Per- and Polyfluoroalkyl Substances Surface Water Monitoring Project

2021 Monitoring Report

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WQDMASTECH-01

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Forward

DEQ prepared this report using PFAS screening levels for surface water that were based on the best available science at the time. Since that time, and prior to final publication of this report, the United States Environmental Protection Agency (EPA) released the 2022 Interim Updated PFOA and PFOS Health Advisories and 2022 Final PFBS and GenX Chemicals Health Advisories for drinking water. Updates to sediment screening levels have also occurred. While the monitoring data in this report is not affected by the new advisories, readers should be aware that the surface water and sediment screening levels used for analysis have not been updated to reflect recent changes. DEQ will continue to review new and forthcoming PFAS guidance from EPA to make the best decisions for Montana. Further information on the EPA's updated PFAS guidance can be found at: https://www.epa.gov/sdwa/drinking-water-health-advisories-pfoa-and-pfos.

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ACRONYMS

Acronym	Definition
6:2 FTS	1-Octanesulfonic acid, 3, 3, 4, 4, 5, 5, 6, 6, 7, 7, 8, 8, 8-tridecafluoro-
DEQ	Montana Department of Environmental Quality
EPA	United States Environmental Protection Agency
FWP	Montana Fish Wildlife and Parks
GIS	Geographic Information System
ITRC	Interstate Technology & Regulatory Council
MAS	Monitoring and Assessment Section
MDL	Method Detection Limit
PFAAs	Perfluoroalkyl acids
PFAS	Pre- and Polyfluoroalkyl Substances
PFHxS	Perfluorohexanesulfonic acid
PFOA	Perfluorooctanoic acid
PFOS	Perfluorooctanesulfonic acid
ppt	parts per trillion
PWS	Public Water Supply
RAGs	Remedial Action Guidelines
SOP	Standard Operating Procedure
TSCA	Toxic Substances Control Act
UCMR	Unregulated Contaminant Monitoring Regulation
WQPB	Water Quality Planning Bureau
WWTP	Wastewater Treatment Plant

Suggested Citation:

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Report Summary

Per- and polyfluoroalkyl substances (PFAS) are a group of thousands of man-made chemicals that have been produced since the 1940s. They have been widely used in industrial and consumer products due to their unique physical and chemical properties. Due to these properties, PFAS are highly persistent, mobile, and bioaccumulative in the environment. Perfluorooctanoic acid (PFOA), Perfluorooctanesulfonic acid (PFOS), and other PFAS can enter surface waters through runoff, industrial and municipal wastewater treatment plants (WWTP), landfill leachate, contaminated biosolids, and deposition from the atmosphere (EPA, 2022).

Currently, only a few PFAS have been studied for their potential human health effects. Studies suggest that exposure to certain PFAS may lead to health problems including changes in the liver, cardiovascular effects, reproductive effects in women, immunological and developmental effects in infants and children, and an increased risk of kidney or testicular cancer.

The state of Montana recognized PFAS as emerging contaminants of concern and implemented the Montana PFAS Action Plan in June of 2020. In 2021, to implement a portion of the action plan, the Montana Department of Environmental Quality's (DEQ) Monitoring and Assessment Section (MAS) conducted a water quality monitoring project to determine the prevalence and magnitude of PFAS contamination in surface water in at-risk areas of Montana (Ebert, 2021). This report provides results from water quality monitoring efforts and discusses next steps.

Monitoring Methodology

This project used a targeted sampling approach to determine the prevalence and magnitude of PFAS contamination in surface water. At-risk areas and sampling sites were selected by performing a risk analysis using Montana's PFAS Work Group's Geographic Information Systems (GIS) layers and existing data (Ebert, 2021). The determination of at-risk locations rapidly began to focus on urban and industrialized landscapes within Montana and four areas were selected in 2021: Bozeman, Helena, Billings, and Great Falls. Waterbodies within two miles of a potential or confirmed source were considered for monitoring. At least one low-risk site was selected in each at-risk area. A low-risk site was defined as an area with a low potential for PFAS contamination and has no potential or confirmed sources of PFAS upstream. All other sites were located downstream of potential or known PFAS sources. Two sites were selected to be resampled due to PFAS detections in sediment from a 2020 PFAS monitoring effort: Missouri River below Whitmore Ravine and Yegan Ditch. A total of 26 sites were sampled throughout the four at-risk areas of Montana.

Sampling was conducted in accordance with DEQ's Water Quality Planning Bureau (WQPB) guidance provided in the PFAS Standard Operating Procedures (SOP) (Makarowski and Skibicki, 2021). Samples were analyzed for 28 PFAS in accordance with Energy Laboratories EPA Method 537 Modified (E537 M).

Results

Although there are thousands of known PFAS, this report focuses on 28 PFAS based on current analytical capabilities. Non-detect results are not provided in this report and any results detected above the method detection limits (MDL) are provided in the result tables (**Appendix C**). Total PFAS concentration results represent the concentration of all PFAS detected from the 28 PFAS analyzed using E537 M.

In 2019, Montana DEQ adopted a Human Health standard for PFOA and PFOS individually or combined in groundwater at 70 parts per trillion (ppt). Since there is no standard for PFAS in surface water to protect human health, this monitoring project used the groundwater standard of PFOA and PFOS individually or combined of 70 ppt as a screening level for surface water samples.

Montana has no sediment standards for PFAS, and the EPA has limited guidance for PFAS in sediment. DEQ used a sediment screening level from Maine's Department of Environmental Protection Remedial Action Guidelines (RAGs) for Contaminated Sites. DEQ used the recreation sediment RAG of 4,900 ng/g for PFOS and 4,900 ng/g for PFOA.

Results of this study add to the increasing knowledge that PFAS are generally pervasive and persistent in areas of use. For all sites sampled, total detectable PFAS concentrations ranged from 0.86 ppt to 12,920.0 ppt. Of at-risk sites, 67% had a detection of one or more PFAS. All at-risk sites with detections of PFAS were downstream of potential or confirmed sources. Of low-risk sites, 20% had a detection of one PFAS compound. A low percentage of detections at low-risk sites indicates proper site selection, as well as, PFAS were not detected outside of at-risk areas, even though monitoring sites were near source areas. The overall findings of the project found 58% of all sites sampled had detections of one or more PFAS compounds. **Section 3.0 and Appendix C** provide detailed information of PFAS detections in each at-risk area.

Whitmore Ravine at the footpath bridge was the only site that exceeded the surface water screening level of 70 ppt for PFOA and PFOS individually or combined. The combined concentration was 1,188.0 ppt. Due to no public or private water supplies on or near Whitmore Ravine, there is currently no immediate threat to human health. However, DEQ recommends the water in Whitmore Ravine not be consumed by people or animals without proper water treatment.

Key Findings

- This project was designed to determine the prevalence and magnitude of PFAS in at-risk areas. Results determined that PFAS are moderately prevalent in at-risk areas and PFAS concentrations range in magnitude depending on site location. Multiple PFAS were detected in each at-risk area of the state near or downstream of confirmed and potential sources.
- PFAS detected relate to the use of fire-fighting foams, food packaging, surfactants used in industrial processes, stain resistant fabrics, metal manufacturing and other uses.
- Results indicate PFAS may be entering surface water from sources such as wastewater treatment plants, industrial facilities, military instillations, airports, and urban runoff.
- More monitoring is needed throughout Montana to understand the presence of PFAS in our waterways and to determine the impact to human health and the environment. **Section 5.0** of the report provides further information on DEQ's next steps.
- The EPA continues to study human health impacts related to PFAS exposure and the EPA will provide federal regulatory thresholds for certain PFAS chemicals to protect human health. This study used the best available science and results could be interpreted differently if updated regulations refine human health thresholds.

1.0 INTRODUCTION AND OBJECTIVES

Per- and polyfluoroalkyl substances (PFAS) are a group of thousands of man-made chemicals that have been produced since the 1940s. PFAS have been widely used in industrial and consumer products due to their unique physical and chemical properties. Properties include resistance to high and low temperatures, chemical stability, and water-, stain-, and grease-resistance (ITRC, 2020). According to the Environmental Protection Agency's (EPA) Toxic Substances Control Act (TSCA), approximately 650 PFAS are currently in commerce (EPA, 2021). To date, perfluorooctanesulfonic acid (PFOS) and perfluorooctanoic acid (PFOA) are the two most commonly used and studied PFAS. Due to the chemical stability of their Carbon-Fluorine (C-F) bond and their properties, PFAS are highly persistent, mobile, and bioaccumulative in the environment. PFOS, PFOA and other PFAS can enter the aquatic environment through runoff, industrial and municipal wastewater treatment plants (WWTP), landfill leachate, contaminated biosolids, and deposition from the atmosphere (EPA, 2022).

Currently, only a few PFAS have been studied for their potential human health effects. Studies suggest that exposure to certain PFAS may lead to health problems including changes in the liver, cardiovascular effects, reproductive effects in women, immunological and developmental effects in infants and children, and an increased risk of kidney or testicular cancer. Research is ongoing and more information will increase over time.

The state of Montana recognized PFAS as emerging contaminants of concern and implemented the Montana PFAS Action Plan in June of 2020. In 2021, to implement a portion of the action plan, the Montana Department of Environmental Quality's (DEQ) Monitoring and Assessment Section (MAS), using EPA Performance partnership funding, conducted a water quality monitoring project to determine the prevalence and magnitude of PFAS contamination in surface water in at-risk areas of Montana (Ebert, 2021).

The objective of this report is to share results from 2021's water quality monitoring efforts and discuss next steps.

2.0 METHODS

2.1 Site Selection Process

This project used a targeted sampling approach to determine the prevalence and magnitude of PFAS contamination in surface water throughout Montana. At-risk areas and sampling sites were selected by performing a risk analysis using Montana's PFAS Work Group's Geographic Information Systems (GIS) layers and existing data (Ebert, 2021). Considerations during risk analysis included mapping potential and confirmed sources of PFAS and existing PFAS surface water sampling results. Potential sources are industries or facilities that are suspected or known to use, store, or discharge PFAS. Confirmed sources are facilities that DEQ has confirmed the use and storage of PFAS, and there is a confirmed detection of PFOS and PFOA in groundwater above the groundwater standard (DEQ-7). The determination of at-risk locations rapidly began to focus on urban and industrialized landscapes within Montana, and the risk analysis concluded that Helena, Bozeman, Billings, and Great Falls had the highest potential for surface water impacts. As such, the 2021 study selected these four areas for further analysis. Within the four areas, waterbodies within two miles of a potential or confirmed source were considered for monitoring.

To assist with data analysis and quality assurance of the results, at least one low-risk site was selected in each at-risk area. A low-risk site was defined as an area with a low potential for PFAS contamination and has no potential or confirmed sources of PFAS upstream. All other sites were located downstream of potential or known PFAS sources. Two sites were selected to be resampled due to PFAS detections in sediment from a 2020 PFAS monitoring effort: the Missouri River below Whitmore Ravine and Yegan Ditch. A total of 26 sites were sampled throughout the four selected at-risk areas of Montana. Funding limited the overall sample size.

Figures 1 - 5 show DEQ's sample locations in four at risk areas around the state: Bozeman, Helena, Billings, and Great Falls. **Appendix A** provides a list of monitoring locations.

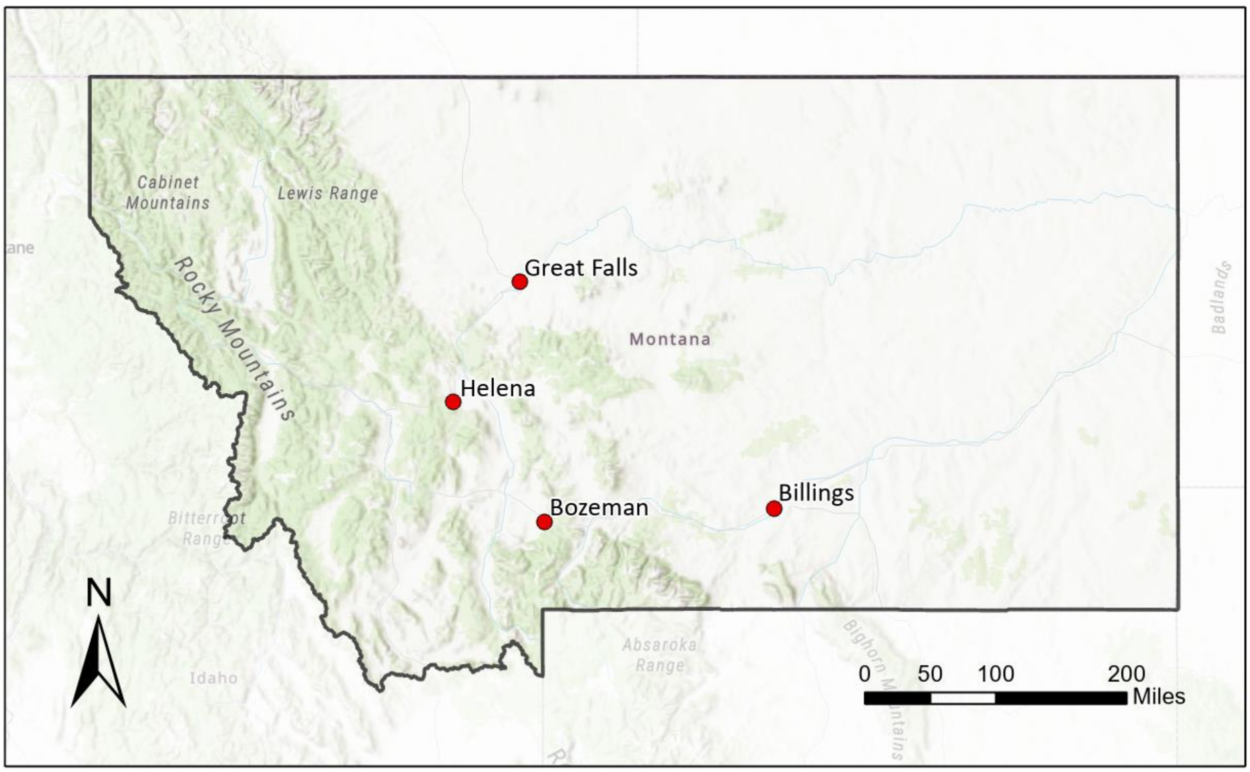

Figure 1. Map of the four PFAS at-risk areas.

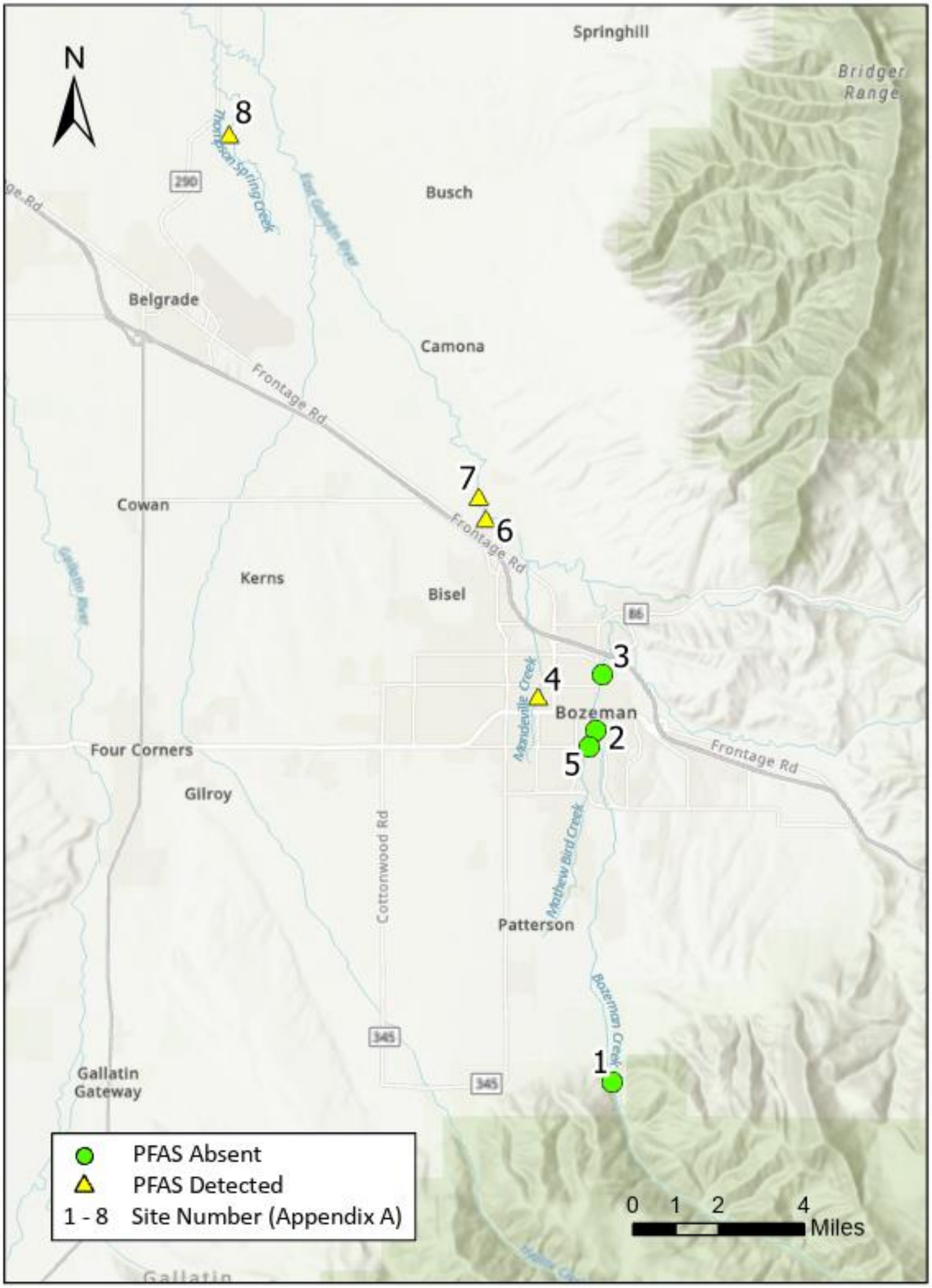

Figure 2. PFAS sampling locations in the Bozeman area.

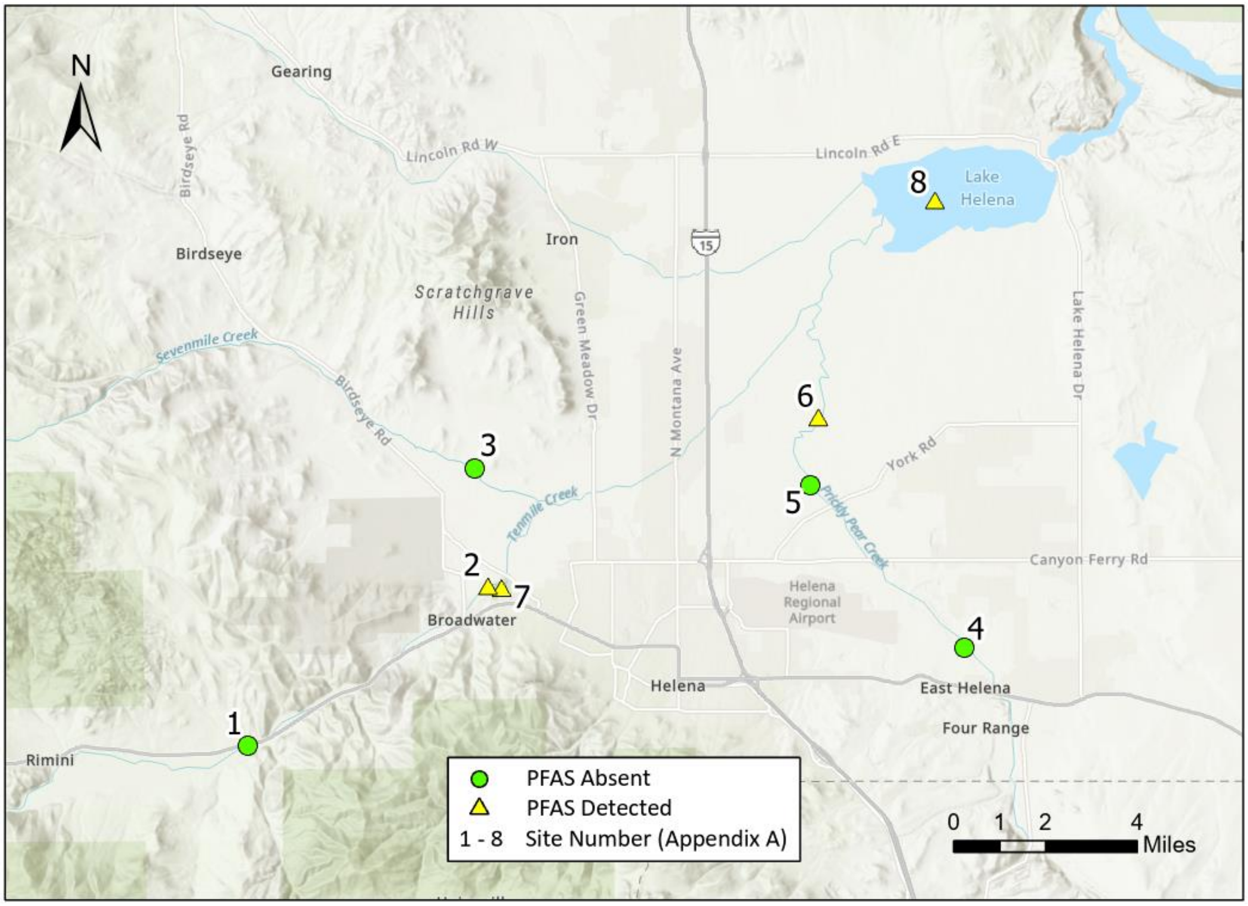

Figure 3. PFAS sampling locations in the Helena area.

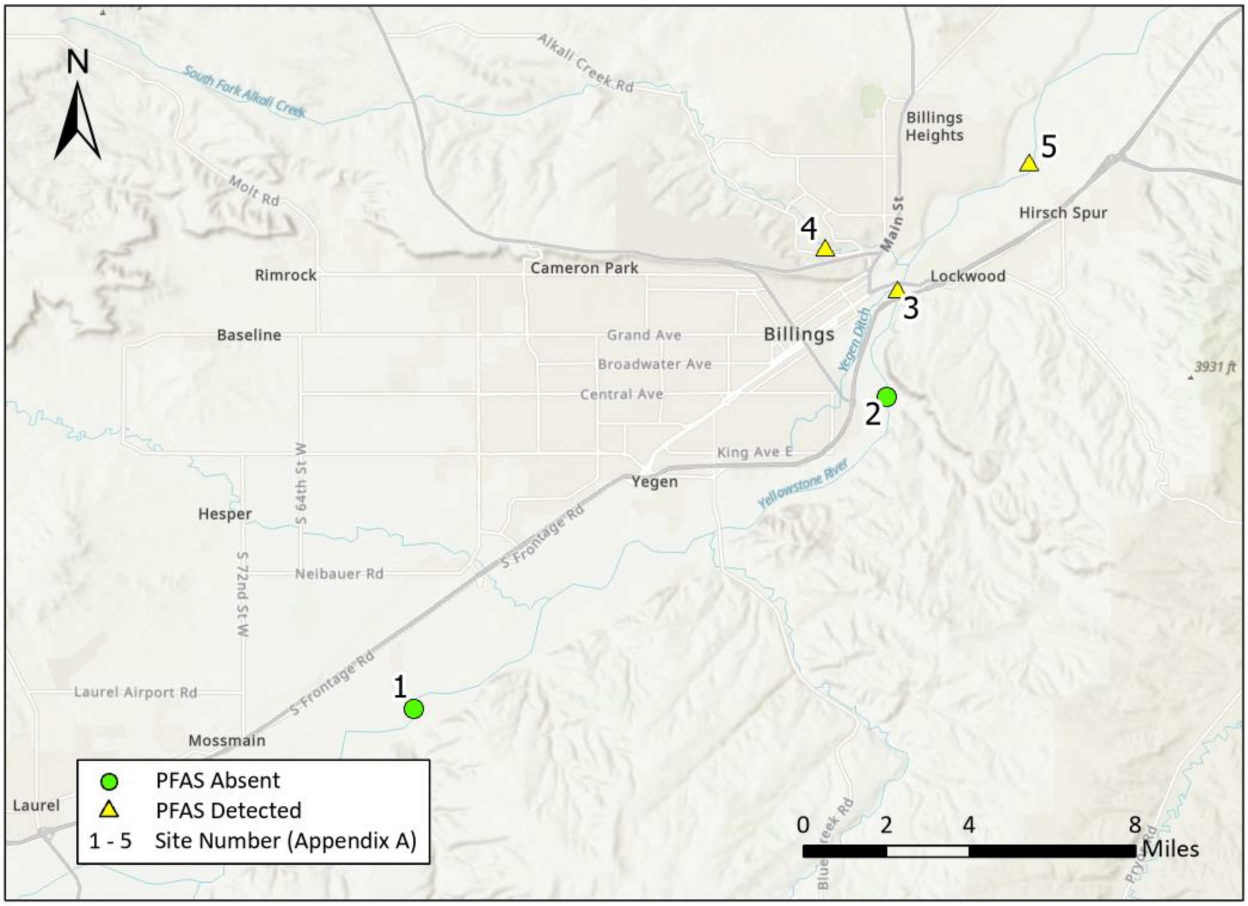

Figure 4. PFAS sampling locations in the Billings area.

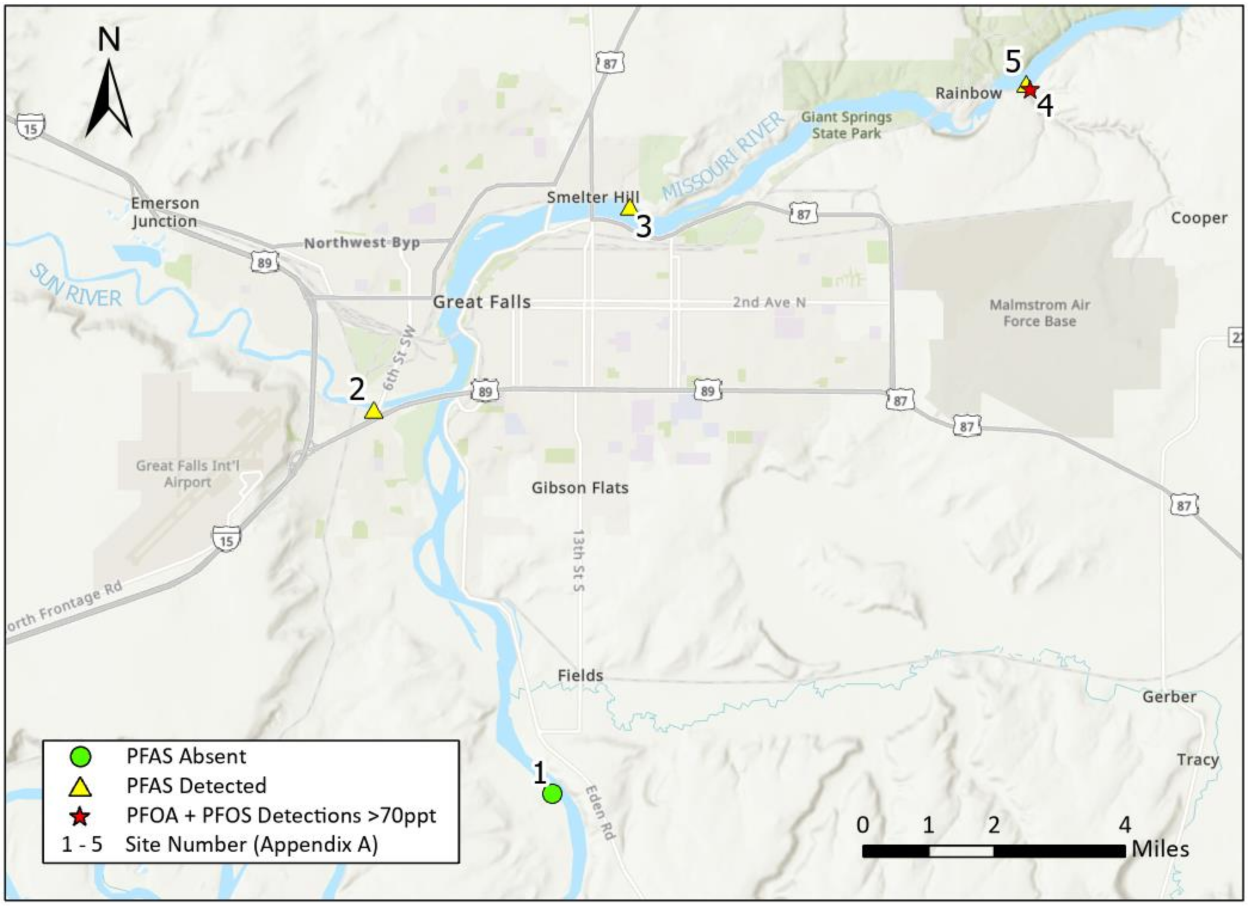

Figure 5. PFAS sampling locations in the Great Falls area.

2.2 Sampling and Analytical Methods

Sampling was conducted in accordance with DEQ's Water Quality Planning Bureau (WQPB) guidance provided in the PFAS Standard Operating Procedures (SOP) (Makarowski and Skibicki, 2021). Each site was monitored once during baseflow conditions between August and October. Samples were analyzed by Energy Laboratories (1120 S 27th St, Billings, MT 59101) according to Energy Laboratories EPA Method 537 Modified (E537 M) (Ebert, 2021). The analyte list includes common PFAS that have been detected in the environment, which are mostly perfluoroalkyl acids (PFAAs). A full analyte list for the project and the laboratory detection limits are provided in **Appendix B**. The analyte list does not cover all the potential PFAS that may be found in the environment.

3.0 RESULTS

For more succinct reporting, non-detect results are not provided in this report and any results detected above the method detection limits (MDL) are provided in the result tables (**Appendix C**). All results are available via the National Water Quality Portal or direct request to DEQ. While the current analytical methods are unable to analyze for all potential PFAS in surface water and sediment, total PFAS concentration results represent the concentration of all PFAS detected from the 28 PFAS analyzed using E537 M.

In 2019, Montana DEQ adopted a Human Health standard for PFOA and PFOS individually or combined in groundwater at 70 parts per trillion (ppt). This standard is based on a Lifetime Health Advisory for drinking water set by the EPA in 2016. The health advisory was developed to provide a margin of protection from adverse health effects for all populations based on a lifetime of exposure to PFOA and PFOS in drinking water (EPA, 2016). Since there currently is no surface water standard to protect human health, this monitoring project used the groundwater standard for PFOA and PFOS individually or combined of 70 ppt as a screening level for surface water samples.

Montana has no sediment standards for PFAS, and the EPA has limited guidance for PFAS in sediment. DEQ used a sediment screening level from Maine's Department of Environmental Protection Remedial Action Guidelines (RAGs) for Contaminated Sites. DEQ used the recreation sediment RAG of 4,900 ng/g for PFOS and 4,900 ng/g for PFOA.

After monitoring and analysis was completed, the EPA released draft aquatic life ambient water quality criteria for PFOA and PFOS, in April 2022**. Table 1** provides the draft acute and chronic water column criteria.

Table 1. EPA Draft Acute and Chronic Water Column Criteria for PFOA and PFOS.

Criteria Component	Acute Water Column Criteria	Chronic Water Column Criteria
PFOA	49,000,000 ppt	94,000 ppt
PFOS	3,000,000 ppt	8,400 ppt

3.1 Bozeman Area Results

Eight sites were sampled in the Bozeman area. No detections of any PFAS were found in sediment samples. Surface water sample results for four sites reported non-detect values for all 28 PFAS: Bozeman Creek near Sourdough Creek Trailhead, Bozeman Creek at E Tamarack Rd Crossing, Bozeman Creek at E Tamarack Rd Crossing, and Mathew Bird Creek East of E College St. Surface water sample results for four sites had detections of one or more PFAS compounds. **Appendix C** provides detection results for surface water samples at four sites in the Bozeman area.

There were no detections of PFOA and PFOS above the surface water and sediment screening levels in the Bozeman area. A total of nine different PFAS were detected and the highest total PFAS concentration in the Bozeman area was 26.4 ppt at Mandeville Creek at Bozeman High School.

3.2 Helena Area Results

Eight sites were sampled in the Helena area. No detections of any PFAS were found in sediment samples. Surface water sample results for four sites reported non-detect values for all 28 PFAS: Tenmile Creek Upstream of Hwy 12 Crossing, Sevenmile Creek at Head Lane Crossing, Prickly Pear Creek below E. Helena, and Prickly Pear Creek at Prickly Pear Fish Access Site. Surface water sample results for four sites had detections of one or more PFAS. **Appendix C** provides detection results for surface water samples at four sites in the Helena area.

There were no detections of PFOA and PFOS above the surface water and sediment screening levels in the Helena area. A total of nine different PFAS were detected and the highest total PFAS concentration in the Helena area was 26.05 ppt at Prickly Pear Creek two miles upstream of the Tenmile Creek confluence.

3.3 Billings Area Results

Five sites were sampled in the Billings area. Sediment sample results at four sites reported non-detect values for all 28 PFAS. Sediment sample results on Yegan Ditch near the mouth had a detection of PFOS (**Appendix C**). Surface water sample results at two sites reported non-detects values for all 28 PFAS: Yellowstone River at Duck Creek Road Crossing and Yellowstone River at Mystic Park. Surface water sample results for three sites had detections of one or more PFAS. **Appendix C** provides detection results for surface water samples at three sites in the Billings area.

There were no detections of PFOA and PFOS above the surface water and sediment screening levels in the area. A total of 10 different PFAS were detected in surface water and the highest total PFAS concentration in the Billings area was 278.5 ppt at the Alkali Creek site.

3.4 Great Falls Area Results

Five sites were sampled in the Great Falls area. Sediment sample results at four sites reported non-detect values for all 28 PFAS. Sediment sample results at the Whitmore Ravine site had detections of two PFAS (**Appendix C**). Surface water sample results at one site, Missouri River at White Bear FAS, reported non-detects values for all 28 PFAS. Surface water sample results for four sites had detections of one or more PFAS. **Appendix C** provides detection results for surface water samples at four sites in the Great Falls area.

The Whitmore Ravine site was the only location with detections of PFOA and PFOS individually and combined above the screening level of 70 ppt. At Whitmore Ravine, the PFOA and PFOS combined concentration was 1,188.0 ppt. A total of 16 different PFAS were detected in surface water in the Great Falls area. The highest total PFAS concentration in the Great Falls area was 12,920.0 ppt at Whitmore Ravine at the footpath bridge.

4.0 Discussion

Although there are thousands of known PFAS, this report focuses on 28 chemicals based on current analytical capabilities. The EPA continues to study human health impacts related to PFAS exposure and the EPA will provide federal regulatory thresholds for certain PFAS chemicals to protect human health. This study used the best available science and results could be interpreted differently if updated regulations refine human health thresholds.

The results of this study add to the increasing knowledge that PFAS are generally pervasive and persistent in areas of use. Of at-risk sites, 14 of 21 sites, or 67%, had a detection of one or more PFAS. All at-risk sites with detections of PFAS were downstream of potential or confirmed sources of PFAS. Of low-risk sites, 1 of 5 sites, or 20%, had a detection of one PFAS. A low percentage of detections at low-risk sites indicates proper site selection, as well as, PFAS were not detected outside of at-risk areas, even though monitoring sites were near source areas. The low-risk site with a detection at East Gallatin River at Springhill Rd crossing is likely related to urban and stormwater influences and may not fully represent a low-risk site. Overall findings of the project found 58% of all sites sampled had detections of one or more PFAS. Project results indicate PFAS are moderately prevalent in at-risk areas of the state.

For all sites sampled, total detectable PFAS concentrations ranged from 0.86 ppt to 12,920.0 ppt. The magnitude of PFAS concentrations are dependent on monitoring site locations and about 85% of total PFAS concentrations from at-risk sites were below 30 ppt. **Figure 6** represents the cumulative percentage of total PFAS concentrations from at-risk sites. **Figure 7** shows the distribution of each individual PFAS detection throughout the four at-risk areas. Certain PFAS, such as PFOS and PFHxS, were detected at a higher frequency, however, most PFAS were detected at a low concentration. The higher concentrations of individual PFAS mostly related to detections at Whitmore Ravine and Alkali Creek in Billings.

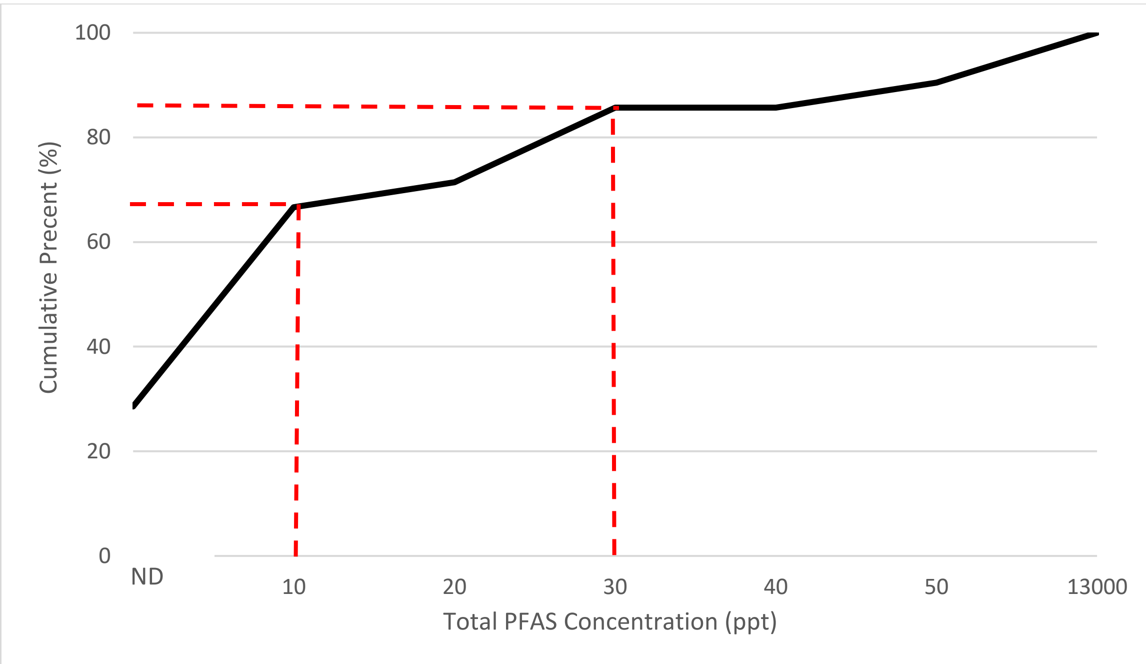

Figure 6. Cumulative percentage of total PFAS concentration from at-risk sites (n=21).

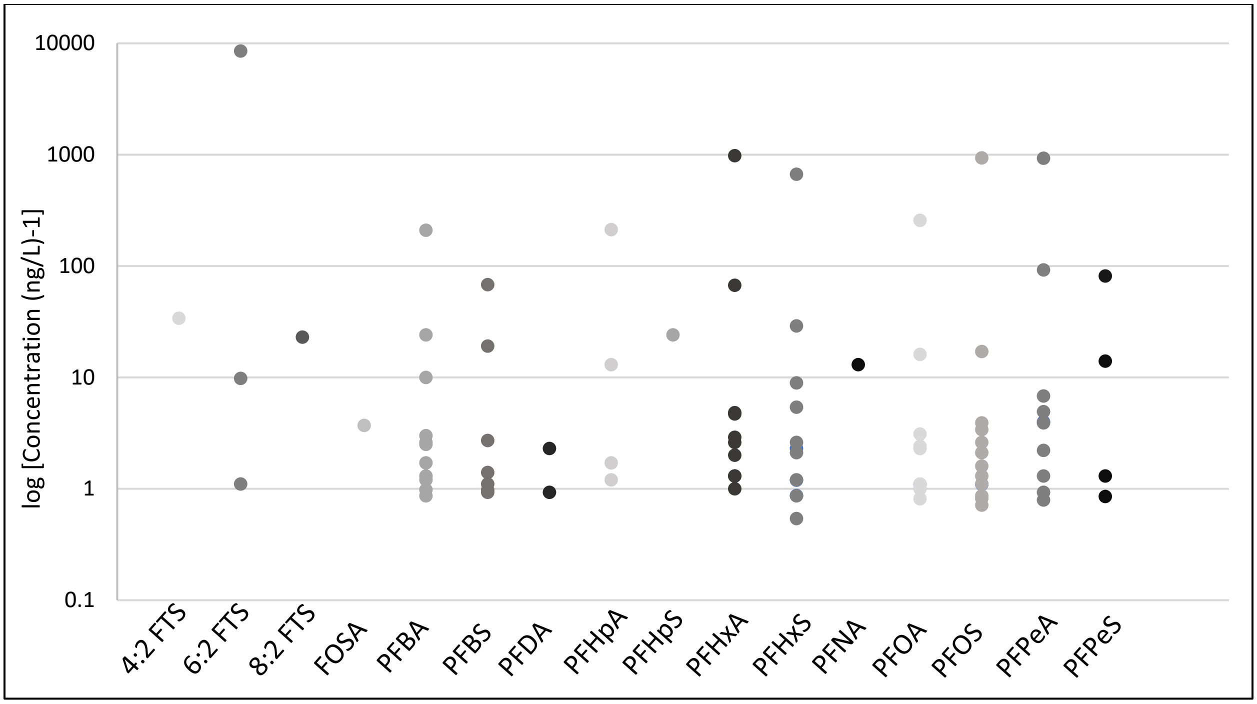

Figure 7. Distribution of each individual PFAS detection throughout the four at-risk areas.

Whitmore Ravine at the footpath bridge was the only site that exceeded the surface water screening level of 70 ppt for PFOA and PFOS individually or combined. Due to no public or private water supplies on or near Whitmore Ravine there is currently no immediate threat to human health, however DEQ recommends the water in Whitmore Ravine not be consumed by people or animals without proper water treatment.

The 2021 sample results in relation to public water supply (PWS) intakes in the four at risk areas, indicated PWS systems are not currently impacted by PFAS contamination in surface water. From 2013 to 2015, 36% of Montana's population served by PWS were tested under the Unregulated Contaminant Monitoring Regulation (UCMR3). All systems PFAS samples tested below the method reporting limits for drinking water. For further information on the systems tested during UCMR3 visit https://deq.mt.gov/cleanupandrec/Programs/pfas#accordion1-collapse2.

None of the surface water samples collected exceeded the acute or chronic water column criteria for aquatic life.

4.1 Chemical Specific Reviews

Perfluorooctanesulfonic acid (PFOS) is one of the most produced and studied PFAS. PFOS has water, grease, and stain resistant properties and has been used to make clothing, carpets, fabrics for furniture, food packaging, and other materials. PFOS has also been used in firefighting foams and in industrial processes (EPA, 2016). Of the 28 PFAS compounds analyzed, PFOS was detected most often in surface water samples throughout the four at-risk areas. In total, PFOS was detected in 13 water samples and two sediment samples. Whitmore Ravine at the footpath bridge was the only site where PFOS was above the screening level of 70 ppt. Yegan Ditch near the mouth and Whitmore Ravine at the footpath bridge had detections of PFOS in sediment samples. Neither of these sites had PFOS detections in sediment above the screening level for PFOS (4,900 ng/g).

Most people are exposed to PFOS through use of consumer products. Drinking water can be an additional route of exposure in a limited number of communities with contaminated water supplies (EPA, 2016). Contamination to drinking water sources is typically isolated around industrial facilities that produce or use PFOS chemicals and airports, military installations, and firefighting training areas that use firefighting foams. Studies suggest exposure to PFOS over certain levels may lead to negative health effects, including developmental, liver, immunological, thyroid, and increased risk of kidney and testicular cancer (EPA, 2016). Due to its harmful effects, the federal government implemented regulations to reduce exposure to PFOS. Between 2000 and 2002, PFOS was voluntarily phased out of production by primary manufacturers in the U.S., and the EPA has issued regulations to limit the importing and manufacturing of PFOS (EPA, 2016). In 2016, the Food and Drug Administration amended regulations to eliminate PFOS and PFOA used in food packaging (EPA, 2016).

The highest detection of a single PFAS was located at Whitmore Ravine at the footpath bridge. The chemical was 1-Octanesulfonic acid, 3, 3, 4, 4, 5, 5, 6, 6, 7, 7, 8, 8, 8-tridecafluoro- (6:2 FTS) at a concentration of 8,490 ppt. 6:2 FTS was detected at three sites throughout the four at-risk areas: Alkali Creek in Billings and Whitmore Ravine and the Missouri River below Whitmore Ravine in Great Falls. 6:2 FTS was created to be a replacement chemical for PFOS in the metal plating industry and has been found to be used in firefighting foams (NASF, 2019). Currently there is limited toxicology studies and human health effect information for 6:2 FTS. The standard testing for regulatory approval for industry manufacturing and use has been completed (NASF, 2019). Studies have shown that rodents highly exposed to 6:2 FTS exhibit harmful kidney and live effects (Sheng et al., 2017).

5.0 CONCLUSION AND NEXT STEPS

This project was designed to determine the prevalence and magnitude of PFAS in at-risk areas of Montana. Results determined PFAS are moderately prevalent in at-risk areas and PFAS concentrations range in magnitude depending on site location. Multiple PFAS were detected in each at-risk area of the state near or downstream of confirmed and potential sources. PFAS detected relate to the use of fire-fighting foams, food packaging, surfactants used in industrial processes, stain resistant fabrics, metal manufacturing, and other uses. Results indicate PFAS may be entering surface water from sources such as wastewater treatment plants, industrial facilities, military instillations, airports, and urban runoff.

Due to the high detections of PFAS in Whitmore Ravine, DEQ took action to send letters to landowners and post caution signs along the River Edge Trail that passes over Whitmore Ravine. This was done to warn livestock and pet owners for animals to not drink the water without proper water treatment. The nearby Malmstrom Air Force Base (MAFB) is already investigating whether it could be a contributor to the PFAS concentrations in Whitmore Ravine. In 2016 and 2017, MAFB contractors performed an investigation that identified areas of potential PFAS contamination on base. As a result, MAFB has developed a work plan to determine the extent and magnitude of PFAS contamination on- and off-base. DEQ, in consultation with its federal partners and has reviewed the draft work plan.

More monitoring is needed throughout Montana to understand the presence of PFAS in our waterways and to determine the impact to human health and the environment. As funding becomes available, DEQ will work with Fish, Wildlife, and Parks (FWP) to complete fish tissue monitoring in areas of the state with PFAS detections. In 2023, the EPA is expecting to finalize a list of PFAS for use in fish consumption advisory programs. This list will guide DEQ and FWP on which PFAS to monitor and how to set fish consumption advisories for PFAS that have human health impacts via fish consumption (EPA, 2021).

In the fall of 2021, the EPA released their PFAS Strategic Roadmap. Between 2021 and 2024 the EPA will release toxicity assessments and health advisories for further PFAS compounds (EPA, 2021). When new or updated standards are accepted by DEQ, the 2021 PFAS results may be compared to updated standards.

The State of Montana will continue to implement the PFAS Action Plan to reduce or eliminate potential risks posed by PFAS to human health and environment. Montana will consider future EPA PFAS guidance for specific permitting, monitoring, source water, and remediation program to make the best decisions for Montana.

6.0 REFERENCES

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APPENDIX A: MONITORING LOCATIONS

Map #	Waterbody	Site Description	Station ID	Rationale for Site Selection
Bozeman Area Monitoring Locations				
1	Bozeman Creek	near trailhead (Forest Service)	M05BOZMC07	Upstream of potential source, low risk site
2	Bozeman Creek	at Bogart Park	M05BOZMC08	Downstream of potential source
3	Bozeman Creek	at E Tamarack Rd crossing	M05BOZMC09	Downstream of potential source
4	Mandeville Creek	at Bozeman High School	M05MANDC02	Downstream of potential source
5	Mathew Bird Creek	East of E College St., near mouth	M05MTHBC02	Downstream of potential source
6	East Gallatin River	at Springhill Rd crossing	M05EGALR05	Upstream of potential source, low risk site
7	East Gallatin River	1 mi d/s Springhill Rd bridge	M05EGALR06	Downstream of potential source
8	Thompson Spring Creek	upstream of Hamilton Road	M05TMPSC02	Downstream of potential source
Helena Area Monitoring Locations				
1	Tenmile Creek	u/s of Hwy 12 crossing	M09TENMC15	Upstream of confirmed source, low risk site
2	Tenmile Creek	at Tenmile Cr Park	M09TENMC20	Downstream of confirmed source
3	Sevenmile Creek	at Head Lane crossing	M09SVNMC03	Downstream of confirmed source
4	Prickly Pear Creek	below E. Helena	M09PKPRC05	Upstream of confirmed source and downstream of potential source
5	Prickly Pear Creek	Prickly Pear Fish Access Site	M09PKPRC01	Downstream of confirmed source
6	Prickly Pear Creek	2 mi. u/s confluence Tenmile Creek	M09PKPRC22	Downstream of confirmed source
7	Spring Meadow Lake	Spring Meadow Lake	M09SPMDL01	Near a confirmed source
8	Lake Helena	at midpoint West	M09LHLNW02	Collects possible PFAS influence of the Helena Valley
Great Falls Area Monitoring Locations				
1	Missouri River	at White Bear FAS	M12MISSR16	Upstream of potential source, low risk site
2	Sun River	just above 6th Street Bridge	M13SUNR08	Downstream of potential source

Map #	Waterbody	Site Description	Station ID	Rationale for Site Selection
3	Missouri River	at Rivers Edge Trail, left side	M12MISSR25	Downstream of potential source
4	Whitmore Ravine	at footpath bridge above mouth	M12WHTMR01	Downstream of confirmed source
5	Missouri River	below Whitmore Ravine	M12MISSR42	Downstream of confirmed source
Billings Area Monitoring Locations				
1	Yellowstone River	at Duck Creek Road crossing	Y06YELSR20	Upstream of potential source, low risk site
2	Yellowstone River	at Mystic Park	Y06YELSR10	Downstream of potential source
3	Yegan Ditch	near mouth	Y06YEGND99	Downstream of potential source
4	Alkali Creek	Alkali Creek	Y12ALKIC03	Downstream of potential source
5	Yellowstone River	3 mi. d/s Hwy 87 bridge	Y12YELSR60	Downstream of potential source

APPENDIX B: LABORATORY ANALYTICAL LOWER REPORTING LIMITS AND METHOD DETECTION LIMITS

Parameter	Analytical Method	Water		Sediment	
		Lower Reporting Limit (LRL) (ppt)	Method Detection Limit (MDL) (ppt)	Lower Reporting Limit (LRL) (ng/g-dry)	Method Detection Limit (MDL) (ng/g-dry)
Hexafluoropropylene oxide dimer acid (HFPO-DA)	EPA 537 Modified	3	0.336	1	0.345
Perfluorooctanesulfonic acid (PFOS)		2	0.336	1	0.152
Perfluoroundecanoic acid (PFUnA)		2	0.654	1	0.227
N-methyl perfluorooctanesulfonamidoacetic acid (NMeFOSAA)		2	0.444	1	0.159
Perfluorovaleric acid (PFPeA)		2	0.4	1	0.314
1-Pentanesulfonic acid, 1,1,2,2,3,3,4,4,5,5,5-undecafluoro- (PFPeS)		2	0.475	1	0.181
1-Octanesulfonic acid, 3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluoro- (6:2 FTS)		8	0.544	1	0.655
N-ethyl perfluorooctanesulfonamidoacetic acid (NEtFOSAA)		3	0.764	1	0.237
Perfluorohexanoic acid (PFHxA)		2	0.527	1	0.333
Perfluorododecanoic acid (PFDoA)		2	0.434	1	0.223
Perfluorooctanoic acid (PFOA)		2	0.336	1	0.168
Perfluorodecanoic acid (PFDA)		2	0.586	1	0.404
1-Decanesulfonic acid, 1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,9,9,10,10,10-heneicosafluoro- (PFDS)		2	0.4	1	0.206
Perfluorohexanesulfonic acid (PFHxS)		2	0.283	1	0.198
Heptafluorobutyric acid (PFBS)		5	0.238	1	0.226
Perfluorobutanesulfonic acid (PFBS)		2	0.119	1	0.223
Perfluoroheptanoic acid (PFHpS)		2	0.394	1	0.181
1-Heptanesulfonic acid, 1,1,2,2,3,3,4,4,5,5,6,6,7,7,7-pentadecafluoro- (PFHpS)		2	0.299	1	0.164
Perfluorononanoic acid (PFNA)		2	0.434	1	0.274
Perfluorotetradecanoic acid (PFTA)		2	0.382	1	0.224
Fluorotelomer sulfonate 8:2 (8:2 FTS)		3	0.713	1	0.387
1-Nonanesulfonic acid, 1,1,2,2,3,3,4,4,5,5,6,6,7,7,8,8,9,9,9-nonadecafluoro- (PFNS)		2	0.509	1	0.15
Perfluorotridecanoic acid (PFTrDA)		2	0.217	1	0.469
Perfluorooctanesulfonamide (FOSA)		2	0.475	1	0.204
9-chlorohexadecafluoro-3-oxanone-1-sulfonic acid (9Cl-PF3ONS)		2	0.238	1	0.234
Fluorotelomer sulfonate 4:2 (4:2 FTS)		2	0.4	1	0.141

Parameter	Analytical Method	Water		Sediment	
		Lower Reporting Limit (LRL) (ppt)	Method Detection Limit (MDL) (ppt)	Lower Reporting Limit (LRL) (ng/g-dry)	Method Detection Limit (MDL) (ng/g-dry)
11-chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11Cl-Pf3Ouds)	EPA 537 Modified	2	0.238	1	0.128
Propanoic acid, 2,2,3-trifluoro-3-[1,1,2,2,3,3-hexafluoro-3-(trifluoromethoxy)propoxy]- (ADONA)	EPA 537 Modified	2	0.307	1	0.474

Appendix C: PFAS Water Quality Results

Non-detects for the project are not reported in Appendix C: Water Quality Result Tables.

Table 1. PFAS Surface Water Detections in the Bozeman Area.

Parameter Acronym	Parameter Name	Concentration (ppt)
East Gallatin River at Springhill Rd crossing (6)		
PFBA	Heptafluorobutyric acid	2.5
	Total PFAS Concentration	**2.5**
East Gallatin River 1 mi. downstream Springhill Rd bridge (7)		
PFOS	Perfluorooctane sulfonic acid	1.3
PFPeA	Perfluorovaleric acid	3.9
PFHxA	Perfluorohexanoic acid	2.6
PFOA	Perfluorooctanoic acid	1.1
PFBA	Heptafluorobutyric acid	3.0
PFBS	Perfluorobutanesulfonic acid	0.93
	Total PFAS Concentration	**12.83**
Mandeville Creek at Bozeman High School (4)		
PFOS	Perfluorooctane sulfonic acid	2.6
PFPeA	Perfluorovaleric acid	4.9
PFHxA	Perfluorohexanoic acid	2.9
PFOA	Perfluorooctanoic acid	2.4
PFDA	Perfluorodecanoic acid	0.93
PFBA	Heptafluorobutyric acid	10.0
PFBS	Perfluorobutanesulfonic acid	0.97
PFHpA	Perfluoroheptanoic acid	1.7
	Total PFAS Concentration	**26.4**
Thompson Spring Creek upstream of Hamilton Road (8)		
PFOS	Perfluorooctane sulfonic acid	1.1
PFHxS	Perfluorohexanesulfonic acid	0.87
PFBA	Heptafluorobutyric acid	0.98
	Total PFAS Concentration	**2.95**

Table 2. PFAS Surface Water Detections in the Helena Area.

Parameter Acronym	Parameter Name	Concentration (ppt)
Tenmile Creek at Tenmile Creek Park (2)		
PFHxS	Perfluorohexanesulfonic acid	0.86
	Total PFAS Concentration	**0.86**
Prickly Pear Creek 2 mi. upstream confluence Tenmile Creek (6)		
PFOS	Perfluorooctane sulfonic acid	2.1
PFPeA	Perfluorovaleric acid	6.8
PFPeS	1-Pentanesulfonic acid, 1,1,2,2,3,3,4,4,5,5,5-undecafluoro-	0.85

Parameter Acronym	Parameter Name	Concentration (ppt)
PFHxA	Perfluorohexanoic acid	4.7
PFOA	Perfluorooctanoic acid	3.1
PFHxS	Perfluorohexanesulfonic acid	5.4
PFBA	Heptafluorobutyric acid	1.7
PFBS	Perfluorobutanesulfonic acid	1.4
Total PFAS Concentration		**26.05**
Spring Meadow Lake (7)		
PFOS	Perfluorooctane sulfonic acid	0.82
PFHxS	Perfluorohexanesulfonic acid	0.54
PFBS	Perfluorobutanesulfonic acid	1.1
Total PFAS Concentration		**2.46**
Lake Helena (8)		
PFOS	Perfluorooctane sulfonic acid	1.6
PFPeA	Perfluorovaleric acid	1.3
PFHxA	Perfluorohexanoic acid	1.3
PFOA	Perfluorooctanoic acid	0.81
PFHxS	Perfluorohexanesulfonic acid	2.1
PFBA	Heptafluorobutyric acid	1.3
Total PFAS Concentration		**8.41**

Table 3. PFAS Surface Water Detections in the Billings Area

Parameter Acronym	Parameter Name	Concentration (ppt)
Yellowstone River 3 miles downstream Hwy 87 bridge (5)		
PFOS	Perfluorooctane sulfonic acid	1.1
PFHxS	Perfluorohexanesulfonic acid	1.2
Total PFAS Concentration		**2.3**
Yegan Ditch near mouth (3)		
PFOS	Perfluorooctane sulfonic acid	17
PFPeA	Perfluorovaleric acid	4
PFPeS	1-Pentanesulfonic acid, 1,1,2,2,3,3,4,4,5,5,5-undecafluoro-	1.3
PFHxA	Perfluorohexanoic acid	4.8
PFOA	Perfluorooctanoic acid	2.3
PFHxS	Perfluorohexanesulfonic acid	8.9
PFBA	Heptafluorobutyric acid	2.6
PFBS	Perfluorobutanesulfonic acid	2.7
PFHpA	Perfluoroheptanoic acid	1.2
Total PFAS Concentration		**44.8**
PFOS + PFOA Concentration		**19.3**
Alkali Creek (4)		
PFOS	Perfluorooctane sulfonic acid	3.4
PFPeA	Perfluorovaleric acid	92

Parameter Acronym	Parameter Name	Concentration (ppt)
PFPeS	1-Pentanesulfonic acid, 1,1,2,2,3,3,4,4,5,5,5-undecafluoro-	14
6:2 FTS	1-Octanesulfonic acid, 3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluoro-	1.1
PFHxA	Perfluorohexanoic acid	67
PFOA	Perfluorooctanoic acid	16
PFHxS	Perfluorohexanesulfonic acid	29
PFBA	Heptafluorobutyric acid	24
PFBS	Perfluorobutanesulfonic acid	19
PFHpA	Perfluoroheptanoic acid	13
Total PFAS Concentration		**278.5**
PFOS + PFOA Concentration		**19.4**

Table 4. PFAS Sediment Detections in the Billings Area

Yegan Ditch near mouth (3)		
Parameter Acronym	**Parameter Name**	**Concentration (ng/g)**
PFOS	Perfluorooctane sulfonic acid	4.9
Total PFAS Concentration		**4.9**

Table 5. PFAS Surface Water Detections in the Great Falls Area

Parameter Acronym	Parameter Name	Concentration (ppt)
Missouri River at Rivers Edge Trail along the left side (3)		
PFOS	Perfluorooctane sulfonic acid	0.86
PFPeA	Perfluorovaleric acid	0.79
PFHxA	Perfluorohexanoic acid	1.0
PFHxS	Perfluorohexanesulfonic acid	1.2
PFBA	Heptafluorobutyric acid	0.86
Total PFAS Concentration		**4.71**
Missouri River below Whitmore Ravine (5)		
PFOS	Perfluorooctane sulfonic acid	3.9
PFPeA	Perfluorovaleric acid	2.2
6:2 FTS	1-Octanesulfonic acid, 3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluoro-	9.8
PFHxA	Perfluorohexanoic acid	2.0
PFOA	Perfluorooctanoic acid	1.0
PFHxS	Perfluorohexanesulfonic acid	2.6
PFBA	Heptafluorobutyric acid	1.2
Total PFAS Concentration		**22.7**
Sun River just above 6th Street Bridge (2)		
PFOS	Perfluorooctane sulfonic acid	0.71
PFPeA	Perfluorovaleric acid	0.93
PFHxA	Perfluorohexanoic acid	1.3

Parameter Acronym	Parameter Name	Concentration (ppt)
PFOA	Perfluorooctanoic acid	1.1
PFHxS	Perfluorohexanesulfonic acid	2.3
Total PFAS Concentration		**6.34**
Whitmore Ravine at footpath bridge (4)		
PFPeS	1-Pentanesulfonic acid, 1,1,2,2,3,3,4,4,5,5,5-undecafluoro-	81.0
PFDA	Perfluorodecanoic acid	2.3
PFBS	Perfluorobutanesulfonic acid	68.0
PFHpS	1-Heptanesulfonic acid, 1,1,2,2,3,3,4,4,5,5,6,6,7,7,7-pentadecafluoro-	24.0
PFNA	Perfluorononanoic acid	13.0
8:2 FTS	Fluorotelomer sulfonate 8:2	23.0
FOSA	Perfluorooctanesulfonamide	3.7
4:2 FTS	Fluorotelomer sulfonate 4:2	34.0
PFOS	Perfluorooctane sulfonic acid	932.0 *
PFPeA	Perfluorovaleric acid	929.0
6:2 FTS	1-Octanesulfonic acid, 3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluoro-	8490.0
PFHxA	Perfluorohexanoic acid	976.0
PFOA	Perfluorooctanoic acid	256.0 *
PFHxS	Perfluorohexanesulfonic acid	667.0
PFBA	Heptafluorobutyric acid	209.0
PFHpA	Perfluoroheptanoic acid	212.0
Total PFAS Concentration		**12920.0**
PFOS + PFOA Concentration		**1188.0 ***

*** Indicates PFOS and PFOA exceed the screening level of 70ppt.**

Table 6. PFAS Sediment Detections in the Great Falls Area

Whitmore Ravine at footpath bridge (4)		
Parameter Acronym	**Parameter Name**	**Concentration (ng/g)**
PFOS	Perfluorooctane sulfonic acid	1.5
6:2 FTS	1-Octanesulfonic acid, 3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluoro-	2.6
Total PFAS Concentration		**4.1**