NORTH FRONT RANGE WATER QUALITY PLANNING ASSOCIATION
257 Johnstown Center Dr.; Unit 206
Johnstown, CO 80534
970-587-8872 – http://www.nfrwqpa.org

ASSOCIATION MEETING AGENDA

February 27, 2025 @ 2:00 PM **Hybrid Meeting**

Microsoft Teams
Join the meeting now
Meeting ID: 217 168 394 855
Passcode: sS79zZ6P
Dial in by phone
+1 720-739-6745 United States, Denver
Find a local number
Phone conference ID: 812 384 622#

Notice is given to the North Front Range Water Quality Planning Association (NFRWQPA) members and the general public that the Association will hold its regular association meeting, which is open to the public.

1. **CALL MEETING TO ORDER.**

2. **NOTICE TO MEMBERSHIP MEETING IS RECORDED.**

3. **DETERMINATION OF A QUORUM FROM MEMBERSHIP.** – Attachment #1 (page 4).

4. **APPROVAL OF AGENDA.**

5. **DISCLOSURE OF POTENTIAL CONFLICTS OF INTEREST.**

6. **PUBLIC COMMENTS.**

7. **APPROVAL OF PAST MINUTES.** – Attachment #2 (pages 5-7).
   For review and consideration are the meeting minutes from January 23, 2025.

8. **FINANCIAL REPORTS:** – Attachment #3 (pages 8-10).
   The January 2025 financial statements are for review and consideration.

9. **DECISION ITEM:** PFAS National Collaborative Project - Phase 2 - Attachment #4 (pages 11-43).
   Dr. Pepper is currently initiating fundraising for Phase 2, which will evaluate crop uptake of PFAS from land application plots. Phase 1 of the research project established a national network of land application plots where soil PFAS concentrations are now known. Utilizing this national network, the study intends to analyze crops grown on these sites to create a paired dataset of soil/crop PFAS concentrations. Multiple crop types will be grown, including corn, oats, and alfalfa. Crop variation will allow the study to evaluate differential crop uptake of PFAS analytes. Additionally, the influence of soil types and climate regimes on plant uptake can be assessed by planting the same crop at different national locations. For Phase 1, contributions ranged from $3,000 to $35,000, and the Association contributed $3,000.

10. **PRESENTATION:** 208 Data Request/FCA Guidance Concerning Feasibility and Implementation.
Mr. Grady Colgan and Mrs. Katelyn Wagner with CDPHE will present how Colorado is working to understand the economic capacities of wastewater facilities to meet limits and improve water quality over time while implementing the Feasibility and Implementation program. This analysis uses an existing EPA framework called the financial capability assessment (FCA) to evaluate a facility's economic capability comprehensively. Gathering detailed economic information from the facility is essential to conduct this analysis. Information regarding financial obligations (e.g., debt), revenues, user fees, service areas, and the number of ratepayers helps provide a clear picture of financial health and operational capacity. The most helpful data for facilities/municipalities to provide are:

- **User fees ($/month)**
- **Number of commercial and residential taps/ratepayers**
- **Service area (used to compile accurate census information used in EPA's framework)**

If the facility/municipality is willing to share data, the division struggles to collect/access the following data on a statewide scale:

- **Permittee Residential Wastewater Flow**
- **Permittee Total Wastewater Flow**
- **Permittee Current Annual Operating and Maintenance Expenses (excluding depreciation)**
- **Current Financial Commitments**
    - **Total Net Debt**
    - **Debt Service Level**
    - **Bonds**
    - **Bond Rating**

11. **DISCUSSION ITEM:** 2025 - 208 Plan Update Survey for Sewer User Rates & PIFs.
For the 2025 - 208 Areawide Water Quality Management Plan Update, please provide the Association with agency monthly sewer rates and plant investment fees for residential users from 2025-2030. Please note that the Association has observed contradictory information within approved Utility Plans compared to online fee schedules regarding sewer user rates and PIFS. As such, this survey intends to provide accurate and current sewer user rates and PIFs within the 208 Areawide Water Quality Management Plan Update for 2025. Access the Survey here: https://www.surveymonkey.com/r/PFYWRSP

12. **DISCUSSION ITEM:** 208 Areawide Water Quality Management Plan (208 AWQMP).
Discuss the recommendations, actions, or goals for the 2025 - 208 AWQMP update. Attachment #5 (pages 44-48) is the 2022-208 AWQMP recommendations, actions, or goals for consideration, with tracked changes for reference. Revising these recommendations, actions, or goals for the 2025 update considering what is achievable by membership agencies and the Association. For example, possible recommendations, actions, or goals could be:

1. Pursue a grant to assess or model the region's water quality to show that it has improved historically.
2. Promote the Regional Nonpoint Source Watershed-Based Plan with further public education and outreach – See NPS Stakeholder Toolkit - Attachment #6 (pages 49-51).
3. Continue to improve the Regional GIS Sewer Infrastructure Map.
4. Form a Feasibility and Implementation Subcommittee – actions TBD.
5. Create a PFAS informational webpage on the Association's website.
6. Gather FCA data for Feasibility and Implementation assessments.
7. Obtain counsel to assess permit options when compared to the Regional Nonpoint Source Watershed-Based Plan, i.e., nutrient trading and Feasibility and Implementation options.

To help engage the membership in the decision-making process, the following surveys will be sent out for input over the next couple of months so that it is manageable or does not seem overwhelming;

1. March - 208 AWQMP General DMOA Recommendations and Actions
2. April - 208 AWQMP Specific DMOA Recommendations and Actions
3. May - 208 AWQMP Association Recommendations and Actions
4. June - 208 AWQMP Association Priorities and Measurable Outcomes Survey

13. DISCUSSION ITEM: Workgroup Update Presentations.
Workgroup updates are available here.

14. ADJOURN

Attachment No. 1

NORTH FRONT RANGE WATER QUALITY PLANNING ASSOCIATION

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Designated Management and Operation Agency Members

		Designation	Primary Contact	Alternate Contact	2025 Dues
1	**Ault, Town of**	Management/Operation Agency	Grant Ruff	Dustin Preston	PAID
2	**Berthoud, Town of**	Management/Operation Agency	Chris Kirk	Wayne Ramey	PAID
3	**Boxelder Sanitation District**	Management/Operation Agency	Brian Zick	David Lewis	PAID
4	**Brighton, Town of**	Management/Operation Agency	Sherry Scaggiari	Emily Meek	PAID
5	**Broomfield, City & County**	Management/Operation Agency	Ken Rutt	Dennis Rodriguez	PAID
6	**Dacono, City of**	Management Agency	Bobby Redd	Jennfier Krieger	
7	**Eaton, Town of**	Management/Operation Agency	Greg Brinck	Wesley LaVanchy	PAID
8	**Erie, Town of**	Management/Operation Agency	Jon Coyle	Bruce Chameroy	
9	**Estes Park Sanitation District**	Operation Agency	Tony Drees		
10	**Evans, City of**	Management/Operation Agency	Robby Porsch		
11	**Fox Acres Community Services**	Private Agency	Richard Hopp	James Cates	PAID
12	**Ft. Collins, City of**	Management/Operation Agency	Kathryne Marko	Jesse Schlam	PAID
13	**Ft. Lupton, City of**	Management/Operation Agency	Chris Cross		PAID
14	**Galeton Water & Sanitation District**	Operation Agency	William Warren		
15	**Greeley, City of**	Management/Operation Agency	Tyler Eldridge	Adam Prior	
16	**Hudson, Town of**	Management/Operation Agency	Bruce Lange	Jennifer Woods	PAID
17	**Johnstown, Town of**	Management/Operation Agency	Ellen Hilbig	Matt LeCerf	
18	**Keenesburg, Town of**	Management/Operation Agency	Mark Gray		PAID
19	**Kersey, Town of**	Management/Operation Agency	Stacy Brown		PAID
20	**Larimer County**	Management Agency	Keila Flores		PAID
21	**LaSalle, Town of**	Management/Operation Agency	Barry Schaeffer		PAID
22	**Lochbuie, Town of**	Management/Operation Agency	AJ Euckert	Wayne Ramey	PAID
23	**Longmont, City of**	Management/Operation Agency	Azara Bilgin	Mary Paterniti	PAID
24	**Loveland, City of**	Management/Operation Agency	Joe Creaghe	Brandon Cayou	PAID
25	**Mead, Town of**	Management/Operation Agency	Hellen Migchelbrink	Erika Rasmussen	PAID
26	**Metro Water Recovery**	Operation Agency	Erik Burggraf	Katie Koplitz	PAID
27	**Milliken, Town of**	Management/Operation Agency	Don Stonebrink	Brad Simons	PAID
28	**Northglenn, City of**	Management/Operation Agency	Manuel Freye	Shelley Stanley	
29	**Pierce, Town of**	Management/Operation Agency	Pat Larson		PAID
30	**Platteville, Town of**	Management/Operation Agency	David Brand	Josh Leyba	PAID
31	**Resource Colorado Water & Sanitation Metro District**		Paul Wilson	Paul Goluskin	PAID
32	**Severance, Town of**	Management/Operation Agency	Nicholas Wharton	Mike Ketterling	PAID
33	**South Ft. Collins San. Dist.**	Management/Operation Agency	Derik Caudill	Eric Bailey	PAID
34	**St. Vrain Sanitation District**	Management/Operation Agency	Alex Arnold	Dan Feller	PAID
35	**Timnath, Town of**	Management/Operation Agency	Earl Smith	Justin Stone	PAID
36	**Upper Thompson San. Dist.**	Management/Operation Agency	Suzanne Jurgens	Matt Allen	PAID
37	**Weld County**	Management Agency	David Eisenbraun	Katie Sall	PAID
38	**Wellington, Town of**	Management/Operation Agency	Bob Gowing	Mike Flores	PAID
39	**Windsor, Town of**	Management/Operation Agency	Dennis Markham		PAID
	Associates and Industries				
40	**NCWCD**	Associate	Anna Hermes	Ester Vincent	PAID

40 Representative Votes / 10 Representatives required for Quorum (25%)

rev. 2-20-25

Attachment #2

NORTH FRONT RANGE WATER QUALITY PLANNING ASSOCIATION
257 Johnstown Center Dr.; Unit 206
Johnstown, CO 80534
970-587-8872 – http://www.nfrwqpa.org

ASSOCIATION MEETING MINUTES

January 23, 2025, 2:00 PM

1. **CALL MEETING TO ORDER.**
   Mr. Thomas called the meeting to order at 2:00 PM.

2. **NOTICE TO MEMBERSHIP MEETING IS RECORDED.**
   Mr. Thomas notified the membership the meeting was recorded.

3. **DETERMINATION OF A QUORUM FROM MEMBERSHIP.**
   Attendance:

   NFRWQPA – Mr. Thomas, Manager
   Executive Committee Officers –
   Vice Chair – Tyler Eldridge – Greeley
   Treasurer – Jesse Schlam – Ft. Collins
   Officer – Randy Kenyon – S. Fort Collins S.D.
   Officer – Matt Allen – Upper Thompson S.D.
   Officer – Chris Kampmann – St. Vrain S.D.
   Officer – Savana Dumler – Berthoud

   Executive Committee Officers Absent –
   Chair – Brian Zick – Boxelder S.D.

   Membership –
   Alex Arnold – St. Vrain S.D.
   Brandon Cayou – Loveland
   David Eisenbraun – Weld County Planning
   Dustin Preston – Ault
   Erik Burggraf – Metro Water Recovery
   Chris Manley – NWCD
   Christina Schroeder – Fort Collins
   Katie Koplitz – Metro Water Recovery
   Katie Sall – Weld County
   Kelia Flores – Larimer County
   Mary Paterniti – Longmont
   Robby Porsch – Evans
   Shelley Stanley – Northglenn
   Stacy Brown – Kersey
   Suzanne Jurgens - Upper Thompson S.D.

   Public –
   Connor Healy – Burns & McDonnell
   Denna Davidson – Tetra Tech
   Elias Katsoulas – Tetra Tech
   Fernando Molina – JBS
   Samantha Lee – Moltz Construction

   – Mr. Thomas announced a quorum.

4. **APPROVAL OF AGENDA.**
   Mr. Kampmann motioned to approve the agenda, seconded by Mrs. Dumler. The motion carried unanimously.

5. **DISCLOSURE OF POTENTIAL CONFLICTS OF INTEREST.**
   No potential conflicts of interest were disclosed.

6. **PUBLIC COMMENTS.**
   No public comments were stated.

7. **APPROVAL OF PAST MINUTES.**
   Mr. Kampmann motioned to approve the December 19, 2024, meeting minutes, seconded by Mr. Schlam. The motion carried unanimously.

8. **FINANCIAL REPORTS.**
Mrs. Dumler moved to approve the December 2024 financial statements, seconded by Mrs. Brown. The motion carried unanimously.

9. **DECISION ITEM:** Town of Berthoud Site Application WWTF BNR Upgrades.
Mr. Connor Healy with Burns & McDonnell presented the Town of Berthoud's site application for Berthoud's WRF Phase 1A improvements, including replacing existing aeration blowers, adding anaerobic/anoxic (ANA) basins upstream of the facility's existing activated sludge basins, and replacing the existing mixed liquor return (MLR) pumps for BNR upgrades to maximize VIP credits. Mr. Thomas also stated that the proposed project is stated within the Town of Berthoud's currently approved (2024) Utility Plan and recommended approval of the project on behalf of the membership, meeting the association's requirements for approval. Mr. Schlam moved to approve the Town of Berthoud's Site Application for the WWTF's BNR upgrades, seconded by Mr. Eldridge. The motion carried unanimously.

10. **DISCUSSION ITEM:** Regional Nonpoint Source EPA 9-Element Watershed Plans.
Mr. Thomas notified the membership that the Regional Nonpoint Source EPA 9-Element Watershed-Based Plans are completed and available on the association's website.

11. **DISCUSSION ITEM:** PFAS in Biosolids Risk Assessment.
Mr. Thomas discussed whether the Association should provide public comments on the EPA's Draft Sewage Sludge Risk Assessment for Perfluorooctanoic Acid (PFOA) and Perfluorooctane Sulfonic Acid (PFOS). Membership declined to offer comments at this time.

12. **DISCUSSION ITEM:** Workgroup Update Presentations.
Mr. Thomas presented the month's workgroup update presentation.

13. **ADJOURN**

Attachment #3

NORTH FRONT RANGE WATER QUALITY PLANNING ASSOCIATION

Balance Sheet
As of January 31, 2025
Cash Basis

Account	Jan 31, 2025	Dec 31, 2024	$ Change
Assets			
Current Assets			
Cash and Cash Equivalents			
1100 - Checking NF	125,429.33	18,789.64	106,639.69
1250 - Colorado Tru	456,786.58	455,037.60	1,748.98
Total Cash and Ca	**582,215.91**	**473,827.24**	**108,388.67**
1500 - Security Dep	1,353.00	1,353.00	0.00
Total Current Assets	**583,568.91**	**475,180.24**	**108,388.67**
Total Assets	**583,568.91**	**475,180.24**	**108,388.67**
Liabilities and Equity			
Liabilities			
Current Liabilities			
2406 - Accrued Vac	1,592.31	1,592.31	0.00
2300 - Pension Pay	844.41	847.52	(3.11)
2407 - PERA Payab	2,535.16	2,556.57	(21.41)
2050 - Mark's CC x5	730.31	1,717.87	(987.56)
Total Current Liabi	**5,702.19**	**6,714.27**	**(1,012.08)**
Total Liabilities	**5,702.19**	**6,714.27**	**(1,012.08)**
Equity			
2810 - Assets Begir	572,240.82	572,240.82	0.00
Current Year Earnin	109,400.75	(148,768.47)	258,169.22
3900 - Retained Ear	(103,774.85)	44,993.62	(148,768.47)
Total Equity	**577,866.72**	**468,465.97**	**109,400.75**
Total Liabilities and E	**583,568.91**	**475,180.24**	**108,388.67**

No assurance is provided on these financial statements.
The financial statements do not include a statement of cash flows.
Substantially all disclosures required by GAAP omitted.

NORTH FRONT RANGE WATER QUALITY PLANNING ASSOCIATION

Statements of Revenue and Expenses - Budget vs Actual
For the one month ended January 31, 2025
Cash Basis

Account	Jan 2025	Jan-Jan 2025	Budget	% of Budget
Income				
9010 - Membership Dues	114,660.00	114,660.00	174,851.00	65.58%
9020 - Interest Income	1,748.98	1,748.98	10,000.00	17.49%
9030 - CDPH & E	0.00	0.00	26,700.00	0.00%
9040 - 319 Grants NPS Watershed Plan	12,500.00	12,500.00	25,000.00	50.00%
Total Income	**128,908.98**	**128,908.98**	**236,551.00**	**54.50%**
Expenses				
3100 - Salary	10,647.75	10,647.75	127,773.00	8.33%
3102 - Dental Insurance	112.00	112.00	1,500.00	7.47%
3103 - Vision Insurance	21.25	21.25	300.00	7.08%
3200 - Health Insurance	2,063.50	2,063.50	25,000.00	8.25%
3300 - Retirement Contributions	319.43	319.43	4,500.00	7.10%
3400 - FICA/PERA Manager	1,731.32	1,731.32	25,000.00	6.93%
3600 - Workman's Compensation	292.00	292.00	550.00	53.09%
5010 - Rent & Utilities	1,566.00	1,566.00	20,000.00	7.83%
5100 - Telephone Cellular	75.00	75.00	900.00	8.33%
5120 - Interest	0.00	0.00	10.00	0.00%
5130 - Internet Service	188.21	188.21	3,000.00	6.27%
5140 - IT Support	1,800.00	1,800.00	5,000.00	36.00%
5150 - Advertising	0.00	0.00	500.00	0.00%
5160 - Insurance	0.00	0.00	750.00	0.00%
5300 - Office Supplies	199.94	199.94	2,500.00	8.00%
5350 - Postage	73.00	73.00	150.00	48.67%
5400 - Dues & Subscriptions	0.00	0.00	5,000.00	0.00%
5425 - Intergovernmental Assist	0.00	0.00	10,000.00	0.00%
5450 - Training	0.00	0.00	500.00	0.00%
5500 - Mileage Reimbursement	0.00	0.00	1,000.00	0.00%
5510 - Meals & Lodging	10.10	10.10	2,500.00	0.40%
5520 - Transportation	0.00	0.00	1,000.00	0.00%
5550 - Conferences	0.00	0.00	3,000.00	0.00%
5600 - Accounting	260.00	260.00	4,500.00	5.78%
5650 - Auditing	0.00	0.00	7,500.00	0.00%
5700 - Legal	0.00	0.00	15,000.00	0.00%
5750 - Bank Charges	0.00	0.00	50.00	0.00%
5800 - Capital Recovery	0.00	0.00	750.00	0.00%
5850 - Capital Expenditures	0.00	0.00	5,000.00	0.00%
6010 - Contract Services/GIS	148.75	148.75	25,000.00	0.60%
6011 - Contract Services Office	0.00	0.00	2,500.00	0.00%
6025 - Operations Contingency w/Board	0.00	0.00	20,000.00	0.00%
6040 - SUSPENSE	(0.02)	(0.02)	0.00	0.00%
Total Expenses	**19,508.23**	**19,508.23**	**320,733.00**	**6.08%**
Net Revenues and Expenses	**109,400.75**	**109,400.75**	**(84,182.00)**	**-129.96%**

No assurance is provided on these financial statements.
The financial statements do not include a statement of cash flows.
Substantially all disclosures required by GAAP omitted.

Attachment #4

NATIONAL COLLABORATIVE STUDY ON THE INCIDENCE AND MOBILITY OF PFAS FOLLOWING LAND APPLICATION OF BIOSOLIDS

Ian Pepper, Mark Brusseau, Sarah Prasek, Jon Chorover and Greg Kester

ABSTRACT

This study successfully produced the largest U.S. dataset of soil PFAS concentrations resulting from land application of municipal biosolids. Overall, median PFAS soil concentrations of four EPA regulated PFAS analytes at 23 land application sites were less than 1 ppb. Mean values were also generally low, but were higher than median values due to the occurrence of very high values at 2 sites. Soil PFAS concentrations showed that land application of municipal biosolids rarely resulted in unacceptably elevated soil PFAS concentrations regardless of land application loading rate. These concentrations were less than or close to soil screening levels (SSLs) calculated using illustrative input parameters. Since the SSLs define the maximum soil concentrations that are protective of groundwater (less than EPA regulatory concentrations), this shows that the potential for significant leaching of PFAS and subsequent groundwater contamination is low at most land application sites across the country. This statement is supported by the significant attenuation of soil PFAS concentration with increased soil depth likely due to adsorption at the air water interface and with soil organic matter. The impact of industrial inputs in biosolids was not evaluated. However, a major factor preventing groundwater contamination is likely the quality and source of biosolids with respect to PFAS concentrations.

BACKGROUND

Perfluoroalkyl and polyfluoroalkyl substances (PFAS) are organic compounds that vary in chain length and contain highly stable carbon-fluorine bonds (Buck et al., 2011). These compounds are often categorized according to their length as short or long chain PFAS. Short chain PFAS generally consist of six or less fluorinated carbons, while long chain PFAS are seven or more (AWWA, 2019). Fluorinated properties contribute to their resistant characteristics and repellent nature against oil, grease, and water. These desirable characteristics have proven useful in many industrial, commercial, and household products. The manufacturing of PFAS began in the 1940s and their beneficial properties are responsible for their continued use. PFAS can be found in some non-stick cookware, textiles, firefighting foams, leather treatments, paper products, packaging for food, waxes, cosmetics, carpets and many other products. At present, there are several thousand compounds that have been identified as PFAS.

Although well known, per and polyfluoroalkyl substances (PFAS) are still emerging contaminants of critical concern that, until recently, have been largely unregulated. They have been shown to result in adverse human health effects and have been documented to be commonly present in the bloodstream of humans at levels of 2 ng per ml or 2 parts per billion (ppb) (Poothong et al., 2020). Current studies have shown some of the negative health effects associated with PFAS include: increased cholesterol levels; changes present in liver enzymes; high blood pressure in pregnant women; increased risk of kidney/testicular cancers; decreases in infant weight at birth; and a decreased immune response to immunizations in children (Steenland et al., 2020; CDC, 2021).

Concern over adverse health effects associated with exposure to PFAS led the EPA to adopt maximum contaminant levels (MCLs) for drinking water of 4 parts per trillion (ppt or ng/L) for perfluorooctanoic acid (PFOA) and perfluorooctane sulfonic acid (PFOS), 10 ppt for perfluorohexane sulfonic acid (PFHxS) and perfluorononanoic acid (PFNA), and a combined hazard index of 1 for 4 other PFAS.

Because of their use in many commercial and household products and ubiquity throughout society, PFAS are inevitably present in the wastewaters entering municipal wastewater treatment plants (WWTP). PFAS persist throughout the treatment process and ultimately end up in treated wastewater and municipal biosolids. The presence of PFAS in municipal sludge and biosolids has been well documented. For example, Venkatesan and Halden (2013) investigated PFAS concentrations in biosolids throughout the US; the most frequently detected PFAS were PFOS, PFOA, and perfluorodecanoic acid (PFDA). PFAS concentrations within biosolids are generally minimal but can be increased from industrial inputs (Washington et *al.,* 2010). In this discussion, we focus on municipal biosolids that are not industrially impacted.

The presence of PFAS in municipal biosolids has led to concern over the potential impacts of land application of biosolids to human health and the environment. Concerns about PFAS in Maine began in 2016, following land application of industrially contaminated biosolids and paper mill sludge. The use of hay grown on impacted fields as fodder for cows resulted in milk with unacceptably high levels of PFAS. A national furor against PFAS followed, and on April 15,2022 the Maine State House and Senate passed a bill that banned the use of all biosolids for land application. In June 2024, Connecticut implemented a ban on land application or distribution with a simple sentence inserted into legislation ("No person shall use, sell, or offer for sale in this state as a soil amendment, any biosolids or wastewater sludge that contain PFAS") (State of Connecticut Substitute Senate Bill No. 292). This raised concern of whether additional states or a national ban could follow. In contrast, similar concerns in Michigan have led to proactive source control measures to mitigate the industrial contamination of biosolids and prevent the land application of industrially contaminated biosolids (EGLE, 2021).

A critical factor limiting our ability to determine health risks from land application of biosolids is the lack of data. More sampling and monitoring data for PFAS in non-industrially impacted biosolids and receiving soils are needed to better characterize the magnitude of PFAS originating from land application. In addition, more detailed investigations of PFAS distributions and leaching in soil are needed beyond the few that have been conducted to date. Several projects have recently started under the auspices of the EPA, USDA, and the Water Research Foundation. These studies are anticipated to add to our understanding of the impacts of land application on soil contamination, leaching potential, and uptake into plants. However, these studies are focused on a single or a select few sites.

To expand this localized approach, a nationwide collaborative project has been initiated by the University of Arizona. This project comprises a national collaborative effort involving field studies conducted across broad geographic regions of the U.S. with differing soils, climates, and depth to groundwater (Pepper, 2022). This project is currently in progress. In this report, we provide an update on the national collaborative project that documents the current status of the project with respect to incidence and distribution of PFAS derived from land applied municipal biosolids.

APPROACH

In January 2020, the Pima County Board of Supervisors in Tucson, Arizona passed a moratorium on land application of biosolids in Pima County because of concern over the presence of PFAS analytes in biosolids. The resulting landfill disposal of Class B biosolids produced by Pima County Wastewater Department rather than land applying increased the annual cost from $1.3M to $3.3M. In response to this situation, the University of Arizona WEST Center began a collaborative research project with Pima County Wastewater, to evaluate whether land application of non-industrially impacted biosolids was a significant route of human exposure to PFAS, via contamination of groundwater subsequently used as a potable water supply.

Research consisted of a replicated field study implemented in Pima County in March 2020. Specifically, surface and depth soil samples were collected from agricultural plots that had received known loadings of biosolids since 1984. Soil samples were collected at three depths and analyzed for PFAS. In addition, current biosolids samples and groundwater samples used for irrigation were also assayed, as well as appropriate control plots which had not been subject to land application.

Data from the study showed that the concentrations of PFAS in long-term land application plots were low, and that the mobility of PFAS was minimal, with approximately 70% attenuation of PFAS occurring within the surface 6 feet of soil. It was also found that the irrigation water used for crops often contained significant levels of PFAS, therefore representing a contributing source of soil PFAS. Upon review of the data, the Pima County Board of Supervisors rescinded the moratorium on land application in November 2020. Pima County subsequently returned to recycling their biosolids to agricultural land as a beneficial soil amendment.

The acknowledgement that a local problem had been solved by a local study, resulting in a science-based regulation, suggested that a national problem could be addressed by a extensive national study. This gave rise to the concept of the "National Collaborative PFAS Project", the goal of which is to evaluate whether land application of municipal biosolids is a significant public health route of exposure to per- and polyfluoroalkyl substances or PFAS. Of greatest concern are two potential indirect routes of exposure, which will be evaluated in two phases of research:

Phase I: Evaluate the potential for migration of PFAS through soil and vadose zones into groundwater following the land application of municipal biosolids.
Phase II: Evaluate the potential for crop uptake of PFAS in a variety of crops following land application of municipal biosolids.

In this report, we provide data for Phase I, which is now close to completion. The specific objectives of Phase I are:

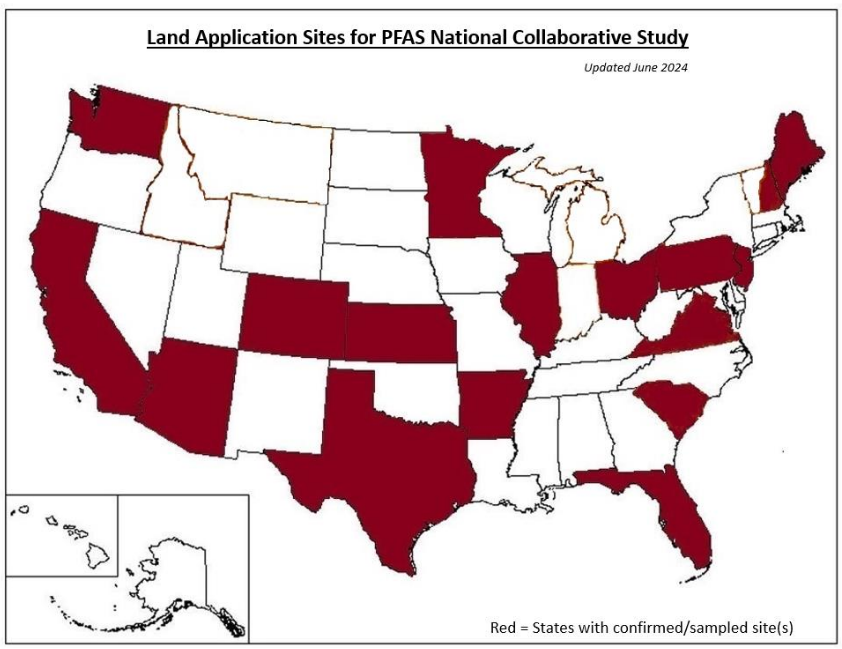
1) Evaluate the concentration of PFAS in surface soil following long-term land application of municipal biosolids.
2) Evaluate PFAS concentrations currently found in municipal biosolids.
3) Assess the potential mobility (leaching) of PFAS through soil.
4) Evaluate PFAS concentrations in groundwater in close proximity to land application sites to create paired datasets of soil and water PFAS concentrations.
5) Compare actual groundwater PFAS concentrations to predicted concentrations using a screening level model for PFAS leaching through soil and vadose zone.

The National Collaborative PFAS Project is unique in several ways. The study is truly nationwide in scope including a variety of different soils, depths to groundwater, and climates at 23 sites in 17 states. Land application sites from across the United States were identified, and soil samples collected from both irrigated and non-irrigated sites. Sampling methodology at each site was identical, allowing for direct comparison of data from a national set of real-world field sites. The study allows for robust calibrated model development, and quantitative data allows for risk assessments on specific land application sites. Importantly, only land application of municipal biosolids is has been considered, precluding industrially contaminated biosolids.

To ensure coordination of the research, a strict sampling and analysis protocol was conducted at all sites. An 18-minute video was provided to all site personnel to standardize sample collection and avoid contamination. In addition, all samples were sent to the University of Arizona prior to being processed and sent on to the University of Arizona Laboratory for Emerging Contaminants (ALEC) for PFAS analysis.

At each site, soil samples were collected at 1, 3 and 6 foot depths from the surface. Wherever possible, groundwater samples from close proximity to each site were also collected. Samples were collected from across the U.S. by farmers and academic researchers utilizing land application sites with records of known biosolid loading rates (See Map 1). Whenever possible, nine soil cores were collected from each site, three from control plots (no biosolids), and three each from plots with two different loading rates of biosolids ("low" and "high"). Lifetime loading rates are shown in Tables 1 and 2. Note that both Class A and B biosolid sites were included in the study. Collecting loading rate data from many years of land application was difficult, and not all sites could provide these data. At most sites, a total of 27 soil samples were collected: 3 plots per site x 3 cores per plot x 3 sample depths per core. Soils were analyzed for 25 different representative PFAS using Method EPA 1633.

Following analysis of all soils for PFAS, select soils will be chosen for characterization based on: i) unique PFAS profiles; ii) higher concentrations of PFAS; and iii) corresponding PFAS analyses of groundwater to create paired data sets of soil and groundwater. Soil characterization data plus corresponding soil PFAS concentrations will be inputted into a screening level model for PFAS leaching (Guo et al., 2022). This model will be used to predict the potential extent of leaching of PFAS into groundwater which will then be compared to actual PFAS groundwater concentrations. The methodology used for PFAS analysis is outlined below.



Map 1. States where samples were collected for the study.

Extracts for liquid chromatography-tandem mass spectrometry (LC-MS/MS) analysis of PFAS were prepared from soil samples and water samples separately, according to EPA Method 1633 guidance. Aliquots of soil (5 g) were mixed with PFAS Extraction Internal Standards (EIS), sequentially extracted three times with 0.3 % ammonium hydroxide in methanol, and centrifuged to combine supernatants before pH adjustment to 6.5, and finally clean- up by solid phase extraction. Water samples (250 ml) were mixed with EIS, adjusted to pH 6.5, and cleaned up by solid phase extraction using Waters Oasis WAX cartridges (also used for soil extractions). After addition of Non-extracted Internal Standards (NIS), extracts (20 ul) were injected onto a reversed phase analytical column (100 x 3 mm, 3 um), and separated with an aqueous 20 mM ammonium acetate - methanol gradient on an HPLC with delay column and Teflon fittings replaced, at 0.5 ml min^{-1} flow rate. Twenty-five PFAS were detected using optimized transitions, collision energies, and declustering potentials on a high resolution, accurate mass quadrupole-time of flight (QToF) tandem mass spectrometer with negative mode electrospray ionization.

RESULTS

Datasets for each site were sent individually to site personnel, and all data will be analyzed in detail in preparation for peer-reviewed publications. In this report, we present an overview of the data that illustrates incidence and distribution of biosolid-derived PFAS in land application plots across the US. Data from 23 sites in 17 states are presented.

Incidence of PFAS analytes in soil samples at 1, 3, and 6 feet depths are illustrated in “Box and Whisker” charts in Figures 2-10. A schematic diagram of a “Box and Whisker” plot is shown below in Figure 1.

A “Box and Whisker” plot, sometimes referred to as a “Box Plot” is a simple way to visually display multiple values of a given parameter in terms of quartiles, where a quartile shows the data distribution for 25% of all data. In the diagram, the median value is the middle value that separates the upper 50% of the values (two quartiles) from the lower 50% (also two quartiles). For the upper 50% of the values, the Upper Quartile (25%) extends from the median value to the upper extremity of the box. The remaining upper 25% is shown as the chart’s whisker and extends from the Upper Quartile value to the Upper Extreme value. Outside of the Upper Extreme are Upper Outliers, whose values are excessively different from the median value. Whether a value is within the Upper Extreme range or is a true Outlier is related to its value relative to the standard deviation of the dataset. Analogous definitions exist for the Lower Quartile and Lower Extreme. In this plot, X represents the mean value of the dataset.

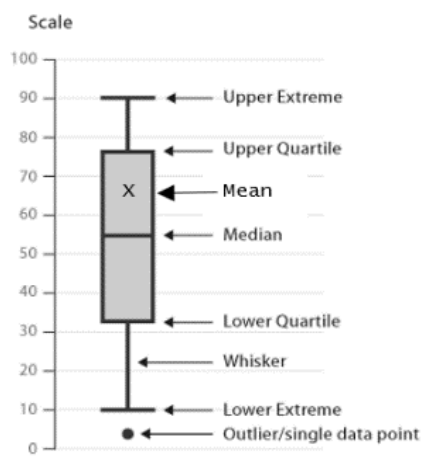


Figure 1. Schematic Box and Whisker

Figures 2-10 illustrate three Box and Whisker charts for each of the Control, Low Biosolid and High Biosolid plots. Each graph shows 25 PFAS analyte concentrations at 1, 3 or 6 feet depths. The color code for the 25 PFAS analytes is shown in Table 3. It is important to note that the concentrations displayed represent the individual concentrations from each site regardless of the actual loading rates, which vary from site to site. Actual biosolid loading rates for each site are shown in Tables 1 and 2. Despite the variability in loading rate, the Box Plots show tangible and distinct differences in PFAS concentrations between the overall Control, Low and High Biosolid plots. Clear differences also exist between the 1, 3 and 6 feet soil samples.

a) Distribution of Soil PFAS Analytes in Land Application Plots Nationally

Figures 2, 3, and 4 show PFAS soil concentrations from Control plots at 1, 3, and 6 feet depths. For all plot types, there are high value outliers, including Control plots. Due to scaling issues related to data display, some outliers are not shown in Figures 2-10. However, overall concentrations of all analytes are low for Control plots as indicated by the mean and median values across all sites. Mean values of all analytes averaged over all sites are less than 1 ppb except for PFOS which is marginally higher than 1 ppb. Overall, PFAS concentrations are highest in the 1 foot control samples, when compared to 3 feet and 6 feet samples. Despite the overall low concentrations of analytes (See Discussion Section d), there are upper outlier values for several compounds.

Soil PFAS data for the Low Biosolid plots are shown in Figures 5, 6, and 7. Concentrations of PFAS analytes in 1 foot samples are still low, but higher than Control plots as evidenced by several mean values greater than 1 ppb, including PFDA, PFUnA. PFHps, 6:2 FTS and PFOS. However, median 1 foot concentrations were all less than 1 ppb. PFAS concentrations in 3 feet and 6 feet samples showed similar trends, but also significant attenuation with increased soil depth.

Samples from High Biosolids plots generally showed increased soil PFAS concentrations relative to Control and Low Biosolid plots (Figures 8, 9, and 10). Several compounds had mean values of soil PFAS concentrations greater than 1 ppb, including PFOA, PFDA, PFUnA, PFHpS and PFOS. PFOS concentrations are notable with a mean value close to 10 ppb. Yet again, significant attenuation occurred with increased soil depth. In addition, median values for all High Biosolid plot samples were less than 1 ppb.

b) Incidence of EPA Regulated Drinking Water PFAS in Soil

Mean, median, maximum and minimum soil concentrations of EPA regulated PFAS compounds are shown in Tables 4, 5, and 6. Values for 1 foot samples are shown since these are normally higher than 3 feet and 6 feet samples. Also shown in these tables are soil screening levels (for discussion of SSLs, see Discussion Section d), and EPA drinking water maximum allowable contaminant levels (MCLs). For Control plots (Table 4), all soil mean and median values are lower than corresponding soil screening levels except for PFOA, which is marginally higher (0.342 versus 0.3). For Low Biosolid plots (Table 5), all median values are less than corresponding soil screening levels except for PFOA. Soil mean values for PFOS, PFHxS and PFNA are lower than the SSLs, whereas the mean value for PFOA is higher than the SSL.

In High Biosolid plots, overall soil median PFAS values were always lower than mean values. PFOS, PFHxS and PFNA median values were lower than corresponding SSLs. The median value for PFOA (0.47 ppb) was slightly higher than the corresponding SSL (0.3 ppb). The mean values for PFOA and PFOS were greater than corresponding SSLs.

Finally note that GenX was not one of the analytes monitored in this study because when the study was initiated, it was not known that GenX would be one of the analytes regulated by EPA.

c) Recent Biosolids PFAS Concentrations

Biosolids samples collected during 2022-2024 were received from most (but not all) sites. PFAS analyte concentrations of these current samples are shown in Tables 7 and 8. Concentrations of analytes are universally low with the exceptions of samples from Site 7 and Site 19. For Site 7, six analyses were in excess of 100 ppb. For Site 19, three samples were in excess of 100 ppb.

d) Groundwater PFAS Concentrations of EPA Regulated Analytes

Table 9 shows the concentrations of PFAS in water samples provided by sites in the study. Note that only 10 sites out of the 23 were able to provide water samples. Additionally, sources and methods of collection of water samples varied from site to site. Concentrations of PFOA, PFOS and PFHxS were often in excess of the corresponding EPA MCL values, whereas PFNA concentrations exceeded the EPA MCL only once.

DISCUSSION

a) Soil PFAS Analytes in Land Application Plots Nationally

Figures 2-10 show the national incidence of PFAS averaged over all sites. This high elevation view of biosolid derived PFAS leads to the initial assessment that land application of municipal biosolids does not lead to unacceptably high levels of soil PFAS. In contrast, previous studies have shown that industrially contaminated biosolids result in very high levels of soil PFAS (Wilhelm *et* al., 2008; Washington *et al*., 2010). Interestingly, even Control plots that had never received land applied biosolids still showed detectable PFAS (Figures 2-4). The source of PFAS in these control plots is generally unclear, but their presence demonstrates the ubiquitous nature of PFAS. In fact, PFAS has been documented to be present in soils worldwide, even in remote areas far removed from obvious industrial inputs of PFAS (Brusseau *et al*., 2020). Two potential explanations for this phenomenon are windblown deposits of PFAS, and documented rain and snow deposits (Johnson *et al.*, 2022).

The concentrations of PFAS in the 1 foot Control soil samples decreased with increased soil depth, showing attenuation of PFAS due to interaction with soil. The degree of PFAS attenuation will depend on many factors but two major factors are likely to be soil type and amount of rainfall and/or irrigation (see Section d later in Discussion). When viewed over multiple sites, attenuation of PFAS with increased soil depth is clearly observed.

Figures 5-7 show soil PFAS concentrations from Low Biosolid plots at soil depths of 1, 3 and 6 feet. A comparison of these data with Control plot values demonstrates increased PFAS, presumably of biosolid origin. However, it is important to note that cores from the Control plots and Low Biosolid plots are taken from physically separated locations, sometimes miles apart and with different soil types. Data from multiple locations clearly establish the correlation between land application of biosolids and enhanced soil PFAS. That being said, increases are modest and mostly below 1 ppb. Similar to Control plot values, PFAS concentrations decreased with increased soil depth. Of all analytes, PFOS mean concentrations from 1 foot samples at Low Biosolids plots were the highest at almost 2 ppb. Note also that mean values averaged over all sites are always higher than median values of the data. This is mostly due to the elevated concentrations at two sites (Sites 3 and 20) that skew the data. Median values reflecting 50% being lower, provide a clearer indication of PFAS soil concentrations.

Figures 8-10 show data from High Biosolid plots. Data show the same trends as those from the Low Biosolid plots. The soil PFOS concentration at 1 foot resulted in the highest mean value of 8 ppb. However, removal of data from Sites 3 and 20 reduces the value to 3.2. Attenuation with soil depth continued to be observed, resulting in all mean concentrations of analytes being less than 2 ppb at the depth of 6 feet. However, the High Biosolid plots provided many more Upper Outliers than the Control and Low Biosolid plots. The source of these outliers is unclear because, in some cases, biosolids have been land applied since the 1980s.

Considering data from all plots nationally, an evaluation of mean and median concentrations shows that: i) land application of municipal biosolids rarely resulted in unacceptably high soil PFAS concentrations; and ii) attenuation of biosolid derived PFAS occurs rapidly within the soil profile and close to the surface.

b) Incidence of EPA Regulated Drinking Water PFAS Analytes

Incidence of EPA regulated PFAS compounds in soil are shown in Tables 4 - 6, along with mean, median, maximum, and minimum soil concentration from the National Study. For PFHxS and PFNA, all soil mean and median concentrations were below 1 ppb. For PFOA, all mean and median values were less than 1 ppb except for the 1 foot High Biosolids plot samples. For PFOS, all median concentrations were less than 1 ppb, but all mean concentrations exceeded 1 ppb and were as high as 8.5 ppb for the 1 foot High Biosolids samples. However, omitting soil PFAS data from Sites 3 and 20 results in a PFOS mean of 3.2 ppb.

Since median values for the EPA regulated analytes were all less than, or close to, the corresponding SSLs, these data indicate that land application of municipal biosolids is generally not a significant source of groundwater contamination. However, it is critical to point out caveats to this assessment. As noted previously, the degree to which PFAS may leach through soil and impact groundwater is dependent upon numerous factors, many of which are site specific. For example, one important factor is the source and nature of the biosolids. If industrially contaminated biosolids are land applied, this can lead to soil and groundwater contamination as demonstrated by studies in Decatur, Alabama (Washington *et al*., 2010) and Sauerland, Germany (Wilhelm *et al*., 2008). Other important factors include soil type, depth to groundwater, and magnitudes of natural and human-induced water inputs (See also Section D).

c) Biosolids and Groundwater PFAS Concentrations

With the exception of two sites, recent biosolids PFAS concentrations were relatively low and these levels in soil further decrease with attenuation. Thus, municipal biosolids, without industrial contamination, are unlikely to cause groundwater contamination since they result in soil PFAS concentrations lower than SSLs that are protective of groundwater. However, biosolids land applied several decades ago may have contained higher PFAS concentrations than recent samples of biosolids. Biosolids from Site 7 contained high PFAS concentrations, and following discussions with site personnel, it was discovered that inputs into the raw wastewater included a direct line with landfill leachate. The source of PFAS in Site 19 biosolids, the other site with higher PFAS concentrations, remains unclear.

In Table 9, groundwater PFAS concentrations are highly variable. At one site, Site 20, groundwater concentrations collected at the High Biosolids plot were higher than concentrations of PFAS in water collected at the Control plot. However, care must be taken in drawing conclusions about direct cause and effect for several reasons: 1) The hydrological conditions (e.g., depth to groundwater and direction of groundwater flow) are unknown; and 2) The history of the site is unknown. The high variability of PFAS concentrations within groundwaters may be due to multiple anthropogenic inputs. For many years, the conventional wisdom was that groundwaters were pristine and free of chemical and microbial contaminants. However, in a major national study of groundwaters, samples of groundwater were collected from 448 sites in 35 US States (Abbaszadegan et al.,2003). Following analysis, it was shown that approximately 1/3 of all groundwaters had received anthropogenic contaminants. Nationally, if all biosolids were land applied, it would only require 0.5% of total cropland (National Biosolids Data Project, 2018). Thus, it is evident that other sources of contamination contributed to those anthropogenic inputs. Such sources could include irrigation water, leachate from sanitary landfills, effluent from industrial plants, and pesticides from agricultural soil or runoff.

d) Potential for Groundwater Contamination

Evaluating the potential for PFAS in soil to impact groundwater requires characterization of the leaching potential of PFAS for the site of interest. The leaching potential in turn is a function of many factors including soil infiltration rates, evapotranspiration, soil properties including texture, the amount of precipitation or irrigation, and the specific PFAS in question (Guo *et al*., 2022).

Overall, the risk of significant PFAS contamination of groundwater from land application of biosolids would most likely be in a scenario where biosolids contaminated with industrial inputs of PFAS are applied to a course textured soil with a shallow depth to groundwater and high rainfall or irrigation (Pepper *et al.*, 2023). In contrast, risk of contamination would be less significant when municipal biosolids with lower PFAS content are applied to finer textured soils with large depth to groundwater. Finally note that there is greater risk of the more mobile short chain PFA analytes leaching, than longer chain PFAS.

To quantify the risk of leaching, a modeling approach is needed. A suite of mathematical models has been developed at The University of Arizona to simulate the migration, retention, and leaching of PFAS in the vadose zone (Guo et al., 2020, 2022; Brusseau and Guo, 2023; Smith et al., 2024). The models range in complexity and associated data-input requirements. The simplest version is based on the widely used EPA dilution-attenuation factor (DAF) soil screening model (EPA, 1996). The EPA model is based on determining the maximum concentration of the target constituent in soil (the soil screening level, SSL) that would be determined to be protective of groundwater (not exceed a selected concentration such as an MCL).

The standard EPA model considers retention of the constituent by sorption to soil solids as well as partitioning to the soil atmosphere. It does not consider adsorption at the air-water interface, which has been determined to be a critical source of retention for PFAS in certain conditions. Brusseau and Guo (2023) revised the EPA DAF model to incorporate adsorption at the air-water interface.

The simplified equation for the SSL is given by:

$$SSL = C_{soil} = C_{gw} DAF \frac{\theta_w}{\rho_b} R_d \qquad [1]$$

where R in the original model is defined as:

$$R_d = \left(1 + K_d \frac{\rho_b}{\theta_w} + H \frac{\theta_a}{\theta_w}\right) \qquad [2]$$

and R in the revised model is defined as:

$$R_d^{Rev} = \left(1 + K_d \frac{\rho_b}{\theta_w} + H \frac{\theta_a}{\theta_w} + K_{aw} \frac{A_{aw}}{\theta_w}\right) \qquad [3]$$

and where DAF is the dilution-attenuation factor, ρ_b is porous-medium bulk density (M/L^3), ϑ_a is volumetric air content (L^3/L^3), and ϑ_w is volumetric water content (L^3/L^3), $\theta_w + \theta_a = n$, where *n* is porosity, K_d (L^3/M) is the sorption coefficient, *H* (-) is Henry's law constant, K_{aw} is the air-water interfacial adsorption coefficient (L^3/L^2), and A_{aw} is the specific air-water interfacial area (L^2/L^3).

The revised model can be used to calculate SSLs for any given PFAS at any land application site, provided soil characteristics at the site are known. Essentially the SSL for a given PFAS at a given site identifies the maximum allowable soil PFAS concentration that would maintain groundwater concentrations to less than or equal to any MCL such as the new EPA drinking water regulation of 4 ppt for PFOS and PFOA.
An example application of the revised DAF model is presented in Tables 10-13 for PFOA, PFOS, PFHxS, and PFNA, respectively. In these examples, a SSL for each PFAS is determined for a hypothetical soil with realistic estimates of soil characteristics such as 1.5 g/cc for bulk density and 1% organic carbon. For each of these calculations' parameters related to both the specific soil and the specific PFAS must be inputted either by estimation, calculation or physical measurement. The newly promulgated MCLs are used as the target groundwater concentration. The source of the various input parameters is noted in the footnotes. It is observed that the SSLs for the revised model higher than those determined with the original model. This is due to the impact of air-water interfacial adsorption. This example illustrates how the revised model can be used to determine SSLs for each site, with the relevant soil characterization data available. SSLs would be determined for each individual PFAS.

It is critical to note that the standard and revised DAF models have uncertainties and that the SSLs determined from the models are for screening purposes. The uncertainties and limitations are discussed in EPA (1996) and Brusseau and Guo (2023). It is also critical to note that the calculated SSL values are for illustrative purposes only. Actual SSL values will be site specific, and would need to be calculated using soil properties measured for the target site.

The site dependency of SSL originates from the influence of soil and PFAS properties on retention. Inspection of equation 1 reveals that C_{gw} and DAF do not change once selected. In addition, soil bulk density varies comparatively minimally across different soil types. Hence, the two parameters in equation 1 that will typically exhibit the greatest variability across sites are R_d and θ_w. Inspection of equations 2 and 3 shows that K_d, K_{aw}, and A_{aw} are the three parameters that cause R_d to exhibit variability, along with θ_w. The air-water interfacial area is a function of both soil properties and θ_w particularly the amount of fine-grained particles in the soil. Kd in turn, is a function of soil properties such as the amount of soil organic carbon as well as the properties of the individual PFAS (such as chain length). K_{aw} is also a function of the properties of the individual PFAS. In total, SSLs for a given PFAS can be anticipated to vary across sites due to differences in K_d and A_{aw}. For example, calculated SSLs for PFOS range from 0.5 to 21 µg/kg when soil organic matter is increased from 0.1% to 10% (Table 14). The 0.5 value results from inputting a soil organic carbon value of 0.1%, decreasing the amount of PFOS sorbed. In contrast, increasing the soil organic carbon to 10% increases the amount of sorption and decreases the amount of PFOS available for leaching. Clearly then, a suite of SSLs are feasible, depending on the particular soil. SSLs will also vary for different PFAS for a given site due to differences in K_d and K_{aw} among the PFAS. This is observed by comparing the SSLs in Tables 10-13 for the four example PFAS. Note that for most soils, organic matter contents are between 1 and 5%.

SUMMARY

The National Collaborative PFAS Study has successfully resulted in the largest U.S. dataset on incidence of soil PFAS concentrations resulting from municipal biosolids land application. The mean and median concentrations of PFAS were low. A set of illustrative SSL calculations were presented for four EPA regulated PFAS, along with a discussion of the site-specific variability that can be anticipated due to differences in soil properties. Overall, all mean and median PFAS soil concentrations measured nationally at land application sites were less than or close to calculated SSLs for specific EPA regulated PFAS analytes in typical soils with modest soil organic carbon content. These data will be utilized for modeling the potential risk of groundwater contamination following leaching of analytes through soil and vadose zone. Wherever possible, predicted groundwater PFAS concentrations will be compared to actual groundwater concentrations at specific sites. Potentially these data could be very useful to several States across the country by illustrating PFAS levels in soils within land application sites. Multiple peer review publications will be produced from Phase 1 of the research.

PHASE 2 of the National PFAS Study

Phase 2 will evaluate the indirect route of exposure to PFAS from the ingestion of foodstuffs from crops grown on land application plots. Phase 1 of the research project established a national network of land application plots where soil PFAS concentrations are now known. Capitalizing on this, an attractive concept is to establish a similar national network of plant uptake data across the U.S. by growing crops on the 23 land application plots already studied. This will allow for the creation of paired data sets of soil and crop PFAS concentrations. Multiple crop types will be grown including for example corn, oats and alfalfa. This will evaluate differential plant uptake of different PFAS analytes by different crops. In addition, planting the same crop at different national locations will allow for the influence of different soil types and climate regimes on plant uptake to be evaluated.

At each site, plant samples of roots, stems and leaves will be collected as well as edible crop produce. All samples will be sent to the University of Arizona for PFAS analyses at the Arizona Laboratory for Emerging Contaminants (ALEC). This will allow for crop uptake analysis. Using estimates of daily food intake and PFAS plant concentrations, the amount of PFAS exposure from ingestion of foodstuffs can be calculated and compared to recommended allowable PFAS exposure.

Currently, fundraising for Phase 2 is underway. Crop planting is anticipated in the spring of 2025, with crop sampling and harvesting undertaken in the summer and fall of 2025.

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Table 1. Low Biosolids Plots - Loading Rates[a]

Site	Biosolid type (class)	Lifetime loading rate (dry tons/acre)	Application period	Application frequency (times)
S01	Class B	13	1987- 2001 (3 applications) and 2012-2019 (3 applications)	6
S02	Class B	13	1987 -2019	6
S03	Class B	36.4	1996-2016	76
S04	Class A	7.5	2017	1
S05	Class B (2016-2019), Class AA (2020-2022)	25.3	2016-2022	7
S06	Class A	24.8 wet tons/acre	2018-2022	3
S07	Class B	70	1980, 1981, 1982, 1984, 1989, 1991, 1993, 1996, 2001, 2006, 2011, 2016, 2021	13
S08	Class B	14	29	7
S10	Class B	10.8	2005-2019 [b]	12+
S12		19.4	2011 - 2022	6
S13	Class A	5	2023	1
S15	Class B	2.5	2023	1
S22	Class B	15 wet tons/acre	2024	1

[a]Plot background information was provided by sites and is not standardized.

[b]Biosolids application records date back to 2005, but biosolids were spread many years prior.

Table 2. High Biosolids Plots - Loading Rates[a]

Site	Biosolid type (class)	Lifetime loading rate (dry tons/acre)	Application period	Application frequency (times)
S01	Class B	40	2014 - 2019	6
S02	Class B	46	1987 - 2016	13
S03	Class B	52.6	1997-2022	38
S04	Class A	25.5	2016, 2018, 2021	3
S05	Class B (2016-2019), Class AA (2020-2022)	31.9	2016-2022	7
S06	Class A	66.2 wet tons/acre	2018-2023	6
S07	Class B	92.4	1981, 1983, 1985, 1986, 1988, 1990, 1992, 1994, 1998, 2002, 2007, 2012, 2017, 2022	14
S08	Class B	31.5	29	7
S10	Class B	25.8	2005-2019[b]	12+
S11		14.3	2007, 2010, 2014	3
S12		35.3	2013 - 2023	11
S13	Class A	20	2023	1
S14	Class B	126 wet tons/acre	2013-2022 (no application in 2014)	9
S17	Class B	82.38	1989 - 2023	35
S22	Class B	30 wet tons/acre	2024	1
S23	Class B	280	1996-2022	14

[a]Plot background information was provided by sites and is not standardized.

[b]Biosolids application records date back to 2005, but biosolids were spread many years prior.

Table 3. Code for PFAS Analytes in Figures 2-10

PFAS Analyte Key

PFBA	PFPeA	PFHxA	PFHpA	PFOA	PFNA	PFDA
PFUnA	PFDoA	PFTriDA	PFTreA	PFBS	PFPeS	PFHxS
PFHpS	PFOS	PFNS	PFDS	4:2 FTS	6:2 FTS	8:2 FTS
FOSA	NMeFOSA	NMeFOSAA	NEtFOSAA			

Table 4. Soil PFAS Concentrations of Analytes Regulated in Drinking Water by EPA

1 Foot, Control Plots

Compound	Soil Mean (ppb)	Soil Median (ppb)	Soil Max (ppb)	Soil Min (ppb)	Soil Screening Level (ppb)	EPA Drinking Water MCL (ppt)
PFOA	0.342	0.115	3.398	0.000	0.3	4.0
PFOS	1.066	0.091	20.906	0.000	3.7	4.0
PFHxS	0.060	0.000	0.898	0.000	0.41	10
PFNA	0.066	0.016	0.869	0.000	4.0	10
HFPO-DA (GenX Chemicals)	Not measured	Not measured	Not measured	Not measured	-	10

Table 5. Soil PFAS Concentrations of Analytes Regulated in Drinking Water by EPA

1 Foot, Low Biosolids Application Plots

Compound	Soil Mean (ppb)	Soil Median (ppb)	Soil Max (ppb)	Soil Min (ppb)	Soil Screening Level (ppb)	EPA Drinking Water MCL (ppt)
PFOA	0.740	0.387	3.269	0.000	0.3	4.0
PFOS	2.260	0.383	17.795	0.000	3.7	4.0
PFHxS	0.083	0.017	0.732	0.000	0.41	10
PFNA	0.122	0.054	0.767	0.000	4.0	10
HFPO-DA (GenX Chemicals)	Not measured	Not measured	Not measured	Not measured	-	10

* If values from S13 Pre Ap are excluded, max concentrations for PFOA is 3.269, for PFOS is 17.795, and for PFHxS is 0.732.

Table 6. Soil PFAS Concentrations of Analytes Regulated in Drinking water by EPA

1 Foot, High Biosolids Application Plots

Compound	Soil Mean (ppb)	Soil Median (ppb)	Soil Max (ppb)	Soil Min (ppb)	Soil Screening Level (ppb)	EPA Drinking Water MCL (ppt)
PFOA	2.410	0.470	19.263	0.000	0.3	4.0
PFOS	8.531	0.527	140.238*	0.000	3.7	4.0
PFHxS	0.252	0.050	3.323	0.000	0.41	10
PFNA	0.812	0.141	8.213	0.000	4.0	10
HFPO-DA (GenX Chemicals)	Not measured	Not measured	Not measured	Not measured	-	10

* If values from S3 and S20 are excluded, max concentration for PFOS is 17.950 and soil mean for PFOS is 3.188.

Table 7. Recent Biosolids PFAS Concentrations, Sites 5 – 13 (ppb)

Analyte/Site	S5 #1	S5 #2	S6	S7	S10 #1	S10 #2	S11	S12	S13
PFBA	5.514	7.965	0.000	337.499	5.096	3.823	0.102	7.625	3.770
PFPeA	6.383	6.808	0.000	1282.833	1.014	ND	ND	27.963	1.120
PFHxA	18.041	16.464	0.000	1229.305	2.898	3.892	0.408	21.811	6.309
PFHpA	1.440	1.792	0.000	472.017	0.376	0.519	0.054	2.704	0.374
PFOA	9.569	8.960	0.000	996.770	1.601	2.721	0.392	20.148	1.862
PFNA	1.076	1.082	ND	8.341	ND	0.398	0.096	2.219	0.753
PFDA	7.883	7.458	NR	5.974	0.433	0.658	0.744	15.441	1.226
PFUnA	0.767	0.655	ND	0.889	0.255	ND	0.000	1.285	0.758
PFDoA	2.440	2.478	ND	ND	0.356	0.681	0.000	4.370	0.994
PFTriDA	0.370	0.509	ND	ND	ND	ND	0.000	0.827	0.211
PFTreA	2.338	1.707	0.000	1.896	0.307	4.745	0.086	2.114	3.533
PFBS	14.873	14.560	NR	1361.222	ND	ND	24.079	19.519	ND
PFPeS	ND	ND	NR	28.645	ND	ND	1.146	ND	ND
PFHxS	0.443	0.339	ND	201.801	ND	ND	1.026	1.899	ND
PFHpS	ND	ND	0.000	9.972	ND	ND	0.000	ND	ND
PFOS	10.082	8.509	ND	71.245	0.726	ND	4.138	37.565	9.806
PFNS	ND	ND	ND	ND	ND	ND	ND	ND	ND
PFDS	0.220	0.187	ND	ND	ND	ND	0.067	0.804	ND
4:2 FTS	ND	ND	ND	ND	ND	ND	ND	ND	ND
6:2 FTS	3.632	6.143	ND	ND	ND	ND	ND	3.777	2.298
8:2 FTS	1.076	0.000	ND	ND	ND	ND	0.157	0.000	1.448
FOSA	0.555	0.592	ND	ND	ND	ND	0.578	2.180	0.394
NMeFOSA	ND	ND	ND	ND	ND	ND	ND	ND	ND
NMeFOSAA	4.493	3.597	NR	ND	ND	1.657	0.000	6.801	2.070
NEtFOSAA	1.815	1.198	ND	ND	ND	ND	ND	2.249	1.551

Table 8. Recent Biosolids PFAS Concentrations, Sites 14 - 22 (ppb)

Analyte/Site	S14	S15	S16	S17	S18	S19	S21	S22
PFBA	0.273	5.189	12.239	NR	2.217	ND	15.676	NR
PFPeA	ND	5.492	ND	ND	7.261	53.511	ND	ND
PFHxA	NR	12.506	3.481	0.000	2.589	86.501	24.442	ND
PFHpA	0.127	1.083	0.943	NR	0.288	6.914	ND	NR
PFOA	0.618	6.618	4.636	NR	2.776	62.392	3.309	NR
PFNA	0.105	1.103	0.498	NR	0.000	23.782	ND	NR
PFDA	1.387	6.773	2.173	NR	1.907	152.773	ND	5.923
PFUnA	0.000	0.888	0.440	NR	0.214	15.295	ND	ND
PFDoA	0.000	2.709	0.825	0.000	0.598	32.989	0.740	1.980
PFTriDA	0.000	0.355	ND	0.000	1.124	13.959	ND	ND
PFTreA	NR	2.455	0.475	0.000	0.769	57.519	0.364	1.231
PFBS	NR	26.224	ND	NR	1.001	8.346	ND	4.488
PFPeS	NR	ND	ND	ND	ND	ND	ND	ND
PFHxS	2.054	0.793	ND	NR	ND	7.775	ND	1.064
PFHpS	0.000	ND	ND	0.000	ND	ND	ND	0.343
PFOS	2.802	7.585	6.596	NR	5.235	387.703	ND	31.886
PFNS	ND	ND	ND	ND	ND	10.178	ND	ND
PFDS	ND	ND	ND	ND	0.231	3.771	ND	4.820
4:2 FTS	ND	ND	ND	ND	ND	ND	ND	1.132
6:2 FTS	0.004	4.252	ND	NR	1.313	12.361	ND	1.309
8:2 FTS	ND	1.858	ND	ND	ND	16.351	ND	ND
FOSA	0.133	0.719	ND	ND	0.435	78.020	ND	ND
NMeFOSA	ND	ND	ND	ND	ND	ND	ND	ND
NMeFOSAA	ND	4.183	2.688	NR	1.766	230.255	ND	NR
NEtFOSAA	ND	2.461	ND	ND	0.000	70.759	ND	ND

Table 9. PFAS Concentrations of EPA Regulated Analytes in Water Samples (ppt)

Sample	Source and Collection Description	PFOA	PFOS	PFHxS	PFNA
S1 #1	groundwater; surface collection	16.006	109.484	88.932	NR
S1 #2	groundwater; surface collection	15.776	50.728	162.161	1.554
S2 #1	groundwater; surface collection	1.597	4.508	13.861	NR
S2 #2	groundwater; surface collection	2.777	2.527	10.194	0.189
S6 - C	canal water	ND	ND	ND	ND
S7 - H	groundwater; auger hole collection	ND	ND	ND	ND
S14 - H #1	groundwater; well collection	17.754	ND	5.132	ND
S14 - H #2	groundwater; well collection	NR	ND	1.063	ND
S14 - H #3	groundwater; well collection	ND	ND	1.554	ND
S17 #1	groundwater; well collection	0.565	ND	2.471	NR
S17 #2	groundwater; well collection	137.325	5.459	21.065	NR
S17 #3	groundwater; well collection	181.102	ND	11.411	ND
S17 #4	groundwater; well collection	0.649	ND	ND	ND
S17 #5	groundwater; well collection	24.362	0.880	6.337	NR
S17 #6	groundwater; well collection	0.321	0.262	2.264	NR
S20 - C	groundwater; auger hole collection	ND	ND	ND	ND
S20 - H	groundwater; auger hole collection	618.176	280.671	140.004	53.881
S21 - C	surface water in field	3.582	1.502	ND	0.346
S22	groundwater; well collection	ND	ND	ND	ND
S23 - H	spring water; surface collection	20.654	5.153	1.117	2.204
	EPA Drinking Water MCL	4.0	4.0	10	10

HFPO-DA (GenX Chemicals), with EPA Drinking Water MCL of 10ppt, was not measured in this study.

C = sample obtained close to control plots

H = sample obtained close to high biosolid plot

Table 10. Example Parameters and Calculated SSLs for PFOA Using the EPA Standard DAF model and the Brusseau and Guo Revised DAF model

Parameter	Standard Model	Revised Model	Notes
Dilution Factor (DF)	20	20	Default, EPA 1996
Attenuation Factor (AF)	1	1	Default, EPA 1996
Dilution-Attenuation Factor (DAF)	20	20	Default, EPA 1996
Bulk density (ρ_b, g/cm^3)	1.5	1.5	Assumed
Water content (volumetric, θ_w, -)	0.24	0.24	Example
Porosity (n, -)	0.4	0.4	Assumed
Sorption coefficient (K_d, cm^3/g)[a]	1.3	1.3	Estimated
Air-water interfacial adsorption coefficient (K_{aw}, cm)[b]	NA	0.008	Measured
Air-water interfacial area (A_{aw}, cm^{-1})[c]	NA	450	Estimated
Distribution term (R_d, -)	8.9	23.9	Calculated
Target groundwater concentration (C_{gw}, µg/L)[d]	0.004	0.004	Set value
Soil Screening Level (SSL, µg/kg)	0.1	0.3	Calculated

[a]Representative OC = 1%; log Koc from Brusseau, 2023a
[b]Measured value from Brusseau and Van Glubt, 2021
[c]Estimated value from Brusseau, 2023b
[d]The target groundwater concentration is based on EPA MCL

Brusseau, M.L. (2023a). Differential sorption of short-chain versus long-chain anionic per- and poly-fluoroalkyl substances by soils. Environments, 10, article 175.

Brusseau, M.L. (2023b). Determining air-water interfacial areas for the retention and transport of PFAS and other interfacially active solutes in unsaturated porous media. Science of the Total Environment, 884, article 163730.

Brusseau, M.L. and Van Glubt, S. (2021). The influence of molecular structure on PFAS adsorption at air-water interfaces in electrolyte solutions. Chemosphere 281, article 130829.

Brusseau, M.L. and Guo, B. (2023). Revising the EPA Dilution-Attenuation Soil Screening Model for PFAS. Journal of Hazardous Materials Letters, 4, article 100077.

EPA 1996. Soil Screening Guidance: User's Guide. Publication 9355.4-23.

Table 11. Example Parameters and Calculated SSLs for PFOS Using the EPA Standard DAF model and the Brusseau and Guo Revised DAF model

Parameter	Standard Model	Revised Model	Notes
Dilution Factor (DF)	20	20	Default, EPA 1996
Attenuation Factor (AF)	1	1	Default, EPA 1996
Dilution-Attenuation Factor (DAF)	20	20	Default, EPA 1996
Bulk density (ρ_b, g/cm^3)	1.5	1.5	Assumed
Water content (volumetric, θ_w, -)	0.24	0.24	Example
Porosity (n, -)	0.4	0.4	Assumed
Sorption coefficient (K_d, cm^3/g)[a]	10	10	Estimated
Air-water interfacial adsorption coefficient (K_{aw}, cm)[b]	NA	0.12	Measured
Air-water interfacial area (A_{aw}, cm^{-1})[c]	NA	450	Estimated
Distribution term (R_d, -)	63.5	288.5	Calculated
Target groundwater concentration (C_{gw}, µg/L)[d]	0.004	0.004	Set value
Soil Screening Level (SSL, µg/kg)	0.8	3.7	Calculated

[a]Representative OC = 1%; log Koc from Brusseau, 2023a
[b]Measured value from Brusseau and Van Glubt, 2021
[c]Estimated value from Brusseau, 2023b
[d]The target groundwater concentration is based on EPA MCL

Brusseau, M.L. (2023a). Differential sorption of short-chain versus long-chain anionic per- and poly-fluoroalkyl substances by soils. Environments, 10, article 175.

Brusseau, M.L. (2023b). Determining air-water interfacial areas for the retention and transport of PFAS and other interfacially active solutes in unsaturated porous media. Science of the Total Environment, 884, article 163730.

Brusseau, M.L. and Van Glubt, S. (2021). The influence of molecular structure on PFAS adsorption at air-water interfaces in electrolyte solutions. Chemosphere 281, article 130829.

Brusseau, M.L. and Guo, B. (2023). Revising the EPA Dilution-Attenuation Soil Screening Model for PFAS. Journal of Hazardous Materials Letters, 4, article 100077.

EPA 1996. Soil Screening Guidance: User's Guide. Publication 9355.4-23.

Table 12. Example Parameters and Calculated SSLs for PFHxS Using the EPA Standard DAF model and the Brusseau and Guo Revised DAF model

Parameter	Standard Model	Revised Model	Notes
Dilution Factor (DF)	20	20	Default, EPA 1996
Attenuation Factor (AF)	1	1	Default, EPA 1996
Dilution-Attenuation Factor (DAF)	20	20	Default, EPA 1996
Bulk density (ρ_b, g/cm^3)	1.5	1.5	Assumed
Water content (volumetric, θ_w, -)	0.24	0.24	Example
Porosity (n, -)	0.4	0.4	Assumed
Sorption coefficient (K_d, cm^3/g)[a]	1.0	1.0	Estimated
Air-water interfacial adsorption coefficient (K_{aw}, cm)[b]	NA	0.003	Measured
Air-water interfacial area (A_{aw}, cm^{-1})[c]	NA	450	Estimated
Distribution term (R_d, -)	7.2	12.9	Calculated
Target groundwater concentration (C_{gw}, µg/L)[d]	0.010	0.010	Set value
Soil Screening Level (SSL, µg/kg)	0.23	0.41	Calculated

[a]Representative OC = 1%; log Koc from Brusseau, 2023a
[b]Measured value from Brusseau and Van Glubt, 2021
[c]Estimated value from Brusseau, 2023b
[d]The target groundwater concentration is based on EPA MCL

Brusseau, M.L. (2023a). Differential sorption of short-chain versus long-chain anionic per- and poly-fluoroalkyl substances by soils. Environments, 10, article 175.

Brusseau, M.L. (2023b). Determining air-water interfacial areas for the retention and transport of PFAS and other interfacially active solutes in unsaturated porous media. Science of the Total Environment, 884, article 163730.

Brusseau, M.L. and Van Glubt, S. (2021). The influence of molecular structure on PFAS adsorption at air-water interfaces in electrolyte solutions. Chemosphere 281, article 130829.

Brusseau, M.L. and Guo, B. (2023). Revising the EPA Dilution-Attenuation Soil Screening Model for PFAS. Journal of Hazardous Materials Letters, 4, article 100077.

EPA 1996. Soil Screening Guidance: User's Guide. Publication 9355.4-23.

Table 13. Example Parameters and Calculated SSLs for PFNA Using the EPA Standard DAF model and the Brusseau and Guo Revised DAF model

Parameter	Standard Model	Revised Model	Notes
Dilution Factor (DF)	20	20	Default, EPA 1996
Attenuation Factor (AF)	1	1	Default, EPA 1996
Dilution-Attenuation Factor (DAF)	20	20	Default, EPA 1996
Bulk density (ρ_b, g/cm^3)	1.5	1.5	Assumed
Water content (volumetric, θ_w, -)	0.24	0.24	Example
Porosity (n, -)	0.4	0.4	Assumed
Sorption coefficient (K_d, cm^3/g)[a]	4.7	4.7	Estimated
Air-water interfacial adsorption coefficient (K_{aw}, cm)[b]	NA	0.05	Measured
Air-water interfacial area (A_{aw}, cm^{-1})[c]	NA	450	Estimated
Distribution term (R_d, -)	30	124	Calculated
Target groundwater concentration (C_{gw}, µg/L)[d]	0.010	0.010	Set value
Soil Screening Level (SSL, µg/kg)	1.0	4.0	Calculated

[a]Representative OC = 1%; log Koc from Brusseau, 2023a
[b]Measured value from Brusseau and Van Glubt, 2021
[c]Estimated value from Brusseau, 2023b
[d]The target groundwater concentration is based on EPA MCL

Brusseau, M.L. (2023a). Differential sorption of short-chain versus long-chain anionic per- and poly-fluoroalkyl substances by soils. Environments, 10, article 175.

Brusseau, M.L. (2023b). Determining air-water interfacial areas for the retention and transport of PFAS and other interfacially active solutes in unsaturated porous media. Science of the Total Environment, 884, article 163730.

Brusseau, M.L. and Van Glubt, S. (2021). The influence of molecular structure on PFAS adsorption at air-water interfaces in electrolyte solutions. Chemosphere 281, article 130829.

Brusseau, M.L. and Guo, B. (2023). Revising the EPA Dilution-Attenuation Soil Screening Model for PFAS. Journal of Hazardous Materials Letters, 4, article 100077.

EPA 1996. Soil Screening Guidance: User’s Guide. Publication 9355.4-23.

Table 14. Soil Organic Carbon vs Calculated Soil Screening Levels (SSLs) for PFOS Using Revised EPA DAF Model

% Organic Carbon	Calculated SSL (ppb)
0.1	0.5
1	3.7
5	6.9
10	21.0

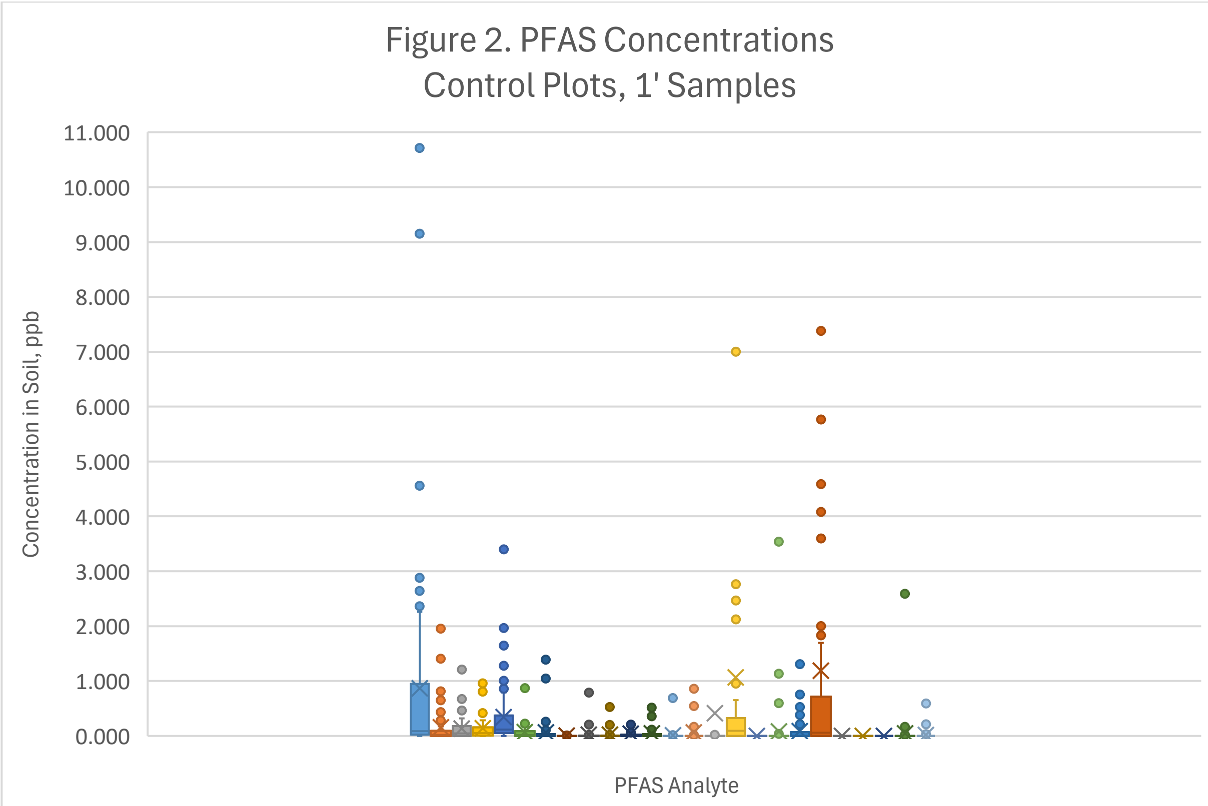
Figure 2. PFAS Concentrations
Control Plots, 1' Samples
11.000
10.000
9.000
8.000
7.000
6.000
5.000
4.000
3.000
2.000
1.000
0.000
Concentration in Soil, ppb
PFAS Analyte

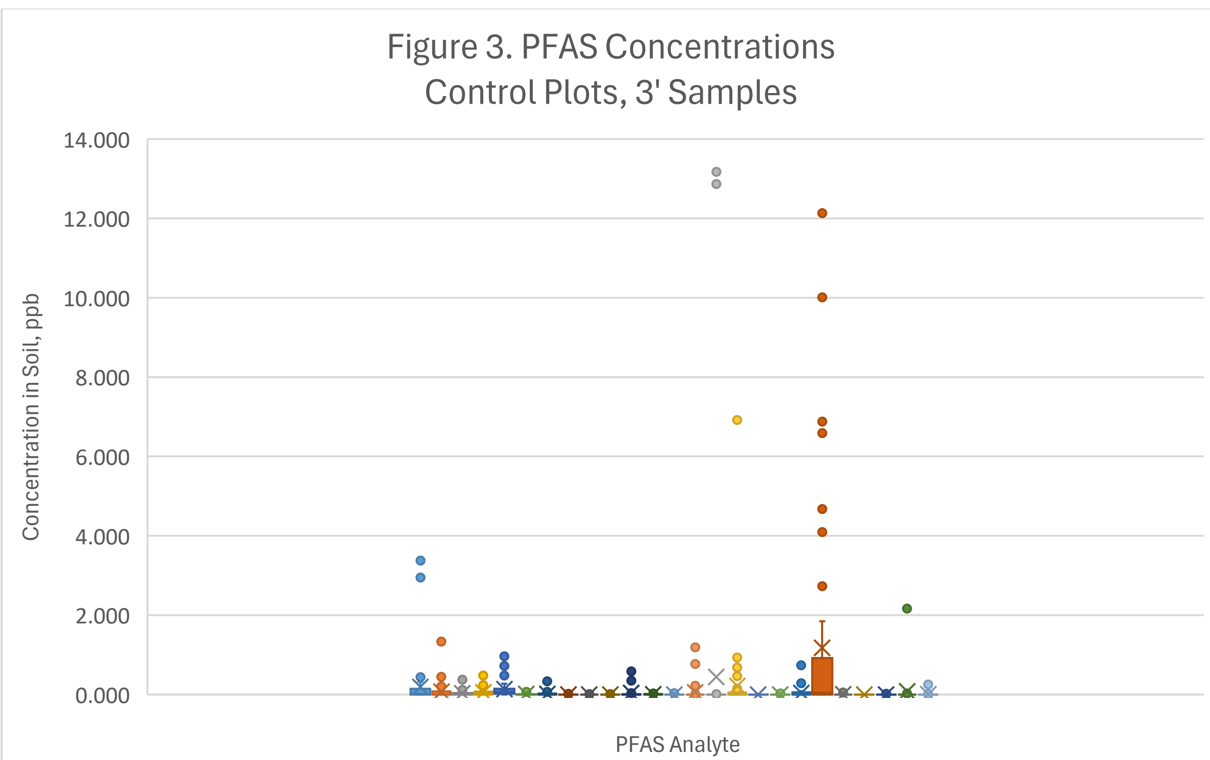
Figure 3. PFAS Concentrations
Control Plots, 3' Samples
14.000
12.000
10.000
8.000
6.000
4.000
2.000
0.000
Concentration in Soil, ppb
PFAS Analyte

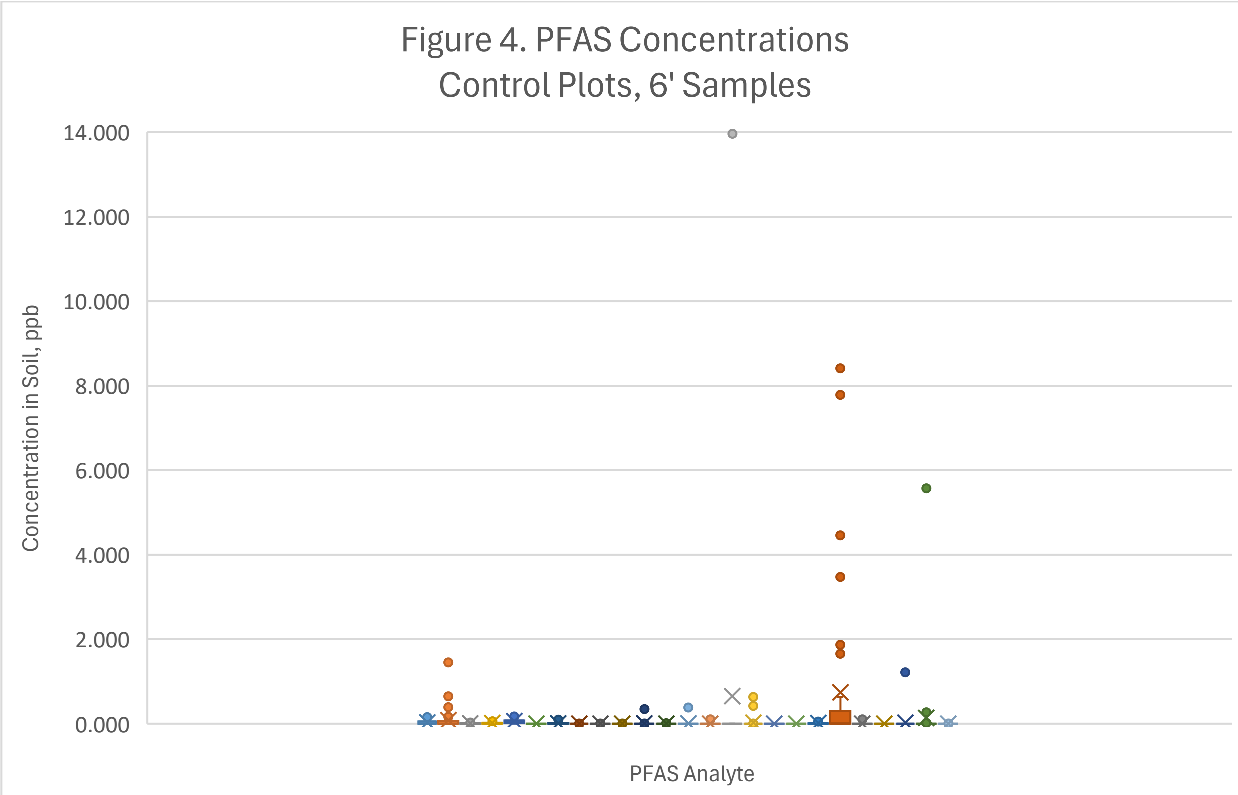
Figure 4. PFAS Concentrations
Control Plots, 6' Samples
Concentration in Soil, ppb
14.000
12.000
10.000
8.000
6.000
4.000
2.000
0.000
PFAS Analyte

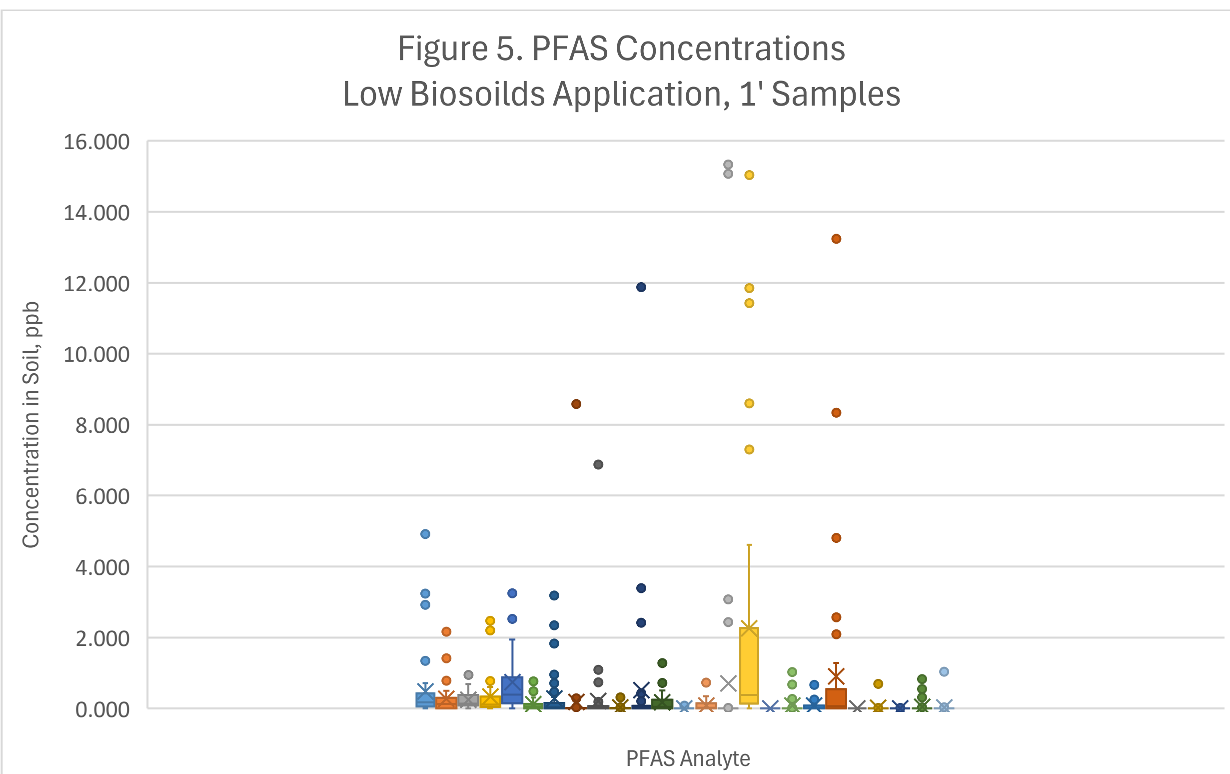
Figure 5. PFAS Concentrations
Low Biosoilds Application, 1' Samples
Concentration in Soil, ppb
16.000
14.000
12.000
10.000
8.000
6.000
4.000
2.000
0.000
PFAS Analyte

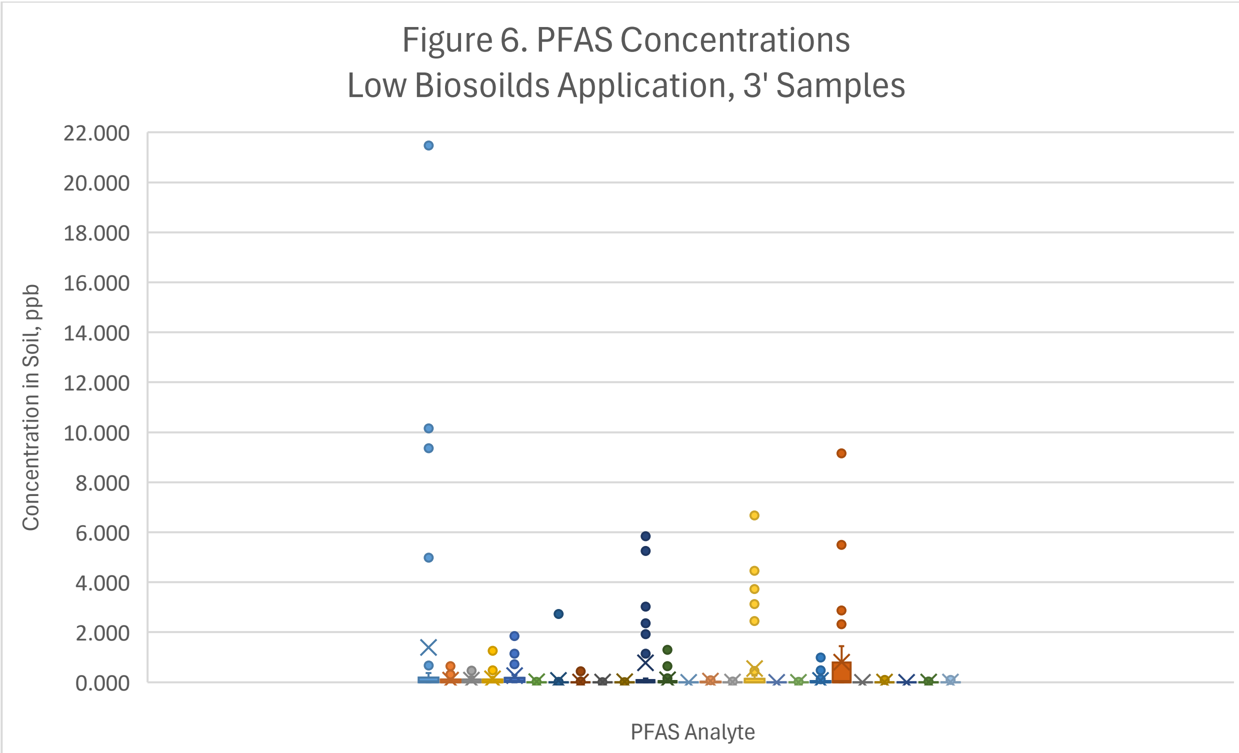
Figure 6. PFAS Concentrations
Low Biosoilds Application, 3' Samples
Concentration in Soil, ppb
22.000
20.000
18.000
16.000
14.000
12.000
10.000
8.000
6.000
4.000
2.000
0.000
PFAS Analyte

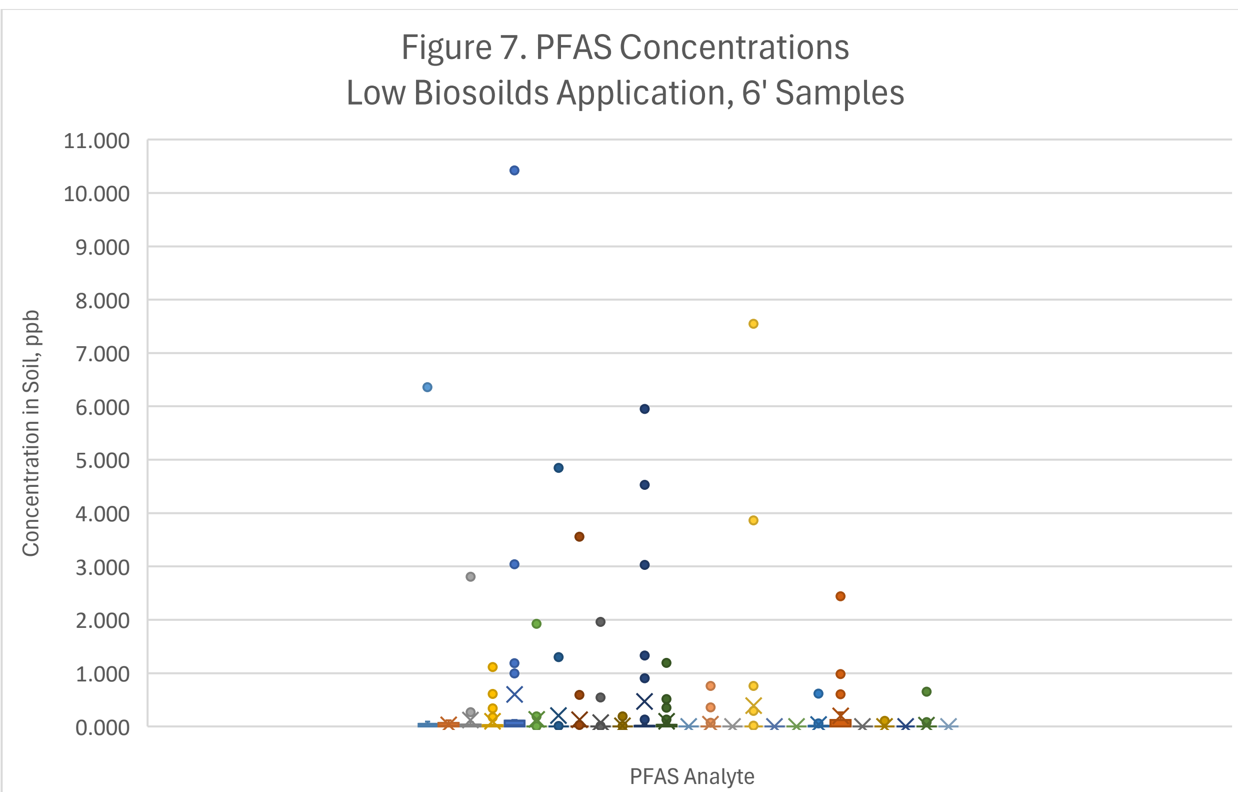
Figure 7. PFAS Concentrations
Low Biosoilds Application, 6' Samples
Concentration in Soil, ppb
11.000
10.000
9.000
8.000
7.000
6.000
5.000
4.000
3.000
2.000
1.000
0.000
PFAS Analyte

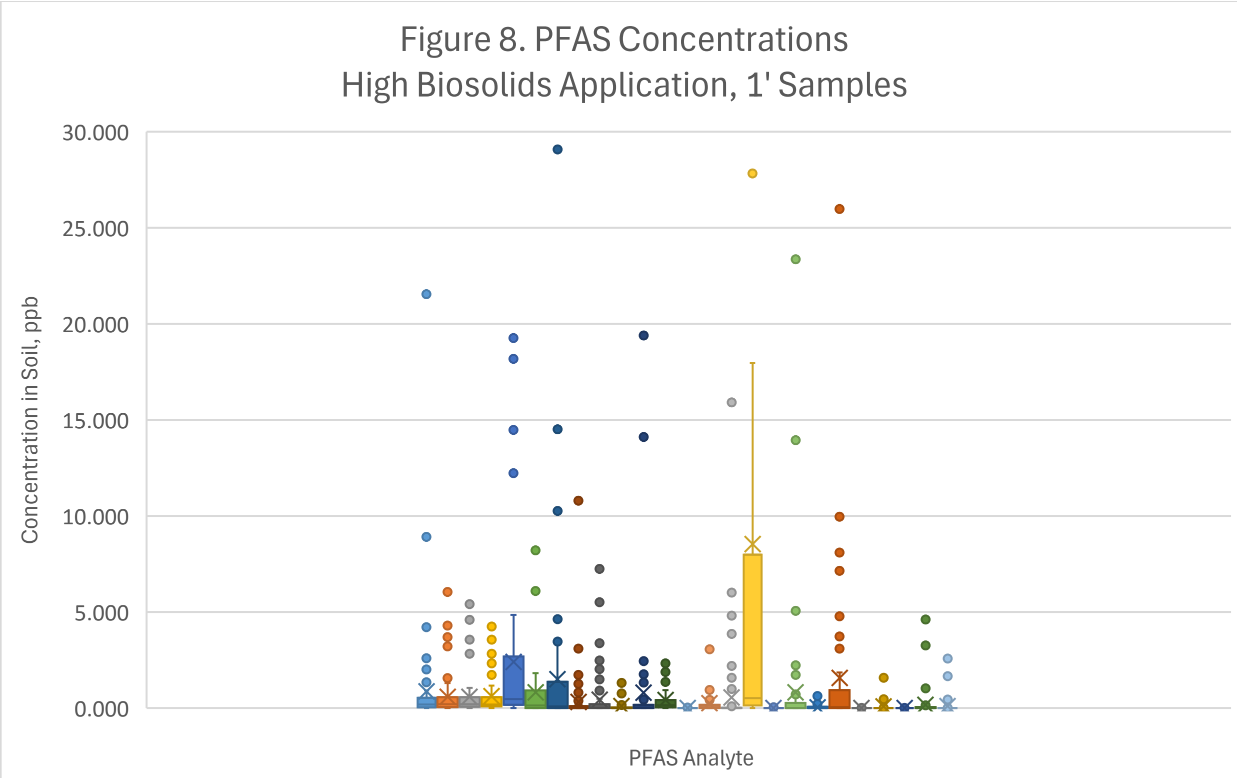
Figure 8. PFAS Concentrations
High Biosolids Application, 1' Samples
30.000
25.000
20.000
15.000
10.000
5.000
0.000
Concentration in Soil, ppb
PFAS Analyte

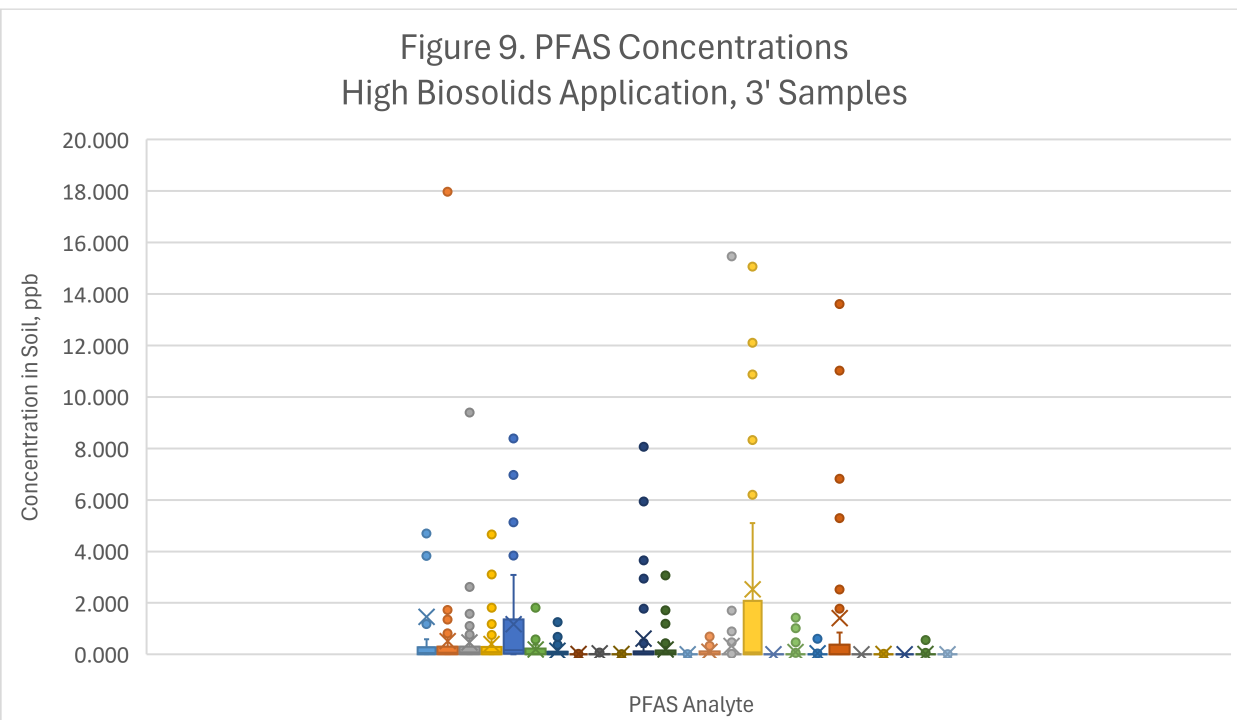
Figure 9. PFAS Concentrations
High Biosolids Application, 3' Samples
20.000
18.000
16.000
14.000
12.000
10.000
8.000
6.000
4.000
2.000
0.000
Concentration in Soil, ppb
PFAS Analyte

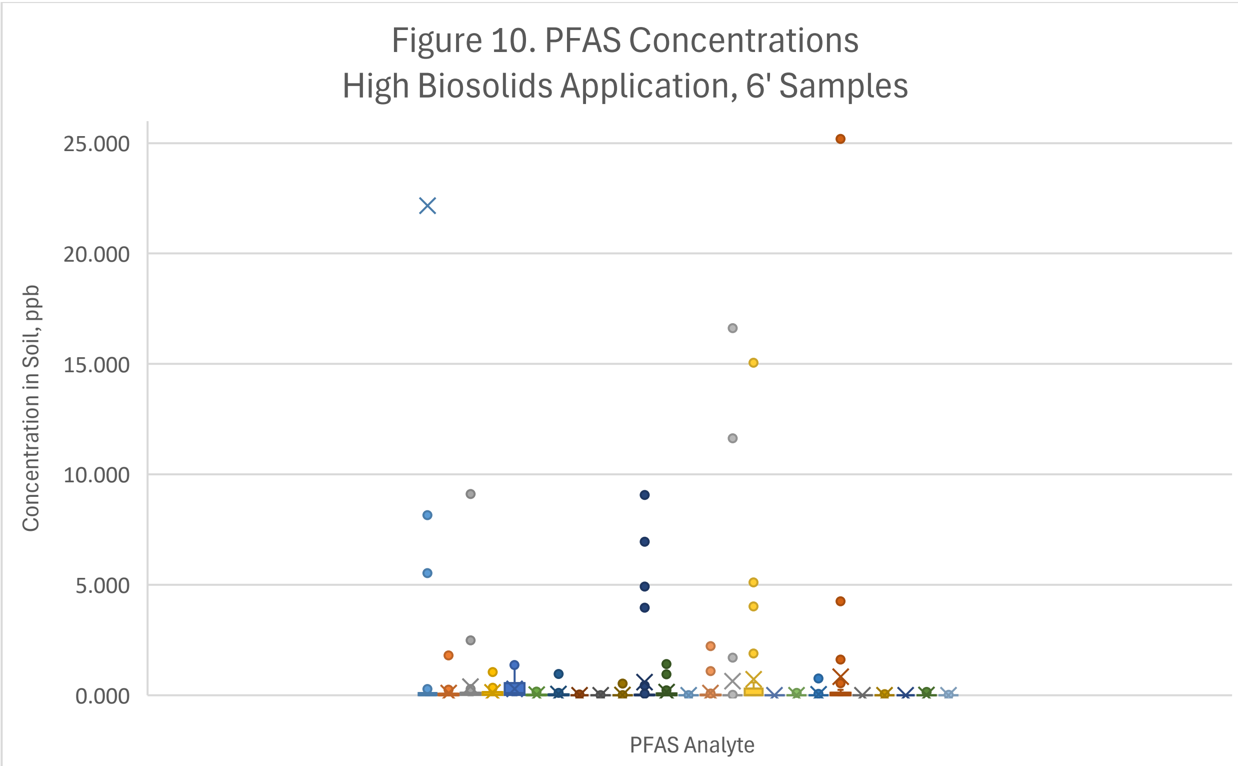
Figure 10. PFAS Concentrations
High Biosolids Application, 6' Samples
Concentration in Soil, ppb
25.000
20.000
15.000
10.000
5.000
0.000
PFAS Analyte

Attachment #5

Chapter 7 NFRWQPA 202~~2~~4 - 208 AWQMP RECOMMENDATIONS OR ACTIONS

The Association organized its recommendations for the 2024~~2~~-208 AWQMP into sections regarding general actions for DMOAs or the entire membership, specific actions for identified DMOAs, and actions for the Association itself. DMOAs will adopt, strengthen, and enforce land-use regulations designed to address water quality impacts of land use developments, including adopting and implementing local comprehensive plans, nonpoint water quality protection standards, WUSA development standards, and consolidation standards. The process is to draw upon existing and projected water quality assessments at the watershed level to identify priority point, nonpoint and stormwater quality problems. The 208 AWQMP recommends appropriate measures and solutions, including the system of treatment works or facilities, management agencies, financial, institutional measures and management strategies, necessary for the implementation of recommended solutions. Recommendations in the 208 AWQMP are consistent with the objectives and goals of the federal Clean Water Act, Colorado Water Quality Control Act and regional watershed programs. The objective of the federal Clean Water Act ...is to restore and maintain the chemical, physical and biological integrity of the nation's waters. Based on this federal objective and consistent with the State Water Quality Control Act, the goal for the region is to restore and maintain the chemical and physical integrity ~~in order~~ to assure a balanced ecological community in waters associated with the region. Stakeholders within the region have a wide variety of interpretations o~~n~~f the meaning of restoring and maintaining the chemical and physical integrity, and a balanced ecological community. As a result, meeting the regional goal to the satisfaction of all stakeholders (DMOA~~S~~s) is probably not achievable by the planning horizon. However, the quality of the region's water bodies, and surrounding land uses will be preserved and enhanced through the implementation of strategies recommended in this 208 AWQMP. Solving regional wastewater collection and treatment ~~regional problems through watershed management will result in better long-term solutions, more cost-effective solutions, and involves all of the areas~~problems through watershed management will result in better long-term and more cost-effective solutions and involve all of the area's regional DMOAs.

- ~~Adopt watershed protection regulations to protect the area located upstream of drinking water intake point(s) for municipal water supply pursuant to C.R.S. § 31-15-7070(1)(b), commonly referred to as watershed protection regulations.~~
- ~~Within the Land Use Code of the County or Municipality Adopt watershed protection regulations found within this 208 Plan.~~
- ~~Require compliance with this 208 Plan when issuing water and/or land development project permits.~~
- ~~Construct a Nonpoint Source Watershed Plan for Region 2 and each watershed basin.~~

- Further investigate and evaluate the status of water quality within Region 2 related to the assessments within this 208 AWQMP.
- Assess all Monitoring and Evaluation (M&E) segments within Region 2.

7.1 208 AWQMP General DMOA Recommendations or Actions

The Association recommends the following general actions for DMOAs in the 20224 208 AWQMP.

1) The Association has written a Regional EPA 9-Element Nonpoint Source Watershed-Based Plan for all four main watersheds: the South Platte, Cache la Poudre, St. Vrain Creek, and Big & Little Thompson and an regional plan summarizing Region 2's recommended control measures or best management practices. All the watershed-based plans may be viewed here: https://www.nfrwqpa.org/region-2-nonpoint-source-watershed-based-plans.
   i. DMOAs are encouraged to construct or implement the region's recommended control measures or best management practices, which are found within the watershed-based plans.

1)2) DMOAs should update, amend, or include water quality protections within their local comprehensive plans or land use code - Section 7.3.
   i. Local comprehensive plans that promote regional 208 planning efforts that consider future population projections and urban growth considering optimizing sewer collection systems and treatment facilities, optimizing sewer collection systems and treatment facilities, and examining consolidation to protect, maintain, or restore regional point and nonpoint source water quality.

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2)3) DMOAs should update, amend, or adopt construction nonpoint water quality protections standards in their municipal code or land use code – Section 7.4.
   i. DMOAs that adopt construction nonpoint water quality protection standards will protect, maintain, and restore nonpoint source water pollution identified by CLEAN assessments related to MS4s.
   ii. Effective and balanced stormwater and nonpoint source management can best be achieved through local DMOA processes.

3)4) DMOAs should adopt WUSA development standards – Section 7.5.
   i. Adopting WUSA development standards would protect point source water quality by promoting the collaboration and coordination of sewer services in Region 2.
   ii. Effective, optimized, and affordable wastewater collection and treatment will be identified through a regional process, with local DMOA implementation and strategies.

4)5) DMOAs should adopt consolidation standards within their municipal code or land use code – Section 7.6.
   i. Adopting consolidation standards would protect point source water quality by promoting the collaboration and coordination of treatment facilities to examine economies of scale in Region 2.

5)6) It is a recommendation that DMOAs with established and approved WUSAs coordinate and collaborate with smaller minor systems inside their WUSAs and pursue opportunities and partnerships to optimize existing DMOA collection systems and regional treatment facilities. For example:

DMOA	Minor System
Wellington, City of	Harvest Farm, Denver Rescue Mission
Fort Collins, City of	Davies Mobile Home Park
Fort Lupton, City of	New Vision Mobile Home Park
Eire, City of	B and B Mobile Home Park
Loveland, City of	Best Western Coach House

7) DMOAs that do not update or adopt any of the above recommendations can provide a statement within their local comprehensive plans, municipal code, or land-use code concerning water quality protection standards, WUSA development standards, and consolidation standards all shall be consistent with the local 208 Areawide Water Quality Management Plan.

6)

7.2 208 AWQMP Specific DMOA Recommendations or Actions

The Association recommends the following specific actions for DMOAs in the 2022 208 AWQMP. Consolidation of wastewater treatment facilities is encouraged, where appropriate. Wastewater utility planning can identify opportunities for facility consolidation. Often, larger wastewater treatment facilities can provide service more effectively while providing a higher degree of treatment than can be achieved through smaller treatment facilities. Consolidation of facilities can eliminate smaller treatment facilities which may not be financially capable of operating properly and may be exceeding their discharge permits. The decision for facility consolidation is determined in the utility planning process and is based on economies of scale, economics, cost effectiveness, maintenance, operations, effluent water quality, water quality impacts, physical constraints and water rights.

1) The Association recommends that the Town of Johnstown and the Town of Milliken continue to examine the consolidation of their sewer collection systems and treatment facilities. Optimizing wastewater collection and treatment alternatives that are economically feasible based on cost and long-term user rate studies considering economies of scale and beneficial water quality. Including examining the assimilative capacity of the Little Thompson and Big Thompson Rivers regarding future water quality concerning population and loading projections.

2) The Association recommends the Town of Mead and St. Vrain Sanitation District continue to examine the consolidation of their sewer collection systems and treatment facilities. Considering the Town of Mead Lake Thomas WWTF could merge with the St. Vrain Sanitation District given its flagpole location within the St. Vrain Sanitation District WUSA separate from Mead’s WUSA. Optimizing wastewater collection and treatment alternatives that are economically feasible based on cost and long-term user rate studies considering economies of scale and beneficial water quality.

3) The Association recommends the City of Fort Lupton continue to examine the consolidation of its sewer collection systems and treatment facilities with Metro Water Recovery or the St. Vrain Sanitation District. Optimizing wastewater collection and treatment alternatives that are economically feasible based on cost and long-term user rate studies considering economies of scale and beneficial water quality.

4) The Association recommends the Town of Estes Park, Estes Park Sanitation District, and Upper Thompson Sanitation District continues to examine the consolidation of their sewer collection systems and treatment facilities. Optimizing wastewater collection and treatment alternatives that are economically feasible based on cost and long-term user rate studies considering economies of scale and beneficial water quality.

5) The Association recommends that the Town of Hudson, Keenesburg, and Resource Colorado Water and Sanitation Metro District continue to examine the consolidation of their sewer collection systems and treatment facilities. Optimizing wastewater collection and treatment alternatives that are economically feasible based on cost and long-term user rate studies considering economies of scale and beneficial water quality.

7.3 208 AWQMP Association Recommendations and Actions

Membership recommends the following actions as responsibilities of the Association.

1) Construct an OWTS GIS platform with depth to groundwater to assess regional groundwater quality. Groundwater quality is considered in the development of long-range management plans. Those activities, which have the potential to adversely affect groundwater resources, need to be properly managed. Groundwater recharge zones must be protected from water quality degradation.
   - ~~1)~~ This project was completed and can be viewed on the Association's GIS webpage.

2) Construct a GIS platform that illustrates all current OWTSs, DMOA sewer collection systems, treatment facilities, proposed DMOA sewer collection systems and treatment facilities, and proposed Association DMOA sewer collection systems and treatment facilities.
   - ~~2)~~ This project was completed in 2023 and is private for security reasons.

3) Perform testing and analysis on the M&E stream segment listings within Region 2 to assess current water quality. DMOAs are willing to spend funds on water quality data collection if this data is used in the state water quality characterization report (305(b)) and subsequent stream segment impairment listing (303(d)).
   - ~~3)~~ This project was completed and presented here within this report.

4) Construct a Nonpoint Source Watershed Based Plan for Region 2 to prioritize and prepare DMOAs as permitted MS4s to aid in managing nonpoint source pollution in areas projected to experience growth.
   - ~~4)~~ This project was completed and presented here within this report.

To foster actions of the Clean Water Plan, the EPA, and WQCD Policy 98-2 planning requirements, NFRWQPA developed the following priorities and corresponding measurable outcomes.

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1) Measure how many DMOAs construct or amend their local comprehensive plan or land use code with a water quality section.
   - ~~1)~~ No action.

2) Measure how many DMOAs adopt or amend their local county or municipal codes or land use code with nonpoint source water quality protection standards.
   - ~~2)~~ No action.

3) Measure how many DMOAs adopt or amend their local county or municipal codes or land use code WUSA development standards.
   - ~~3)~~ No action.

4) Measure how many DMOAs submit consolidation examinations for inclusion into the 208 AWQMP.
   - ~~4)~~ No action.

5) Document the progress of the OWTS GIS platform and completion date.
   - ~~5)~~ Completed.

6) Document the progress of the sewer collection systems GIS platform illustrating all current OWTSs, sewer collection systems, all future sewer collection and treatment facilities, and completion date.
   - ~~6)~~ Completed.

7) Measure how many M&E stream segment listings the Association assesses for current water quality and is able to delist from the M&E listing.
   - ~~7)~~ Completed.

8) Document the progress of the Nonpoint Source Watershed Based plan for Region 2.
   - ~~8)~~ Completed.

Attachment #6

Stakeholder Toolkit
June 18, 2024

Introduction

The North Front Range Water Quality Planning Association (NFRWQPA) seeks to compile a stakeholder toolkit for one regional comprehensive Nonpoint Source (NPS) Watershed Plan and five local NPS watershed plans in Larimer and Weld Counties.

This toolkit will help association members reach, inform and partner with their networks on the NPS watershed educational resources. It can also help to secure financial and technical assistance to advance watershed projects. Here is a link to a final stakeholder toolkit formatting example.

Digital Communications

Digital communications can reach a large audience on a broad scale, with tactics including:

- **Press releases:** This document will serve as NFRWQPA's official statement on the NPS watersheds and respective plans. The press release can be distributed to industry-relevant publications as well as local news outlets.
    - Example
- **Social media:** Targeted social posts to reach industry-specific and locally relevant audiences. Content can vary based on NFRWQPA's needs, seasonality and other updates.
    - Example
- **Newsletters:** Regular updates to an email list of subscribers about the plans, NPS findings and other news.
    - Example
- **Website:** Content updates such as banner announcements, blog posts and home page edits upon project completion.
    - Example
- **Story Map:** Multimedia application to share plan findings, next steps and other dynamic information.
    - Example
- **"Report a Concern" button or website:** Dedicated resource for stakeholders to use when submitting an NPS issue to NFRWQPA (similar to a "contact us" button).
    - Example – Contact Info at bottom of webpage
- **Radio ads and interviews:** Reach stakeholders on a local and national level through a radio ad or securing a news station interview.
    - Example

Print Communications
Print communications can reach targeted, local audiences using the following tactics:

- **Signage:** Capture pedestrian, biking and other rolling traffic's attention with signage strategically placed in a given area. Informational signage can include water quality awareness signage in parks near streams, pet waste pickup stations, and general project information signage.
    - Example
- **Mailers:** Reach residents and businesses via postcard to communicate project benefits and updates, as well as solicit feedback.
    - Example

Community Outreach
Community outreach is a boots-on-the-ground approach to connecting with stakeholders and disseminating information. Community outreach also helps put a face to a project through the following tactics:

- **Educational campaign:** Increase awareness about the plan and NPS concerns in ways that are simplified and relatable for stakeholders.
    - Example
- **Volunteer cleanup program:** Foster community pride and engagement through organizing a park cleanup day.
    - Example
- **School visits, tours and field trips:** Create memories, connect with younger stakeholders and ignite a lifelong interest in the environment by inviting project team members to visit schools for presentations, organize park tours and host field trips.
    - Example – project engineers visited a local library to show students that popular game Fortnite had real-life applications and similarities to simulating virtual environments in the construction industry.