Western Refining Southwest LLC
A subsidiary of Marathon Petroleum Corporation
I-40 Exit 39
Jamestown, NM 87347

September 29, 2023

Mr. Ricardo Maestas, Interim Chief
New Mexico Environment Department
Hazardous Waste Bureau
2905 Rodeo Park Drive East, Building 1
Santa Fe, NM 87505

RE: Response to Disapproval
OW-63 PFAS Investigation Work Plan
Western Refining Southwest LLC, Gallup Refinery
EPA ID# NMD000333211

Dear Mr. Maestas:

Western Refining Southwest LLC (D/B/A Marathon Gallup Refinery) is submitting this response to disapproval contained in the New Mexico Environment Department (NMED) "Disapproval, OW-63 PFAS Investigation Work Plan" letter dated May 23, 2023. A timeline of the report is as follows:

- Investigation Work Plan, submitted December 7, 2022
- *Disapproval*, received May 23, 2023

The response to comments is provided in Attachment A. This submittal includes two hard copies of the report and a CD with an electronic copy of the red-line, strike-out version of the report and the revised report (Attachment B). The electronic copies will also be submitted by email to NMED.

If you have any questions or comments regarding the information contained herein, please do not hesitate to contact Ms. Kateri Luka at (714) 713-1218.

Western Refining Southwest LLC
A subsidiary of Marathon Petroleum Corporation
I-40 Exit 39
Jamestown, NM 87347

Certification

I certify under penalty of law that this document and all attachments were prepared under my direction of supervision according to a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Sincerely,
Western Refining Southwest LLC, Marathon Gallup Refinery

Timothy J. Peterkoski
Director of Environment and Climate Strategy
Marathon Petroleum Company LP

Enclosure

cc:
L. Andress, NMED HWB
L. Tsinnajinnie, NMED HWB
S. Wells, NMOCD
H. Jones, Trihydro Corporation
M. Suzuki, NMED HWB
L. King, EPA Region 6
K. Luka, Marathon Petroleum Company

ATTACHMENT A

Response to the New Mexico Environment Department (NMED) To Western Refining Southwest LLC (D/B/A Marathon Gallup Refinery [Refinery]) Disapproval Letter for OW-63 PFAS Investigation Work Plan (May 23, 2023)

NMED Comments	Refinery Responses
Comment 1:	**Response 1:**
In Section 1.1 (Background), pages 4 and 5 of 18, the Permittee states, "Trihydro conducts groundwater sampling for PFAS at OW-63 on a quarterly basis… [t]hese [PFAS] results are included in the annual groundwater monitoring reports." The Permittee did not include previous per- and polyfluoroalkyl substances (PFAS) analytical results for the groundwater samples collected from well OW-63 in the current Work Plan. The previous PFAS analytical results prompted this investigation; therefore, the results should be included in the Work Plan. Include the previous PFAS analytical results and provide a discussion in the revised Work Plan.	This comment has been acknowledged and addressed. PFAS analytical results have been added as a new Appendix A. Other Appendices have been adjusted accordingly.
Comment 2:	**Response 2:**
Section 1.3 (PFAS-Containing Materials at the Refinery), page 5 of 18 states, "[s]ince the 1950s, PFAS have been incorporated into many consumer and industrial products." PFAS are often detected in wastewater where many consumer and industrial products end up. Therefore, it is possible that wastewater containing PFAS may have been released to the evaporation ponds (SWMU-2) and the Sanitary Lagoon in the past. Propose to submit a separate work plan to investigate potential PFAS contamination associated with a discharge of wastewater to SWMU-2 and the Sanitary Lagoon in the response letter. No revision is required for the current Work Plan.	A work plan entitled "Solid Waste Management Unit 2 – Evaporation Ponds Investigation Work Plan" was submitted to NMED on March 15, 2023, and was stamped "received" on March 22, 2023. Modifications to this work plan will be made if and when NMED comments on the document are made available.

Response to the New Mexico Environment Department (NMED) To Western Refining Southwest LLC (D/B/A Marathon Gallup Refinery [Refinery]) Disapproval Letter for OW-63 PFAS Investigation Work Plan (May 23, 2023)

NMED Comments	Refinery Responses
Comment 3:	**Response 3:**
Section 1.3 (PFAS-Containing Materials at the Refinery), page 6 of 18 states, "[m]odern AFFF products contain little to no PFOA or PFOS but may contain shortchain PFAS compounds such as perfluorobutane sulfonate (PFBS)." It is not clear if the firefighting foams that have recently been used at the facility no longer contain PFAS. Revise the Work Plan to confirm and state that the recent firefighting foams that the facility uses do not contain any PFAS. If the firefighting foams used at the facility contain short chain PFAS, the foams stored for use in the future should be replaced so to remove any source of PFAS contamination at the site. Include this proposal in the revised Work Plan.	The Refinery is currently idled, and firefighting foam has been removed from the site. When the Refinery resumes operation, the associated equipment and available foams will be evaluated. It is also noted that the U.S. Department of Defense issued specifications for fluorine-free foam (F3) in January 2023. As of August 2023, no commercial products have been certified under these specifications. Section 1.3 has been revised to include, "[a]ll firefighting foams have been removed from the Refinery."
Comment 4:	**Response 4:**
Section 2.0 (Field Investigation Activities), page 7 of 18 states, "[m]any PFAS compounds are potentially mobile in groundwater and are prone to accumulate at air/water and oil/water interfaces (Brusseau 2018, ITRC 2022b). The sampling program described herein has been developed to account for these aspects, with sampling designed to identify potentially mobile PFAS within the bulk water phase (i.e., avoiding interfaces) associated with shallow groundwater." Groundwater samples collected from the bulk water phase may present false-negative results because PFAS accumulates at interfaces. It is more appropriate to collect groundwater samples at a depth where PFAS are likely to accumulate (e.g., air/water interface). Revise the Work Plan to collect PFAS groundwater samples from the air/water and	The Refinery respectfully disagrees that sampling at the water surface in a monitoring well is necessary for the following reasons: • No applicable guidance recommends sample collection from the surface in a monitoring well. • PFAS accumulation at surface interfaces is an area of active research, and understanding of processes governing PFAS accumulation at interfaces remains limited. The state of the science does not support interface sampling for site characterization. • Data generated via sampling a mixture of water at and below the air/water interface would provide an arbitrary mixture that would be difficult to interpret accurately.

NMED Comments	Refinery Responses
oil/water interfaces rather than the bulk water phase, where applicable.	• Sampling protocols from monitoring wells are designed to provide samples that are representative of water within the formation. The processes controlling PFAS interfacial accumulation in a monitoring well would be very different from the processes occurring in porous media (i.e., within the formation). Thus, a sample collected at the air/water interface within a monitoring well would not serve the purpose of being representative of the formation. • Interface water may contain higher PFAS concentrations than within the water column, but the water column is representative of mobile water within the formation, and therefore presents a better indication of risk associated with potential occurrence of PFAS in groundwater. References: ▪ ITRC - Per - and Polyfluoroalkyl Substances 11.1.1 ▪ ITRC - Per - and Polyfluoroalkyl Substances 11.1.7 ▪ ITRC - Per - and Polyfluoroalkyl Substances 11.1.7.2

Response to the New Mexico Environment Department (NMED) To Western Refining Southwest LLC (D/B/A Marathon Gallup Refinery [Refinery]) Disapproval Letter for OW-63 PFAS Investigation Work Plan (May 23, 2023)

NMED Comments	Refinery Responses
Comment 5:	**Response 5:**
Section 2.0 (Field Investigation Activities), page 7 of 18 states, "[g]roundwater sampling [will be conducted] at four existing groundwater monitoring wells (OW-14, OW-57, OW-63, and OW-70). These wells are located cross gradient and down gradient of OW-63 (Figure 1-1)." Address the following: a) All four monitoring wells proposed to be sampled for PFAS are screened to the Chinle/Alluvial Interface. Since many PFAS compounds are potentially mobile in groundwater as stated above Comment 4, the Sonsela aquifer beneath the Fire Training area may potentially be affected by PFAS. Well OW-12 is screened to the Sonsela and located near the Fire Training area. Propose to also collect groundwater samples from well OW-12 for PFAS analysis in the revised Work Plan. b) The screened interval of well OW-14 is submerged under the water table. Comment 4 above directs the Permittee "to collect PFAS groundwater samples from the air/water interface rather than the bulk water phase, where applicable." Well OW-55 is located directly downgradient of the Fire Training area and the screened interval of well OW-55 intersects the water table; thus, well OW-55 allows for collection of groundwater samples at the interface. Add well OW-55 to the list of the proposed wells to be samples in the revised Work Plan.	A) The Refinery will include OW-12 in the revised Work Plan. Section 2.1 – Phase 1: Groundwater Sampling at Existing Monitoring Wells, page 9 of 18, has been revised to state, "[f]ive existing groundwater wells are selected for PFAS sampling" and "[a]dditional information for OW-12, OW-14, OW-63, OW-57, and OW-70…". Figure 1-1, Table 2-1, and Table 2-2 have also been revised to include OW-12. B) The Refinery respectfully disagrees that sampling at OW-55 is necessary at this time. Sampling at OW-55 was directed because "the screened interval of well OW-55 intersects the water table; thus, well OW-55 allows for collection of groundwater samples at the interface." As noted in Response 4, no appropriate entities advise sampling at the water surface within a monitoring well.

Response to the New Mexico Environment Department (NMED) To Western Refining Southwest LLC (D/B/A Marathon Gallup Refinery [Refinery]) Disapproval Letter for OW-63 PFAS Investigation Work Plan (May 23, 2023)

NMED Comments	Refinery Responses
Comment 6:	**Response 6:**
In Section 2.1 (Phase 1: Groundwater Sampling at Existing Monitoring Wells), page 8 of 18, the Permittee states, "[t]he reporting limits for the analytes on Table 2-3 will be dependent upon the lab selected for PFAS analysis. Reporting limits will be evaluated against NMED PFAS screening levels once a lab has been selected." The PFAS reporting limits (e.g., limits of quantitation) must be evaluated prior to the selection of a laboratory. The Permittee must ensure that the laboratory is capable of provided reporting limits lower than applicable PFAS groundwater screening levels (SLs) and soil screening levels (SSLs). Acknowledge this provision in the response letter. No revision is required to the Work Plan.	This comment has been acknowledged.

Response to the New Mexico Environment Department (NMED) To Western Refining Southwest LLC (D/B/A Marathon Gallup Refinery [Refinery]) Disapproval Letter for OW-63 PFAS Investigation Work Plan (May 23, 2023)

NMED Comments	Refinery Responses
Comment 7:	**Response 7:**
Section 2.1.2 (Groundwater Sample Collection), page 8 of 18 states, "[n]o-purge sampling involves collecting water directly from the screened interval after deploying the sampling device in the well for an extended period, thus allowing groundwater within the well to achieve dynamic equilibrium with formation groundwater." The proposed no-purge sampling must be approved by NMED prior to being implemented in the field. The analytical results and water quality parameter readings obtained from no-purge (i.e., passive) sampling and grab (i.e., active) sampling methods must be comparable to be acceptable. If the Permittee chooses to use passive sampling for PFAS analysis, propose to submit a separate work plan that proposes to demonstrate its acceptability. In this case, the submittal due date for the revised Work Plan provided in this letter may be deferred until such demonstration is complete. Alternatively, if the Permittee chooses to propose an active sampling method (e.g., low-flow sampling), revise the Work Plan accordingly.	The Refinery has revised the Work Plan to reflect low flow sampling. Appendix C has been revised from a HydraSleeve™ standard operating procedure (SOP) to a low flow SOP. Low flow sampling methodology allows for the collection of groundwater samples without unnaturally altering or stressing the aquifer. The Work Plan has been revised to describe the low flow sampling techniques. Sections 2.1.2, 2.4, 2.5, and Appendix C have been revised to reflect the low-flow sampling method.

Response to the New Mexico Environment Department (NMED) To Western Refining Southwest LLC (D/B/A Marathon Gallup Refinery [Refinery]) Disapproval Letter for OW-63 PFAS Investigation Work Plan (May 23, 2023)

NMED Comments	Refinery Responses
Comment 8:	**Response 8:**
Section 2.1.2 (Groundwater Sample Collection), page 9 of 18 states, "HydraSleeve™ samplers will be deployed for a minimum of a week and up to four weeks prior to sampling and will be retrieved following procedures described in the SOP." According to Table 2-1 (Summary of PFAS Soil and Groundwater Sample, Identification, Sample Methods, and Analytical Methods), all groundwater samples collected by the HydraSleeve™ samples are identified as "grab" samples. Grab samples refer to instantaneous grab groundwater samples. Since the HydraSleeve™ sampler is deployed for a minimum of a week, it is not clear how it allows collection of grab samples. Provide a clarification in the revised Work Plan. In addition, explain whether the HydraSleeve™ is capable of collecting representative formation water at the air/water interface as required by Comment 4 above in the revised Work Plan (See also Comment 7). Note that the Interstate Technology and Regulatory Council (ITRC) recommends that the passive samplers be installed for a minimum of two weeks. In addition, ITRC states that passive samplers should not be used if the hydraulic conductivity is less than 0.283 feet per day (ft/day), the hydraulic gradient is less than 0.001 or the groundwater velocity is less than 0.5 ft/day. These conditions must be met if the passive samplers are proposed to be used for the investigation.	NMED correctly notes that HydraSleeve™ samples are not "grab" samples. However, the Refinery has chosen to revise the sampling method from HydraSleeve™ to low flow sampling.

Response to the New Mexico Environment Department (NMED) To Western Refining Southwest LLC (D/B/A Marathon Gallup Refinery [Refinery]) Disapproval Letter for OW-63 PFAS Investigation Work Plan (May 23, 2023)

NMED Comments	Refinery Responses
Comment 9:	**Response 9:**
Section 2.1.2 (Groundwater Sample Collection), page 9 of 18 states, "[t]he target sampling depth for each of the wells is the mid-point of the screened interval." Since PFAS accumulates at interface, groundwater samples collected at the mid-point of the screened interval may have a low bias. It is more appropriate to collect groundwater samples at air/water interface where PFAS are likely to accumulate. Propose to collect PFAS groundwater samples from the air/water interface rather than at the mid-point of the screened interval, where applicable. See Comment 4 above.	The Refinery respectfully disagrees that sampling at the air/water interface is appropriate, in accordance with current guidance and best practices. In accordance with the response to Comment 4, the target sample depths will remain as proposed.

Response to the New Mexico Environment Department (NMED) To Western Refining Southwest LLC (D/B/A Marathon Gallup Refinery [Refinery]) Disapproval Letter for OW-63 PFAS Investigation Work Plan (May 23, 2023)

NMED Comments	Refinery Responses
Comment 10:	**Response 10:**
Section 2.2 (Phase 2: Soil Sampling and Temporary Well Installation), page 10 of 18 states, "[s]urface soil samples will be collected at five locations within the OW-63 area based on Phase 1 groundwater data and site topography, as identified on Figure 1-1." Address the following: a) It appears that the PFAS detected from OW-63 are likely to have been released from the Fire Training area. Therefore, it is necessary to collect additional surface soil samples directly within the boundary of the Fire Training area to evaluate for surface soil contamination. Include this provision in the revised Work Plan. b) Since the exact location(s) where firefighting foams were used is unknown, three additional surface soil samples must be collected from the areas where sediment accumulation and drainages are identified within the OW-63 area. Include this provision in the revised Work Plan.	The Refinery respectfully disagrees that surface soil sampling is necessary at the Historical Fire Training Area. The Historical Fire Training Area has been excavated and subsequently capped. Because the excavation removed soil which may have been impacted by historical PFAS contamination, surface soil would not be representative of historical contamination.
Comment 11:	**Response 11:**
Section 2.2.2 (Subsurface Soil Samples), page 10 of 18 states, "Trihydro field staff will prepare continuous boring logs of soil samples to the water table, recording lithology and appearance of the boring, and performing field screening of the soil cores using a photoionization detector (PID)." NMED agrees with the use of a photoionization detector (PID) for field screening because soil and groundwater in the area where the investigation takes place may be contaminated with petroleum hydrocarbons. Evaluate	This comment has been acknowledged. There are currently no field screening tools for PFAS comparable to a PID. Total organic fluorine tools are becoming commercially available, but these would still require subsampling and analysis, and would therefore not be comparable to PID data. At this time there is no effective field screening that the Refinery proposes to use.

NMED Comments	Refinery Responses
whether there is an effective field screening method for PFAS and if so, propose to use that method in the revised Work Plan.	
Comment 12:	**Response 12:**
In Section 3.0 (Analytical Methods), page 13 of 18, the Permittee states, "PFAS analysis will be conducted by a laboratory with PFAS-specific experience, using method 537.1 or equivalent." Table 2-3 (Proposed Groundwater and Soil Sample Constituent List) presents PFAS analytes proposed to be included in this investigation. NMED notes that the proposed analytes are consistent with the PFAS listed in Table 5-2 of the NMED's October 2022 *Risk Assessment Guidance* (RAG). The 2022 RAG currently lists the SLs and SSLs for 12 PFAS species in Appendix A; however, six (6) species (i.e., perfluorobutanesulfonate, perfluorohexanesulfonate, perfluorononoate, perfluorooctanoate, potassium perfluorobutanesulfonate, and potassium perfluorooctanesulfonate) are not included in Table 2-3. Propose to include these six PFAS species as analytes to better assess potential risks associated with PFAS in the revised Work Plan, if practicable. In addition, include the values of SLs and SSLs and reporting limits (e.g., limit of quantitation) for each analyte in Table 2-3, where applicable.	PFAS compounds may occur in different forms, including acid, anion, or salt. For example, perfluorobutanesulfonic acid (acid form), perfluorobutanesulfonate (anion form), and potassium perfluorobutanesulfonate (salt form) all refer to the same compound. In water, these PFAS compounds are present in mostly the anion form; laboratories may report results in one of the other forms, but whether reported in the acid, anion, or salt form, the results still refer to the same constituent. Each of the constituents in this list have already been included in Table 2-3, in the acid form and no changes have been made. Screening levels have not been added to Table 2-3. A laboratory has not been selected for the investigation and screening levels may be changed before the sampling event occurs. The Refinery will ensure that laboratory detection levels will be able to achieve the screening levels listed in Table 5-2 of the NMED Risk Assessment Guidance.

Response to the New Mexico Environment Department (NMED) To Western Refining Southwest LLC (D/B/A Marathon Gallup Refinery [Refinery]) Disapproval Letter for OW-63 PFAS Investigation Work Plan (May 23, 2023)

NMED Comments	Refinery Responses
Comment 13:	**Response 13:**
Table 2-3 (Proposed Groundwater and Soil Sample Constituent List) indicates that the target analytes are only PFAS for this investigation. Since the soil and groundwater samples collected for the investigation may also be contaminated with petroleum hydrocarbons, the Permittee must propose to include total petroleum hydrocarbons (TPH) analysis as well in the revised Work Plan.	The Refinery respectfully disagrees that TPH analysis is necessary at this time. TPH is present in the subsurface at this refinery facility. Impacts have been well-characterized and are being actively managed. TPH impact is not relevant to this Work Plan.

ATTACHMENT B

OW-63 PFAS Investigation Work Plan

Western Refining Southwest LLC
Gallup Refinery
Gallup, New Mexico

EPA ID# NMD000333211

December 31, 2022
Revised September 29, 2023

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List of Acronyms

AFFF	aqueous film forming foams
CLP	Contract Laboratory Program
COC	chain of custody
DP	direct push
EDD	electronic data deliverables
ft/day	foot/feet per day
HDPE	high-density polyethylene
I-40	Interstate 40
IDW	investigation derived waste
LCS/LCSD	laboratory control samples/laboratory control sample duplicates
MS/MSD	matrix spike/matrix spike duplicates
NM	New Mexico
NMED	New Mexico Environment Department
PE	polyethylene
PFAS	per- and polyfluoroalkyl substances
PFBS	perfluorobutane sulfonate
PFOA	perfluorooctanoic acid
PFOS	perfluorooctane sulfonate
PID	photoionization detector
PPE	personal protective equipment
PVC	polyvinyl chloride
QA/QC	quality assurance and quality control
QSM	Quality System Manual
SOP	standard operating procedure
SPH	separate phase hydrocarbons
USEPA	United States Environmental Protection Agency
VOC	volatile organic compound

1.0 Introduction

Trihydro Corporation (Trihydro) has prepared this per- and polyfluoroalkyl substances (PFAS) Investigation Work Plan (Work Plan) to conduct PFAS sampling in soil and groundwater near monitoring well OW-63 at the Gallup Refinery (Refinery). Figure 1-1 shows the site location and the area surrounding OW-63. This Work Plan was developed per New Mexico Environment Department's (NMED) request in Comment 12 of the "Approval with Modifications 2021 Annual Groundwater Monitoring Report" (NMED 2022), dated August 23, 2022: "…a PFAS plume may be present in the vicinity of OW-63. Submit a work plan to investigate the extent of the PFAS contamination no later than December 31, 2022".

The following objectives were developed to address NMED's comment:

- Identify PFAS-containing materials near OW-63.
- Identify areas where potential PFAS-containing materials have been potentially stored and/or used near OW-63.
- Describe a proposed sampling and analysis plan for various environmental matrices that delineates the extent of PFAS contamination near OW-63.

1.1 Background

Built in the 1950s, the Refinery is located within a rural and sparsely populated area east of Gallup, New Mexico (NM). The nearest population centers are the Pilot Flying J Travel Center refueling plaza, the Interstate 40 (I-40) corridor, and a small cluster of residential homes located on the south side of I-40 approximately 2 miles southwest of the Refinery (Jamestown, NM).

The Refinery was indefinitely idled on October 9, 2020. During operation, the Refinery was a crude oil refining and petroleum products manufacturing facility. There were no organic chemicals, plastics, or synthetic fibers manufactured that contributed to the process flow of wastewater. The Refinery did not manufacturer lubricating oils. As a result of the processing steps, the Refinery produced a wide range of petroleum products including propane, butane, unleaded gasoline, diesel, residual fuel, and commercial products of fertilizer and solid elemental sulfur.

Historically, the Refinery primarily received crude oil via two 6-inch diameter pipelines, which entered the Refinery property from the north (Four Corners Area). In addition, the Refinery also received natural gasoline feedstock via a 4-inch diameter pipeline that came in from the west along the I-40 corridor from the Western Refining Southwest LLC Wingate Plant, which is also indefinitely idled. Crude oil and other products also arrived at the Refinery via railroad cars. These feed stocks were then stored in tanks until refined into products.

Trihydro conducts groundwater sampling for PFAS at OW-63 on a quarterly basis. PFAS sampling in OW-63 began with NMED's request in Comment 30 in the "Disapproval Annual Groundwater Monitoring Report Gallup Refinery – 2019" (NMED, 2020) dated November 23, 2020: "…Well OW-63 is appropriately located to evaluate for the presence of PFAS in the vicinity of the training area. Propose to conduct PFAS analysis for the groundwater samples collected from well OW-63 in the 2021 Facility-wide Groundwater Monitoring Work Plan." These results are included in the annual groundwater monitoring reports and in Appendix A. Currently, no other wells at the Refinery are sampled for PFAS.

The sections below describe site hydrogeology and PFAS-containing materials likely used at the refinery. More information regarding site background and hydrology can be found in the annual groundwater work plans and reports.

1.2 Hydrogeology

Groundwater flow within the shallow alluvium and the upper Chinle Formation is highly variable due to the presence of complex and irregular stratigraphy including sand stringers, cobble beds, and dense clay layers. Hydraulic conductivity ranges from 30 feet per day (ft/day) for gravel-like sands immediately overlying the Petrified Forest Formation to 3×10^{-5} ft/day in the clay soils located near the surface. Groundwater flow within the Lower Chinle Formation is extremely slow and typically averages less than 2.83×10^{-7} ft/day (i.e., less than 0.01 ft per year).

Water level data are collected routinely at the Refinery. Wells at the Refinery have been categorized based on the hydrogeologic unit in which they are screened, including the alluvial/fluvial upper sand aquifer, the Chinle/alluvium aquifer, and the Sonsela Sandstone aquifer. The alluvial/fluvial upper sand aquifer has a limited lateral extent, existing only on the western margin of the Refinery. Groundwater occurrence in this aquifer is sporadic and limited.

Most of the wells monitored lie within the shallow weathered sediments that comprise the Chinle/alluvium aquifer. Within the Chinle/alluvium aquifer, shallow groundwater located under the Refinery property generally flows along the upper contact of the Chinle Formation. The prevailing flow is from the southeast to the northwest, although localized areas may have varying flow directions based on the subsurface geology.

Groundwater within the Sonsela aquifer flows southeast to northwest. Hydraulic heads measured within the Sonsela are generally lower than those observed within the shallow aquifer near the topographic high on which the Refinery process area and tank farm are situated, and higher than those observed within the shallow aquifer in topographically low areas to the west and northwest, near the evaporation ponds. The higher head in the Sonsela in low areas is due to confining pressure from lower permeability Chinle Formation bedrock between the shallow Chinle/alluvium aquifer and the Sonsela Sandstone bed at depth, which makes the Sonsela Sandstone aquifer artesian. Figures 1-2, 1-3, 1-4, and 1-5 show quarterly potentiometric surface maps for the investigation area.

1.3 PFAS-Containing Materials at the Refinery

Since the 1950s, PFAS have been incorporated into many consumer and industrial products. One of the many historical uses is in firefighting foams ("Aqueous Film Forming Foams," or AFFF). AFFF products may be used for fire suppression at facilities where Class B fires (i.e., those involving flammable liquids and gases) may be a concern, including airports, firefighting training areas, and other facilities where flammable hydrocarbons are present. AFFF formulations include hundreds to thousands of individual fluorinated and non-fluorinated surfactant compounds. Perfluorooctanoic acid (PFOA), perfluorooctane sulfonate (PFOS), and perfluorohexane sulfonate (PFHxS) are potential PFAS constituents in AFFF products, particularly in those produced between the 1960s and 1990s (ITRC 2022a). Modern AFFF products contain little to no PFOA or PFOS but may contain short-chain PFAS compounds such as perfluorobutane sulfonate (PFBS).

Firefighting is a component of petroleum refinery management. AFFF has been stored and historically used for fire suppression at the Refinery. Located to the northwest of OW-63 is the former Fire Training Area, where PFAS-containing foam was confirmed to be used. OW-63 is located downgradient of the Tank Farm and cross gradient of the former Fire Training Area. There are no known applications of PFAS-containing foam in the Tank Farm area immediately adjacent to OW-63. All firefighting foams have been removed from the Refinery.

2.0 Field Investigation Activities

Many PFAS compounds are potentially mobile in groundwater and are prone to accumulate at air/water and oil/water interfaces (Brusseau 2018, ITRC 2022b). The sampling program described herein has been developed to account for these aspects, with sampling designed to identify potentially mobile PFAS within the bulk water phase (i.e., avoiding interfaces) associated with shallow groundwater. The sections below describe the sampling locations, field methods for groundwater sampling and soil sampling, and details of temporary well installation.

This field investigation will be completed in a three-phase plan:

- Phase 1: Groundwater sampling at four existing groundwater monitoring wells (OW-12, OW-14, OW-57, OW-63, and OW-70). These wells are located cross gradient and down gradient of OW-63 (Figure 1-1).
- Phase 2: Soil sampling at five surface locations and three soil boring locations. The three soil boring locations will be constructed as temporary groundwater monitoring wells. Exact locations for the surface sample locations and temporary monitoring wells will be chosen based on groundwater analytical results from Phase 1.
- Phase 3: Groundwater sampling at the three temporary well locations.

Phase 1 of the investigation will be implemented so analytical results from existing groundwater monitoring wells can be used to determine the most beneficial locations for the temporary groundwater monitoring wells. Groundwater samples will be obtained from existing groundwater monitoring wells during Phase 1. After the Phase 1 investigation is complete, the Refinery will schedule a meeting with NMED to discuss and agree upon proposed Phase 2 sample locations.

The Phase 2 soil sampling and temporary groundwater monitoring well installations will occur during the same field event after Phase 1 analytical data are received. Soil sampling will involve surface sample collection and the drilling of boreholes using direct push drilling techniques. Phase 3 of the investigation is for the collection of groundwater samples, which will occur after the temporary groundwater monitoring wells have been installed for a minimum of seven days. Supporting activities include utility location, boring abandonment, waste management, and equipment decontamination. A handheld global positioning system unit will be used to log location coordinates for utilities, soil sampling locations, and the temporary monitoring wells. Table 2-1 presents a summary of the proposed soil and groundwater sample identifications, sample methods, sample type, constituents, and analytical methods.

Sampling will be conducted by experienced PFAS sampling personnel who will review and be familiar with the prohibited material list, in terms of clothing, personal protective equipment (PPE), sunscreens, insect repellent, rain-repellent gear, and other sampling equipment that are prohibited when sampling for PFAS as to prevent cross-contamination. Care will be taken to ensure that any materials contacting sample containers, from the time of removal from laboratory-supplied coolers through completion of sampling, comply with Table 1 of

Trihydro's PFAS Standard Operating Procedure (SOP) (Appendix B). A fresh pair of powderless nitrile gloves will be worn at each location, and gloves will be changed immediately before collecting each sample, in accordance with the SOP. Additional hand washing before donning of the new pair of gloves is necessary if the old pair was compromised or ungloved hands touched items that may contain PFAS. Sampling procedures will be reviewed prior to field activities to identify potential conflicts between site PPE requirements and PFAS-compatible materials. If conflicts are identified, procedures will be developed to minimize PFAS cross-contamination risks without compromising the Refinery's health and safety procedures.

2.1 Phase 1: Groundwater Sampling at Existing Monitoring Wells

The former Fire Training Area was identified as a potential PFAS-containing foam application area at the Refinery. Based on this identification, five existing groundwater wells are selected for PFAS sampling. Figure 1-1 provides the sample well locations. Additional information for OW-12, OW-14, OW-63, OW-57, and OW-70, including the screened interval, depth to groundwater, and total measured depth of well, is shown in Table 2-2. Groundwater samples will be analyzed for the PFAS parameters listed in Table 2-3. The reporting limits for the analytes on Table 2-3 will be dependent upon the lab selected for PFAS analysis. Reporting limits will be evaluated against NMED PFAS screening levels once a lab has been selected.

2.1.1 Fluid Level Monitoring

Fluid levels will be monitored in all wells prior to sampling using an interface probe. Fluid level monitoring will be conducted to evaluate for the presence of separate phase hydrocarbons (SPH) in wells and measure depth to groundwater. Historically, the wells selected for groundwater sampling have not had SPH in them. The interface probe will only be used to measure the fluid surface and SPH thickness (total depth will not be measured as part of the PFAS sampling event) to limit cross-contamination by minimizing contact between groundwater and the interface probe. Any well with detectable SPH will be removed from the monitoring list for this event and, if possible, an alternative well will be selected. The interface probe will be decontaminated prior to first use, and between each monitoring well, using PFAS-compatible methods in accordance with Appendix B.

2.1.2 Groundwater Sample Collection

Groundwater samples will be collected from monitoring wells OW-12, OW-14, OW-63, OW-57, and OW-70 using low flow sampling techniques and analyzed for PFAS compounds (Table 2-3). Low-flow or no-purge sampling approaches are generally preferred for PFAS sampling. PFAS may be associated with suspended solids, droplets of SPH, or entrained gas bubbles, any of which may be mobilized via high-volume purging sampling methods. Low flow sampling involves collecting groundwater directly from the screened interval without disturbing stagnant water above the screen. This is accomplished by pumping the well at low enough flow rates to maintain minimal drawdown of the water column.

Groundwater sampling for PFAS compounds will be conducted using low flow sampling methods in general accordance with the following guidance documents:

- Trihydro's PFAS SOP, included in Appendix B
- Trihydro's SOP for low flow sampling, included in Appendix C

Since this method is not based upon the removal of well volumes, it requires in-line monitoring of water-quality parameters (i.e., pH, specific conductivity, temperature, dissolved oxygen, redox potential) to determine when the groundwater to be sampled has stabilized. Stabilization occurs when three consecutive readings of water-quality parameters are within 10 percent. The sample is then collected, using the same pump, directly from the discharge tubing. Wells with dedicated pumps (i.e., OW-12 and OW-63) will be noted on the field logs and will use existing equipment in place.

Prior to placing the discharge line of the pump into the well, the sampler will verify the screened interval of the well to determine the length of discharge line to be placed in the well. The target sampling depth for each of the wells is the mid-point of the screened interval. This information is used to ensure that the samples are collected within the screened interval, and that water samples are representative of the formation. They will also verify the recharge capacity of the well to determine what flow the pump will be set at so that draw down is not occurring.

Sample containers will be filled immediately from the pump discharge line. Bottles will be filled in accordance with the low flow SOP and laboratory instructions. After being filled, sample containers will be placed in a cooler with double-bagged water-based ice (i.e., Blue Ice^{TM} or similar substitute materials are prohibited) for shipment.

To the extent practical, disposable sampling equipment will be used at each location to minimize the potential disturbance of formation groundwater and to reduce the risk of cross-contamination. Furthermore, all down-hole monitoring or sampling equipment will not contain or be coated with Teflon® or other PFAS-incompatible materials (Appendix B). If reusable equipment is required, decontamination will occur as described in Section 2.5.

Equipment to be used during field sampling will be examined to certify that it is in operating condition. This includes checking the manufacturer's operating manual, as well as the instructions for each instrument, to ensure that maintenance requirements are being observed. Sample coolers will be shipped to an analytical laboratory via overnight delivery under chain of custody (COC) protocol.

2.2 Phase 2: Soil Sampling and Temporary Well Installation

Surface soil samples will be collected at five locations within the OW-63 area based on Phase 1 groundwater data and site topography, as identified on Figure 1-1. In addition, surface and subsurface soil samples will be collected from the three proposed temporary groundwater monitoring well boreholes that will be installed within the OW-63 area based on Phase 1 groundwater data, as identified on Figure 1-1. All soil samples will be analyzed for the PFAS parameters listed in Table 2-3.

2.2.1 Surface Soil Sampling

Surface soil samples will be collected from 0 to 1 ft below ground surface (ft bgs). Soil samples will be collected using a PFAS-free disposable hand trowel. At each location, a new hand trowel will be used. Sampling information will be recorded on an example log provided in Appendix D-1.

2.2.2 Subsurface Soil Sampling

Subsurface soil sampling will be conducted using a direct-push (DP) drilling rig capable of advancing continuous soil sample barrels. DP soil sampling will be conducted at three locations to be determined based on analytical results from Phase 1 of the investigation. Soil samples will be collected from the borings at two intervals: the surface (0 to 1 ft bgs) and 1 ft above the water table (approximately 17 to 34 ft-bgs).

Soil sample barrels will be decontaminated prior to each boring. Samples will be collected in an acetate liner or approved equivalent. The acetate sleeve containing the sample interval will be split in half and samples will be transferred directly from the sleeve to a lab-provided sample jar. For these locations, Trihydro field staff will prepare continuous boring logs of soil samples to the water table, recording lithology and appearance of the boring, and performing field screening of the soil cores using a photoionization detector (PID). An example boring log is shown in Appendix D-2.

2.2.3 Temporary Well Installation

Three proposed temporary wells will be completed in the soil borings installed as described in Section 2.2.2. The locations will be determined based on the analytical results from the groundwater sampling in the existing monitoring wells. Temporary wells will be completed with schedule 40 polyvinyl chloride (PVC). Slotted (0.01 inch) PVC well screen will be placed at the bottom of soil borings completed as a temporary well completion. The screen will extend 10 to 15 ft to ensure that the well is screened across the water table. A 10/20 sand filter pack will be installed to 2 ft above the top of the well screen. The well will be completed to the surface with bentonite chips.

2.3 Phase 3: Groundwater Sampling at Temporary Wells

After temporary well completion, the wells will be left to stand for a minimum of 7 days to allow for the possible entry of SPH into the well, if present. After a minimum of 7 days, the temporary wells will be gauged and sampled using the same methods described in Sections 2.1.1 and 2.1.2.

After groundwater samples are collected from the temporary wells, the PVC casing and well screen will be pulled and all borings will be abandoned with bentonite chips, pellets, or grout, from the bottom of the boring to the ground surface. Bentonite chips or pellets placed above the water table will be hydrated with at least 1 gallon of water per 5 feet of boring.

2.4 Investigation Derived Waste

Investigation derived waste (IDW) will include solid IDW (drill cuttings and excess direct-push soil), liquid phase IDW (purged water), and debris (used acetate liners, nitrile gloves, etc.). IDW will be labeled appropriately to identify the generator, contents, date of generation, and provide contact information.

Solid phase IDW will be stored in a lined roll-off container or in sealed Department of Transportation-rated drums at a location to be determined at the site, pending waste characterization. Solid phase IDW is not expected to be characteristically hazardous but may contain PFAS or volatile organic compounds (VOCs) at concentrations requiring disposal at an appropriately licensed solid waste facility. After all solid phase IDW is accumulated, Trihydro will collect a composite sample for waste characterization. Analytical requirements will depend on the receiving solid waste facility and will be determined prior to disposal. IDW will be transported to the disposal facility by a licensed waste hauler.

Liquid phase IDW will be stored in drums at a location to be determined at the site pending characterization for disposal. Liquid phase IDW is not expected to be characteristically hazardous but may contain PFAS or VOCs at concentrations requiring disposal at an appropriately licensed facility. After all liquid phase IDW is accumulated, Trihydro will collect a composite sample for waste characterization. Analytical requirements will depend on the receiving facility and will be determined prior to disposal. IDW will be transported to the disposal facility by a licensed waste hauler.

Investigation debris will be disposed of as non-hazardous municipal waste at a local landfill.

2.5 Equipment Decontamination

Reusable sampling and drilling equipment will be decontaminated between samples using Alconox or a pressure washer, followed by rinsing with PFAS-free potable water. When not in use, cleaned reusable sample equipment will be stored in HDPE plastic bags or sheeting to minimize the potential for cross-contamination.

PFAS tend to adhere to sampling equipment and have been noted in certain detergents. To the extent practical, disposable equipment will be used for each monitoring/temporary well. Reusable sampling components will be decontaminated, for potential future redeployment in the same well, in accordance with Trihydro's SOP (Attachment A) with the following notes/modifications. Specifically, decontamination will also be required for the interface probe and will be performed between each well to reduce the risk of cross-contamination. Decontamination of the reusable components will consist of three steps:

1. Wash in Alconox or Liquinox detergents (Decon 90 is on the prohibited material list and will not be used).
2. Triple rinse with distilled water.
3. Final triple-rinse with commercially available or laboratory-provided PFAS-free deionized water in an HDPE container.

If necessary, sampling equipment will be scrubbed using a polyethylene (PE) or polyvinyl chloride (PVC) brush to remove particulates prior to completing the decontamination steps listed above.

3.0 Analytical Methods

PFAS analysis will be conducted by a laboratory with PFAS-specific experience, using method 537.1 or equivalent that utilizes isotope dilution and is compliant with Quality Systems Manual (QSM) version 5.3 (or later) Table B-15. Promulgated United States Environmental Protection Agency (USEPA) Methods 533 and 537 are both specified as drinking water methods and cannot be applied to the sample matrices collected in this event. There are no promulgated USEPA methods for analyzing PFAS in groundwater (Method 1633 is still in draft form). As such, the analytical results for these media using standardized drinking water methods, or non-standardized laboratory specific methods, must be interpreted with caution. Additional discussion is provided in Appendix B.

The selected laboratory will provide fully documented commercial-type data packages (e.g., equivalent to full USEPA Contract Laboratory Program data packages) for all analytical results and electronic data deliverables (EDDs).

4.0 Quality Assurance And Quality Control

This section addresses the qualitative and quantitative criteria that will be used to evaluate the quality of the field and analytical data collected during the field activities.

4.1 Field Quality Assurance and Quality Control Samples

Five kinds of field quality assurance and quality control samples (QA/QC) will be collected during the sampling event as described below.

1. Duplicate Samples. Duplicate samples will be collected to evaluate precision associated with the reproducibility of sampling techniques and the homogeneity of sample matrices. One duplicate sample will be collected per matrix, and at a minimum frequency of 10%, or one for every 10 samples. The duplicate sample will be "blind" to the laboratory; therefore, it will have a coded identity on its label and on the COC. The actual sampling location and identification will be recorded on the sampling log.
2. Trip Blanks. Trip blanks are generally not required for PFAS samples but may be helpful to identify sources of contamination, should they occur. A trip blank, comprising PFAS-free water supplied by the laboratory, will accompany each cooler that contains PFAS samples. Experience has shown that cross-contamination at analytical laboratories can lead to spurious PFAS detections. The trip blanks prepared by the laboratory can point to the reagent water used by the laboratory as a source of contamination not related to field sampling procedures.
3. Field Blanks. Field blanks will be collected in the vicinity of the project area. Field blanks will be collected by pouring laboratory provided PFAS-free water into the appropriate containers and submitted for PFAS analysis. A field blank will be collected at each separate groundwater well, groundwater, and soil sampling event.
4. Equipment Blanks. Equipment blanks will be prepared and submitted for laboratory analysis to assess sampling equipment for potential PFAS impacts and to verify that equipment decontamination procedures are effective. One equipment blank will be collected for groundwater samples from the interface probe to verify that decontamination procedures are effective. Additional equipment blanks will be collected from the trowels to verify that each of the batches received from the manufacturer is PFAS free.
5. Matrix Spike/Matrix Spike Duplicates (MS/MSD). MS/MSDs will be prepared and analyzed by the laboratory for each matrix sampled. The following MS/MSDs will be collected: one from a permanent groundwater well and one from a temporary groundwater well. MS/MSDs are samples in which known quantities of specific PFAS compounds are added before extraction and analyses. The recoveries for spiked compounds can be used to assess how well the method for analysis recovers target compounds.

4.2 Laboratory Assurance and Quality Control Samples

QA/QC samples will be analyzed by the laboratory. The laboratory will follow proper QA/QC procedures, including laboratory blanks, duplicates, and spiked samples for calibration and identification of potential matrix effects. Data from the QC samples are used as a measure of performance and as an indicator of potential sources of cross-contamination. In addition, for PFAS analysis, the laboratory will follow QC procedures compliant with QSM Table B-15 QC. QC data generated by the laboratory are submitted with the results in the fully documented commercial type data packages.

1. MS/MSD. MS/MSD will be performed if sufficient sample is recovered and indicated on the COC. If not, lab will perform laboratory control samples (LCS) and laboratory control sample duplicates (LCSD).
2. Surrogate Spiking. Surrogate compounds are added before sample preparation for organics to all samples prior to extraction and analysis. The review for surrogate compounds can be used to assess method accuracy for each sample matrix.

4.3 Data Validation

Analytical data received from the laboratory will undergo Trihydro's data validation process. Minimally, data will be evaluated by the Tier I and Tier II data validation process. Trihydro uses the following guidance documents for validation of organic and inorganic data:

- Data for organic analyses are evaluated according to validation criteria set forth in the USEPA Contract Laboratory Program (CLP) National Functional Guidelines for Organic Superfund Methods Data Review, document number EPA-540-R-20-005, November 2020 with additional reference to the USEPA CLP National Functional Guidelines for Organic Data Review, document number EPA 540/R-99/008, October 1999.

- Review of PFAS data will also use criteria set forth in the Department of Defense / Department of Energy QSM for Environmental Laboratories, Version 5.3, 2019. This reference document has specific criteria for review of PFAS data in Appendix C, Table B-15 that are used in conjunction with the National Functional Guidelines.

- Data for inorganic analyses is evaluated according to validation criteria set forth in the USEPA CLP National Functional Guidelines for Inorganic Superfund Methods Data Review, document number EPA-542-R-20-006, November 2020 with additional reference to the USEPA CLP National Functional Guidelines for Inorganic Data Review, document number EPA 540-R-04-004, October 2004.

- Review of field duplicates will be conducted according to the USEPA Region 1 - New England Environmental Data Review Supplement for Region 1 Data Review Elements and Superfund Specific Guidance/Procedures, EQADR-Supplement2, September 2020.

Precision, accuracy, method compliance, and completeness of the data packages will be assessed during the data validation process. Precision is determined by evaluating the calculated relative percent difference values from: laboratory duplicate pairs, MS/MSD pairs, and LCS/LCSD pairs. Laboratory accuracy is established by reviewing the demonstrated percent recoveries of the following items to identify potential biases in the analytical data: MS/MSD samples, LCS/LCSD samples, and organic system monitoring compounds (surrogates). Field accuracy is established by collecting and analyzing field QA/QC samples to monitor for possible ambient or cross-contamination during sampling and transportation. Method compliance is established by reviewing sample integrity, holding times, detection limits, surrogate recoveries, laboratory blanks, initial and continuing calibrations (where applicable), and the LCS/LCSD percent recoveries against method-specific requirements. Completeness is evaluated by determining the overall ratio of the number of samples and analyses planned versus the number of samples with valid analyses. Determination of completeness includes a review of the COC, laboratory analytical methods, and other laboratory and field documents associated with the analytical data set

5.0 Schedule and Reporting

The scheduling of field activities associated with the Work Plan are dependent upon regulatory review and approval. Field coordination will commence upon written approval of the Work Plan by NMED. Trihydro estimates the field portion of the Work Plan will take approximately one to two weeks to complete over several months due to the phased approach. Phase 1 through 3 of the investigation are planned to be completed in 2023, pending written Work Plan approval. Interpretation of results and preparation of documents are planned to be completed in late 2023 or early 2024, pending field investigation.

The final report will include the following:

1. A description of the sampling activities performed and deviations from the Work Plan
2. A summary table of the analytical results (including QA/QC samples)
3. A copy of the COC forms
4. A copy of the field sampling logs
5. A copy of existing monitoring well construction details and historical survey data for OW-12, OW-14, OW-57, OW-63, and OW-70
6. A copy of the site map showing the sampling/monitoring locations
7. A copy of laboratory certified analytical results

6.0 References

Armstrong, M., M.J. Seitz, F. Beetle-Moorcroft, and D.S. Lipson. 2020. No-Purge Groundwater Sampling for PFAS. Groundwater–Vol. 58, No. 6. November-December 2020.

Brusseau. 2018. Assessing the Potential Contributions of Additional Retention Processes to PFAS Retardation in the Subsurface. Science of the Total Environment 613–614 (2018) pp. 176–185.

Interstate Technology Regulatory Council (ITRC). 2022a. History and Use of Per- and Polyfluoroalkyl Substances (PFAS) Found in the Environment. Updated July 2022. Available from: https://pfas-1.itrcweb.org/wp-content/uploads/2022/09/HistoryandUse_PFAS_Fact-Sheet_090722_508.pdf.

ITRC. 2022b. Fate and Transport of Per- and Polyfluoroalkyl Substances (PFAS). July 2022. Available from: https://pfas-1.itrcweb.org/wp-content/uploads/2022/09/FT_PFAS_Fact_Sheet_083122_508.pdf.

NMED. 2020. Disapproval Annual Groundwater Monitoring Report Gallup Refinery - 2019, Western Refining Southwest LLC, Gallup Refinery, McKinley County, Gallup, New Mexico, EPA ID #NMD000333211, HWB-WRG-20-013. November 23.

NMED. 2022. Approval with Modifications 2021 Annual Groundwater Monitoring Report, Western Refining

Southwest LLC, Gallup Refinery, McKinley County, Gallup, New Mexico, EPA ID #NMD000333211, HWB-WRG-22-006. October 18.

Figures

EXPLANATION

● OW–12	CHINLE / ALLUVIUM AQUIFER WELL AND DESIGNATION (WELLS FOR GROUNDWATER SAMPLING DURING PHASE 1)
⌗ RW–5	RECOVERY WELL AND DESIGNATION
🟩	PROPOSED TEMPORARY WELL AND SOIL INVESTIGATION AREA (SEE NOTE A)
–×–	FENCE LINE

PFAS HEALTH ADVISORY LEVELS

CONCENTRATION IN PARTS PER TRILLION		SOURCE
PFOA+PFOS+PFHxS[4]	70	NMED HEALTH ADVISORY
PFBS[5,6]	2000	FINAL HEALTH ADVISORY LIMIT (UPDATED AS OF 6/15/2022)
PFOA[5,6]	0.004	2022 INTERIM HAL UPDATED (UPDATED AS OF 6/15/2022)
PFOS[5,6]	0.02	2022 INTERIM HAL UPDATED (UPDATED AS OF 6/15/2022)

NOTES:

A. THREE TEMPORARY WELLS AND FIVE SURFACE SAMPLES WILL BE LOCATED WITHIN THE INVESTIGATION AREA BASED ON EXISTING WELL GROUNDWATER RESULTS RECEIVED DURING PHASE 1

B. ALL CONCENTRATIONS ARE REPORTED IN NANOGRAMS PER LITER (ng/L) WHICH IS EQUIVALENT TO PARTS PER TRILLION (ppt)

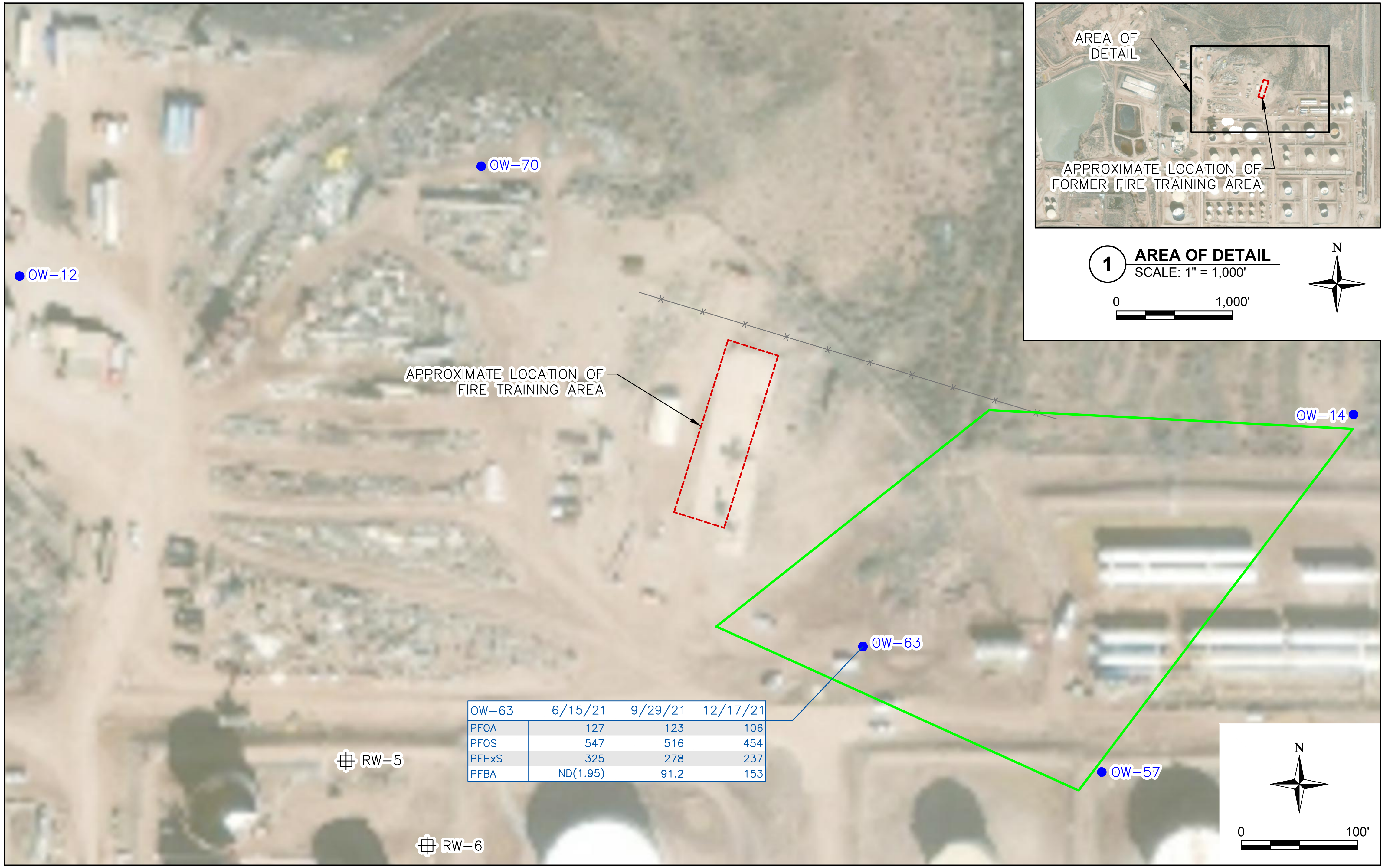
C. PFAS = PER- AND POLYFLUOROALKYL SUBSTANCES

D. COC = CONSTITUENT OF CONCERN

E. PFBS = PERFLUOROBUTANE SULFONATE

F. HAL = HEALTH ADVISORY LEVELS

G. HFPO = HEXAFLUOROPROPYLENE OXIDE



OW–63	6/15/21	9/29/21	12/17/21
PFOA	127	123	106
PFOS	547	516	454
PFHxS	325	278	237
PFBA	ND(1.95)	91.2	153

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ANALYTE TABLE EXPLANATION

WELL DESIGNATION → OW–63; 6/15/21 ← SAMPLE DATE

OW–63			6/15/21
PFOA[1,2]	5	0.46	5
PFOS[1,2]	N/A	2.8	N/A
PFHxS[2]	5	0.17	3.8
PFBA[3]	N/A	0.46	N/A

PERFLUOROOCTANOIC ACID → PFOA
PERFLUOROOCTANE SULFONIC ACID → PFOS
PERFLUOROHEXANE SULFONATE → PFHxS
PERFLUOROBUTANOIC ACID → PFBA

NOTES:

1. EPA IDENTIFIED PFOS COC
2. NMED IDENTIFIED PFOS COC
3. NOT AN EPA/NMED PFOS COC; HOWEVER, HIGH MOBILITY. DATA PROVIDED FOR INFORMATION.
4. NEW MEXICO ENVIRONMENT DEPARTMENT, RISK ASSESSMENT GUIDANCE FOR SITE INVESTIGATIONS AND REMEDIATION, VOLUME I, SOIL SCREENING GUIDANCE FOR HUMAN HEALTH RISK ASSESSMENTS, APPENDIX E, NOVEMBER 2021.
5. HAL FOUND AT https://www.epa.gov/system/files/documents/2022-06/prepublication-four-pfas-june-2022.pdf
6. HAL FOUND AT https://www.trihydro.com/news/news-details//2022/06/15/epa-announces-new-health-advisory-levels-for-pfas-%241b-in-funding

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FIGURE 1-1
GROUNDWATER AND SOIL SAMPLING LOCATION MAP
OW-63 PFAS INVESTIGATION WORK PLAN
WESTERN REFINING SOUTHWEST LLC
GALLUP REFINERY
GALLUP, NEW MEXICO

Drawn By: REP	Checked By: CF	Scale: AS SHOWN	Date: 9/13/23	File: 697-PFAS_OW-202309

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EXPLANATION

● OW-64 6939.65	CHINLE / ALLUVIUM AQUIFER WELL AND DESIGNATION (SHOWING GROUNDWATER ELEVATION IN FEET ABOVE MEAN SEA LEVEL)
● OW-63 6913.13	WELL AND DESIGNATION FOR GROUNDWATER SAMPLING DURING PHASE 1 (SHOWING GROUNDWATER ELEVATION IN FEET ABOVE MEAN SEA LEVEL)
6938	LINE OF EQUAL ELEVATION OF POTENTIOMETRIC SURFACE (FEET ABOVE MEAN SEA LEVEL, DASHED WHERE INFERRED)
←	ESTIMATED GROUNDWATER FLOW DIRECTION
● MKTF-50	SPH MONITORING WELL AND DESIGNATION
● OW-12	SONSELLA MONITORING WELL AND DESIGNATION
⌖ RW-1	RECOVERY WELL
NM	NOT MEASURED
SPH	SEPARATE-PHASE HYDROCARBON

N

0 100' 200'

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FIGURE 1-2

POTENTIOMETRIC SURFACE MAP
(DECEMBER 2021)
OW-63 PFAS INVESTIGATION WORK PLAN
WESTERN REFINING SOUTHWEST LLC
GALLUP REFINERY
GALLUP, NEW MEXICO

Drawn By: REP	Checked By: BB	Scale: 1" = 100'	Date: 11/10/2022	File: 697-PFAS_OW-PS-202112

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EXPLANATION

● OW−64 6939.65	CHINLE / ALLUVIUM AQUIFER WELL AND DESIGNATION (SHOWING GROUNDWATER ELEVATION IN FEET ABOVE MEAN SEA LEVEL)
● OW−63 6913.13	WELL AND DESIGNATION FOR GROUNDWATER SAMPLING DURING PHASE 1 (SHOWING GROUNDWATER ELEVATION IN FEET ABOVE MEAN SEA LEVEL)
— 6938 − −	LINE OF EQUAL ELEVATION OF POTENTIOMETRIC SURFACE (FEET ABOVE MEAN SEA LEVEL, DASHED WHERE INFERRED)
←	ESTIMATED GROUNDWATER FLOW DIRECTION
● MKTF−50	SPH MONITORING WELL AND DESIGNATION
● OW−12	SONSELLA MONITORING WELL AND DESIGNATION
⌖ RW−1	RECOVERY WELL
NM	NOT MEASURED
SPH	SEPARATE-PHASE HYDROCARBON

N

0 100' 200'

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FIGURE 1-3
POTENTIOMETRIC SURFACE MAP
(MARCH 2022)
OW-63 PFAS INVESTIGATION WORK PLAN
WESTERN REFINING SOUTHWEST LLC
GALLUP REFINERY
GALLUP, NEW MEXICO

Drawn By: REP | Checked By: BB | Scale: 1" = 100' | Date: 11/2/2022 | File: 697-PFAS_OW-PS-202203

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EXPLANATION

● OW-64 6939.65	CHINLE / ALLUVIUM AQUIFER WELL AND DESIGNATION (SHOWING GROUNDWATER ELEVATION IN FEET ABOVE MEAN SEA LEVEL)
● OW-63 6913.13	WELL AND DESIGNATION FOR GROUNDWATER SAMPLING DURING PHASE 1 (SHOWING GROUNDWATER ELEVATION IN FEET ABOVE MEAN SEA LEVEL)
— 6938 - -	LINE OF EQUAL ELEVATION OF POTENTIOMETRIC SURFACE (FEET ABOVE MEAN SEA LEVEL, DASHED WHERE INFERRED)
←	ESTIMATED GROUNDWATER FLOW DIRECTION
● MKTF-50	SPH MONITORING WELL AND DESIGNATION
● OW-12	SONSELLA MONITORING WELL AND DESIGNATION
⊕ RW-1	RECOVERY WELL
NM	NOT MEASURED
SPH	SEPARATE-PHASE HYDROCARBON

N

0 100' 200'

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FIGURE 1-4

POTENTIOMETRIC SURFACE MAP
(JUNE 2022)
OW-63 PFAS INVESTIGATION WORK PLAN

WESTERN REFINING SOUTHWEST LLC
GALLUP REFINERY
GALLUP, NEW MEXICO

Drawn By: REP | Checked By: BB | Scale: 1" = 100' | Date: 11/2/2022 | File: 697-PFAS_OW-PS-202206

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EXPLANATION

● OW−64 6939.65	CHINLE / ALLUVIUM AQUIFER WELL AND DESIGNATION (SHOWING GROUNDWATER ELEVATION IN FEET ABOVE MEAN SEA LEVEL)
● OW−63 6913.13	WELL AND DESIGNATION FOR GROUNDWATER SAMPLING DURING PHASE 1 (SHOWING GROUNDWATER ELEVATION IN FEET ABOVE MEAN SEA LEVEL)
— 6938 - -	LINE OF EQUAL ELEVATION OF POTENTIOMETRIC SURFACE (FEET ABOVE MEAN SEA LEVEL, DASHED WHERE INFERRED)
←	ESTIMATED GROUNDWATER FLOW DIRECTION
● MKTF−50	SPH MONITORING WELL AND DESIGNATION
● OW−12	SONSELLA MONITORING WELL AND DESIGNATION
⊞ RW−1	RECOVERY WELL
NM	NOT MEASURED
SPH	SEPARATE-PHASE HYDROCARBON

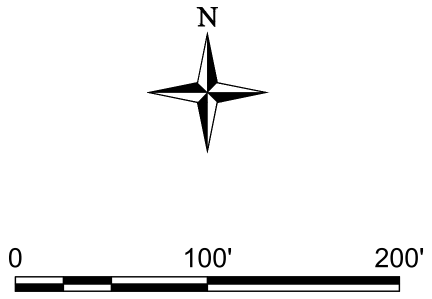

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FIGURE 1-5
POTENTIOMETRIC SURFACE MAP (SEPTEMBER 2022) OW-63 PFAS INVESTIGATION WORK PLAN
WESTERN REFINING SOUTHWEST LLC
GALLUP REFINERY
GALLUP, NEW MEXICO

Drawn By: REP	Checked By: BB	Scale: 1" = 100'	Date: 11/2/2022	File: 697-PFAS_OW-PS-202209

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Tables

TABLE 2-1. SUMMARY OF PFAS SOIL AND GROUNDWATER SAMPLE IDENTIFICATION, SAMPLE METHODS, AND ANALYTICAL METHODS
OW-63 PFAS INVESTIGATION WORK PLAN
WESTERN REFINING SOUTHWEST LLC, GALLUP REFINERY, GALLUP, NEW MEXICO

Sampling Media Type	Sample ID	Sampling Method	Sample Type	Constituents	Analytical Method	Extraction Hold Time
Groundwater Samples	OW-12	low flow sampling	grab	See Table 2-3 (PFAS)	Compliant with QSM 5.3, Table B-15 (PFAS)	14 days (PFAS)
	OW-14	low flow sampling	grab	See Table 2-3 (PFAS)	Compliant with QSM 5.3, Table B-15 (PFAS)	14 days (PFAS)
	OW-57	low flow sampling	grab	See Table 2-3 (PFAS)	Compliant with QSM 5.3, Table B-15 (PFAS)	14 days (PFAS)
	OW-63	low flow sampling	grab	See Table 2-3 (PFAS)	Compliant with QSM 5.3, Table B-15 (PFAS)	14 days (PFAS)
	OW-70	low flow sampling	grab	See Table 2-3 (PFAS)	Compliant with QSM 5.3, Table B-15 (PFAS)	14 days (PFAS)
	TW-1	low flow sampling	grab	See Table 2-3 (PFAS)	Compliant with QSM 5.3, Table B-15 (PFAS)	14 days (PFAS)
	TW-2	low flow sampling	grab	See Table 2-3 (PFAS)	Compliant with QSM 5.3, Table B-15 (PFAS)	14 days (PFAS)
	TW-3	low flow sampling	grab	See Table 2-3 (PFAS)	Compliant with QSM 5.3, Table B-15 (PFAS)	14 days (PFAS)
	GW Phase 1 Duplicate	low flow sampling	QA/QC	See Table 2-3 (PFAS)	Compliant with QSM 5.3, Table B-15 (PFAS)	14 days (PFAS)
	GW Phase 3 Duplicate	low flow sampling	QA/QC	See Table 2-3 (PFAS)	Compliant with QSM 5.3, Table B-15 (PFAS)	14 days (PFAS)
	GW Phase 1 Field Blank	NA	QA/QC	See Table 2-3 (PFAS)	Compliant with QSM 5.3, Table B-15 (PFAS)	14 days (PFAS)
	GW Phase 3 Field Blank	NA	QA/QC	See Table 2-3 (PFAS)	Compliant with QSM 5.3, Table B-15 (PFAS)	14 days (PFAS)
	GW Phase 1 Equipment Blank (Interface Probe)	NA	QA/QC	See Table 2-3 (PFAS)	Compliant with QSM 5.3, Table B-15 (PFAS)	14 days (PFAS)
	GW Phase 3 Equipment Blank (Interface Probe)	NA	QA/QC	See Table 2-3 (PFAS)	Compliant with QSM 5.3, Table B-15 (PFAS)	14 days (PFAS)
	GW Phase 1 Equipment Blank (Reusable equipment)	NA	QA/QC	See Table 2-3 (PFAS)	Compliant with QSM 5.3, Table B-15 (PFAS)	14 days (PFAS)
	GW Phase 3 Equipment Blank (Reusable equipment)	NA	QA/QC	See Table 2-3 (PFAS)	Compliant with QSM 5.3, Table B-15 (PFAS)	14 days (PFAS)
	GW Phase 1 Equipment Blank (Swagelock®)	NA	QA/QC	See Table 2-3 (PFAS)	Compliant with QSM 5.3, Table B-15 (PFAS)	14 days (PFAS)
	GW Phase 3 Equipment Blank (Swagelock®)	NA	QA/QC	See Table 2-3 (PFAS)	Compliant with QSM 5.3, Table B-15 (PFAS)	14 days (PFAS)
	GW Phase 1 MS/MSD	low flow sampling	QA/QC	See Table 2-3 (PFAS)	Compliant with QSM 5.3, Table B-15 (PFAS)	14 days (PFAS)
	GW Phase 3 MS/MSD	low flow sampling	QA/QC	See Table 2-3 (PFAS)	Compliant with QSM 5.3, Table B-15 (PFAS)	14 days (PFAS)
	Trip Blank	NA	QA/QC	See Table 2-3 (PFAS)	Compliant with QSM 5.3, Table B-15 (PFAS)	14 days (PFAS)

TABLE 2-1. SUMMARY OF PFAS SOIL AND GROUNDWATER SAMPLE IDENTIFICATION, SAMPLE METHODS, AND ANALYTICAL METHODS
OW-63 PFAS INVESTIGATION WORK PLAN
WESTERN REFINING SOUTHWEST LLC, GALLUP REFINERY, GALLUP, NEW MEXICO

Sampling Media Type	Sample ID	Sampling Method	Sample Type	Constituents	Analytical Method	Extraction Hold Time
Soil Samples	SS-1	trowel	grab	See Table 2-3 (PFAS)	Compliant with QSM 5.3, Table B-15 (PFAS)	14 days (PFAS)
	SS-2	trowel	grab	See Table 2-3 (PFAS)	Compliant with QSM 5.3, Table B-15 (PFAS)	14 days (PFAS)
	SS-3	trowel	grab	See Table 2-3 (PFAS)	Compliant with QSM 5.3, Table B-15 (PFAS)	14 days (PFAS)
	SS-4	trowel	grab	See Table 2-3 (PFAS)	Compliant with QSM 5.3, Table B-15 (PFAS)	14 days (PFAS)
	SS-5	trowel	grab	See Table 2-3 (PFAS)	Compliant with QSM 5.3, Table B-15 (PFAS)	14 days (PFAS)
	TW-1 (surface)	low flow sampling	grab	See Table 2-3 (PFAS)	Compliant with QSM 5.3, Table B-15 (PFAS)	14 days (PFAS)
	TW-1 (above water table)	low flow sampling	grab	See Table 2-3 (PFAS)	Compliant with QSM 5.3, Table B-15 (PFAS)	14 days (PFAS)
	TW-2 (surface)	low flow sampling	grab	See Table 2-3 (PFAS)	Compliant with QSM 5.3, Table B-15 (PFAS)	14 days (PFAS)
	TW-2 (above water table)	low flow sampling	grab	See Table 2-3 (PFAS)	Compliant with QSM 5.3, Table B-15 (PFAS)	14 days (PFAS)
	TW-3 (surface)	low flow sampling	grab	See Table 2-3 (PFAS)	Compliant with QSM 5.3, Table B-15 (PFAS)	14 days (PFAS)
	TW-3 (above water table)	low flow sampling	grab	See Table 2-3 (PFAS)	Compliant with QSM 5.3, Table B-15 (PFAS)	14 days (PFAS)
	SS - Duplicate	direct push sleeve or trowel	QA/QC	See Table 2-3 (PFAS)	Compliant with QSM 5.3, Table B-15 (PFAS)	14 days (PFAS)
	Trip Blank	NA	QA/QC	See Table 2-3 (PFAS)	Compliant with QSM 5.3, Table B-15 (PFAS)	14 days (PFAS)
	Field Blank	NA	QA/QC	See Table 2-3 (PFAS)	Compliant with QSM 5.3, Table B-15 (PFAS)	14 days (PFAS)
	Equipment Blank 4	NA	QA/QC	See Table 2-3 (PFAS)	Compliant with QSM 5.3, Table B-15 (PFAS)	14 days (PFAS)

Notes:
ID - identification
GW - groundwater
NA - not applicable
PFAS - per- and polyfluoroalkyl substances
QA/QC - quality assurance/quality control
QSM - Department of Defense, Department of Energy, Consolidated Quality Systems Manual (QSM) for Environmental Laboratories, DoD Quality Systems Manual Version 5.3, Appendix B, 2019
SS - surface sample
TW - temporary well

All samples will be cooled to ≤ 6 degrees Celsius (°C)

TABLE 2-2. SUMMARY OF EXISTING WELLS
OW-63 PFAS INVESTIGATION WORK PLAN
WESTERN REFINING SOUTHWEST LLC, GALLUP REFINERY, GALLUP, NEW MEXICO

Location	Date Measured	Depth to Product (ft-bgs)	Depth to Water (ft-bgs)	Product Thickness (ft)	Water Elevation (ft-msl)	Ground Surface Elevation (ft-msl)	Measuring Point Elevation (ft-msl)	Well Casing Height (ft)	Total Depth (ft-bgs)	Depth Top Screen (ft-bgs)	Depth Bottom Screen (ft-bgs)
OW-12	9/12/2014	ND	47.78	NA	6892.91	6939.57	6940.69	1.12	130.08	117.8	137.8
OW-12	8/13/2015	ND	47.42	NA	6893.27	6939.57	6940.69	1.12	130.08	117.8	137.8
OW-12	9/8/2016	ND	47.23	NA	6893.46	6939.57	6940.69	1.12	130.08	117.8	137.8
OW-12	9/19/2017	ND	46.74	NA	6893.95	6939.57	6940.69	1.12	130.08	117.8	137.8
OW-12	8/15/2018	ND	46.50	NA	6894.19	6939.57	6940.69	1.12	130.08	117.8	137.8
OW-12	6/30/2020	ND	Dry	NA	Dry	6939.57	6940.69	1.12	127.73	117.8	137.8
OW-12	9/14/2020	ND	45.33	NA	6894.24	6939.57	6940.69	1.12	130.08	117.8	137.8
OW-12	11/9/2020	ND	45.37	NA	6894.20	6939.57	6940.69	1.12	130.08	117.8	137.8
OW-12	1/28/2021	ND	45.08	NA	6894.49	6939.57	6940.69	1.12	130.08	117.8	137.8
OW-12	9/28/2021	ND	45.78	NA	6893.79	6939.57	6940.69	1.12	130.08	117.8	137.8
OW-12	12/3/2022	ND	45.93	NA	6893.64	6939.57	6940.69	1.12	130.08	117.8	137.8
OW-14	3/7/2014	ND	22.02	NA	6902.53	6924.55	6926.65	2.10	44.42	35.0	45.0
OW-14	6/3/2014	ND	22.05	NA	6902.50	6924.55	6926.65	2.10	44.42	35.0	45.0
OW-14	9/15/2014	ND	22.30	NA	6902.25	6924.55	6926.65	2.10	44.42	35.0	45.0
OW-14	11/10/2014	ND	22.15	NA	6902.40	6924.55	6926.65	2.10	44.42	35.0	45.0
OW-14	3/9/2015	ND	21.85	NA	6902.70	6924.55	6926.65	2.10	44.42	35.0	45.0
OW-14	6/1/2015	ND	21.78	NA	6902.77	6924.55	6926.65	2.10	44.42	35.0	45.0
OW-14	8/10/2015	ND	21.86	NA	6902.69	6924.55	6926.65	2.10	44.42	35.0	45.0
OW-14	10/27/2015	ND	21.59	NA	6902.96	6924.55	6926.65	2.10	44.42	35.0	45.0
OW-14	3/4/2016	ND	21.10	NA	6903.45	6924.55	6926.65	2.10	44.42	35.0	45.0
OW-14	6/6/2016	ND	21.08	NA	6903.47	6924.55	6926.65	2.10	44.42	35.0	45.0
OW-14	8/31/2016	ND	21.40	NA	6903.15	6924.55	6926.65	2.10	44.42	35.0	45.0
OW-14	11/15/2016	ND	21.18	NA	6903.37	6924.55	6926.65	2.10	44.42	35.0	45.0
OW-14	2/27/2017	ND	20.73	NA	6903.82	6924.55	6926.65	2.10	44.42	35.0	45.0
OW-14	5/30/2017	ND	21.08	NA	6903.47	6924.55	6926.65	2.10	44.42	35.0	45.0
OW-14	9/6/2017	ND	20.46	NA	6904.09	6924.55	6926.65	2.10	44.42	35.0	45.0
OW-14	12/11/2017	ND	20.10	NA	6904.45	6924.55	6926.65	2.10	44.42	35.0	45.0
OW-14	2/27/2018	ND	19.70	NA	6904.85	6924.55	6926.65	2.10	44.42	35.0	45.0
OW-14	4/26/2018	ND	19.65	NA	6904.90	6924.55	6926.65	2.10	44.65	35.0	45.0
OW-14	8/14/2018	ND	19.85	NA	6904.70	6924.55	6926.65	2.10	44.68	35.0	45.0
OW-14	11/6/2018	ND	19.72	NA	6904.83	6924.55	6926.65	2.10	44.42	35.0	45.0
OW-14	2/5/2019	ND	19.54	NA	6905.01	6924.55	6926.65	2.10	44.42	35.0	45.0
OW-14	5/1/2019	ND	19.35	NA	6905.20	6924.55	6926.65	2.10	44.42	35.0	45.0
OW-14	12/7/2020	ND	22.30	NA	6902.25	6924.55	6926.65	2.10	44.42	35.0	45.0
OW-14	6/30/2020	ND	20.65	NA	6903.90	6924.55	6926.65	2.10	44.42	35.0	45.0
OW-14	2/27/2021	ND	21.22	NA	6903.33	6924.55	6926.65	2.10	44.42	35.0	45.0
OW-14	6/2/2021	ND	21.55	NA	6903.00	6924.55	6926.65	2.10	44.42	35.0	45.0
OW-14	9/23/2021	ND	21.63	NA	6902.92	6924.55	6926.65	2.10	44.42	35.0	45.0
OW-14	12/29/2021	ND	20.70	NA	6903.85	6924.55	6926.65	2.10	44.42	35.0	45.0
OW-14	3/1/2022	ND	20.66	NA	6903.89	6924.55	6926.65	2.10	46.31	35.0	45.0
OW-14	6/2/2022	ND	22.19	NA	6902.36	6924.55	6926.65	2.10	45.20	35.0	45.0

TABLE 2-2. SUMMARY OF EXISTING WELLS
OW-63 PFAS INVESTIGATION WORK PLAN
WESTERN REFINING SOUTHWEST LLC, GALLUP REFINERY, GALLUP, NEW MEXICO

Location	Date Measured	Depth to Product (ft-bgs)	Depth to Water (ft-bgs)	Product Thickness (ft)	Water Elevation (ft-msl)	Ground Surface Elevation (ft-msl)	Measuring Point Elevation (ft-msl)	Well Casing Height (ft)	Total Depth (ft-bgs)	Depth Top Screen (ft-bgs)	Depth Bottom Screen (ft-bgs)
OW-14	9/5/2022	ND	22.65	NA	6901.90	6924.55	6926.65	2.10	45.20	35.0	45.0
OW-57	6/20/2017	ND	18.06	NA	6912.58	6930.64	6933.10	2.46	25.89	15.0	25.0
OW-57	9/19/2017	ND	17.69	NA	6912.95	6930.64	6933.10	2.46	25.89	15.0	25.0
OW-57	12/5/2017	ND	17.65	NA	6912.99	6930.64	6933.10	2.46	25.89	15.0	25.0
OW-57	2/19/2018	ND	17.42	NA	6913.22	6930.64	6933.10	2.46	25.89	15.0	25.0
OW-57	4/25/2018	ND	17.56	NA	6913.08	6930.64	6933.10	2.46	25.60	15.0	25.0
OW-57	8/15/2018	ND	17.70	NA	6912.94	6930.64	6933.10	2.46	25.61	15.0	25.0
OW-57	11/29/2018	ND	17.84	NA	6912.80	6930.64	6933.10	2.46	25.89	15.0	25.0
OW-57	2/19/2019	ND	17.83	NA	6912.81	6930.64	6933.10	2.46	25.64	15.0	25.0
OW-57	5/15/2019	ND	17.56	NA	6913.08	6930.64	6933.10	2.46	25.64	15.0	25.0
OW-57	8/20/2019	ND	17.32	NA	6913.32	6930.64	6933.10	2.46	25.61	15.0	25.0
OW-57	11/4/2019	ND	17.51	NA	6913.13	6930.64	6933.10	2.46	25.89	15.0	25.0
OW-57	3/4/2020	ND	17.51	NA	6913.13	6930.64	6933.10	2.46	25.64	15.0	25.0
OW-57	6/30/2020	ND	17.76	NA	6912.88	6930.64	6933.10	2.46	25.64	15.0	25.0
OW-57	9/14/2020	ND	18.04	NA	6912.60	6930.64	6933.10	2.46	25.63	15.0	25.0
OW-57	11/9/2020	ND	18.07	NA	6912.57	6930.64	6933.10	2.46	25.63	15.0	25.0
OW-57	12/7/2020	ND	18.18	NA	6912.46	6930.64	6933.10	2.46	25.93	15.0	25.0
OW-57	1/28/2021	ND	18.27	NA	6912.37	6930.64	6933.10	2.46	25.93	15.0	25.0
OW-57	2/27/2021	ND	18.27	NA	6912.37	6930.64	6933.10	2.46	25.63	15.0	25.0
OW-57	3/31/2021	ND	18.52	NA	6912.12	6930.64	6933.10	2.46	25.33	15.0	25.0
OW-57	4/26/2021	ND	18.61	NA	6912.03	6930.64	6933.10	2.46	25.03	15.0	25.0
OW-57	5/20/2021	ND	17.42	NA	6913.22	6930.64	6933.10	2.46	24.73	15.0	25.0
OW-57	6/2/2021	ND	18.57	NA	6912.07	6930.64	6933.10	2.46	24.73	15.0	25.0
OW-57	9/9/2021	ND	19.24	NA	6911.40	6930.64	6933.10	2.46	24.73	15.0	25.0
OW-57	12/13/2021	ND	19.29	NA	6911.35	6930.64	6933.10	2.46	24.73	15.0	25.0
OW-57	3/1/2022	ND	19.34	NA	6911.30	6930.64	6933.10	2.46	25.62	15.0	25.0
OW-57	6/2/2022	ND	19.89	NA	6910.75	6930.64	6933.10	2.46	25.92	15.0	25.0
OW-57	9/2/2022	ND	20.19	NA	6910.45	6930.64	6933.10	2.46	25.92	15.0	25.0
OW-63	3/21/2018	ND	17.47	NA	6914.87	6932.34	6935.06	2.72	29.46	9.0	29.0
OW-63	4/24/2018	ND	17.61	NA	6914.73	6932.34	6935.06	2.72	29.46	9.0	29.0
OW-63	8/16/2018	ND	17.88	NA	6914.46	6932.34	6935.06	2.72	29.48	9.0	29.0
OW-63	11/29/2018	ND	18.23	NA	6914.11	6932.34	6935.06	2.72	29.28	9.0	29.0
OW-63	2/19/2019	ND	17.74	NA	6914.32	6932.34	6935.06	3.00	29.00	9.0	29.0
OW-63	5/15/2019	ND	17.35	NA	6914.71	6932.34	6935.06	3.00	29.00	9.0	29.0
OW-63	8/19/2019	ND	17.12	NA	6914.94	6932.34	6935.06	3.00	29.20	9.0	29.0
OW-63	11/18/2019	ND	17.30	NA	6914.76	6932.34	6935.06	3.00	29.00	9.0	29.0
OW-63	3/4/2020	ND	17.41	NA	6914.65	6932.34	6935.06	3.00	29.00	9.0	29.0
OW-63	6/29/2020	ND	17.46	NA	6914.60	6932.34	6935.06	3.00	29.00	9.0	29.0
OW-63	9/14/2020	ND	17.73	NA	6914.33	6932.34	6935.06	3.00	29.05	9.0	29.0
OW-63	11/9/2020	ND	17.85	NA	6914.21	6932.34	6935.06	3.00	29.05	9.0	29.0
OW-63	12/8/2020	ND	17.97	NA	6914.09	6932.34	6935.06	3.00	29.22	9.0	29.0

TABLE 2-2. SUMMARY OF EXISTING WELLS
OW-63 PFAS INVESTIGATION WORK PLAN
WESTERN REFINING SOUTHWEST LLC, GALLUP REFINERY, GALLUP, NEW MEXICO

Location	Date Measured	Depth to Product (ft-bgs)	Depth to Water (ft-bgs)	Product Thickness (ft)	Water Elevation (ft-msl)	Ground Surface Elevation (ft-msl)	Measuring Point Elevation (ft-msl)	Well Casing Height (ft)	Total Depth (ft-bgs)	Depth Top Screen (ft-bgs)	Depth Bottom Screen (ft-bgs)
OW-63	1/28/2021	ND	18.15	NA	6913.91	6932.34	6935.06	3.00	29.22	9.0	29.0
OW-63	2/27/2021	ND	18.13	NA	6913.93	6932.34	6935.06	3.00	29.22	9.0	29.0
OW-63	3/31/2021	ND	18.28	NA	6913.78	6932.34	6935.06	3.00	29.22	9.0	29.0
OW-63	4/26/2021	ND	18.40	NA	6913.66	6932.34	6935.06	3.00	29.22	9.0	29.0
OW-63	5/20/2021	ND	18.52	NA	6913.54	6932.34	6935.06	3.00	29.22	9.0	29.0
OW-63	6/2/2021	ND	18.37	NA	6913.69	6932.34	6935.06	3.00	29.22	9.0	29.0
OW-63	9/28/2021	ND	18.85	NA	6913.21	6932.34	6935.06	3.00	29.22	9.0	29.0
OW-63	12/16/2021	ND	18.93	NA	6913.13	6932.34	6935.06	3.00	29.22	9.0	29.0
OW-63	3/1/2022	ND	18.95	NA	6913.11	6932.34	6935.06	3.00	29.22	9.0	29.0
OW-63	6/1/2022	ND	19.51	NA	6912.55	6932.34	6935.06	3.00	29.22	9.0	29.0
OW-63	9/2/2022	ND	19.25	NA	6912.81	6932.34	6935.06	3.00	29.22	9.0	29.0
OW-70	12/16/2021	ND	28.71	NA	6914.36	6943.07	6945.95	2.88	44.82	25.0	44.7
OW-70	9/8/2021	ND	28.53	NA	6917.42	6943.07	6945.95	2.88	44.82	25.0	44.7
OW-70	3/2/2022	ND	28.76	NA	6914.31	6943.07	6945.95	2.88	44.83	25.0	44.7
OW-70	6/1/2022	ND	29.24	NA	6913.83	6943.07	6945.95	2.88	44.84	25.0	44.7
OW-70	9/7/2022	ND	29.41	NA	6913.66	6943.07	6945.95	2.88	44.84	25.0	44.7

Notes:

ft	feet
ft msl	feet above mean sea level
ft-bgs	feet below ground surface
NA	not applicable
ND	not detected
PFAS	per- and polyfluoroalkyl substances

TABLE 2-3. PROPOSED GROUNDWATER AND SOIL SAMPLE CONSTITUENT LIST
OW-63 PFAS INVESTIGATION WORK PLAN
WESTERN REFINING SOUTHWEST LLC, GALLUP REFINERY, GALLUP, NEW MEXICO

Chemical Name	Abbreviation	Fluorinated Alkane Carbon Chain Length	CAS No.
Perfluoroalkylcarboxylic acids (PFCAs)			
Perfluorobutanoic acid	PFBA	C3*	375-22-4
Perfluoropentanoic acid	PFPeA	C4*	2706-90-3
Perfluorohexanoic acid	PFHxA	C5*	307-24-4
Perfluoroheptanoic acid	PFHpA	C6*	375-85-9
Perfluorooctanoic acid	PFOA	C7*	335-67-1
Perfluorononanoic acid	PFNA	C8*	375-95-1
Perfluorodecanoic acid	PFDA	C9*	335-76-2
Perfluoroundecanoic acid	PFUnA	C10*	2058-94-8
Perfluorododecanoic acid	PFDoA	C11*	307-55-1
Perfluorotridecanoic acid	PFTriA	C12*	72629-94-8
Perfluorotetradecanoic acid	PFTeA	C13*	376-06-7
Perfluorinated sulfonic acids (PFSAs)			
Perfluorobutanesulfonic acid	PFBS	C4	375-73-5
Perfluoropentanesulfonic acid	PFPeS	C5	2706-91-4
Perfluorohexanesulfonic acid	PFHxS	C6	355-46-4
Perfluoroheptanesulfonic acid	PFHpS	C7	375-92-8
Perfluorooctanesulfonic acid	PFOS	C8	1763-23-1
Perfluorononanesulfonic acid	PFNS	C9	68259-12-1
Perfluorodecanesulfonic acid	PFDS	C10	335-77-3
Perfluoroocante Sulfonamide and Derivatives (PFOSA, FOSEs, FOSAs, and FOSAAs)			
Perfluoroictabesylfonamide	PFOSA	C8	754-91-6
2-(N-Methylperfluorooctanesulfonamido) acetic acid	NMeFOSAA	C8 Precursor	2355-31-9
2-(N-Ethylperfluorooctanesulfonamido) acetic acid	N-EtFOSAA	C8 Precursor	2991-50-6
Fluorotelomer sulfonates (FTS)			
4:2 Fluorotelomer sulfonic acid	FtS 4:2	C4 Precursor	757124-72-4
6:2 Fluorotelomer sulfonic acid	FtS 6:2	C6 Precursor	27619-97-2
8:2 Fluorotelomer sulfonic acid	FtS 8:2	C8 Precursor	39108-34-4

Notes:
PFAS - per- and polyfluoroalkyl substances
CAS No. - Chemical Abstracts Service Number
C - carbon

Reporting limits will be dependent upon the lab selected for PFAS analysis; they will be evaluated against New Mexico PFAS screening levels once a lab has been selected.

* - The fluorinated carbon chain length is shown, although the total carbon chain length for PFCAs is one greater due to presence of a non-fluorinated carboxylic acid (COOH) functional group.

Appendix A – OW-63 PFAS Sampling Results

APPENDIX A. OW-63 PFAS SAMPLING RESULTS
WESTERN REFINING SOUTHWEST LLC, D/B/A MARATHON GALLUP REFINERY
GALLUP, NEW MEXICO

Location	Sample Date	4:2 Fluorotelomer sulfonic acid (4:2 FTS) (ng/L)	6:2 Fluorotelomer sulfonic acid (6:2 FTS) (ng/L)	8:2 Fluorotelomer sulfonic acid (8:2 FTS) (ng/L)	N-ethyl perf sulf acid (NEtFOSAA) (ng/L)	2-(N-methyl-perfluorooctane sulfonamido) acetic acid (NMeFOSAA) (ng/L)	Perfluorobutanesulfonic acid (PFBS) (ng/L)	Perfluorobutanoic acid (PFBA) (ng/L)	Perfluorodecanesulfonic acid (PFDS) (ng/L)	Perfluorodecanoic acid (PFDA) (ng/L)	Perfluorododecanoic acid (PFDoA) (ng/L)
OW-63	6/15/2021	ND(1.95)	400	46.1	ND(2.56)	ND(1.95)	38.4	ND(1.95)	ND(2.69)	12.8	ND(1.95)
OW-63	9/29/2021	ND(2.04)	494	44.6	ND(2.68)	ND(2.04)	39.2	91.2	ND(2.81)	12.4	ND(2.04)
OW-63	12/17/2021	ND(1.96)	638	51.1	ND(1.96)	ND(1.96)	34.2	153	ND(1.96)	11.5	ND(1.96)
OW-63	3/10/2022	ND(2.09)	679	70.8	ND(2.09)	ND(2.09)	41.9	ND(2.09) R	ND(2.09)	11.2	ND(2.09)
OW-63	6/8/2022	ND(2.08)	712	71.7	ND(2.08)	ND(2.08)	40.2	ND(2.08)	ND(2.08)	13.2	ND(2.08)
OW-63	9/20/2022	ND(2.01) UJ	556 J	71.4 J	ND(2.01) UJ	ND(2.01) UJ	35.1 J	121 J	ND(2.01) UJ	12.3 J	ND(2.01) UJ
OW-63	12/7/2022	ND(2.03)	562	70.1	ND(2.03)	ND(2.03)	34.9	140 J+	ND(2.03)	12.1	ND(2.03)
NMED Cleanup Level		NA	NA	NA	NA	NA	6016.48	NA	NA	NA	NA

Notes:
NMED Cleanup Level - New Mexico Environment Department, Risk Assessment Guidance, Table A-1, Tap Water, November 2022
Bolded detections exceed the screening level
J = Estimated concentration
J+ = Estimated concentration, possibly biased high
NA = Not applicable
ND(x) = Not detected, where x = the reporting limit
ng/L = Nanograms per liter
PFAS = Per- and Polyfluoroalkyl Substances
R = Rejected, Data not usable
UJ = Estimated reporting limit

APPENDIX A. OW-63 PFAS SAMPLING RESULTS
WESTERN REFINING SOUTHWEST LLC, D/B/A MARATHON GALLUP REFINERY
GALLUP, NEW MEXICO

Location	Sample Date	Perfluoroheptanesulfonic acid (PFHpS) (ng/L)	Perfluoroheptanoic acid (PFHpA) (ng/L)	Perfluorohexanesulfonic acid (PFHxS) (ng/L)	Perfluorohexanoic acid (PFHxA) (ng/L)	Perfluorononanesulfonic acid (PFNS) (ng/L)	Perfluorononanoic acid (PFNA) (ng/L)	Perfluorooctanesulfonamide (PFOSA) (ng/L)	Perfluorooctanesulfonic acid (PFOS) (ng/L)
OW-63	6/15/2021	12.4	137	325	355	ND(1.95)	**522**	ND(1.95)	**547**
OW-63	9/29/2021	11.9	131	278	313	ND(2.04)	**494**	ND(2.04)	**516**
OW-63	12/17/2021	9.26	114	237	347	ND(1.96)	**508**	ND(1.96)	**454**
OW-63	3/10/2022	9.19	128	263	347	ND(2.09)	**523**	ND(2.09)	**351**
OW-63	6/8/2022	13.2	128	232	442	ND(2.08)	**604**	ND(2.08)	**360**
OW-63	9/20/2022	8.81 J	134 J	255 J	352 J	ND(2.01) UJ	**482 J**	ND(2.01) UJ	**316 J**
OW-63	12/7/2022	7.25	124	258	344	ND(2.03)	**479**	ND(2.03) UJ	**331**
NMED Cleanup Level		NA	NA	401.10	NA	NA	60.16	NA	60.16

Notes:
NMED Cleanup Level - New Mexico Environment Department, Risk Assessment Guidance, Table A-1, Tap Water, November 2022
Bolded detections exceed the screening level
J = Estimated concentration
J+ = Estimated concentration, possibly biased high
NA = Not applicable
ND(x) = Not detected, where x = the reporting limit
ng/L = Nanograms per liter
PFAS = Per- and Polyfluoroalkyl Substances
R = Rejected, Data not usable
UJ = Estimated reporting limit

APPENDIX A. OW-63 PFAS SAMPLING RESULTS
WESTERN REFINING SOUTHWEST LLC, D/B/A MARATHON GALLUP REFINERY
GALLUP, NEW MEXICO

Location	Sample Date	Perfluorooctanoic acid (PFOA) (ng/L)	Perfluoropentanesulfonic acid (PFPeS) (ng/L)	Perfluoropentanoic acid (PFPA) (ng/L)	Perfluorotetradecanoic acid (PFTeDA) (ng/L)	Perfluorotridecanoic acid (PFTriA) (ng/L)	Perfluoroundecanoic acid (PFUnA) (ng/L)
OW-63	6/15/2021	**127**	44.5	352	ND(1.95)	ND(1.95)	82.3
OW-63	9/29/2021	**123**	37.9	417	ND(2.04)	ND(2.04)	88.2
OW-63	12/17/2021	**106**	37.4	464	ND(1.96)	ND(1.96)	86.6
OW-63	3/10/2022	**124**	41.7	486	ND(2.09)	ND(2.09)	ND(2.09)
OW-63	6/8/2022	**110**	53.3	445	ND(2.08)	ND(2.08)	103
OW-63	9/20/2022	**108 J**	42.5 J	470 J	ND(2.01) UJ	ND(2.01) UJ	71.7 J
OW-63	12/7/2022	**106**	34.4	505	ND(2.03)	ND(2.03)	76.8
NMED Cleanup Level		60.16	NA	NA	NA	NA	NA

Notes:
NMED Cleanup Level - New Mexico Environment Department, Risk Assessment Guidance, Table A-1, Tap Water, November 2022
Bolded detections exceed the screening level
J = Estimated concentration
J+ = Estimated concentration, possibly biased high
NA = Not applicable
ND(x) = Not detected, where x = the reporting limit
ng/L = Nanograms per liter
PFAS = Per- and Polyfluoroalkyl Substances
R = Rejected, Data not usable
UJ = Estimated reporting limit

Appendix B - Trihydro's PFAS Site Characterization Standard Operation Procedure

Trihydro
CORPORATION

memorandum

To: Trihydro Employees
From: Mitch Olson
Date: September 2, 2022
Re: PFAS Sampling Standard Operating Procedure

1.0 INTRODUCTION

This standard operating procedure (SOP) establishes protocols for Trihydro employees and subcontractors to be followed when collecting samples for per- and polyfluoroalkyl substances (PFAS). This SOP includes general PFAS sampling procedures as well as procedures for specific activities including sampling of drinking water, groundwater, surface water/sediment, soils, and other media.

This PFAS SOP is divided into the following Sections:

Although PFAS sampling procedures are generally similar to conventional sampling, several aspects of sampling and analysis for PFAS are unique, and following these PFAS-specific procedures is critical. PFAS-specific procedures are necessary due to their high tendency for sample cross-contamination, which is related to the following characteristics:

- Extremely low environmental concentrations of interest
- Large numbers of individual analytes that may be present in environmental samples
- Potential presence in many standard sampling materials, especially in Teflon® or polytetrafluoroethylene (PTFE)
- Presence in everyday materials including food packaging and clothing
- Greater scrutiny of results than for other contaminants

The objective of this SOP is to establish general PFAS sampling procedures to guide PFAS sampling events across the company, provide defensible PFAS data, and remain consistent with current PFAS sampling guidance and best practices.

Due to anticipated/ongoing changes in procedures and the state of the science for PFAS, this SOP will be reviewed and/or updated annually, at a minimum, during the first quarter of each calendar year. Project teams need to use the most recent version of this document before planning and implementation of field work.

1.1 PFAS BACKGROUND

Since the 1950s, PFAS have been incorporated into many consumer and industrial products. One of the many historical uses is in firefighting foams ("Aqueous Film Forming Foams," or AFFF). AFFF products may be used for fire suppression at facilities where Class B fires (i.e., those involving flammable liquids and gases) may be a concern, including airports, firefighting training areas, and other facilities where flammable hydrocarbons are present. PFAS have also been used for widespread industries including non-stick material (e.g., Teflon®) manufacturing, metal plating, paper/fabric production, plastics, semiconductors, aerospace industries, and in processes such as mist/dust suppression. Environmental releases of PFAS compounds have resulted from their historical uses in AFFF and industrial processes.

In total, the chemical class of PFAS includes thousands of individual compounds. The most well-known and widely regulated of these compounds include perfluorooctanoic acid (PFOA) and perfluoroalkyl sulfonate (PFOS). The United States Environmental Protection Agency (EPA) released final Health Advisory (HA) levels for these compounds of 70 parts per trillion (ppt) (i.e., 0.070 parts per billion); in June 2022, the EPA released updated interim HA levels of 0.004 ppt and 0.020 ppt for PFOA and PFOS, respectively. The EPA also released final HA values for two additional PFAS compounds, perfluorobutane sulfonate (PFBS) and hexafluoropropylene oxide (HFPO) dimer acid (otherwise known as GenX) of 10 and 2,000 ppt, respectively. Furthermore, several states have established their own standard values for PFAS in drinking water, surface water, and soils (ITRC 2022). Many states have adopted values lower than the EPA HA levels.

PFAS also exhibit unique chemical and physical properties, with important implications for sample collection. The molecular structure includes a nonpolar/fluorinated tail and a non-fluorinated head. The polar/nonpolar structure makes PFAS function as surfactants (e.g., substances that decrease a liquid's surface tension), and are prone to accumulate at air/water interfaces (especially where foam may be formed). Because of this tendency to accumulate at interfaces, surface/stormwater sampling should avoid interfaces, if possible, to avoid high-biased sample data. In terms of sampling, PFAS are considered to be "sticky" in that they may temporarily sorb to sampling materials, which increases the risk of cross contamination if procedures described herein are not strictly observed.

1.2 PFAS SAMPLING GUIDANCE DOCUMENTS

The SOP presented herein has been developed in consideration of select state-specific guidance documents as well as the Interstate Regulatory Guidance Council (ITRC). Additional guidance may need to be referenced for site-specific circumstances, for example, several states have published independent guidance documents (in addition to the California and Michigan documents noted herein). PFAS sampling and analytical guidance documents include the following:

- Per- and Polyfluoroalkyl Substances (PFAS) Sampling Guidelines for Non-Drinking Water published by the California State Water Quality Control Board (The Water Boards) Division of Water Quality in September 2020 (The Water Boards 2020).
- General PFAS Sampling Guidance published by the Michigan Department of Environmental Quality (MDEQ) in October 2018 (MDEQ 2018).
- ITRC's guidance document, *Technical Resources for Addressing Environmental Releases of Per- and Polyfluorinated Compounds (PFAS)*, Chapter 11, Sampling and Analytical Methods, provides detailed information on sampling protocols (ITRC 2022).

2.0 PFAS SAMPLING TRAINING REQUIREMENTS

Due to the need for specialized procedures used for PFAS sampling, only personnel who have completed Trihydro's training program should collect environmental samples for PFAS. Trihydro's PFAS sampling training program includes the following elements:

- Initial office-based training conducted by one or more members of the Trihydro PFAS technical team, including PFAS background, overview of this SOP, and discussion of unique aspects of PFAS sampling with a detailed discussion of the material compatibility table. Training should include discussion of procedures commensurate with sampling to be conducted. Office-based training will cover items in the checklist (Attachment A) and is anticipated to require 1 hour for drinking/waste-water sampling conducted above ground (e.g., from spigots) and 1-2 hours for environmental sampling including soils, sediment, surface water, groundwater. The office-based training is considered sufficient for personnel collecting tapwater/spigot sampling; personnel conducting environmental sampling (e.g., groundwater, surface water, soils, and sediment) must complete on-site training.
- On-site training will be led by an experienced PFAS sampler. Experienced PFAS samplers will use the Field Training Checklist included as Attachment B of this SOP to ensure that the applicable aspects of PFAS field techniques are discussed during the on-site training event.
- Annual refreshers will consist of office-based training/discussion to share information learned throughout the company during PFAS sampling events, updates in terms of standard methods, and to provide feedback on lessons learned.

3.0 General PFAS Sampling Procedures

This section provides general information on PFAS sampling procedures, to be used for all PFAS sampling activities. In general, collection of PFAS samples follows similar procedures to those employed for conventional sampling; however, due to the unique properties of PFAS discussed in Section 1, there are several key aspects of PFAS sampling that warrant additional attention. This SOP focuses on areas where PFAS sampling requires different considerations than conventional sampling procedures. PFAS may be present in a wide variety of commercial products including common household items (e.g., food wrappers, Gore-Tex® or other waterproof fabrics, stain-resistant fabrics, cosmetics, sunscreens, and moisturizing lotions). Table 1 presents a list of sampling materials that are prohibited or acceptable, following The California Water Boards 2020, MDEQ 2018, and ITRC 2022 guidance. **It is very important that PFAS-compatible materials are used and that sampling procedures follow protocols to minimize risk of cross contamination.** This section provides guidance on how to manage sampling to minimize risks of PFAS contamination. PFAS sampling procedures for specific media types are provided in subsequent sections.

While planning for PFAS sampling, the following guidelines should be kept in mind:

- Plan ahead to ensure materials and procedures can be properly vetted for PFAS compatibility
- For PFAS field sampling, include extra time, such that the field crew does not have to rush
- Simplify procedures and minimize clutter to reduce cross-contamination risks

3.1 CLOTHING AND PERSONAL CARE PRODUCTS

The sample collection team should be aware of clothing compatibility (per Table 1) with PFAS sampling. PFAS are present in waterproof and stainproof fabrics, and may be present in new clothing, regardless of whether clothing is considered "waterproof". Clothing worn during PFAS sampling should meet the following criteria:

- All clothing should be well-laundered, i.e., washed at least six times after purchase.
- Before sampling, clothing should be laundered without fabric softener or dryer sheets.
- For clothing and jackets worn during PFAS sampling, cotton or synthetic fabrics are acceptable, if the fabrics are not treated to be water/stain resistant (and all clothing regardless of material must be well laundered).
- Clothing containing Gore-Tex® (or similar waterproofing) should not be present at the field site; if traveling, such clothing should not be packed next to clothing that will be worn for sampling.
- Waterproof clothing made with polyurethane, PVC, wax-coated fabrics, rubber, or neoprene (e.g., *Helly Hansen Storm Waterproof Rain Jacket*, with a shell made of PVC) is acceptable.

- Do not use unnecessary personal care products on the day of sampling (e.g., nail polish, cologne/perfume, lotions); wash hands with soap and water after applying personal care products on the day of sampling.

3.2 PFAS SAMPLING HEALTH AND SAFETY CONSIDERATIONS

In some circumstances, personal protective equipment (PPE) requirements may create conflicts with the PFAS sampling compatible materials shown in Table 1. Such conflicts should be identified during the planning/work-plan development process so they can be managed. **Do not sacrifice PPE requirements for PFAS sample collection.** Through planning, a solution can generally be found. For example, waterproof steel-toed workboots may be covered by overshoes made of polyvinyl chloride (PVC) or similar PFAS-compatible materials. Sunblock, insect repellant, and/or related materials should be applied ahead of time and hands washed with soap and water after these are applied.

Potential health-and-safety/PFAS conflicts and resolutions should be documented in field notes. The sampler should be conscientious about potential pathways between these products and the sample, and look for ways to eliminate these pathways.

3.3 SAMPLING EQUIPMENT AND MATERIALS

PFAS are potentially present in many common sampling materials; Table 1 provides a summary of materials that are compatible/incompatible with PFAS sampling. Many common sampling materials are not compatible with PFAS, thus it is important that the sampling team is familiar with this table.

Materials that are useful to have on-site for PFAS sampling include the following:

- Polyethylene (PE) sheeting (and scissors to cut the sheeting)
- Packing tape to attach sheeting to sample preparation surfaces (optional)
- Sample staging table (optional)
- Nitrile gloves - excess quantity for frequent changing of gloves
- Ziploc bags - excess quantity for sample containers, double-bagged ice, and separating/containing sampling equipment
- Untreated paper towels - excess quantity for general use
- Waste containers (e.g., contractor bags) to ensure that waste materials may be removed from the sample processing area immediately after being generated, thus avoiding unnecessary clutter
- Loose leaf paper, pre-printed for recording sample log information
- PFAS-compatible pens, such as a Uni-ball Power Tank RT Retractable Ballpoint Pen

If decontamination is required, purchase PFAS-free water from the laboratory along with the sample container order. PFAS-free water may be expected to cost approximately $20 per liter. If a large volume (e.g., multiple gallons) of decontamination water is required, a local water source may be used only if tested and verified to be ‘PFAS-free’ ahead of time.

3.4 SAMPLING CONTAINERS

Sampling containers provided by the laboratory for PFAS analysis consist of polypropylene or high-density polyethylene (HDPE). Glass containers are never suitable for PFAS analysis of water samples, as PFAS can adsorb onto glass; glass containers are not ideal for soil sampling, but may be used if nothing else is available. Teflon-lined lids are not acceptable for PFAS sampling. Before sampling, confirm PFAS compatibility, including sample-container composition with the selected analytical laboratory. For drinking water samples, USEPA method 537.1 requires 250 milliliters (mL) per sample container and USEPA Method 533 requires 100-250 mL per sample container; laboratories generally require two containers per sample. Volume requirements may vary per laboratory requirements; confirm with laboratory before sampling. Requirements for preservatives (Trizma® buffer or ammonium acetate) are discussed in Section 8.3.

For non-drinking water matrices, the absence of USEPA-promulgated analytical methods allows for flexibility in the sample quantity and preservation; required quantities, bottles, and preservatives should be confirmed with the analytical laboratory prior to field activities.

3.5 SAMPLING AREA PREPARATION

To minimize the potential for cross contamination, designate separate sampling and preparation spaces within the work area. For PFAS sampling of all media types, the following area preparation steps can facilitate successful PFAS sampling:

- Remove unnecessary materials from the sampling area. This includes materials that are part of the sampling event but are not needed for sample collection (e.g., field notes).
- Under certain circumstances (e.g., residential water sampling), a Ziploc bag may be used to transport/store sampling containers and sampling materials. These materials must be disposed of after a single use and are <u>not</u> to be used at multiple locations.
- Consider using disposable PE sheeting to setup a workspace for sampling equipment. For small, localized sample collection (e.g., from a spigot) use PE sheeting or untreated paper towels to setup a workspace.
- For certain types of sampling, a portable/collapsible table may be used, with PE sheeting used to cover the table. Packaging tape is acceptable to secure PE sheeting, as long as the tape is applied beneath the table surface and does not contact sample containers during processing. The top of a

cooler may also be used for equipment storage, if covered by PE/untreated paper towels or thoroughly decontaminated.

- Have an excess quantity of nitrile gloves accessible; gloves are to be changed frequently, including as a last step before sample collection. Gloves should be kept in the box (or in a clean Ziploc bag) until use and should not be carried in a pocket, or in a similar uncontrolled manner. Avoid handling of the nitrile glove box after donning clean nitrile gloves.
- Make sure personnel that are not equipped for PFAS sampling remain outside of the immediate sampling area (at least 6 feet away).

Preparing sample containers and coolers before the event:

- Always wear clean nitrile gloves while handling sample containers and PFAS-free water containers, even when organizing before the sampling event.
- Preparing bottle sets before the sampling event is helpful to minimize handling of containers required in the field. Preparation might include grouping of bottle sets in Ziploc bags. Sample container labels may be filled out (with all information except sample time) and applied ahead of time. Ziploc bags can be labeled using an Ultra-Fine point sharpie or Uni-ball Power Tank RT Retractable Ballpoint Pen.
- Ensure that sample containers are controlled through the entire preparation process. They may be in a cooler, placed in Ziploc bags, or placed on PE sheeting. Sample containers should be stored in a liner-bag or Ziploc bag within the cooler. Do not place sample containers on ‘uncontrolled’ surfaces, such as the exposed lid of a cooler, the tailgate of a truck, or a carpeted floor, unless the surface is decontaminated or covered with PE sheeting or clean, untreated paper towels.
- Prepare separate coolers for clean/empty sample containers and filled containers such that clean/empty and filled containers are not mixed in a single cooler.

3.6 SAMPLE COLLECTION AND HANDLING

PFAS are sticky, in that they tend to adhere to solid surfaces, and therefore may be transferred from source to sample during the handling process. The following presents a list of sampling dos and don’ts that mitigate this cross-contamination risk.

Do	Don't
Change gloves frequently, including immediately before sampling.	Touch anything besides sample containers with final pair of nitrile gloves.
Keep sample containers controlled through the entire sampling process, and keep containers closed/sealed until filling with a sample.	Put sample containers or sampling equipment on the ground or in contact with any surface that cannot be shown to be free of PFAS.
Have at least two coolers, one for unused sampling containers and one for the PFAS samples.	Put PFAS samples in a cooler with unused sampling containers.
Practice good housekeeping by keeping sample collection area clean and free of used paper towels, gloves, sampled media (soil and water).	Bring items into the sample collection area that are not necessary to the process of sample collection (notebooks, work plans, food/drink containers, etc.). Water bottles for hydration are allowable at the sampling site, but should be kept in the car and out of the sampling/staging area.
When sampling liquids, fill the container to the shoulder. Some headspace is preferred.	Field filter the PFAS sample. If filtration is required, notify the laboratory.
Collect PFAS samples first, then other samples. This minimizes contact of PFAS samples with the handling of other sampling containers.	Intermingle PFAS and non-PFAS sample containers.
Remove excess sample media (soil, sediment or water) to the extent practicable from the exterior of sample containers to minimize cross contamination in cooler and at laboratory.	Rinse reusable sampling equipment with regular tap water. After a thorough decontamination, rinse with PFAS free water.

3.7 SAMPLE SHIPMENT

PFAS samples also have unique requirements for packaging and shipment. Additional considerations for PFAS sample shipment include use of additional Ziploc bags to mitigate cross-contamination potential during sample handling or during shipment. All sample sets should be packaged in separate Ziploc bags; the two (or more) containers filled for each sample set can be placed in a single sealed bag. If high PFAS concentrations are expected, samples containers may be double-bagged to minimize cross-contamination risk in the cooler (under such circumstances a trip blank should be included, as described in Section 8.4). PFAS samples are shipped to the analytical laboratory in a cooler, via expedited delivery or overnight shipping if possible, following similar protocols used for conventional sampling. Finally, as with conventional sampling, the samples must be received by the laboratory at 4±2 degrees Celsius (°C) or as required by the sample method specified in the work plan. For cooling of samples during shipment, use water-based ice instead of gel ice (e.g., Blue Ice). Under circumstances where gel ice may be needed, make sure the gel ice is double bagged in Ziploc bags and/or properly decontaminated, with an equipment blank collected. Even water-based ice is a potential PFAS source within the coolers, therefore the ice must be double-bagged in Ziploc (or similar) bags. Clean nitrile gloves should be worn while handling ice, and should be changed prior to handling sample containers.

Additional considerations for PFAS sampling in specific matrices (drinking water, groundwater, surface water/sediment, and other media types) are provided in the following sections:

- Section 4 Drinking Water and Supply Well Sampling
- Section 5 Groundwater Sampling
- Section 6 Surface Water and Sediment Sampling
- Section 7 Surface and Subsurface Soil Sampling
- Section 8 Other Sampling Matrices

3.8 DECONTAMINATION

- To reduce/minimize investigation-derived waste (IDW) a spray-bottle method of decontamination may be used where adequate. Zepp® brand spray bottles are recommended.
- Decontamination should use a phosphate-based detergent, such as Alconox® or Liquinox® Note that Simple Green® has not been confirmed to be PFAS free, and is therefore not approved for PFAS sampling decontamination at this time.
- PFAS-free water (lab supplied is preferable) should be used for a final rinse. If a large volume of decontamination water is needed, a local water source may be used, but the water source should be tested and verified as being PFAS-free. Best practice is to use lab-supplied PFAS-free water for a final rinse.
- Equipment blanks should be collected from non-dedicated equipment that contacts the sampled media to validate decontamination procedures.
- Decontaminated equipment may be stored in fresh Ziploc bags, in decontaminated equipment cases, on HDPE sheeting, or similar, until immediately prior to sampling, to minimize risk of contamination.
- Additional decontamination considerations for sampling of different media types are provided in Sections 4 through 7.

3.9 INVESTIGATION DERIVED WASTE

IDW may include purge water, soils, disposable tubing from groundwater sampling, purge water from spigot/sample port sampling, spent PPE, or other solid waste generated during the collection of PFAS samples. Although PFAS compounds are new analytes for many facilities where sampling is conducted, the chemistry of purged groundwater will be similar to that of water generated during regular sampling events. Therefore, depending on local, state, or site-specific requirements, all IDW water may be handled following normal site-sampling procedures. Other solid waste will be discarded in an appropriate on-site container, following standard site procedures for solid waste. Potential PFAS-impacted IDW will need to be profiled and managed in accordance with local/state or client requirements.

3.10 FIELD DOCUMENTATION

The information documented during the field activities should include, at a minimum:

- Photo-documentation (if allowable – photo documentation can be helpful for documenting unconventional site conditions for potential PFAS impacts)
- Descriptions of sample matrices
- Descriptions of sampling locations
- Sample collection dates and times
- Sample container sizes, amounts, types, and preservatives
- Sampling methodology
- Deviations from this SOP or site-specific work plans

An example field documentation form used for PFAS sampling is provided in Attachment C.

3.11 SITE DATA MANAGEMENT

Due to the prolific nature of PFAS, its status as an emerging contaminant, and the high degree of uncertainty surrounding environmental liability associated with PFAS, many PFAS sites are the subject of potential or ongoing litigation. As such, additional care should be used when managing site data. This may include various best practices that should be discussed with the client prior to initiating sampling activities, including:

- Determining what documentation to collect for sample procedures to verify that samples are representative of site conditions.
- Determining if existing judicial orders are present which may direct sample activities, notifications, or document retention and production requirements.
- Being thorough, yet careful to only record data observations (as opposed to including qualitative speculation, judgement, or opinion) when producing field notes, sample logs, sample figures, and other documentation.
- Determining whom may receive/respond to inquiries from members of the public.
- Discussing with field staff and project managers what information can and cannot be disclosed about site activities.

- Evaluating potential conflicts of interest and making staffing and project selection determinations accordingly.

4.0 DRINKING WATER AND SUPPLY WELL SAMPLING

This section provides PFAS sampling considerations for drinking water and supply well matrices. This section is not intended to teach water sampling fundamentals, but rather to provide instruction on differences in procedures and considerations specific to PFAS sampling. Procedures discussed in this section are additional considerations to the general PFAS sampling guidelines provided in Section 3. Due to the potential sensitivity to low-level detections in drinking water samples, drinking water and supply well sampling should be undertaken with the utmost consideration of cross contamination risk, materials used, and planning of sampling procedure.

4.1 EQUIPMENT/MATERIALS

In addition to the general and decontamination supplies listed in Sections 3.3 and 3.8, respectively, additional sample materials and supplies may include:

- Purge water collection buckets (optional), in the event that purge water needs to be contained, or a sample tap is located in a vault or other undrained location.
- A garden hose (optional) may be used to direct purge water from an exterior spigot, if needed to direct drainage to a suitable location; however, the hose must be removed prior to sampling such that a sample is collected directly from the spigot.

4.2 SAMPLING PROCEDURES

Sample collection for PFAS should generally follow these procedures. During most steps, samplers should don new (unused) nitrile gloves, even if it is not expressly identified below. New gloves should always be donned before handling sample containers, at any time.

- Using appropriate pen or ultra-fine Sharpie, fill out sample labels with all information except sample time and apply labels to sample containers. Pre-labeled sample containers may be stored in labeled 1-gallon Ziploc bags prior to sampling.
- Prepare a clean workspace for the sample staging area, using a decontaminated surface, clean PE sheeting, or untreated paper towels.
- Prepare the sampling area, removing moveable/unnecessary materials from the sampling area, including unnecessary hoses, aerators, filters, or other attachments/extensions of the tap (as noted, a hose may be in place during purging from an exterior spigot, only if needed to direct purge water, but must be removed prior to sampling).
- Don new nitrile gloves, changing as needed. Identify the sample port and open to allow purging and stabilization of the water flow for at least 3 minutes (purge time may vary based on project objectives) at a moderate to high flow.

- After purging is complete, reduce the discharge rate to a slow stream (generally less than 1 liter per minute) to minimize potential sample aeration.
- Don new nitrile gloves and collect the sample, filling each sample container to the shoulder.
- After closing sample containers, remove excess water from sample container surface with a fresh, untreated paper towel (excess water can facilitate cross-contamination) and place sample containers inside a new Ziploc bag. Double bag samples if they come from an area with known elevated PFAS levels.
- Place the samples in a cooler with ice, separate from any cooler with empty sample bottles.
- After sample handling is complete, close the sample spigot.

4.3 DECONTAMINATION AND IDW MANAGEMENT

The need for decontamination of reusable sampling equipment is not anticipated for water sampling from spigots. If reusable equipment such as a portable table for sample staging is used, which cannot be covered with PE sheeting, decontaminate using Alconox or similar and PFAS-free water.

Use a plastic contractor’s bag (or similar) to contain solid IDW, including PE sheeting, nitrile gloves, Ziploc baggies, and other sampling materials, to minimize risks of cross contamination.

4.4 OTHER NOTES

- If a hose is used to direct water during purging, it must be removed prior to sampling.
- If Teflon® tape is visible at the sample port locations where water exists the port, document on the field forms. Although PFAS are associated with Teflon® tape production, experience to date suggests that it isn’t a significant source of PFAS contamination in samples collected; nevertheless, its presence should be noted.

Domestic water may flow through a pressure tank or treatment system (e.g., water softener) before being discharged from a tap. For domestic wells, depending on sampling objectives, it may be necessary to collect water samples pre-treatment, post-treatment, or both. Pre-treatment sampling may be best if sampling is being conducted to evaluate local source-water impacts, but post-treatment may be best if sampling is conducted to evaluate drinking water exposure.

5.0 GROUNDWATER SAMPLING

This section provides PFAS sampling considerations specific to groundwater matrices. This section assumes general understanding of basic groundwater sampling procedures, and is not intended to teach groundwater sampling fundamentals, but rather to provide instruction on differences in procedures and considerations specific to PFAS sampling. Groundwater sampling typically requires purging of groundwater from wells using standard (“high-volume”) or low-flow methods; alternatively, no-purge methods such as HydraSleeves are available. Where appropriate, Trihydro's preferred groundwater sampling method for PFAS is no-purge sampling using HydraSleeves, to limit risk of cross-contamination and minimize risk of bias in sampling results due to artificially mobilizing PFAS in groundwater during purging. If no-purge sampling is not feasible, or is not accepted by regulatory agencies, low-flow sampling is recommended. Standard, high-volume purging methods should be avoided if possible, but may be required due to deep groundwater or other location-specific needs. Regardless of sampling method, sampling materials should be screened for PFAS compatibility. Additional considerations for sampling materials associated with these methods are provided in this section. The procedures discussed in this section are additional considerations to the general PFAS sampling guidelines provided in Section 3.

5.1 EQUIPMENT/MATERIALS

In addition to the general and decontamination supplies listed in Sections 3.3 and 3.8, respectively, additional sample materials and supplies required for PFAS sampling via no-purge sampling, low-flow sampling, bailer sampling, and submersible pump sampling are described below.

No-purge sampling (preferred). No-purge sampling may be conducted using HydraSleeve or other passive samplers constructed of HDPE or similar PFAS-compatible material. Passive diffusion samplers are also available for PFAS sampling. When ordering HydraSleeves (or similar no-purge sampling devices), communicate with the vendor that they are to be used for PFAS sampling, and materials must be PFAS compatible. PFAS-compatible rope (e.g., cotton or nylon) must be used for HydraSleeve deployment; it is recommended (but not required) to procure the PFAS-compatible rope from the HydraSleeve vendor. Deployment of no-purge sampling equipment can generally follow manufacturer's instructions but should also follow the general PFAS sampling approach described herein.

The HydraSleeve samplers consist of collapsible HDPE plastic sleeves that are deployed in a well at a fixed depth within the screened interval (typically near the bottom of the screened interval). A check valve at the top of the sleeve prevents groundwater from entering the sleeve during deployment. After deployment, the samplers are left in place for a prescribed amount of time (typically a week) to allow groundwater within the well to equilibrate with the formation. For sample collection and recovery, the HydraSleeve sampler is pulled upward, which opens the check valve and allows water to fill the sleeve. The HydraSleeve sampler is then recovered to the surface, and a sample collected from the sleeve. The sleeves are available in 1-liter, 2-inch well diameter size ('Super/SkinnySleeve 1-Liter', part number PFCHDSS-1L) and 2-liter, 2-inch well diameter size ('Super/SkinnySleeve 2-Liter', part number PFCHDSS-2L). For groundwater sampling in 4-inch wells, the HydraSleeve sampler may be deployed with a 4- to 2-inch reducer and spring clip, which is available from the vendor. Non-disposable components (dedicated materials) associated with the HydraSleeves (i.e., reducer, spring clip, and weight) should be dedicated to each well.

Low-flow sampling. Low-flow sampling involves well-purging at a limited flow rate (e.g., <500 mL/min) until parameters stabilize (EPA 1996). A peristaltic pump is recommended for PFAs sampling, if water depth can accommodate a peristaltic pump, to reduce/eliminate the need for equipment decontamination between sampling locations. If needed (e.g., for water too deep for a peristaltic pump), bladder pumps or electric submersible pumps may be used. Dedicated pumps are preferred, otherwise PFAS-compatible decontamination procedures must be completed between locations. For a bladder pump, the pump body should be constructed of stainless steel (or other PFAS compatible material), and the bladder and O-rings must be constructed of polyethylene or similar PFAS-compatible materials, and be replaced between sample locations. If an electric submersible pump is selected, evaluate that the pump is free of PTFE and other fluoropolymer fittings. Additional considerations for low-flow PFAS sampling are as follows:

- For a rental pump used for PFAS sampling, verify with the vendor that the pump is designed and constructed to be PFAS compatible.
- Downhole tubing should be either disposable or dedicated to a single location, and constructed of HDPE or a similar PFAS-compatible material; tubing constructed of Teflon, PTFE, or similar fluoropolymers cannot be used.
- Standard silicone tubing may be used for a peristaltic pump, but the tubing should be replaced between sample locations.
- A flow-through cell with a multi-parameter meter may be used to track parameters stabilization during low-flow purging. The flow-through cell does not need to be completely constructed of PFAS-compatible materials, but the meter/flow-through-cell must be removed from the flow path before sample containers are filled.

Bailer sampling. Samples can also be collected via bailer, though it is generally not preferred due to sample agitation and potential mixing with the air-water interface. Bailer materials are available that are compatible with PFAS sampling, such as HDPE. PFAS-compatible rope (e.g., cotton or nylon) must be used for bailer sampling. When used for PFAS sampling, bailers should be gently lowered across the water surface to minimize turbidity, and should be lowered sufficiently below the water surface such that the sample represents formation water rather than interfacial water.

Submersible pump sampling. High-flow purging with a submersible pump is generally not recommended for PFAS sampling, due to potential for PFAS contamination by pump components, cross-contamination between wells, and the possibility of mobilizing PFAS in a non-representative manner (e.g., via air bubbles) during high-volume purging. However, submersible pumps may be the only practical sampling device for deep wells. When practicable, use dedicated pump systems to eliminate cross contamination. The purge-water flow rate should be kept low, to eliminate or minimize entrained air bubbles in the water stream while purging and sampling.

Additional groundwater sampling considerations.

- Sampling materials should never be placed directly on the ground. Use a clean surface or PE sheeting for work space.
- If turbidity is noted, do not field-filter samples as filtration may affect PFAS concentrations. The laboratory should be informed of highly turbid samples; under certain circumstances, the laboratory may use centrifugation to prepare the sample for analysis.
- Purge water may generally be collected in standard 5-gallon buckets.
- Fluid level or interface probes may be used to monitor water levels before/during sampling. PFAS-compatible decontamination procedures must be followed between locations. Unless necessary, measurement of in-well total depth is not recommended during PFAS sampling to minimize cross-contamination risks.
- PFAS-compatible rope/twine (typically cotton or nylon) may be used for securing HydraSleeves, submersible pumps, or bailers.
- Equipment that contacts water within the well (e.g., pumping equipment and water meters) should not contain or be coated with Teflon®, unless the Teflon® is internal to the equipment and does not contact the external environment. Often, equipment suppliers will label products as “PFAS Testing Approved” or “PFAS-free.” It is highly recommended that equipment and supplies be identified as PFAS-free. If unsure whether a product is suitable for collecting a PFAS sample, contact the supplier and/or collect an equipment blank.

5.2 SAMPLING PROCEDURES

Sample collection for PFAS should generally follow these procedures. During most steps, samplers should don new nitrile gloves, even if it is not expressly identified below. New gloves should always be donned before handling sample containers, at any time.

- Decontaminate reusable equipment that will contact groundwater prior to use. Gauge depth to water and determine targeted pump-intake or screened interval for sampling.
- Using appropriate pen or ultra-fine Sharpie, fill out sample labels with all information except sample time (which can be added after the sample is collected and the lid replaced) and apply labels to sample containers. Pre-labeled sample containers may be stored in labeled 1-gallon Ziploc bags prior to sampling.
- Prepare a clean workspace for the sample staging area, using a decontaminated surface, clean PE sheeting, or untreated paper towels.
- Prepare the sample collection area, removing any moveable/unnecessary materials from the sampling area. Deploy PE sheeting as needed for staging of sampling materials, providing workspace to keep materials off the ground.

- Lower the pump, intake tubing, bailer, or passive sampler to the desired sample interval. Importantly, the sample interval should be several feet below the groundwater-air interface to ensure the collection of a representative groundwater sample and avoid sampling of PFAS accumulated at the interface.
- If low-flow purging is performed, connect the water quality meter to the flow path and initiate purging. Collect purge-water in a dedicated container (e.g., plastic 5-gallon bucket) and make sure that water does not splash or come into contact with the sample staging area and sample bottles. Record parameters at regular intervals, in accordance with standard practice for low-flow purging. After groundwater parameters have stabilized, disconnect the water quality meter before sampling.
- Collect the sample - don new nitrile gloves and fill the sample containers without touching other equipment or surfaces, including the sample tubing.
- It is preferable to have two personnel for sampling, one person to handle the sample device (e.g., HydraSleeve) and pour, and the other person to manage the sample containers, without needing to set down the sampling device and containers and risk potential cross-contamination.
- After sample containers are filled and closed, use clean, untreated paper towels to remove excess water from the exterior of the sample containers (excess water poses a cross-contamination risk during sample handling). Immediately place sealed sample containers in Ziploc bags, and place the bags in a sample cooler. Always have at least two dedicated coolers, one for clean sample bottles, and one for collected samples, to further minimize risk of cross-contamination during sample collection and handling.

5.3 EQUIPMENT DECONTAMINATION

Ideally, sampling should use disposable or dedicated equipment that does not require decontamination. Rental equipment should be treated as potentially contaminated, and be decontaminated before initial use. If a bladder pump is utilized, the bladder should be changed between sample locations and the pump body thoroughly decontaminated. Reusable equipment, including a pump or water-level meter, should be decontaminated using a Alconox, Liquinox, or Citrinox wash and a final, triple-rinse using laboratory-supplied water that is certified PFAS-free. Note that Simple Green® has not been confirmed to be PFAS free, and is therefore not approved for PFAS sampling decontamination at this time.

5.4 OTHER NOTES

If existing sample tubing is present in the well, unless the tubing composition is known, it should be assumed to be PFAS-containing (e.g., Teflon). In this case, it is highly recommended that the tubing be removed from the well, and at least one well volume of water purged from the well prior to sampling. Greater fluid volumes can be removed from the well if deemed necessary, however removal of at least one well volume is required before sampling.

Samples should not be collected from wells with measurable light non-aqueous phase liquids (LNAPL), due to the tendency of PFAS to accumulate at oil/water interfaces (e.g., Brusseau 2018). Similarly, PFAS will also preferentially tend to accumulate at air-water interfaces. To ensure representative sample collection, do not collect groundwater samples directly from the groundwater-air interface, where practicable.

6.0 SURFACE WATER AND SEDIMENT SAMPLING

This section provides PFAS sampling considerations specific to surface water and sediment matrices. This section assumes general understanding of basic surface water and sediment sampling procedures, and is not intended to teach surface water and sediment sampling fundamentals, but rather to provide instruction on differences in procedures and considerations specific to PFAS sampling. The procedures discussed in this section are additional considerations to the general PFAS sampling guidelines provided in Section 3.

6.1 EQUIPMENT/MATERIALS

In addition to the general and decontamination supplies listed in Sections 3.3 and 3.8, respectively, additional sample materials and supplies may include:

- Waders that have not been treated with waterproof coating (Table 1)
- Transfer containers, such as beakers or dippers, and extension rods
- Stainless-steel sample spoons, sample augers, or sample core barrels
- Disposable sample spoons constructed of PFAS-compatible material
- Single-use PVC or acetate sediment sampler liners (as needed)
- HDPE core-liner caps (preferred) or LDPE liner caps (if HDPE are not available) as needed
- Self-retracting utility knife with hook blades (decontaminated)
- Hacksaw with uncoated blade (decontaminated)
- Wrist- or elbow-length nitrile or PVC gloves for sediment sampling beneath shallow surface water

6.2 SURFACE WATER SAMPLING PROCEDURES

Where surface water and sediment samples are to be co-located, surface water samples should be collected first, to minimize potential for suspended sediment in the water sample. Surface-water samples should be collected below the surface and avoid water from the surface film, to avoid sample bias due to PFAS accumulation at air-water interfaces. During most steps, samplers should don new nitrile gloves, even if it is not expressly identified below. New nitrile gloves should always be donned before handling sample containers, at any time. Sample collection for PFAS should generally be conducted in accordance with the following procedures:

1. Before use, decontaminate reusable equipment that will contact surface water or sediment.
2. Using appropriate pen or ultra-fine Sharpie, fill out sample labels with all information except sample time (which can be added after the sample is collected and the lid replaced) and apply labels to sample containers. Pre-labeled sample containers may be stored in labeled 1-gallon Ziploc bags prior to sampling.
3. Prepare a clean workspace for the sample staging area, using a decontaminated surface, clean PE sheeting, or untreated paper towels.
4. Select a location where a sample can be collected from a depth of at least 10 centimeters (cm) (4 inches) from the sediment bed, at least 10 cm below the surface-water level, and as close to the center of the channel as practicable.
5. Where surface water can be collected by hand, samplers should approach the sample location from downstream.
6. Keeping the lid in place, submerge the sample container to the target sample depth.
7. Orient the sample container upstream; remove the cap to fill the container. The container should be filled to the shoulder, some headspace is preferred, if practical while filling underwater.
8. Replace the cap while the container is still submerged and close tightly before bringing the container above the water's surface.
9. Remove excess water from the outside of the sample container with a clean, untreated paper towel, add sample time to label, and immediately place inside a clean Ziploc bag, and place in the sample cooler.

Use of a transfer container is not recommended for PFAS sampling, but under certain circumstances may be required. A transfer container may be needed where sample locations are not directly accessible, such that extension rods or dippers are needed, or if sample containers require preservation and cannot be submerged. Transfer containers may be used under such circumstances, but must be clean and constructed of PFAS-compatible materials.

6.3 SEDIMENT SAMPLING PROCEDURES

Surface water sampling should be completed before sediment sampling. Spoons or scoops may be used to sample shallow sediments, however these methods may not be ideal due to agitation of the sample, mixing and washing during collection, and the inability to accurately determine sediment interval. For deeper/depth-discrete sampling, the preferred sediment sample collection method is to use a sediment sample auger (or similar). General sample collection procedures are as follows:

1. Before use, decontaminate reusable equipment that will contact surface water or sediment.
2. Using appropriate pen or ultra-fine Sharpie, fill out sample labels with all information except sample time (which can be added after the sample is collected and the lid replaced) and apply labels to sample containers. Pre-labeled sample containers may be stored in labeled 1-gallon Ziploc bags prior to sampling.
3. Prepare a clean workspace for the sample staging area, using a decontaminated surface, clean PE sheeting, or untreated paper towels.
4. If sediment sampling beneath shallow surface water using a spoon/scoop, don wrist-length nitrile or PVC gloves to avoid contact between skin and surface water, reducing risk potential for cross-contamination.
5. Approach the desired sediment sampling location from downstream if using waders. Sample should be collected from the midpoint of the channel, where practicable.
6. Drive the sediment sampler into the sediment. It is best to ‘overshoot’ the target sample depth, so that organics and debris overlying the sediment can be discarded, allowing collection of a representative sample.
7. Remove the sediment sampler, and place the sediment on an PE-lined sample table. Be sure to note the top and bottom of the sediment interval.
   - If using a sediment sampler with an acetate liner:
     - The liner can be opened using the self-retracting knife, to identify the desired sample interval. Change gloves after handling the knife. Discard organic material and debris on the surface, and transfer target sample intervals to HDPE sample containers. The samples can be transferred using a decontaminated stainless-steel scoop or disposable scoop. Use a fresh scoop and change nitrile gloves if collecting samples from more than one interval.
     - Alternatively, the liner can be cut into segments, capped with a liner cap, and placed into Ziploc bags for shipping to the analytical laboratory. Remove excess silt and debris from the exterior of the liners before cutting. Place each liner section in its own separate bag.
   - If using a sediment sampler without a liner:
     - Place the sampler on a clean, PE-lined table. Identify the desired sample interval. Do not allow organic material and debris on the surface to be entrained in the sample. Transfer target sample intervals to HDPE sample containers. The samples can be transferred using a decontaminated stainless-steel scoop or disposable scoop. Use a new scoop and change nitrile gloves if collecting samples from more than one interval. Fill the sample container and replace the cap.
8. Clean the outside of the sample container with a untreated paper towel, add the time sampled, and place into a Ziploc bag and then directly into the sample cooler.

6.4 EQUIPMENT DECONTAMINATION

Ideally, sampling should use disposable or dedicated equipment that does not require decontamination. Rental equipment should be treated as potentially contaminated, and be decontaminated before first use. Reusable equipment, including a sediment sample spoon or hand-auger, should be decontaminated using a Alconox, Liquinox, or Citrinox wash and a triple-rinse using laboratory-supplied water that is certified PFAS-free. Note that Simple Green® has not been confirmed to be PFAS free, and is therefore not approved for PFAS sampling decontamination at this time.

7.0 SURFACE AND SUBSURFACE SOIL SAMPLING

This section provides sampling considerations specific to surface and subsurface matrices. This section assumes general understanding of basic soil sampling procedures, and is not intended to teach soil sampling fundamentals, but rather to provide instruction on differences in procedures and considerations specific to PFAS sampling. Surface soil sampling may be conducted using hand tools or drill equipment. Generally, standard soil sampling and/or drilling equipment is compatible with PFAS sampling, with certain considerations noted in this section. When subcontracting a driller for soil sampling, it is important to communicate PFAS requirements early in the process, so they are able to prepare and plan accordingly. Procedures discussed in this section are additional considerations to the general PFAS sampling guidelines provided in Section 3.

7.1 EQUIPMENT/MATERIALS

In addition to the general and decontamination supplies listed in Sections 3.3 and 3.8, respectively, additional sample materials and supplies may include:

1. Disposable polyvinyl chloride (PVC), high density polyethylene (HDPE), or acetate liners
2. HDPE liner caps (preferred) or LDPE liner caps (if HDPE are not available) as needed
3. Self-retracting utility knife with uncoated hook blades or uncoated razor blades
4. Hacksaw with uncoated blade
5. Stainless-steel hand auger, trowel, or shovel
6. Polyethylene or polyvinyl brush to remove particles during decontamination

Equipment that contacts soil should not contain or be coated with Teflon® (or other PFAS incompatible material) unless the Teflon® is internal to the equipment and does not contact the external environment. If uncertain, contact the supplier and/or an equipment blank may be collected.

7.2 SAMPLING PROCEDURES

Surface and subsurface soil samples may be collected to delineate surficial and vertical extent of impacts where PFAS are potentially or known to be released to land/soil. Overall, sampling procedures used for PFAS are similar to those used for conventional soil sampling, with certain material limitations and precautions against cross-contamination as noted herein. Surface and shallow soil samples can be collected using a decontaminated stainless-steel hand auger, trowel, or shovel; a disposable plastic scoop may also be used. If sampling from a hand auger, the sample material may be removed from the auger into a decontaminated stainless-steel bowl. Soil samples collected using a trowel or shovel may be transferred directly into the sample container using a disposable scoop, decontaminated spoon, or a new nitrile glove. Care should be taken to ensure the samples avoid contact with uncontrolled surfaces such as the ground, contaminated equipment, cooler-top, or tailgate.

Several methods are available for PFAS-related subsurface soil sampling, including hand-auger, direct-push, hollow-stem auger/split-spoon sampler, or continuous core collection via sonic drill rig or other drill method. Direct push and split spoon samplers, which generate cores in acetate, HDPE, or PVC liners, are preferred due to the minimization of sample contact with drilling equipment, as well as minimization of agitation. For accurate assessment of subsurface PFAS impacts, collection of cores with minimal disturbance is preferred. Drilling methods that produce loose cuttings such as those obtained by auger and rotary drilling processes should be avoided if possible. Additional considerations for drilling are provided in the following section.

After collection, soil core liners may be cut open using a decontaminated stainless-steel cutting device, such as a retractable-blade utility knife. Soil core samples may be transferred to a decontaminated stainless-steel bowl for consolidation and subsampling, or samples may be collected directly from the core liners and transferred to laboratory-provided HDPE or polypropylene sample bottles. Soil samples should be transferred from the core liners using disposable scoops, decontaminated spoons, or new nitrile gloves. If other analytical suites are to be collected (e.g., metals, volatile organic compounds), collect the PFAS samples first and secure the PFAS samples in coolers before collecting other analytical suites to prevent container cross-contamination. Do not touch other sample containers, which may have PTFE-containing septa or lids, prior to collecting the PFAS sample. Place PFAS samples in separate bags or separate coolers from other analytical samples for shipping. When collecting samples, the sample container cap should never be placed directly on the ground during sampling; sample container caps/lids should be held, or only placed on surfaces that are known to be PFAS-free. Once collected, soil sample containers should be stored in their own Ziploc bags within the sample cooler, and placed on double-bagged ice to begin the cooling process in accordance with the procedures in Section 3.7. Soil samples stored in bags should be double bagged.

Alternatively, soil core samples may remain in the PVC, HDPE, or acetate liners for shipping to the analytical laboratory. Full soil cores inside the sample liners should be cut crosswise using a decontaminated, untreated hook blade knife or hacksaw, into the target sample intervals. The core-liner segments can be capped on both ends using HDPE liner caps. LDPE liner caps may be used if HDPE caps are unavailable; however, PFAS compounds may adsorb to LDPE liner caps. Bulk soil on the exterior of each core-liner segments should be removed using clean, untreated paper towels and each core segment should be placed in a Ziploc bag (core segments should be double-bagged if elevated PFAS concentrations are suspected). The capped/bagged core segments can then be placed in a sample cooler on double-bagged ice.

7.3 DRILLING PROCEDURES

Subsurface soil sampling necessarily involves the use of non-dedicated equipment such as drill rods, core barrels, split spoons, augers, trowels, shovels, and other drilling related equipment. These equipment can be a potential source of cross contamination both from boring to boring as well as between vertical intervals within a single boring. Lubricants used during drilling should not be labeled as containing PTFE or other fluoropolymer. Thorough decontamination of the exterior and interior surfaces of drill rods, core barrels, and other drill rig tooling should be conducted between every boring location. Due to the size and quantity of this equipment, it may not be practical to use laboratory supplied PFAS-free water for decontamination purposes. Therefore, a source of clean decontamination water may be identified and confirmed as PFAS-free by laboratory analysis prior to the field event.

Beyond drilling equipment, there are additional cross-contamination risks inherent to the drilling process. Drillers handle drilling equipment manually when advancing the drilling tooling. Work gloves, boots, and clothing worn by the drillers can pose a cross-contamination risk. Clothing requirements discussed in Section 3 should be communicated to drill crews in advance of the field event. Drill crews should avoid wearing waterproof, water resistant, or stain proof clothing. Nitrile gloves should be worn outside work gloves and changed often when handling drill tooling. Work boot overshoes, PVC coveralls, and other mitigation measures may be considered to limit cross-contamination risks. However, personnel safety is paramount and should not be sacrificed for cross-contamination mitigation. Cross-contamination risks can also be mitigated using procedural measures such as ensuring that drillers do not touch the internal surfaces of drilling equipment (e.g., inside of core barrels) or other surfaces which might come in direct contact with the soil sample. For this reason, it is recommended that PFAS considerations be communicated with the drilling contractor and also included in a kickoff meeting, held with the drill crew in advance of the event where detailed procedures and cross-contamination mitigation best practices are discussed. Selection of a drilling contractor with PFAS-specific experience is also recommended.

7.4 EQUIPMENT DECONTAMINATION

Where possible, sampling should use disposable or dedicated equipment that does not require decontamination. Decontamination of soil-drilling and soil-sampling equipment (cores, grab samples) can be conducted via pressure-washing or using Alconox, Liquinox, and Citranox solutions (see Table 1). Equipment should be scrubbed with a plastic brush and rinsed thoroughly in tap water to wash away debris or material on exposed surfaces. Replace decontamination solution if sediment has accumulated or between locations where high PFAS concentrations may be expected. As a final decontamination step, triple rinse equipment in laboratory-supplied PFAS-free water. Use a spray bottle for the PFAS-free water rinse, to avoid contaminating decon rinse water. PVC or acetate liners should be discarded and not decontaminated between sampling sites.

8.0 OTHER SAMPLING MATRICES

PFAS sampling may be required in other matrices, such as sludge/biosolids, air, non-aqueous phase liquids (NAPLs), asphalt, concrete, and plant or animal tissues. This SOP does not include protocols for these matrices. The general PFAS sampling guidelines should be followed, and a laboratory consulted for specific guidelines on sample requirements. Consult a member of Trihydro's PFAS sampling team for assistance.

9.0 PFAS LABORATORY REQUIREMENTS

This section includes procedures and considerations for initial laboratory communications, PFAS analytical methods, container preservation requirements, and sample quality control/quality analysis (QA/QC) requirements.

9.1 LABORATORY COMMUNICATION

Communication is recommended with the selected analytical laboratory before sampling, or during pre-project communications with candidate analytical laboratories, to confirm the following:

1. Does the laboratory have the necessary accreditation?
2. Can the laboratory meet the required reporting limits for all PFAS analytes?
3. Do the laboratory-specific methods (e.g., 537-MOD) use isotope dilution for quantification?
4. Can the laboratory accommodate project-specific needs, such as high concentrations or unusual matrices?
5. Can the laboratory provide certified PFAS-free water for decontamination and QA/QC samples?
6. Can the laboratory meet the required turnaround time? What is the current backlog for PFAS samples?

9.2 ANALYTICAL METHODS

As of July 2022, the EPA has published the following PFAS analytical methods:

1. Method 533: drinking water, 24 analytes
2. Method 537.1: drinking water, 18 analytes
3. Method 8327: non-drinking water aqueous samples, 24 analytes
4. DRAFT Method 1633: wastewater, surface water, groundwater, soil, biosolids, sediment, landfill leachate, and fish tissue; 40 analytes
5. DRAFT Method 1621: aqueous matrices, adsorbable organic fluorine (AOF) (i.e., total organic fluorine)

For non-drinking-water matrices, most laboratories have established independent methods for PFAS analysis, typically involving isotope dilution to account for matrix interference and including both branched and linear isomers. Although often referred to as 'modified 537' or '537-MOD' these laboratory-independent methods are in fact unrelated to EPA 537.1. To ensure consistent and repeatable analysis for non-drinking water samples, the laboratory should have proper accreditation and have capability to perform analysis that is consistent with U.S. Department of Defense (DoD) Quality System Manual (QSM) Version 5.1 or later (5.3 is the most recent version), Table B-15. QSM 5.3 Table B-15 is not an analytical method, per se, but provides a standardized set of laboratory quality control procedures. Compliance with QSM Table B-15 protocol has generally been required for regulatory-ordered PFAS samples, although this requirement may change as the EPA finalizes more methods. Trihydro's PFAS team recommends that samples be analyzed in compliance with QSM Table B-15 protocol to ensure data quality, even if not specifically required. PFAS analytes associated with each of these methods are provided on Table 2.

1. **EPA 537.1**: Determination of Selected Per-and Polyfluorinated Alkyl Substances in Drinking Water by Solid Phase Extraction and Liquid Chromatography/Tandem Mass Spectrometry. November 2018. Drinking water method for 18 analytes, does not use isotope dilution*.
2. **EPA 533**: Determination of Per- and Polyfluoroalkyl Substances in Drinking Water by Isotope Dilution Anion Exchange Solid Phase Extraction and Liquid Chromatography/Tandem Mass Spectrometry. November 2019. Drinking water method for 25 analytes, uses isotope dilution*.
3. **EPA 8327**: Per- and Polyfluoroalkyl Substances by Liquid Chromatography/Tandem Mass Spectrometry (LC/MS/MS). July 2021. Aqueous, non-drinking water matrices (groundwater, surface water, waste water), considered as a screening-level method, does not use isotope dilution*.
4. **DRAFT EPA 1633**: Analysis of Per- and Polyfluoroalkyl Substances (PFAS) in Aqueous, Solid, Biosolids, and Tissue Samples by LC-MS/MS. August 2021. DRAFT method for ground water, surface water, waste water, soil and sediment matrices, using isotope dilution*. This method has not been finalized as of March 2022. Despite "draft" status, the method is being used and required by some states in monitoring permits. Unless required for a specific sampling event, this method is not recommended at this time by Trihydro's PFAS team.
5. **DRAFT Method 1621**: Screening Method for the Determination of Adsorbable Organic Fluorine (AOF) in Aqueous Matrices by Combustion Ion Chromatography (CIC). Provides a single result ("AOF") representing total PFAS concentration.
6. **DoD QSM 5.3 Table B-15**: DoD Quality Systems Manual Version 5.3. May 2019. Table B-15: Per- and Polyfluoroalkyl Substances (PFAS) Using Liquid Chromatography Tandem Mass Spectrometry (LC/MS/MS) With Isotope Dilution or Internal Standard. As of March 2022, this is recommended as a standardized method for groundwater, surface water, waste water, soils, and sediment samples. Can be referenced in work plans as "the samples will be analyzed at a certified laboratory using methods compliant with DoD QSM Table B-15" (uses isotope dilution*).

> **Note regarding isotope dilution*: the descriptions above indicate which methods use isotope dilution to quantify analytes. Isotope dilution is an internal standard, and methods that do not use isotope dilution use external standards. Isotope dilution increases detection accuracy, which can be very important to quantify and control matrix interference, which can be very important for complex environmental matrices.

The specific analyte list is an important consideration for PFAS site investigation. PFOA, PFOS, perfluorobutane sulfonate (PFBS), and GenX are the only PFAS compounds with USEPA Health Advisory Levels (as of July 2022), but hundreds to thousands of additional PFAS compounds are also present in the environment. Typical laboratory methods quantify a relatively small fraction of these compounds. The specific analyte list for each project should be determined based on method requirements, sampling objectives, and client needs. PFAS analytes associated with the above methods are shown on Table 2. Unless a USEPA method is referenced for a compound list, a list of target PFAS analytes should be attached to the chain of custody (COC) form. State-issued sampling orders may require other PFAS or non-PFAS analytes.

9.3 USE OF PRESERVATIVE

For drinking water samples, each 250 mL sample bottle may be required to contain a preservative. EPA method 537.1 a small amount (1.25 g) of Trizma® and method 533 requires 1 g/L ammonium acetate, both of which are included to remove free chlorine from chlorinated drinking water (USEPA 2015). Before sampling drinking water for PFAS analysis, confirm the need for the Trizma® or ammonium acetate with the selected analytical laboratory. For groundwater samples or other water matrices, inclusion of Trizma® is not required but is considered harmless (in terms of potential effects on measured PFAS concentrations) and may be included.

The Trizma® and ammonium acetate buffers are required for samples analyzed via EPA Method 537.1 and EPA Method 533, respectively. The buffer is required regardless of whether the water being sampled is chlorinated.

9.4 FIELD QUALITY ASSURANCE AND QUALITY CONTROL SAMPLES

Field quality-assurance / quality-control (QA/QC) samples are imperative for PFAS analysis. Five different types of QA/QC samples may be collected during the sampling event as described below. Each type of QA/QC sample listed below is provided a "Required" or "Optional" label. QA/QC sampling needs may be determined in a Quality Assurance Project Plan (QAPP).

Field Blanks (Required): Field blanks (or field reagent blanks) are collected to verify that the sampling environment and site-required PPE worn during the sampling event do not contaminate samples. At a minimum, one field blank should be collected for each site, with each sampling event that involves collecting an aqueous sample. Field blanks are analyzed for the same list of PFAS constituents as analyzed for associated field samples. The field blank is collected by pouring PFAS-free reagent water received from the laboratory into an empty, clean sample container at the sampling site. Generally, two laboratory-provided sample containers are filled for each field-blank sample.

Equipment Blanks (Required): Equipment blanks will be prepared and submitted for laboratory analysis to verify that equipment decontamination procedures are effective, and to verify that sampling equipment is PFAS-free and not causing contamination. Equipment blanks are analyzed for the same PFAS constituents as required for the field samples. Minimally, equipment blanks should be collected for sampling equipment that may contact the sample matrix, such as HDPE core liners, bailers, pump tubing, using PFAS-free water provided by the laboratory. Equipment blanks should be collected at a rate of at least 1 per event per piece of equipment used for sampling. Equipment blanks are not required for tapwater sampling, where sample containers are filled directly from source water.

Blind Duplicates (Recommended): Blind Duplicate samples can be collected to evaluate reproducibility of analytical techniques and the homogeneity of sample matrices. Duplicate samples are submitted for the same PFAS analyses that are required for the field samples. Duplicate samples will be collected at a frequency of 10%, or one for every 10 samples for aqueous sampling matrices. If less than 10 samples are collected during a particular sampling event, one blind duplicate sample will be collected. The duplicate sample will be "blind" to the laboratory, therefore will have a coded identity on its label and on the COC. The actual sampling location and identification will be recorded on the sampling log.

Trip Blanks (Optional): Trip blanks are laboratory-prepared bottles containing PFAS-free water that travel from the laboratory to the site, and then transported back to the laboratory with the samples in the sample coolers. A set of trip blanks can accompany each cooler that contains PFAS samples. Trip blanks should be supplied by the laboratory and will accompany the sample containers throughout the sampling event. Trip blanks will only be analyzed by the laboratory for PFAS if instructed to do so by the PM; these samples should otherwise be held once received by the laboratory. Trip blanks are generally not required for PFAS samples but may be helpful to identify sources of contamination, should they occur.

Matrix Spikes/Matrix Spike Duplicates (MS/MSD) (Optional): MS/MSDs can be prepared and analyzed by the laboratory for each matrix sampled. MS/MSDs are samples in which known quantities of specific PFAS compounds are added before extraction and analyses. The recoveries for spiked compounds can be used to assess how well the method for analysis recovers target compounds. MS/MSD samples are submitted for the same PFAS analyses that are required for the field samples.

10.0 REFERENCES

Brusseau ML. 2018. Assessing the potential contributions of additional retention processes to PFAS retardation in the subsurface. Sci Total Environ. February 1, 2018; 613-614:176-185.

California Office of Environmental Health Hazard Assessment (OEHHA). 2021. Notification Levels for Chemicals in Drinking Water. oehha.ca.gov. 2021. Available from: https://oehha.ca.gov/water/notification-levels-chemicals-drinking-water.

California State Water Quality Control Board (The Water Boards), Division of Water Quality. 2020a. Per- and Polyfluoroalkyl Substances (PFAS) Sampling Guidelines for Non-Drinking Water. September 2020. Available from: https://www.waterboards.ca.gov/pfas/docs/sept_2020_pfas_sampling_guidelines.pdf.

California State Water Resources Control Board. 2021. WQ 2021-0006-DWQ Water Code Sections 13267 and 13383 Order for the Determination of the Presence of Per- and Polyfluoroalkyl Substances at Bulk Fuel Storage Terminals and Refineries. March 12, 2021.

EPA. 1996. Puls, R.W. and M.J. Barcelona. Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures. EPA/540/S-95/504. April 1996.

Interstate Technology Regulatory Council (ITRC). 2022. ITRC's guidance document, Technical Resources for Addressing Environmental Releases of Per- and Polyfluorinated Compounds (PFAS), Chapter 11, Sampling and Analytical Methods, Updated September 2022. Available from: https://pfas-1.itrcweb.org/11-sampling-and-analytical-methods/.

Michigan Department of Environmental Quality (MDEQ). 2018. General PFAS Sampling Guidance. Revised October 16, 2018. Available from: https://www.michigan.gov/documents/pfasresponse/General_PFAS_Sampling_Guidance_634597_7.pdf.

United States Environmental Protection Agency (USEPA). 2015. Method 537. Determination of selected perfluorinated alkyl acids in drinking water by solid phase extraction and liquid chromatography/tandem mass spectrometry (LC/MS/MS). Revised October 7, 2015. Available from: https://cfpub.epa.gov/si/si_public_record_report.cfm?dirEntryId=198984&simpleSearch=1&searchAll=EPA%2F600%2FR-08%2F092.

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TABLES

TABLE 1. PFAS SAMPLING ITEMS[1]
SOP FOR CHARACTERIZATION OF PFAS AT BULK FUEL STORAGE TERMINALS AND REFINERIES

Prohibited Items/Materials	Acceptable Items/Materials
Sampling Equipment[1]	
Polytetrafluoroethylene (PTFE), including Teflon® and Hostaflon®-containing materials (tubing, bailers, tape, and plumbing paste)	High-density polyethylene (HDPE) materials including polypropylene[2]
Polyvinylidene fluoride (PVDF), including Kynar®-containing materials (tubing, coatings on aluminum and steel, lithium-ion batteries)	Stainless steel
Polychlorotrifluoroethylene (PCTFE), including Neoflon®-containing materials (valves, seals, gaskets, food packaging)	Nylon or cotton
Ethylene-tetrafluoro-ethylene (ETFE), including Tefzel® (wire/cable insulation, pipe liners)	Polyvinyl chloride (PVC)
Fluorinated ethylene propylene (FEP), including Teflon® FEP and Hostaflon® FEP-containing materials (wire/cable insulation, pipe liners)	Acetate liners
Low-density polyethylene (LDPE)	Silicone tubing
Aluminum foil	Natural rubber
Sample Labeling and Field Documentation	
Waterproof field books	Loose paper (non-waterproof)
Plastic clipboards, binders, spiral hard cover notebooks	Aluminum field clipboards or with Masonite®; Rite-in-the-Rain is acceptable in staging area if gloves are changed after note taking.
Post-It Notes	Ballpoint pens
Regular/thick size markers (Sharpie®)	Fine and Ultra-Fine point Sharpie® markers are acceptable to label empty sample bottles while in staging area provided the lid is on the sample bottle and gloves are changed following sample bottle labeling.
Re-usable chemical (blue) ice packs	Water-based ice in polyethylene bags (double bagged)
Clothing and Personal Protective Equipment (PPE) used by Field Personnel[3]	
Clothing laundered using fabric softener	Synthetic or cotton clothing that has been well-laundered clothing, defined as clothing that has been washed 6 or more times after purchase
New cotton clothing or synthetic water-resistant/ waterproof clothing or dirt/stain-resistant treated clothing, clothing containing GORE-TEX™, Scotchgard™, and RUCO®	Waterproof clothing made with polyurethane, PVC, wax-coated fabrics, rubber, or neoprene
Boots containing GORE-TEX™	Boots made with polyurethane and/or PVC
Latex gloves	Powderless nitrile gloves
Clothes chemically treated for insect resistance and ultraviolet protection	
Coated Tyvek®	

TABLE 1. PFAS SAMPLING ITEMS[1]
SOP FOR CHARACTERIZATION OF PFAS AT BULK FUEL STORAGE TERMINALS AND REFINERIES

Prohibited Items/Materials	Acceptable Items/Materials
Personal Care Products, Sun/Biological Protection	
No cosmetics, moisturizers, fragrances, hand cream, or other related products as part of personal cleaning showering routine on the day of sampling, and 24 hours prior to sampling.	**Sunscreens** - Alba Organics Natural Sunscreen, Yes To Cucumbers, Aubrey Organics, Jason Natural Sun Block, Kiss my face, Baby sunscreens that are “free” or “natural” -- **Insect Repellents** - Jason Natural Quit Bugging Me, Repel Lemon Eucalyptus Insect repellant, Herbal Armor, California Baby Natural Bug Spray, BabyGanics -- **Sunscreen and insect repellent** - Avon Skin So Soft Bug Guard Plus – SPF 30 Lotion
Sample Containers	
LDPE or glass containers	HDPE or polypropylene
Teflon®-lined caps	Unlined polypropylene caps
Rain Events	
Waterproof or water-resistant rain gear	Gazebo tent that is only touched or moved before and following sampling activities
Equipment Decontamination	
Decon 90® , Simple Green®	Alconox®, Liquinox®, or Citranox®
	Laboratory supplied PFAS-free water
	Commercially available deionized water if verified to be PFAS-free
Water from an on-site well	Potable water from municipal drinking-water supply if known to be PFAS-free
Food Considerations	
All food and drink, with exceptions noted herein. Note that fast-food and prepackaged food containers may contain PFAS.	Bottled water and hydration drinks (i.e., Gatorade® and Powerade®) to be brought and consumed only in the staging area

Notes:

1. PFAS sampling-item restrictions apply to the entire sample collection and processing area, including vehicles used by sampling personnel
2. The United States Environmental Protection Agency (USEPA) and American Society for Testing and Materials (ASTM) method for the analysis of PFAS in solid and liquids specify polypropylene or HDPE with polypropylene lids. Check with the laboratory regarding their polypropylene or HPDE preference.
3. Sampling personnel includes all personnel who:
    - Are directly involved in the collection, handling, and/or processing of samples before the samples leave the site.
    - Handle any part of equipment that directly contacts surface water or stormwater.
    - Are within 2 to 3 meters (i.e., 6 to 9 feet) of the borehole during soil sampling.

Personnel are not included as sampling personnel if they remain at least 2 to 3 meters away from sample-collection areas before and during sampling.

TABLE 2. PFAS REFERENCE TABLE - CHEMICAL NAMES, ACRONYMS, AND ANALYTICAL METHODS
PFAS SAMPLING STANDARD OPERATING PROCEDURES
TRIHYDRO CORPORATION

This table presents a select subset of the 3,000+ compounds classified as PFAS.

									Analytical methods				
Classification	**Family**	**Class**	**Group**	**PFAS Compound**	**Acronym**	**Chemical Abstract Service (CAS) #**	**Mol. Wt.**	**Chemical Formula fluorinated tail (red) head (blue)**	**EPA 537.1**	**EPA 533**	**EPA 8327**	**DoD QSM 5.1**	**EPA 1633 (draft)**
Per and Poly Fluoroalkyl Substances (PFAS)	Perfluorinated Compounds	Perfluoroalkyl Acid (PFAA)	1	Perfluorobutanoic acid *	PFBA	375-22-4	214.0	C_3F_7COOH		X	X	X	X
				Perfluoropentanoic acid *	PFPeA	2706-90-3	264.1	C_4F_9COOH		X	X	X	X
				Perfluorohexanoic acid *	PFHxA	307-24-4	314.1	$C_5F_{11}COOH$	X	X	X	X	X
				Perfluoroheptanoic acid *	PFHpA	375-85-9	364.1	$C_6F_{13}COOH$	X	X	X	X	X
				Perfluorooctanoic acid **	PFOA	335-67-1	414.1	$C_7F_{15}COOH$	X	X	X	X	X
				Perfluorononanoic acid **	PFNA	375-95-1	464.1	$C_8F_{17}COOH$	X	X	X	X	X
				Perfluorodecanoic acid **	PFDA	335-76-2	514.1	$C_9F_{19}COOH$	X	X	X	X	X
				Perfluoroundecanoic acid **	PFUnA	2058-94-8	564.1	$C_{10}F_{21}COOH$	X	X	X	X	X
				Perfluorododecanoic acid **	PFDoA	307-55-1	614.1	$C_{11}F_{23}COOH$	X	X	X	X	X
				Perfluorotridecanoic acid **	PFTriA	72629-94-8	664.1	$C_{12}F_{25}COOH$	X		X	X	X
				Perfluorotetradecanoic acid **	PFTeA	376-06-7	714.1	$C_{13}F_{27}COOH$	X		X	X	X
			2	Perfluorobutane sulfonic acid *	PFBS	375-73-5	300.1	$C_4F_9SO_3H$	X	X	X	X	X
				Perfluoropentane sulfonic acid *	PFPeS	2706-91-4	350.1	$C_5F_{11}SO_3H$		X	X	X	X
				Perfluorohexane sulfonic acid **	PFHxS	355-46-4	400.1	$C_6F_{13}SO_3H$	X	X	X	X	X
				Perfluoroheptane sulfonic acid **	PFHpS	375-92-8	450.1	$C_7F_{15}SO_3H$		X	X	X	X
				Perfluorooctane sulfonic acid **	PFOS	1763-23-1	500.1	$C_8F_{17}SO_3H$	X	X	X	X	X
				Perfluorononane sulfonic acid **	PFNS	68259-12-1	550.1	$C_9F_{19}SO_3H$			X	X	X
				Perfluorodecane sulfonic acid **	PFDS	335-77-3	600.1	$C_{10}F_{21}SO_3H$			X	X	X
				Perfluorododecane sulfonic acid **	PFDoS	79780-39-5	600.1	$C_{11}F_{23}SO_3H$					X
		FASA		Perfluorooctane sulfonamide	PFOSA	754-91-6	499.1	$C_8F_{17}SO_2NH_2$			X	X	X
				N-methyl perfluorooctane sulfonamide	N-MeFOSA	31506-32-8	513.2	$C_8F_{17}SO_2N(CH_3)H$					X
				N-ethyl perfluorooctane sulfonamide	N-EtFOSA	4151-50-2	527.2	$C_8F_{17}SO_2N(C_2H_5)H$					X
	Replacement Compounds	Fluoroalkyl Ethers		Hexafluoropropylene oxide dimer acid (GenX)	HFPO-DA	13252-13-6	330.2	$C_3F_7O(CF_2)_2COOH$	X	X			X
				4,8-dioxa-3H-perfluorononanoic acid	ADONA	919005-14-4	378.1	$CF_3O(CF_2)_3OC_2HF_3COOH$	X	X			X
				Nonafluoro-3,6-dioxaheptanoic acid	NFDHA	151772-58-6	296.0	$CF_3O(CF_2)_2OCF_2COOH$		X			X
				Perfluoro(2-ethoxyethane)sulfonic acid	PFEESA	113507-82-7	316.1	$C_2F_5O(CF_2)_2SO_3H$		X			X
				Perfluoro-3-methoxypropanoic acid	PFMPA	377-73-1	230.0	$CF_3O(CF_2)_2COOH$		X			X
				Perfluoro-4-methoxybutanoic acid	PFMBA	863090-89-5	280.0	$CF_3O(CF_2)_3COOH$		X			X
				11-Chloroeicosafluoro-3-oxaundecade-1-sulfonic acid	11Cl-PF3OUdS	763051-92-9	632.6	$Cl(CF_2)_8O(CF_2)_2SO_3H$	X	X			X
				9-Chlorohexadecafluoro-3-oxanone-1-sulfonic acid	9Cl-PF3ONS	756426-58-1	532.6	$Cl(CF_2)_6O(CF_2)_2SO_3H$	X	X			X
	Polyfluorinated / Precursors	Fluorotelomers	3	4:2 Fluorotelomer sulfonic acid	4:2 FTSA	757124-72-4	328.2	$C_4F_9(CH_2)_2SO_3H$		X	X	X	X
				6:2 Fluorotelomer sulfonic acid	6:2 FTSA	27619-97-2	428.2	$C_6F_{13}(CH_2)_2SO_3H$		X	X	X	X
				8:2 Fluorotelomer sulfonic acid	8:2 FTSA	39108-34-4	528.2	$C_8F_{17}(CH_2)_2SO_3H$		X	X	X	X
			4	6:2 Fluorotelomer alcohol	6:2 FTOH	647-42-7	364.1	$C_6F_{13}(CH_2)_2OH$					
				8:2 Fluorotelomer alcohol	8:2 FTOH	678-39-7	464.1	$C_8F_{17}(CH_2)_2OH$					
		Perfluoroalkane Sulfonamido	5	N-ethyl perfluorooctanesulfonamido acetic acid	N-EtFOSAA	2991-50-6	585.2	$C_8F_{17}SO_2N(C_2H_5)CH_2CO_2H$	X		X	X	X
				N-methyl perfluorooctanesulfonamido acetic acid	N-MeFOSAA	2355-31-9	571.2	$C_8F_{17}SO_2N(CH_3)CH_2CO_2H$	X		X	X	X
			6	N-ethyl perfluorooctane sulfonamido ethanol	EtFOSE	1691-99-2	571.3	$C_8F_{17}SO_2N(C_2H_5)(CH_2)_2OH$					X
				N-methyl perfluorooctane sulfonamido ethanol	MeFOSE	24448-09-7	557.2	$C_8F_{17}SO_2N(CH_3)(CH_2)_2OH$					X
		Fluorotelomer Carboxylic Acids		3-Perfluoropropyl propanoic acid	3:3 FTCA	356-02-5	242.1	$C_3F_7C_2H_4COOH$					X
				2H,2H,3H,3H-Perfluorooctanoic acid	5:3 FTCA	914637-49-3	342.1	$C_5F_{11}C_2H_4COOH$					X
				3-Perfluoroheptyl propanoic acid	7:3 FTCA	812-70-4	442.1	$C_7F_{15}C_2H_4COOH$					X

Notes:
* denotes short chain perfluoroalkyl acid
** denotes long chain perfluoroalkyl acid

PFAS Class Acronyms
PFAA: Perfluoroalkyl acid
FASA: Perfluoroalkane sulfonamide

PFAS Group Names and Acronyms
1. PFCA: Perfluoroalkyl carboxylic acid
2. PFSA: Perfluoroalkane sulfonic acid
3. FTSA: Fluorotelomer sulfonic acid
4. FTOH: Fluorotelomer alcohols
5. FASAA: Perfluoroalkyl sulfonamido acetic acids
6. FASE: Perfluoroalkane sufonamido ethanols

References:
ITRC guidance document, Chapter 2. https://pfas-1.itrcweb.org/2-pfas-chemistry-and-naming-conventions-history-and-use-of-pfas-and-sources-of-pfas-releases-to-the-environment-overview/
EPA working list of PFAS compounds: https://www.epa.gov/chemical-research/ord-subset-pfas-research

ATTACHMENT A

OFFICE TRAINING CHECKLIST

ATTACHMENT A. OFFICE TRAINING CHECKLIST
PFAS SAMPLING STANDARD OPERATING PROCEDURES
TRAINING PROGRAM
TRIHYDRO CORPORATION

(development/review in progress)

1. PFAS Overview – basic information to understand rationale for PFAS sampling approaches and to address basis questions
    a. Chemistry
    b. PFAS uses/environmental sources
    c. Regulatory status
2. Unique elements of PFAS sampling
    a. Hundreds/thousands of compounds
    b. Presence in common materials
    c. Highly scrutinized results
3. Standard Operating Procedures Overview
    a. Table of Contents overview/key elements
    b. Material compatibility table
    c. General PFAS sampling steps
4. Project Sampling Discussion
    a. Types of sampling
    b. Additional training needs
    c. Project specific preparation needs/focus on relevant SOP sections

ATTACHMENT B

FIELD TRAINING CHECKLIST

ATTACHMENT B. FIELD TRAINING CHECKLIST
PFAS SAMPLING STANDARD OPERATING PROCEDURES
TRAINING PROGRAM
TRIHYDRO CORPORATION

(development/review in progress)

1. Allowable materials
    a. Clothing/PPE
    b. Gloves
    c. Paper Towels
    d. Buckets
    e. Sampling Materials
    f. Pens/Sharpies
    g. Field Notes
2. Prohibited Materials
    a. Area Inspection
    b. Clothing/PPE
    c. Food wrappers
3. Site Preparation and Area Management
    a. Staging Area
    b. Sampling Area
    c. Personnel
    d. Coolers
    e. Housekeeping
4. Hands
    a. Awareness
    b. Changing gloves
5. Sampling considerations
    a. Groundwater pumps, tubing, supplies
    b. Soil Sampling: drilling and hand-auger
6. Sample Container Management
    a. Pre-collection
    b. During collection
    c. Post-collection
7. Decontamination
    a. Plastic brush
    b. Spray bottles

ATTACHMENT C

EXAMPLE FIELD SAMPLING DOCUMENTATION FORM

ATTACHMENT C. EXAMPLE FIELD SAMPLING DOCUMENTATION FORM

Client / Project # :

Boring / Sample ID ____________ Sample Date/Time: ____________
Analysis: 537.1 / 537 MOD / Other ____________ QC samples: ____________
Sample Depth: ____________ Sample Recovery: ____________
Sample Description: ____________

Boring / Sample ID ____________ Sample Date/Time: ____________
Analysis: 537.1 / 537 MOD / Other ____________ QC samples: ____________
Sample Depth: ____________ Sample Recovery: ____________
Sample Description: ____________

Boring / Sample ID ____________ Sample Date/Time: ____________
Analysis: 537.1 / 537 MOD / Other ____________ QC samples: ____________
Sample Depth: ____________ Sample Recovery: ____________
Sample Description: ____________

Boring / Sample ID ____________ Sample Date/Time: ____________
Analysis: 537.1 / 537 MOD / Other ____________ QC samples: ____________
Sample Depth: ____________ Sample Recovery: ____________
Sample Description: ____________

Boring / Sample ID ____________ Sample Date/Time: ____________
Analysis: 537.1 / 537 MOD / Other ____________ QC samples: ____________
Sample Depth: ____________ Sample Recovery: ____________
Sample Description: ____________

Trihydro

Sampling Equipment: ____________
Field Personnel:

Appendix C - Standard Operating Procedure for Low Flow Groundwater Sampling

Trihydro
CORPORATION

memorandum

To: Trihydro Employees
From: OSE
Date: June 24, 2011
Re: Standard Operating Procedure – Low-Flow (Micro-Purge) Well Sampling

---

1.0 PURPOSE, SCOPE, AND RESPONSIBILITIES

This standard operating procedure (SOP) is intended to provide methods for low-flow sampling of groundwater from monitoring wells. Low-flow (micro-purge) sampling is a method of collecting samples from a well; the method does not require the removal of large volumes of water, and therefore does not overly agitate the water and suspended particles or potentially aspirate volatile organic compounds (VOCs) (which can affect sample integrity).

Low-flow sampling includes collecting water directly from the screened interval without disturbing stagnant water above the screen. This is accomplished by pumping the well at low enough flow rates to maintain minimal drawdown of the water column, followed by in-line sample collection. Typical flow rates for low-flow sampling typically range from 0.1 to 0.5 L/min (Liter per minute). Some regulatory agencies recommend not using peristaltic and suction pumps for VOC sample collection because of de-gassing concerns. Local regulations should be understood prior to choosing equipment.

This SOP is applicable to all Trihydro projects where groundwater samples are collected from a monitoring well via low-flow methods and where no project or program-specific procedure is in use. Detailed safety procedures are included in the site-specific health and safety plan (HASP) and job safety analyses (JSAs). The project manager should be contacted for additional health and safety information.

This SOP is intended for the sole use of Trihydro Corporation and its employees. This SOP cannot be copied or used by others without the express written consent of Trihydro. In Trihydro's sole discretion, this SOP may be modified when field or other conditions warrant.

The Operational and Service Excellence (OSE) Business Unit is responsible for SOP maintenance, management, and revisions. Trihydro employees performing tasks within this SOP are responsible for meeting SOP requirements. For projects where activities within this SOP are necessary, the project manager (or designee) is responsible for ensuring that those activities are conducted in accordance with this and other SOPs. Project team members are responsible for documenting procedural information in sufficient detail (i.e., calculations, field notes, reports, etc.) and reporting these changes to OSE. Such documentation will be included as a component of project records.

2.0 PLANNING AND PROCEDURES

As stated above, low-flow sampling involves removing water directly from the screened interval without disturbing stagnant water above the screen and without significantly lowering the water table. Since this method is not based upon the removal of well volumes, it requires in-line monitoring of water-quality parameters (i.e., pH, specific conductivity, temperature, dissolved oxygen, redox potential) to determine when the groundwater to be sampled has stabilized. The sample is then collected, using the same pump, directly from the discharge tubing.

2.1 VARIABLES

The following variables should be considered in planning for low-flow purging and sampling:

- **Recharge capacity of each well:** The recharge capacity of a well will determine how fast the well should be purged. To prevent water-table drawdown, the purge rate should be no greater than the recharge rate of the groundwater zone.
- **Well-construction details, including well depth, diameter, screened interval, screen size, material of construction, and depth to water table:** The diameter and well depth determine the size of the pump and the location from which the pump will operate. Peristaltic and suction draw pumps are only viable at depths of less than 25 feet. The pump intake should be placed within the well screen.
- **Pump:** Low-flow purging and sampling can be employed in any well that can be pumped at a constant rate less than or equal to 1.0 L/min. Continuous discharge and cycle discharge pumps with adjustable flow-rate controls should be used to avoid causing continuous drawdown. Whenever possible, dedicated pumps should be installed to avoid disturbing the water column.
- **Groundwater quality, including type and concentration of chemical compounds present:** Low-flow methods can be used for aqueous-phase contamination, including VOCs, semi-volatile organic compounds (SVOCs), metals, pesticides, polychlorinated biphenyls, radionuclides, and microbiological constituents. Pump parts and tubing should be made of materials that are compatible with the constituents of concern.
- **Regulatory requirements:** As stated in Section 1.0, some regulatory agencies recommend not using peristaltic and suction pumps for VOC sample collection because of de-gassing concerns. Local regulations should be understood prior to selecting equipment.

2.2 EQUIPMENT

The following equipment is recommended for well purging:

☐ Required personal protective equipment (PPE), listed in site-specific health and safety plan (HASP) (generally nitrile gloves and safety glasses for low-flow sampling)

☐ Pump and discharge hose and line constructed of compatible materials capable of <1.0 L/min draw rates

☐ Water-level meter

☐ Swabbing materials

☐ Flow-through water-quality meter (for pH, specific conductance, temperature, dissolved oxygen, redox potential) calibrated daily

☐ Nephelometer (calibrated, if required)

☐ Photoionization detector (PID) (calibrated, if screening for VOCs is required)

☐ Drums or tanks to hold purge water

☐ Plastic sheeting

☐ Decontamination solutions: deionized (DI) water and detergent (e.g., Alcinox, Liqui-Nox, Simple Green, depending on the application). Non-phosphate detergents, such as Alconox or Liqui-Nox, should be considered for sites or wells with only trace-level contamination or where phosphates are a constituent of concern. Phosphate detergents, such as Simple Green, should be considered for heavily contaminated sites or wells where phosphates are not a constituent of concern.

☐ Sample containers and preservatives

☐ Sample labels

☐ Chain-of-custody forms

☐ Paper towels

☐ Ice chest or cooler

☐ Ice and resealable plastic bags

☐ Field logbook

☐ Calculator

☐ Wrist watch (with digital display)

2.3 PRE-SAMPLING

To prevent cross contaminating other wells, upgradient and background wells should be sampled first. The procedure for pre-sampling is as follows:

1. Don a pair of clean nitrile gloves, safety glasses, and other required PPE (listed in HASP).
2. Prepare the area surrounding the well by placing plastic sheeting on the ground surface to prevent potential cross-contamination of the pump and discharge hose or sample equipment and materials.

3. Place and secure the drum, tank, or suitable purge water container in close proximity to the well for purge-water collection and storage. Purge water must be containerized and disposed of in the manner specified in the project and program plan or as the client directs. Never return purge water to the well. If in doubt, or where requirements are not specified, handle all purge water as waste and dispose of it accordingly.
4. If performing VOC screening, measure and record the background organic vapors in the ambient air using a PID (in accordance with manufacturer specifications and recommendations).
5. Open the well casing, remove the well cap, and immediately measure and record the organic vapor levels from the head space within the well casing using a PID (in accordance with manufacturer specifications and recommendations).
6. Measure the depth to the static water level using the water-level meter.

2.4 WELL PURGING

The procedure for well purging is as follows:

1. Review and understand the proper operating and maintenance instructions for the pump prior to placing the pump in the well. Each pump type has specific operating procedures.
2. Don a pair of clean nitrile gloves, safety glasses, and other required PPE (listed in HASP).
3. Some wells may include a dedicated pump that is already placed in the well along the well screen. If this is the case, review well-construction data to verify the proper placement of the pump intake. Inspect the location where the discharge line and pump support cable exit the well to determine that they are in the proper position (markings should be present at the well head to show this).
4. Assemble the pump and discharge line in accordance with manufacturer instructions. Ensure the pump discharge line is long enough so that the pump intake can be located within the well-screen area and the discharge end can reach the purge-water container.
5. Slowly lower the pump into the well until it is submerged and at the desired pumping depth.
6. Connect the pump discharge to the flow-through water-quality meter (in accordance with the manufacturer's procedure).
7. Start the pump and begin monitoring discharge rates and the collected water volume. Adjust flows if necessary to remain in a range of 0.1 to 0.5 L/min without exceeding the well-discharge rate.
8. Monitor and record the pH, conductivity, temperature, dissolved oxygen, redox potential, and turbidity at set intervals (2 to 10 minutes; refer to the site work plan for required interval).
9. When water-quality parameters are stable (pH, dissolved oxygen, and turbidity), and, as indicated by three consecutive readings within 10 percent, begin sample collection.

2.5 SAMPLE COLLECTION

The procedure for sample collection is as follows:

1. Don a pair of clean nitrile gloves, safety glasses, and other required PPE (listed in HASP).
2. Prepare sample bottles and preservatives for sampling.
3. Immediately after purging, collect the sample through the pump discharge line.
4. Fill volatile organic analysis (VOA) vials first (reduce the flow rate of the pump discharge), allowing the liquid to slowly fill the container without agitation, and obtain a meniscus slightly above the top of the vial. (If multiple cycles are needed to fill the VOA, cover the VOA with the cap between cycles to reduce the chance of volatilization).
5. Place cap on VOA and check for entrained air by slowly tipping, tapping against the palm of one hand, and observing for bubbles. If bubbles are present, discard the sample and collect again, as above.
6. Continue filling sample bottles.
7. Add preservatives to the samples as needed, and place the sample bottles on ice. Note that most sample bottles come with preservatives already added. If such is the case, do not overfill the bottles. If a sample bottle containing preservatives is overfilled, discard the overfilled bottle and collect again, as above.
8. Replace the well cap, if required, and lock the cover.
9. Record the sampling information.
10. Secure the area by removing equipment and materials; properly dispose of plastic sheeting and other sampling materials, and close the purge-water container(s).
11. Decontaminate the pumping and sampling equipment. Dedicated pumping equipment should not be decontaminated.

3.0 STANDARD OPERATING PROCEDURE NAMING CONVENTION, PROCEDURAL CHANGES, AND REVISION SCHEDULE

This section includes information on the Standard Operating Procedure (SOP) naming convention, procedural changes, and revision schedule.

3.1 NAMING CONVENTION

The SOP naming convention will be included in the upper corner of each page and will appear as follows:

ID #: FS001_LowFlow

Rev. #: Original

Explanation of above:

ID # = Identification Number

FS001_LowFlow: FS = Field Sampling, 001 = Field Sampling SOP #1, LowFlow = Sampling Technique

3.2 PROCEDURAL CHANGES

When procedures change, Trihydro will update and reapprove this SOP. Modifications may address a small component of the SOP or the entire SOP. The OSE Business Unit will facilitate SOP reviews 2 years after the previous revision date. The revision date will be added to the schedule (below), the title page, and the naming convention that appears in the corner of each page.

If an SOP describes a process that is no longer followed, it will be withdrawn from its active file location and archived.

3.3 REVISION SCHEDULE

Revision Date and Number	Reason for Revision	Most Recent Revision Date and SOP Library Upload	Facilitator	Technical Reviewer
Original	New SOP	June 24, 2011	David Ludwin	Kirk Hardy

4.0 GLOSSARY: ACRONYMS, ABBREVIATIONS, AND DEFINITIONS

HASP – health and safety plan: includes a complete list of project personal protective equipment requirements, evacuation routes, medical services, and other pertinent health and safety information

L/min – liter per minute: unit used to measure pump rates

Low-flow – refers to the velocity used during well pumping; draws water to the surface slowly

Micro-purge – another term for low-flow sampling, referred to as such because pre-sampling groundwater removal (purging) is performed at flow rates 2 to 3 orders of magnitude less than typical bailer or pump methods

OSE – Operational and Service Excellence Business Unit: Trihydro's designated authority for facilitating standard operating procedure reviews

PID – photoionization detector: a type of gas detector used to measure volatile organic compounds

PPE – personal protective equipment: minimum-required site-safety equipment; a full list is included in the site-specific HASP

Pump – an electric, compressed air, or inert gas-driven device that raises liquids by means of pressure or suction. The types of pumps used for well purging should be chosen based on the well size and depth, contaminant type, and specific factors affecting the overall performance of the sampling effort. Low-flow and micro-purge sampling is performed using specially constructed pumps, usually of centrifugal, peristaltic, or submersible design, with low draw rates (<1.0 L/min).

Purging – the action of removing groundwater from well using mechanical means from a monitoring well prior to collecting groundwater samples. Purging removes stagnant groundwater from the column, allowing groundwater surrounding the well screen to enter the collection area.

SOP – standard operating procedure: procedure to be followed when performing a routine task

SVOC – semi-volatile organic compound: an organic compound with a boiling point higher than water; may vaporize when exposed to temperatures above room temperature

VOC – volatile organic compound: gases from certain solids or liquids, including a variety of chemicals, some of which may have short- and long-term adverse health effects

VOA – volatile organic analysis vial: small vial used for groundwater sampling (typically contains preservatives)

5.0 REFERENCES

ASTM International. 1998. ASTM D6771-02. Standard Practice for Low-Flow Purging and Sampling for Wells and Devices Used for Ground-Water Quality Investigations.

ASTM International. 2007. ASTM D4448-01. Standard Guide for Sampling Ground-Water Monitoring Wells.

U.S. Army Corps of Engineers. 2001. Requirements for the Preparation of Sampling and Analysis Plans, Appendix C, Section C.2, EM200-1-3. Washington, DC.

U.S. Environmental Protection Agency. 2011. Terms of Environment. Available from: (http://www.epa.gov/OCEPATERMS/).

U.S. Environmental Protection Agency. 2007. Guidance for Preparing Standard Operating Procedures. EPA QA/G-6. Accessed April 1, 2011. Available from: (http://www.epa.gov/quality/qs-docs/g6-final.pdf).

U.S. Environmental Protection Agency, Region 1, 1996. Low Stress (Low Flow) Purging and Sampling Procedure for the Collection of Ground Water Samples from Monitoring Wells, SOP GW0001, Revision 2. July 30.

QAQ-SCO-P00

Appendix D - Example Logs

Appendix D-1 - Example Soil Sample Log

PFAS SAMPLING FIELD FORM

Trihydro CORPORATION

Sample Area/Category: ______________________ **Recorded by:** ______________________

SAMPLE COLLECTION INFORMATION				PRECAUTIONS TAKEN PRIOR TO EACH SAMPLE				SAMPLE DESCRIPTION
Date	Time	Field Sample Location/ID	Sample Depth [e.g. 0 - 0.5"]	Hammer drill bit deconned	New nitrile gloves	New trowel	PFAS-free sheeting surrounding sample area	
				Yes / No / NA	Yes / No	Yes / No / NA	Yes / No	
				Yes / No / NA	Yes / No	Yes / No / NA	Yes / No	
				Yes / No / NA	Yes / No	Yes / No / NA	Yes / No	
				Yes / No / NA	Yes / No	Yes / No / NA	Yes / No	
				Yes / No / NA	Yes / No	Yes / No / NA	Yes / No	
				Yes / No / NA	Yes / No	Yes / No / NA	Yes / No	
				Yes / No / NA	Yes / No	Yes / No / NA	Yes / No	
				Yes / No / NA	Yes / No	Yes / No / NA	Yes / No	
				Yes / No / NA	Yes / No	Yes / No / NA	Yes / No	
				Yes / No / NA	Yes / No	Yes / No / NA	Yes / No	

NOTES, OBSERVATIONS, COMMENTS

Describe any unusual conditions, visible impacts, deviations from work plan.

Appendix D-2 - Example Boring Log

Trihydro
CORPORATION

LOCATION ID

Lithology Log

Sheet 1 of

Project Name	Project Number	Site ID

Drilling Company	Driller	Ground Elevation	Total Drilled Depth __ feet-bgs

Drilling Equipment	Drilling Method	Borehole Diameter __ inches	Date/Time Drilling Started	Date/Time Total Depth Reached

Type of Sampling Device	Water Level (bgs) First __ feet-bgs Final
Sample Hammer Type Driving Weight Drop	Hydrogeologist
	Checked by/Date

Location Description (include sketch in field logbook)

Depth	Interval	Recovery	Blow Counts	Description (Include lithology, grain size, sorting, angularity, Munsell color name & notation, minerology, bedding, plasticity, density, consistency, etc., as applicable)	ASTM Code	Lithology	Water Content	Estimate % of Gr	Estimate % of Sa	Estimate % of Fi	Remarks (Include all sample types & depth, odor, organic vapor measurements, etc.)
0											
1											
2											
3											
4											
5											
6											
7											
8											
9											
10											

Trihydro
CORPORATION

LOCATION ID

Lithology Log (continued)

Sheet 2 of

Depth	Interval	Recovery	Blow Counts	Description (Include lithology, grain size, sorting, angularity, Munsell color name & notation, minerology, bedding, plasticity, density, consistency, etc., as applicable)	ASTM Code	Lithology	Water Content	Estimate % of			Remarks (Include all sample types & depth, odor, organic vapor measurements, etc.)
								Gr	Sa	Fi	
10											
11											
12											
13											
14											
15											
16											
17											
18											
19											
20											
21											
22											
23											

Trihydro CORPORATION

LOCATION ID

Lithology Log (continued)

Sheet 3 of

Depth	Interval	Recovery	Blow Counts	Description (Include lithology, grain size, sorting, angularity, Munsell color name & notation, minerology, bedding, plasticity, density, consistency, etc., as applicable)	ASTM Code	Lithology	Water Content	Estimate % of Gr	Estimate % of Sa	Estimate % of Fi	Remarks (Include all sample types & depth, odor, organic vapor measurements, etc.)
23											
24											
25											
26											
27											
28											
29											
30											
31											
32											
33											
34											
35											
36											

Lithology Log (continued)

Sheet 4 of

LOCATION ID

Depth	Interval	Recovery	Blow Counts	Description (Include lithology, grain size, sorting, angularity, Munsell color name & notation, minerology, bedding, plasticity, density, consistency, etc., as applicable)	ASTM Code	Lithology	Water Content	Estimate % of			Remarks (Include all sample types & depth, odor, organic vapor measurements, etc.)
								Gr	Sa	Fi	
36											
37											
38											
39											
40											
41											
42											
43											
44											
45											
46											
47											
48											
49											

Trihydro
CORPORATION

LOCATION ID

Lithology Log (continued)

Sheet 5 of

Depth	Interval	Recovery	Blow Counts	Description (Include lithology, grain size, sorting, angularity, Munsell color name & notation, minerology, bedding, plasticity, density, consistency, etc., as applicable)	ASTM Code	Lithology	Water Content	Estimate % of			Remarks (Include all sample types & depth, odor, organic vapor measurements, etc.)
								Gr	Sa	Fi	
49											
50											
51											
52											
53											
54											
55											
56											
57											
58											
59											
60											
61											
62											

OW-63 PFAS Investigation Work Plan

Western Refining Southwest LLC
Gallup Refinery
Gallup, New Mexico

EPA ID# NMD000333211

~~September 28, 2023~~December 31, 2022
Revised September 2~~8~~9, 2023

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~~C.~~D. Example Logs

List of Acronyms

AFFF	aqueous film forming foams
CLP	Contract Laboratory Program
COC	chain of custody
DP	direct push
EDD	electronic data deliverables
ft/day	foot/feet per day
HDPE	high-density polyethylene
I-40	Interstate 40
IDW	investigation derived waste
LCS/LCSD	laboratory control samples/laboratory control sample duplicates
MS/MSD	matrix spike/matrix spike duplicates
NM	New Mexico
NMED	New Mexico Environment Department
PE	polyethylene
PFAS	per- and polyfluoroalkyl substances
PFBS	perfluorobutane sulfonate
PFOA	perfluorooctanoic acid
PFOS	perfluorooctane sulfonate
PID	photoionization detector
PPE	personal protective equipment
PVC	polyvinyl chloride
QA/QC	quality assurance and quality control
QSM	Quality System Manual
SOP	standard operating procedure
SPH	separate phase hydrocarbons
USEPA	United States Environmental Protection Agency
VOC	volatile organic compound

1.0 Introduction

Trihydro Corporation (Trihydro) has prepared this per- and polyfluoroalkyl substances (PFAS) Investigation Work Plan (Work Plan) to conduct PFAS sampling in soil and groundwater near monitoring well OW-63 at the Gallup Refinery (Refinery). Figure 1-1 shows the site location and the area surrounding OW-63. This Work Plan was developed per New Mexico Environment Department's (NMED) request in Comment 12 of the "Approval with Modifications 2021 Annual Groundwater Monitoring Report" (NMED 2022), dated August 23, 2022: "…a PFAS plume may be present in the vicinity of OW-63. Submit a work plan to investigate the extent of the PFAS contamination no later than December 31, 2022".

The following objectives were developed to address NMED's comment:

- Identify PFAS-containing materials near OW-63.
- Identify areas where potential PFAS-containing materials have been potentially stored and/or used near OW-63.
- Describe a proposed sampling and analysis plan for various environmental matrices that delineates the extent of PFAS contamination near OW-63.

1.1 Background

Built in the 1950s, the Refinery is located within a rural and sparsely populated area east of Gallup, New Mexico (NM). The nearest population centers are the Pilot Flying J Travel Center refueling plaza, the Interstate 40 (I-40) corridor, and a small cluster of residential homes located on the south side of I-40 approximately 2 miles southwest of the Refinery (Jamestown, NM).

The Refinery was indefinitely idled on October 9, 2020. During operation, the Refinery was a crude oil refining and petroleum products manufacturing facility. There were no organic chemicals, plastics, or synthetic fibers manufactured that contributed to the process flow of wastewater. The Refinery did not manufacturer lubricating oils. As a result of the processing steps, the Refinery produced a wide range of petroleum products including propane, butane, unleaded gasoline, diesel, residual fuel, and commercial products of fertilizer and solid elemental sulfur.

Historically, the Refinery primarily received crude oil via two 6-inch diameter pipelines, which entered the Refinery property from the north (Four Corners Area). In addition, the Refinery also received natural gasoline feedstock via a 4-inch diameter pipeline that came in from the west along the I-40 corridor from the Western Refining Southwest LLC Wingate Plant, which is also indefinitely idled. Crude oil and other products also arrived at the Refinery via railroad cars. These feed stocks were then stored in tanks until refined into products.

Trihydro conducts groundwater sampling for PFAS at OW-63 on a quarterly basis. PFAS sampling in OW-63 began with NMED's request in Comment 30 in the "Disapproval Annual Groundwater Monitoring Report Gallup Refinery – 2019" (NMED, 2020) dated November 23, 2020: "…Well OW-63 is appropriately located to evaluate for the presence of PFAS in the vicinity of the training area. Propose to conduct PFAS analysis for the groundwater samples collected from well OW-63 in the 2021 Facility-wide Groundwater Monitoring Work Plan." These results are included in the annual groundwater monitoring reports and in Appendix A. Currently, no other wells at the Refinery are sampled for PFAS.

The sections below describe site hydrogeology and PFAS-containing materials likely used at the refinery. More information regarding site background and hydrology can be found in the annual groundwater work plans and reports.

1.2 Hydrogeology

Groundwater flow within the shallow alluvium and the upper Chinle Formation is highly variable due to the presence of complex and irregular stratigraphy including sand stringers, cobble beds, and dense clay layers. Hydraulic conductivity ranges from 30 feet per day (ft/day) for gravel-like sands immediately overlying the Petrified Forest Formation to 3 x 10^{-5} ft/day in the clay soils located near the surface. Groundwater flow within the Lower Chinle Formation is extremely slow and typically averages less than 2.83 x 10^{-7} ft/day (i.e., less than 0.01 ft per year).

Water level data are collected routinely at the Refinery. Wells at the Refinery have been categorized based on the hydrogeologic unit in which they are screened, including the alluvial/fluvial upper sand aquifer, the Chinle/alluvium aquifer, and the Sonsela Sandstone aquifer. The alluvial/fluvial upper sand aquifer has a limited lateral extent, existing only on the western margin of the Refinery. Groundwater occurrence in this aquifer is sporadic and limited.

Most of the wells monitored lie within the shallow weathered sediments that comprise the Chinle/alluvium aquifer. Within the Chinle/alluvium aquifer, shallow groundwater located under the Refinery property generally flows along the upper contact of the Chinle Formation. The prevailing flow is from the southeast to the northwest, although localized areas may have varying flow directions based on the subsurface geology.

Groundwater within the Sonsela aquifer flows southeast to northwest. Hydraulic heads measured within the Sonsela are generally lower than those observed within the shallow aquifer near the topographic high on which the Refinery process area and tank farm are situated, and higher than those observed within the shallow aquifer in topographically low areas to the west and northwest, near the evaporation ponds. The higher head in the Sonsela in low areas is due to confining pressure from lower permeability Chinle Formation bedrock between the shallow Chinle/alluvium aquifer and the Sonsela Sandstone bed at depth, which makes the Sonsela Sandstone aquifer artesian. Figures 1-2, 1-3, 1-4, and 1-5 show quarterly potentiometric surface maps for the investigation area.

1.3 PFAS-Containing Materials at the Refinery

Since the 1950s, PFAS have been incorporated into many consumer and industrial products. One of the many historical uses is in firefighting foams ("Aqueous Film Forming Foams," or AFFF). AFFF products may be used for fire suppression at facilities where Class B fires (i.e., those involving flammable liquids and gases) may be a concern, including airports, firefighting training areas, and other facilities where flammable hydrocarbons are present. AFFF formulations include hundreds to thousands of individual fluorinated and non-fluorinated surfactant compounds. Perfluorooctanoic acid (PFOA), perfluorooctane sulfonate (PFOS), and perfluorohexane sulfonate (PFHxS) are potential PFAS constituents in AFFF products, particularly in those produced between the 1960s and 1990s (ITRC 2022a). Modern AFFF products contain little to no PFOA or PFOS but may contain short-chain PFAS compounds such as perfluorobutane sulfonate (PFBS).

Firefighting is a component of petroleum refinery management. AFFF has been stored and historically used for fire suppression at the Refinery. Located to the northwest of OW-63 is the former Fire Training Area, where PFAS-containing foam was confirmed to be used. OW-63 is located downgradient of the Tank Farm and cross gradient of the former Fire Training Area. There are no known applications of PFAS-containing foam in the Tank Farm area immediately adjacent to OW-63. All firefighting foams have been removed from the Refinery.

2.0 Field Investigation Activities

Many PFAS compounds are potentially mobile in groundwater and are prone to accumulate at air/water and oil/water interfaces (Brusseau 2018, ITRC 2022b). The sampling program described herein has been developed to account for these aspects, with sampling designed to identify potentially mobile PFAS within the bulk water phase (i.e., avoiding interfaces) associated with shallow groundwater. The sections below describe the sampling locations, field methods for groundwater sampling and soil sampling, and details of temporary well installation.

This field investigation will be completed in a three-phase plan:

- Phase 1: Groundwater sampling at four existing groundwater monitoring wells (OW-12, OW-14, OW-57, OW-63, and OW-70). These wells are located cross gradient and down gradient of OW-63 (Figure 1-1).
- Phase 2: Soil sampling at five surface locations and three soil boring locations. The three soil boring locations will be constructed as temporary groundwater monitoring wells. Exact locations for the surface sample locations and temporary monitoring wells will be chosen based on groundwater analytical results from Phase 1.
- Phase 3: Groundwater sampling at the three temporary well locations.

Phase 1 of the investigation will be implemented so analytical results from existing groundwater monitoring wells can be used to determine the most beneficial locations for the temporary groundwater monitoring wells. Groundwater samples will be obtained from existing groundwater monitoring wells during Phase 1. After the Phase 1 investigation is complete, the Refinery will schedule a meeting with NMED to discuss and agree upon proposed Phase 2 sample locations.

The Phase 2 soil sampling and temporary groundwater monitoring well installations will occur during the same field event after Phase 1 analytical data are received. Soil sampling will involve surface sample collection and the drilling of boreholes using direct push drilling techniques. Phase 3 of the investigation is for the collection of groundwater samples, which will occur after the temporary groundwater monitoring wells have been installed for a minimum of seven days. Supporting activities include utility location, boring abandonment, waste management, and equipment decontamination. A handheld global positioning system unit will be used to log location coordinates for utilities, soil sampling locations, and the temporary monitoring wells. Table 2-1 presents a summary of the proposed soil and groundwater sample identifications, sample methods, sample type, constituents, and analytical methods.

Sampling will be conducted by experienced PFAS sampling personnel who will review and be familiar with the prohibited material list, in terms of clothing, personal protective equipment (PPE), sunscreens, insect repellent, rain-repellent gear, and other sampling equipment that are prohibited when sampling for PFAS as to prevent cross-contamination. Care will be taken to ensure that any materials contacting sample containers, from the time of removal from laboratory-supplied coolers through completion of sampling, comply with Table 1 of

Trihydro's PFAS Standard Operating Procedure (SOP) (Appendix B~~A~~). A fresh pair of powderless nitrile gloves will be worn at each location, and gloves will be changed immediately before collecting each sample, in accordance with the SOP. Additional hand washing before donning of the new pair of gloves is necessary if the old pair was compromised or ungloved hands touched items that may contain PFAS. Sampling procedures will be reviewed prior to field activities to identify potential conflicts between site PPE requirements and PFAS-compatible materials. If conflicts are identified, procedures will be developed to minimize PFAS cross-contamination risks without compromising the Refinery's health and safety procedures.

2.1 Phase 1: Groundwater Sampling at Existing Monitoring Wells

The former Fire Training Area was identified as a potential PFAS-containing foam application area at the Refinery. Based on this identification, ~~four~~ five existing groundwater wells are selected for PFAS sampling. Figure 1-1 provides the sample well locations. Additional information for OW-12, OW-14, OW-63, OW-57, and OW-70, including the screened interval, depth to groundwater, and total measured depth of well, is shown in Table 2-2. Groundwater samples will be analyzed for the PFAS parameters listed in Table 2-3. The reporting limits for the analytes on Table 2-3 will be dependent upon the lab selected for PFAS analysis. Reporting limits will be evaluated against NMED PFAS screening levels once a lab has been selected.

2.1.1 Fluid Level Monitoring

Fluid levels will be monitored in all wells prior to sampling using an interface probe. Fluid level monitoring will be conducted to evaluate for the presence of separate phase hydrocarbons (SPH) in wells and measure depth to groundwater. Historically, the wells selected for groundwater sampling have not had SPH in them. The interface probe will only be used to measure the fluid surface and SPH thickness (total depth will not be measured as part of the PFAS sampling event) to limit cross-contamination by minimizing contact between groundwater and the interface probe. Any well with detectable SPH will be removed from the monitoring list for this event and, if possible, an alternative well will be selected. The interface probe will be decontaminated prior to first use, and between each monitoring well, using PFAS-compatible methods in accordance with Appendix B~~A~~.

2.1.2 Groundwater Sample Collection

Groundwater samples will be collected from monitoring wells OW-12, OW-14, OW-63, OW-57, and OW-70 using ~~no-purge~~ low flow sampling techniques and analyzed for PFAS compounds (Table 2-3). Low-flow or no-purge sampling approaches are generally preferred for PFAS sampling. PFAS may be associated with suspended solids, droplets of SPH, or entrained gas bubbles, any of which may be mobilized via high-volume purging sampling methods. ~~To minimize the chances of cross-contamination, no-purge sampling is proposed (Armstrong et al. 2020). No-purge~~Low flow sampling involves collecting groundwater directly from the screened interval without disturbing stagnant water above the screen. This is accomplished by pumping the well at low enough flow rates to maintain minimal drawdown of the water column. ~~after deploying the sampling device in the well for an extended period, thus allowing groundwater within the well to achieve dynamic equilibrium with formation groundwater. The no-purge sampling approach reduces possibilities for cross-contamination by eliminating the~~

~~need to deploy reusable equipment in multiple monitoring wells and using only disposable materials or dedicated materials designed to be compatible with PFAS sampling. Disposable materials are single use and will not be reused. Dedicated materials can be reused but will be designated for a single sample location to avoid cross-contamination.~~

Groundwater sampling for PFAS compounds will be conducted using low flow sampling methods in general accordance with the following guidance documents:

- Trihydro's PFAS SOP, included in Appendix B
- Trihydro's SOP for low flow sampling, included in Appendix C

Since this method is not based upon the removal of well volumes, it requires in-line monitoring of water-quality parameters (i.e., pH, specific conductivity, temperature, dissolved oxygen, redox potential) to determine when the groundwater to be sampled has stabilized. Stabilization occurs when three consecutive readings of water-quality parameters are within 10 percent. The sample is then collected, using the same pump, directly from the discharge tubing. Wells with dedicated pumps (i.e., OW-12 and OW-63) will be noted on the field logs and will use existing equipment in place.

~~Groundwater sampling for PFAS compounds will be conducted using no-purge methods (HydraSleeve™ samplers) in general accordance with the following guidance documents:~~

- ~~Trihydro's SOP, included in Appendix BA~~
- ~~SOP for HydraSleeve™ sampling (GeoInsight 2016), included in Appendix CB~~

~~To the extent practical, disposable sampling equipment will be used at each location to minimize the potential disturbance of formation groundwater and to reduce the risk of cross-contamination. Non-disposable components (dedicated materials) associated with the Hydrasleeves™ (i.e., reducer, spring clip, and weight) will be dedicated to each well. Furthermore, all down-hole monitoring or sampling equipment will not contain or be coated with Teflon® or other PFAS-incompatible materials (Appendix BA).~~ Prior to placing the discharge line of the pump into the well, the sampler will verify the screened interval of the well to determine the length of discharge line to be placed in the well.

~~The HydraSleeve™ samplers consist of collapsible high-density polyethylene (HDPE) sleeves that are deployed in a well at a fixed depth within the screened interval (typically near the bottom of the screened interval). A check valve at the top of the sleeve prevents groundwater from entering the sleeve during deployment. After deployment, the samplers are left in place for a prescribed amount of time to allow groundwater within the well to equilibrate with the formation. For sample collection and recovery, the HydraSleeve™ sampler is pulled upward, which opens the check valve and allows water to fill the sleeve. The HydraSleeve™ sampler is then recovered to the surface, and a sample collected from the sleeve. Modified HydraSleeve™ samplers constructed of HDPE are available, which is compatible with PFAS sampling (low-density polyethylene is considered incompatible). The PFAS-compatible HydraSleeve™ samplers are available in 1-liter, 2-inch well diameter size ('Super/SkinnySleeve 1-Liter', part number PFCHDSS-1L) and 2-liter, 2-inch well diameter size ('Super/SkinnySleeve 2-Liter', part number PFCHDSS-2L). For groundwater sampling in 4-inch wells, the~~

~~HydraSleeve™ sampler may be deployed with a 4- to 2-inch reducer and spring clip, which is available from the HydraSleeve™ vendor. HydraSleeve™ samplers will be deployed for a minimum of a week and up to four weeks prior to sampling and will be retrieved following procedures described in the SOP.~~

The target sampling depth for each of the wells is the mid-point of the screened interval. ~~Prior to deployment of the HydraSleeve™ samplers, required information will be assessed for each well, including depth to water, screened interval, and the most recent total depth measurement.~~ This information is used to ensure that the ~~HydraSleeve™ samplers~~samples are collected ~~are deployed~~ within the screened interval, and that water samples are representative of the formation. They will also verify the recharge capacity of the well to determine what flow the pump will be set at so that draw down is not occurring.

Sample containers will be filled immediately ~~after recovery of the HydraSleeve™ samplers~~from the pump discharge line. Bottles will be filled in accordance with ~~HydraSleeve™~~ the low flow SOP~~s~~ and laboratory instructions. After being filled, sample containers will be placed in a cooler with double-bagged water-based ice (i.e., Blue Ice™ or similar substitute materials are prohibited) for shipment.

To the extent practical, disposable sampling equipment will be used at each location to minimize the potential disturbance of formation groundwater and to reduce the risk of cross-contamination. Furthermore, all down-hole monitoring or sampling equipment will not contain or be coated with Teflon® or other PFAS-incompatible materials (Appendix B). If reusable equipment is required, decontamination will occur as described in Section 2.5.

Equipment to be used during field sampling will be examined to certify that it is in operating condition. This includes checking the manufacturer's operating manual, as well as the instructions for each instrument, to ensure that maintenance requirements are being observed. Sample coolers will be shipped to an analytical laboratory via overnight delivery under chain of custody (COC) protocol.

2.2 Phase 2: Soil Sampling and Temporary Well Installation

Surface soil samples will be collected at five locations within the OW-63 area based on Phase 1 groundwater data and site topography, as identified on Figure 1-1. In addition, surface and subsurface soil samples will be collected from the three proposed temporary groundwater monitoring well boreholes that will be installed within the OW-63 area based on Phase 1 groundwater data, as identified on Figure 1-1. All soil samples will be analyzed for the PFAS parameters listed in Table 2-3.

2.2.1 Surface Soil Sampling

Surface soil samples will be collected from 0 to 1 ft below ground surface (ft bgs). Soil samples will be collected using a PFAS-free disposable hand trowel. At each location, a new hand trowel will be used. Sampling information will be recorded on an example log provided in Appendix ~~C~~D-1.

2.2.2 Subsurface Soil Sampling

Subsurface soil sampling will be conducted using a direct-push (DP) drilling rig capable of advancing continuous soil sample barrels. DP soil sampling will be conducted at three locations to be determined based on analytical results from Phase 1 of the investigation. Soil samples will be collected from the borings at two intervals: the surface (0 to 1 ft bgs) and 1 ft above the water table (approximately 17 to 34 ft-bgs).

Soil sample barrels will be decontaminated prior to each boring. Samples will be collected in an acetate liner or approved equivalent. The acetate sleeve containing the sample interval will be split in half and samples will be transferred directly from the sleeve to a lab-provided sample jar. For these locations, Trihydro field staff will prepare continuous boring logs of soil samples to the water table, recording lithology and appearance of the boring, and performing field screening of the soil cores using a photoionization detector (PID). An example boring log is shown in Appendix ~~C~~D-2.

2.2.3 Temporary Well Installation

Three proposed temporary wells will be completed in the soil borings installed as described in Section 2.2.2. The locations will be determined based on the analytical results from the groundwater sampling in the existing monitoring wells. Temporary wells will be completed with schedule 40 polyvinyl chloride (PVC). Slotted (0.01 inch) PVC well screen will be placed at the bottom of soil borings completed as a temporary well completion. The screen will extend 10 to 15 ft to ensure that the well is screened across the water table. A 10/20 sand filter pack will be installed to 2 ft above the top of the well screen. The well will be completed to the surface with bentonite chips.

2.3 Phase 3: Groundwater Sampling at Temporary Wells

After temporary well completion, the wells will be left to stand for a minimum of 7 days to allow for the possible entry of SPH into the well, if present. After a minimum of 7 days, the temporary wells will be gauged and sampled using the same methods described in Sections 2.1.1 and 2.1.2.

After groundwater samples are collected from the temporary wells, the PVC casing and well screen will be pulled and all borings will be abandoned with bentonite chips, pellets, or grout, from the bottom of the boring to the ground surface. Bentonite chips or pellets placed above the water table will be hydrated with at least 1 gallon of water per 5 feet of boring.

2.4 Investigation Derived Waste

Investigation derived waste (IDW) will include solid IDW (drill cuttings and excess direct-push soil), liquid phase IDW (~~HydraSleeve™ excess~~purged water), and debris (used acetate liners, nitrile gloves, etc.). IDW will be labeled appropriately to identify the generator, contents, date of generation, and provide contact information.

Solid phase IDW will be stored in a lined roll-off container or in sealed Department of Transportation-rated drums at a location to be determined at the site, pending waste characterization. Solid phase IDW is not expected to be characteristically hazardous but may contain PFAS or volatile organic compounds (VOCs) at concentrations requiring disposal at an appropriately licensed solid waste facility. After all solid phase IDW is accumulated, Trihydro will collect a composite sample for waste characterization. Analytical requirements will depend on the receiving solid waste facility and will be determined prior to disposal. IDW will be transported to the disposal facility by a licensed waste hauler.

Liquid phase IDW will be stored in drums at a location to be determined at the site pending characterization for disposal. Liquid phase IDW is not expected to be characteristically hazardous but may contain PFAS or VOCs at concentrations requiring disposal at an appropriately licensed facility. After all liquid phase IDW is accumulated, Trihydro will collect a composite sample for waste characterization. Analytical requirements will depend on the receiving facility and will be determined prior to disposal. IDW will be transported to the disposal facility by a licensed waste hauler.

Investigation debris will be disposed of as non-hazardous municipal waste at a local landfill.

2.5 Equipment Decontamination

Reusable sampling and drilling equipment will be decontaminated between samples using Alconox or a pressure washer, followed by rinsing with PFAS-free potable water. When not in use, cleaned reusable sample equipment will be stored in HDPE plastic bags or sheeting to minimize the potential for cross-contamination.

PFAS tend to adhere to sampling equipment and have been noted in certain detergents. To the extent practical, disposable equipment will be used for each monitoring/temporary well. Reusable ~~The sleeve portion of the HydraSleeve™, which comes into direct contact with the groundwater sample, will be discarded after use. Reusable HydraSleeve™ components (i.e., reducer, spring clip, and weight) will be dedicated to each well. The dedicated HydraSleeve™~~sampling components will be decontaminated, for potential future redeployment in the same well, in accordance with Trihydro's SOP (Attachment A) with the following notes/modifications. Specifically, decontamination will also be required for the interface probe and will be performed between each well to reduce the risk of cross-contamination. Decontamination of the ~~interface probe and HydraSleeve™~~ reusable components will consist of three steps:

1. Wash in Alconox or Liquinox detergents (Decon 90 is on the prohibited material list and will not be used).
2. Triple rinse with distilled water.
3. Final triple-rinse with commercially available or laboratory-provided PFAS-free deionized water in an HDPE container.

If necessary, sampling equipment will be scrubbed using a polyethylene (PE) or polyvinyl chloride (PVC) brush to remove particulates prior to completing the decontamination steps listed above.

3.0 Analytical Methods

PFAS analysis will be conducted by a laboratory with PFAS-specific experience, using method 537.1 or equivalent that utilizes isotope dilution and is compliant with Quality Systems Manual (QSM) version 5.3 (or later) Table B-15. Promulgated United States Environmental Protection Agency (USEPA) Methods 533 and 537 are both specified as drinking water methods and cannot be applied to the sample matrices collected in this event. There are no promulgated USEPA methods for analyzing PFAS in groundwater (Method 1633 is still in draft form). As such, the analytical results for these media using standardized drinking water methods, or non-standardized laboratory specific methods, must be interpreted with caution. Additional discussion is provided in Appendix B~~A~~.

The selected laboratory will provide fully documented commercial-type data packages (e.g., equivalent to full USEPA Contract Laboratory Program data packages) for all analytical results and electronic data deliverables (EDDs).

4.0 Quality Assurance And Quality Control

This section addresses the qualitative and quantitative criteria that will be used to evaluate the quality of the field and analytical data collected during the field activities.

4.1 Field Quality Assurance and Quality Control Samples

Five kinds of field quality assurance and quality control samples (QA/QC) will be collected during the sampling event as described below.

1. Duplicate Samples. Duplicate samples will be collected to evaluate precision associated with the reproducibility of sampling techniques and the homogeneity of sample matrices. One duplicate sample will be collected per matrix, and at a minimum frequency of 10%, or one for every 10 samples. The duplicate sample will be "blind" to the laboratory; therefore, it will have a coded identity on its label and on the COC. The actual sampling location and identification will be recorded on the sampling log.
2. Trip Blanks. Trip blanks are generally not required for PFAS samples but may be helpful to identify sources of contamination, should they occur. A trip blank, comprising PFAS-free water supplied by the laboratory, will accompany each cooler that contains PFAS samples. Experience has shown that cross-contamination at analytical laboratories can lead to spurious PFAS detections. The trip blanks prepared by the laboratory can point to the reagent water used by the laboratory as a source of contamination not related to field sampling procedures.
3. Field Blanks. Field blanks will be collected in the vicinity of the project area. Field blanks will be collected by pouring laboratory provided PFAS-free water into the appropriate containers and submitted for PFAS analysis. A field blank will be collected at each separate groundwater well, groundwater, and soil sampling event.
4. Equipment Blanks. Equipment blanks will be prepared and submitted for laboratory analysis to assess sampling equipment for potential PFAS impacts and to verify that equipment decontamination procedures are effective. One equipment blank will be collected for groundwater samples from the interface probe to verify that decontamination procedures are effective. Additional equipment blanks will be collected from the ~~HydraSleeves™ and~~ trowels to verify that each of the batches received from the manufacturer is PFAS free.
5. Matrix Spike/Matrix Spike Duplicates (MS/MSD). MS/MSDs will be prepared and analyzed by the laboratory for each matrix sampled. The following MS/MSDs will be collected: one from a permanent groundwater well and one from a temporary groundwater well. MS/MSDs are samples in which known quantities of specific PFAS compounds are added before extraction and analyses. The recoveries for spiked compounds can be used to assess how well the method for analysis recovers target compounds.

4.2 Laboratory Assurance and Quality Control Samples

QA/QC samples will be analyzed by the laboratory. The laboratory will follow proper QA/QC procedures, including laboratory blanks, duplicates, and spiked samples for calibration and identification of potential matrix effects. Data from the QC samples are used as a measure of performance and as an indicator of potential sources of cross-contamination. In addition, for PFAS analysis, the laboratory will follow QC procedures compliant with QSM Table B-15 QC. QC data generated by the laboratory are submitted with the results in the fully documented commercial type data packages.

1. MS/MSD. MS/MSD will be performed if sufficient sample is recovered and indicated on the COC. If not, lab will perform laboratory control samples (LCS) and laboratory control sample duplicates (LCSD).
2. Surrogate Spiking. Surrogate compounds are added before sample preparation for organics to all samples prior to extraction and analysis. The review for surrogate compounds can be used to assess method accuracy for each sample matrix.

4.3 Data Validation

Analytical data received from the laboratory will undergo Trihydro's data validation process. Minimally, data will be evaluated by the Tier I and Tier II data validation process. Trihydro uses the following guidance documents for validation of organic and inorganic data:

- Data for organic analyses are evaluated according to validation criteria set forth in the USEPA Contract Laboratory Program (CLP) National Functional Guidelines for Organic Superfund Methods Data Review, document number EPA-540-R-20-005, November 2020 with additional reference to the USEPA CLP National Functional Guidelines for Organic Data Review, document number EPA 540/R-99/008, October 1999.

- Review of PFAS data will also use criteria set forth in the Department of Defense / Department of Energy QSM for Environmental Laboratories, Version 5.3, 2019. This reference document has specific criteria for review of PFAS data in Appendix C~~B~~, Table B-15 that are used in conjunction with the National Functional Guidelines.

- Data for inorganic analyses is evaluated according to validation criteria set forth in the USEPA CLP National Functional Guidelines for Inorganic Superfund Methods Data Review, document number EPA-542-R-20-006, November 2020 with additional reference to the USEPA CLP National Functional Guidelines for Inorganic Data Review, document number EPA 540-R-04-004, October 2004.

- Review of field duplicates will be conducted according to the USEPA Region 1 - New England Environmental Data Review Supplement for Region 1 Data Review Elements and Superfund Specific Guidance/Procedures, EQADR-Supplement2, September 2020.

Precision, accuracy, method compliance, and completeness of the data packages will be assessed during the data validation process. Precision is determined by evaluating the calculated relative percent difference values from: laboratory duplicate pairs, MS/MSD pairs, and LCS/LCSD pairs. Laboratory accuracy is established by reviewing the demonstrated percent recoveries of the following items to identify potential biases in the analytical data: MS/MSD samples, LCS/LCSD samples, and organic system monitoring compounds (surrogates). Field accuracy is established by collecting and analyzing field QA/QC samples to monitor for possible ambient or cross-contamination during sampling and transportation. Method compliance is established by reviewing sample integrity, holding times, detection limits, surrogate recoveries, laboratory blanks, initial and continuing calibrations (where applicable), and the LCS/LCSD percent recoveries against method-specific requirements. Completeness is evaluated by determining the overall ratio of the number of samples and analyses planned versus the number of samples with valid analyses. Determination of completeness includes a review of the COC, laboratory analytical methods, and other laboratory and field documents associated with the analytical data set

5.0 Schedule and Reporting

The scheduling of field activities associated with the Work Plan are dependent upon regulatory review and approval. Field coordination will commence upon written approval of the Work Plan by NMED. Trihydro estimates the field portion of the Work Plan will take approximately one to two weeks to complete over several months due to the phased approach. Phase 1 through 3 of the investigation are planned to be completed in 2023, pending written Work Plan approval. Interpretation of results and preparation of documents are planned to be completed in late 2023 or early 2024, pending field investigation.

The final report will include the following:

1. A description of the sampling activities performed and deviations from the Work Plan
2. A summary table of the analytical results (including QA/QC samples)
3. A copy of the COC forms
4. A copy of the field sampling logs
5. A copy of existing monitoring well construction details and historical survey data for OW-12, OW-14, OW-57, OW-63, and OW-70
6. A copy of the site map showing the sampling/monitoring locations
7. A copy of laboratory certified analytical results

6.0 References

Armstrong, M., M.J. Seitz, F. Beetle-Moorcroft, and D.S. Lipson. 2020. No-Purge Groundwater Sampling for PFAS. Groundwater–Vol. 58, No. 6. November-December 2020.

Brusseau. 2018. Assessing the Potential Contributions of Additional Retention Processes to PFAS Retardation in the Subsurface. Science of the Total Environment 613–614 (2018) pp. 176–185.

~~GeoInsight. 2016. Standard Operating Procedure: Sampling Groundwater with a HydraSleeve™. 2016.~~

Interstate Technology Regulatory Council (ITRC). 2022a. History and Use of Per- and Polyfluoroalkyl Substances (PFAS) Found in the Environment. Updated July 2022. Available from: https://pfas-1.itrcweb.org/wp-content/uploads/2022/09/HistoryandUse_PFAS_Fact-Sheet_090722_508.pdf.

ITRC. 2022b. Fate and Transport of Per- and Polyfluoroalkyl Substances (PFAS). July 2022. Available from: https://pfas-1.itrcweb.org/wp-content/uploads/2022/09/FT_PFAS_Fact_Sheet_083122_508.pdf.

NMED. 2020. Disapproval Annual Groundwater Monitoring Report Gallup Refinery - 2019, Western Refining Southwest LLC, Gallup Refinery, McKinley County, Gallup, New Mexico, EPA ID #NMD000333211, HWB-WRG-20-013. November 23.

NMED. 2022. Approval with Modifications 2021 Annual Groundwater Monitoring Report, Western Refining

Southwest LLC, Gallup Refinery, McKinley County, Gallup, New Mexico, EPA ID #NMD000333211, HWB-WRG-22-006. October 18.

Figures

Tables

Appendix A – OW-63 PFAS Sampling Results

Appendix B~~A~~ - Trihydro's PFAS Site Characterization Standard Operation Procedure

Appendix C~~B~~ - Standard Operating Procedure for ~~HydraSleeveTM~~ Low Flow Groundwater Sampling

Appendix D~~C~~ - Example Logs

Appendix D~~C~~-1 - Example Soil Sample Log

Appendix D~~C~~-2 - Example Boring Log

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CONDITIONS

Action 269207

CONDITIONS

Operator: Western Refining Southwest LLC 539 South Main Street Findlay, OH 45840	OGRID: 267595
	Action Number: 269207
	Action Type: [UF-DP] NOI Discharge Permit (DISCHARGE PERMIT NOI)

CONDITIONS

Created By	Condition	Condition Date
joel.stone	Accepted for OCD record retention purposes.	2/7/2025