}
10^{1}
10^{2}
10^{3}

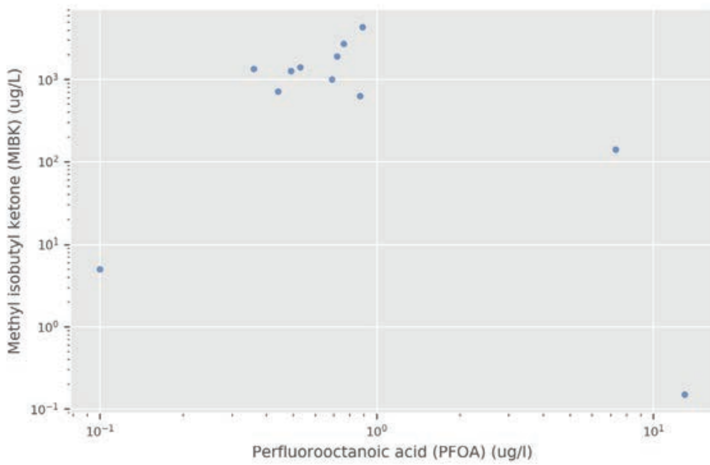

Xylene, o (ug/L)
Perfluorooctanoic acid (PFOA) (ug/l)
10^{-2}
10^{-1}
10^{0}
10^{1}
10^{2}
10^{-1}
10^{0}
10^{1}
10^{2}
10^{3}

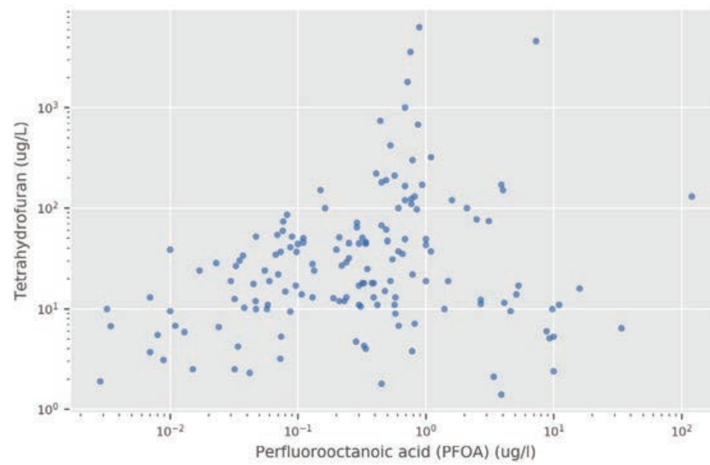

Trichlorofluoromethane (Freon-11) (ug/L)
Perfluorooctanoic acid (PFOA) (ug/l)
10^{-2}
10^{-1}
10^{0}
10^{1}
10^{0}
10^{1}

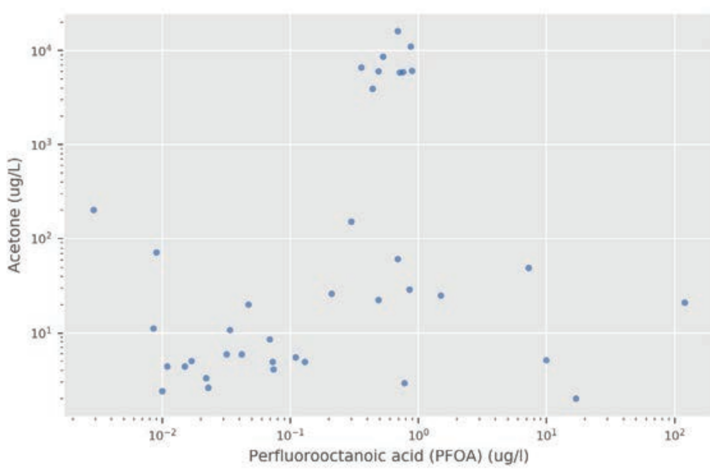

Vinyl chloride (ug/L)
Perfluorooctanoic acid (PFOA) (ug/l)
10^{-2}
10^{-1}
10^{0}
10^{1}
10^{-2}
10^{-1}
10^{0}
10^{1}
10^{2}
10^{3}

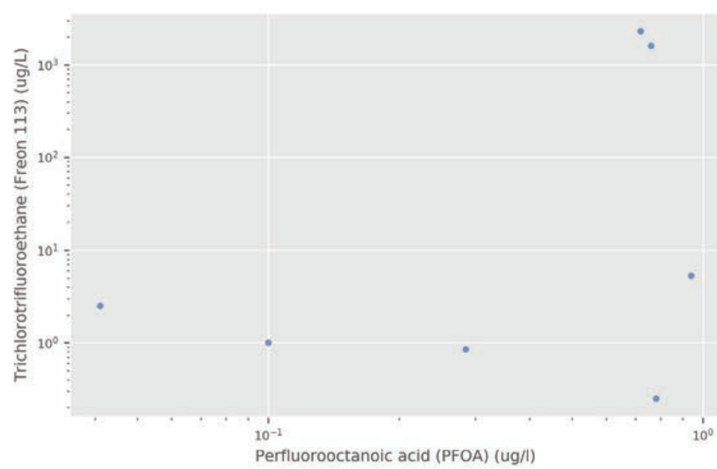

Methyl ethyl ketone (2-butanone) (ug/L)
10^4
10^3
10^2
10^1
10^0
Perfluorooctanoic acid (PFOA) (ug/l)

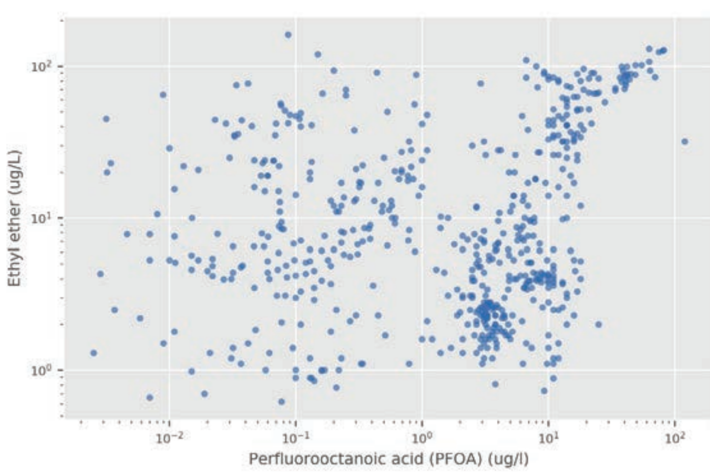

Methyl tertiary butyl ether (MTBE) (ug/L)
10^0
10^{-1}
10^{-2}
10^{-1}
10^0
10^1
Perfluorooctanoic acid (PFOA) (ug/l)

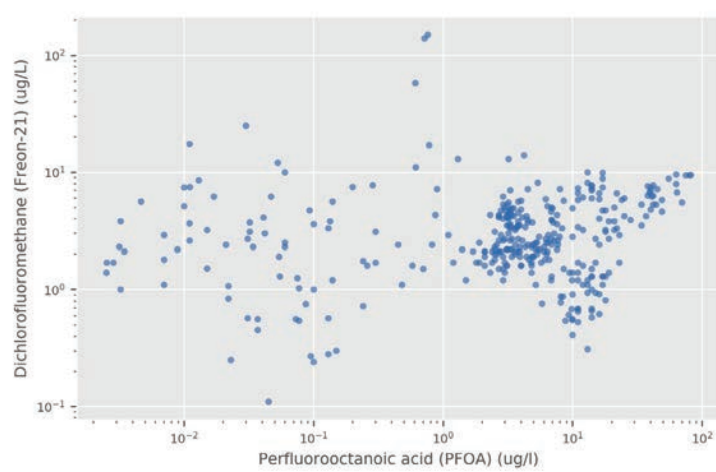

Methyl isobutyl ketone (MIBK) (ug/L)
10^3
10^2
10^1
10^0
10^{-1}
10^{-1}
10^0
10^1
Perfluorooctanoic acid (PFOA) (ug/l)

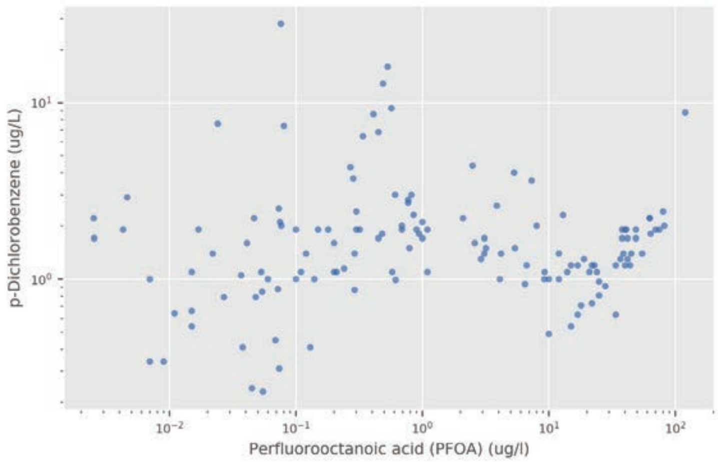

Tetrahydrofuran (ug/L)
10^3
10^2
10^1
10^0
10^{-2}
10^{-1}
10^0
10^1
10^2
Perfluorooctanoic acid (PFOA) (ug/l)


Acetone (ug/L)
10^4
10^3
10^2
10^1
10^{-2}
10^{-1}
10^0
10^1
10^2
Perfluorooctanoic acid (PFOA) (ug/l)

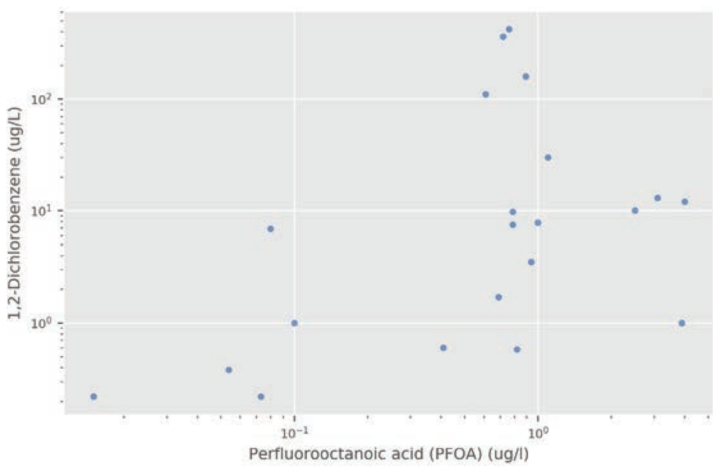

Trichlorotrifluoroethane (Freon 113) (ug/L)
10^3
10^2
10^1
10^0
10^{-1}
10^0
Perfluorooctanoic acid (PFOA) (ug/l)


Ethyl ether (ug/L)
10^2
10^1
10^0
10^{-2}
10^{-1}
10^0
10^1
10^2
Perfluorooctanoic acid (PFOA) (ug/l)

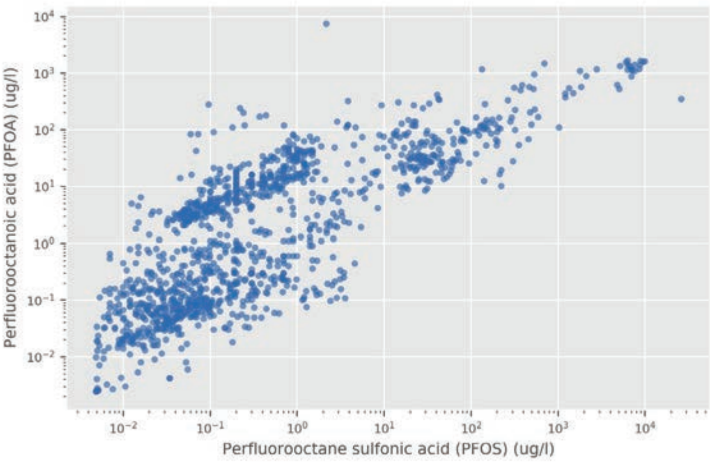

Dichlorofluoromethane (Freon-21) (ug/L)
10^2
10^1
10^0
10^{-1}
10^{-2}
10^{-1}
10^0
10^1
10^2
Perfluorooctanoic acid (PFOA) (ug/l)

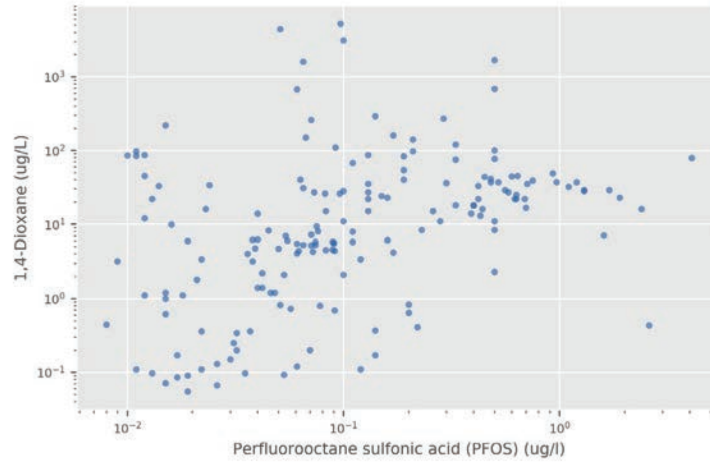


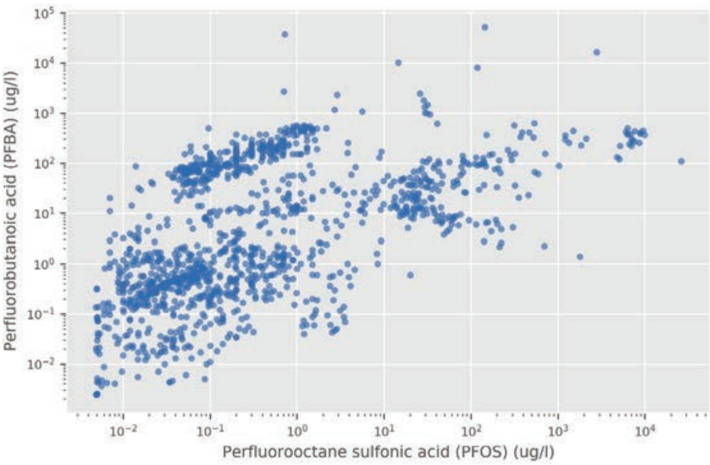
p-Dichlorobenzene (ug/L)
Perfluorooctanoic acid (PFOA) (ug/l)

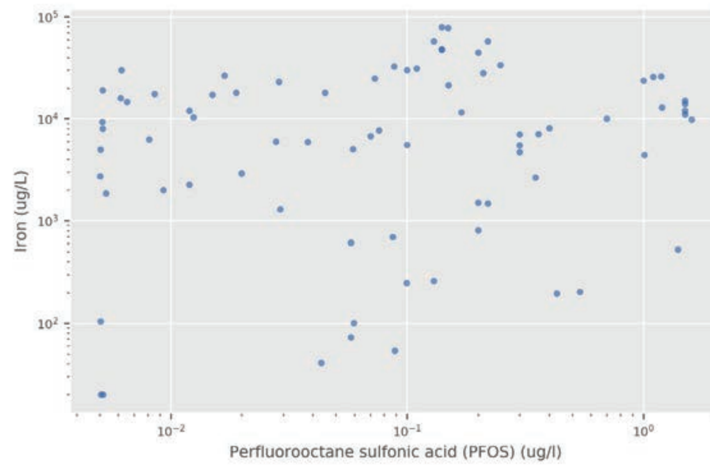


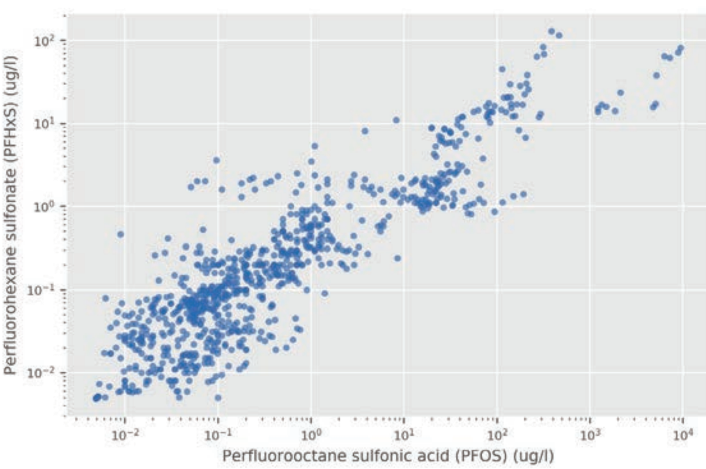
1,2-Dichlorobenzene (ug/L)
Perfluorooctanoic acid (PFOA) (ug/l)

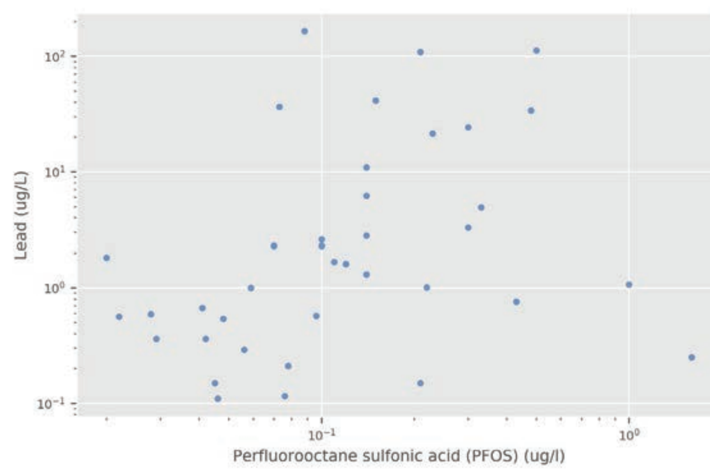

Perfluorooctanoic acid (PFOA) (ug/l)
Perfluorooctane sulfonic acid (PFOS) (ug/l)

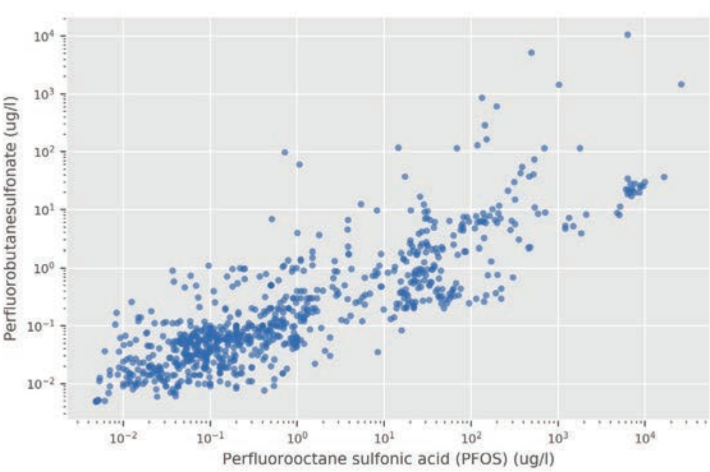

1,4-Dioxane (ug/L)
Perfluorooctane sulfonic acid (PFOS) (ug/l)

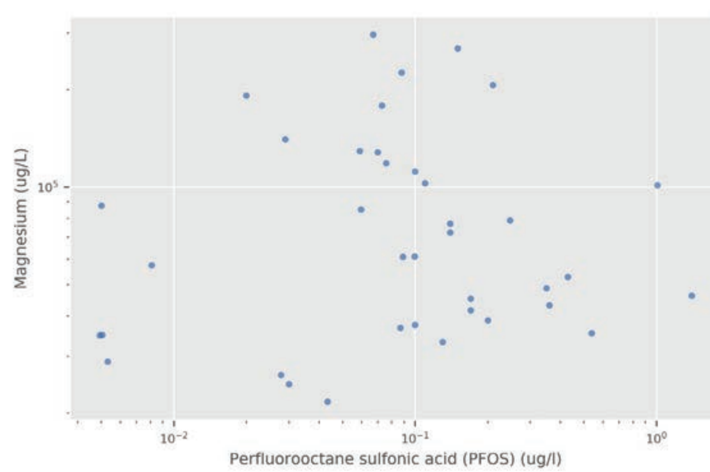

Perfluorobutanoic acid (PFBA) (ug/l)
Perfluorooctane sulfonic acid (PFOS) (ug/l)

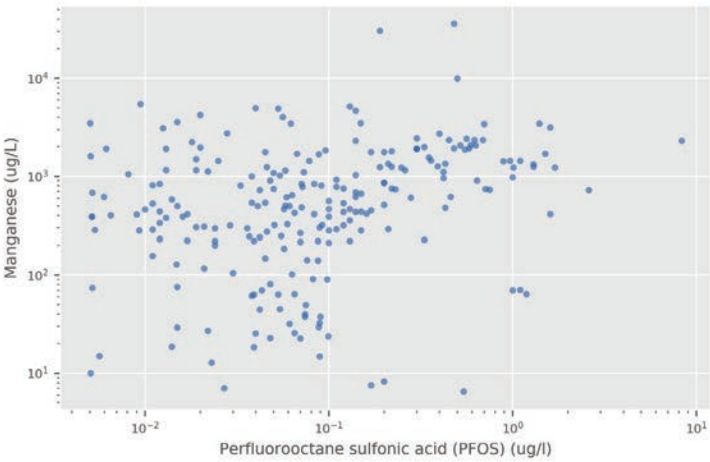

Iron (ug/L)
Perfluorooctane sulfonic acid (PFOS) (ug/l)

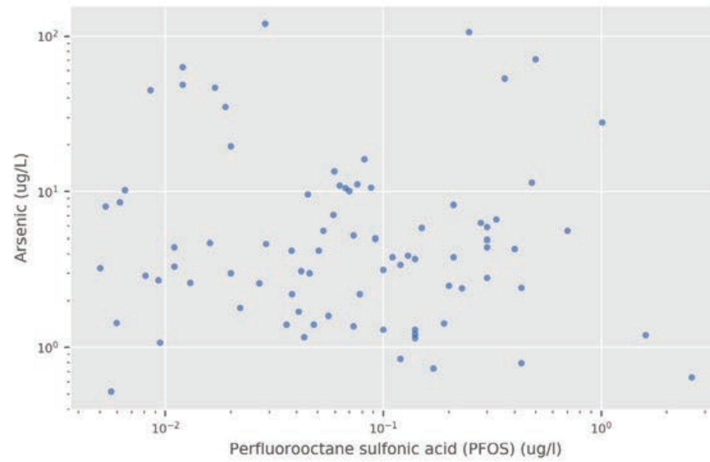

Perfluorohexane sulfonate (PFHxS) (ug/l)
Perfluorooctane sulfonic acid (PFOS) (ug/l)

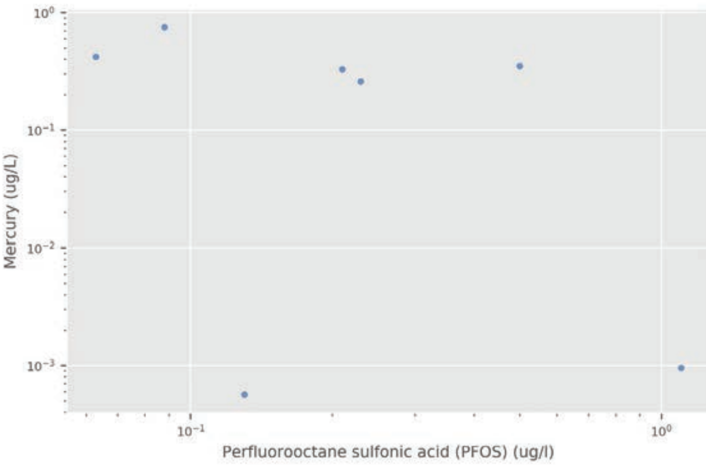

Lead (ug/L)
Perfluorooctane sulfonic acid (PFOS) (ug/l)

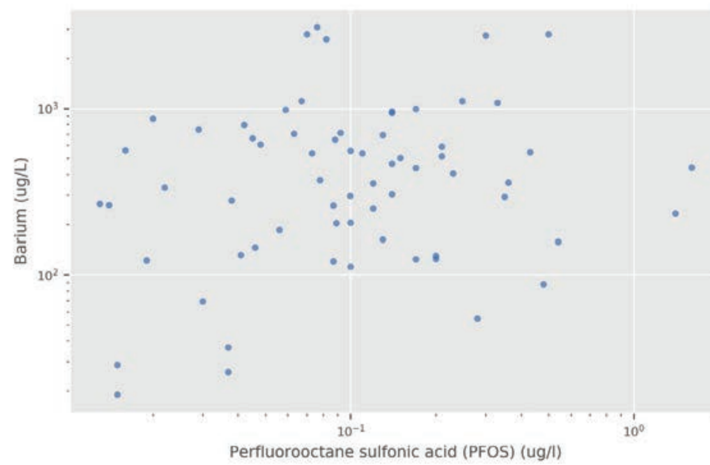

Perfluorobutanesulfonate (ug/l)
Perfluorooctane sulfonic acid (PFOS) (ug/l)

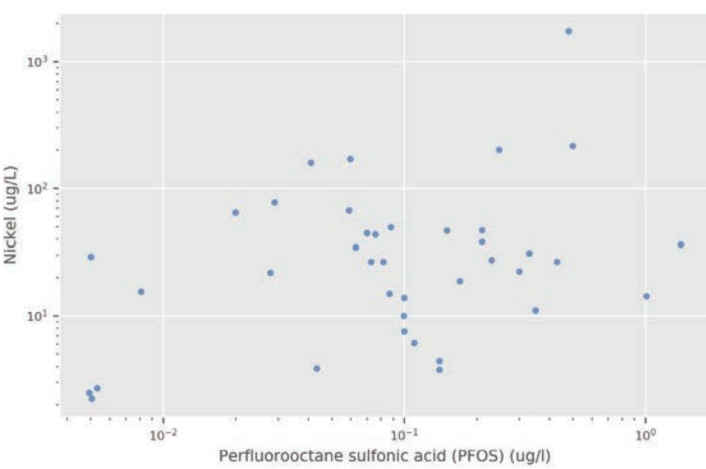

Magnesium (ug/L)
Perfluorooctane sulfonic acid (PFOS) (ug/l)

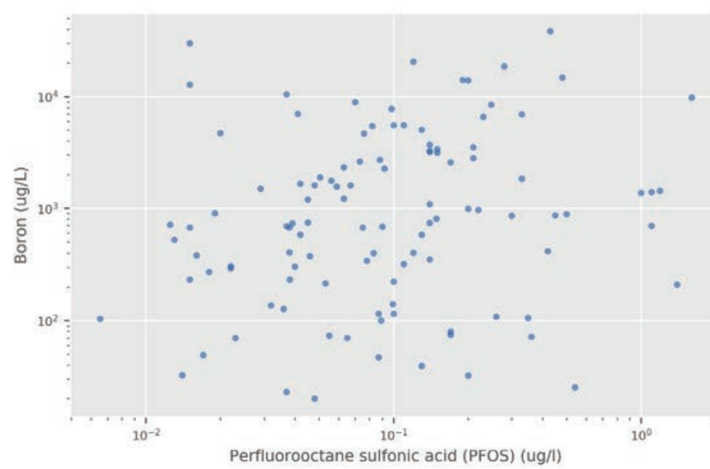

Manganese (ug/L)
Perfluorooctane sulfonic acid (PFOS) (ug/l)

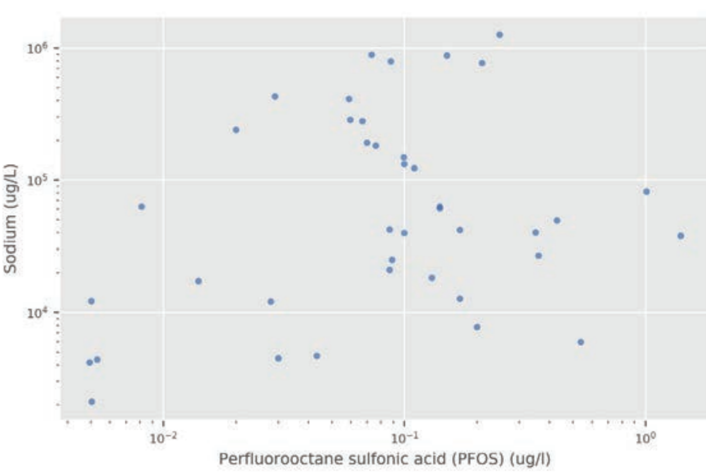

Arsenic (ug/L)
Perfluorooctane sulfonic acid (PFOS) (ug/l)

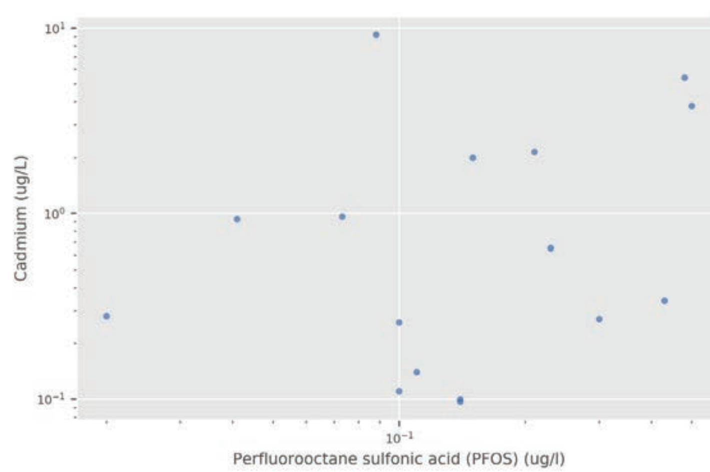

Mercury (ug/L)
Perfluorooctane sulfonic acid (PFOS) (ug/l)

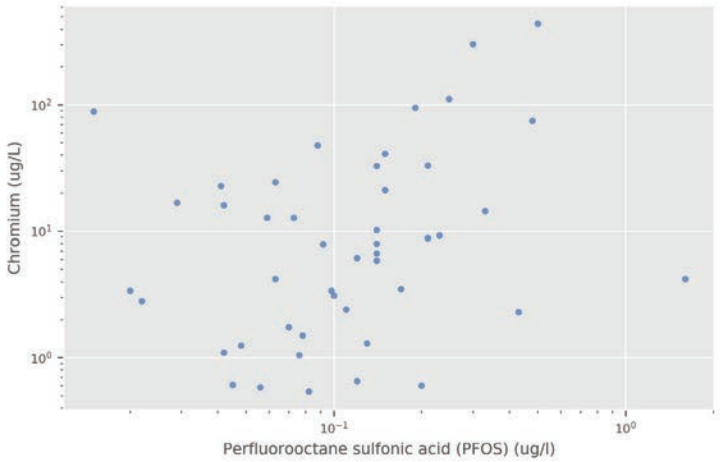

Barium (ug/L)
Perfluorooctane sulfonic acid (PFOS) (ug/l)

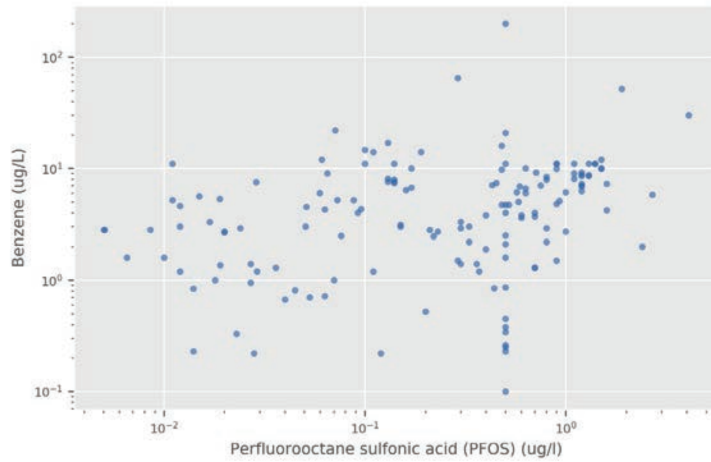

Nickel (ug/L)
Perfluorooctane sulfonic acid (PFOS) (ug/l)

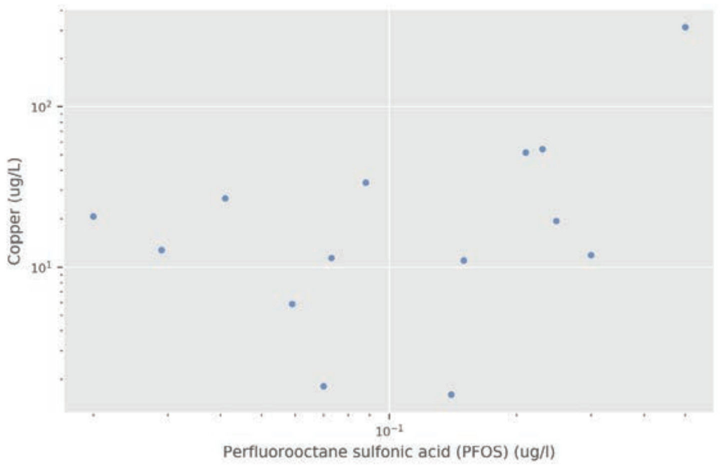

Boron (ug/L)
Perfluorooctane sulfonic acid (PFOS) (ug/l)

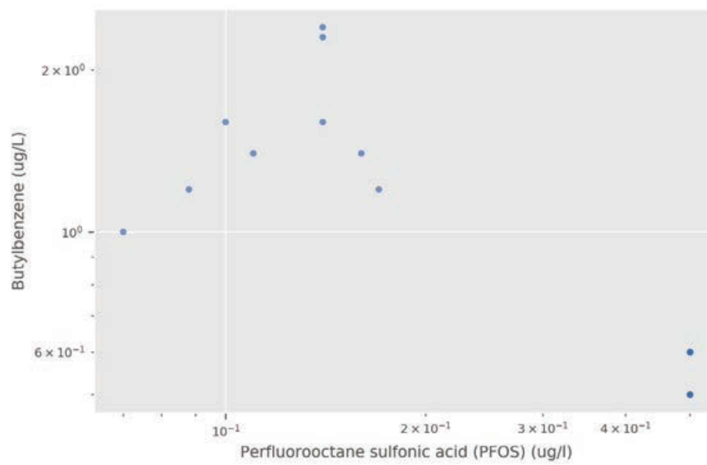

Sodium (ug/L)
Perfluorooctane sulfonic acid (PFOS) (ug/l)

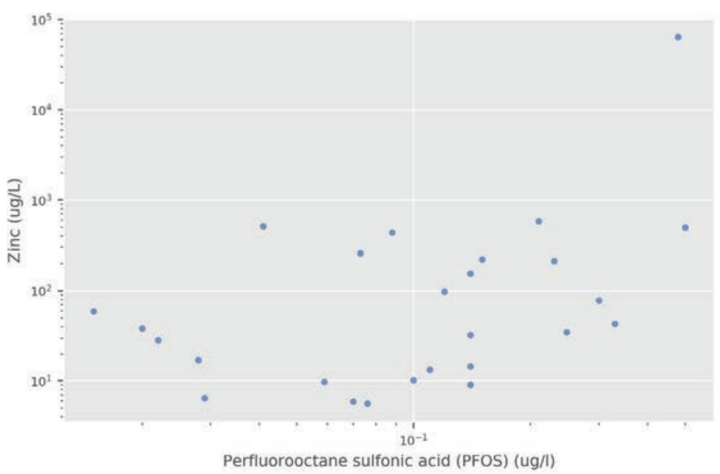

Cadmium (ug/L)
Perfluorooctane sulfonic acid (PFOS) (ug/l)

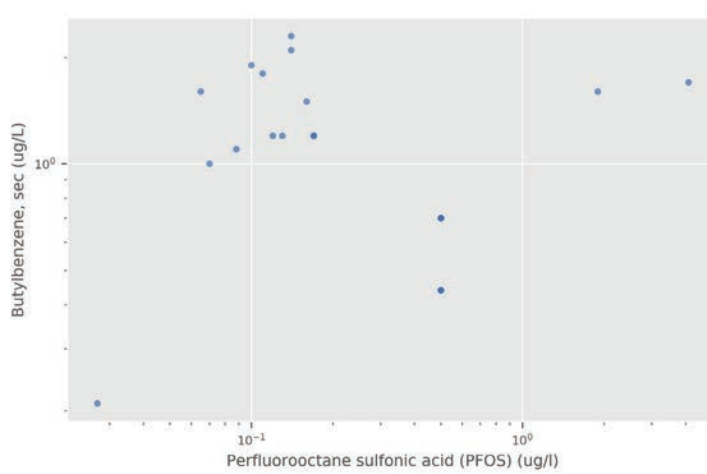

Chromium (ug/L)
10^0
10^1
10^2
10^{-1}
10^0
Perfluorooctane sulfonic acid (PFOS) (ug/l)

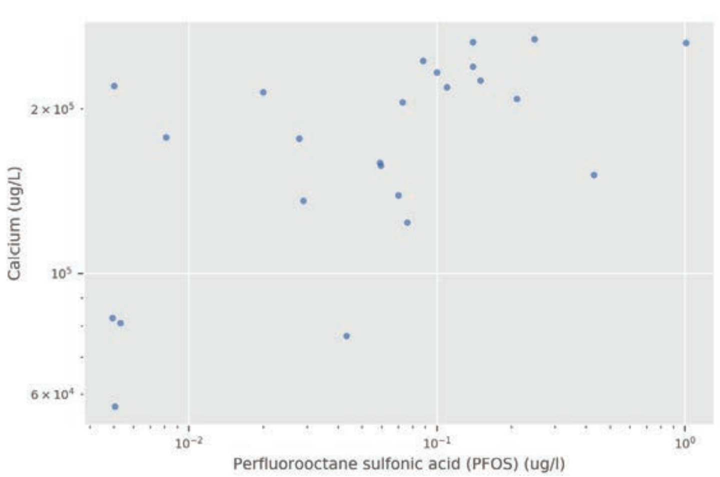

Benzene (ug/L)
10^2
10^1
10^0
10^{-1}
10^{-2}
10^{-1}
10^0
Perfluorooctane sulfonic acid (PFOS) (ug/l)

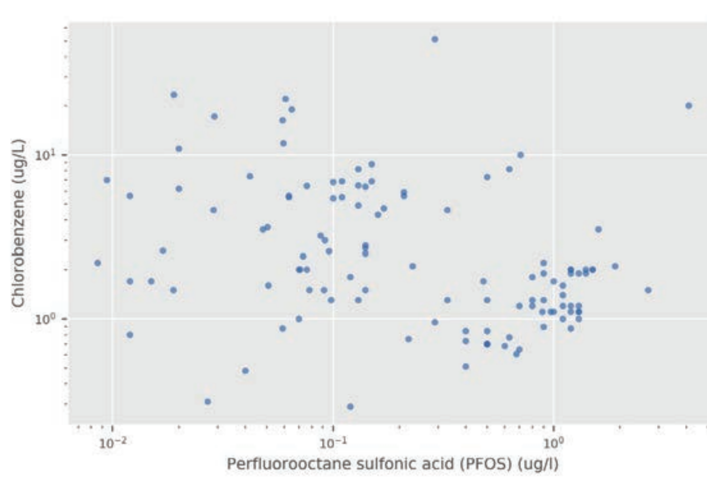

Copper (ug/L)
10^2
10^1
10^{-1}
Perfluorooctane sulfonic acid (PFOS) (ug/l)

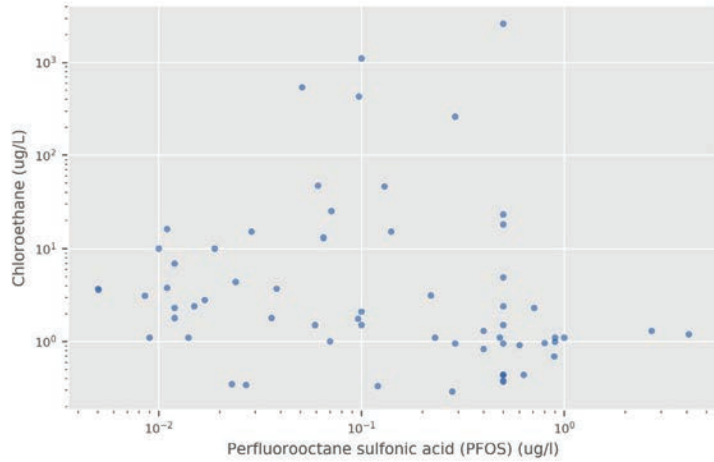

Butylbenzene (ug/L)
2×10^0
10^0
6×10^{-1}
10^{-1}
2×10^{-1}
3×10^{-1}
4×10^{-1}
Perfluorooctane sulfonic acid (PFOS) (ug/l)

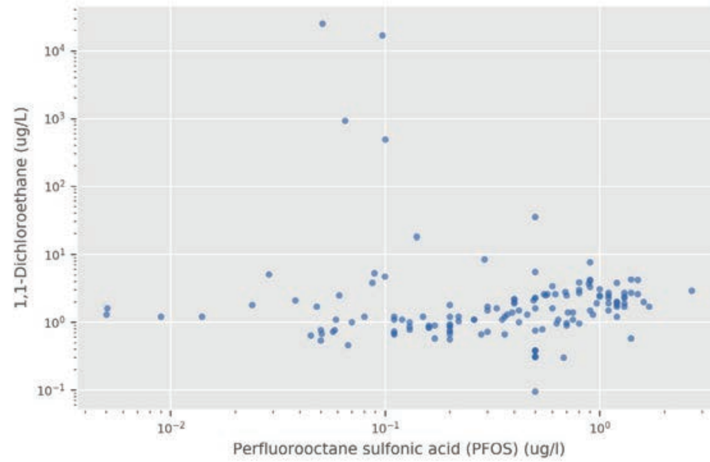

Zinc (ug/L)
10^5
10^4
10^3
10^2
10^1
10^{-1}
Perfluorooctane sulfonic acid (PFOS) (ug/l)

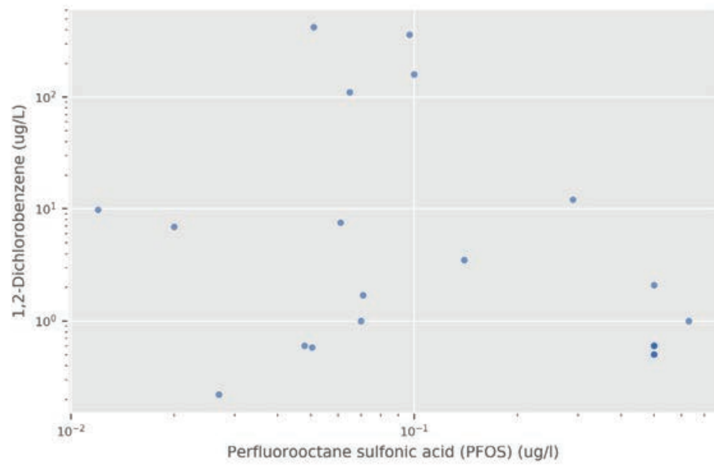

Butylbenzene, sec (ug/L)
10^0
10^{-1}
10^0
Perfluorooctane sulfonic acid (PFOS) (ug/l)

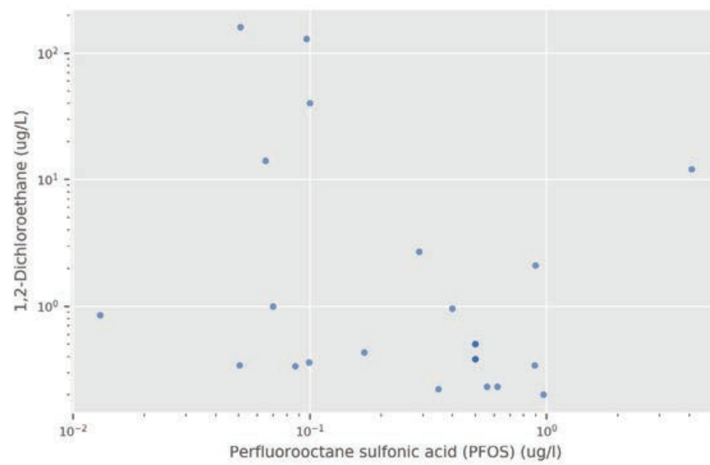

Calcium (ug/L)
2×10^5
10^5
6×10^4
10^{-2}
10^{-1}
10^0
Perfluorooctane sulfonic acid (PFOS) (ug/l)

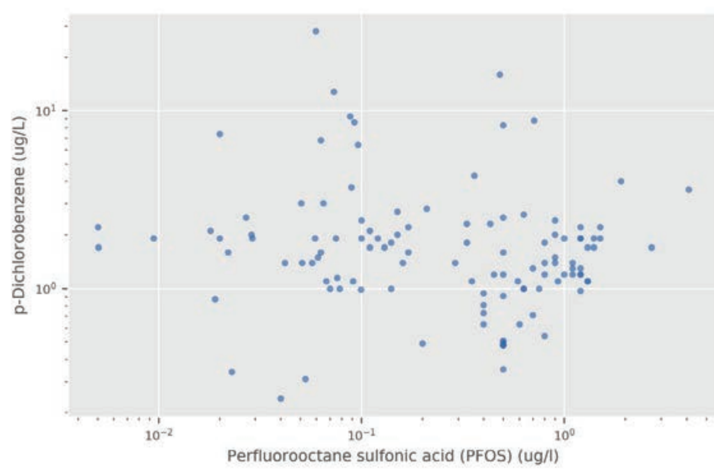

Chlorobenzene (ug/L)
10^1
10^0
10^{-2}
10^{-1}
10^0
Perfluorooctane sulfonic acid (PFOS) (ug/l)

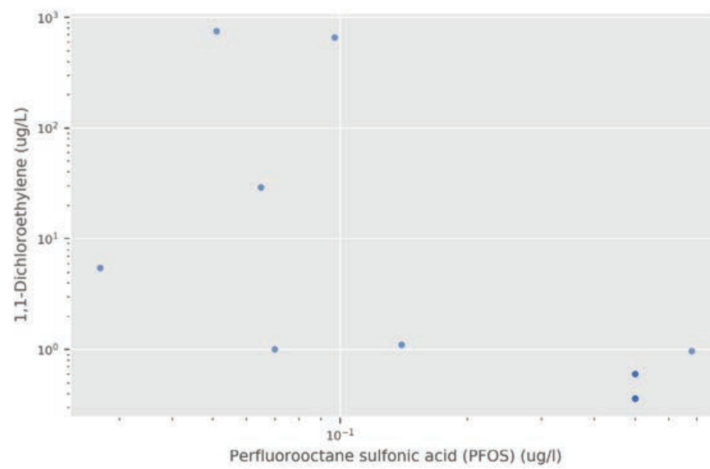

Chloroethane (ug/L)
Perfluorooctane sulfonic acid (PFOS) (ug/l)

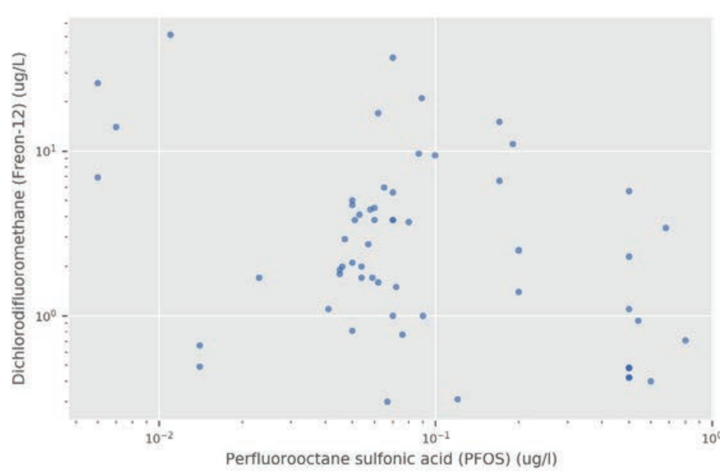

1,1-Dichloroethane (ug/L)
Perfluorooctane sulfonic acid (PFOS) (ug/l)

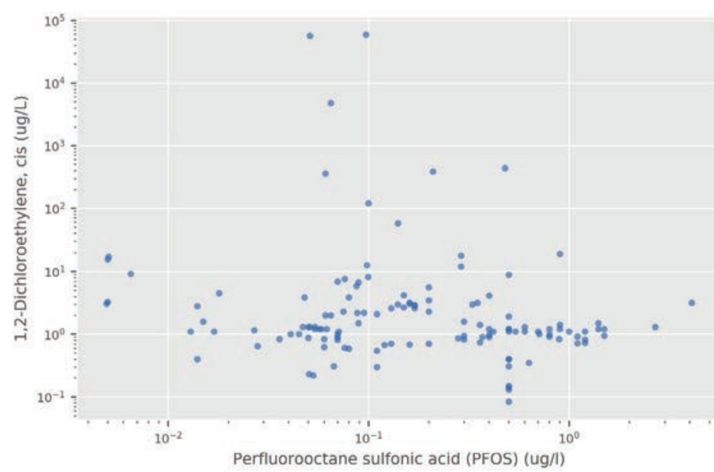

1,2-Dichlorobenzene (ug/L)
Perfluorooctane sulfonic acid (PFOS) (ug/l)

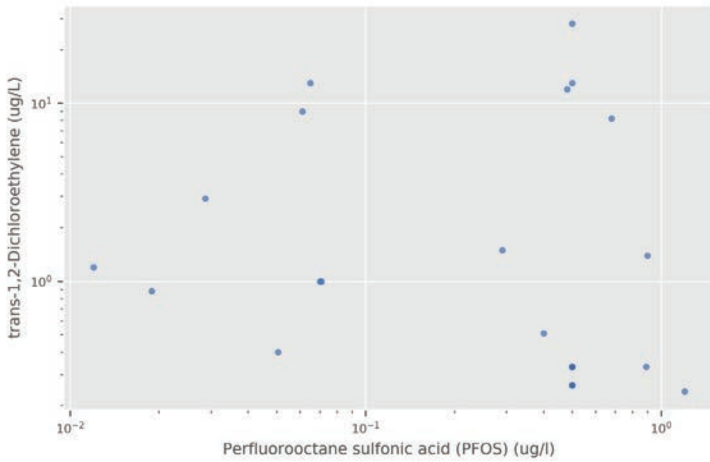

1,2-Dichloroethane (ug/L)
Perfluorooctane sulfonic acid (PFOS) (ug/l)

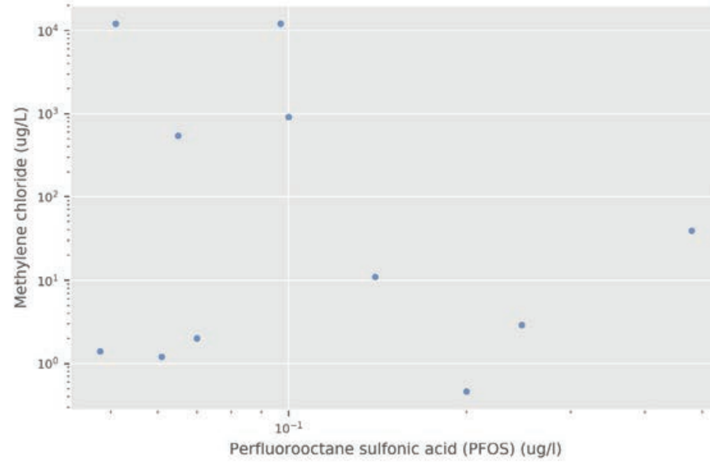

p-Dichlorobenzene (ug/L)
Perfluorooctane sulfonic acid (PFOS) (ug/l)

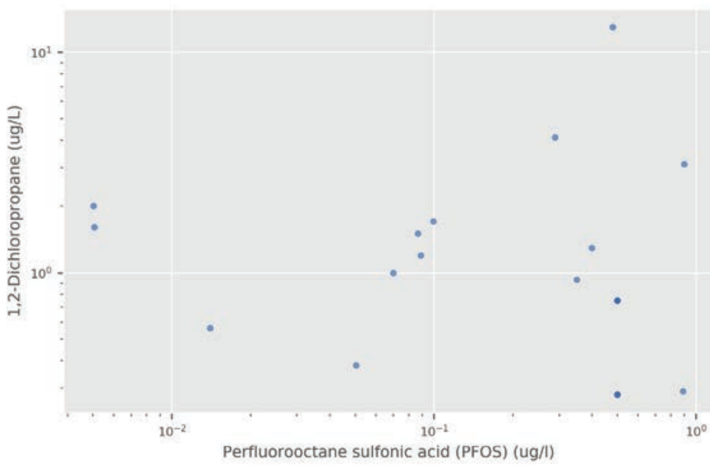

1,1-Dichloroethylene (ug/L)
Perfluorooctane sulfonic acid (PFOS) (ug/l)

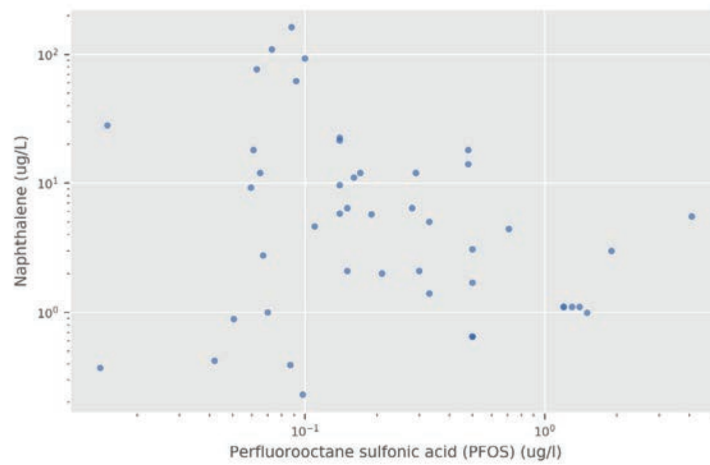

Dichlorodifluoromethane (Freon-12) (ug/L)
Perfluorooctane sulfonic acid (PFOS) (ug/l)

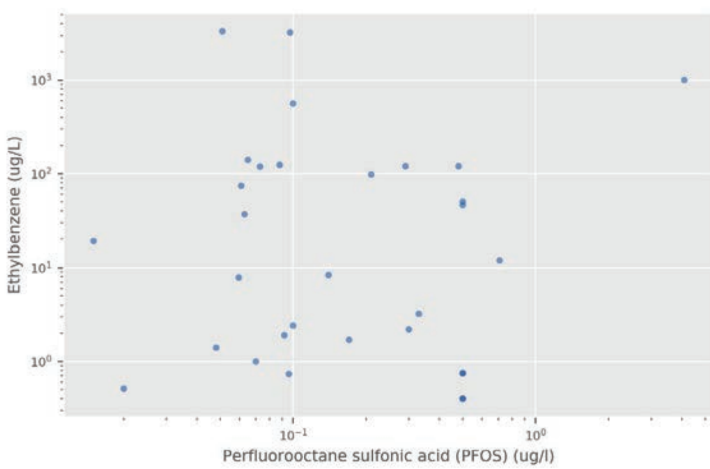

1,2-Dichloroethylene, cis (ug/L)
Perfluorooctane sulfonic acid (PFOS) (ug/l)

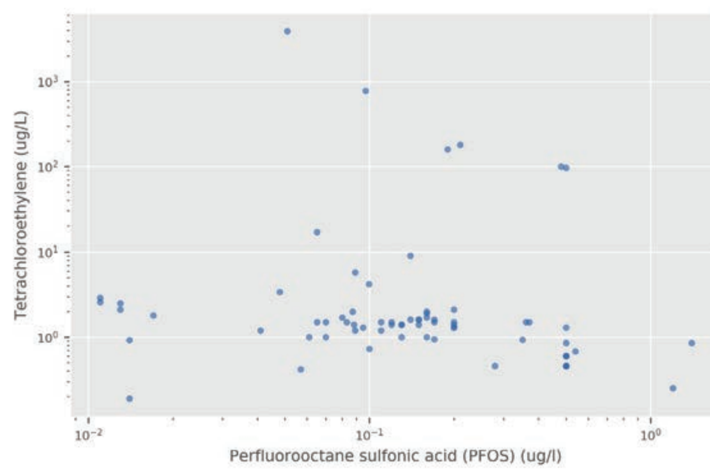

trans-1,2-Dichloroethylene (ug/L)
Perfluorooctane sulfonic acid (PFOS) (ug/l)
10^{1}
10^{0}
10^{-2}
10^{-1}
10^{0}

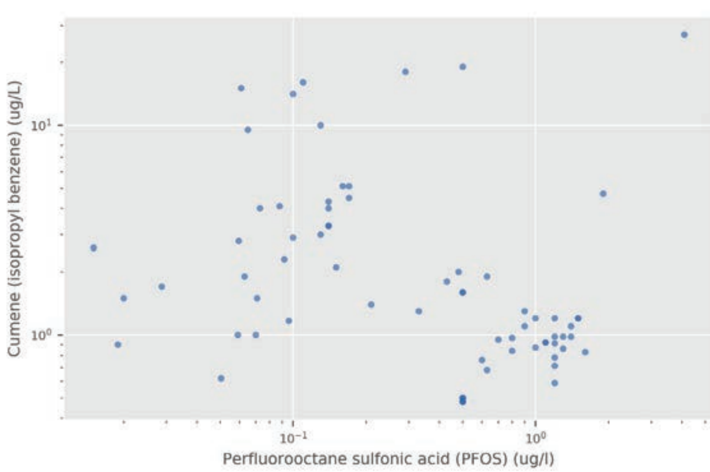

Methylene chloride (ug/L)
Perfluorooctane sulfonic acid (PFOS) (ug/l)
10^{4}
10^{3}
10^{2}
10^{1}
10^{0}
10^{-1}

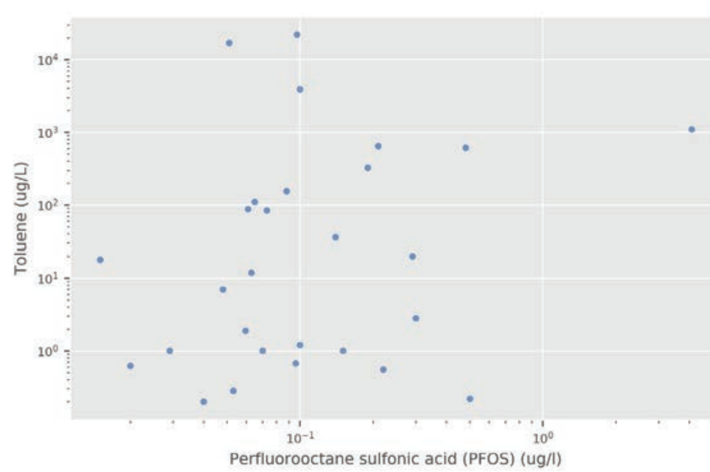

1,2-Dichloropropane (ug/L)
Perfluorooctane sulfonic acid (PFOS) (ug/l)
10^{1}
10^{0}
10^{-2}
10^{-1}
10^{0}

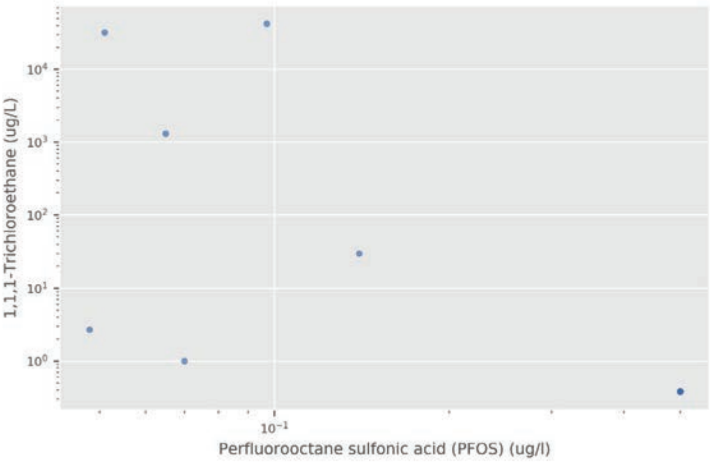

Naphthalene (ug/L)
Perfluorooctane sulfonic acid (PFOS) (ug/l)
10^{2}
10^{1}
10^{0}
10^{-1}
10^{0}

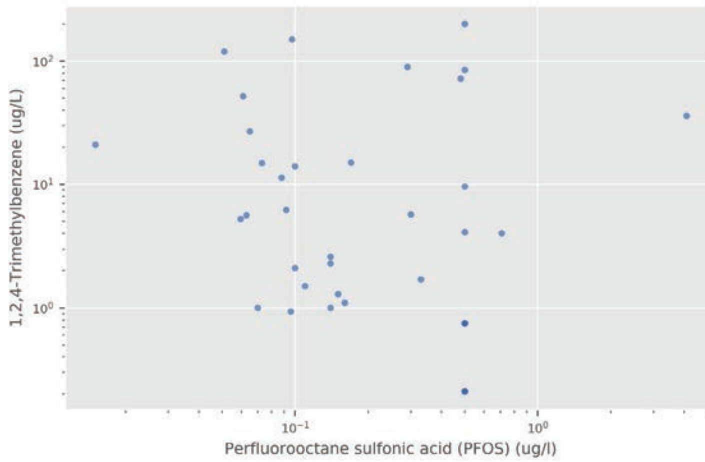

Ethylbenzene (ug/L)
Perfluorooctane sulfonic acid (PFOS) (ug/l)
10^{3}
10^{2}
10^{1}
10^{0}
10^{-1}
10^{0}

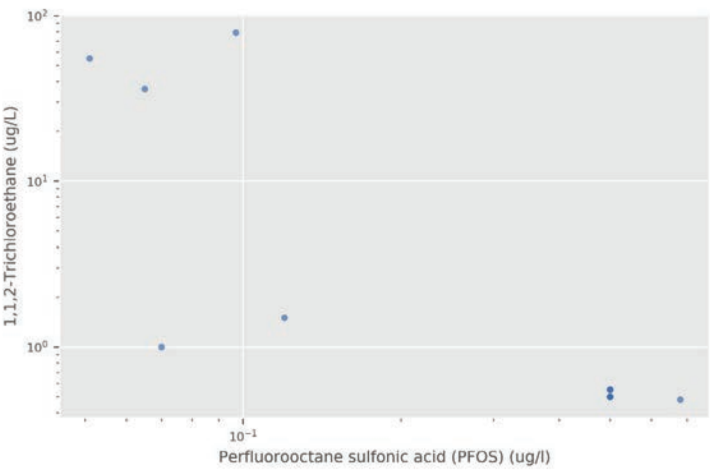

Tetrachloroethylene (ug/L)
Perfluorooctane sulfonic acid (PFOS) (ug/l)
10^{3}
10^{2}
10^{1}
10^{0}
10^{-2}
10^{-1}
10^{0}

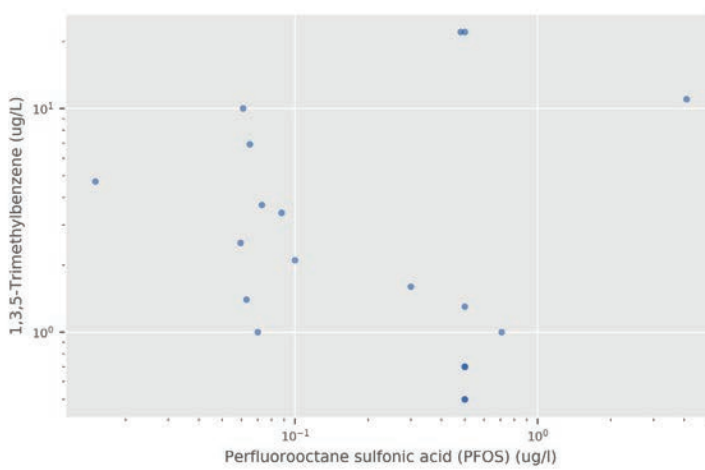

Cumene (isopropyl benzene) (ug/L)
Perfluorooctane sulfonic acid (PFOS) (ug/l)
10^{1}
10^{0}
10^{-1}
10^{0}

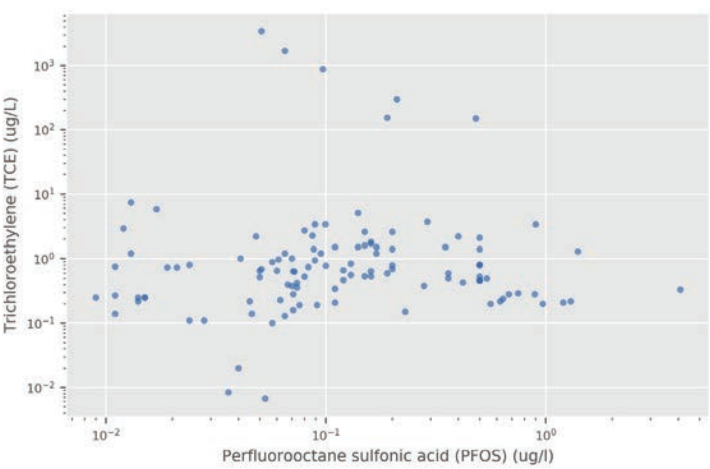

Toluene (ug/L)
Perfluorooctane sulfonic acid (PFOS) (ug/l)
10^{4}
10^{3}
10^{2}
10^{1}
10^{0}
10^{-1}
10^{0}

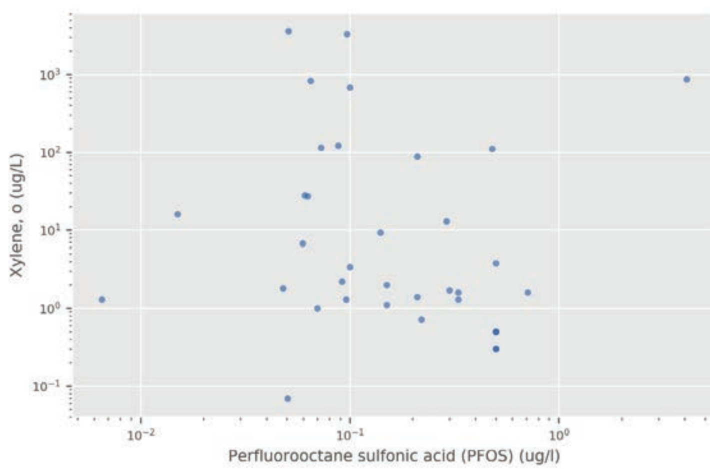

1,1,1-Trichloroethane (ug/L)
10^{4}
10^{3}
10^{2}
10^{1}
10^{0}
10^{-1}
Perfluorooctane sulfonic acid (PFOS) (ug/l)

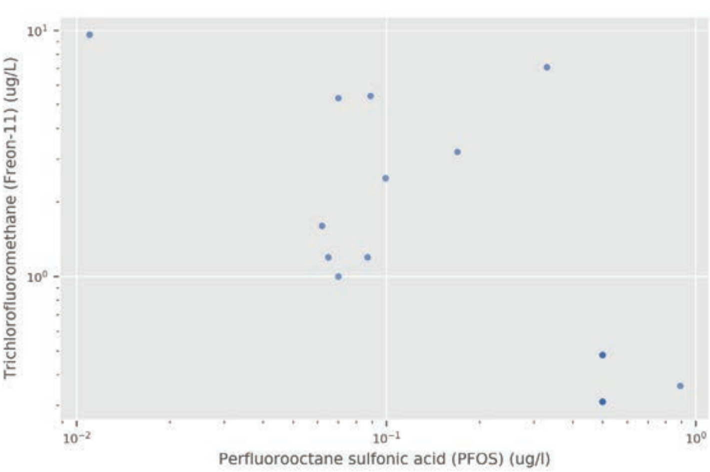

1,2,4-Trimethylbenzene (ug/L)
10^{2}
10^{1}
10^{0}
10^{-1}
10^{0}
Perfluorooctane sulfonic acid (PFOS) (ug/l)

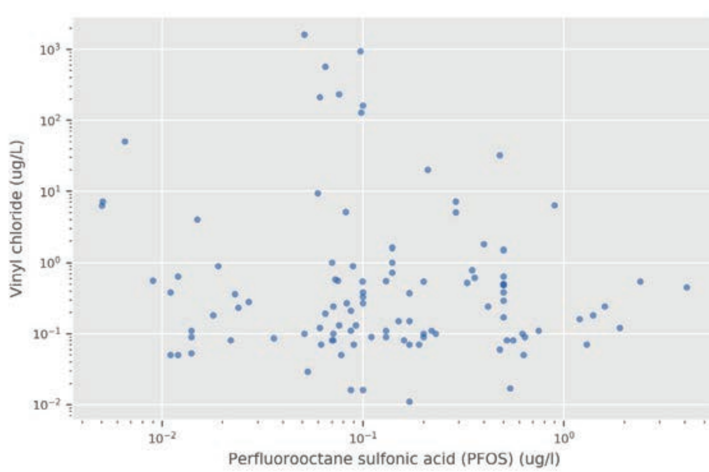

1,1,2-Trichloroethane (ug/L)
10^{2}
10^{1}
10^{0}
10^{-1}
Perfluorooctane sulfonic acid (PFOS) (ug/l)

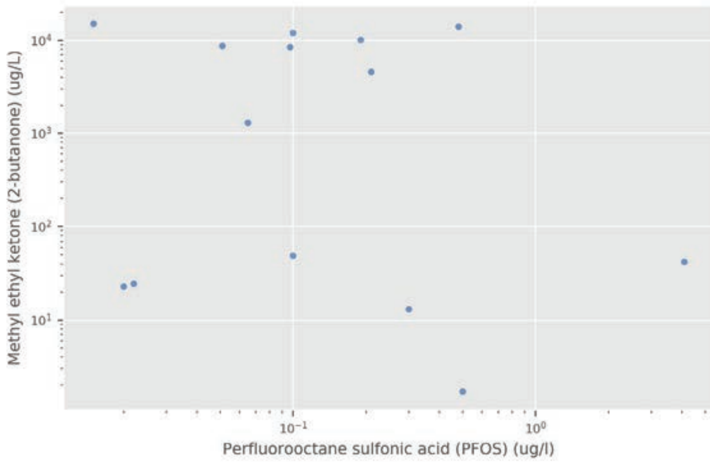

1,3,5-Trimethylbenzene (ug/L)
10^{1}
10^{0}
10^{-1}
10^{0}
Perfluorooctane sulfonic acid (PFOS) (ug/l)

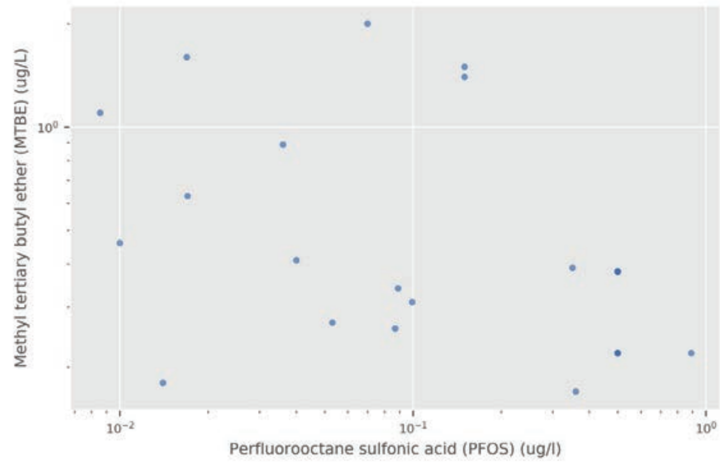

Trichloroethylene (TCE) (ug/L)
10^{3}
10^{2}
10^{1}
10^{0}
10^{-1}
10^{-2}
10^{-2}
10^{-1}
10^{0}
Perfluorooctane sulfonic acid (PFOS) (ug/l)

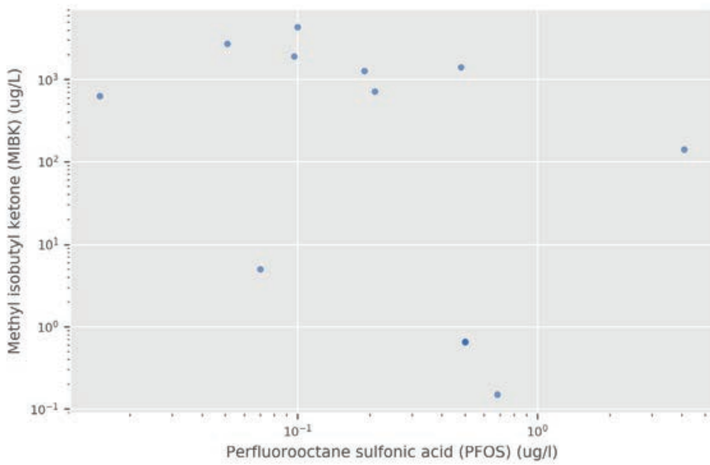

Xylene, o (ug/L)
10^{3}
10^{2}
10^{1}
10^{0}
10^{-1}
10^{-2}
10^{-1}
10^{0}
Perfluorooctane sulfonic acid (PFOS) (ug/l)

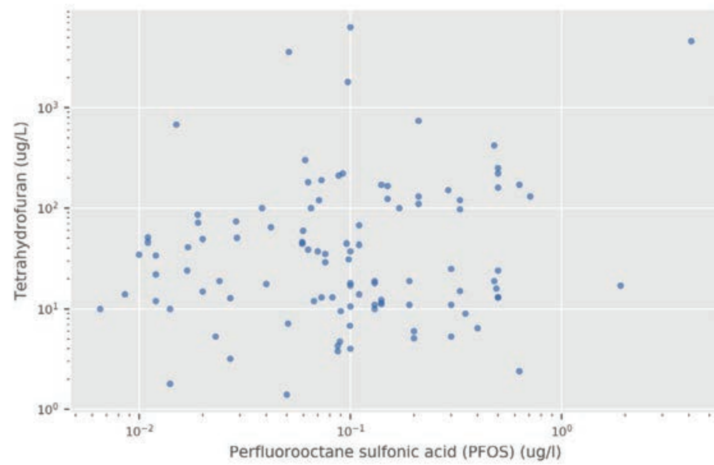

Trichlorofluoromethane (Freon-11) (ug/L)
10^{1}
10^{0}
10^{-2}
10^{-1}
10^{0}
Perfluorooctane sulfonic acid (PFOS) (ug/l)

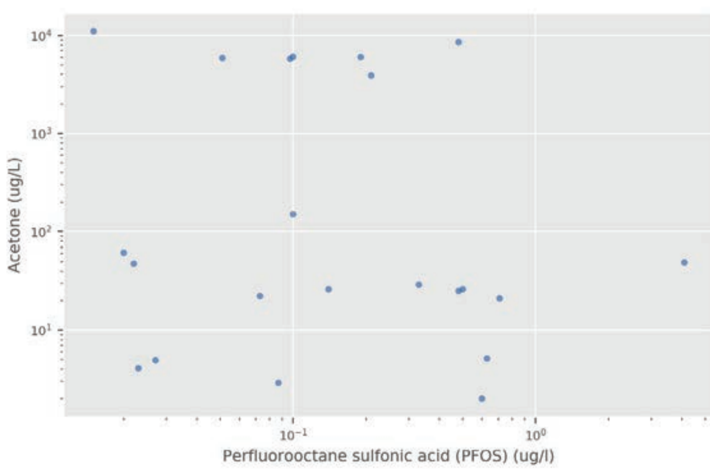

Vinyl chloride (ug/L)
10^{3}
10^{2}
10^{1}
10^{0}
10^{-1}
10^{-2}
10^{-2}
10^{-1}
10^{0}
Perfluorooctane sulfonic acid (PFOS) (ug/l)

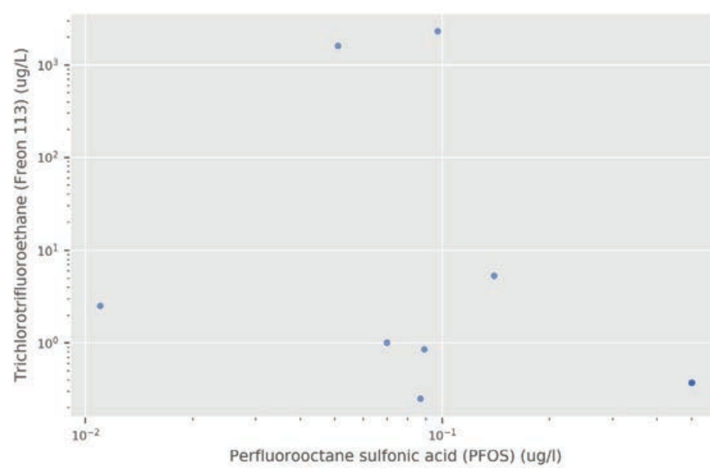

Methyl ethyl ketone (2-butanone) (ug/L)
Perfluorooctane sulfonic acid (PFOS) (ug/l)

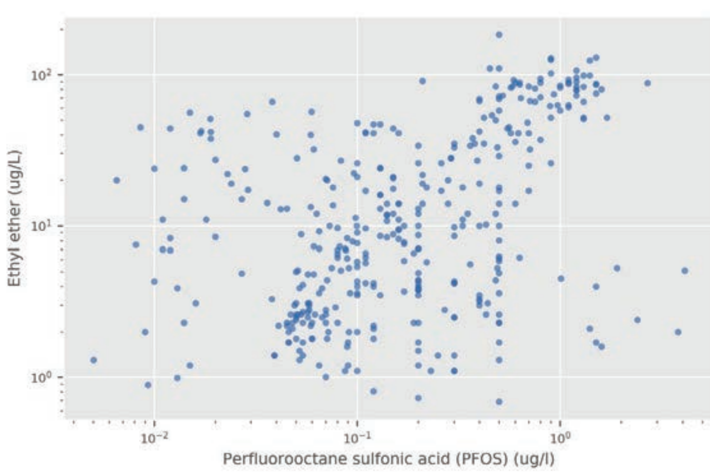

Methyl tertiary butyl ether (MTBE) (ug/L)
Perfluorooctane sulfonic acid (PFOS) (ug/l)

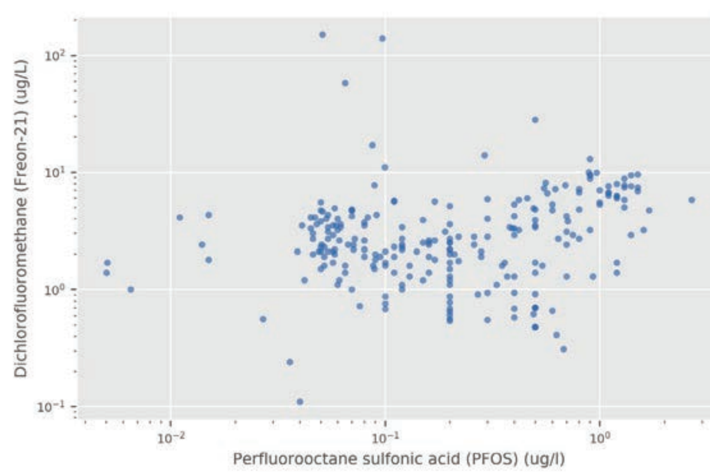

Methyl isobutyl ketone (MIBK) (ug/L)
Perfluorooctane sulfonic acid (PFOS) (ug/l)

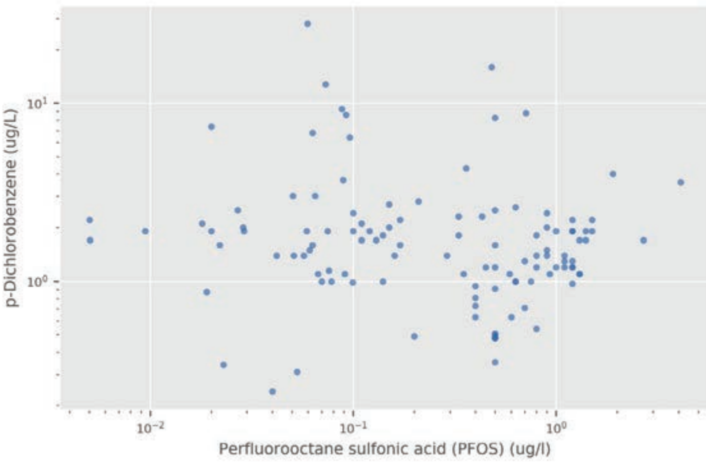

Tetrahydrofuran (ug/L)
Perfluorooctane sulfonic acid (PFOS) (ug/l)

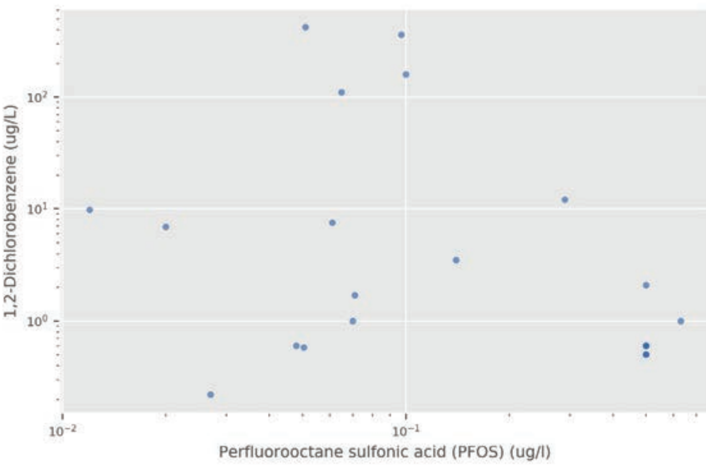

Acetone (ug/L)
Perfluorooctane sulfonic acid (PFOS) (ug/l)

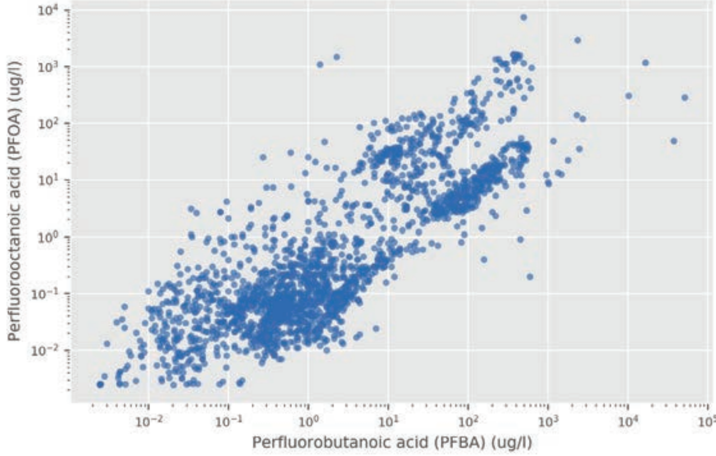

Trichlorotrifluoroethane (Freon 113) (ug/L)
Perfluorooctane sulfonic acid (PFOS) (ug/l)

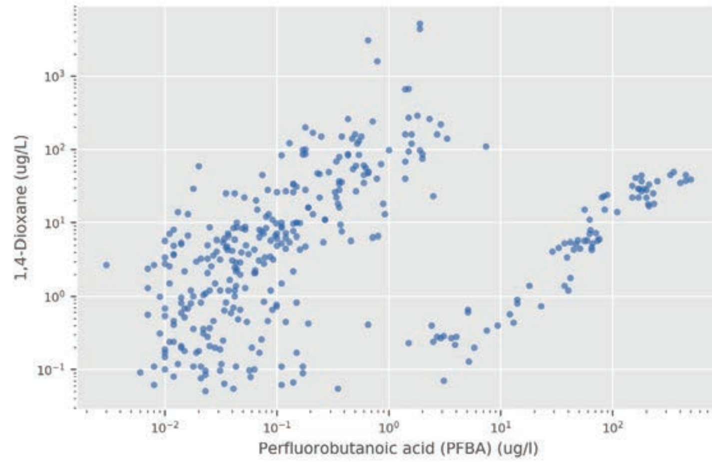

Ethyl ether (ug/L)
Perfluorooctane sulfonic acid (PFOS) (ug/l)

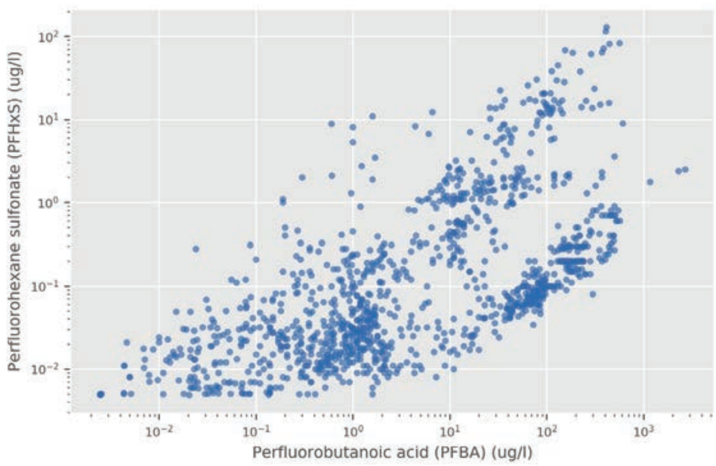

Dichlorofluoromethane (Freon-21) (ug/L)
Perfluorooctane sulfonic acid (PFOS) (ug/l)

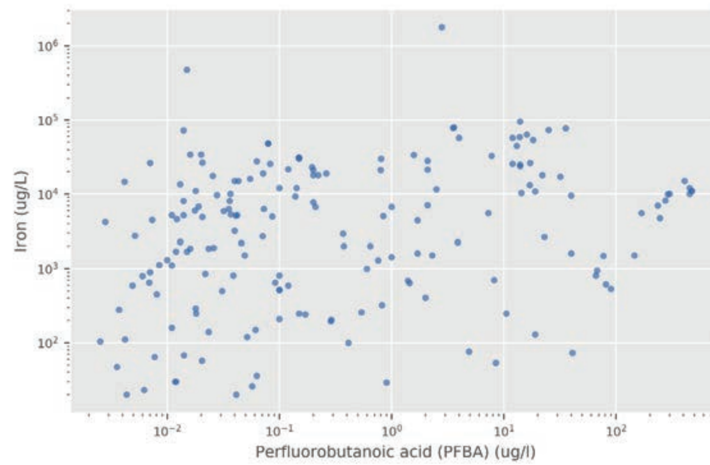

p-Dichlorobenzene (ug/L)
Perfluorooctane sulfonic acid (PFOS) (ug/l)

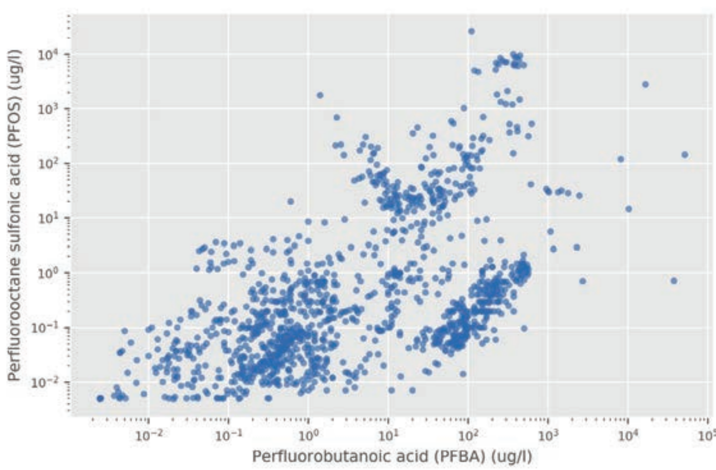

1,2-Dichlorobenzene (ug/L)
Perfluorooctane sulfonic acid (PFOS) (ug/l)

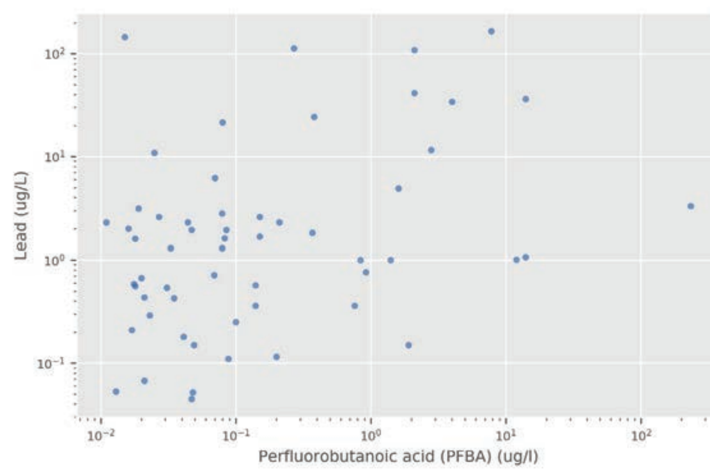

Perfluorooctanoic acid (PFOA) (ug/l)
Perfluorobutanoic acid (PFBA) (ug/l)

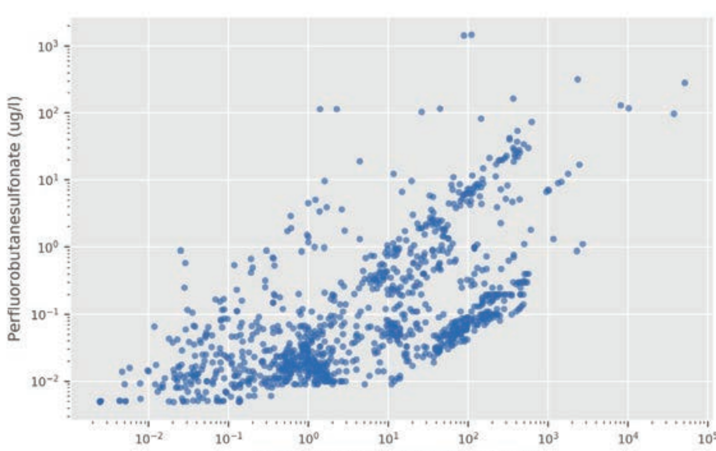

1,4-Dioxane (ug/L)
Perfluorobutanoic acid (PFBA) (ug/l)

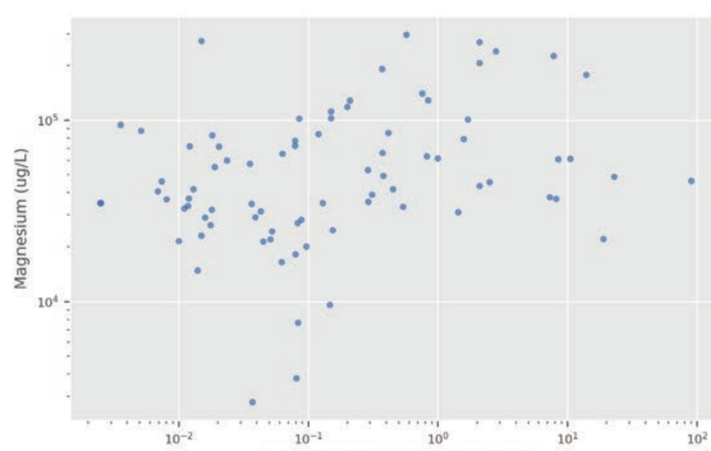

Perfluorohexane sulfonate (PFHxS) (ug/l)
Perfluorobutanoic acid (PFBA) (ug/l)

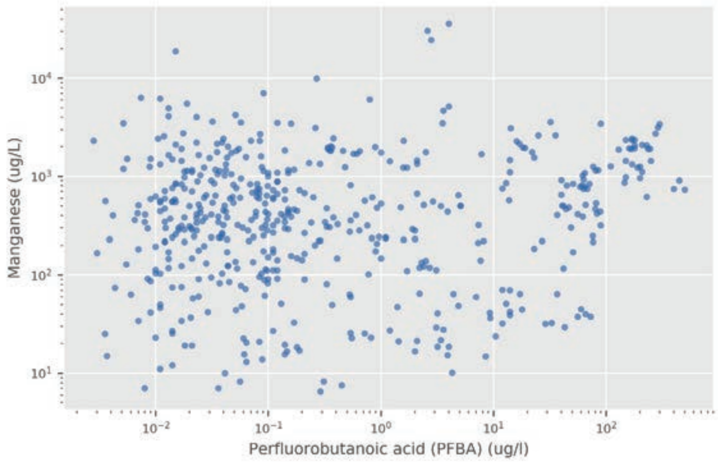

Iron (ug/L)
Perfluorobutanoic acid (PFBA) (ug/l)

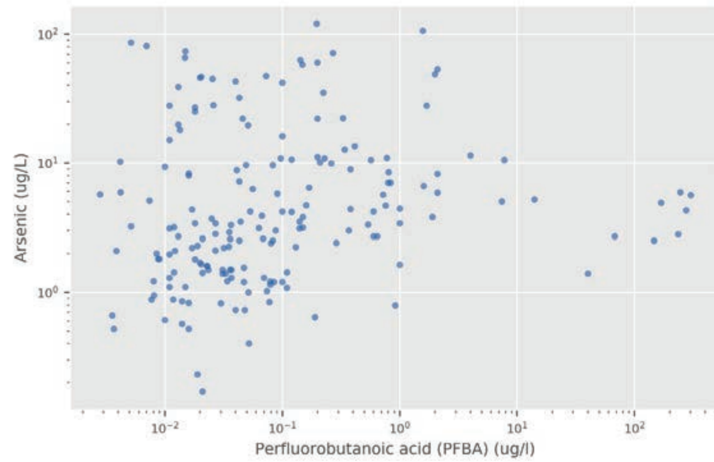

Perfluorooctane sulfonic acid (PFOS) (ug/l)
Perfluorobutanoic acid (PFBA) (ug/l)

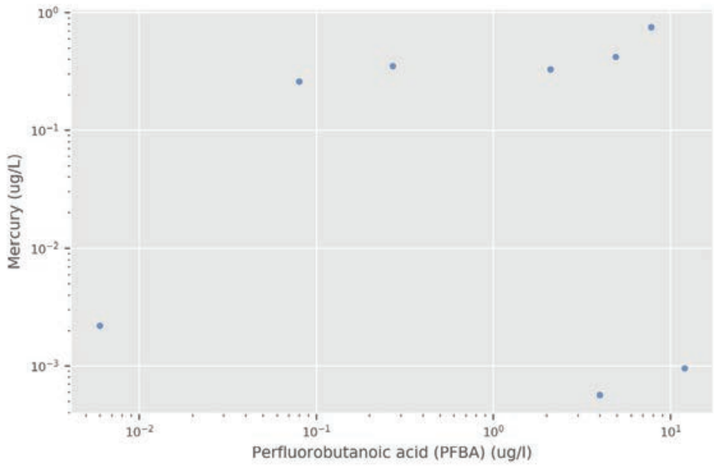

Lead (ug/L)
Perfluorobutanoic acid (PFBA) (ug/l)

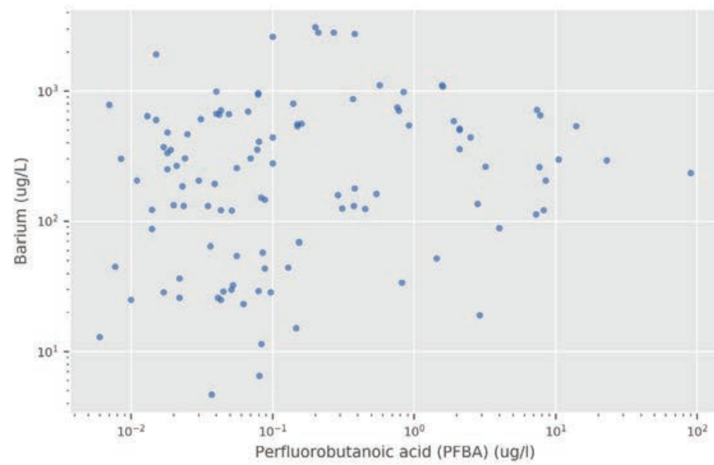

Perfluorobutanesulfonate (ug/l)
Perfluorobutanoic acid (PFBA) (ug/l)

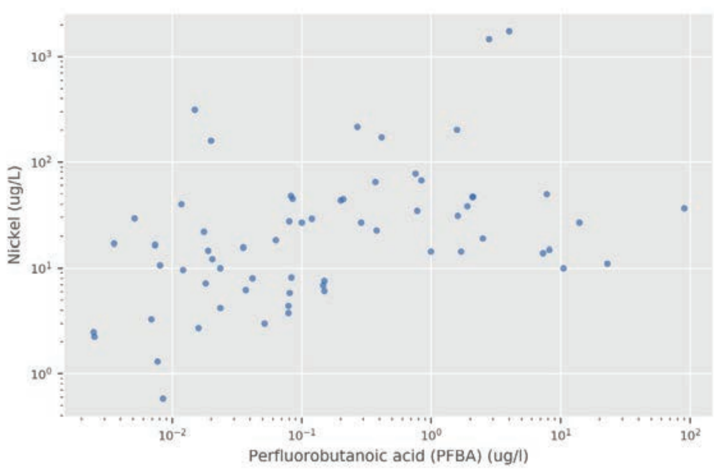

Magnesium (ug/L)
Perfluorobutanoic acid (PFBA) (ug/l)

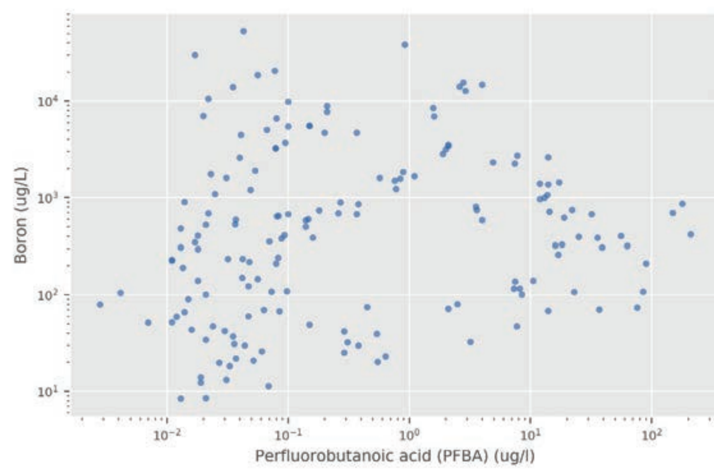

Manganese (ug/L)
Perfluorobutanoic acid (PFBA) (ug/l)

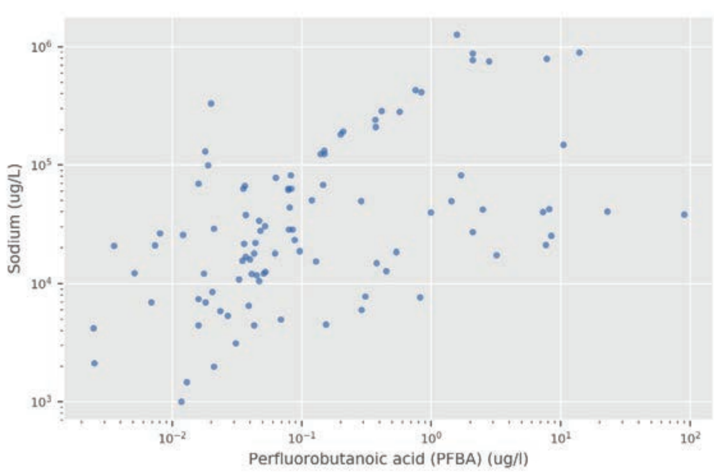

Arsenic (ug/L)
Perfluorobutanoic acid (PFBA) (ug/l)

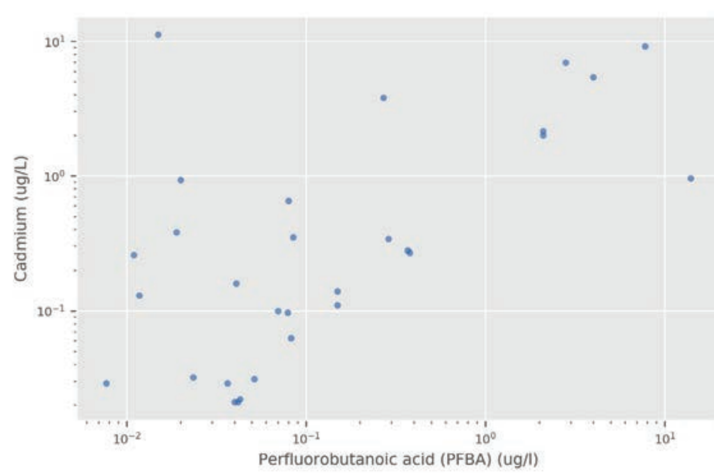

Mercury (ug/L)
Perfluorobutanoic acid (PFBA) (ug/l)

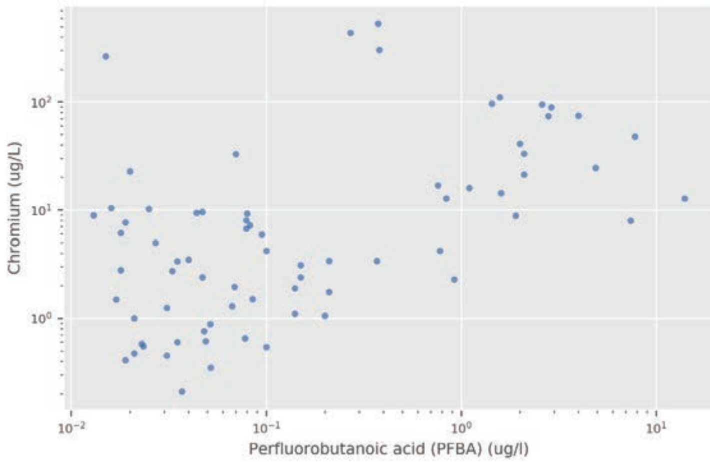

Barium (ug/L)
Perfluorobutanoic acid (PFBA) (ug/l)

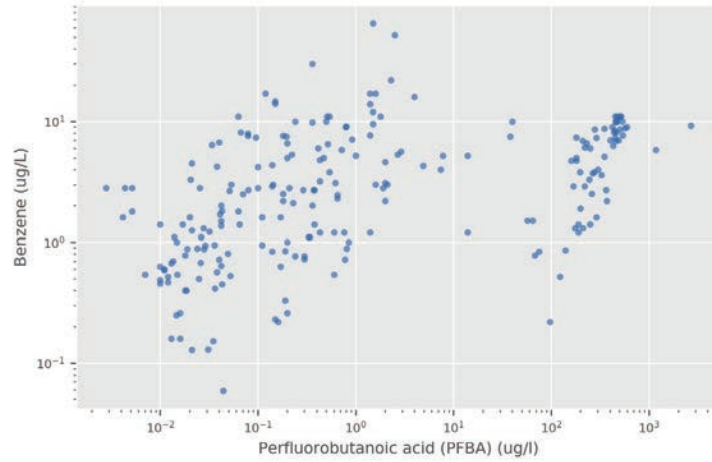

Nickel (ug/L)
Perfluorobutanoic acid (PFBA) (ug/l)

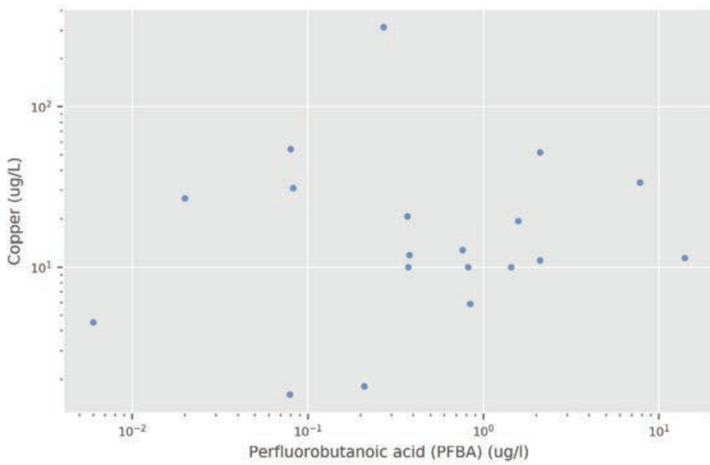

Boron (ug/L)
Perfluorobutanoic acid (PFBA) (ug/l)

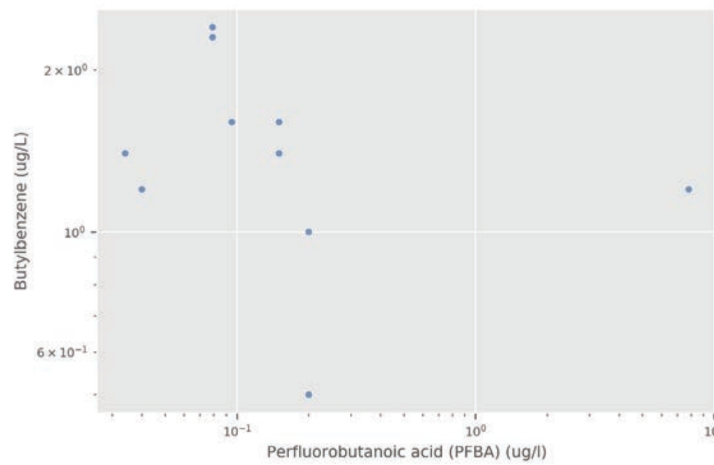

Sodium (ug/L)
Perfluorobutanoic acid (PFBA) (ug/l)

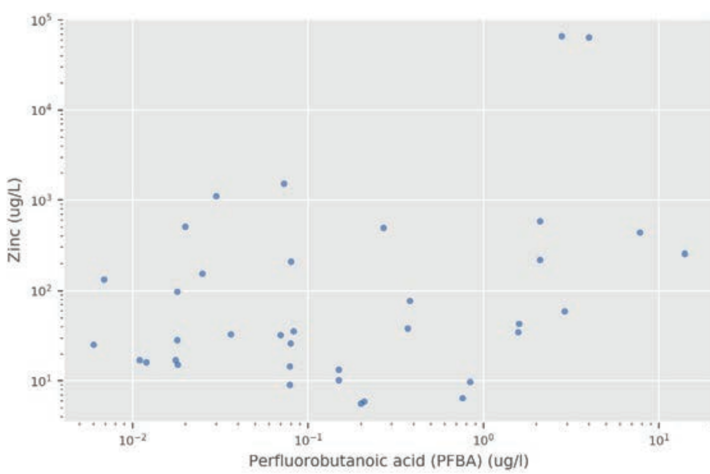

Cadmium (ug/L)
Perfluorobutanoic acid (PFBA) (ug/l)

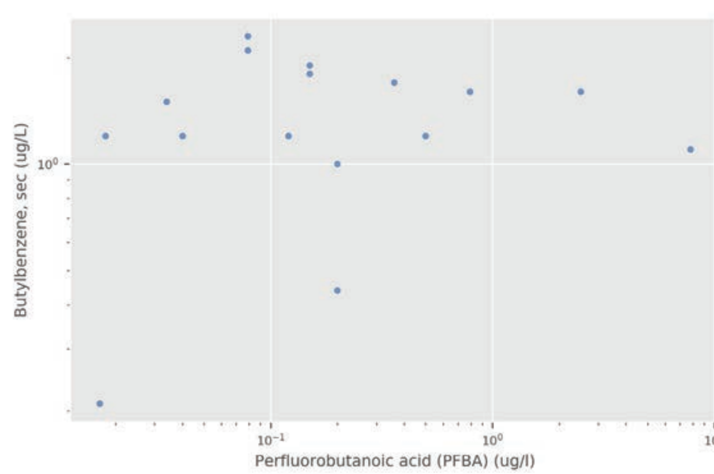

Chromium (ug/L)
Perfluorobutanoic acid (PFBA) (ug/l)

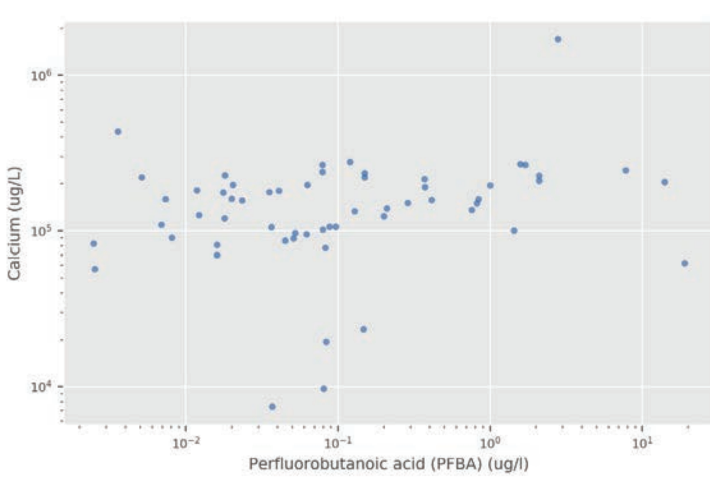

Benzene (ug/L)
Perfluorobutanoic acid (PFBA) (ug/l)

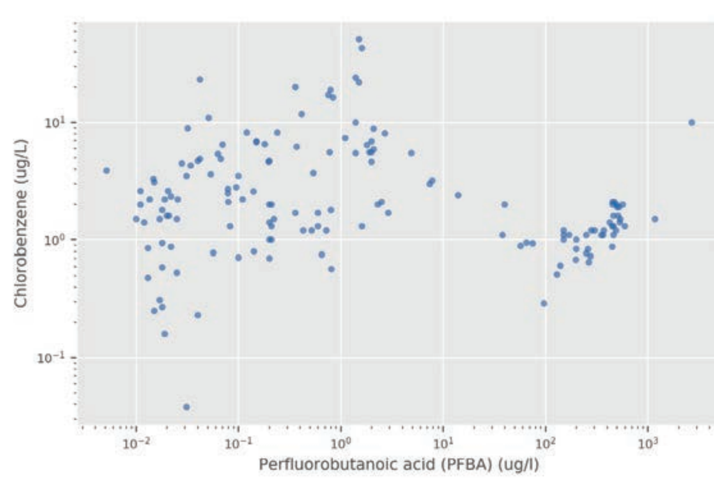

Copper (ug/L)
Perfluorobutanoic acid (PFBA) (ug/l)

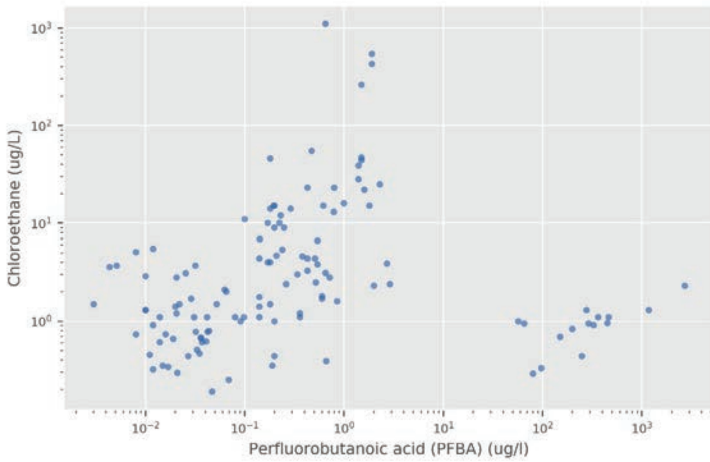

Butylbenzene (ug/L)
Perfluorobutanoic acid (PFBA) (ug/l)

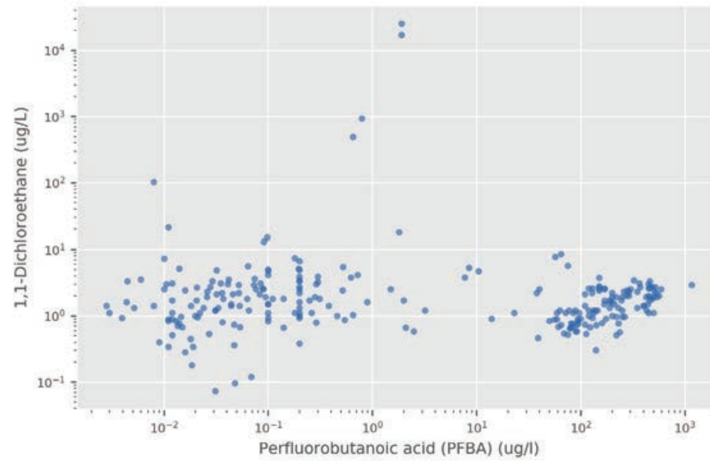

Zinc (ug/L)
Perfluorobutanoic acid (PFBA) (ug/l)

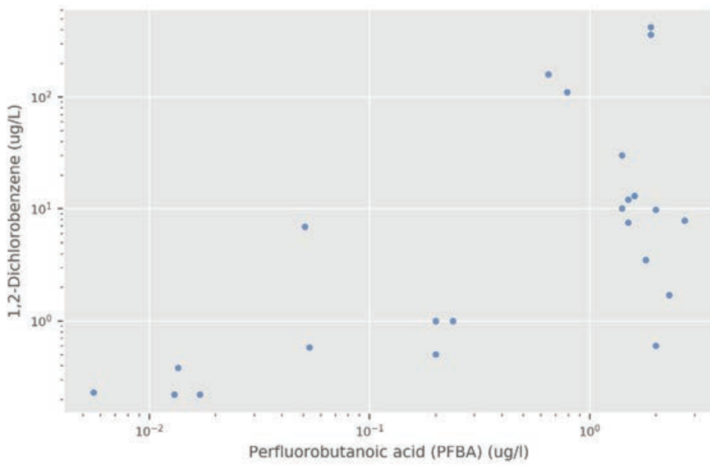

Butylbenzene, sec (ug/L)
Perfluorobutanoic acid (PFBA) (ug/l)

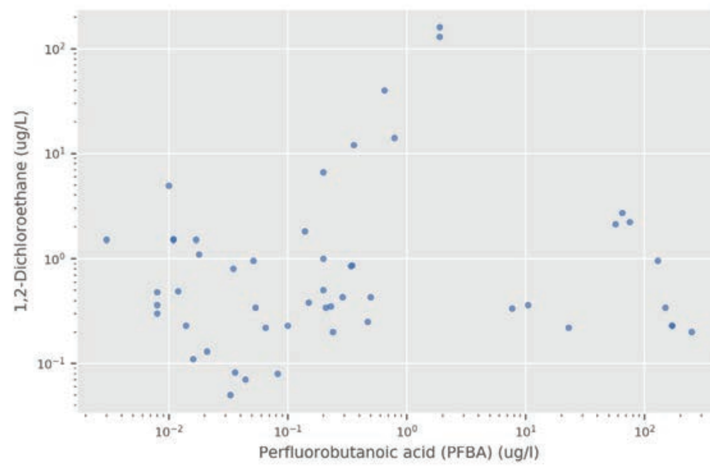

Calcium (ug/L)
Perfluorobutanoic acid (PFBA) (ug/l)

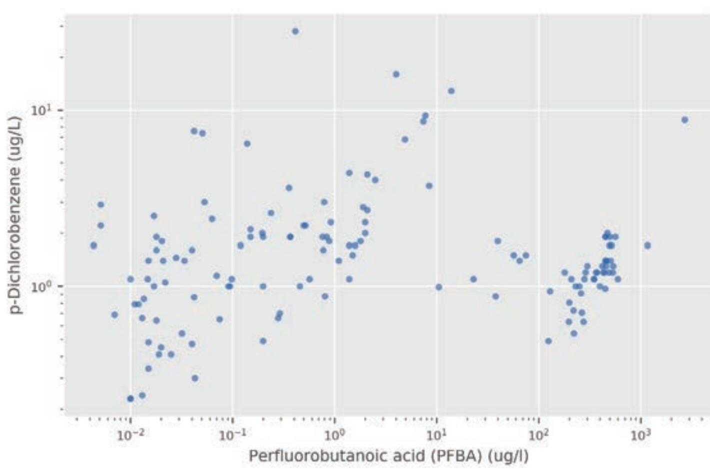

Chlorobenzene (ug/L)
Perfluorobutanoic acid (PFBA) (ug/l)

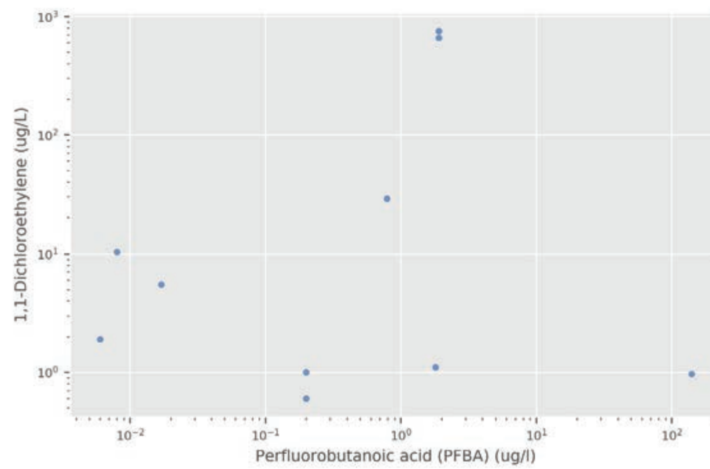

Chloroethane (ug/L)
Perfluorobutanoic acid (PFBA) (ug/l)
10^{-2} 10^{-1} 10^{0} 10^{1} 10^{2} 10^{3}
10^{0} 10^{1} 10^{2} 10^{3}

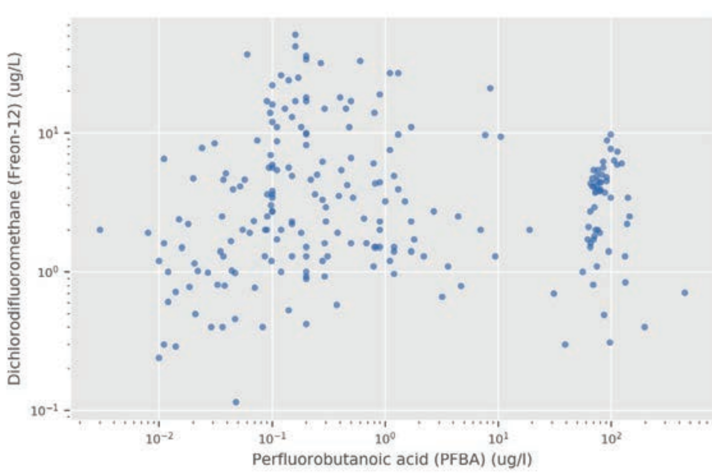

1,1-Dichloroethane (ug/L)
Perfluorobutanoic acid (PFBA) (ug/l)
10^{-2} 10^{-1} 10^{0} 10^{1} 10^{2} 10^{3}
10^{-1} 10^{0} 10^{1} 10^{2} 10^{3} 10^{4}

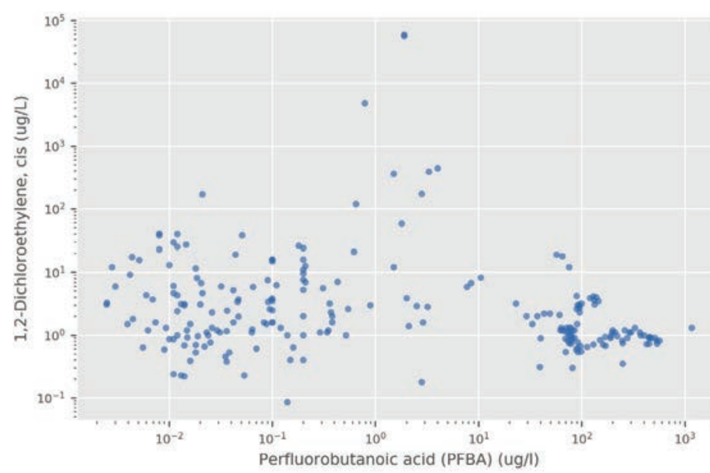

1,2-Dichlorobenzene (ug/L)
Perfluorobutanoic acid (PFBA) (ug/l)
10^{-2} 10^{-1} 10^{0}
10^{0} 10^{1} 10^{2}

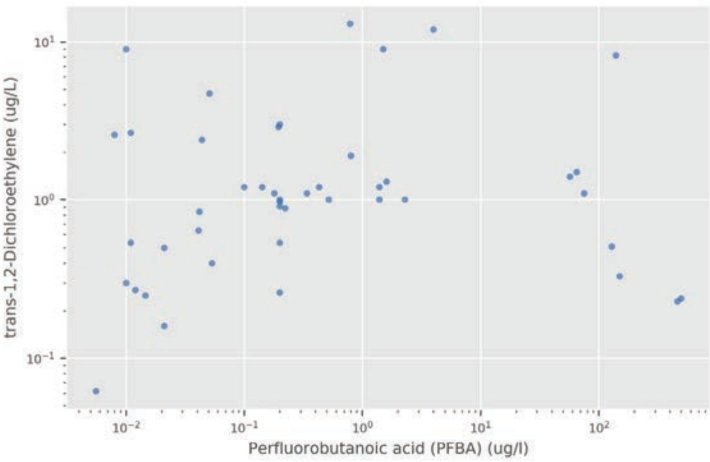

1,2-Dichloroethane (ug/L)
Perfluorobutanoic acid (PFBA) (ug/l)
10^{-2} 10^{-1} 10^{0} 10^{1} 10^{2}
10^{-1} 10^{0} 10^{1} 10^{2}

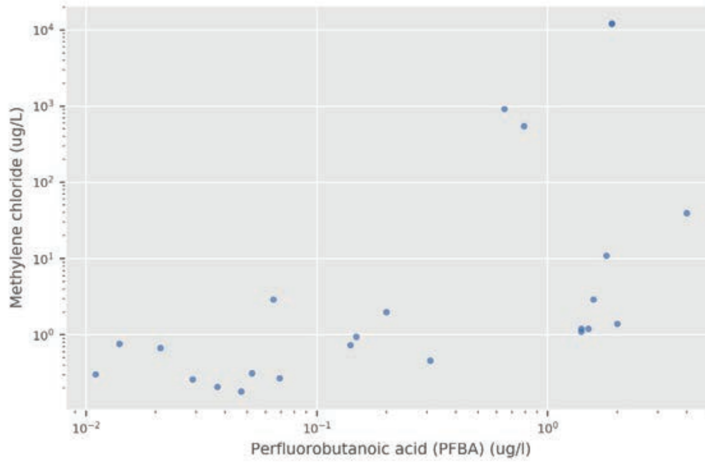

p-Dichlorobenzene (ug/L)
Perfluorobutanoic acid (PFBA) (ug/l)
10^{-2} 10^{-1} 10^{0} 10^{1} 10^{2} 10^{3}
10^{0} 10^{1}

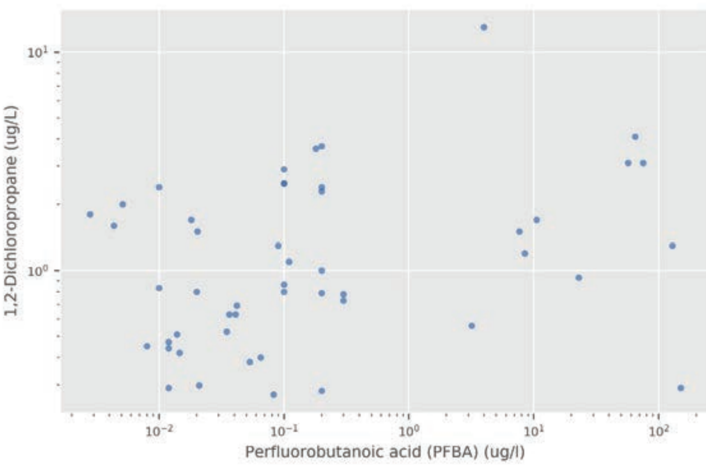

1,1-Dichloroethylene (ug/L)
Perfluorobutanoic acid (PFBA) (ug/l)
10^{-2} 10^{-1} 10^{0} 10^{1} 10^{2}
10^{0} 10^{1} 10^{2} 10^{3}

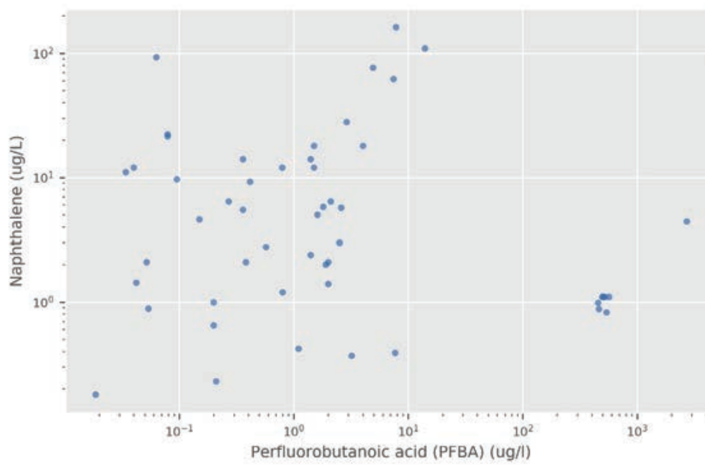

Dichlorodifluoromethane (Freon-12) (ug/L)
Perfluorobutanoic acid (PFBA) (ug/l)
10^{-2} 10^{-1} 10^{0} 10^{1} 10^{2}
10^{-1} 10^{0} 10^{1}

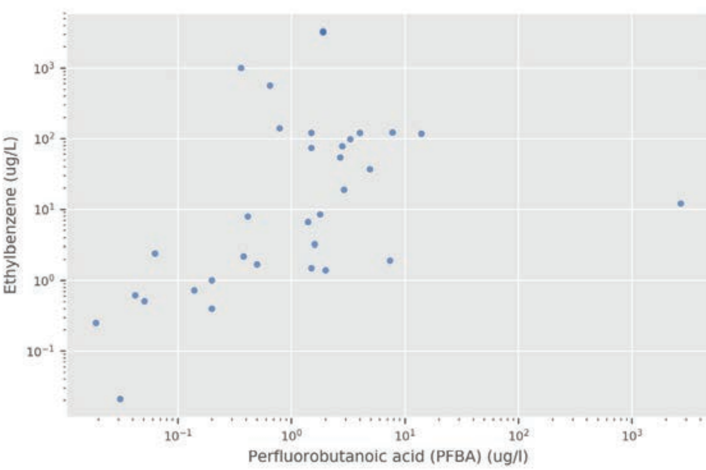

1,2-Dichloroethylene, cis (ug/L)
Perfluorobutanoic acid (PFBA) (ug/l)
10^{-2} 10^{-1} 10^{0} 10^{1} 10^{2} 10^{3}
10^{-1} 10^{0} 10^{1} 10^{2} 10^{3} 10^{4} 10^{5}

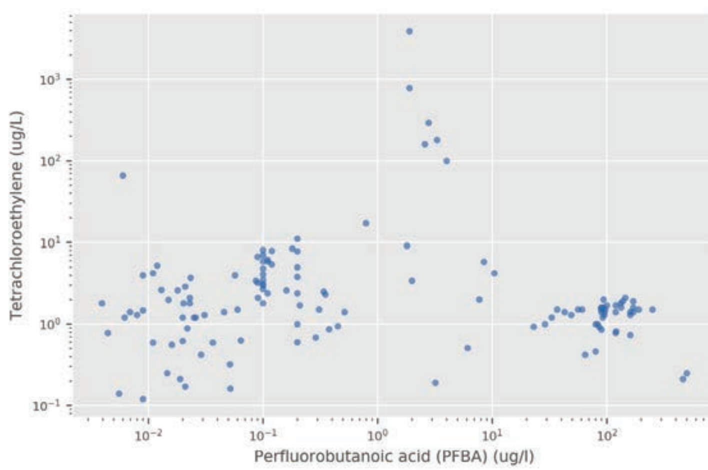

trans-1,2-Dichloroethylene (ug/L)
Perfluorobutanoic acid (PFBA) (ug/l)

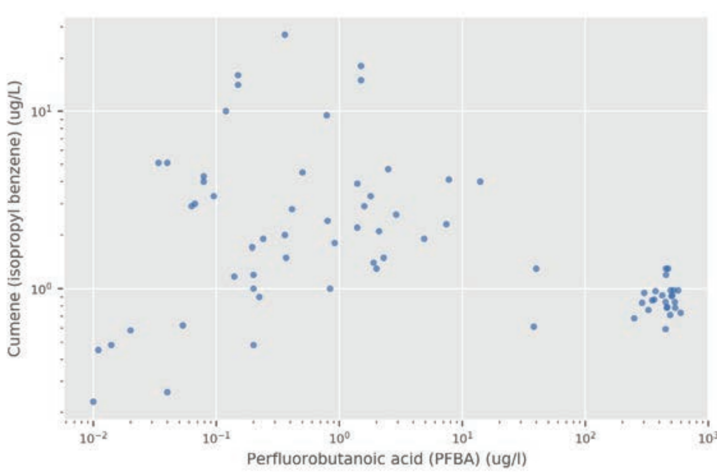

Methylene chloride (ug/L)
Perfluorobutanoic acid (PFBA) (ug/l)

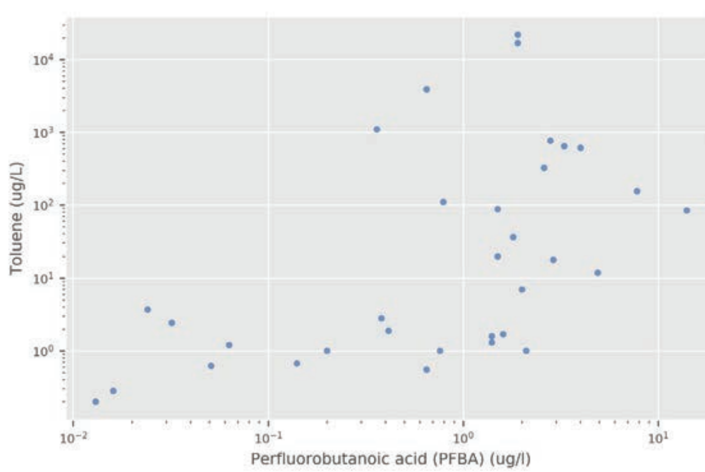

1,2-Dichloropropane (ug/L)
Perfluorobutanoic acid (PFBA) (ug/l)

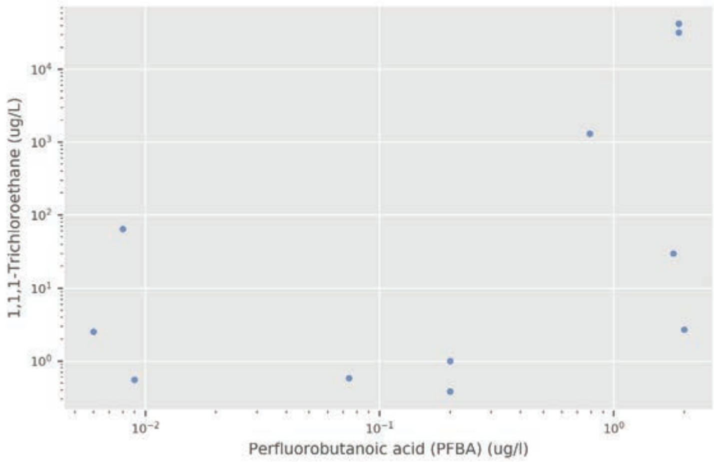

Naphthalene (ug/L)
Perfluorobutanoic acid (PFBA) (ug/l)

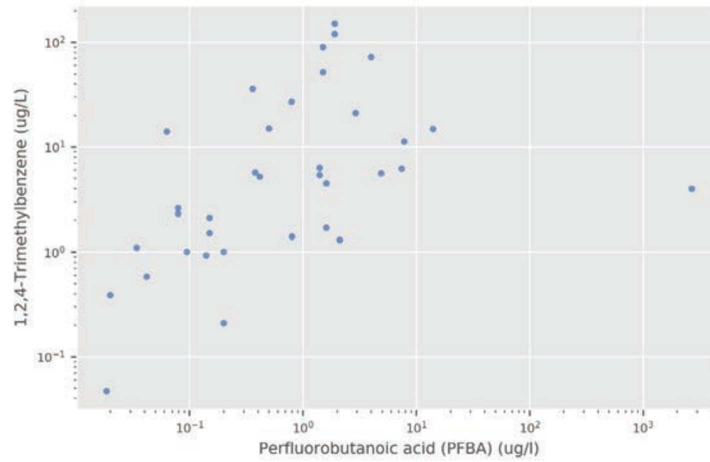

Ethylbenzene (ug/L)
Perfluorobutanoic acid (PFBA) (ug/l)

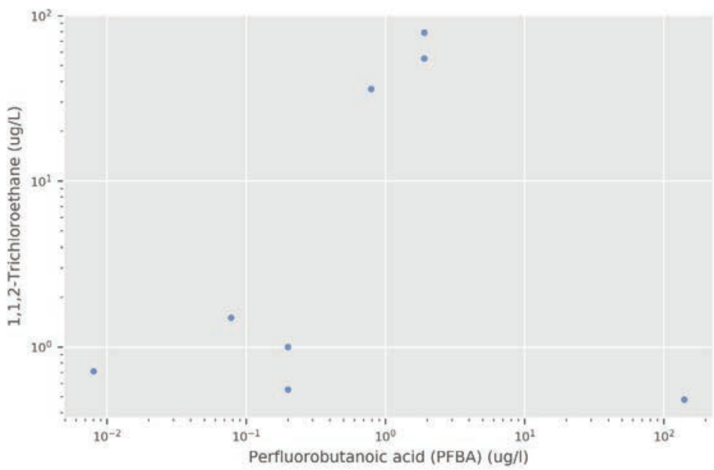

Tetrachloroethylene (ug/L)
Perfluorobutanoic acid (PFBA) (ug/l)

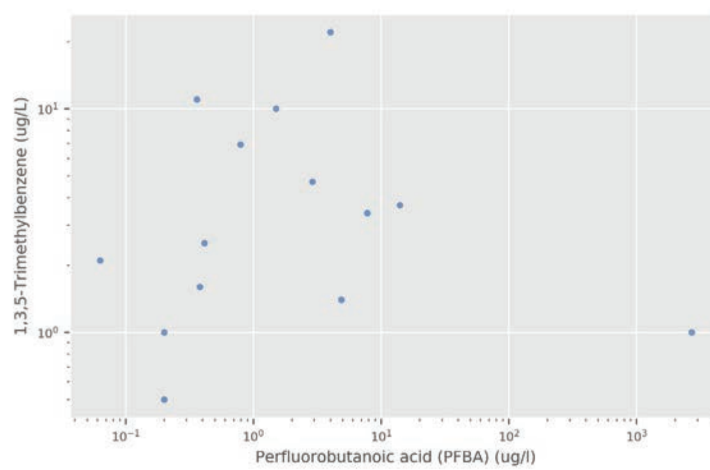

Cumene (isopropyl benzene) (ug/L)
Perfluorobutanoic acid (PFBA) (ug/l)

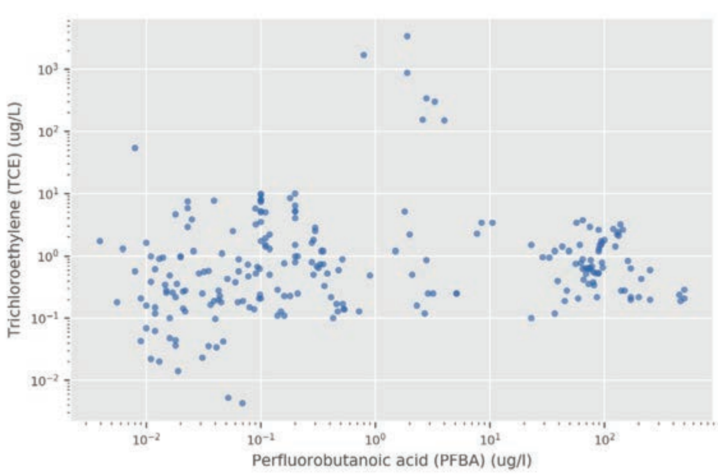

Toluene (ug/L)
Perfluorobutanoic acid (PFBA) (ug/l)

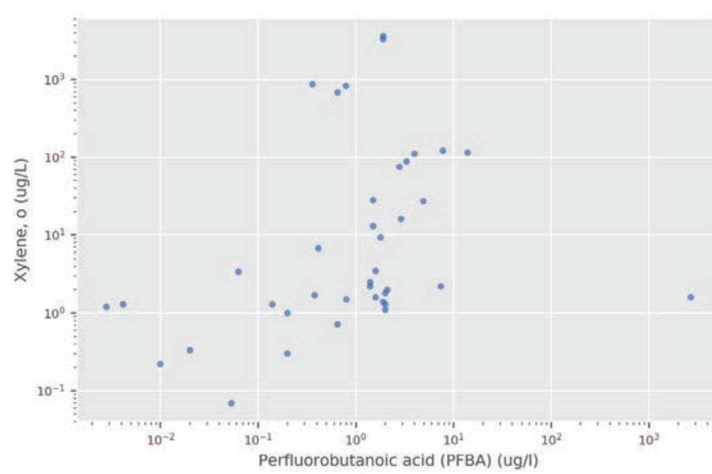

1,1,1-Trichloroethane (ug/L)
Perfluorobutanoic acid (PFBA) (ug/l)

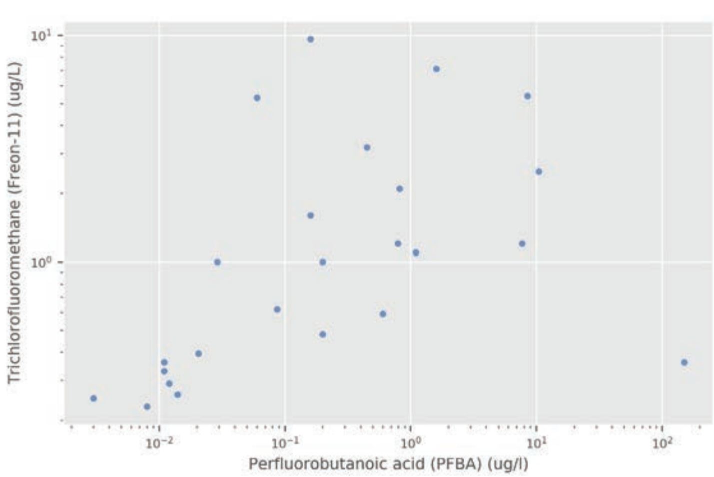

1,2,4-Trimethylbenzene (ug/L)
Perfluorobutanoic acid (PFBA) (ug/l)

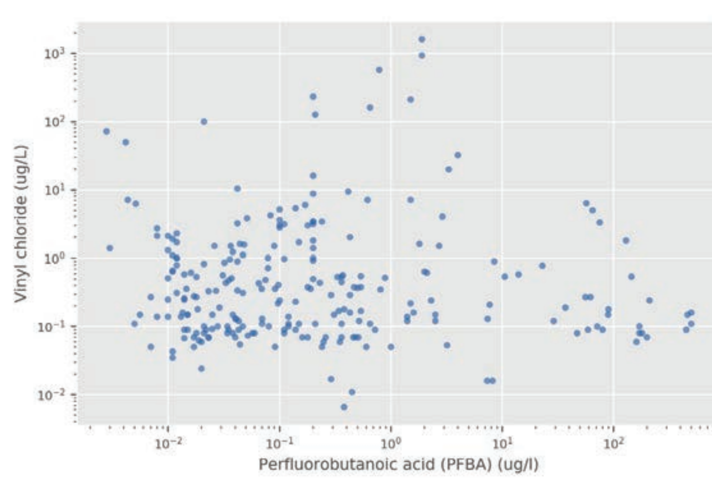

1,1,2-Trichloroethane (ug/L)
Perfluorobutanoic acid (PFBA) (ug/l)

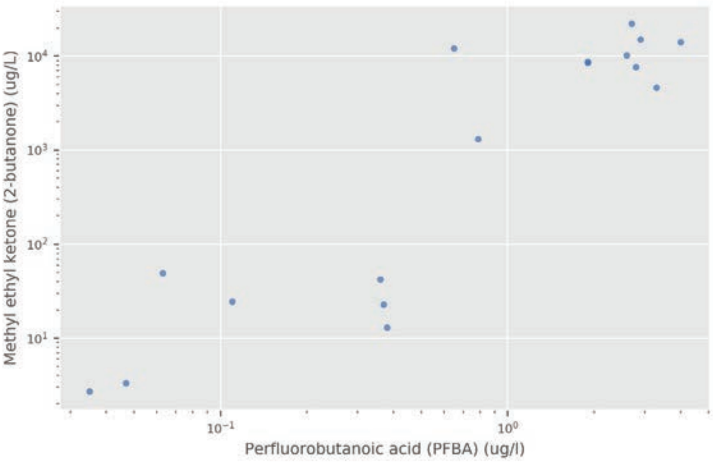

1,3,5-Trimethylbenzene (ug/L)
Perfluorobutanoic acid (PFBA) (ug/l)

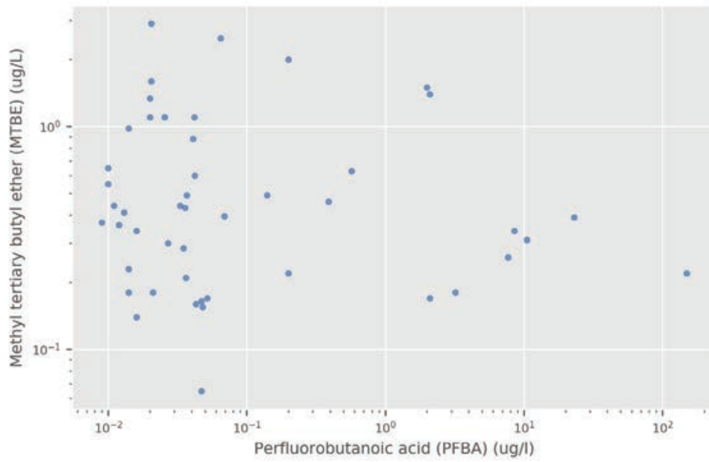

Trichloroethylene (TCE) (ug/l)
Perfluorobutanoic acid (PFBA) (ug/l)

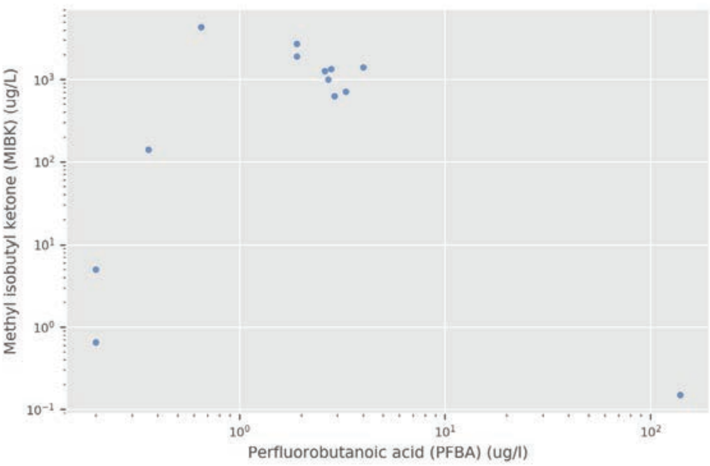

Xylene, o (ug/L)
Perfluorobutanoic acid (PFBA) (ug/l)

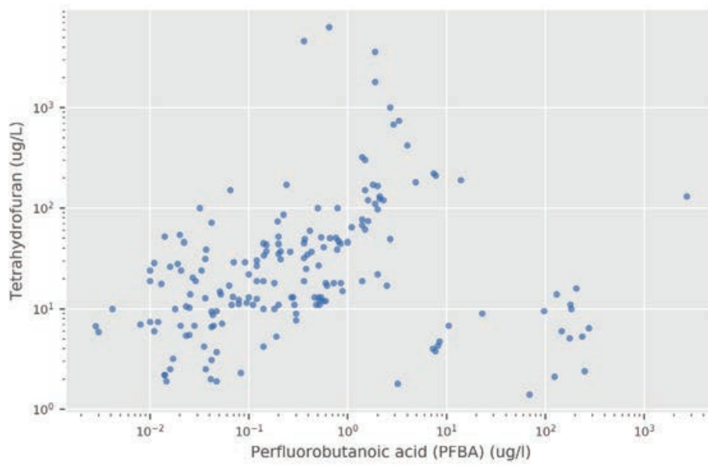

Trichlorofluoromethane (Freon-11) (ug/L)
Perfluorobutanoic acid (PFBA) (ug/l)

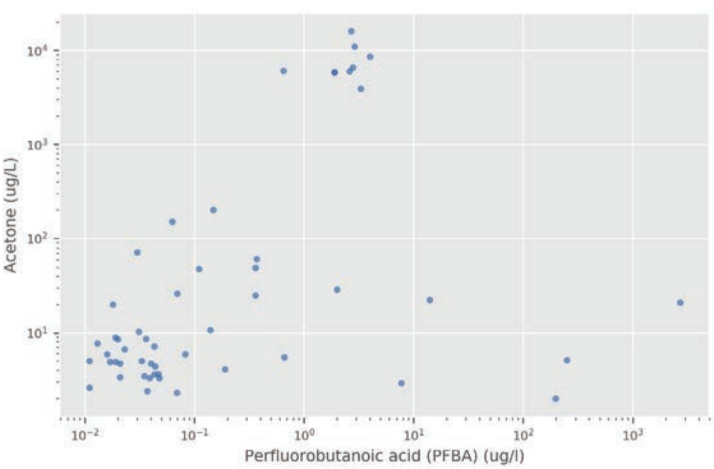

Vinyl chloride (ug/L)
Perfluorobutanoic acid (PFBA) (ug/l)

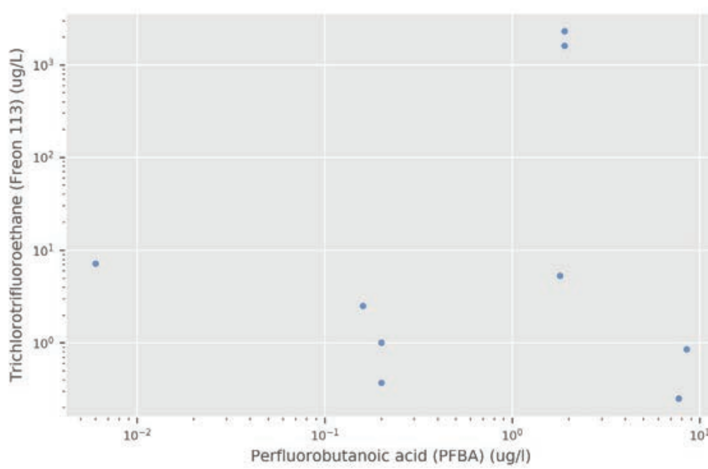

Methyl ethyl ketone (2-butanone) (ug/L)
10^4
10^3
10^2
10^1
10^{-1}
10^0
Perfluorobutanoic acid (PFBA) (ug/l)

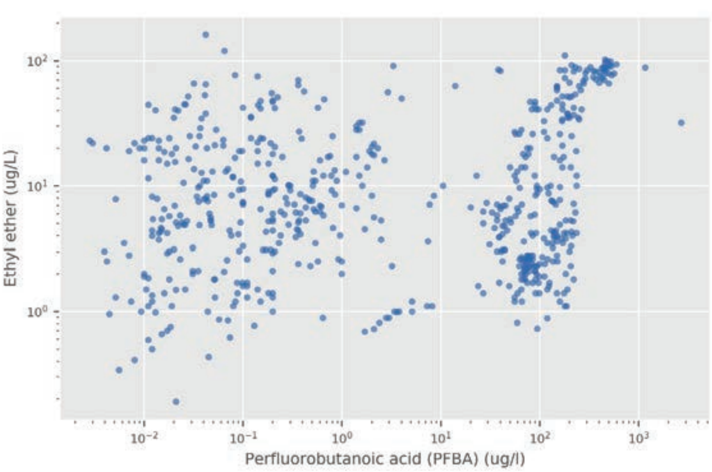

Methyl tertiary butyl ether (MTBE) (ug/L)
10^0
10^{-1}
10^{-2}
10^{-1}
10^0
10^1
10^2
Perfluorobutanoic acid (PFBA) (ug/l)

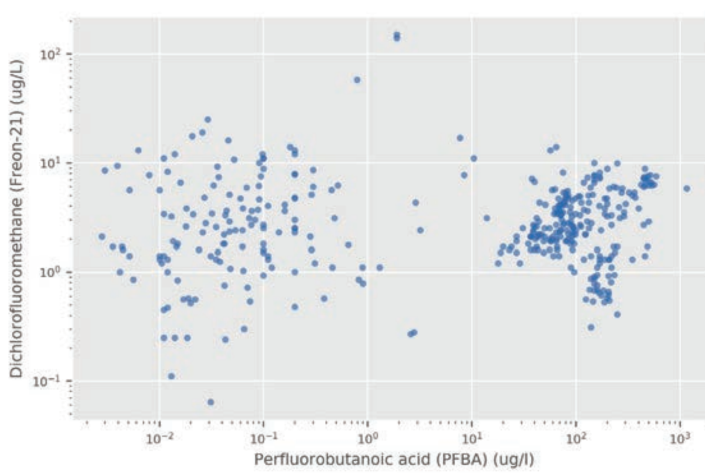

Methyl isobutyl ketone (MIBK) (ug/L)
10^3
10^2
10^1
10^0
10^{-1}
10^0
10^1
10^2
Perfluorobutanoic acid (PFBA) (ug/l)

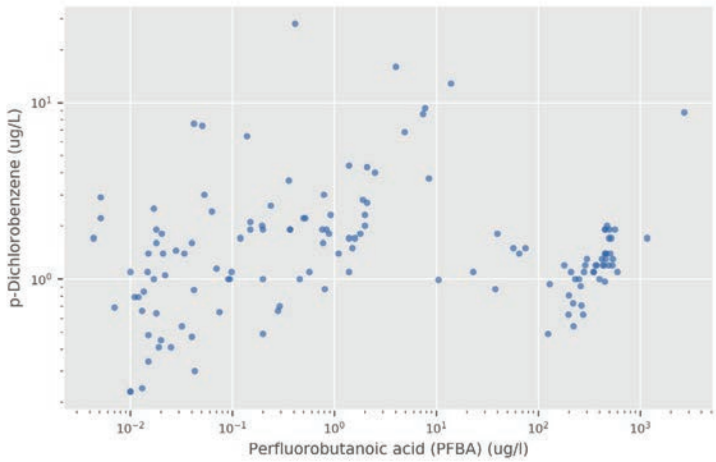

Tetrahydrofuran (ug/L)
10^3
10^2
10^1
10^0
10^{-2}
10^{-1}
10^0
10^1
10^2
10^3
Perfluorobutanoic acid (PFBA) (ug/l)

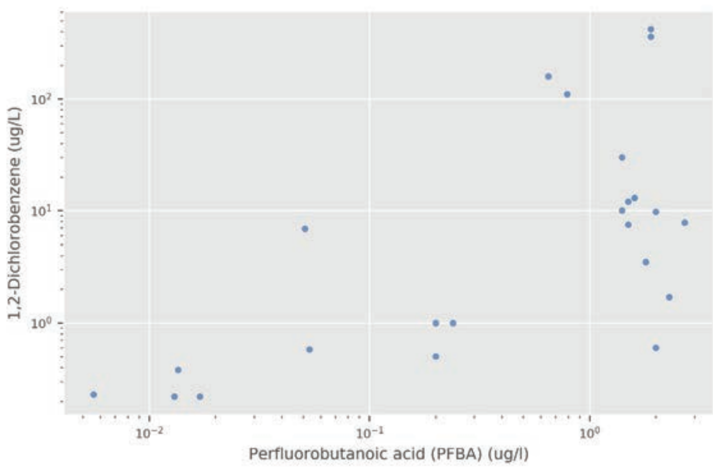

Acetone (ug/L)
10^4
10^3
10^2
10^1
10^{-2}
10^{-1}
10^0
10^1
10^2
10^3
Perfluorobutanoic acid (PFBA) (ug/l)

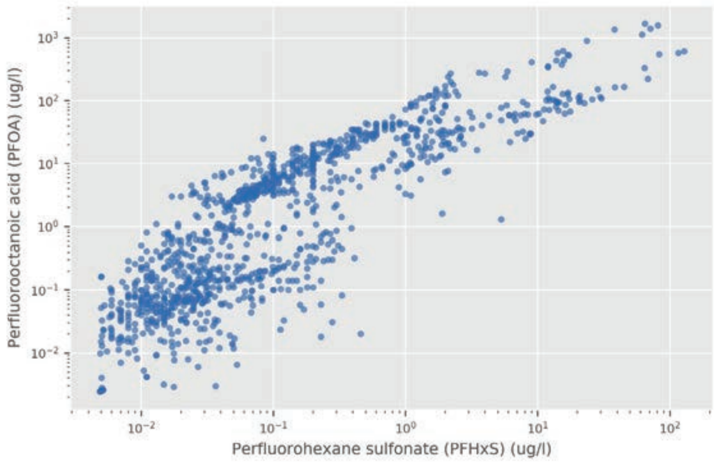

Trichlorotrifluoroethane (Freon 113) (ug/L)
10^3
10^2
10^1
10^0
10^{-2}
10^{-1}
10^0
10^1
Perfluorobutanoic acid (PFBA) (ug/l)

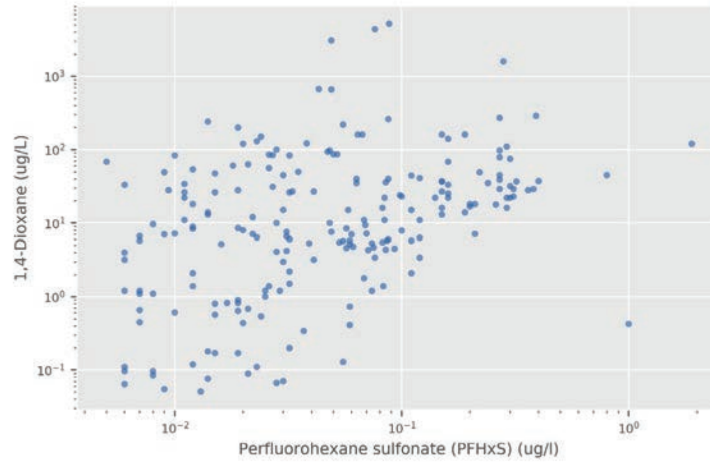

Ethyl ether (ug/L)
10^2
10^1
10^0
10^{-2}
10^{-1}
10^0
10^1
10^2
10^3
Perfluorobutanoic acid (PFBA) (ug/l)

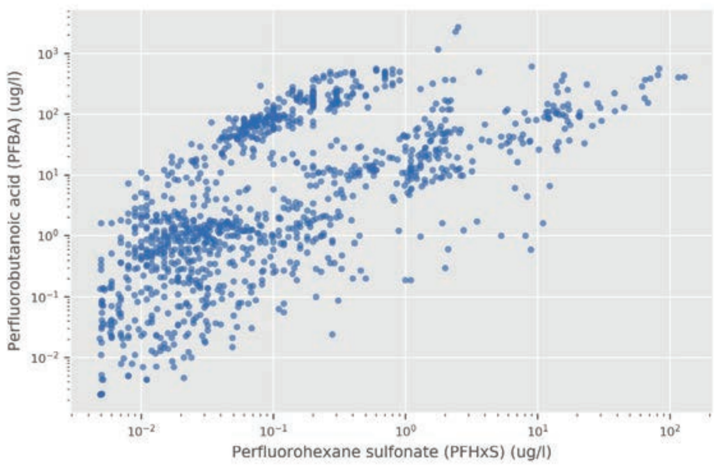

Dichlorofluoromethane (Freon-21) (ug/L)
10^2
10^1
10^0
10^{-1}
10^{-2}
10^{-1}
10^0
10^1
10^2
10^3
Perfluorobutanoic acid (PFBA) (ug/l)

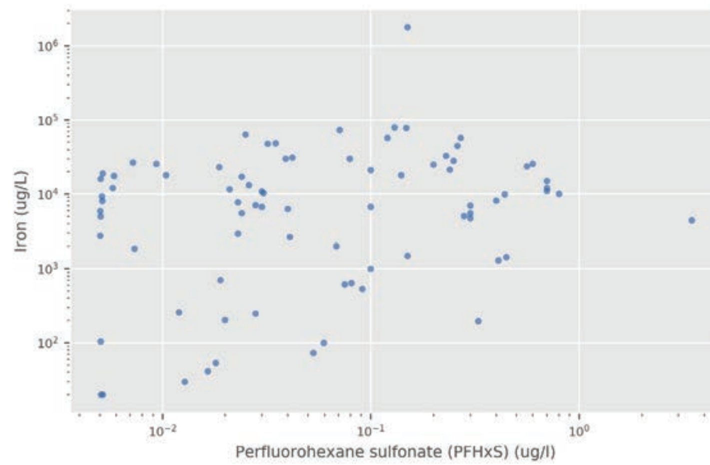

p-Dichlorobenzene (ug/L)
Perfluorobutanoic acid (PFBA) (ug/l)

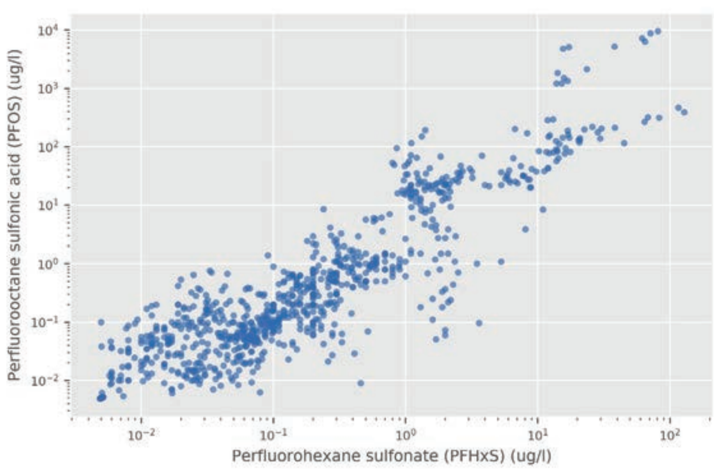

1,2-Dichlorobenzene (ug/L)
Perfluorobutanoic acid (PFBA) (ug/l)

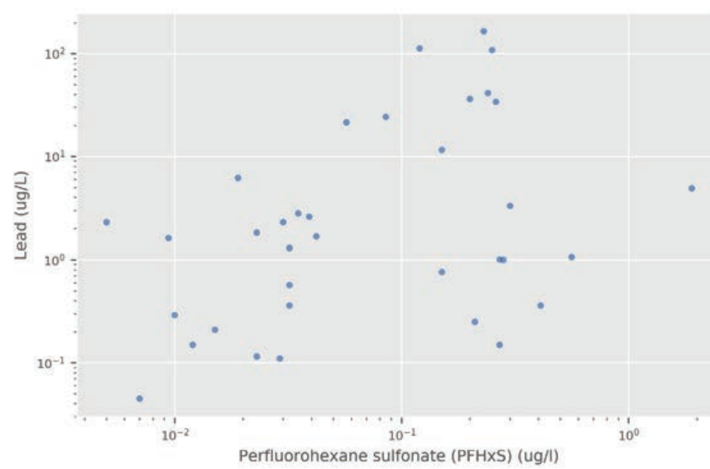

Perfluorooctanoic acid (PFOA) (ug/l)
Perfluorohexane sulfonate (PFHxS) (ug/l)

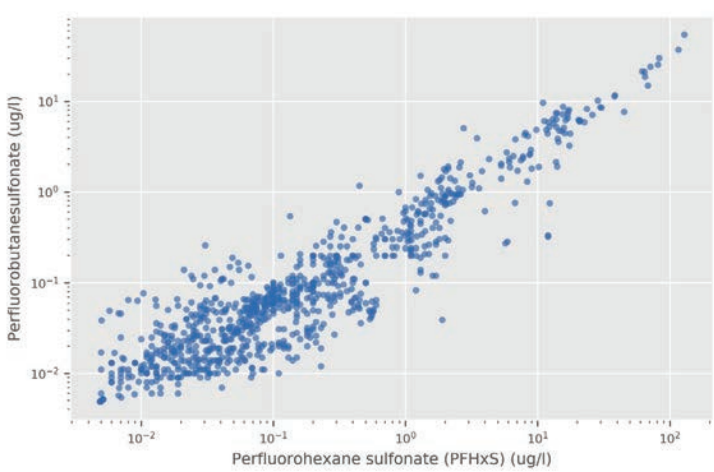

1,4-Dioxane (ug/L)
Perfluorohexane sulfonate (PFHxS) (ug/l)

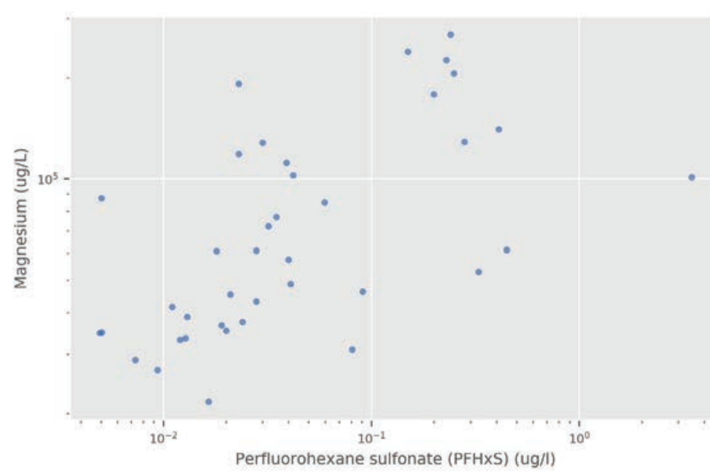

Perfluorobutanoic acid (PFBA) (ug/l)
Perfluorohexane sulfonate (PFHxS) (ug/l)

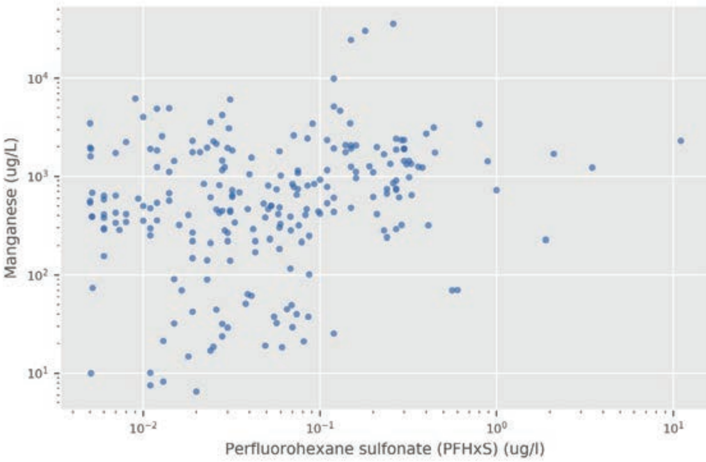

Iron (ug/L)
Perfluorohexane sulfonate (PFHxS) (ug/l)

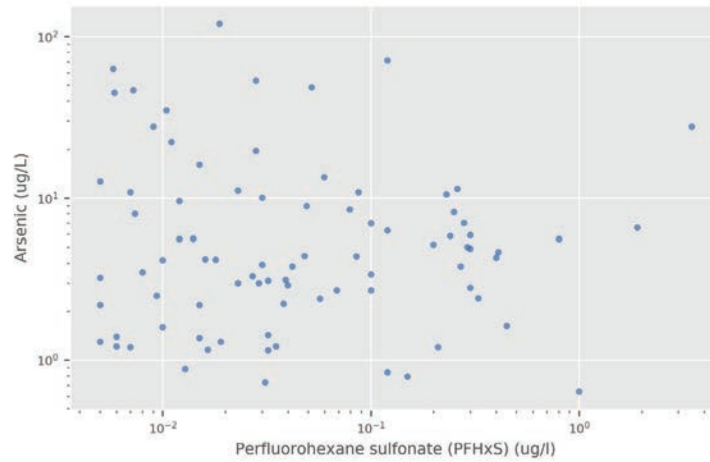

Perfluorooctane sulfonic acid (PFOS) (ug/l)
Perfluorohexane sulfonate (PFHxS) (ug/l)

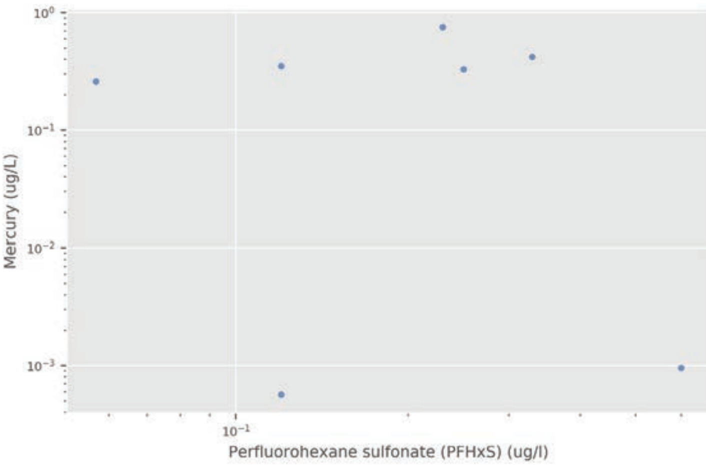

Lead (ug/L)
Perfluorohexane sulfonate (PFHxS) (ug/l)

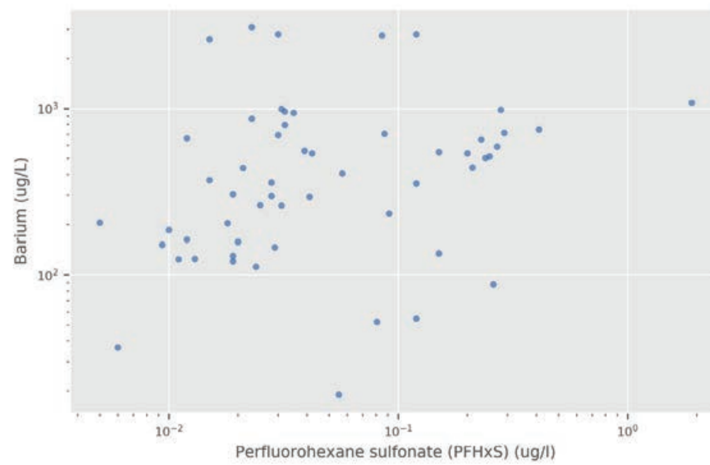

Perfluorobutanesulfonate (ug/l)
Perfluorohexane sulfonate (PFHxS) (ug/l)

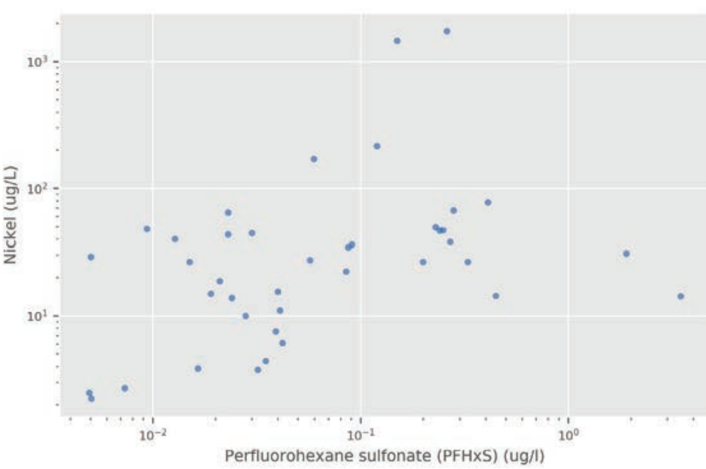

Magnesium (ug/L)
Perfluorohexane sulfonate (PFHxS) (ug/l)

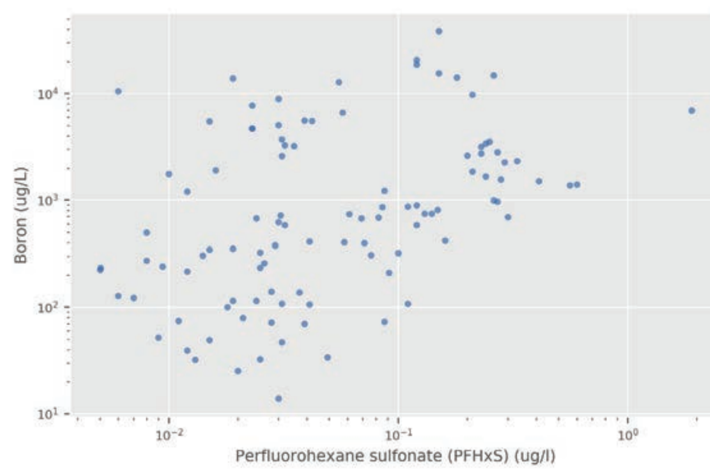

Manganese (ug/L)
10^4
10^3
10^2
10^1
10^{-2}
10^{-1}
10^0
10^1
Perfluorohexane sulfonate (PFHxS) (ug/l)

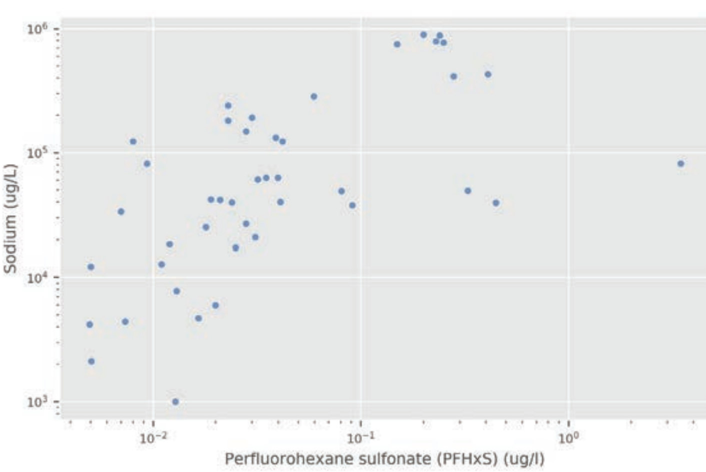

Arsenic (ug/L)
10^2
10^1
10^0
10^{-2}
10^{-1}
10^0
Perfluorohexane sulfonate (PFHxS) (ug/l)

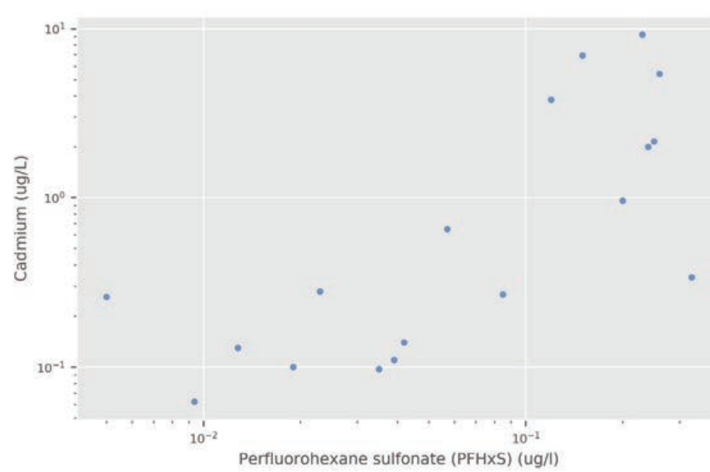

Mercury (ug/L)
10^0
10^{-1}
10^{-2}
10^{-3}
10^{-1}
Perfluorohexane sulfonate (PFHxS) (ug/l)

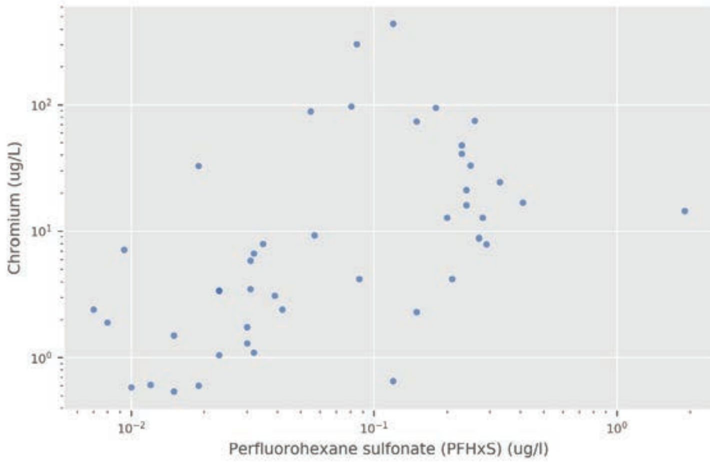

Barium (ug/L)
10^3
10^2
10^{-2}
10^{-1}
10^0
Perfluorohexane sulfonate (PFHxS) (ug/l)

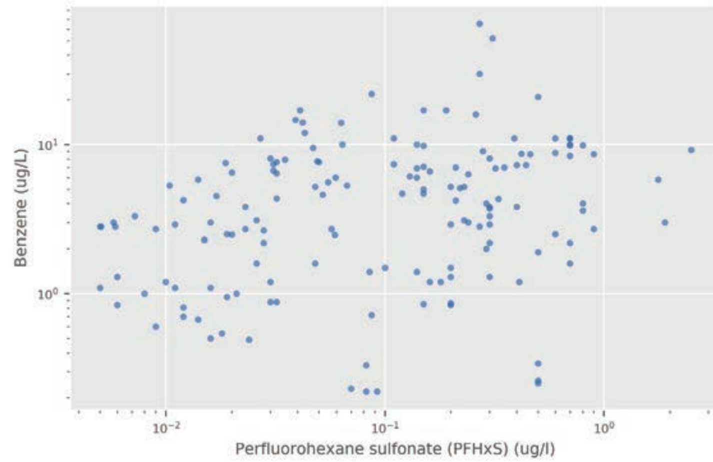

Nickel (ug/L)
10^3
10^2
10^1
10^{-2}
10^{-1}
10^0
Perfluorohexane sulfonate (PFHxS) (ug/l)

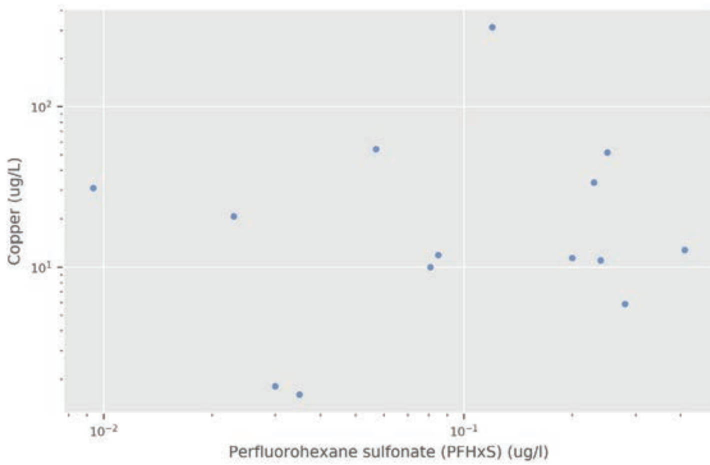

Boron (ug/L)
10^4
10^3
10^2
10^1
10^{-2}
10^{-1}
10^0
Perfluorohexane sulfonate (PFHxS) (ug/l)

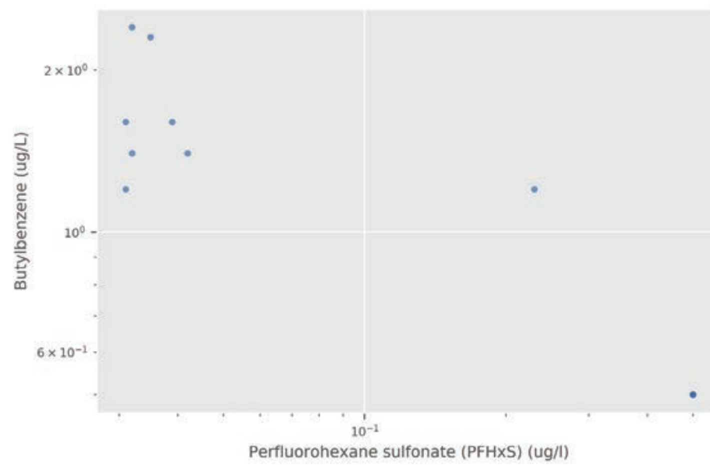

Sodium (ug/L)
10^6
10^5
10^4
10^3
10^{-2}
10^{-1}
10^0
Perfluorohexane sulfonate (PFHxS) (ug/l)

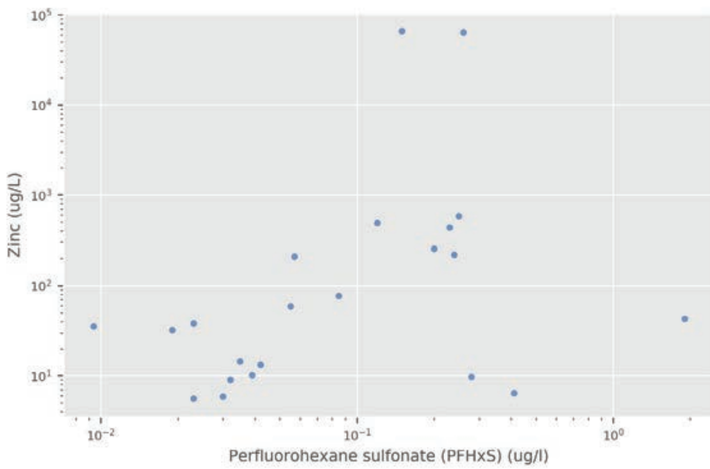

Cadmium (ug/L)
10^1
10^0
10^{-1}
10^{-2}
10^{-1}
Perfluorohexane sulfonate (PFHxS) (ug/l)

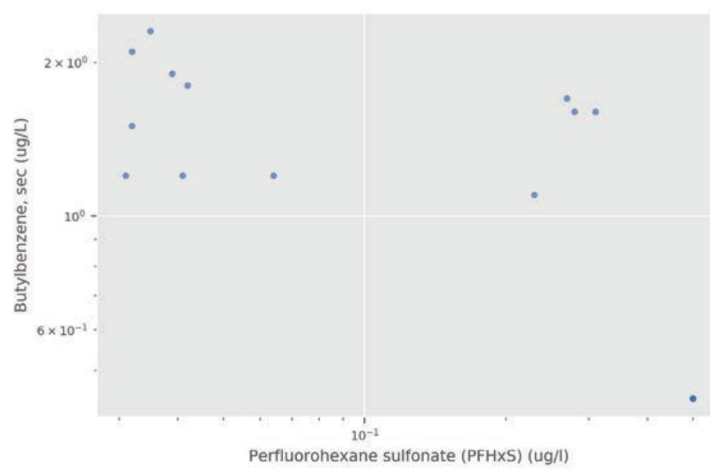

Chromium (ug/L)
Perfluorohexane sulfonate (PFHxS) (ug/l)

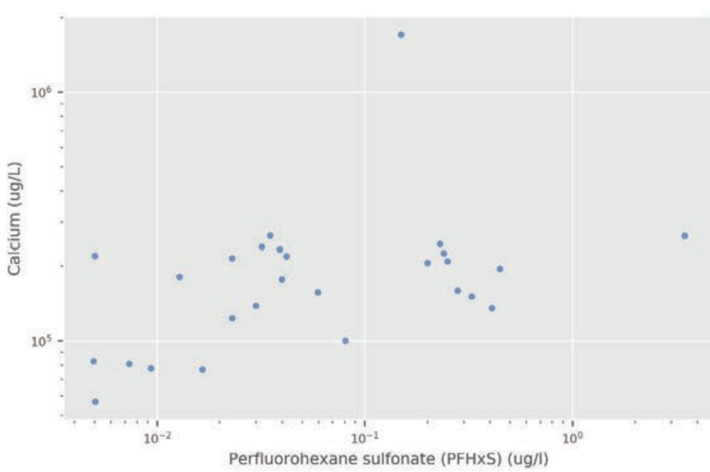

Benzene (ug/L)
Perfluorohexane sulfonate (PFHxS) (ug/l)

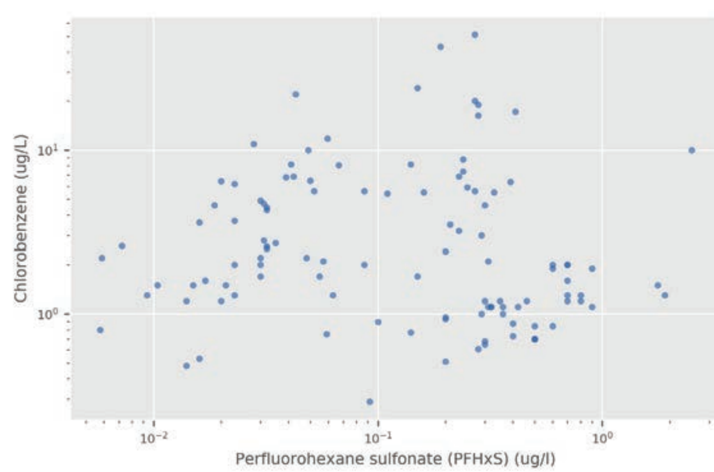

Copper (ug/L)
Perfluorohexane sulfonate (PFHxS) (ug/l)

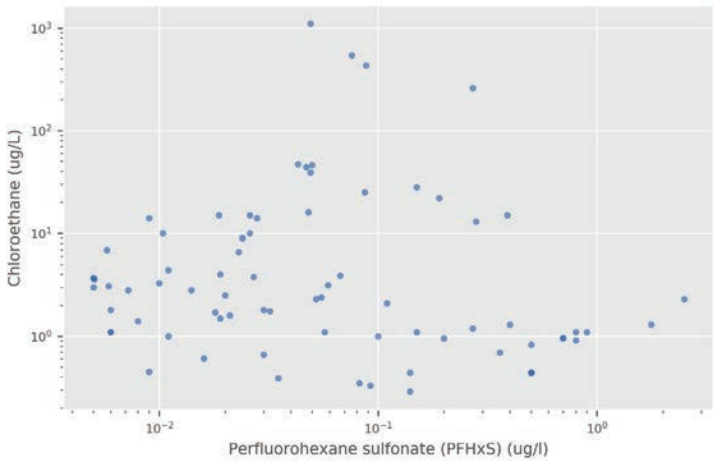

Butylbenzene (ug/L)
Perfluorohexane sulfonate (PFHxS) (ug/l)

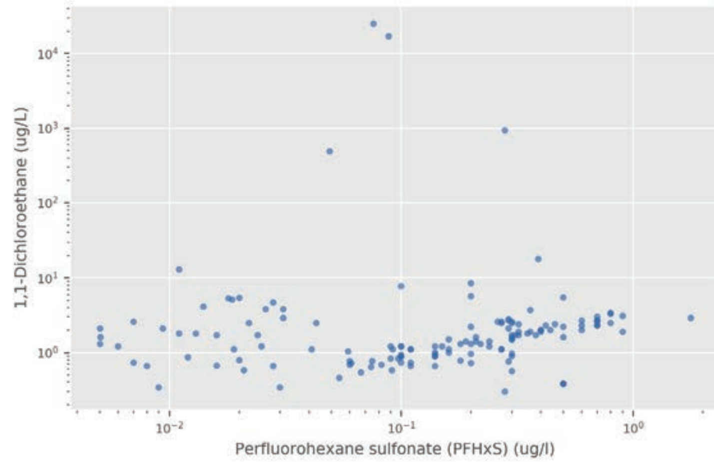

Zinc (ug/L)
Perfluorohexane sulfonate (PFHxS) (ug/l)

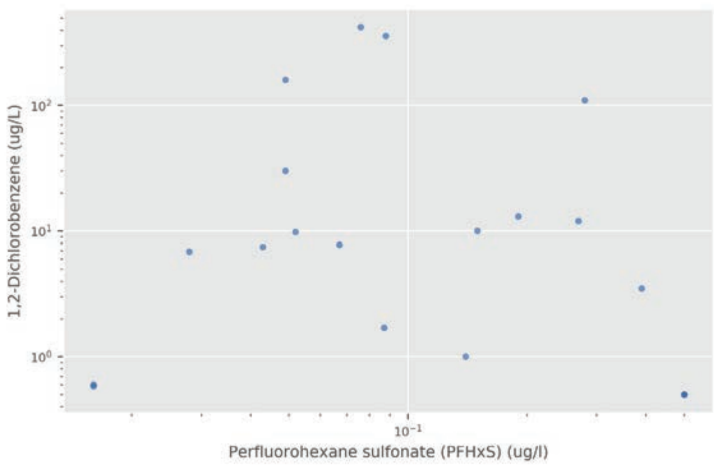

Butylbenzene, sec (ug/L)
Perfluorohexane sulfonate (PFHxS) (ug/l)

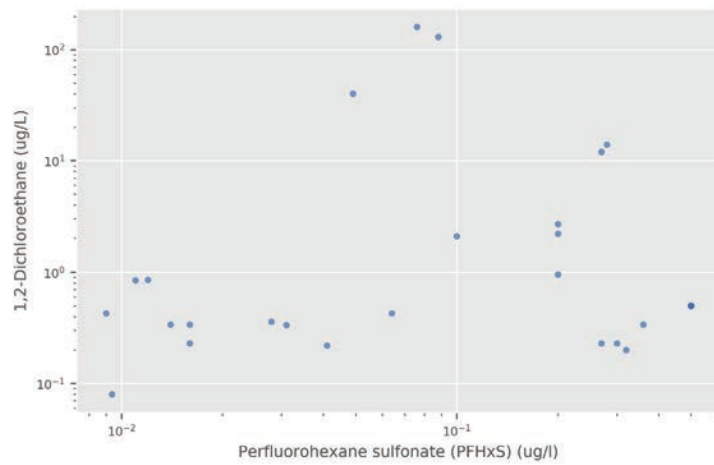

Calcium (ug/L)
Perfluorohexane sulfonate (PFHxS) (ug/l)

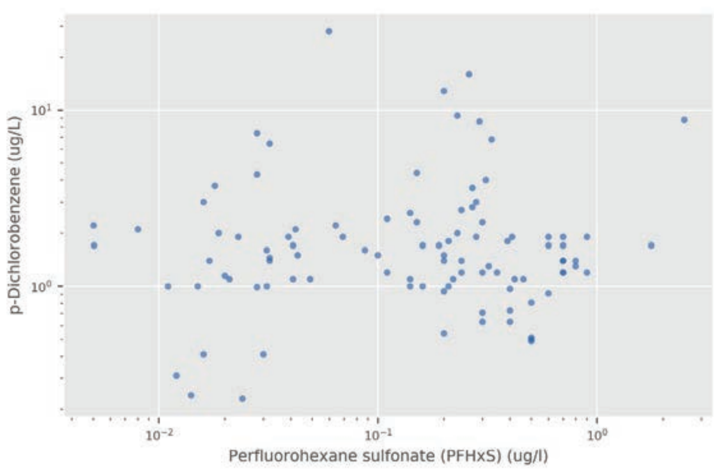

Chlorobenzene (ug/L)
Perfluorohexane sulfonate (PFHxS) (ug/l)

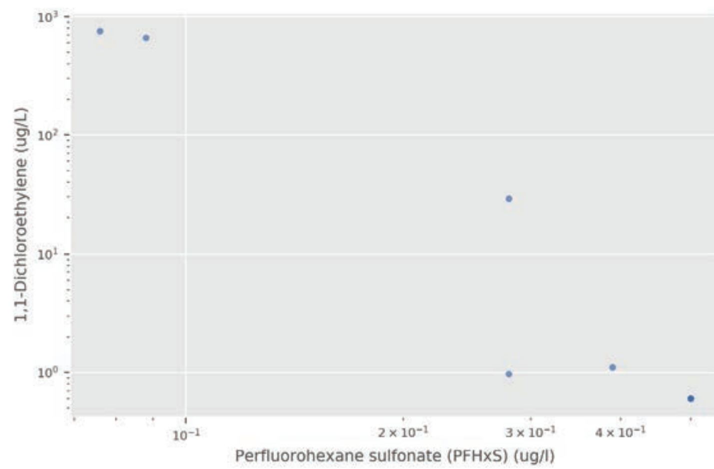

Chloroethane (ug/L)
Perfluorohexane sulfonate (PFHxS) (ug/l)

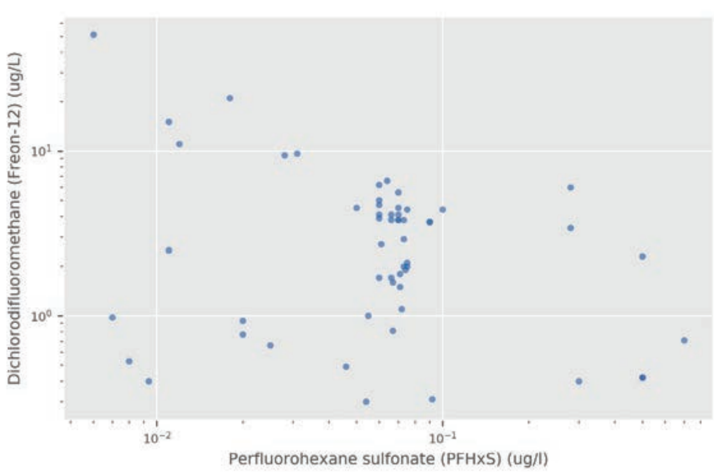

1,1-Dichloroethane (ug/L)
Perfluorohexane sulfonate (PFHxS) (ug/l)

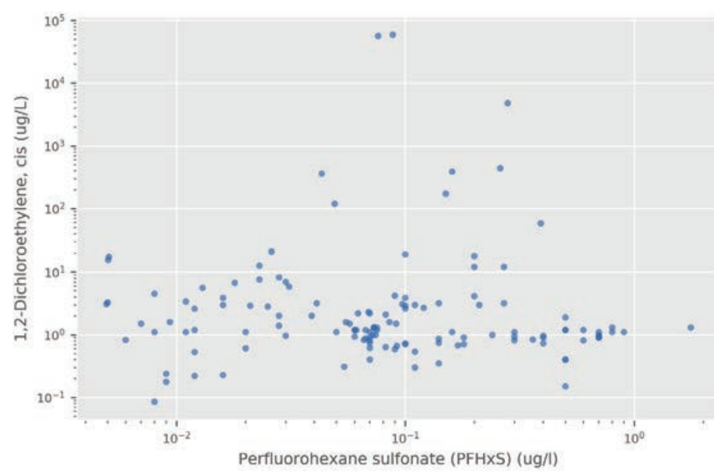

1,2-Dichlorobenzene (ug/L)
Perfluorohexane sulfonate (PFHxS) (ug/l)

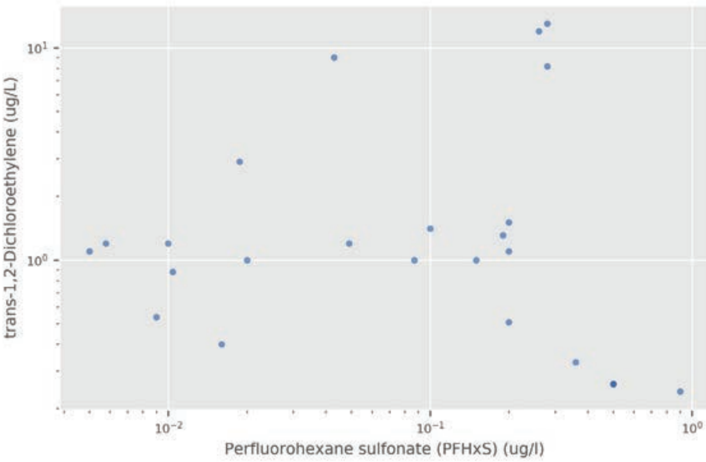

1,2-Dichloroethane (ug/L)
Perfluorohexane sulfonate (PFHxS) (ug/l)

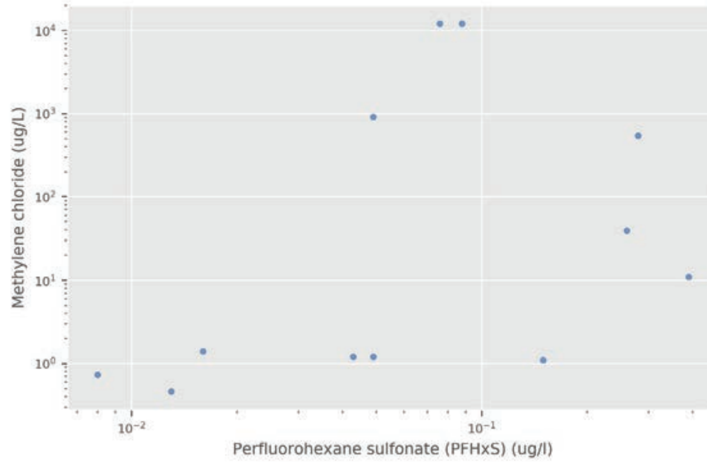

p-Dichlorobenzene (ug/L)
Perfluorohexane sulfonate (PFHxS) (ug/l)

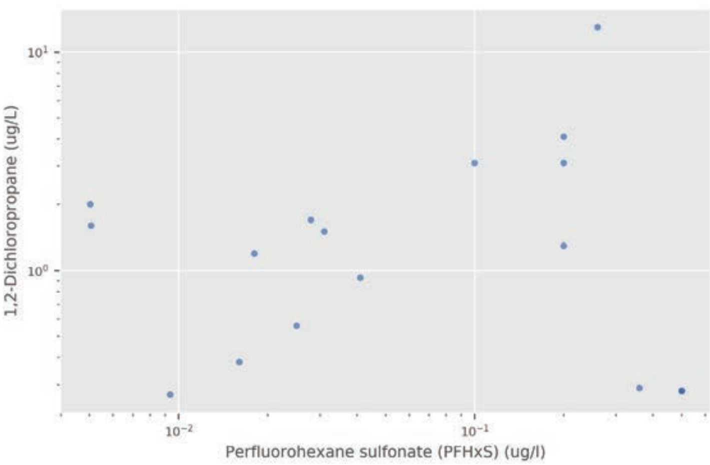

1,1-Dichloroethylene (ug/L)
Perfluorohexane sulfonate (PFHxS) (ug/l)

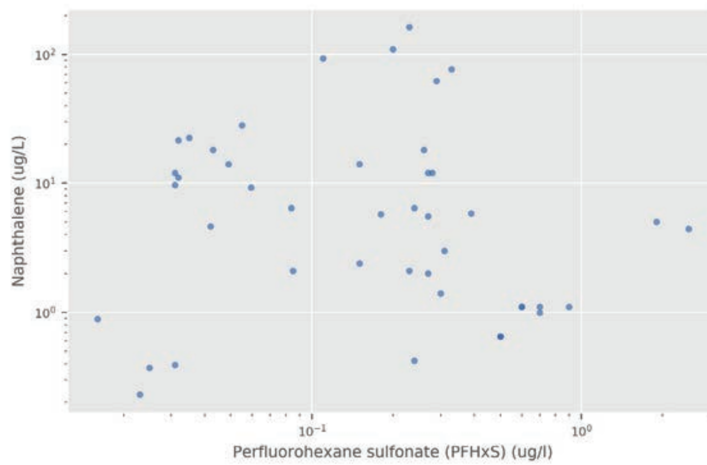

Dichlorodifluoromethane (Freon-12) (ug/L)
Perfluorohexane sulfonate (PFHxS) (ug/l)

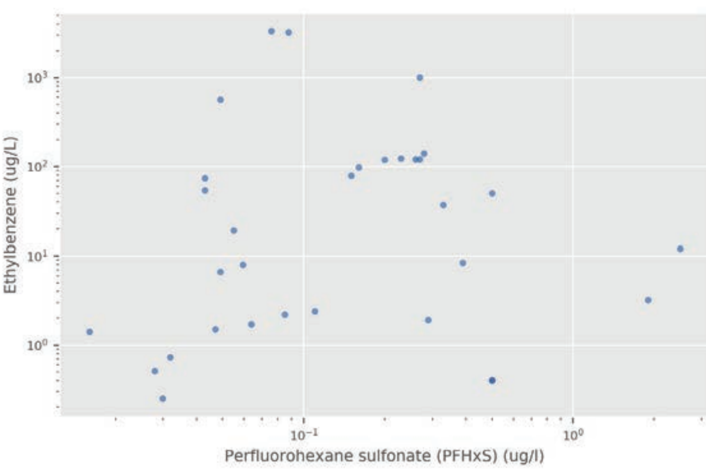

1,2-Dichloroethylene, cis (ug/L)
Perfluorohexane sulfonate (PFHxS) (ug/l)

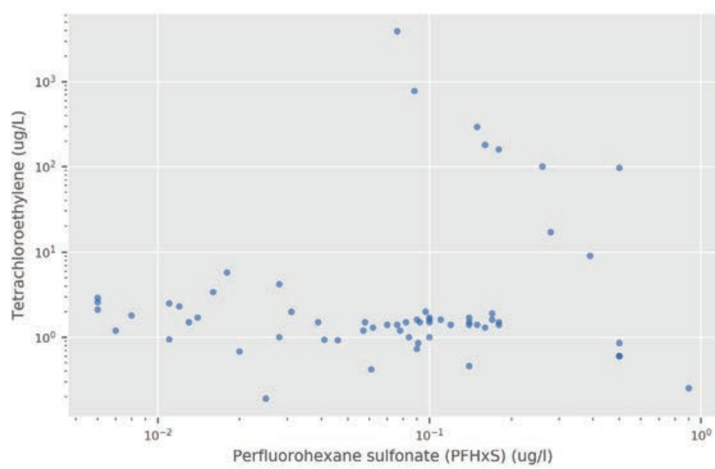

trans-1,2-Dichloroethylene (ug/L)
Perfluorohexane sulfonate (PFHxS) (ug/l)
10^1
10^0
10^{-2}
10^{-1}
10^0

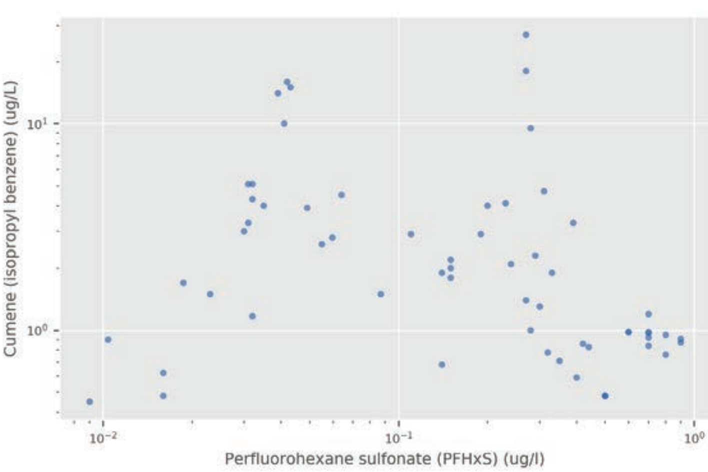

Methylene chloride (ug/L)
Perfluorohexane sulfonate (PFHxS) (ug/l)
10^4
10^3
10^2
10^1
10^0
10^{-2}
10^{-1}

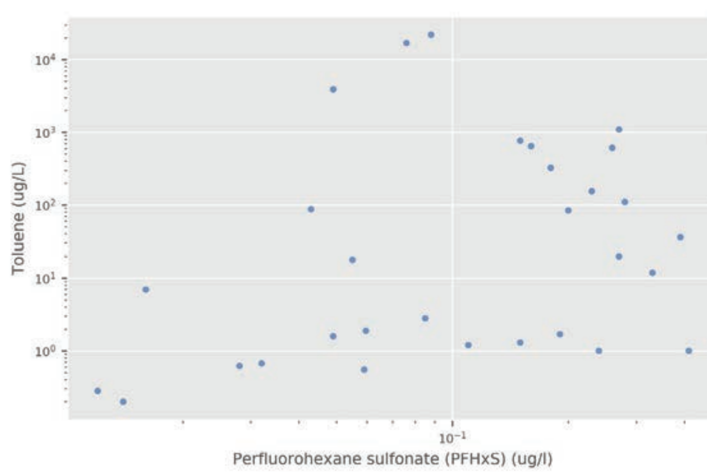

1,2-Dichloropropane (ug/L)
Perfluorohexane sulfonate (PFHxS) (ug/l)
10^1
10^0
10^{-2}
10^{-1}

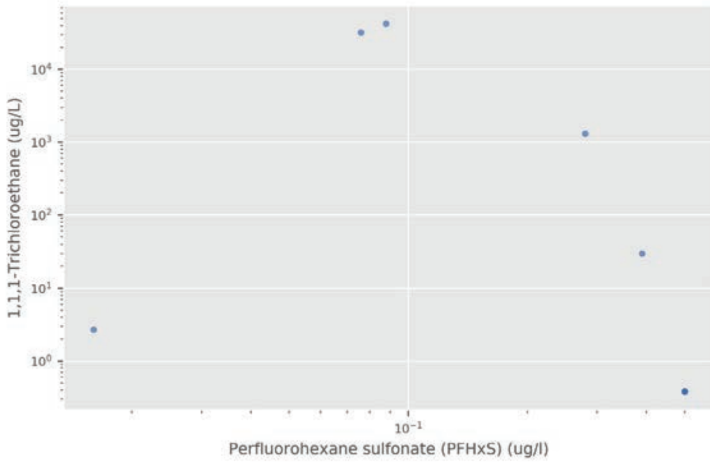

Naphthalene (ug/L)
Perfluorohexane sulfonate (PFHxS) (ug/l)
10^2
10^1
10^0
10^{-1}
10^0

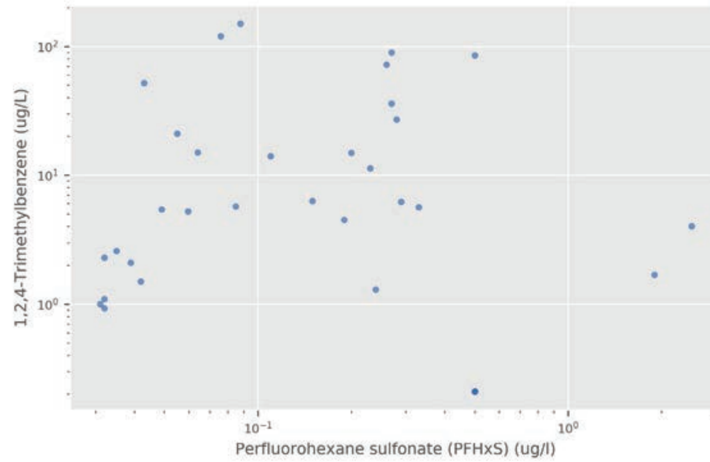

Ethylbenzene (ug/L)
Perfluorohexane sulfonate (PFHxS) (ug/l)
10^3
10^2
10^1
10^0
10^{-1}
10^0

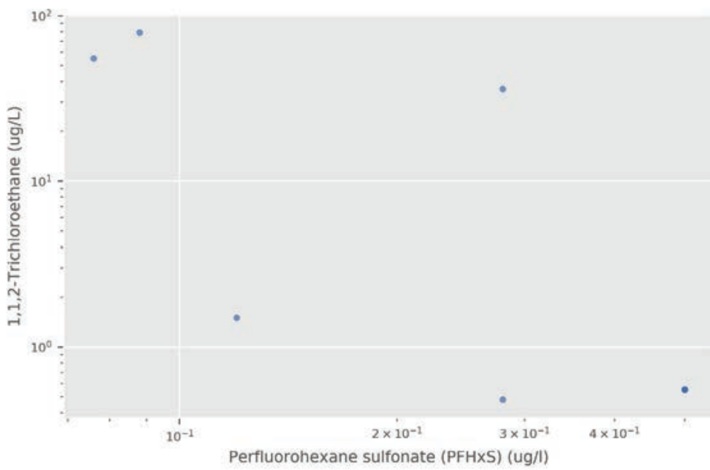

Tetrachloroethylene (ug/L)
Perfluorohexane sulfonate (PFHxS) (ug/l)
10^3
10^2
10^1
10^0
10^{-2}
10^{-1}
10^0

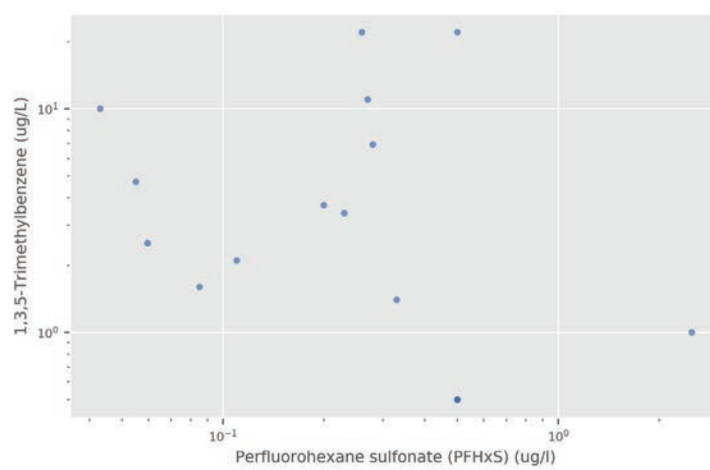

Cumene (isopropyl benzene) (ug/L)
Perfluorohexane sulfonate (PFHxS) (ug/l)
10^1
10^0
10^{-2}
10^{-1}
10^0

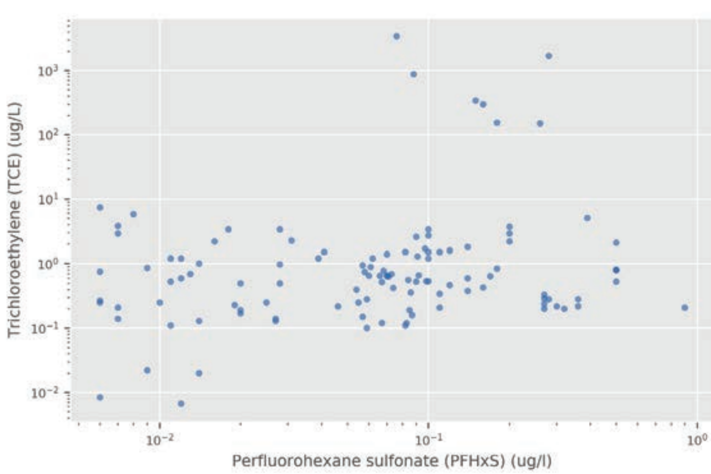

Toluene (ug/L)
Perfluorohexane sulfonate (PFHxS) (ug/l)
10^4
10^3
10^2
10^1
10^0
10^{-1}

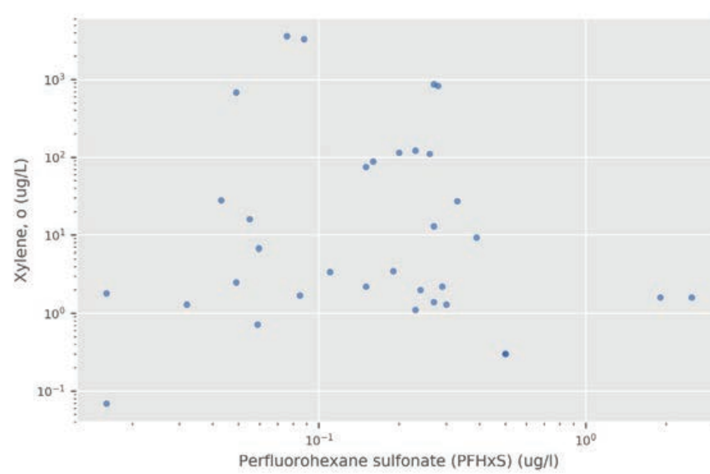

1,1,1-Trichloroethane (ug/L)
Perfluorohexane sulfonate (PFHxS) (ug/l)

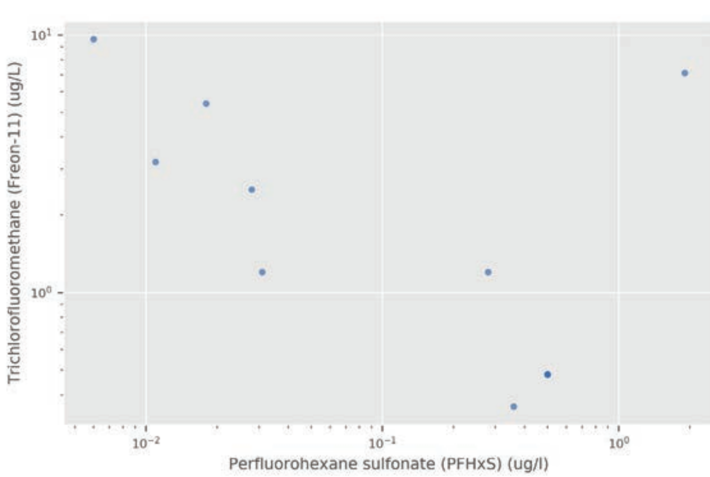

1,2,4-Trimethylbenzene (ug/L)
Perfluorohexane sulfonate (PFHxS) (ug/l)

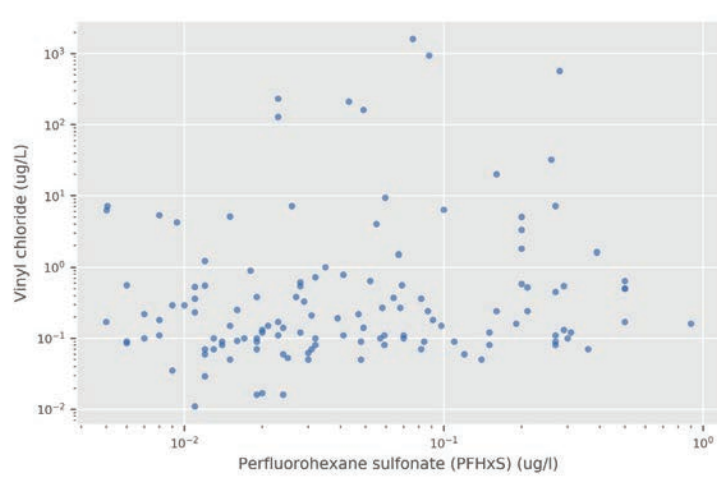

1,1,2-Trichloroethane (ug/L)
Perfluorohexane sulfonate (PFHxS) (ug/l)

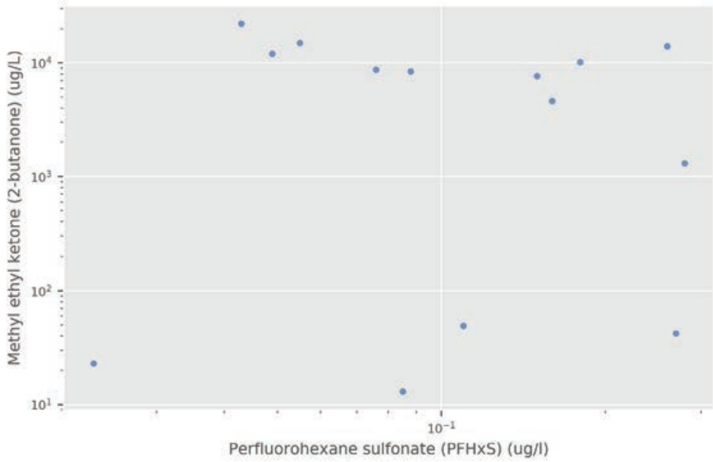

1,3,5-Trimethylbenzene (ug/L)
Perfluorohexane sulfonate (PFHxS) (ug/l)

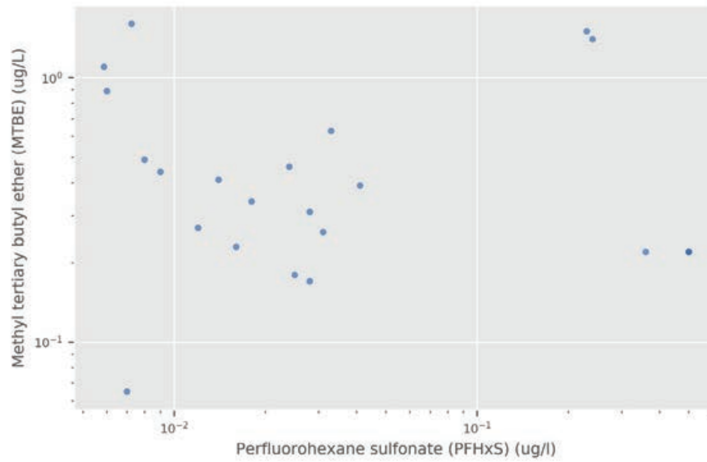

Trichloroethylene (TCE) (ug/L)
Perfluorohexane sulfonate (PFHxS) (ug/l)

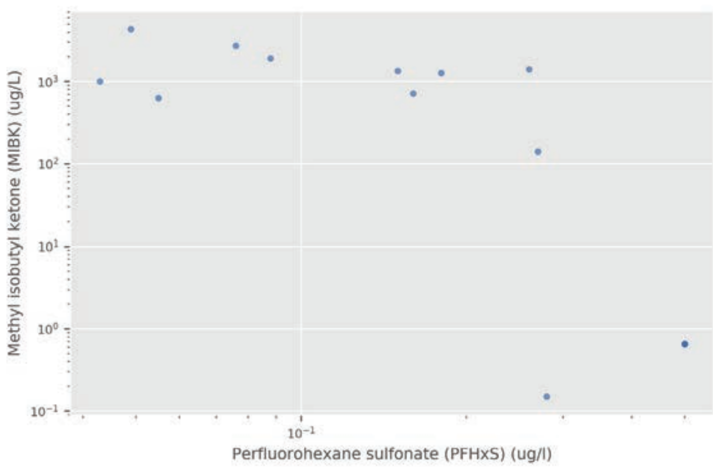

Xylene, o (ug/L)
Perfluorohexane sulfonate (PFHxS) (ug/l)

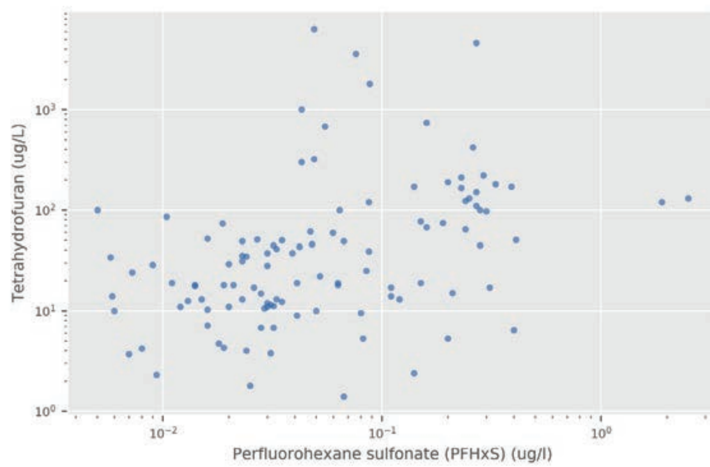

Trichlorofluoromethane (Freon-11) (ug/L)
Perfluorohexane sulfonate (PFHxS) (ug/l)

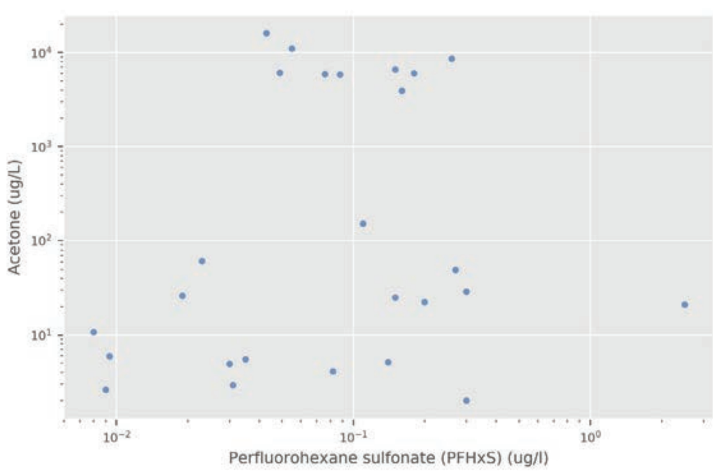

Vinyl chloride (ug/L)
Perfluorohexane sulfonate (PFHxS) (ug/l)

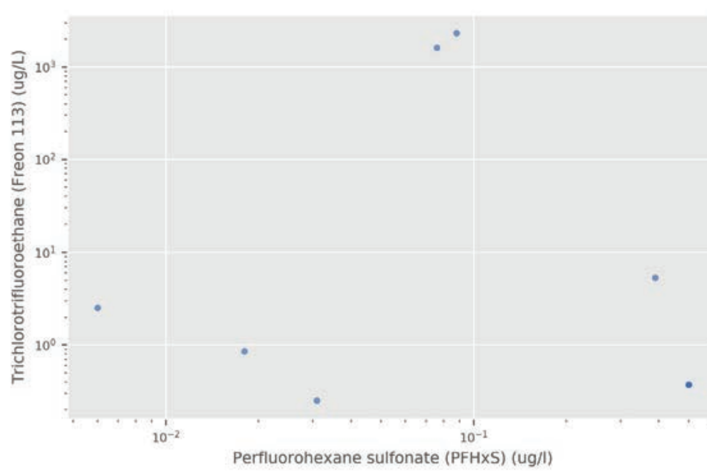

Methyl ethyl ketone (2-butanone) (ug/L)
10^4
10^3
10^2
10^1
10^{-1}
Perfluorohexane sulfonate (PFHxS) (ug/l)

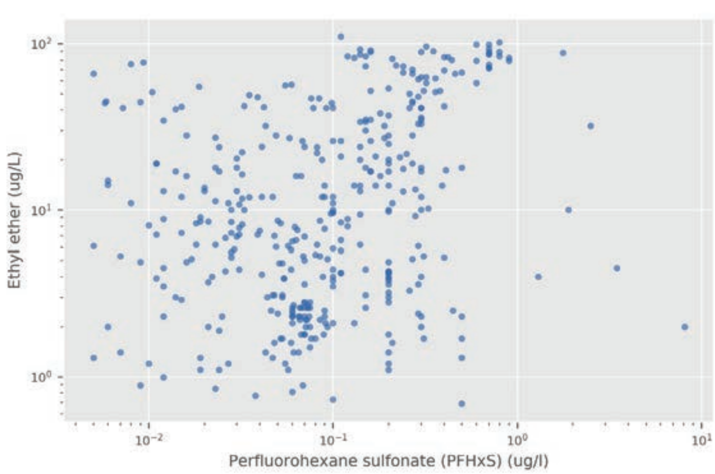

Methyl tertiary butyl ether (MTBE) (ug/L)
10^0
10^{-1}
10^{-2}
10^{-1}
Perfluorohexane sulfonate (PFHxS) (ug/l)

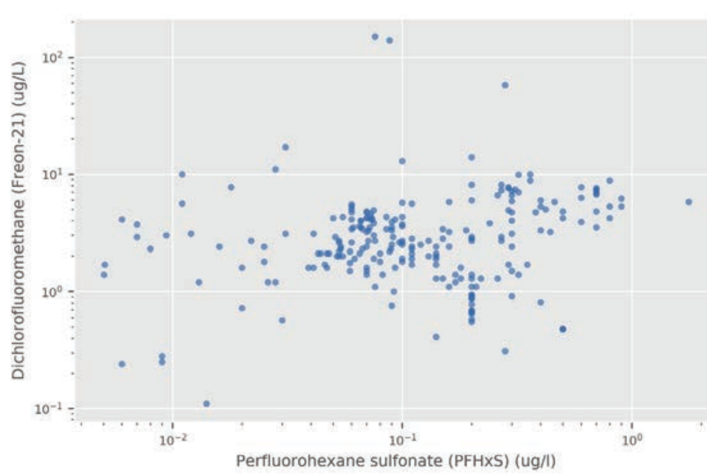

Methyl isobutyl ketone (MIBK) (ug/L)
10^3
10^2
10^1
10^0
10^{-1}
10^{-1}
Perfluorohexane sulfonate (PFHxS) (ug/l)

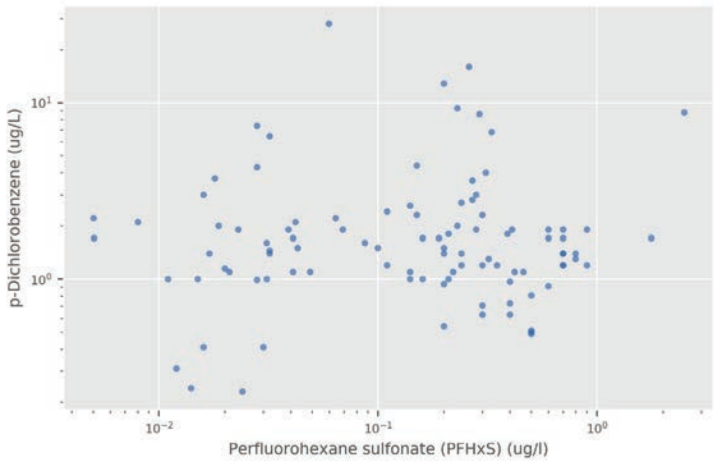

Tetrahydrofuran (ug/L)
10^3
10^2
10^1
10^0
10^{-2}
10^{-1}
10^0
Perfluorohexane sulfonate (PFHxS) (ug/l)

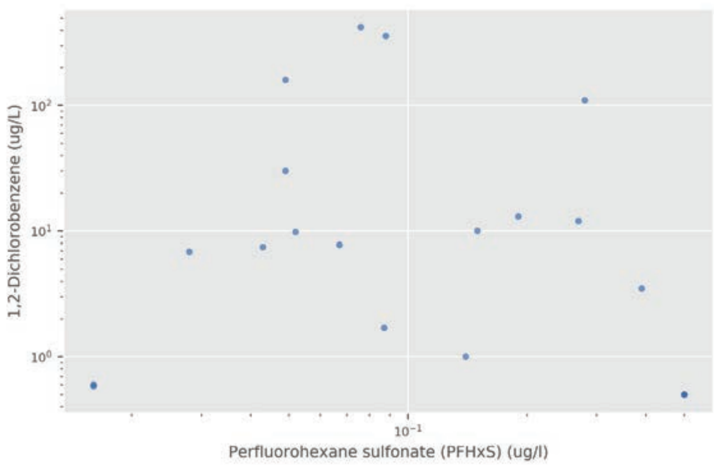

Acetone (ug/L)
10^4
10^3
10^2
10^1
10^{-2}
10^{-1}
10^0
Perfluorohexane sulfonate (PFHxS) (ug/l)

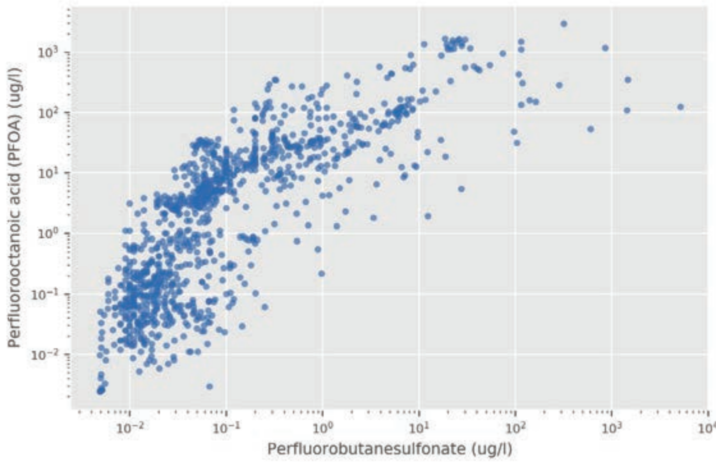

Trichlorotrifluoroethane (Freon 113) (ug/L)
10^3
10^2
10^1
10^0
10^{-2}
10^{-1}
Perfluorohexane sulfonate (PFHxS) (ug/l)


Ethyl ether (ug/L)
10^2
10^1
10^0
10^{-2}
10^{-1}
10^0
10^1
Perfluorohexane sulfonate (PFHxS) (ug/l)


Dichlorofluoromethane (Freon-21) (ug/L)
10^2
10^1
10^0
10^{-1}
10^{-2}
10^{-1}
10^0
Perfluorohexane sulfonate (PFHxS) (ug/l)

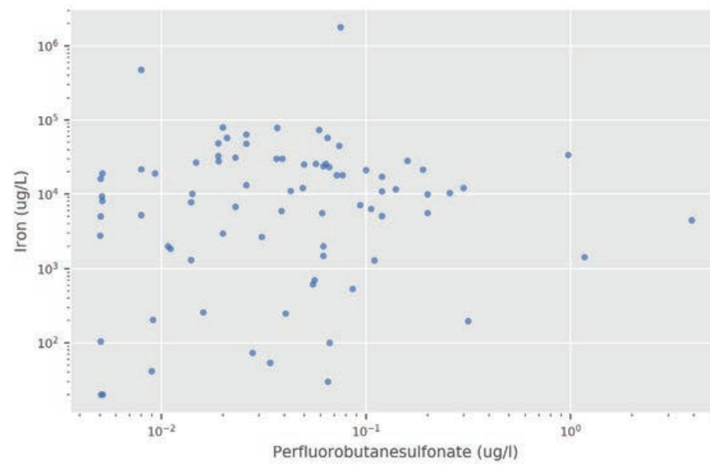

p-Dichlorobenzene (ug/L)
Perfluorohexane sulfonate (PFHxS) (ug/l)

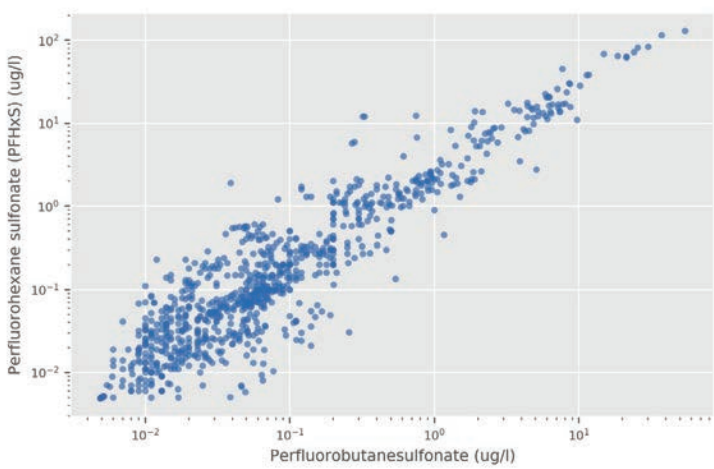

1,2-Dichlorobenzene (ug/L)
Perfluorohexane sulfonate (PFHxS) (ug/l)

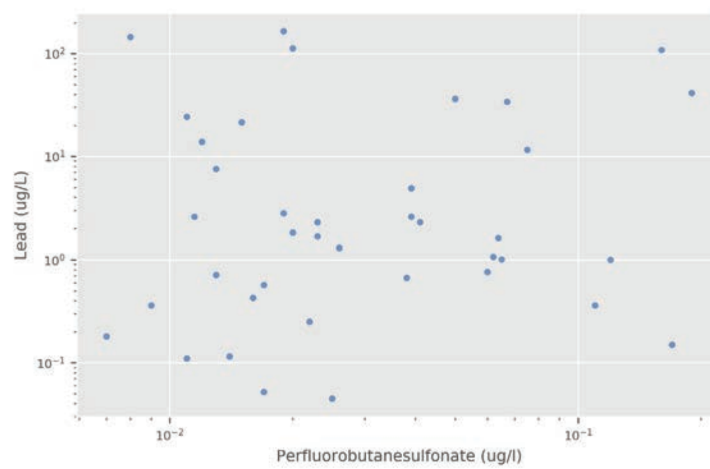

Perfluorooctanoic acid (PFOA) (ug/l)
Perfluorobutanesulfonate (ug/l)

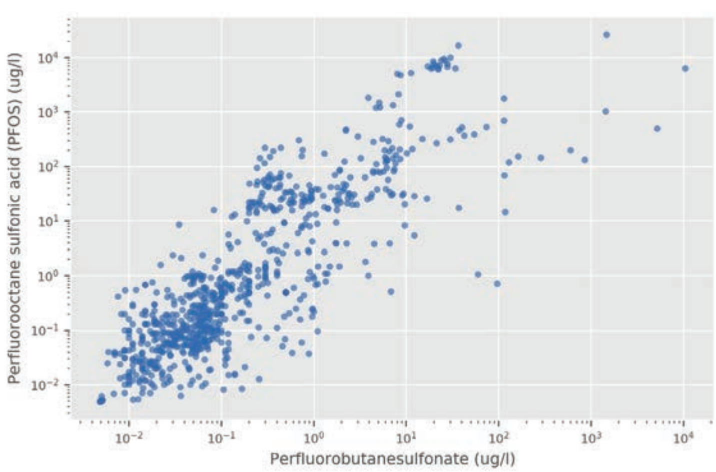

1,4-Dioxane (ug/L)
Perfluorobutanesulfonate (ug/l)

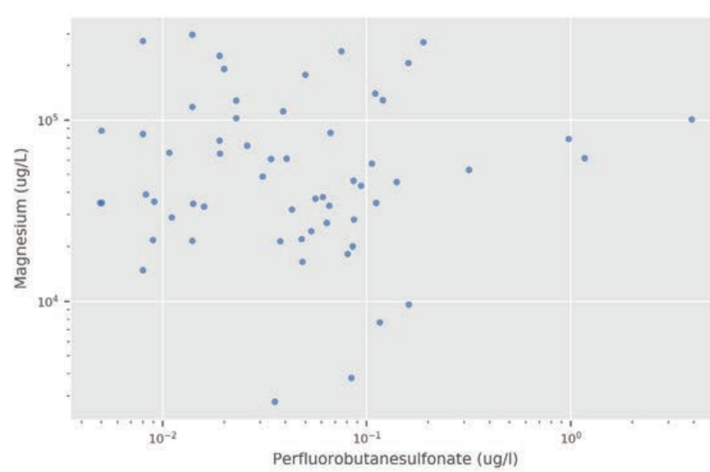

Perfluorobutanoic acid (PFBA) (ug/l)
Perfluorobutanesulfonate (ug/l)

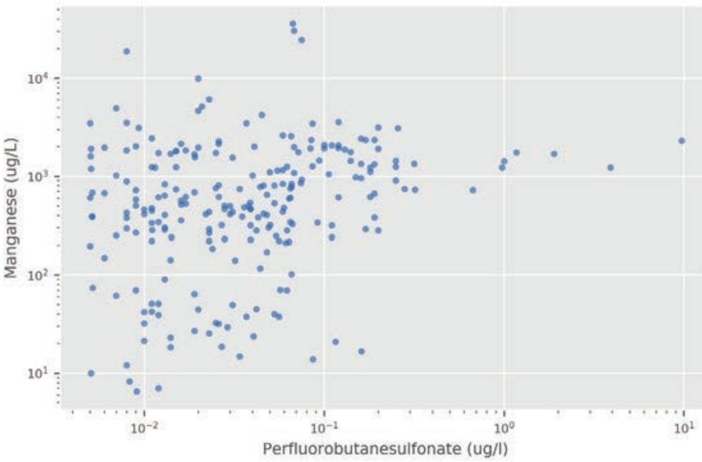

Iron (ug/L)
Perfluorobutanesulfonate (ug/l)


Perfluorohexane sulfonate (PFHxS) (ug/l)
Perfluorobutanesulfonate (ug/l)

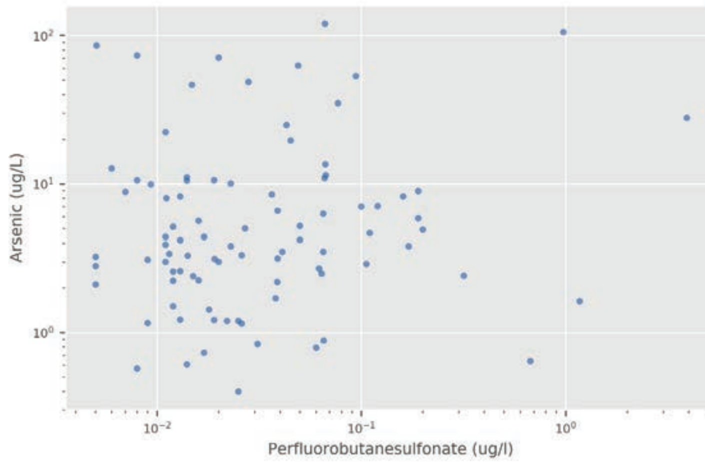

Lead (ug/L)
Perfluorobutanesulfonate (ug/l)


Perfluorooctane sulfonic acid (PFOS) (ug/l)
Perfluorobutanesulfonate (ug/l)

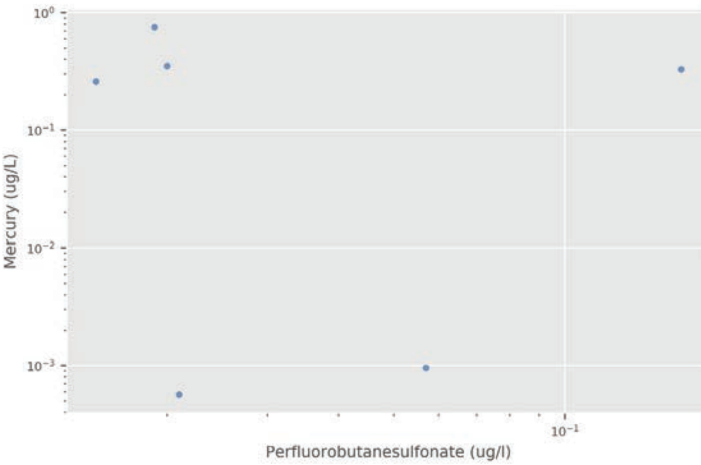

Magnesium (ug/L)
Perfluorobutanesulfonate (ug/l)



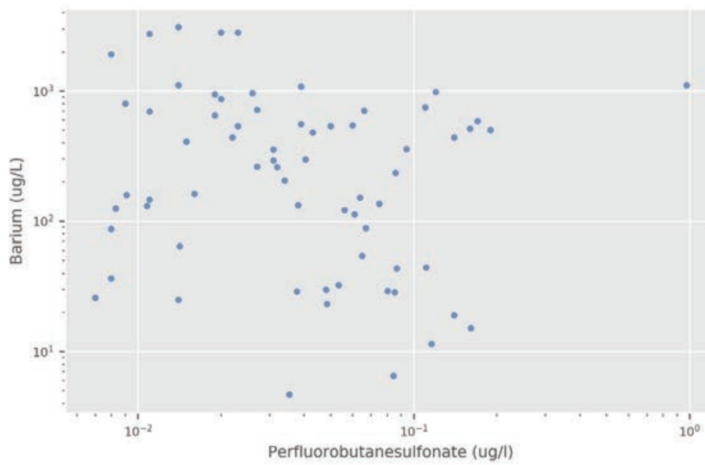
Manganese (ug/L)
10^{4}
10^{3}
10^{2}
10^{1}
10^{-2}
10^{-1}
10^{0}
10^{1}
Perfluorobutanesulfonate (ug/l)



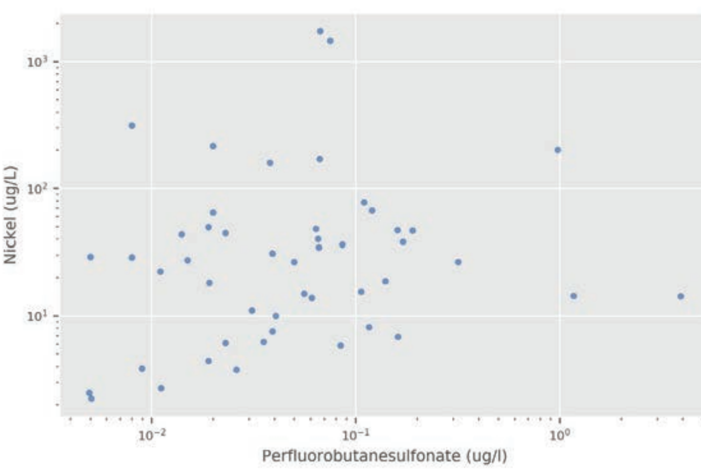
Arsenic (ug/L)
10^{2}
10^{1}
10^{0}
10^{-2}
10^{-1}
10^{0}
Perfluorobutanesulfonate (ug/l)



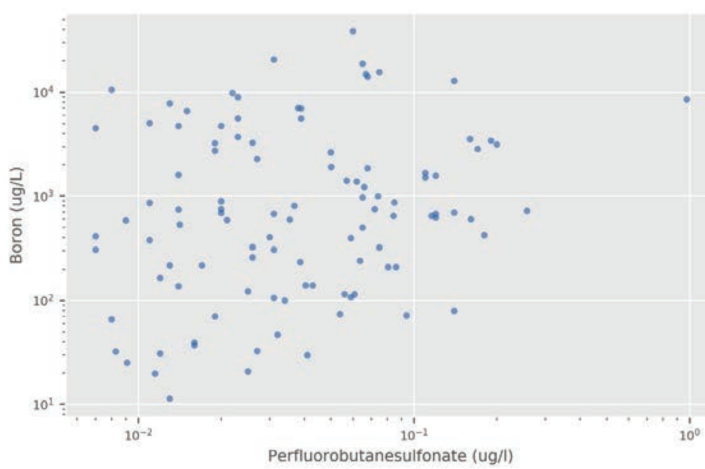
Mercury (ug/L)
10^{0}
10^{-1}
10^{-2}
10^{-3}
10^{-1}
Perfluorobutanesulfonate (ug/l)



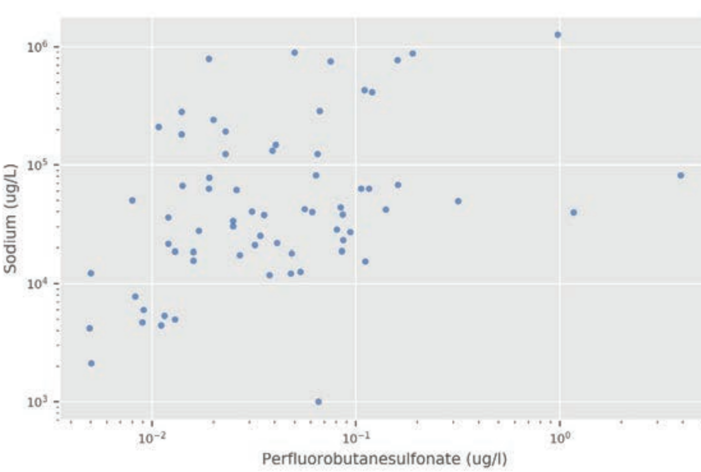
Barium (ug/L)
10^{3}
10^{2}
10^{1}
10^{-2}
10^{-1}
10^{0}
Perfluorobutanesulfonate (ug/l)



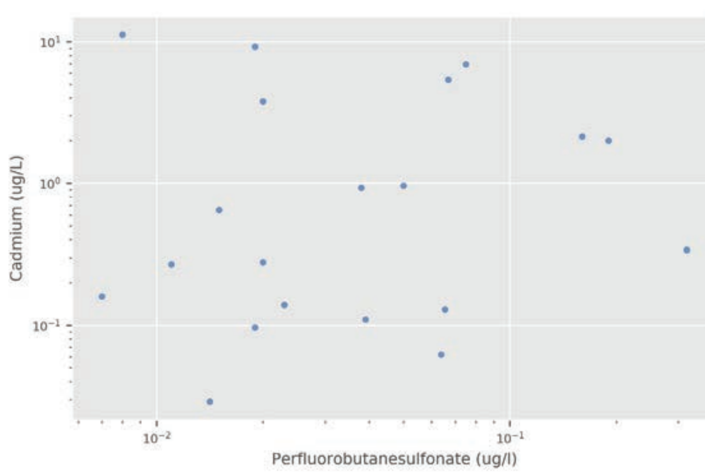
Nickel (ug/L)
10^{3}
10^{2}
10^{1}
10^{-2}
10^{-1}
10^{0}
Perfluorobutanesulfonate (ug/l)



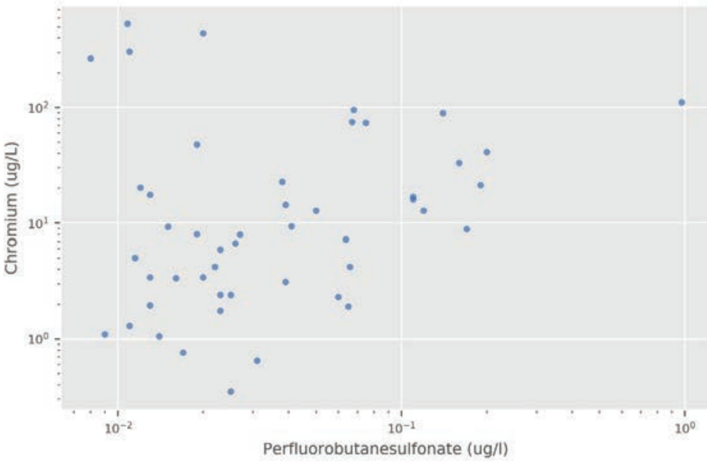
Boron (ug/L)
10^{4}
10^{3}
10^{2}
10^{1}
10^{-2}
10^{-1}
10^{0}
Perfluorobutanesulfonate (ug/l)

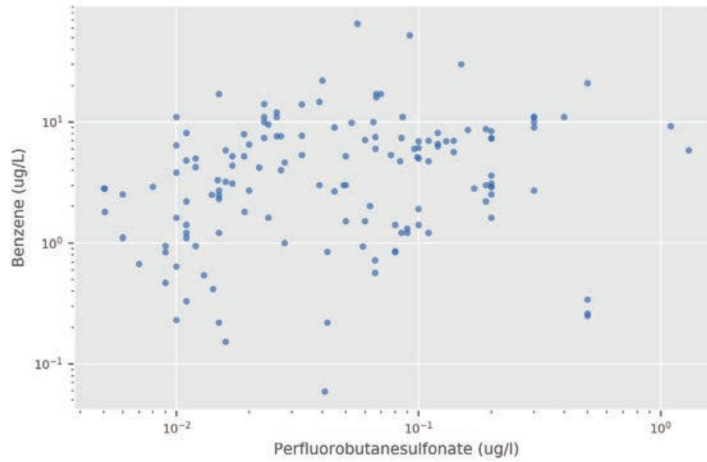


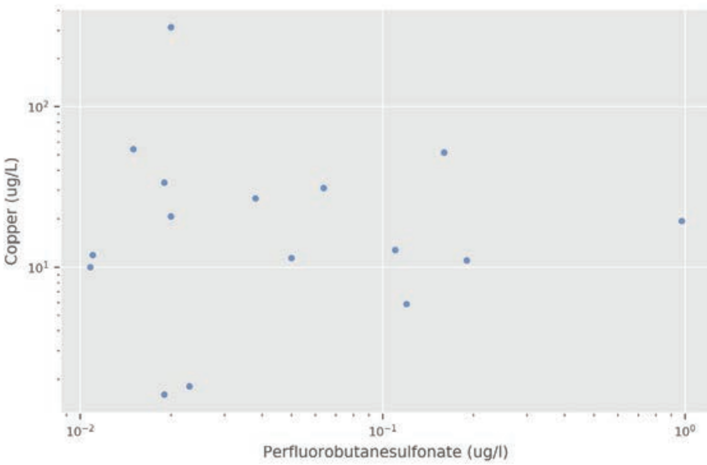
Sodium (ug/L)
10^{6}
10^{5}
10^{4}
10^{3}
10^{-2}
10^{-1}
10^{0}
Perfluorobutanesulfonate (ug/l)

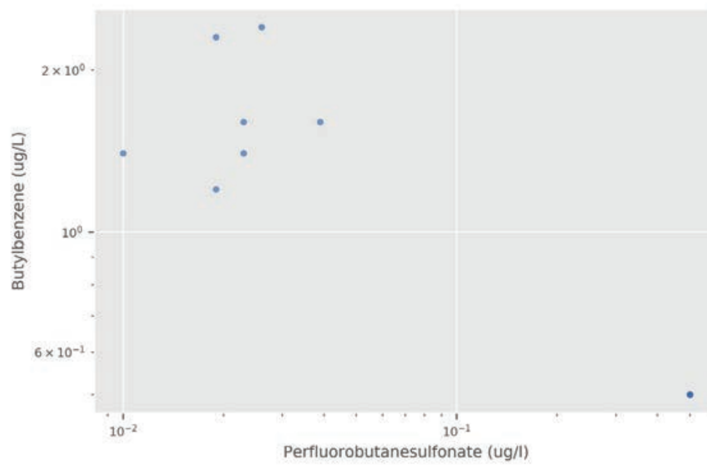


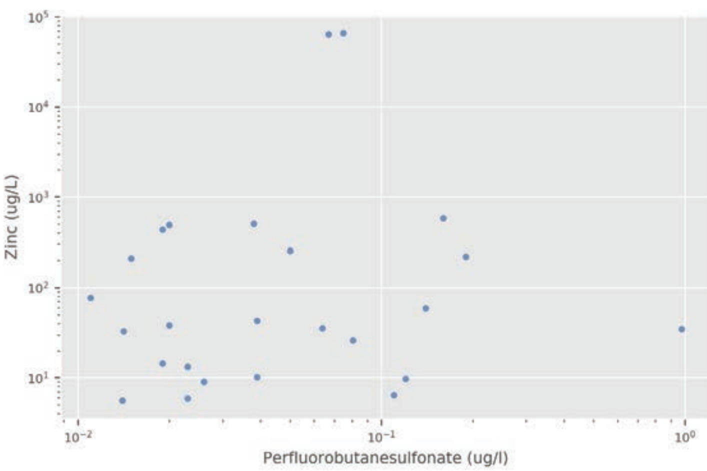
Cadmium (ug/L)
10^{1}
10^{0}
10^{-1}
10^{-2}
10^{-1}
Perfluorobutanesulfonate (ug/l)

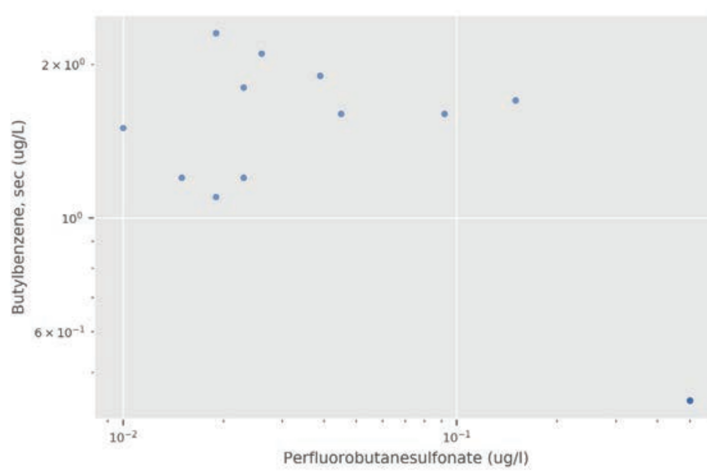

Chromium (ug/L)
Perfluorobutanesulfonate (ug/l)

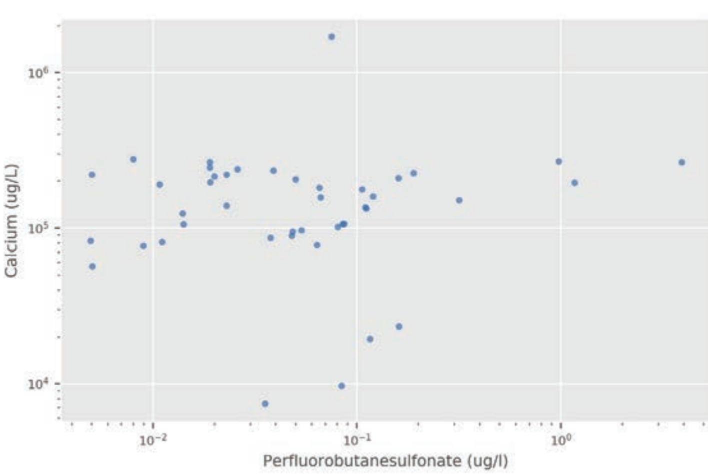

Benzene (ug/L)
Perfluorobutanesulfonate (ug/l)

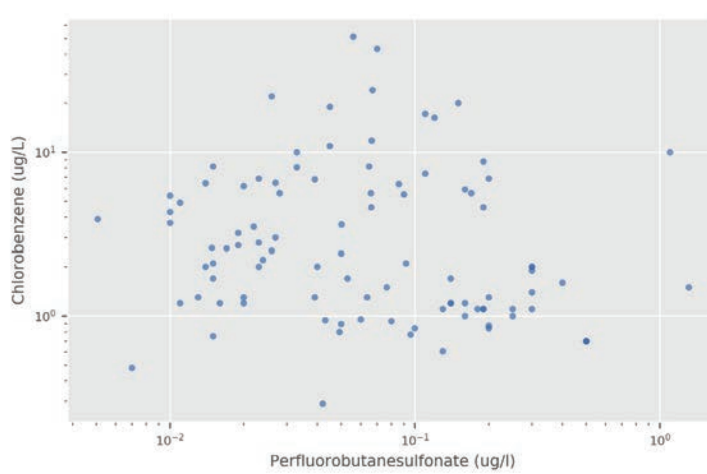

Copper (ug/L)
Perfluorobutanesulfonate (ug/l)

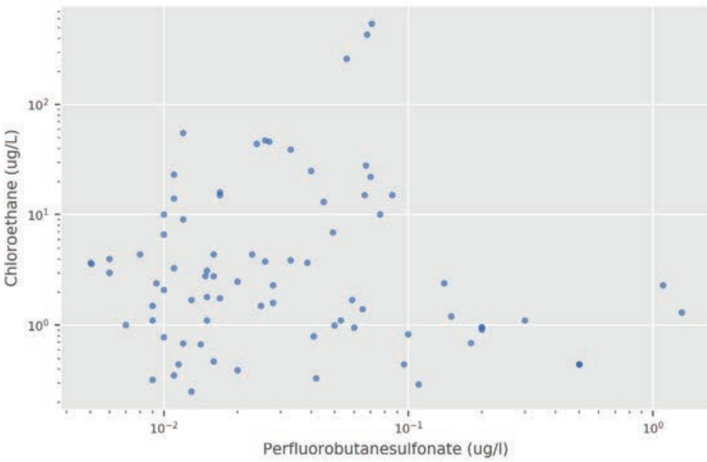

Butylbenzene (ug/L)
Perfluorobutanesulfonate (ug/l)

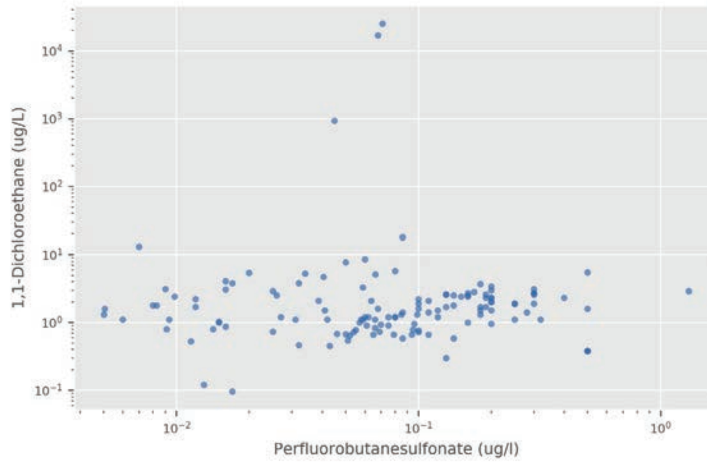

Zinc (ug/L)
Perfluorobutanesulfonate (ug/l)

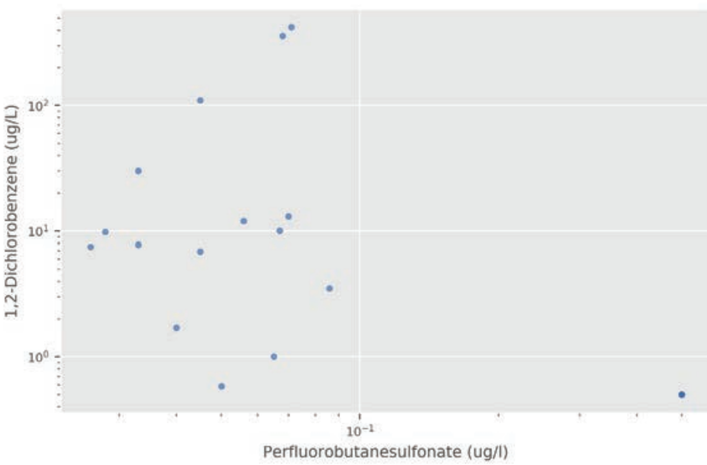

Butylbenzene, sec (ug/L)
Perfluorobutanesulfonate (ug/l)

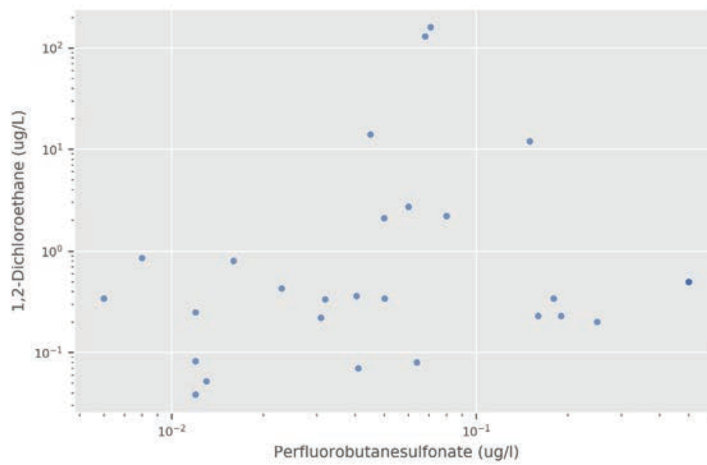

Calcium (ug/L)
Perfluorobutanesulfonate (ug/l)

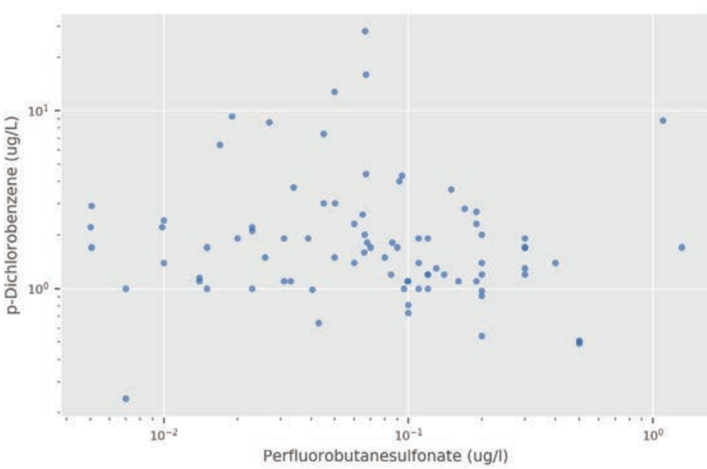

Chlorobenzene (ug/L)
Perfluorobutanesulfonate (ug/l)

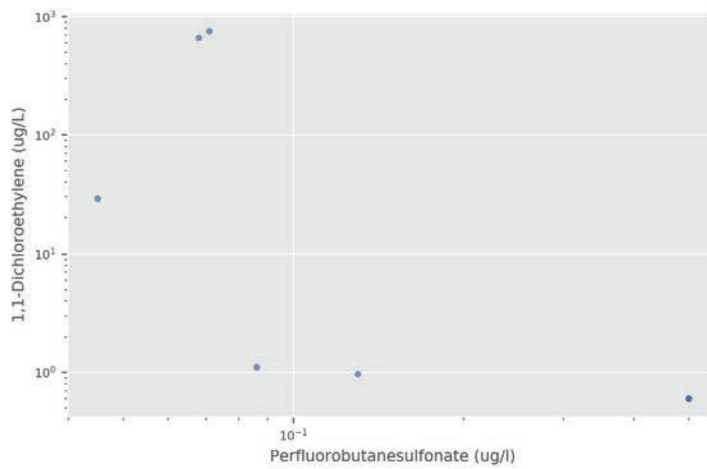

Chloroethane (ug/L)
Perfluorobutanesulfonate (ug/l)

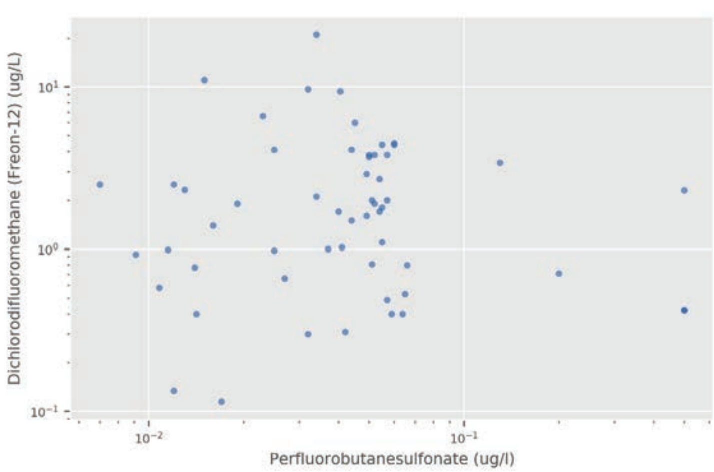

1,1-Dichloroethane (ug/L)
Perfluorobutanesulfonate (ug/l)

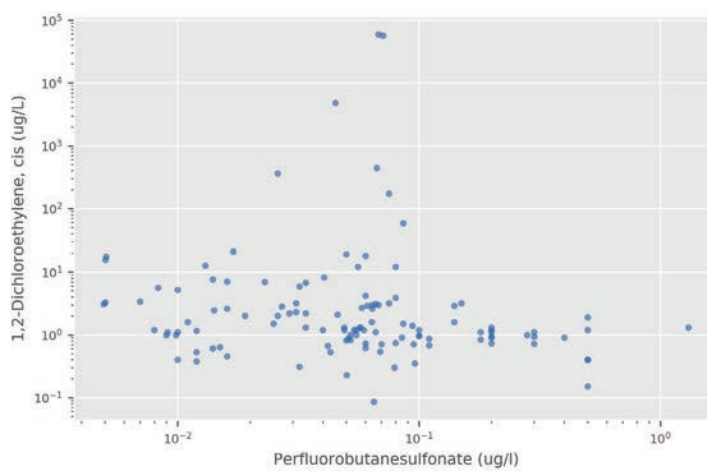

1,2-Dichlorobenzene (ug/L)
Perfluorobutanesulfonate (ug/l)

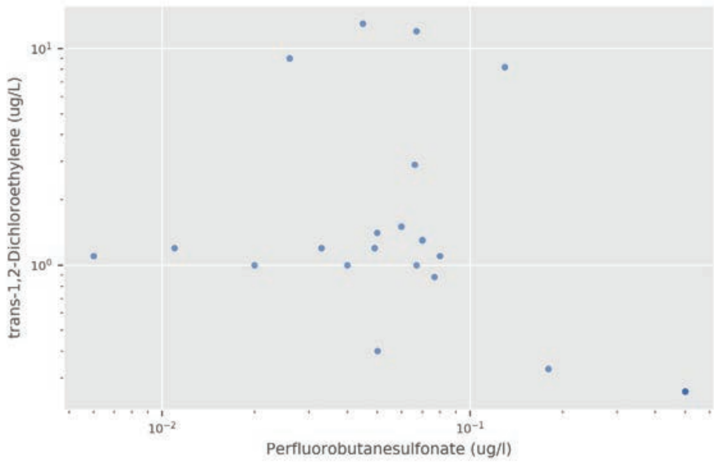

1,2-Dichloroethane (ug/L)
Perfluorobutanesulfonate (ug/l)


p-Dichlorobenzene (ug/L)
Perfluorobutanesulfonate (ug/l)

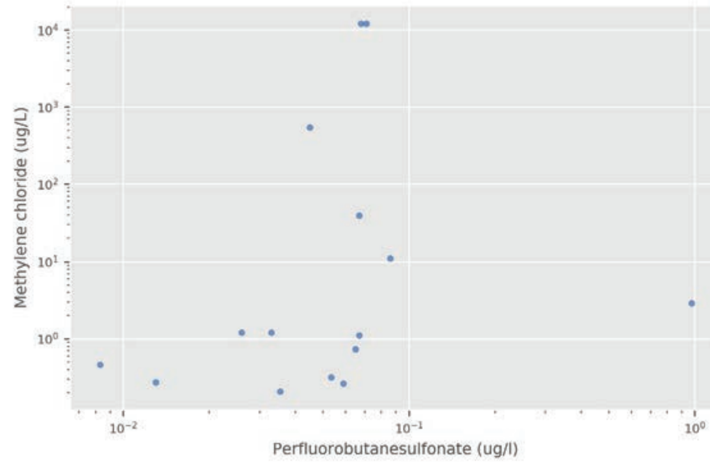

1,1-Dichloroethylene (ug/L)
Perfluorobutanesulfonate (ug/l)


Dichlorodifluoromethane (Freon-12) (ug/L)
Perfluorobutanesulfonate (ug/l)

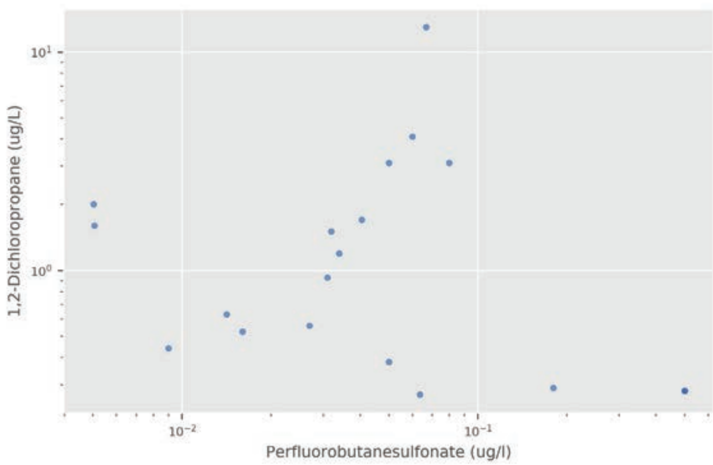

1,2-Dichloroethylene, cis (ug/L)
Perfluorobutanesulfonate (ug/l)



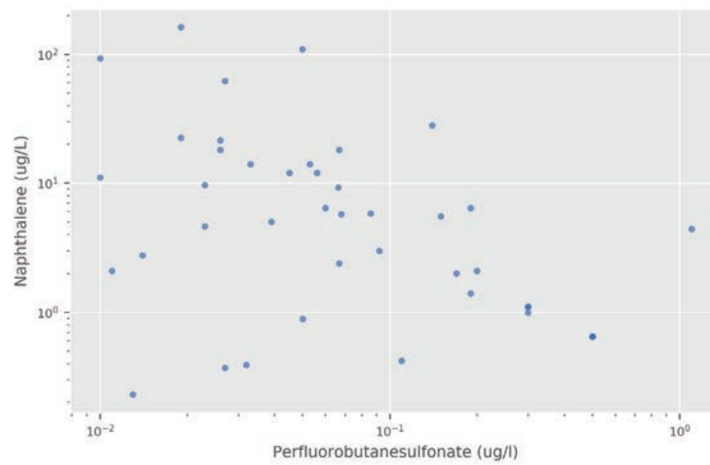
trans-1,2-Dichloroethylene (ug/L)
10^{1}
10^{0}
10^{-2}
10^{-1}
Perfluorobutanesulfonate (ug/l)



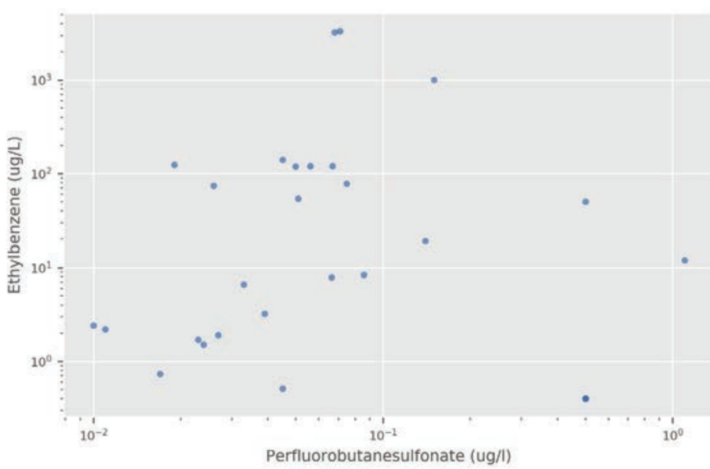
Methylene chloride (ug/L)
10^{4}
10^{3}
10^{2}
10^{1}
10^{0}
10^{-2}
10^{-1}
10^{0}
Perfluorobutanesulfonate (ug/l)



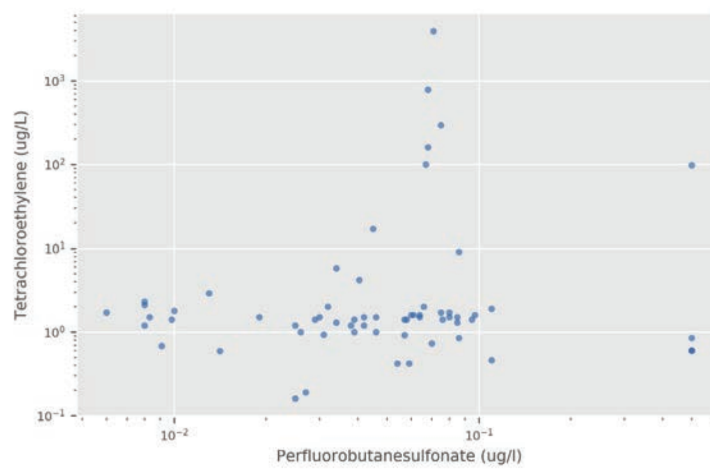
1,2-Dichloropropane (ug/L)
10^{1}
10^{0}
10^{-2}
10^{-1}
Perfluorobutanesulfonate (ug/l)



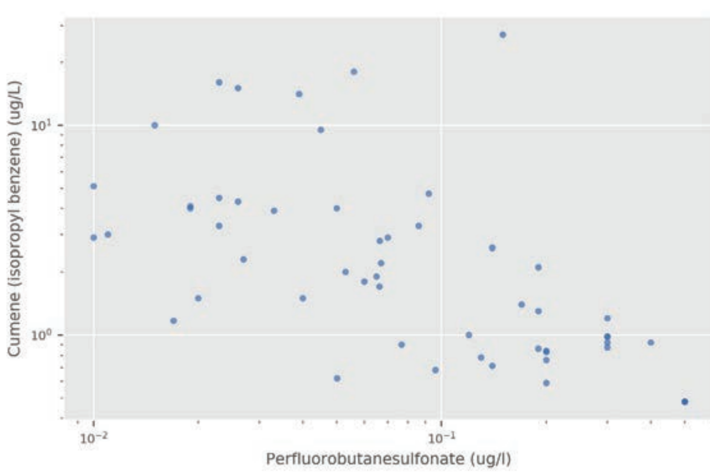
Naphthalene (ug/L)
10^{2}
10^{1}
10^{0}
10^{-2}
10^{-1}
10^{0}
Perfluorobutanesulfonate (ug/l)



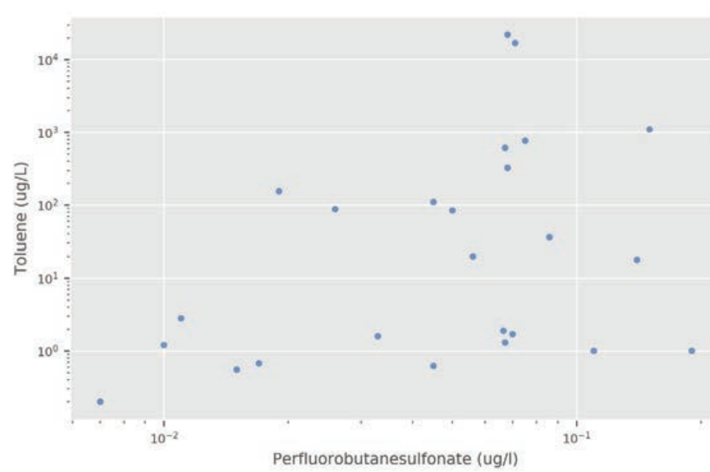
Ethylbenzene (ug/L)
10^{3}
10^{2}
10^{1}
10^{0}
10^{-2}
10^{-1}
10^{0}
Perfluorobutanesulfonate (ug/l)



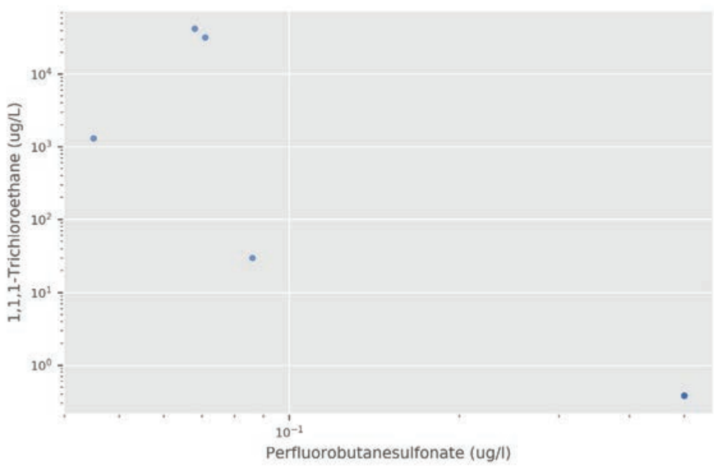
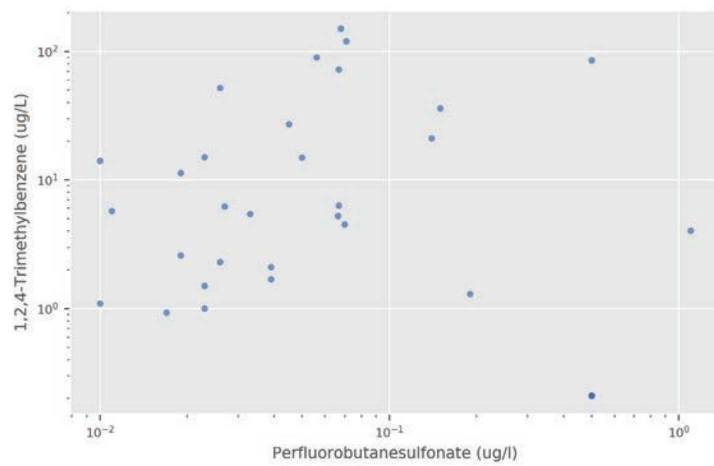
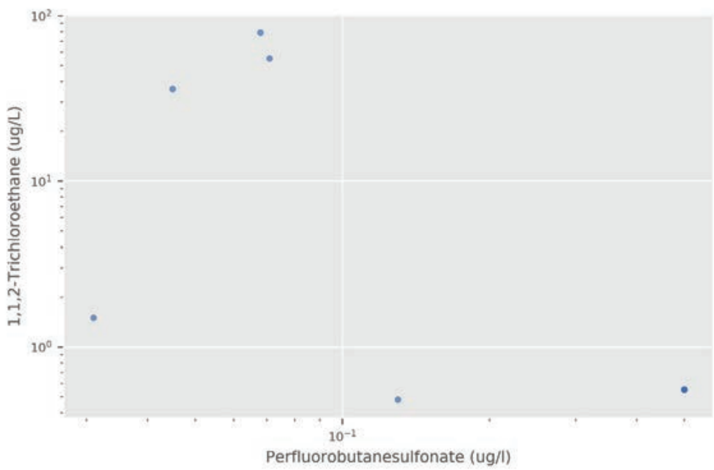
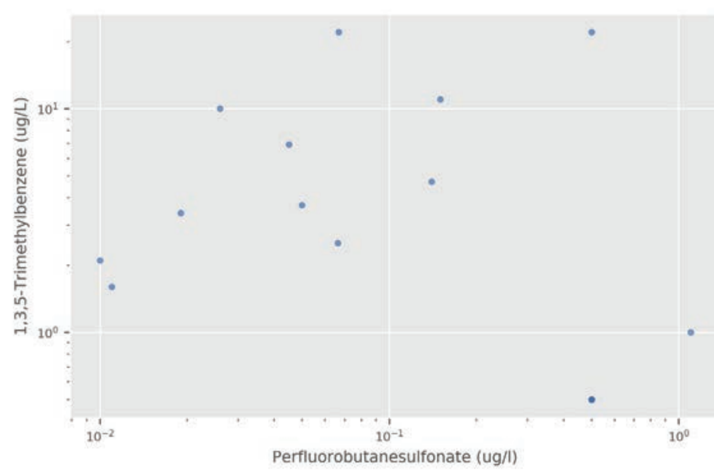
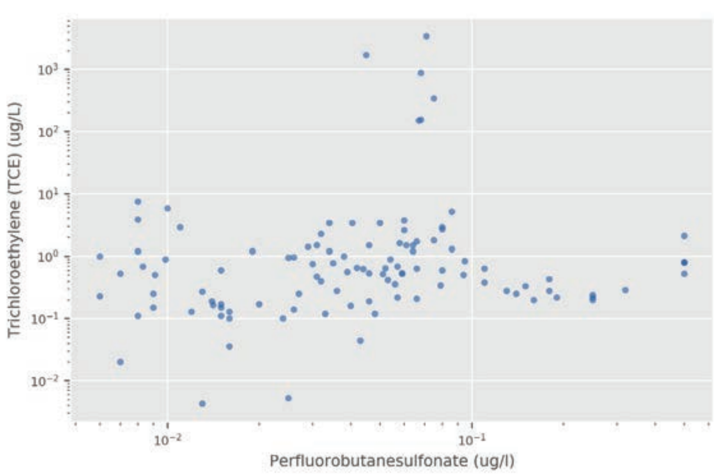
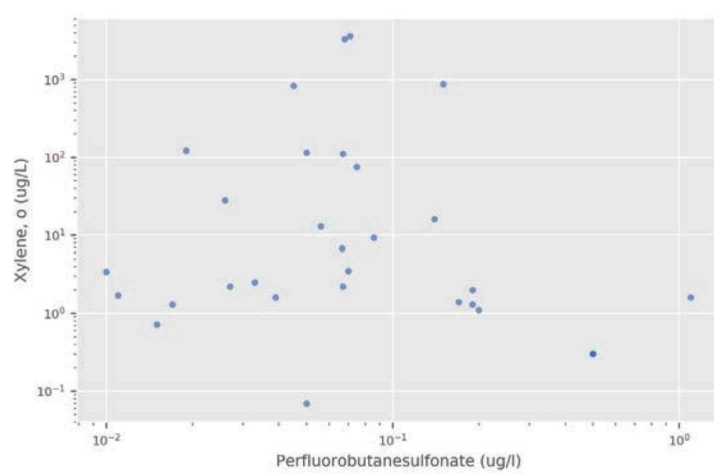
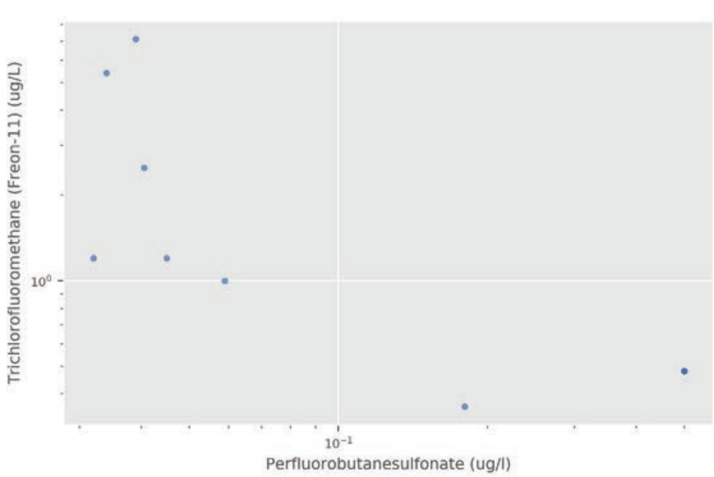
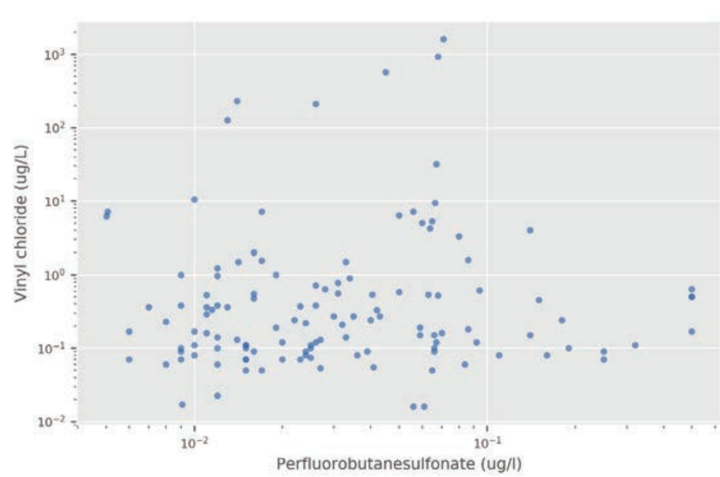
Tetrachloroethylene (ug/L)
10^{3}
10^{2}
10^{1}
10^{0}
10^{-1}
10^{-2}
10^{-1}
Perfluorobutanesulfonate (ug/l)

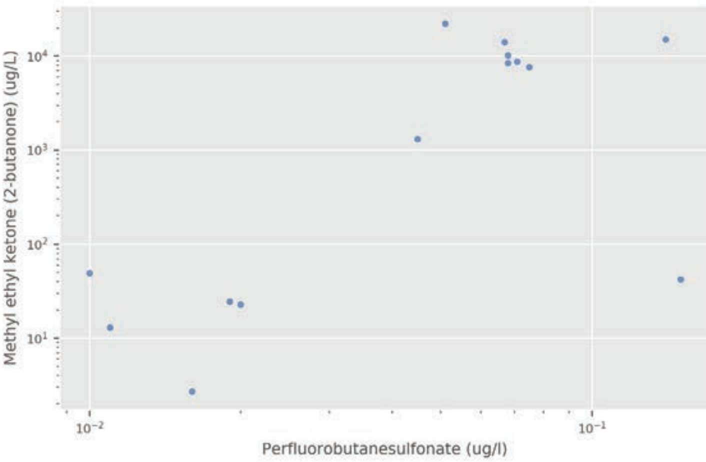


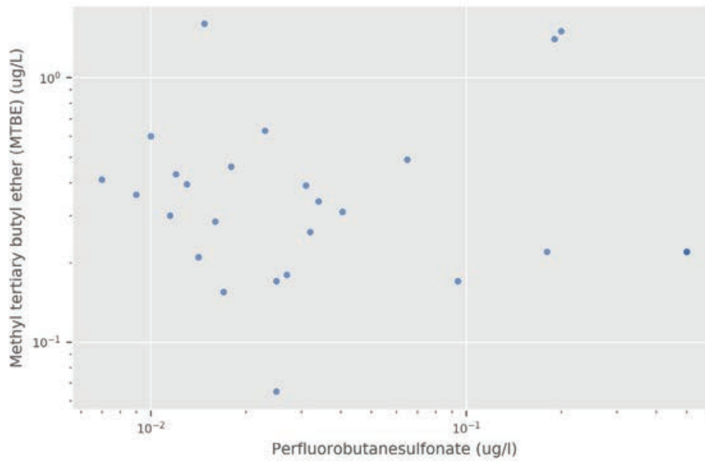
Cumene (isopropyl benzene) (ug/L)
10^{1}
10^{0}
10^{-2}
10^{-1}
Perfluorobutanesulfonate (ug/l)

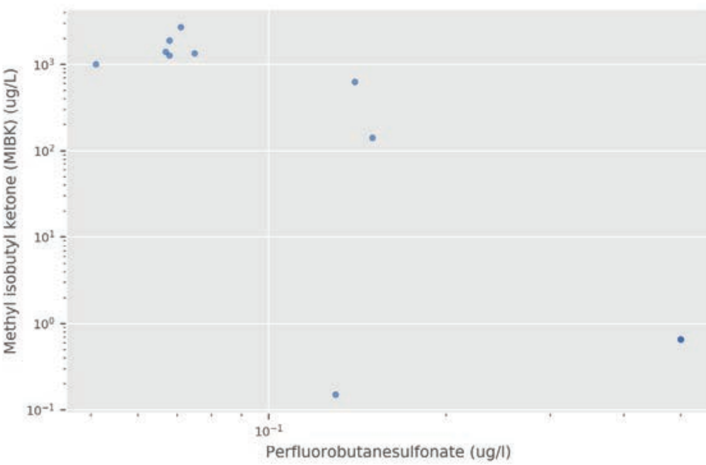


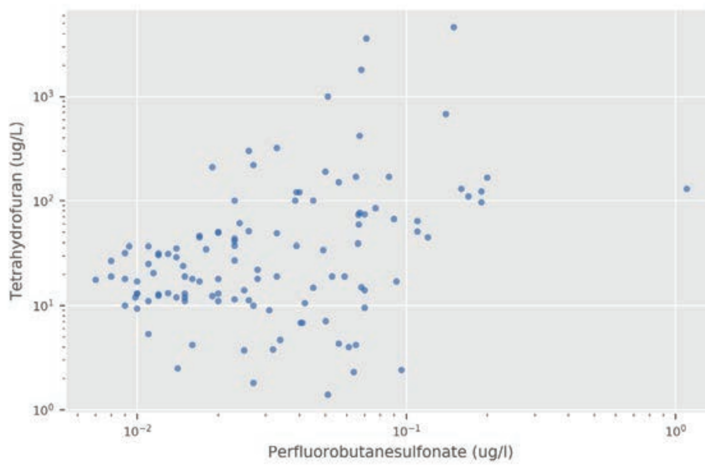
Toluene (ug/L)
10^{4}
10^{3}
10^{2}
10^{1}
10^{0}
10^{-2}
10^{-1}
Perfluorobutanesulfonate (ug/l)

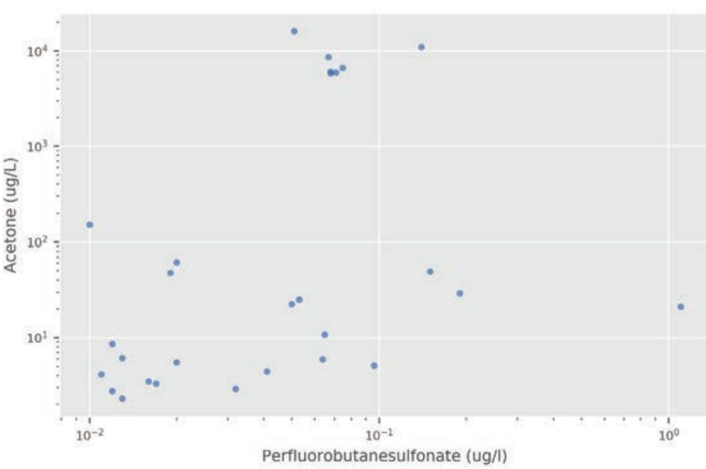

1,1,1-Trichloroethane (ug/L)
10^4
10^3
10^2
10^1
10^0
10^{-1}
Perfluorobutanesulfonate (ug/l)

1,2,4-Trimethylbenzene (ug/L)
10^2
10^1
10^0
10^{-2}
10^{-1}
10^0
Perfluorobutanesulfonate (ug/l)

1,1,2-Trichloroethane (ug/L)
10^2
10^1
10^0
10^{-1}
Perfluorobutanesulfonate (ug/l)

1,3,5-Trimethylbenzene (ug/L)
10^1
10^0
10^{-2}
10^{-1}
10^0
Perfluorobutanesulfonate (ug/l)

Trichloroethylene (TCE) (ug/L)
10^3
10^2
10^1
10^0
10^{-1}
10^{-2}
10^{-2}
10^{-1}
Perfluorobutanesulfonate (ug/l)

Xylene, o (ug/L)
10^3
10^2
10^1
10^0
10^{-1}
10^{-2}
10^{-1}
10^0
Perfluorobutanesulfonate (ug/l)

Trichlorofluoromethane (Freon-11) (ug/L)
10^0
10^{-1}
Perfluorobutanesulfonate (ug/l)

Vinyl chloride (ug/L)
10^3
10^2
10^1
10^0
10^{-1}
10^{-2}
10^{-2}
10^{-1}
Perfluorobutanesulfonate (ug/l)

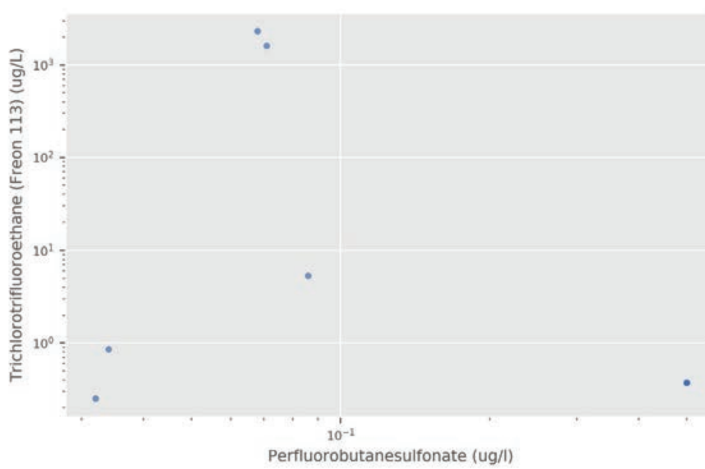

Methyl ethyl ketone (2-butanone) (ug/L)
10^4
10^3
10^2
10^1
10^{-2}
10^{-1}
Perfluorobutanesulfonate (ug/l)

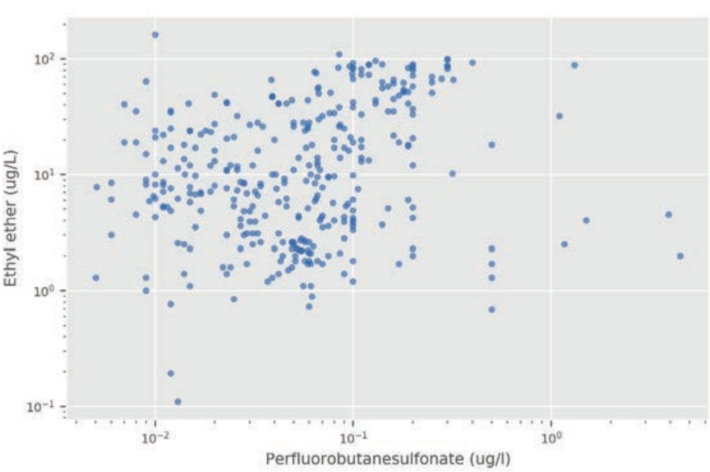

Methyl tertiary butyl ether (MTBE) (ug/L)
10^0
10^{-1}
10^{-2}
10^{-1}
Perfluorobutanesulfonate (ug/l)

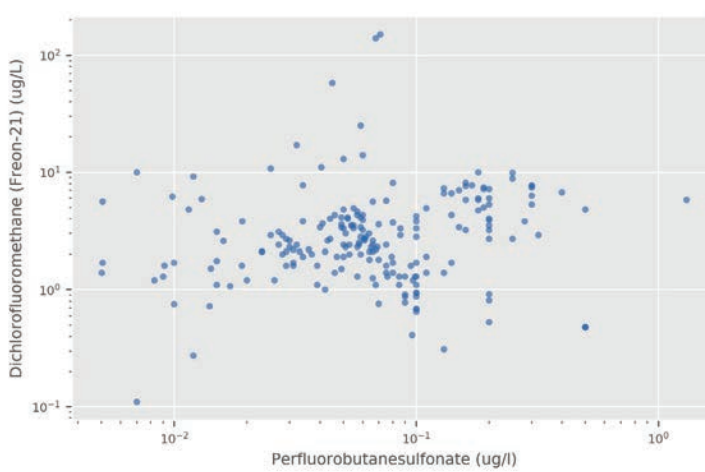

Methyl isobutyl ketone (MIBK) (ug/L)
10^3
10^2
10^1
10^0
10^{-1}
10^{-1}
Perfluorobutanesulfonate (ug/l)

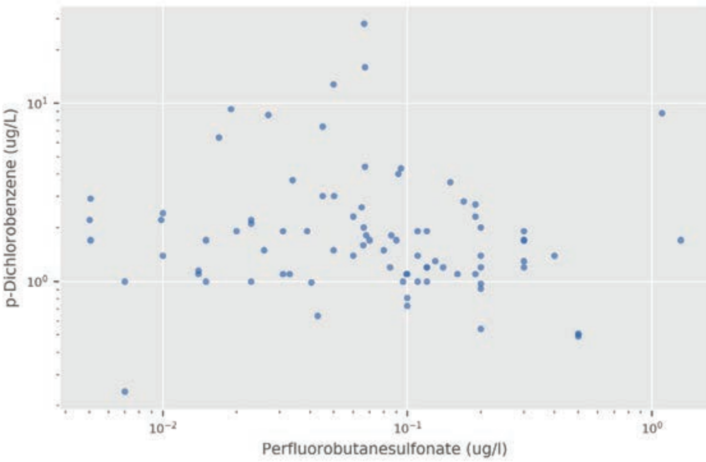

Tetrahydrofuran (ug/L)
10^3
10^2
10^1
10^0
10^{-2}
10^{-1}
10^0
Perfluorobutanesulfonate (ug/l)


Acetone (ug/L)
10^4
10^3
10^2
10^1
10^{-2}
10^{-1}
10^0
Perfluorobutanesulfonate (ug/l)

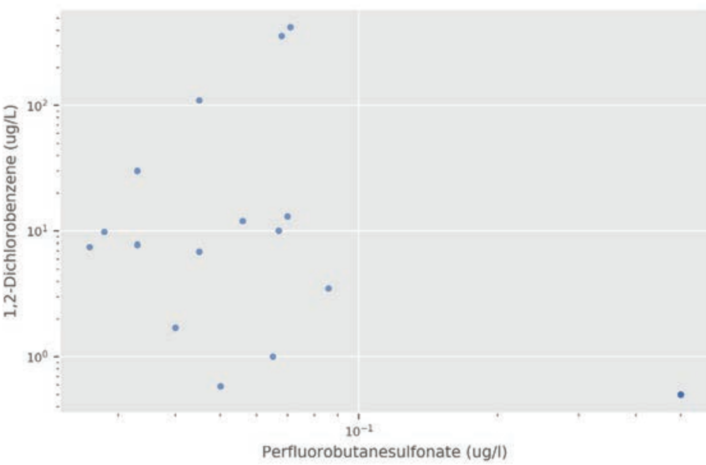

Trichlorotrifluoroethane (Freon 113) (ug/L)
10^3
10^2
10^1
10^0
10^{-1}
Perfluorobutanesulfonate (ug/l)


Ethyl ether (ug/L)
10^2
10^1
10^0
10^{-1}
10^{-2}
10^{-1}
10^0
Perfluorobutanesulfonate (ug/l)

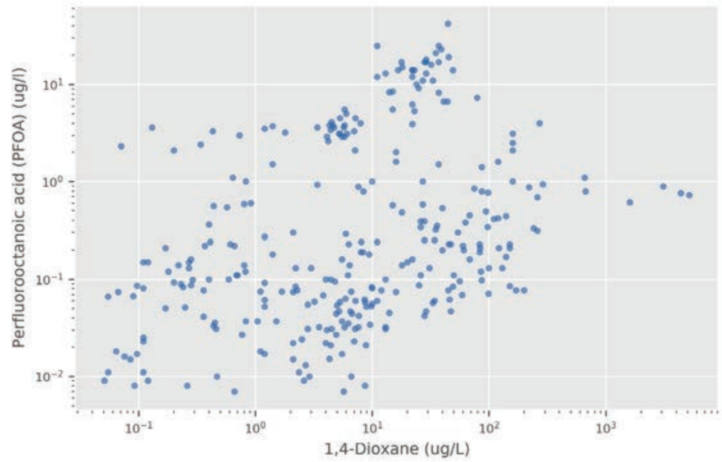

Dichlorofluoromethane (Freon-21) (ug/L)
10^2
10^1
10^0
10^{-1}
10^{-2}
10^{-1}
10^0
Perfluorobutanesulfonate (ug/l)

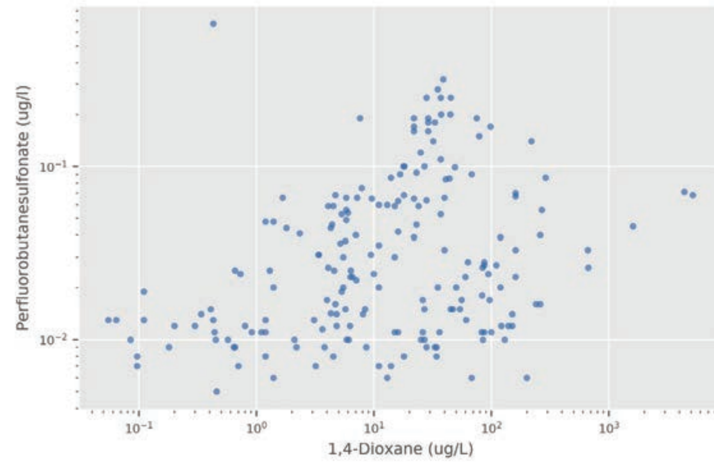


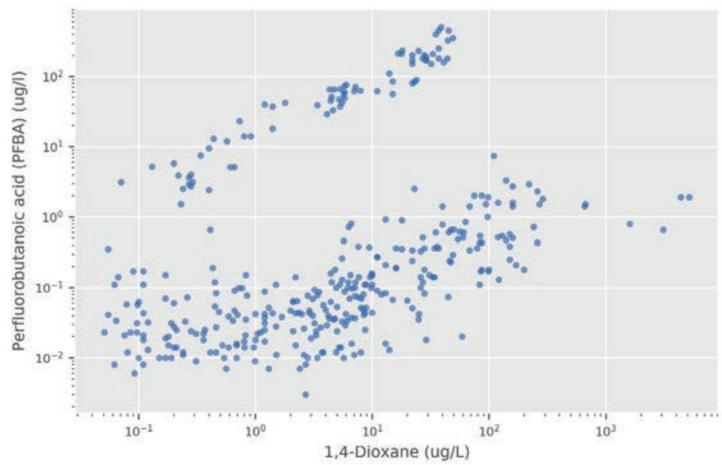
p-Dichlorobenzene (ug/L)
Perfluorobutanesulfonate (ug/l)

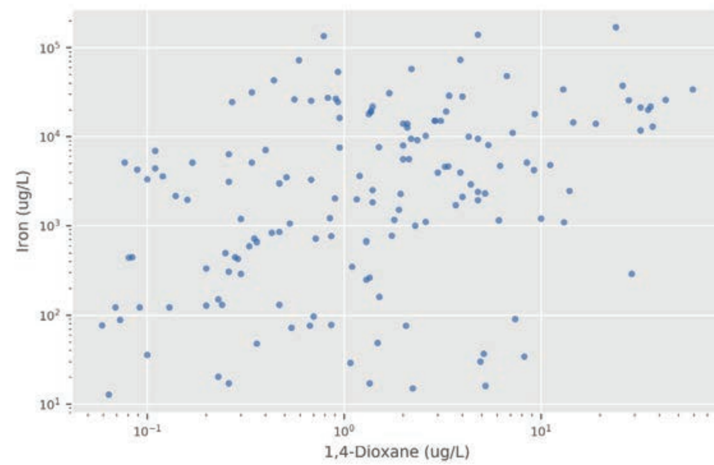


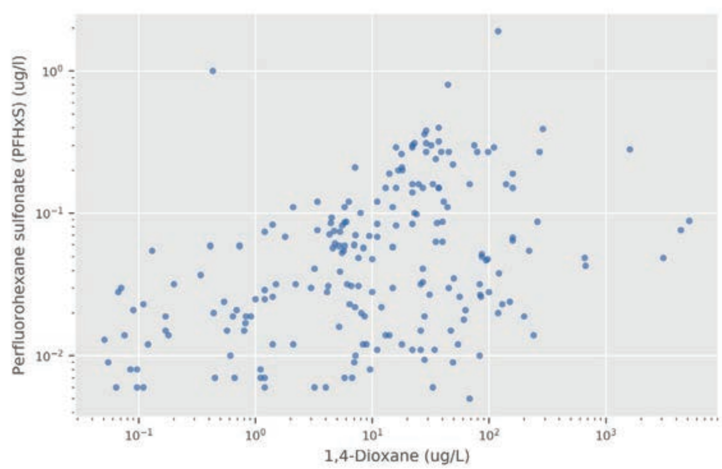
1,2-Dichlorobenzene (ug/L)
Perfluorobutanesulfonate (ug/l)

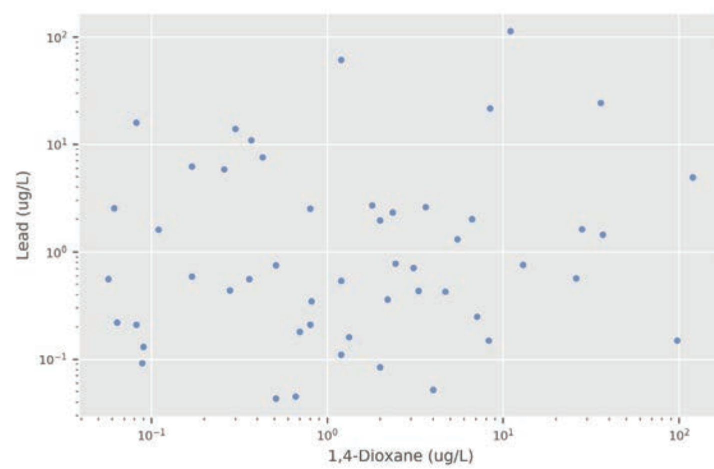

Perfluorooctanoic acid (PFOA) (ug/l)
1,4-Dioxane (ug/L)

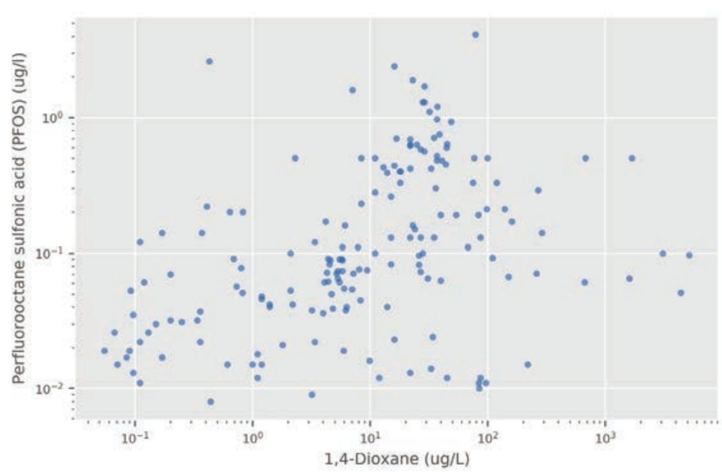

Perfluorobutanesulfonate (ug/l)
1,4-Dioxane (ug/L)

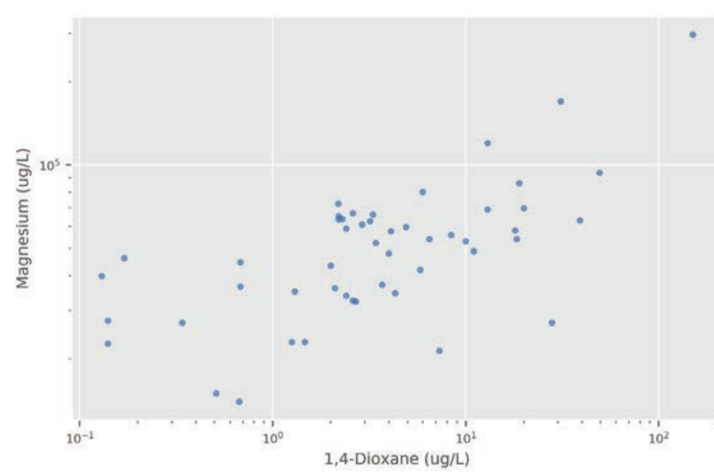

Perfluorobutanoic acid (PFBA) (ug/l)
1,4-Dioxane (ug/L)

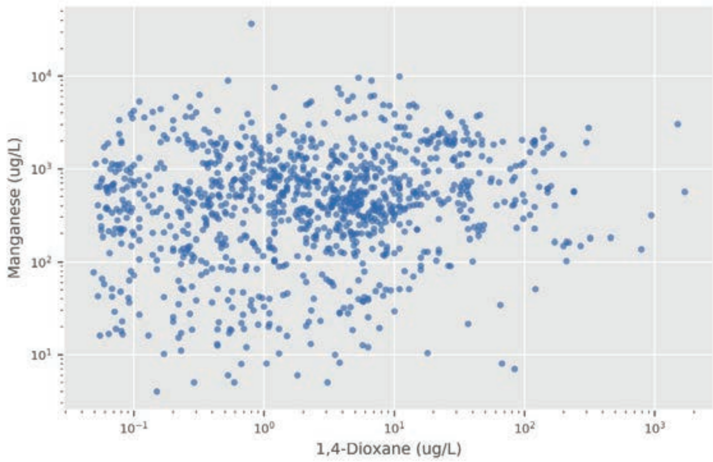

Iron (ug/L)
1,4-Dioxane (ug/L)

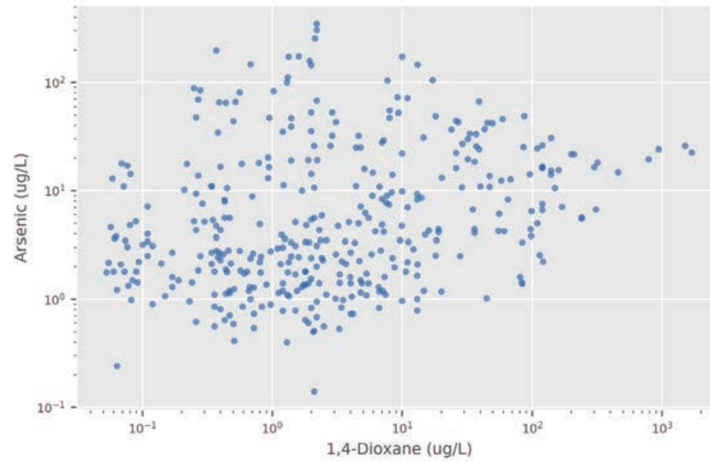

Perfluorohexane sulfonate (PFHxS) (ug/l)
1,4-Dioxane (ug/L)

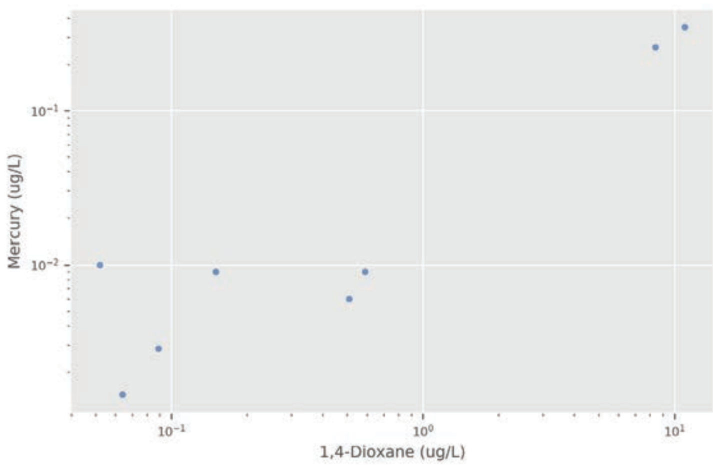

Lead (ug/L)
1,4-Dioxane (ug/L)

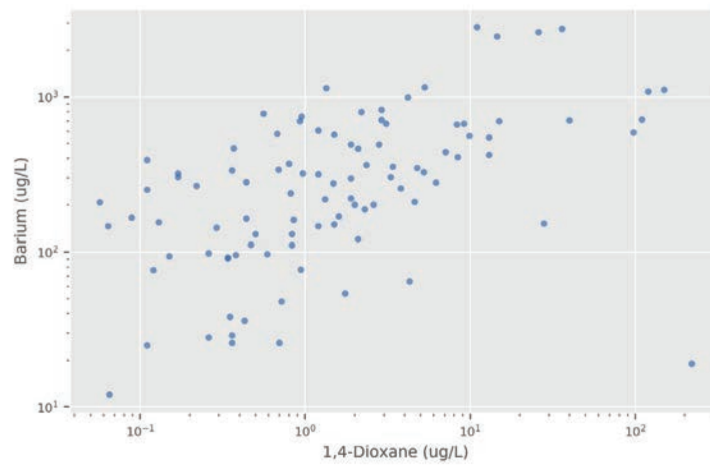

Perfluorooctane sulfonic acid (PFOS) (ug/l)
1,4-Dioxane (ug/L)

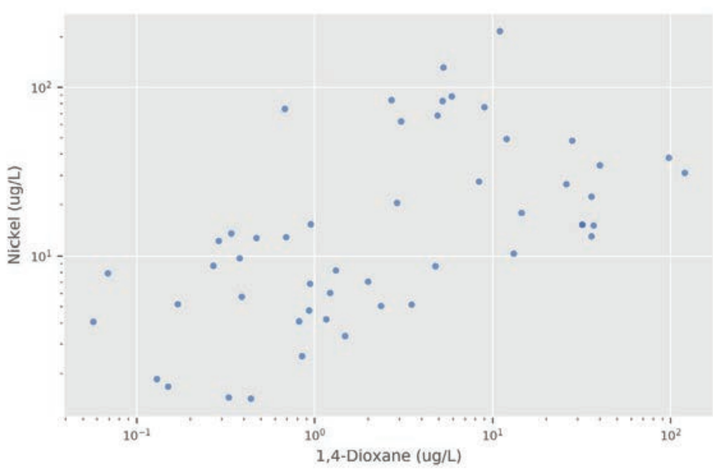

Magnesium (ug/L)
1,4-Dioxane (ug/L)

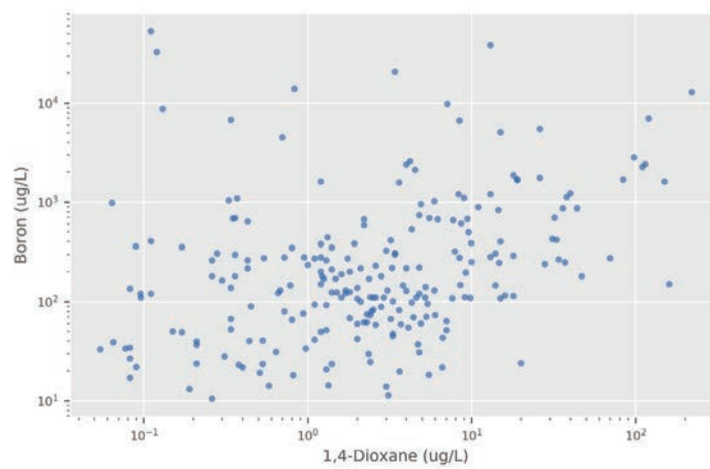

Manganese (ug/L)
1,4-Dioxane (ug/L)
10^{1} 10^{2} 10^{3} 10^{4}
10^{-1} 10^{0} 10^{1} 10^{2} 10^{3}

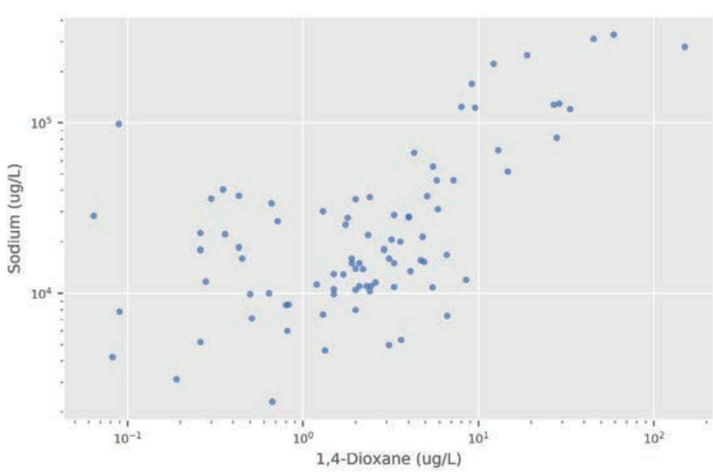

Arsenic (ug/L)
1,4-Dioxane (ug/L)
10^{-1} 10^{0} 10^{1} 10^{2}
10^{-1} 10^{0} 10^{1} 10^{2} 10^{3}

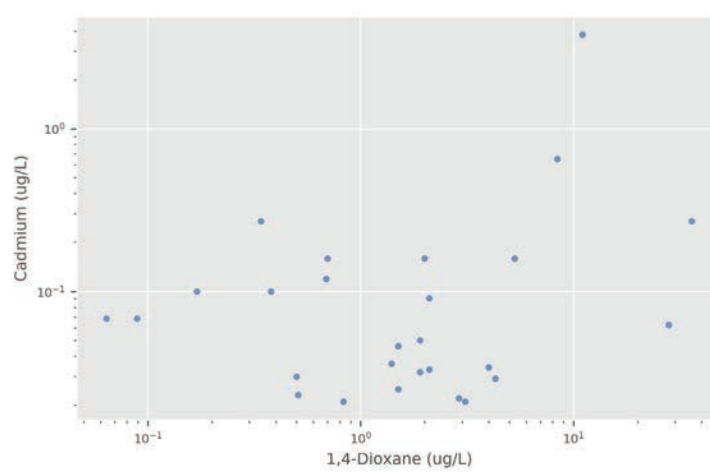

Mercury (ug/L)
1,4-Dioxane (ug/L)
10^{-2} 10^{-1}
10^{-1} 10^{0} 10^{1}

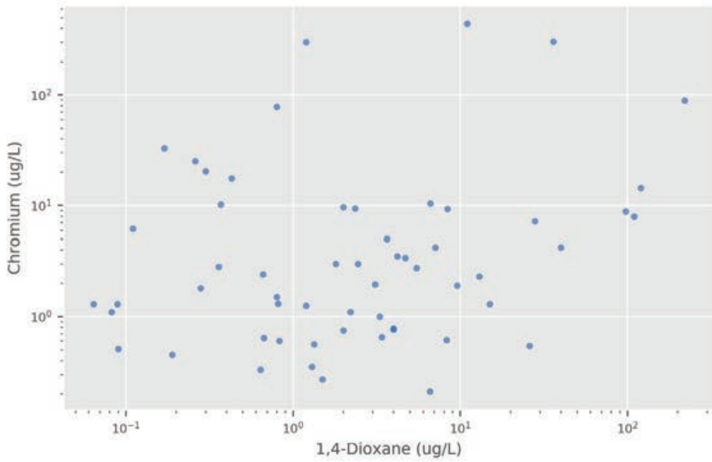

Barium (ug/L)
1,4-Dioxane (ug/L)
10^{1} 10^{2} 10^{3}
10^{-1} 10^{0} 10^{1} 10^{2}

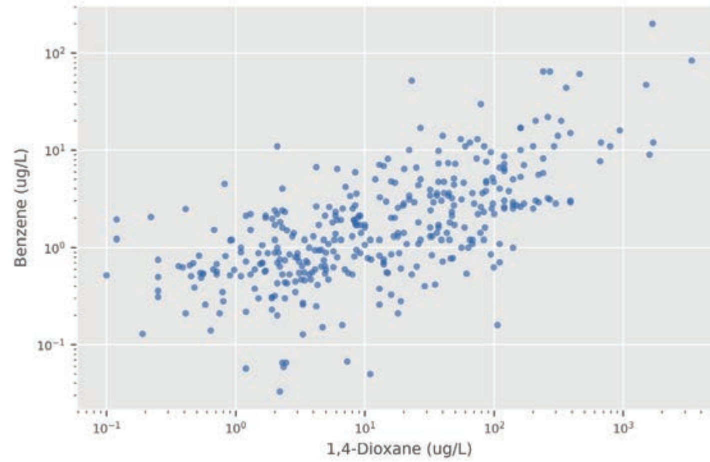

Nickel (ug/L)
1,4-Dioxane (ug/L)
10^{1} 10^{2}
10^{-1} 10^{0} 10^{1} 10^{2}

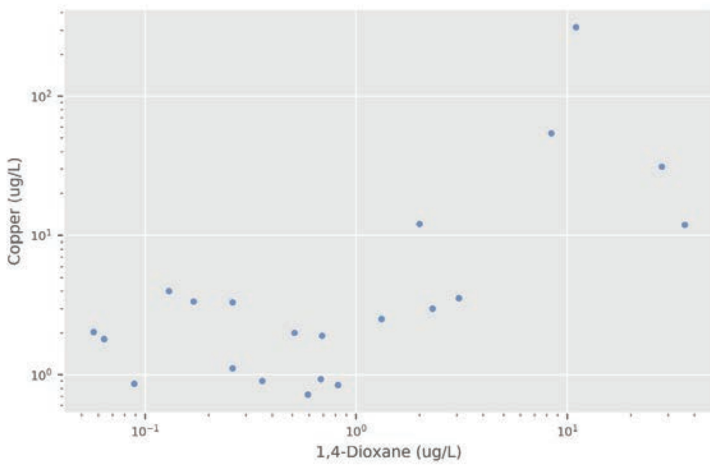

Boron (ug/L)
1,4-Dioxane (ug/L)
10^{1} 10^{2} 10^{3} 10^{4}
10^{-1} 10^{0} 10^{1} 10^{2}

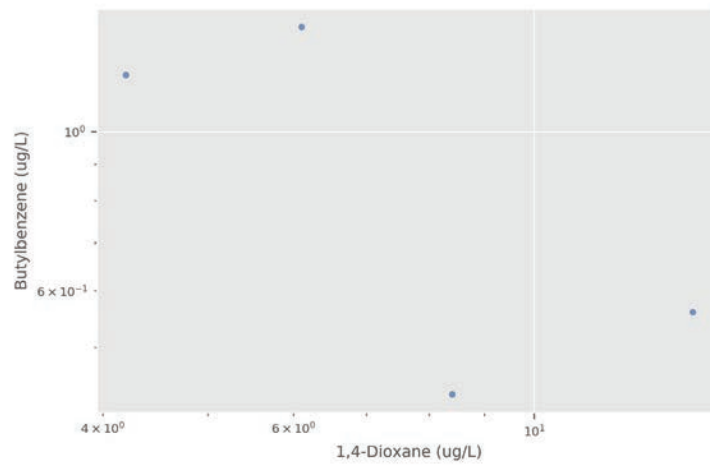

Sodium (ug/L)
1,4-Dioxane (ug/L)
10^{4} 10^{5}
10^{-1} 10^{0} 10^{1} 10^{2}

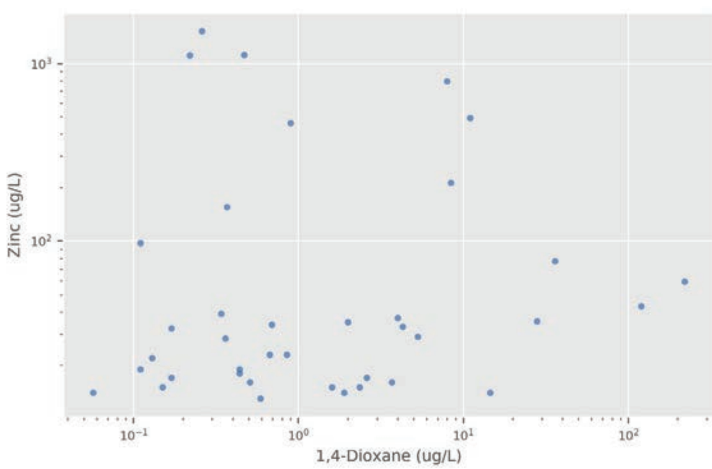

Cadmium (ug/L)
1,4-Dioxane (ug/L)
10^{-1} 10^{0}
10^{-1} 10^{0} 10^{1}

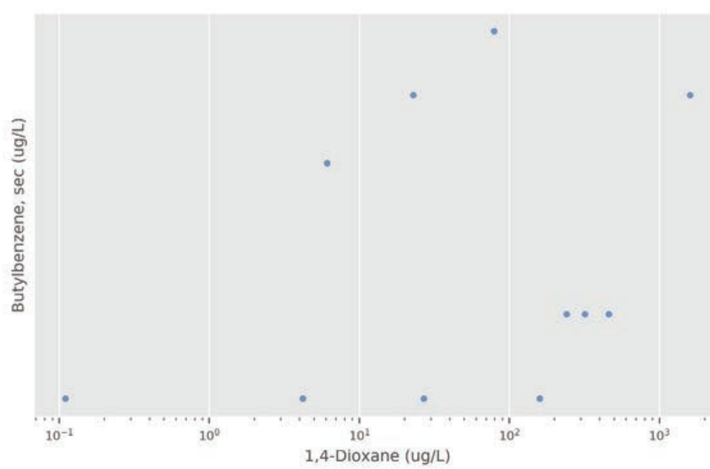

Chromium (ug/L)
10^2
10^1
10^0
10^{-1}
10^0
10^1
10^2
1,4-Dioxane (ug/L)

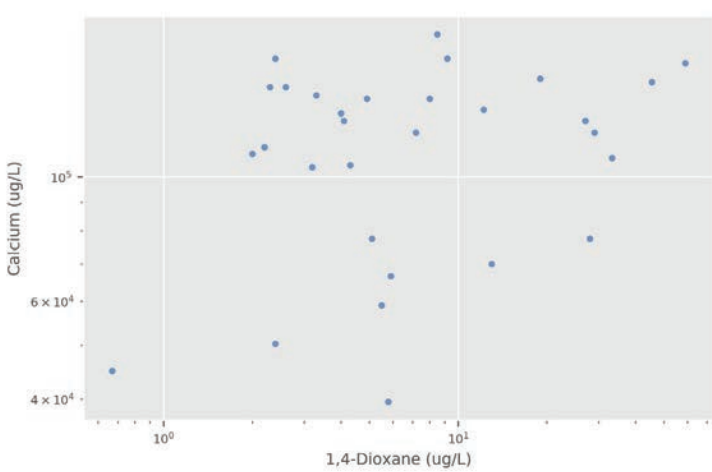

Benzene (ug/L)
10^2
10^1
10^0
10^{-1}
10^{-1}
10^0
10^1
10^2
10^3
1,4-Dioxane (ug/L)

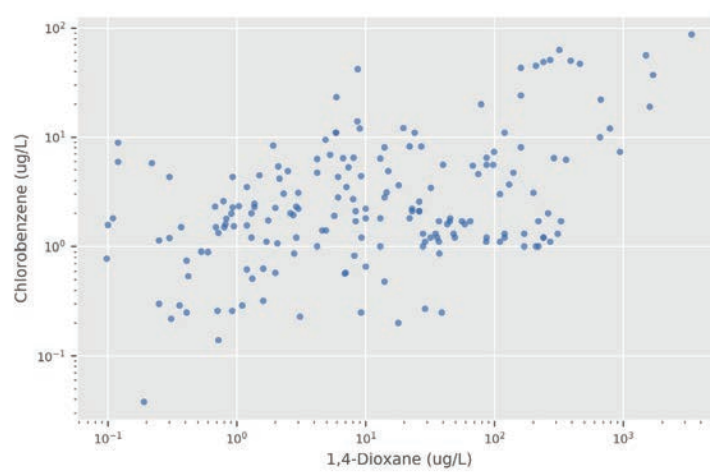

Copper (ug/L)
10^2
10^1
10^0
10^{-1}
10^0
10^1
1,4-Dioxane (ug/L)

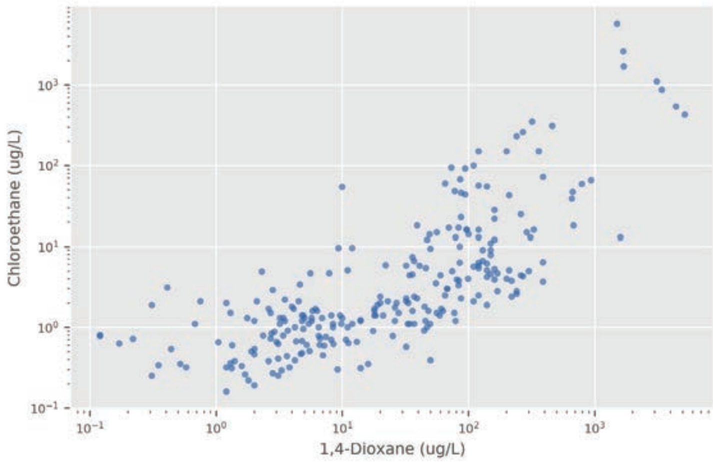

Butylbenzene (ug/L)
10^0
6×10^{-1}
4×10^0
6×10^0
10^1
1,4-Dioxane (ug/L)

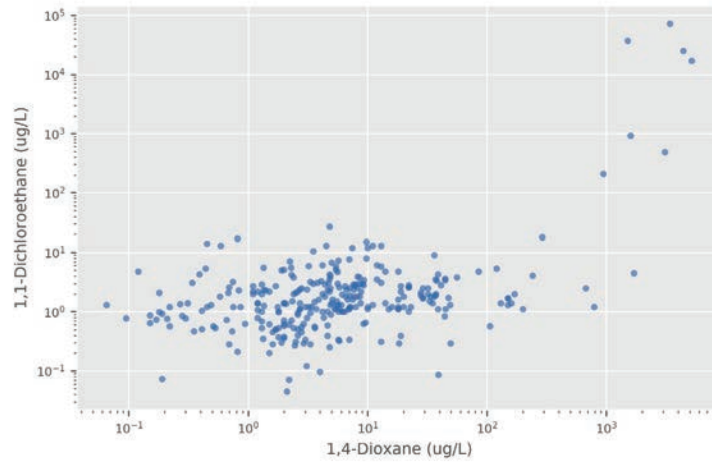

Zinc (ug/L)
10^3
10^2
10^{-1}
10^0
10^1
10^2
1,4-Dioxane (ug/L)

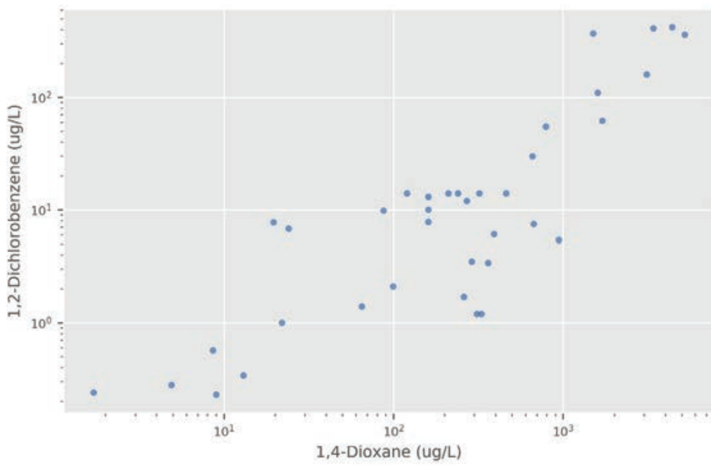

Butylbenzene, sec (ug/L)
10^{-1}
10^0
10^1
10^2
10^3
1,4-Dioxane (ug/L)

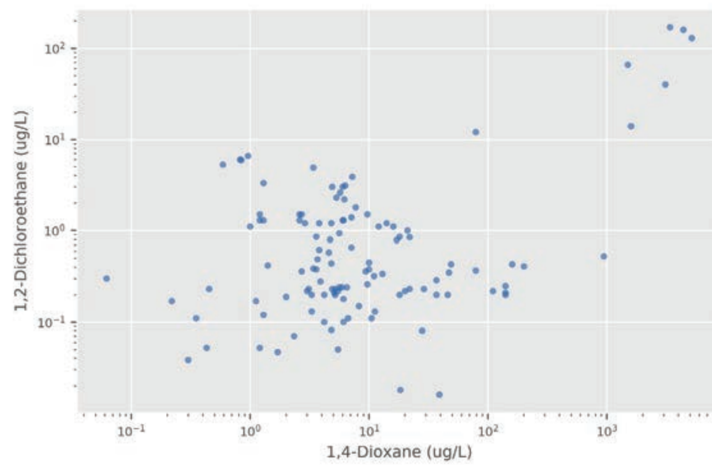

Calcium (ug/L)
10^5
6×10^4
4×10^4
10^0
10^1
1,4-Dioxane (ug/L)

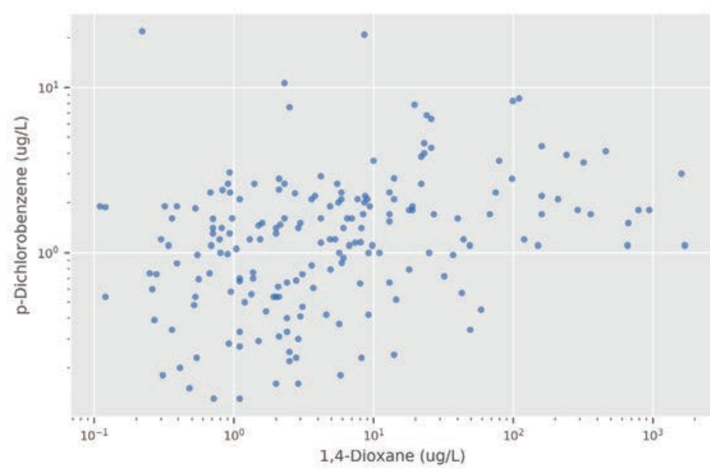

Chlorobenzene (ug/L)
10^2
10^1
10^0
10^{-1}
10^{-1}
10^0
10^1
10^2
10^3
1,4-Dioxane (ug/L)

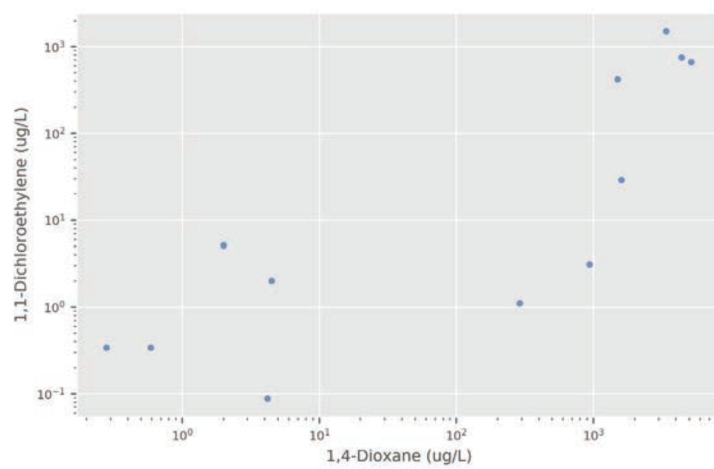

Chloroethane (ug/L)
1,4-Dioxane (ug/L)

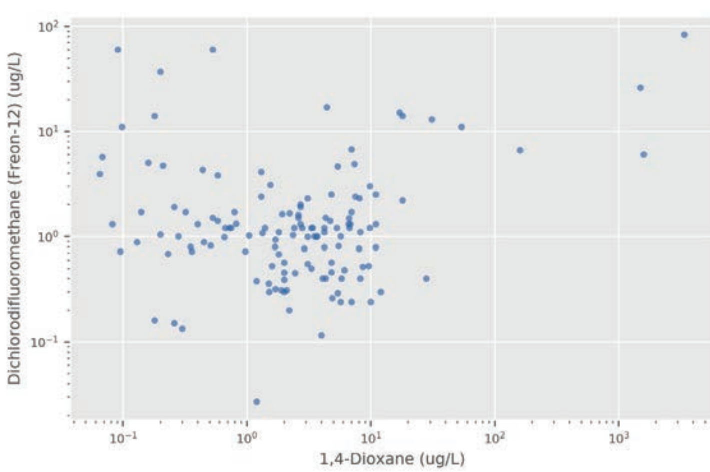

1,1-Dichloroethane (ug/L)
1,4-Dioxane (ug/L)

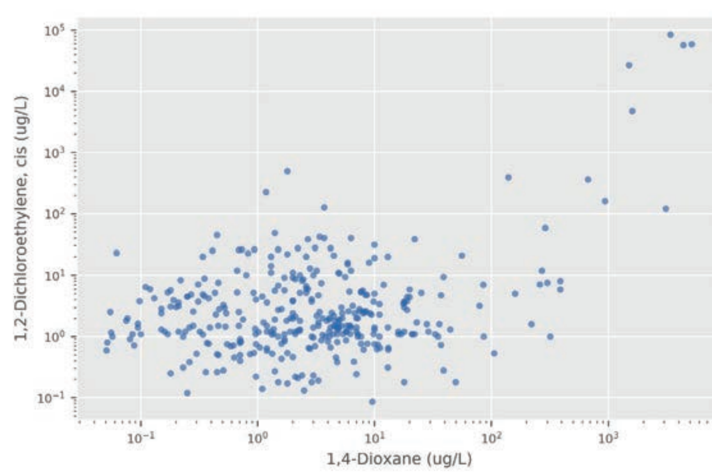

1,2-Dichlorobenzene (ug/L)
1,4-Dioxane (ug/L)

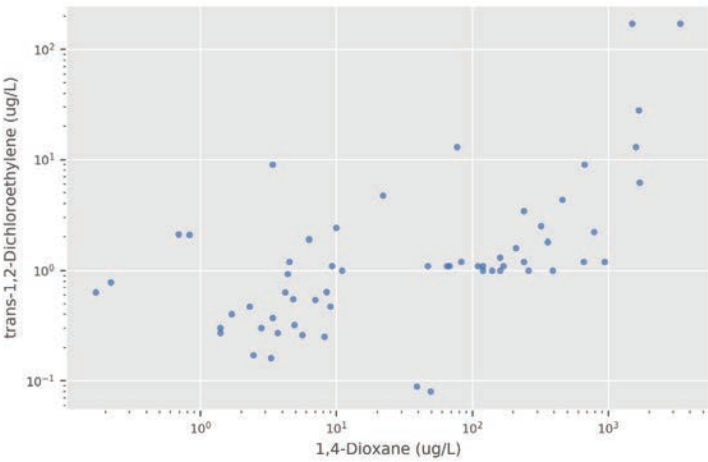

1,2-Dichloroethane (ug/L)
1,4-Dioxane (ug/L)

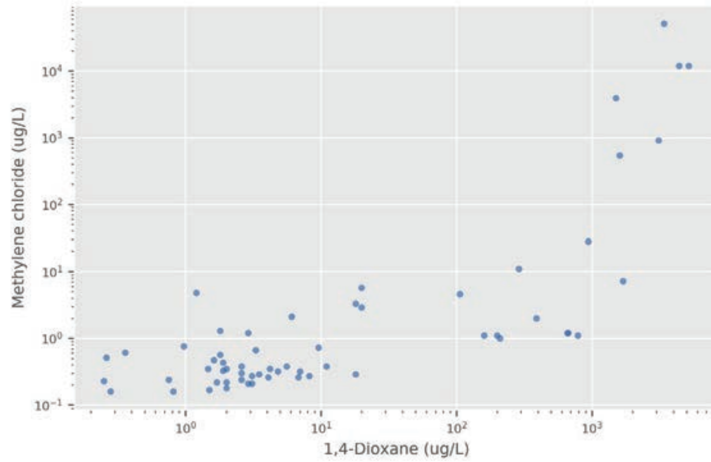

p-Dichlorobenzene (ug/L)
1,4-Dioxane (ug/L)

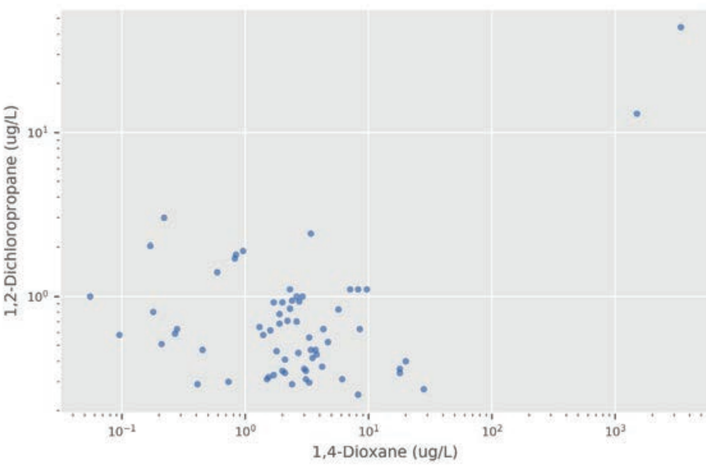

1,1-Dichloroethylene (ug/L)
1,4-Dioxane (ug/L)

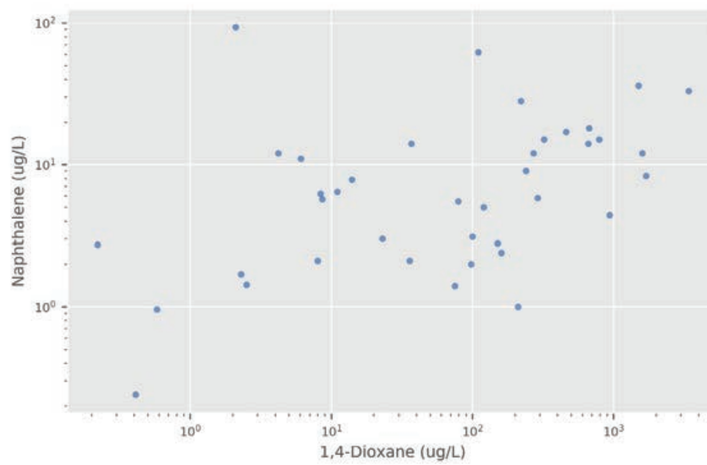

Dichlorodifluoromethane (Freon-12) (ug/L)
1,4-Dioxane (ug/L)

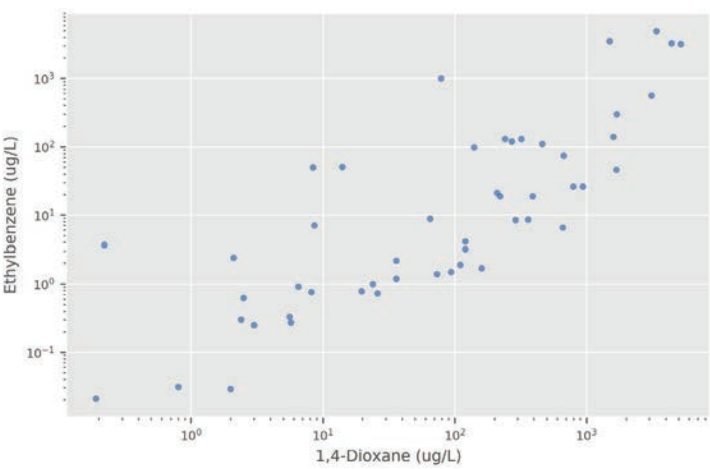

1,2-Dichloroethylene, cis (ug/L)
1,4-Dioxane (ug/L)

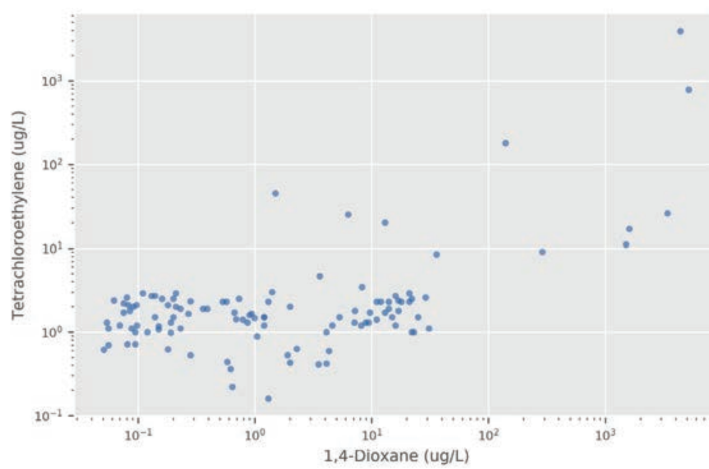

trans-1,2-Dichloroethylene (ug/L)
1,4-Dioxane (ug/L)

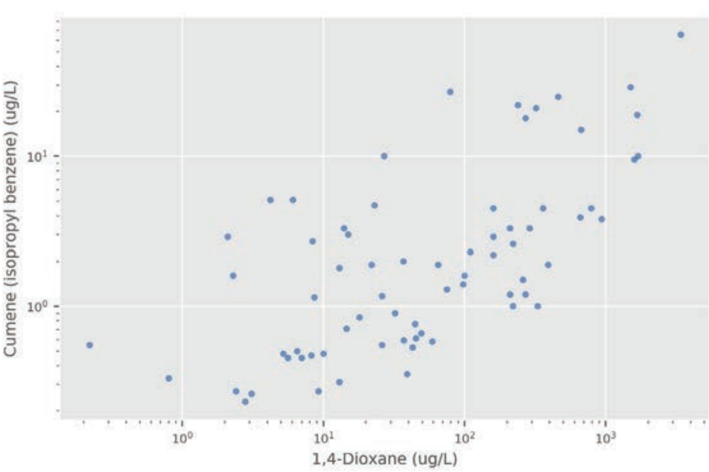

Methylene chloride (ug/L)
1,4-Dioxane (ug/L)

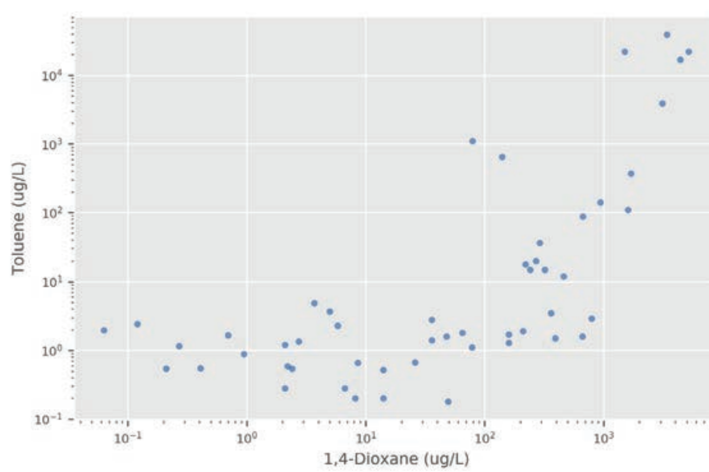

1,2-Dichloropropane (ug/L)
1,4-Dioxane (ug/L)

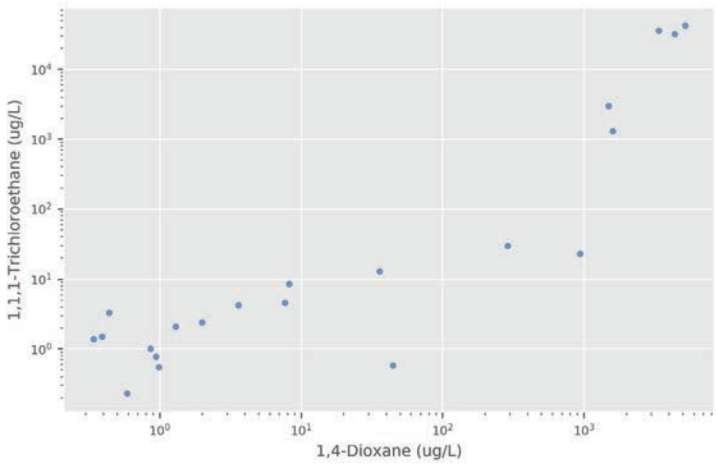

Naphthalene (ug/L)
1,4-Dioxane (ug/L)

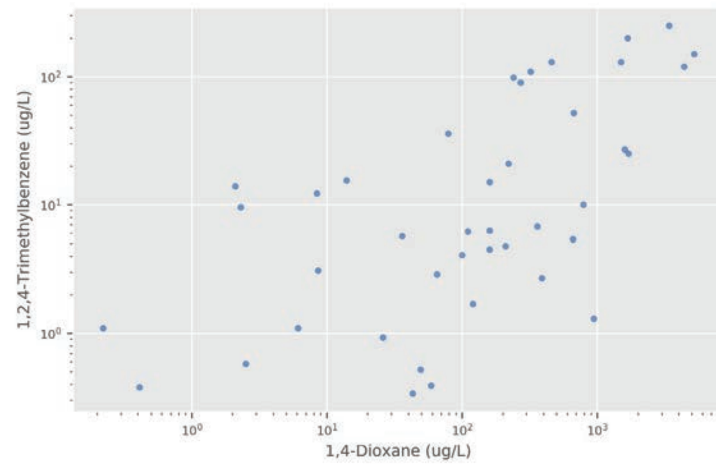

Ethylbenzene (ug/L)
1,4-Dioxane (ug/L)

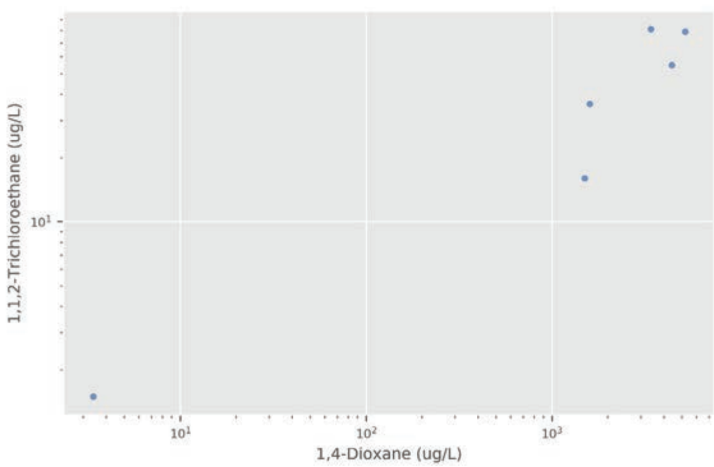

Tetrachloroethylene (ug/L)
1,4-Dioxane (ug/L)

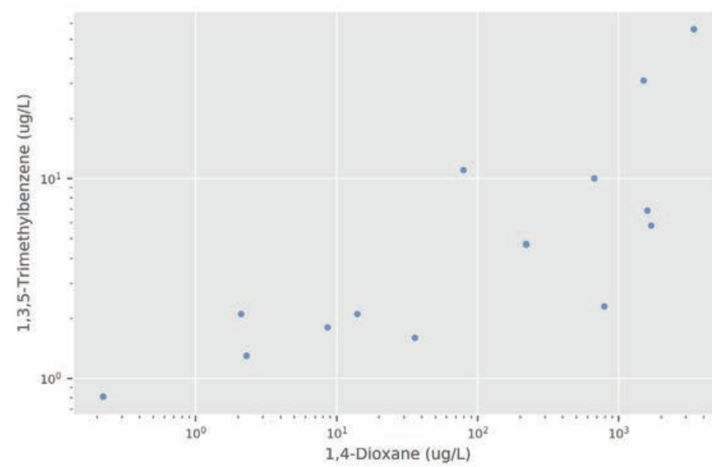

Cumene (isopropyl benzene) (ug/L)
1,4-Dioxane (ug/L)

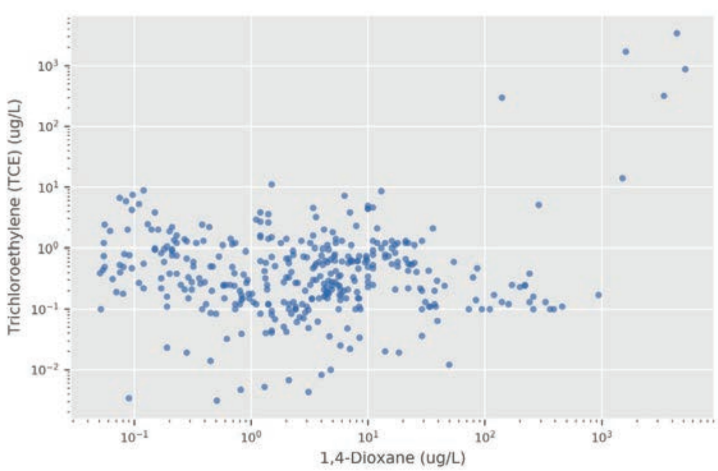

Toluene (ug/L)
1,4-Dioxane (ug/L)

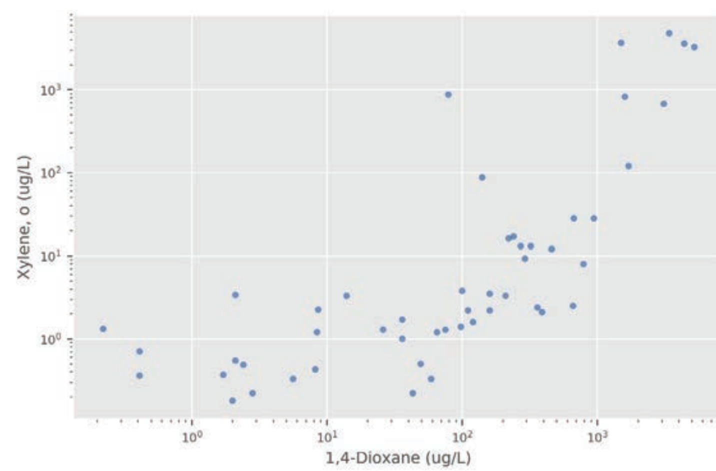

1,1,1-Trichloroethane (ug/L)
1,4-Dioxane (ug/L)

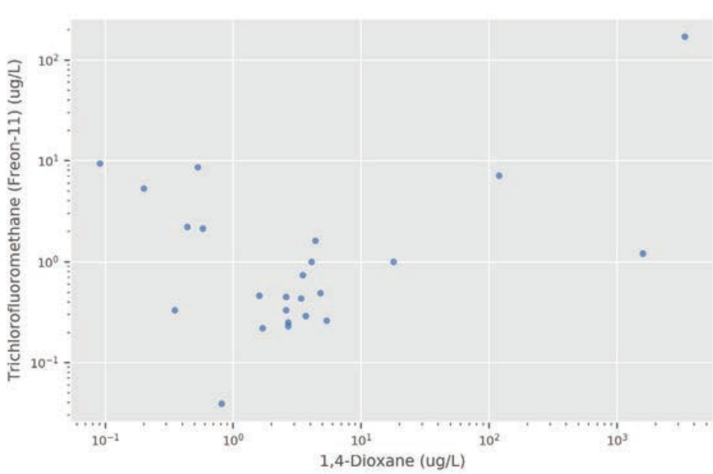

1,2,4-Trimethylbenzene (ug/L)
1,4-Dioxane (ug/L)

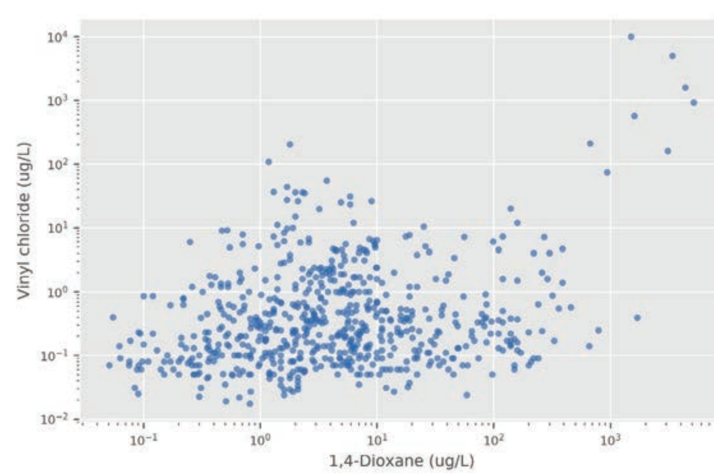

1,1,2-Trichloroethane (ug/L)
1,4-Dioxane (ug/L)

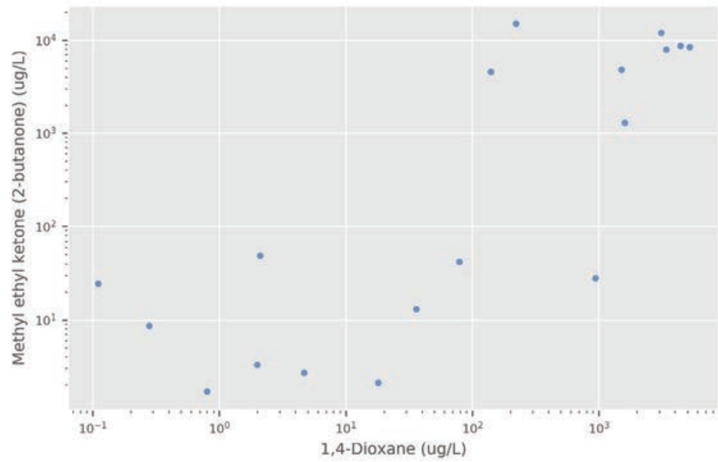

1,3,5-Trimethylbenzene (ug/L)
1,4-Dioxane (ug/L)


Trichloroethylene (TCE) (ug/L)
1,4-Dioxane (ug/L)

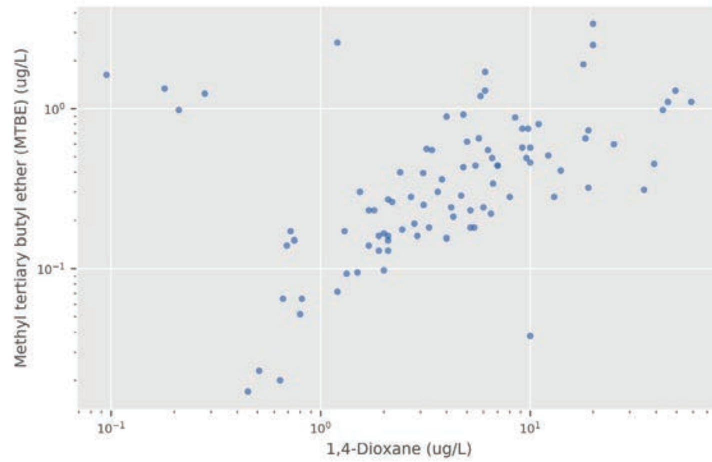

Xylene, o (ug/L)
1,4-Dioxane (ug/L)


Trichlorofluoromethane (Freon-11) (ug/L)
1,4-Dioxane (ug/L)

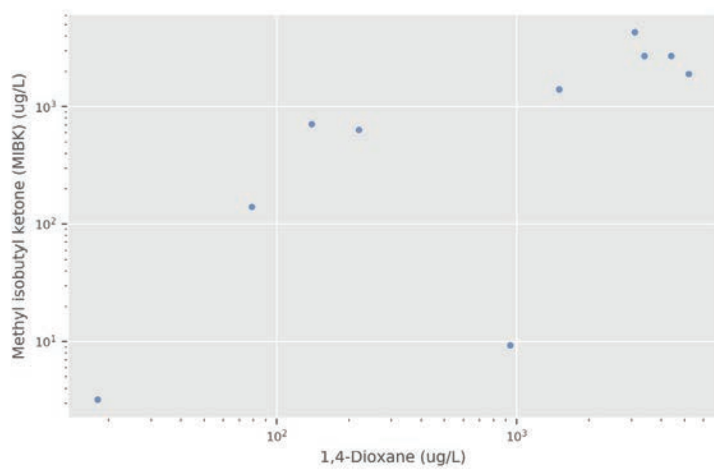

Vinyl chloride (ug/L)
1,4-Dioxane (ug/L)



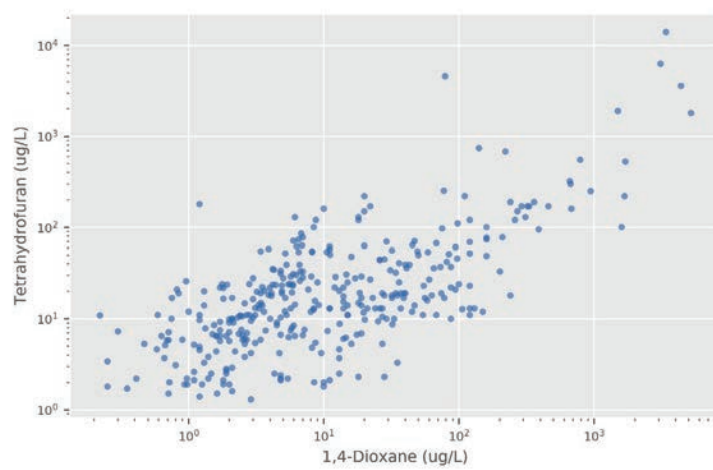
Methyl ethyl ketone (2-butanone) (ug/L)
10^{1}
10^{2}
10^{3}
10^{4}
10^{-1}
10^{0}
10^{1}
10^{2}
10^{3}
1,4-Dioxane (ug/L)



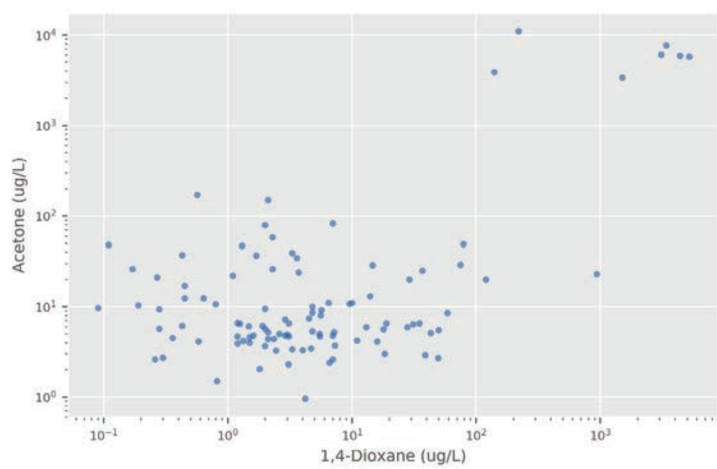
Methyl tertiary butyl ether (MTBE) (ug/L)
10^{-1}
10^{0}
10^{-1}
10^{0}
10^{1}
1,4-Dioxane (ug/L)



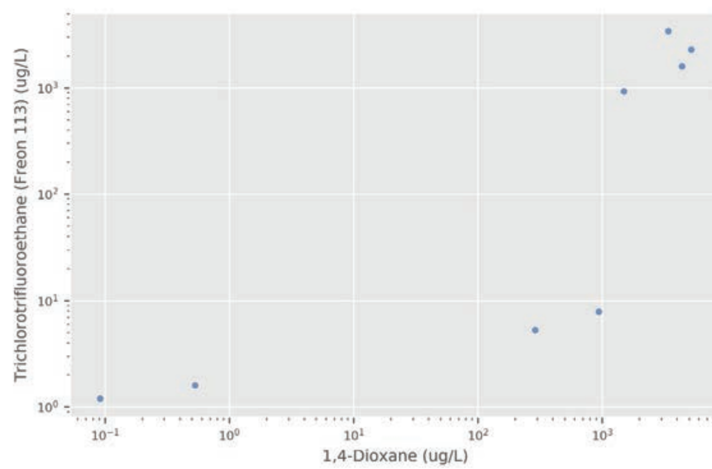
Methyl isobutyl ketone (MIBK) (ug/L)
10^{1}
10^{2}
10^{3}
10^{2}
10^{3}
1,4-Dioxane (ug/L)



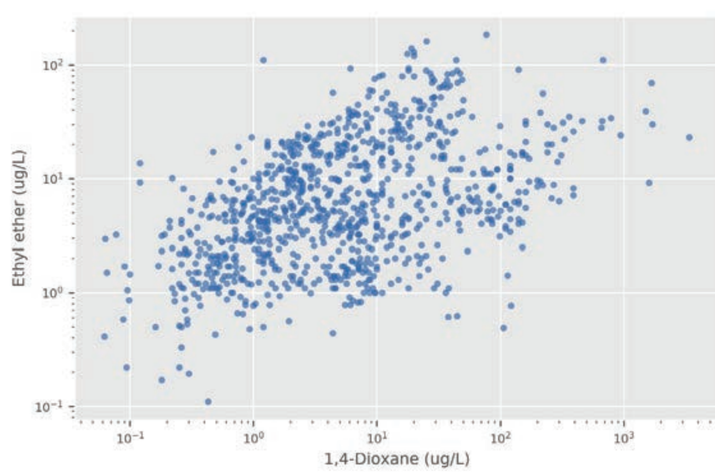
Tetrahydrofuran (ug/L)
10^{0}
10^{1}
10^{2}
10^{3}
10^{4}
10^{0}
10^{1}
10^{2}
10^{3}
1,4-Dioxane (ug/L)



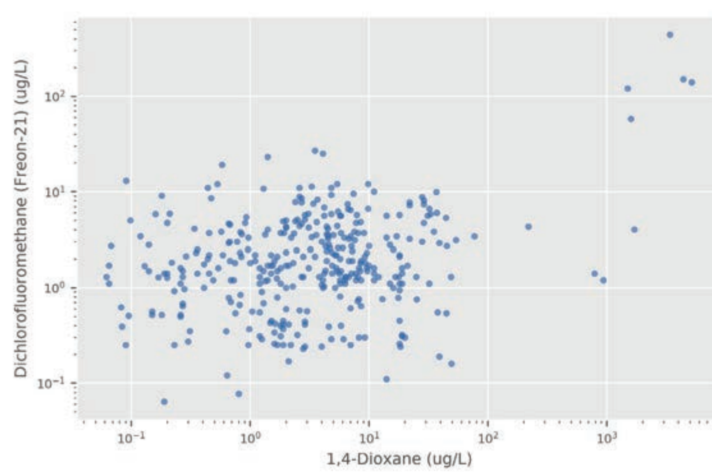
Acetone (ug/L)
10^{0}
10^{1}
10^{2}
10^{3}
10^{4}
10^{-1}
10^{0}
10^{1}
10^{2}
10^{3}
1,4-Dioxane (ug/L)



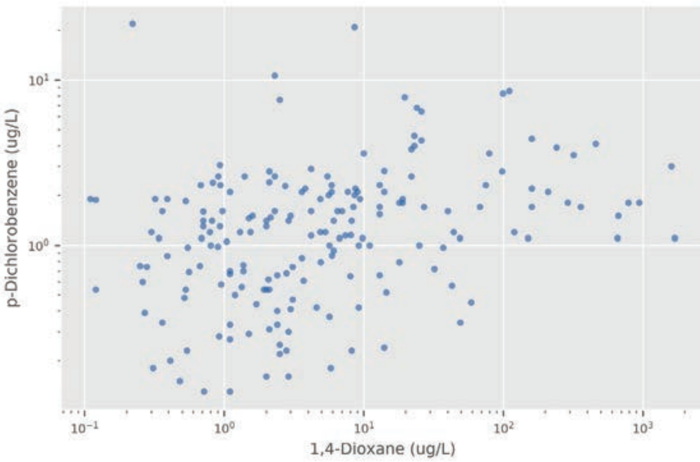
Trichlorotrifluoroethane (Freon 113) (ug/L)
10^{0}
10^{1}
10^{2}
10^{3}
10^{-1}
10^{0}
10^{1}
10^{2}
10^{3}
1,4-Dioxane (ug/L)

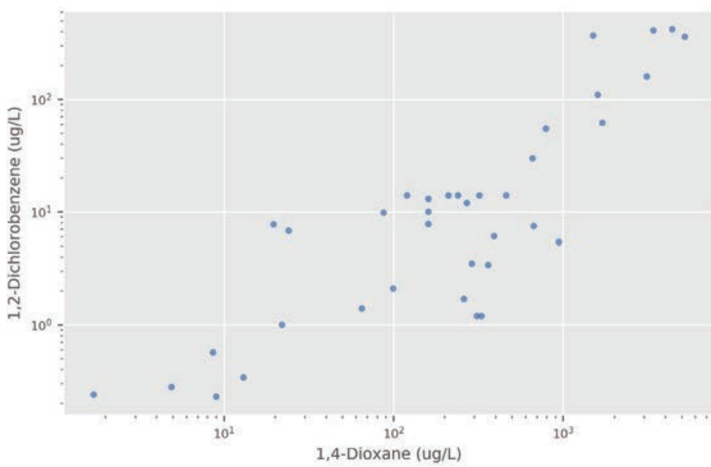


Ethyl ether (ug/L)
10^{-1}
10^{0}
10^{1}
10^{2}
10^{-1}
10^{0}
10^{1}
10^{2}
10^{3}
1,4-Dioxane (ug/L)



Dichlorofluoromethane (Freon-21) (ug/L)
10^{-1}
10^{0}
10^{1}
10^{2}
10^{-1}
10^{0}
10^{1}
10^{2}
10^{3}
1,4-Dioxane (ug/L)


p-Dichlorobenzene (ug/L)
1,4-Dioxane (ug/L)


1,2-Dichlorobenzene (ug/L)
1,4-Dioxane (ug/L)

Appendix E

Maximum PFAS HRI for Each Facility

Table E-1
Maximum Facility PFAS HRI Values

Facility Code	Facility Name	Facility Type	Maximum HRI
SR0000365	3M Woodbury	East Metro PFAS	1763998.33
SR0000055	Oakdale Dump Sites	East Metro PFAS	711114.90
SR0000117	Pigs Eye Landfill	East Metro PFAS	14727.15
SW-1	Washington County Sanitary Landfill	East Metro PFAS	2402.86
SW-76	Gofer Sanitary Landfill	Closed Landfill	2381.37
SW-45	Pine Bend Sanitary Landfill	Operating MSW	196.72
SW-57	Freeway Sanitary Landfill	Closed Landfill	45.18
SW-31	Kummer Sanitary Landfill	Closed Landfill	44.25
SW-117	Lindala Sanitary Landfill	Closed Landfill	44.22
SW-47	East Bethel Demolition/Sanitary Landfill	Closed Landfill	44.22
SW-32	Louisville Landfill Inc.	Closed Landfill	40.34
SW-28	Waste Disposal Engineering Landfill	Closed Landfill	30.40
SW-35	St. Augusta Sanitary Landfill	Closed Landfill	27.20
SW-353	Vonco Demolition Debris Landfill	Other Solid Waste	23.93
SW-63	Minnesota Sanitation Services Landfill	Closed Landfill	22.65
SW-16	Crosby American Properties Landfill	Closed Landfill	21.57
SW-67	Tellijohn Sanitary Landfill	Closed Landfill	18.80
SW-43	Oak Grove Sanitary Landfill	Closed Landfill	14.40
SW-61	Woodlake Sanitary Landfill	Closed Landfill	11.91
SW-134	Begin Dump and Demolition Landfill	Other Solid Waste	10.56
SW-406	Douglas County Demolition Landfill	Other Solid Waste	10.54
SW-387	Summit Avenue Demolition Landfill	Other Solid Waste	9.59
SW-101	Jackson County Sanitary Landfill	Closed Landfill	9.56
SW-501	Lyon County Demolition Landfill	Other Solid Waste	8.84
SW-232	Western Lake Superior Sanitary District Lf	Closed Landfill	8.65
SW-58	Hopkins Sanitary Landfill	Closed Landfill	8.29
SW-126	Houston County Sanitary Landfill	Closed Landfill	7.51
SW-175	Cotton Area Sanitary Landfill	Closed Landfill	7.33
SW-120	Pipestone County Sanitary Landfill	Closed Landfill	7.24
SW-56	Burnsville Sanitary Landfill	Operating MSW	5.96
SW-262	Hwy 77 Sanitary Landfill	Closed Landfill	5.90
SW-405	St Louis County Regional Landfill	Operating MSW	5.72
SW-94	Anoka Municipal Regional Landfill	Closed Landfill	5.72
SW-91	Sun Prairie Sanitary Landfill	Closed Landfill	5.63
SW-6	Spruce Ridge Resource Management	Operating MSW	5.30
SW-303	Dawnway Demolition Landfill	Other Solid Waste	5.21
SW-102	Carlton County 2 Sanitary Landfill	Closed Landfill	5.12
SW-2	Sibley County Sanitary Landfill	Closed Landfill	4.51
SW-178	Northeast Otter Tail Co. Landfill	Closed Landfill	4.36
SW-33	Maple Landfill	Closed Landfill	4.30
SW-68	Northwoods Sanitary Landfill	Closed Landfill	4.26
SW-22	Barnesville Sanitary Landfill	Closed Landfill	3.89
SW-70	Meeker County Sanitary Landfill	Closed Landfill	3.84
SW-25	Winona County Sanitary Landfill	Closed Landfill	3.53
SW-335	Bueckers City Sanitation Services	Other Solid Waste	3.15
SW-19	Korf Brothers Sanitary Landfill	Closed Landfill	2.86

Table E-1
Maximum Facility PFAS HRI Values

SW-44	Lindenfelser Demolition Landfill	Closed Landfill	2.64
SW-62	Red Rock Sanitary Landfill	Closed Landfill	2.58
SW-42	Yellow Medicine County Sanitary Landfill	Closed Landfill	2.27
SW-115	Karlstad Sanitary Landfill	Closed Landfill	1.87
SW-79	Kandiyohi County Sanitary Landfill	Operating MSW	1.80
SW-8	Johnson Bros./Lochness Park Sanitary Landfill	Closed Landfill	1.47
SW-111	Crow Wing County Landfill	Closed Landfill	1.45
SW-49	Ironwood Sanitary Landfill	Closed Landfill	1.42
SW-14	Flying Cloud Sanitary Landfill	Closed Landfill	1.42
SW-536	Vonco V - Duluth	Other Solid Waste	1.41
SW-161	Hibbing Sanitary Landfill	Closed Landfill	1.35
SW-85	Albert Lea Sanitary Landfill	Closed Landfill	1.21
SW-64	Mankato Sanitary Landfill	Closed Landfill	1.14
SW-291	Hengel Demolition Landfill	Other Solid Waste	1.12
SW-428	Voyageur Disposal & Processing Inc	Other Solid Waste	1.02
SW-263	Wanamingo Demolition Landfill	Other Solid Waste	0.91
SW-73	Iron Range Sanitary Landfill	Closed Landfill	0.85
SW-376	Crow Wing County MMSW Landfill	Operating MSW	0.79
SW-29	Kluver Sanitary Landfill	Closed Landfill	0.75
SW-7	Wadena Sanitary Landfill	Closed Landfill	0.73
SW-154	Wabasha County Sanitary Landfill	Closed Landfill	0.68
SW-114	Anderson Sanitary Landfill	Closed Landfill	0.66
SW-52	Chippewa County Sanitary Landfill	Closed Landfill	0.63
SW-74	Elk River Landfill	Operating MSW	0.62
SW-486	Meeker County Demolition Landfill	Other Solid Waste	0.61
SW-108	Benson Sanitary Landfill	Closed Landfill	0.61
SW-135	Grand Rapids Area Sanitary Landfill	Closed Landfill	0.61
SW-343	SKB Rich Valley Demolition Waste Mgmt Facility	Other Solid Waste	0.60
SW-137	Salol Landfill	Closed Landfill	0.53
SW-253	Carlton South Sanitary Landfill	Closed Landfill	0.51
SW-60	Advanced Disposal Services - Rolling Hills Landfill	Other Solid Waste	0.50
SW-383	SKB Rosemount Industrial Waste Facility	Other Solid Waste	0.48
SW-408	Glenwood Demolition Disposal LLC	Other Solid Waste	0.46
SW-333	TK Demolition Disposal LLC	Other Solid Waste	0.38
SW-318	Hubbard Co So Transfer & Demo Landfill	Other Solid Waste	0.38
SW-82	Mille Lacs Sanitary Landfill	Closed Landfill	0.37
SW-131	Steele County Sanitary Landfill	Operating MSW	0.30
SW-145	Aitkin County Sanitary Landfill	Closed Landfill	0.29
SW-50	Dakhue Sanitary Landfill	Closed Landfill	0.27
SW-83	Redwood County Sanitary Landfill	Closed Landfill	0.27
SW-113	Hansen Sanitary Landfill	Closed Landfill	0.26
SW-541	Oak Ridge Demolition Landfill	Other Solid Waste	0.25
SW-72	Pine Lane Sanitary Landfill	Closed Landfill	0.24
SW-121	Dodge County Sanitary Landfill	Closed Landfill	0.23
SW-100	Waseca County Sanitary Landfill	Closed Landfill	0.23
SW-34	Clay County Sanitary Landfill	Operating MSW	0.16
SW-412	Crosslake Construction Demolition Debris	Other Solid Waste	0.15

Table E-1

Maximum Facility PFAS HRI Values

SW-5	Olmsted County - Oronoco Sanitary Landfill	Closed Landfill	0.10
SW-306	Beltrami County Demolition Landfill	Other Solid Waste	0.01
SW-429	DKV Demolition Landfill	Other Solid Waste	0.01
SW-157	Goodhue Cooperative Landfill	Closed Landfill	0.01
SW-174	Red Wing Land Disposal Facility	Other Solid Waste	0.01
SW-191	Koochiching County Sanitary Landfill	Closed Landfill	0.01
SW-141	La Grand Sanitary Landfill	Closed Landfill	0.00
SW-51	Eighty Acres Sanitary Landfill	Closed Landfill	0.00
SW-407	Lakes Area Demolition Landfill	Other Solid Waste	0.00
SW-99	Becker County Sanitary Landfill	Closed Landfill	0.00
SW-77	Rock County Sanitary Landfill	Closed Landfill	0.00
SW-181	Crosby Sanitary Landfill	Closed Landfill	0.00
SW-59	French Lake Sanitary Landfill	Closed Landfill	0.00
SW-548	Waste Management Demolition Landfill	Other Solid Waste	0.00
SW-542	Vonco 4 - Austin Demolition Landfill	Other Solid Waste	0.00
SW-104	Murray County Sanitary Landfill	Closed Landfill	0.00
SW-129	Isanti-Chisago County Sanitary Landfill	Closed Landfill	0.00
SW-179	Walker-Hackensack Landfill	Closed Landfill	0.00
SW-18	Bueckers #1 Sanitary Landfill	Closed Landfill	0.00
SW-204	Orr Sanitary Landfill	Closed Landfill	0.00
SW-237	Cook Area Sanitary Landfill	Closed Landfill	0.00