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State of Washington

Addendum 1 to Programmatic Quality Assurance Project Plan:

Statewide Preliminary PFAS Assessments

June 2024

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This report was prepared under the supervision of a licensed hydrogeologist. A signed and stamped copy of the report is available upon request.

Addendum 1 to
Programmatic Quality Assurance Project Plan

Statewide Preliminary PFAS Assessments

By Jacob Carnes, LG

June 2024

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HWTR: Hazardous Waste and Toxics Reduction
EAP: Environmental Assessment Program

1.0 Table of Contents

Note: The numbered headings in this document correspond to the headings in the original QAPP. Only relevant sections are included here; therefore, some numbered headings may be missing.

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3.0 Background

3.1 Introduction and problem statement

Yakima Training Center (YTC) is a sub-installation of Joint Base Lewis-McChord (JBLM), owned and operated by the U.S. Army (Army). The westernmost portion of YTC is approximately 5 miles north-northeast of Yakima and approximately 3 miles east of Selah (Figure 1).

In 2018, the Army established a program to perform preliminary assessments of Army installations to identify potential locations of per- and polyfluoroalkyl substances (PFAS) release into the environment (Army 2018). In 2019, the consultant Arcadis performed a preliminary assessment at YTC. Arcadis identified three potential source areas of PFAS contamination associated with the use of aqueous film-forming foam (AFFF). These potential source areas include two fire training pits where AFFF was used and one location where fire nozzles were tested (Arcadis 2019).

In response to concerns over the possibility that groundwater contamination was migrating off-base, the Army conducted sampling of domestic wells. Sampling was conducted between 2021 and 2023, west of YTC in the East Selah area. The 2022 National Defense Authorization Act required public reporting of off-base analytical data; earlier analytical data is unpublished. From 2022 to 2023, the Army collected and analyzed 287 groundwater samples for 18 PFAS analytes (Table 1). More than 100 of those samples exceeded at least one of Ecology's Preliminary Cleanup Levels (PCL) established for PFAS compounds in groundwater under the Model Toxics Control Act (Ecology 2024).

Table 1. Summary of Department of Defense domestic well sampling PFAS data 2022-2023 (DoD 2022a, 2022b, 2023a, 2023b)

Parameter	PCL (ng/L)	Range of Concentrations	Number of samples with positive detections	Number of Samples with detections > PCL	Percent of Samples with detections > PCL
Perfluorooctanoic acid (PFOA)	10	0.45–130	152	59	20.6%
Perfluorooctanesulfonic acid (PFOS)	15	0.43–1000	154	105	36.6%
Perfluorobutanesulfonic acid (PFBS)	345	0.43–120	179	0	0%
Perfluorohexanesulfonic acid (PFHxS)	65	0.44–1000	181	73	25.4%
Perfluorononanoic acid (PFNA)	9	0.41–12	68	2	0.7%
Hexafluoropropylene oxide dimer acid (HFPO-DA/GenX)	24	0.58	1	0	0%
Perfluorobutanoic acid (PFBA)	8000	NAF	NAF	NAF	NAF

PCL: Preliminary Cleanup Level (Ecology 2024)
NAF: Not analyzed for

Perfluorooctane sulfonic acid (PFOS) concentrations exceeded the 15 ng/L Preliminary Cleanup Level (PCL) in 105 samples. Perfluorohexanesulfonic acid concentrations were above the 65 ng/L PCL in 73 samples. Perfluorooctanoic acid (PFOA) concentrations exceeded the 10 ng/L PCL in 59 samples. Perfluorononanoic acid concentrations exceeded the 9 ng/L PCL in two samples (DoD 2022a, 2022b, 2023a, 2023b).

Exact location data for the Army sampling is unavailable. Maps prepared by Ecology's Hazardous Waste and Toxics Reduction (HWTR) program show that elevated PFOA + PFOS concentrations in groundwater exist across a swath of land, up to two miles wide, between the western end of the YTC and the Yakima River (Ecology 2023a, 2023b). Depths of domestic wells in this area range from tens of feet to greater than 700 feet.

Surface water in the area, including the Yakima River, Elton Pond, and irrigation canals, has not been sampled for PFAS contamination. Contaminant transport occurs faster in surface water than in groundwater. Determining whether contamination is reaching surface water will lead to a better understanding of the potential extent of impacts.

3.2 Study area and surroundings

The headwaters of the Yakima River are near Snoqualmie Pass in the Cascade Mountains. The river flows south-southeast for more than 200 miles to its confluence with the Columbia River near Richland, Washington. The entire Yakima River basin covers more than 6,100 square miles in central Washington and spans parts of Benton, Kittitas, Klickitat, and Yakima Counties. While the upland western and northern parts of the basin receive about 140 inches of precipitation yearly, the lower valley receives considerably less precipitation, typically less than 10 inches annually (BOR/Ecology 2012).

Flows of the Yakima River are highly controlled by the United States Department of the Interior Bureau of Reclamation's (USBR) Yakima Project. From mid-April through early September, USBR releases most of the water needed for irrigation in the Lower Yakima River valley from the Upper Yakima River reservoirs. These reservoirs include the Roza Diversion Dam, which is about 7.5 miles upstream of the study area. During this time, releases from the Naches River basin are minimized. In early September each year, the USBR begins to limit releases from the Upper Yakima River reservoirs and relies on the Naches basin to provide most of the needed flows (YSFWPB 2004).

Elton Pond is immediately east of Interstate 82. The Washington Department of Fish and Wildlife (WDFW) manages the pond and opens it to fishing from late November through the end of March. The pond is stocked with rainbow trout. Largemouth bass, pumpkinseed sunfish, and common carp are also present (WDFW 2024). The pond has no stream inputs and is presumably groundwater-fed.

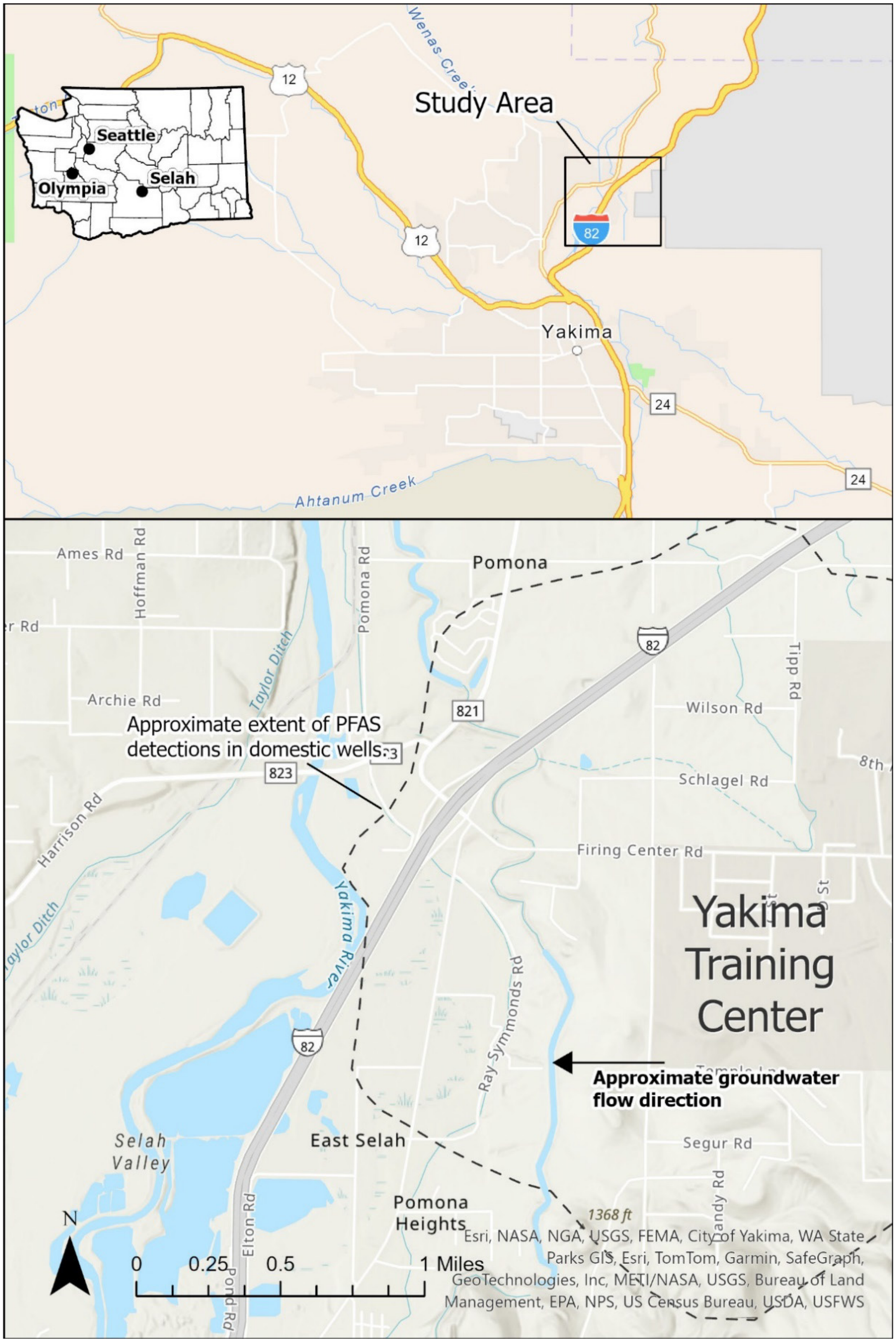

Figure 1. Location map of the East Selah study area.

The Roza Irrigation District manages the irrigation canals in the study area. The primary canal, the Roza Canal, is nearly 95 miles long. The Roza Canal begins at the Roza Diversion Dam and ends about 13 miles east of Richland, WA. Two laterals from the Roza Canal, P1L (Low Canal) and P1H (High Canal), traverse the western portions of the YTC near East Selah. Water for these two laterals is removed from the Roza Canal by a pumping station at canal mile 7.2. The Low Canal has a total length of 4.2 miles. The main stem of the Low Canal enters an underground pipe immediately east of Shotgun Lane. It extends north and east across the developed westernmost part of the YTC and re-emerges off base north of Firing Center Road. The High Canal has a total length of 5.6 miles. The High Canal originates as an underground pipe and becomes an open-air canal in the western part of the YTC, south of the Vagabond Army Airfield. The main stem of the High Canal travels across a largely underdeveloped part of the western YTC, southeast of the Low Canal. The High Canal exits about 1,300 feet south of Pomona Road.

A wetland about 1,100 feet from the western edge of the YTC drains into the Roza Canal. This canal is in an area with some of the highest levels of PFAS detected in the Army's domestic well sampling (Ecology 2023a, 2023b).

3.2.1 Geology and hydrogeology

The East Selah area is underlain by thick lava flows of the Columbia River Basalt Group. Poorly consolidated sediments are interbedded with the basalts. Individual basalt flows range from a few feet to more than 100 feet thick. Flows are characterized by a vesicular or rubbly flow top, an internal zone with randomly distributed cooling joints, and a columnar jointed lower zone. The Sedimentary Ellensburg Formation overlies the basalt succession in the area, except where it's been incised by the Yakima River. The Ellensburg Formation is a sequence of unconsolidated to well-indurated sediments. In the area between the river and the YTC, the alluvial sediments, including floodplain deposits, terraces, and alluvial fan deposits, overlie the Ellensburg Formation (Campbell 1977). Regional deformation of the Yakima Fold Belt resulted in a series of east-northeast trending ridges and valleys. The study area is in one of these valleys, bounded by the Yakima Ridge to the south and Umtanum Ridge to the north (Tetra Tech 2018).

Groundwater in the study area is in unconsolidated alluvial deposits, sand and gravel beds of the Ellensburg Formation, and the underlying basalts. Groundwater depths range from about 20 feet below ground surface (bgs) in stream valleys to more than 200 feet bgs at higher elevations. The groundwater flow direction off-base from YTC is westward towards the Yakima River and locally northwestward close to the river (Tetra Tech 2018).

Contaminant fate and transport depend highly on groundwater flow and groundwater-surface water interactions. Due to the extent of flow regulation and seasonal snow-melt runoff, the ability to determine reliable base flow values on the Yakima River near YTC is limited (Sinclair and Pitz 1999). Further investigations may be warranted to determine detailed aspects of the fate and transport of PFAS originating from YTC. If necessary, this work will be described in a new QAPP.

4.0 Project Description

4.1 Project goals

The primary goal of this preliminary assessment is to determine whether PFAS-contaminated groundwater originating at the YTC affects surface water near East Selah. Groundwater between YTC and the Yakima River is contaminated with PFAS, as documented by the Army's sampling of domestic wells. Sampling performed under this assessment will attempt to document whether that contamination is reaching the Yakima River and other surface water bodies, including Elton Pond and irrigation canals in the area.

Determining whether PFAS-contaminated groundwater affects surface water will help prioritize areas for further investigation based on the magnitude of effects and the proximity of nearby receptors. Further investigations may include new studies by EAP under a new QAPP or work done by other Ecology programs informed by results produced under this programmatic QAPP.

4.2 Project objectives

The objective of this assessment is to identify and characterize PFAS concentrations in surface water of the Yakima River, Elton Pond, irrigation canals, and shallow groundwater in areas identified as discharging to those surface waters.

4.4 Tasks required

The primary tasks for this preliminary assessment include:

- Coordinate any permissions needed for site access and sampling.
- Scout field sites before sampling to determine the feasibility of access and sampling.
- Coordinate with laboratories before sampling.
- Prepare and decontaminate field equipment.
- Conduct sampling according to section 7 of this QAPP addendum and section 8 of the programmatic QAPP.
- Ship samples to labs for analysis of PFAS and general chemistry.
- Review and assess lab data quality.
- Conduct data analysis and write a summary report.

5.0 Organization and Schedule

5.4 Proposed project schedule

Table 2. Sample schedule for completing field and laboratory work.

Task	Due date	Lead staff
Fieldwork	October 2024	Jacob Carnes
Laboratory analyses	February 2025	—
Contract lab data validation	June 2025	—

Table 3. Schedule for data entry.

Task	Due date	Lead staff
EIM data loaded[a]	August 2025	Jacob Carnes
EIM QA	September 2025	Siana Wong
EIM complete	October 2025	Jacob Carnes

EIM: Environmental Information Management system
[a]EIM Project ID: StatewidePFAS01

Table 4. Schedule for final report.

Task	Due date	Lead staff/support staff
Draft to supervisor	August 2025	Jacob Carnes/Siana Wong
Draft to client/ peer reviewer	September 2025	Jacob Carnes/Siana Wong
Draft to external reviewers	NA	Jacob Carnes/Siana Wong
Final draft to publications team[1]	October 2025	Jacob Carnes/Siana Wong
Final report due on the web	November 2025	Jacob Carnes/Siana Wong

QA: Quality assurance
NA: Not Applicable

5.5 Budget and funding

Table 5 summarizes the costs for laboratory analysis of samples. Ecology's Manchester Environmental Laboratory (MEL) will analyze samples for dissolved organic carbon, total organic carbon, and total suspended solids. A contract laboratory will be used for PFAS analyses until MEL is accredited for method 1633 (EPA 2024).

Table 5. Outline of laboratory costs broken down by parameter and sample matrix

Date	Parameter	Sample Type	Laboratory	Cost Per Sample ($)	Number of samples	Total ($)
Spring 2024	PFAS Analytes	Groundwater	Contract[a]	385	8	3,080
	PFAS Analytes	Surface Water	Contract[a]	385	21	8,085
	DOC	Groundwater	MEL	45	8	360
	TOC	Surface Water	MEL	35	21	735
	DOC	Surface Water	MEL	45	18	810
	TSS	Surface Water	MEL	15	17	255
Fall 2024	PFAS Analytes	Groundwater	MEL[b]	500	8	4,000
	PFAS Analytes	Surface Water	MEL[b]	500	21	10,500
	DOC	Groundwater	MEL	45	8	360
	TOC	Surface Water	MEL	35	21	735
	DOC	Surface Water	MEL	45	18	810
	TSS	Surface Water	MEL	15	17	255
Total						**29,985**

[a]Analyses performed by contract labs are subject to a 30% surcharge for contracting and data review by MEL. The surcharge for 29 PFAS samples will be $3,349.50, which is not included in the price per sample cost in this table.
[b]If MEL is not accredited for method 1633 by the fall sampling event, a contract lab will be used.
MEL: Manchester Environmental Laboratory
PFAS: Per- and polyfluoroalkyl substances
DOC: Dissolved organic carbon
TOC: Total organic carbon
TSS: Total suspended solids

6.0 Quality Objectives

6.2 Measurement quality objectives

The EPA published the final Method 1633 in January 2024 and issued errata in March 2024 (EPA 2024). Laboratories should use the draft of this method for which they are accredited. The laboratory must be capable of meeting the requirements for precision, accuracy, and limits of quantitation applicable to this method.

Table 6 and Appendix A summarize the measurement quality objectives (MQOs) for the aqueous samples analyzed by method 1633. These MQOs apply to this and future environmental assessments completed under the Programmatic QAPP. Laboratories must meet the precision, accuracy, and limits of quantitation defined in method 1633 (EPA 2024).

Table 6. Measurement quality objectives for aqueous samples analyzed by method 1633.

Lab and Field Duplicate Samples (RPD)[a]	Matrix Spike/Matrix Spike Duplicate (% Recovery)	Matrix Spike/Matrix Spike (RPD)	Method Blank	Ongoing Precision and Recovery and Low-level OPR (% Recovery)	Surrogate Standards (% Recovery)	Method Detection Limit
≤40	50–150	≤30	No analytes detected >½ LOQ or ML	See Table B1	See Table B2	0.1–4.0 ng/L

PFAS: Per- and polyfluoroalkyl substances
RPD: Relative Percent Difference
[a]This criteria applies to results >5x the ML; for duplicate results <5x the ML, the acceptance criteria will be the absolute difference of the sample results <2x the ML.

7.0 Study Design

7.1 Study boundaries

This assessment encompasses four sample locations between the YTC and the Yakima River and nine sample locations on the Yakima River (Figure 2).

7.2 Field data collection

7.2.1 Sampling locations and frequency

The overall goal of this assessment is to determine whether the PFAS-contaminated groundwater near the YTC is migrating to nearby surface waters. Sampling will occur twice, once in late April while water is being released from the Roza Dam and once in the fall while no water is being released from the dam. Table 7 summarizes the planned spring and fall sampling events and lists the total number of samples to be collected for this assessment, including quality assurance samples.

Table 7. Summary of samples to be collected.

Planned Sampling Event	Lab	Parameter	Matrix	Number of Samples	Sample arrival to lab date	Expected Range of Results
Spring 2024	Contract	PFAS	Water	29	May 2024	<0.2–1,600 ng/L
Spring 2024	MEL	TSS	Water	17	May 2024	<1–50 mg/L
Spring 2024	MEL	DOC	Water	26	May 2024	<1–10 mg/L
Spring 2024	MEL	TOC	Water	21	May 2024	1–10 mg/L
Fall 2024	Contract or MEL	PFAS	Water	29	October 2024	<0.2–1,600 ng/L
Fall 2024	MEL	TSS	Water	17	October 2024	<1–50 mg/L
Fall 2024	MEL	DOC	Water	26	October 2024	<1–10 mg/L
Fall 2024	MEL	TOC	Water	21	October 2024	1–10 mg/L

PFAS: Per- and polyfluoroalkyl substances
DOC: Dissolved organic carbon
TOC: Total organic carbon
TSS: Total suspended solids

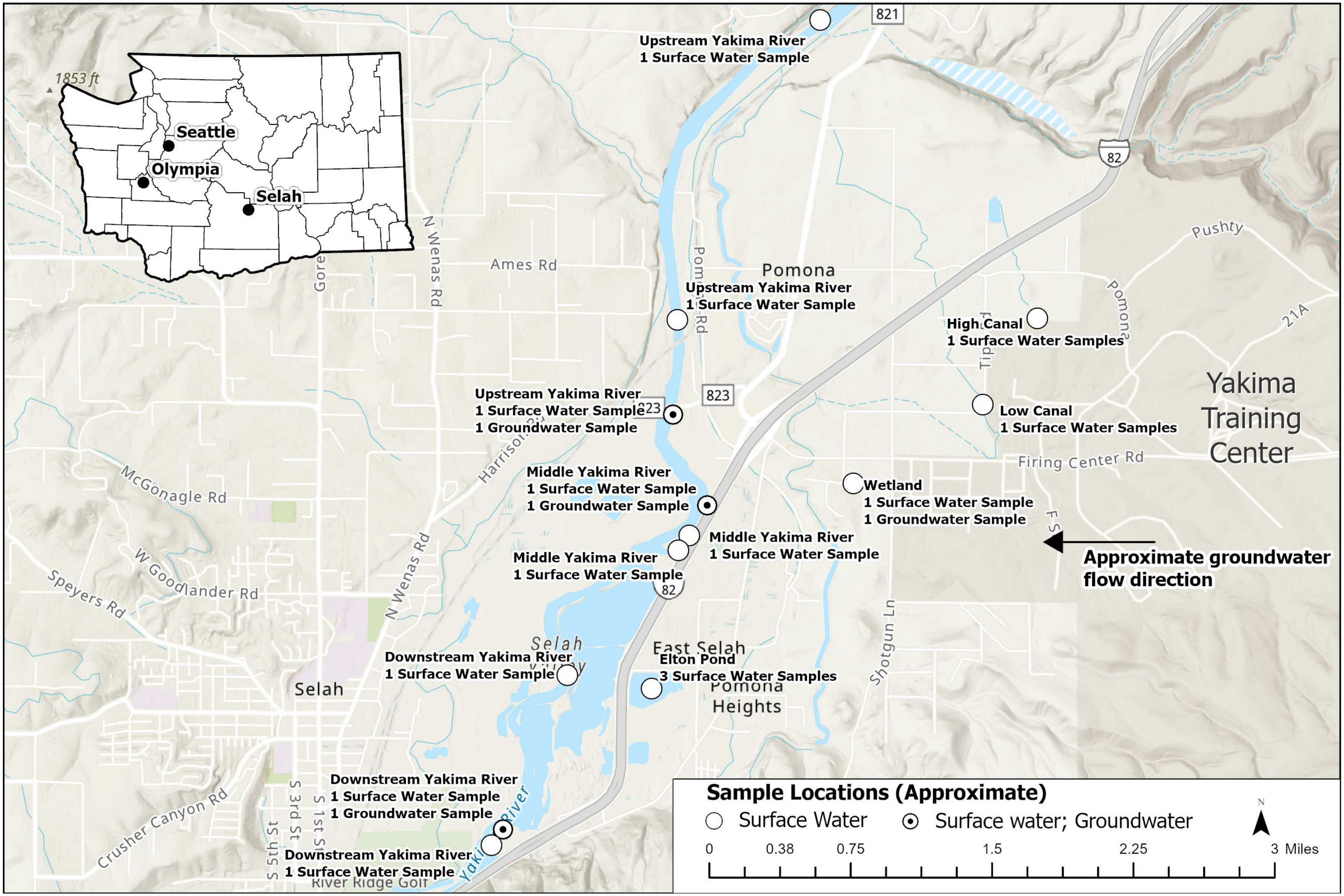

Figure 2. Map of prospective sample locations.

The following locations will be sampled (Figure 2):

- **Yakima River:** Nine surface water samples and three shallow groundwater samples will be collected at nine locations along the Yakima River near the YTC (Figure 2), with 3 locations adjacent to the area with the highest PFAS concentrations detected in domestic wells, 3 locations downstream of the area with the highest PFAS concentrations, and 3 locations upstream of the area with elevated PFAS concentrations in domestic wells (to measure background PFAS concentrations in the river). Prospective sample locations for shallow groundwater will be assessed with a temperature probe and multiparameter sonde to identify locations with apparent groundwater discharge into the river. Surface water samples will be collected at the groundwater sample location, as well as upstream and downstream of the groundwater sampling location.
- **Elton Pond:** Three surface water samples will be collected from locations distributed across Elton Pond to account for potential sample variability. If possible, the pond will be sampled using a small boat; otherwise, samples will be collected from the shore.
- **Irrigation canals:** One surface water sample will be collected directly from the two irrigation canals that pass through the western end of YTC. Samples from both canals will be collected downstream of and as close to YTC as possible.
- **Wetland:** Approximately 1,100 feet west of the YTC, a wetland area discharges into the Roza Canal. This wetland will be sampled for surface water and shallow groundwater.

We may also collect limited "opportunistic" samples, if one or more of the planned sample locations is inaccessible. Opportunistic sample locations will be selected to replace inaccessible sample location, or for supplemental information.

Samples will be collected following section 8.2 of the original programmatic QAPP and PFAS-specific surface water sampling guidance developed by the state of Michigan (MDEQ 2022).

For surface water sampling at locations with a depth greater than one foot, samples will be collected approximately six inches below the water surface. If any sample locations have less than one foot of depth, samples will be collected from the approximate mid-point of the water column (MDEQ 2022)

To select groundwater sample locations for the PushPoint sampler, the relative temperatures of river water and sediment porewater will be measured to identify areas along the riverbank where groundwater discharge is likely occurring. Surface water temperatures vary with ambient air temperatures, while groundwater maintains a relatively stable temperature year-round. Surface water temperatures are typically lower than groundwater temperatures in the winter and higher in the summer. The difference in temperature between surface water and sediment pore water can indicate whether groundwater is discharging to surface water. Losing surface water reaches (surface water discharging to groundwater) are marked by sediment porewater temperatures that are close to surface water temperatures. Gaining surface water reaches (groundwater discharging to surface water) are marked by sediment porewater temperatures that are warmer than surface water temperatures.

Conductivity values in river water will also be used to identify locations where groundwater discharges to the river. Groundwater conductivity values in the study area range from 250 uS/cm to 1,500 uS/cm (Carey and Jacobson 1994; Tetra Tech 2018). Surface water conductivity values in the Yakima River are less than 150 uS/cm (Urmos-Berry et al. 2021). Localized areas of elevated conductivity in river water may indicate groundwater discharge to the river.

Once a sample location is chosen, the hydraulic head in the PushPoint sampler will be compared to the stream's water level to confirm gaining stream conditions at the sampling point.

Further investigations may be warranted to fully describe the PFAS distribution in the water column, pore water, and sediment. Additional sampling with methodology not included in this QAPP addendum (e.g., sediments samples, depth-integrated surface-water samples) will be described in a new QAPP Addendum or new QAPP.

11.0 Data Management Procedures

11.3 Electronic transfer requirements

The contract laboratory will deliver an electronic data deliverable (EDD) in Microsoft Excel spreadsheet format following the Ecology EIM results template to the project manager via email.

13.0 Data Verification

13.3 Validation requirements, if necessary

Stage 4 data validation for all PFAS analyses is required for studies completed under this QAPP. The validation will be performed by MEL or a contracted firm. The stage 4 data validation will be completed using the technical specifications of the following the MEL PFAS data validation SOP (Frans 2024)

14.0 Data Quality (Usability) Assessment

14.2 Treatment of non-detects

Contract laboratory sample results that are non-detects are reported to the contract-required detection limit or sample-specific detection limit, whichever is higher.

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Appendix B. Method 1633 Acceptance Criteria

Table B1. IPR/OPR/LLOPR acceptance limits for target analytes in aqueous matrices.

Target Analyte	IPR Mean Recovery (%)[a]	IPR RSD (%)	ORP/LLORP Recovery (%)[a]
PFBA	70–135	21	70–140
PFPeA	70–135	23	65–135
PFHxA	70–135	24	70–145
PFHpA	70–135	28	70–150
PFOA	65–155	27	70–150
PFNA	70–140	28	70–150
PFDA	65–140	26	70–140
PFUnA	70–135	29	70–145
PFDoA	70–130	21	70–140
PFTrDA	60–145	29	65–140
PFTeDA	70–145	27	60–140
PFBS	70–140	23	60–145
PFPeS	70–135	25	65–140
PFHxS	70–135	27	65–145
PFHpS	70–140	30	70–150
PFOS	70–140	29	55–150
PFNS	70–135	29	65–145
PFDS	70–135	30	60–145
PFDoS	45–135	35	50–145
4:2FTS	70–135	27	70–145
6:2FTS	70–135	32	65–155
8:2FTS	70–140	33	60–150
PFOSA	70–135	22	70–145
NMeFOSA	70–135	30	60–150
NEtFOSA	70–130	26	65–145
NMeFOSAA	65–140	32	50–140
NEtFOSAA	70–135	28	70–145
NMeFOSE	70–135	29	70–145
NEtFOSE	70–130	21	70–135
HFPO-DA	70–135	23	70–140
ADONA	70–135	23	65–145
PFMPA	60–140	23	55–140
PFMBA	65–145	27	60–150
NFDHA	65–140	37	50–150
9Cl-PF3ONS	70–145	30	70–155
11Cl-PF3OUdS	50–150	35	55–160
PFEESA	70–135	25	70–140
3:3FTCA	70–130	23	65–130
5:3FTCA	70–130	24	70–135
7:3FTCA	55–130	34	50–145

IPR: Initial precision and recovery
OPR: On-going precision and recovery
LLOPR: Low-level ongoing precision and recovery
[a]The recovery limits apply to the target analyte results for IPR, OPR, and LLOPR samples for aqueous matrices. Data for this matrix type are derived from the multi-laboratory validation study and are, therefore, the limits required for this method.

Table B2. Acceptance limits for EIS compounds in all aqueous matrices and QC samples.

EIS Compound	Recovery (%)[a]
$^{13}C_4$-PFBA	5[b]–130
$^{13}C_5$-PFPeA	40–130
$^{13}C_5$-PFHxA	40–130
$^{13}C_4$-PFHpA	40–130
$^{13}C_8$-PFOA	40–130
$^{13}C_9$-PFNA	40–130
$^{13}C_6$-PFDA	40–130
$^{13}C_7$-PFUnA	30–130
$^{13}C_2$-PFDoA	10–130
$^{13}C_2$-PFTeDA	10–130
$^{13}C_3$-PFBS	40–135
$^{13}C_3$-PFHxS	40–130
$^{13}C_8$-PFOS	40–130
$^{13}C_2$-4:2FTS	40–200
$^{13}C_2$-6:2FTS	40–200
$^{13}C_2$-8:2FTS	40–300
$^{13}C_8$-PFOSA	40–130
D_3-NMeFOSA	10–130
D_5-NEtFOSA	10–130
D_3-NMeFOSAA	40–170
D_5-NEtFOSAA	25–135
D_7-NMeFOSE	10–130
D_9-NEtFOSE	10–130
$^{13}C_3$-HFPO-DA	40–130

EIS: Extracted Internal Standards
IPR: Initial precision and recovery
OPR: On-going precision and recovery
LLOPR: Low-level ongoing precision and recovery
RSD: Relative Standard Deviation

[a]The recovery limits for the EIS compounds were derived by the EPA from the aqueous sample data from a multi-laboratory validation study. To simplify laboratory operations, the EPA has applied the same EIS recovery limits used for field sample analyses to the EIS recoveries in the IPR, OPR, and LLOPR samples. There are no IPR mean or RSD criteria for the EIS compounds.

[b]Recovery of $^{13}C_4$-PFBA can be problematic in some field samples. Although the lower limit for recovery for this EIS is set below 10%, laboratories should routinely track recovery of this EIS and take reasonable steps to ensure that recovery is at least 10% in most samples.