TETRA TECH

AAA Storage Additional Cleanup Actions Work Plan

Cool-Ox™ Injection and Groundwater Monitoring

Facility ID 25-08847, TID 17125, Release 3840, Work Plan ID 34839

Updated January 16, 2026

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1.0 EXECUTIVE SUMMARY

Tetra Tech is pleased to present this Cleanup Work Plan for the subject property located at 1530 Columbia Avenue in Helena, MT, known as AAA Storage. AAA Storage is listed as Facility ID 25-008847 with Release 3840. This work plan was prepared in response to the Montana Department of Environmental Quality (DEQ) letter dated November 25, 2024.

A gasoline release at AAA Storage (the Site) was discovered in 1999 during remedial investigation work at the adjacent Montana Power Company. While installing monitoring wells an underground storage tank (UST) was discovered with gasoline-impacted soils to 40 feet below ground surface. Investigations followed with monitoring well installation and storage tank removal, with removal of some contaminated soils. Several treatment systems have been in operation at the site at various times including soil vapor extraction and air sparge systems and iSOC™, an automated dissolved oxygen release unit suspended in designated wells. After 22 years of various treatment technologies and groundwater monitoring, hydrocarbon concentrations, though generally significantly reduced from historical high levels in 2000, remain above Montana Risk-Based Screening Levels (RBSLs) for groundwater in wells AAA-3, AAA-4, AAA-6, OBS-1, OBS-2, SP-1, and M12 and the site cannot achieve closure. The groundwater plume is centered around OBS-1, SP-1, and AAA-3 and extends to the west-northwest past AAA-6. Figures showing the Site well network, former UST basin excavation area, and iso-concentration maps for benzene from the most recent groundwater report (2023) are presented in **Attachment A**.

Cleanup Actions proposed by this Work Plan seeks to address the persistent dissolved phase petroleum contamination by injecting Cool-Ox® product into impacted wells at the Site. The injection will be performed using the experienced team at DeepEarth Technologies, Inc (DTI), who manage all site work including product mixing and injection, active well monitoring, and site cleanup with their own equipment. Tetra Tech will provide pre-injection field work, injection subcontractor oversight and logistics support.

The proposed scope of work is:

- Conduct a pre-injection groundwater monitoring event for baseline field parameters, petroleum hydrocarbons, and intrinsic biodegradation indicators.
- Conduct a multi-day product injection of Cool-Ox® remediation product in up to 10 site wells that display moderate to significant benzene contamination. Conduct a synoptic water level and grab sample to read field parameters (temperature, pH, conductivity, oxidative-reduction potential [ORP], and dissolved oxygen from each well prior to start of injection. Monitor water levels and pH, oxidative-reduction potential (ORP), and dissolved oxygen as needed during injections.
- Conduct two post-injection groundwater monitoring events 30 days and 90 days after, to evaluate contaminant concentrations and intrinsic biodegradation indicators (IBI).
- Prepare a Data Summary Report after the 90-day sampling event.
- Conduct a groundwater monitoring event 1-year post-injection
- Prepare Cleanup Report with updated Release Closure Plan after the last monitoring event.

It is our expectation that injecting a proven remediation product technology will have significant reductions in persistent petroleum contamination at the site. Cool-Ox is a mixture of hydrogen peroxide and soluble iron-producing hydroxyl radicals that react with gasoline, other hydrocarbons, or chlorinated solvents without producing heat, odors, or harmful byproducts associated with the degradation of certain solvents. The insitu reaction also creates a longer-term oxygen-enhanced environment that contributes to favorable biodegradation conditions for an extended period of time (up to 90 days) after the injection is completed.

The referenced figures in this Cleanup Plan are included in **Attachment A**, a breakdown of costs is included as **Attachment B**, and the DTI Injection and Energy Laboratory quotes received for this project are contained in **Attachment C**. Standard operating procedures for groundwater monitoring are in **Attachment D**.

2.0 FACILITY SUMMARY AND CURRENT CONDITIONS

AAA Storage is located east of North Last Chance Gulch and south of Montana Rail Link's main lines through Helena (**Figure 1**, **Appendix A**). The site is located in Section 30, Township 10 North, Range 3 West, Lewis and Clark County. The adjoining property to the west, south, and east is owned by Northwestern Energy Company (formerly Montana Power Company) (**Figure 2**, **Appendix A**), which is also an active remediation site. A summary of investigation and remediation work performed at the AAA Storage site is presented below.

- **November 1999** – A gasoline release was discovered at AAA Storage during a remedial investigation conducted for the former Montana Power Company Operating Center (currently owned by Northwestern Energy). As part of that investigation, several monitoring wells (M-8 through M-13, M-15, and M-17) were installed, in and around AAA Storage, under the mistaken belief groundwater flowed to the northeast (**Figure 2**, **Appendix A**). A borehole drilled north of the AAA Storage office building encountered an empty underground storage tank (UST) and gasoline-impacted soil to a depth of approximately 40 feet below grade. According to a former employee, the UST provided gasoline for vehicles and equipment operated by a previous site owner, Waddell Construction, and was taken out of service around 1985 (Tetra Tech, 2008).
- **August 2000** – Maxim Technologies installed three monitoring wells: downgradient (AAA-1), upgradient (AAA-2), and adjacent to the UST (AAA-3) on AAA Storage property (**Figure 2**, **Appendix A**); and started a groundwater monitoring program (Tetra Tech, 2008).
- **May 2001** – Maxim Technologies coordinated removal of the abandoned UST, along with 50 cubic yards of impacted soil (Tetra Tech, 2008).
- **July 2001** – Maxim Technologies activated a soil vapor extraction (SVE) system connected to well AAA-3 and slotted piping in the UST excavation backfill to abate residual gasoline constituents in soil. The system was deactivated in September 2004 due to low gasoline recovery rates (Tetra Tech, 2008).
- **March 2003** – Maxim Technologies prepared a *Focused Feasibility Study* to assess remedial options applicable to the Site and to identify the preferred alternative (Maxim, 2003). Results of the study indicated the preferred remedial alternative was to install air sparge (AS) and SVE wells in the gasoline source area and along the downgradient edge of the dissolved phase plume (Tetra Tech, 2008).
- **April 2006** – Maxim Technologies installed three monitoring wells (AAA-4, AAA-5, and AAA-6) downgradient of the former UST to better delineate the extent of dissolved gasoline constituents in groundwater (**Figure 2**, **Appendix A**). In addition, one AS injection well (SP-1) and two AS observation wells (OBS-1 and OBS-2) were installed near the former UST (Maxim, 2006a).
- **May 2006** – Maxim Technologies completed an AS test of 6 hours duration (Maxim, 2006b). The AS test involved injecting air and a helium tracer approximately 20 feet below the water table through sparge well SP-1 and measuring the response of various parameters in three observation wells (AAA-3, OBS-1, and OBS-2).
- **June 2007** – Tetra Tech (formerly Maxim Technologies) installed one additional monitoring well (AAA-7) at the northwest corner of the property to better delineate the downgradient extent of gasoline constituents dissolved in groundwater (**Figure 2**, **Appendix A**). During well installation activities, Tetra Tech activated and monitored the SVE system to identify if occasional operation of the system would prove an effective method for removing free product identified in AAA-3.
- **2015** – DEQ requested a work plan for groundwater sampling to be resumed at the Site (Tetra Tech, 2017).
- **February 2017** – Tetra Tech conducted one vapor intrusion (VI) sampling event at the Site, collecting indoor air samples from the AAA Storage office building and an onsite residence; an ambient air sample was also collected

outside the office. One sub-slab soil vapor sample was obtained from beneath the utility room floor. Some constituents were found within indoor and sub-slab samples, but not above 2016 industrial RBSLs (Tetra Tech, 2017)

- **March 2017** – Tetra Tech oversaw the installation of well SVE-1, which had a soil oxidant demand (SOD) test performed on soil samples obtained during well installation using groundwater obtained from AAA-3. Two SVE pilot tests were also conducted on wells SVE-1 and AAA-3 and an AS pilot test was conducted on well SP-1. Results indicated that while SVE and AS is technologically feasible at the Site, it would be economically infeasible due to the large number of wells required for optimization of an SVE-AS treatment system (Tetra Tech, 2017).
- **March 2018** – During groundwater monitoring, absorbent socks were placed into well AAA-3 to absorb free product (Tetra Tech, 2018).
- **October 2019** – An iSOC™ treatment system was installed and put into operation. Three wells were installed using a roto-sonic drill rig with piping trenched to a centrally located shed at the Site, with iSOC™ units installed in each of the wells (iSOC-1, iSOC-2, iSOC-3). The iSOC™ system was chosen to add dissolved oxygen to the water column as an in-situ treatment option for enhanced degradation of gasoline products (Tetra Tech, 2020). Well AAA-8 was also installed as a background well to replace AAA-2 during this event.
- **June 2020** – Well AAA-2 was abandoned due to an obstruction in the well casing preventing monitoring activities (Tetra Tech, 2020).
- **November 2020** – Boland Drilling conducted pavement removal and well vault reinstallation following damage and well access restrictions resulting from repaving the parking lot at the Site during July 2020 (Tetra Tech, 2021).
- **July 2022** – Prior to the semi-annual groundwater monitoring event, O&M was conducted including cleansing acid baths to remove any biomass buildup on the iSOC units, and dissolved oxygen measurements at the wells to assess system function when changing tanks. Later, during the July 2022 groundwater monitoring event, the iSOC™ unit was pulled from well iSOC-2 due to no water in the well, leaving two iSOC™ units in operation at the Site.
- **February 2023** – Groundwater monitoring was conducted with a Groundwater Monitoring Report submitted to DEQ in December 2023.

2.1 CURRENT CONDITIONS

After the monitoring events in 2022 and 2023, Tetra Tech made the following evaluation at the Site in the Groundwater Monitoring and iSOC™ Operation and Maintenance Report (Tetra Tech, 2023):

    - All Site wells sampled displayed evidence of petroleum impacts over both sampling events. Samples from wells AAA-3, AAA-4, AAA-6, OBS-1, and SP-1 continue to display exceedances of DEQ water quality standards with stable to increasing concentrations of petroleum hydrocarbons.
        - Samples from wells AAA-3, AAA-4, AAA-6, OBS-1, and SP-1 continue to exhibit several dissolved petroleum hydrocarbon concentrations exceeding DEQ water quality standards.
    - Benzene concentrations decreased in well M12 between the July 2022 and February 2023 monitoring events, but increased in wells AAA-3, AAA-4, AAA-6, OBS-2, and SP-1 over the same time period. The hydrocarbon plume appears to be persistent and potentially expanding west past AAA-6.

- Field parameters indicated anerobic degradation is likely occurring in wells AAA-3, AAA-4, AAA-6, AAA-8, OBS-1, SP-1, and M12, based on negative to low ORP values and low DO concentrations in wells during at least one of the monitoring events.
- IBI parameters indicate that well AAA-4 with higher dissolved oxygen, low to no nitrate levels, and low manganese levels are experiencing increased degradation. While AAA-6 has similar IBI trends, benzene concentrations in this well are increasing.

- Field parameters for the other wells indicate that oxidizing conditions at the Site are favorable for aerobic biodegradation based on elevated DO, neutral pH values, moderate conductivity, and positive ORP values.
- No free product has been measured in Site wells since 2016.

In summary, groundwater monitoring wells AAA-3, AAA-4, AAA-6, OBS-1, OBS-2, SP-1, and M12 remain impacted with hydrocarbon concentrations well above Montana RBSLs. iSOC-1 well had a benzene concentration of 5.3 ug/L, just above the RBSL of 5 ug/L in February 2023. See **Attachment A** for cumulative groundwater analytical data for site wells (Table 1).

3.0 OBJECTIVES

The specific goals for Site cleanup actions are:

- Address the persistent hydrocarbon contamination in the groundwater and remaining in subsurface sediment by direct injection of an insitu chemical oxidation (ISCO) treatment product within the center and edges of the groundwater plume using the existing well network.
- Reduce groundwater contamination levels from the hundred or thousands micrograms per liter level to below RBSLs (see Table 1 in Attachment A for cumulative historical analytical data).
    - Constituents of concern include benzene, naphthalene, C5-C8 Aliphatics, C9-C12 Aliphatics, C9-C10 Aromatics in wells AAA-3, AAA-4, and AAA-6.
    - Wells OBS-1, SP-1, and M12 have constituents of concern including benzene, toluene, ethylbenzene, xylenes, naphthalene, C5-C8 Aliphatics, C9-C12 Aliphatics, C9-C10 Aromatics, and lead scavengers (1,2-dibromomethane and 1,2-dichloroethane).
- Treat accessible and residual contamination in sediment by injecting a treatment product under pressure and attempting to flush the material into the formation to target soil contamination.
    - As a note that was discussed with DEQ, soil contamination has not been fully delineated due to the difficulties drilling in the cobble-containing lithology. Air rotary drilling methods used to install wells from 40 to 60 ft bgs were used but the cuttings return method produces unusable samples for volatile analysis. Additionally, the lack of soil samples collected over the Site history has led to limited information on aquifer characteristics. No data targets have been developed for soil given the data gaps present.

4.0 TREATMENT OPTION EVALUATION

Based on the evaluated conditions at the site at the 2022 and 2023 groundwater events, and other data from measured field parameters and intrinsic biodegradation indicators (IBI), Tetra Tech's treatment options included:

1. Expansion of the iSOC treatment system, with additional trenching work to supply each unit with their own oxygen tank for better control and delivery of dissolved oxygen. Units were recommended in existing wells OBS-1, OBS-2, and AAA-3 to reduce high concentrations of dissolved petroleum hydrocarbons in groundwater near the source area. Well iSOC-2 would potentially need to be replaced with a deeper screened interval to account for low groundwater conditions. An iSOC unit in well AAA-6 was proposed to address rising benzene concentrations on the west boundary of the Site, where the plume may be expanding. This recommendation, however, is expensive to install and maintain, and lithology at the site limits the sphere of influence of iSOC technology. No licensed contractors returned any requests for estimates after several attempts. Also, the limited site space and trenching required makes troubleshooting and controlling individual iSOC units difficult.
2. Another suggestion was to start a 3% nitrate infusion regimen on impacted wells AAA-3, OBS-1, OBS-2 with no or low concentrations of nitrate and dissolved manganese and iron, that show some evidence of

potential biodegradation. Purchase of a Hach™ nitrate test kit would be required with weekly sampling to monitor nitrate concentrations. This was recommended as an inexpensive (equipment-wise) solution to attempt prior to iSOC system installation, though could not be implemented on all wells since adding nitrate which is a monitored nutrient in aquifer systems, needs to be conducted carefully and with acceptance by DEQ. This option was suggested as short-term treatment, with unknown results.

Given that the well iSOC-2 went dry in 2022, low groundwater conditions demonstrated the limitations of the iSOC treatment system effectiveness. Fluctuating water levels also have the function of releasing or flushing hydrocarbons bound in sediments once water levels rise again during seasonal conditions.

In March 2024 DEQ issued a work plan request for Cleanup Actions in May 2024 to implement installation of iSOC units and simple amendment options. During work plan development, significant issues with contractor availability and response arose, which led to re-evaluating the confidence and cost-effectiveness of the iSOC network expansion and nitrate amendment treatment strategy. Tetra Tech entered into talks with two injection product companies, Regenesis and DTI, to discuss a more intensive up-front cleanup action with less downstream operation and maintenance costs. Subsequent discussions with DEQ led to the Work Plan Request being rescinded and new Request issued in November 2024 to pursue injection treatment as a cleanup action to see significant treatment and reduction in gasoline contamination, instead of the limited treatment allowed by the current iSOC system. Additionally the injection treatment method is a one-time expense without expensive and intrusive operation and maintenance activities.

4.1 SELECTED TREATMENT OPTION – COOL-OX® BY DEEPEARTH TECHNOLOGIES (DTI)

DEQ issued Work Plan Request 34839 in November 2024. After researching more complete injection treatment technologies, in light of the long history of persistent hydrocarbon contamination, Tetra Tech recommends injection of Cool-Ox®, a hydrogen peroxide-based product that was developed by DTI. Cool-Ox® was designed to influence a variety of organic contaminants in various soil types and groundwater, including gasoline and other hydrocarbons, and chlorinated solvents. For a description of Cool-Ox® see the manufacturer's website at https://www.cool-ox.com/cool-ox. Case studies provided by DTI and injection reports prepared by Montana DEQ personnel from treatment sites in Missoula and Harlem are available upon request and further discussion.

According to the manufacturer's website and conversations with product developers, Cool-Ox was designed using a modified Fenton's reagent (a mixture of hydrogen peroxide and soluble iron-producing hydroxyl radicals) that oxidize contaminants in the subsurface. Cool-Ox works to directly degrade existing hydrocarbon contamination in groundwater and sediment, deliver nutrient amendments during the product-contamination reaction and facilitate natural insitu bioremediation.

Cool-Ox has a neutral pH and does not produce heat, odors, or harmful byproducts, which would be safer in the Site environment. Additionally, the injection site remains enriched in oxygen for an extended period of time (up to 90 days according to the DTI website), enhancing the environment for native soil bacteria to continue product degradation long after the injection. Additionally, the chemistry of the Cool-Ox® product does not foul well screens or well filter packs. Discussions with operations staff noted that the peroxide chemical cleans the well screens and can reduce biomass or buildup in the filter pack.

Tetra Tech selected this product also because DTI would provide their own equipment and experienced staff to manage the mixing and deployment of the injection product. The crews come with their own injection equipment mounted on trailers, water tanks, wellhead adaptors or packers, as needed. All aspects of the injection are monitored by the crews who can make quick field decisions about product acceptance in wells and move through the well network for best product delivery. The injection method would utilize the existing monitoring network rather than further disturb the Site activities with several new well or injection point installations.

Cleanup objectives will be evaluated by monitoring groundwater pre-injection (at least one month prior to injection) and post-injection at 30-day, 90-day, and one-year intervals. Samples will be collected and analyzed for volatile petroleum hydrocarbons (VPH) and lead scavengers to monitor changes in hydrocarbon concentrations. Intrinsic biodegradation indicator (IBI) samples will be used to monitor conditions favorable to biodegradation, along with field parameters, to determine if native soil bacteria are degrading petroleum products within the injection area.

5.0 CLEANUP WORK PLAN TASKS

The proposed tasks for the work plan are:

- Work Plan Development. The Cleanup Work Plan (WP) presents an itemized list of expected costs associated with the proposed activities. This document must be submitted to the DEQ and the Petroleum Tank Release Compensation Board (PTRCB) for approval to remain eligible for reimbursement of costs associated with cleanup activities.
- Project Management. This task includes Cleanup Work Plan meetings with DTI and DEQ manager, all labor costs associated with purchasing and/or renting supplies, contractor coordination, field coordination, invoicing, and client and regulatory communications.
    - To comply with Occupation Safety and Health Administration Code of Federal Regulations (CFR) 29 1910.120, Tetra Tech will prepare a health and safety plan (HASP) for projects that involve field investigation activities, especially for projects where environmental contaminants may be encountered. The objective of the HASP is to disclose potential chemical and physical hazards that may be encountered at a site, identify job hazards associated with field activities, describe safe work practices, identify personal protective equipment, decontamination procedures, identify project contacts, emergency medical procedures, and the location of the nearest medical facilities
- Fieldwork – Cool-Ox injection event and four groundwater monitoring events (see **Sections 5.1** and **5.2** below, respectively).
- Reporting - Interim Data Submittal to be prepared after the sampling event 90 days after the Injection work.
    - Laboratory reports and updated groundwater tables can be provided to DEQ after the 90-day post injection sampling event.
    - Cleanup Report with Release Closure Plan update to be prepared after the one-year post-injection monitoring event.

5.1 COOL-OX INJECTION FIELD WORK

DTI would mobilize specialized personnel and injection equipment and support truck to the site. The AAA Storage facility would remain open and operational during the work, with injection areas cordoned off and trailer-based equipment being moved around the site as needed. No utility notifications will be required since no new borings or ground disturbance are required. Water is also reportedly available onsite and will be sufficient for the scope of work.

The Cool-Ox® product would be mixed onsite and injected into each well using a wellhead adapter or packer, based on field evaluation. Based on DTI reviews of well logs and well construction information, injections of up to 500 gallons per well will be conducted in up to 10 wells for a total of approximately 5,000 gallons. Product delivery and well/groundwater response will be monitored continuously throughout the work, with DTI personnel adjusting to conditions in the field as needed. Injection of product into a well will be followed immediately by clean water injection to disperse Cool-Ox into the formation.

The proposed monitoring wells receiving injectate are SP-1, OBS-1, OBS-2, AAA-3, ISOC-1, ISOC-2, ISOC-3, SVE-1, M12, and potentially AAA-6. Proposed observation wells ISOC-1 and 2, AAA-5, AAA-6 will be selected based on location and/or screened intervals. AAA-6 is chosen particularly as a sentinel well given its location near the edge of the site and downgradient side of the plume, which may be valuable in evaluating injectate travel and impacts within the aquifer. Given the Cool-Ox product does not foul well screens all wells would remain useful within the existing monitoring network.

Pre-injection, synoptic water levels and field parameters including temperature, pH, conductivity, ORP, and dissolved oxygen will be collected in each well for baseline information using calibrated multi-parameter meters.

Tetra Tech field tasks will include pre-injection well gaging, sampling and parameter measurement, conducting and/or participating in site-specific health and safety tailgate meetings during the injection, general subcontractor oversight, logistics assistance, and site work documentation. DTI personnel will monitor injection activities and parameters including product mixtures, gallons injected, injection times and rates, and wellhead pressures. Periodic depth to water, pH, ORP, and dissolved oxygen measurements will be collected in selected observation wells during the work and documented.

Cleanup will be conducted during the field work and the site returned to normal operating conditions.

5.2 GROUNDWATER MONITORING

To support the Cool-Ox injection project, groundwater monitoring will be conducted on the following schedule:

- An initial baseline monitoring event will be conducted at least thirty days before the injection event to re-establish baseline concentrations and field parameters of the Site well network since the most recent groundwater monitoring was conducted in February 2023. Field parameter and water level data will be provided to DTI crew members for work planning purposes.
- Thirty days after injection, the first post-injection groundwater monitoring event
- 90 days post-injection
- One year after the initial injection event.

Higher groundwater levels are expected as the water injected into the formation continues to dissipate. Elevated conductivity, ORP, and dissolved oxygen parameters are expected in the first few months as the product reactions continue, with higher dissolved oxygen expected for several months.

Static water level and/or free product thickness measurements (if applicable) will be measured in all 15 onsite wells, and the sampling of eleven monitoring wells including ISOC-1, ISOC-2, ISOC-3, AAA-3, AAA-4, AAA-5, AAA-6, OBS-1, OBS-2, M-12, and SP-1, if sufficient water is present. Four wells (AAA-1, AAA-7, AAA-8, and SVE-1) will have water levels measured only. These wells have not had historical detections of petroleum hydrocarbons. AAA-5 had significant historical detections of petroleum hydrocarbons in 2006 and 2007 but very low to no detections starting in 2016 through 2021 and has not been sampled since and will be re-evaluated for changes.

Groundwater will be purged and sampled using low-flow techniques according to the Montana DEQ Groundwater Sampling Guidance document (DEQ, 2018). The pump intake will be placed in the center of the water column, unless water is within and below the top of the screened interval, then the intake will be set halfway within the available water column.

During well purging, drawdown and water quality parameters (temperature, pH, conductivity, oxidation-reduction potential, dissolved oxygen, and turbidity) will be monitored. The parameters will be recorded until three stable readings are reached, per the Montana DEQ Groundwater Sampling Guidance document (DEQ, 2018) shown below.

Table 2. Stabilization Parameters for Groundwater

Water Quality Indicator Parameter	Stabilization Range

pH	± 0.1 units
Specific Conductance	± 3%
Dissolved Oxygen (DO)	± 10%
Turbidity	± 10%
Oxidation/Reduction Potential (ORP)	± 10 millivolts

All parameters and sampling information will be recorded on paper or electronic field forms. Disposable tubing and bladders will be used, as needed, with all non-dedicated equipment decontaminated with a three-rinse method that includes a Liquinox™ soap solution, 10% isopropanol rinse, finished with a final deionized water rinse. An equipment blank will be collected from a decontaminated bladder pump using deionized water during each sampling event and analyzed for VPH.

Groundwater samples for ten wells will be analyzed for VPH using the Massachusetts Method, lead scavengers, and IBI parameters at Energy Labs in Helena, Montana. One duplicate sample will be collected during each monitoring event and laboratory-provided trip blanks will be analyzed for VPH. Samples will be submitted daily to the analytical laboratory within recommended holding times based on preservation and analytical requirements, shown in Table 3 below.

Table 3. Groundwater Analyses and Holding Times

<table>
<tr><th>Wells</th><th>Analysis</th><th>Container</th><th>Holding Time</th></tr>
<tr><td rowspan="5">• ISOC-1
• ISOC-2
• ISOC-3
• AAA-3
• AAA-4
• AAA-5
• AAA-6
• OBS-1
• OBS-2
• M-12
• SP-1

Quality Control samples:
• Duplicate
• Equipment Blank (EB) – VPH ONLY</td><td>VPH – MA-VPH</td><td>3-40mL VOAs, preserved with hydrochloric acid</td><td>14 days</td></tr>
<tr><td>Lead Scavengers
• 1,2-Dibromoethane– SW8011 SW8260D;
• 1,2-Dichloroethane – VOC short list SW8260D</td><td>6-40 mL VOAs, preserved with hydrochloric acid</td><td>14 days</td></tr>
<tr><td>Nitrate, Nitrogen – E353.2</td><td>250 mL HDPE, unpreserved</td><td>48 hours</td></tr>
<tr><td>Sulfate – E300.0
Nitrite</td><td>250 mL HDPE, unpreserved</td><td>48 hours</td></tr>
<tr><td>Dissolved Iron (ferrous) and Manganese – E200.7_8</td><td>250 mL HDPE with nitric acid preservative, field filtered with 0.45µm filter</td><td>180 days</td></tr>
</table>

	Methane – Headspace Gas Analysis – SW8015M	2 – 40 mL VOAs, preserved with sulfuric acid	14 days

Purge water without free product from sampling will be broadcast on-site consistent with previous monitoring events. Wells containing measurable free product will bailed of product and have absorbent socks installed. Product will be collected and evaluated using the Montana DEQ's Guidance Document "Disposal of Untreated Purge Water from Monitoring wells, dated 7/27/2015."

5.3 REPORTING

After the 90 day groundwater monitoring event, an Interim Data Submittal will be prepared which will include a summary of injection activities, groundwater monitoring activities, tabulated (cumulative) groundwater results, field data sheets, data validation forms, and groundwater contour figure with water levels and direction of groundwater flow.

After the final monitoring event, at one year post injection, a Cleanup Report will be prepared evaluating hydrocarbon concentrations, using the Cleanup Report Guidance (DEQ, 2020). An updated Release Closure Plan (RCP) will be prepared, which summarizes the information presented in the Cleanup Report with focus on risks, impacts, utilities, potential cleanup remedies, and estimated time frames for achieving closure.

Analytical results will be added to existing cumulative groundwater data tables with applicable RBSLs along with figures documenting injection and monitoring well locations, groundwater contours, benzene concentration maps, and other required items from the Cleanup Report Guidance (DEQ, 2020) such as Table H.1: Chemical Oxidation Performance Table. Analytical results will be compared to the most recent Risk-Based Screening Levels (RBSLs), updated February 2024 (DEQ, 2024).

Analytical data will be validated using the DEQ Data Validation Summary Form Report and attached to the Interim Data Submittal and Cleanup Report.

5.4 SCHEDULE AND BUDGET

Tetra Tech will initiate scheduling work upon receiving authorization from DEQ. Prior to site investigation work, a site-specific health and safety plan (HASP) will be generated in accordance with Tetra Tech's corporate Health and Safety Program, and DTI's Safety Program as applicable, to identify anticipated hazards and management techniques, relevant emergency phone numbers, hospital routes, and required personal protective equipment for site work. Most importantly, notification of facility staff and coordination with scheduled site activities will be balanced with the injection schedule.

A cost estimate is presented in **Attachment C**. Exceedance of the proposed amount will be contingent on approval from DEQ or PTRCB, if there are identified field changes. Any modifications required can be submitted via email or telephone conversation.

If you have questions or comments about this work plan, please reach out via email or at my mobile number (406) 422-7457.

Sincerely,

L. Rhianna Reed

L. Rhianna Reed

Hydrogeologist/Project Manager

6.0 REFERENCES

Montana Department of Environmental Quality. 2020. Cleanup of Petroleum Releases (draft). Dated November 16.

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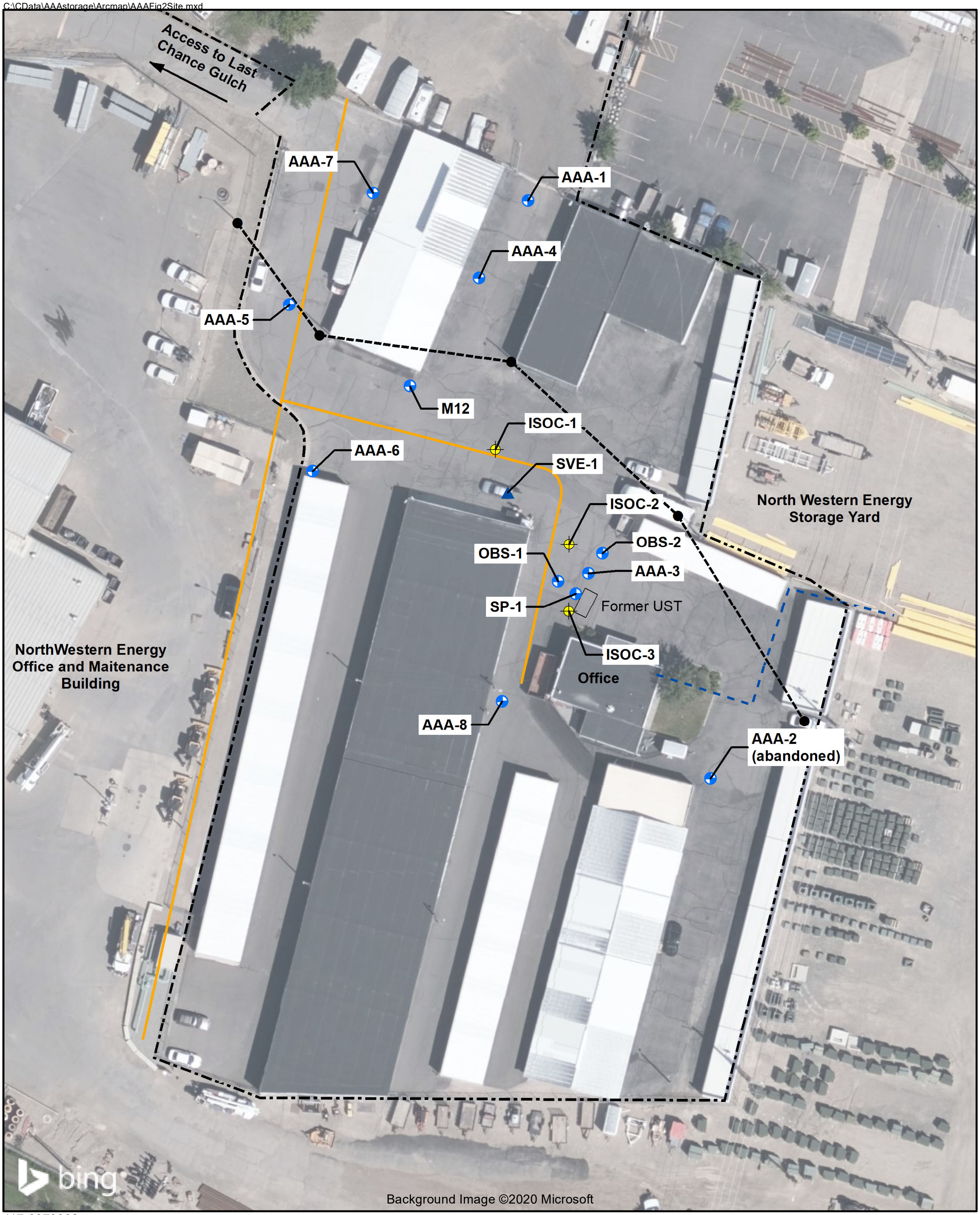
ATTACHMENT A - FIGURES

C:\CData\AAAstorage\Arcmap\AAAFig2Site.mxd



117-8070002
9/20/2021

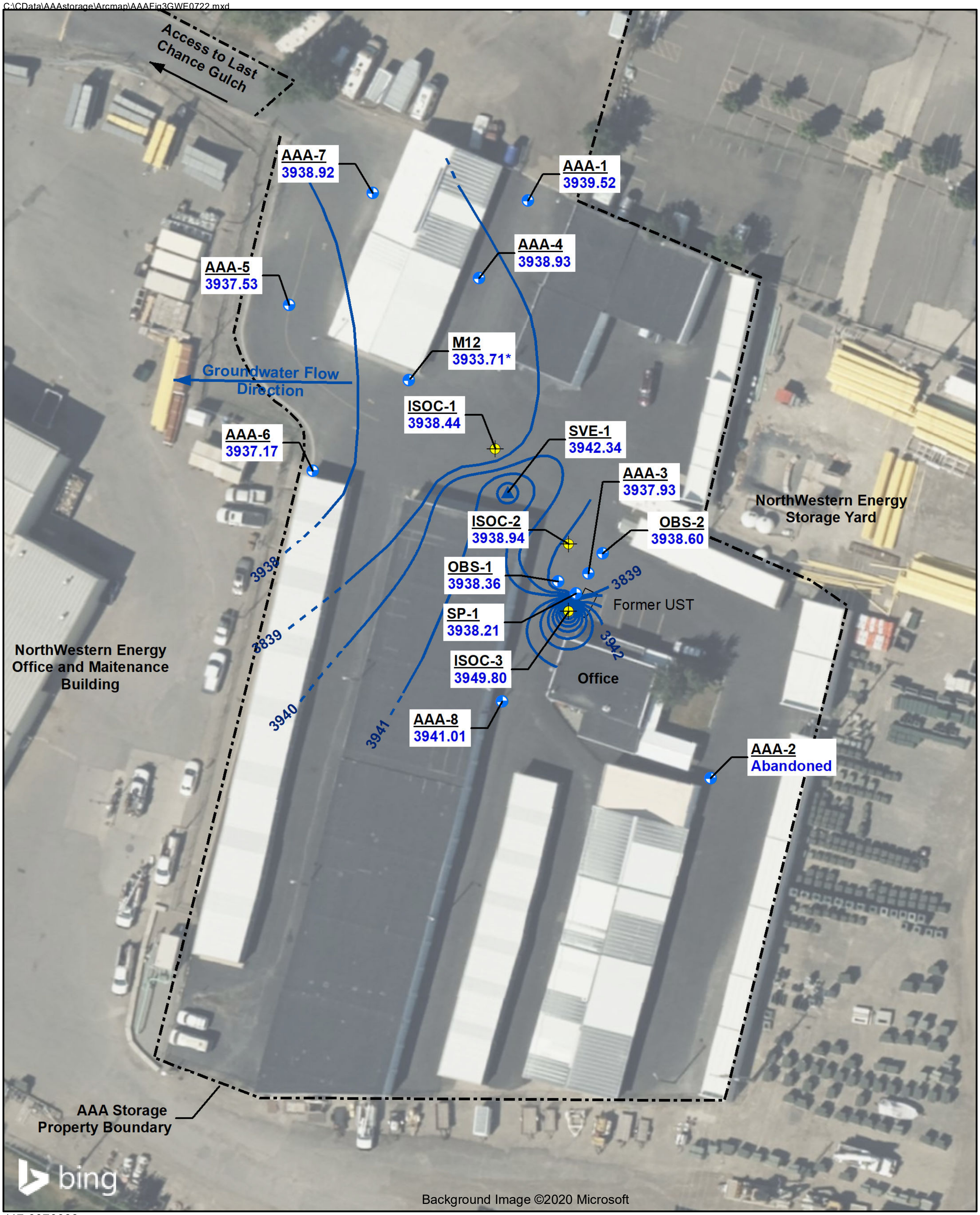
N

Feet
0 1:720 60

Blue circle	Monitoring Well	Solid orange line	Natural Gas Line
Blue triangle	Soil Vapor Extraction Well	Black dashed line	Overhead Electric Line
Yellow circle with cross	ISOC Well	Blue dashed line	Water Line
Black dot	Power/Light Pole	Black dash-dot line	AAA Storage Property Boundary/Fence

Site Map
AAA Storage
1530 Columbia Avenue
Helena, Montana
Figure 1

C:\CData\AAAstorage\Arcmap\AAAFig3GWE0722.mxd



117-8070003
4/3/2023

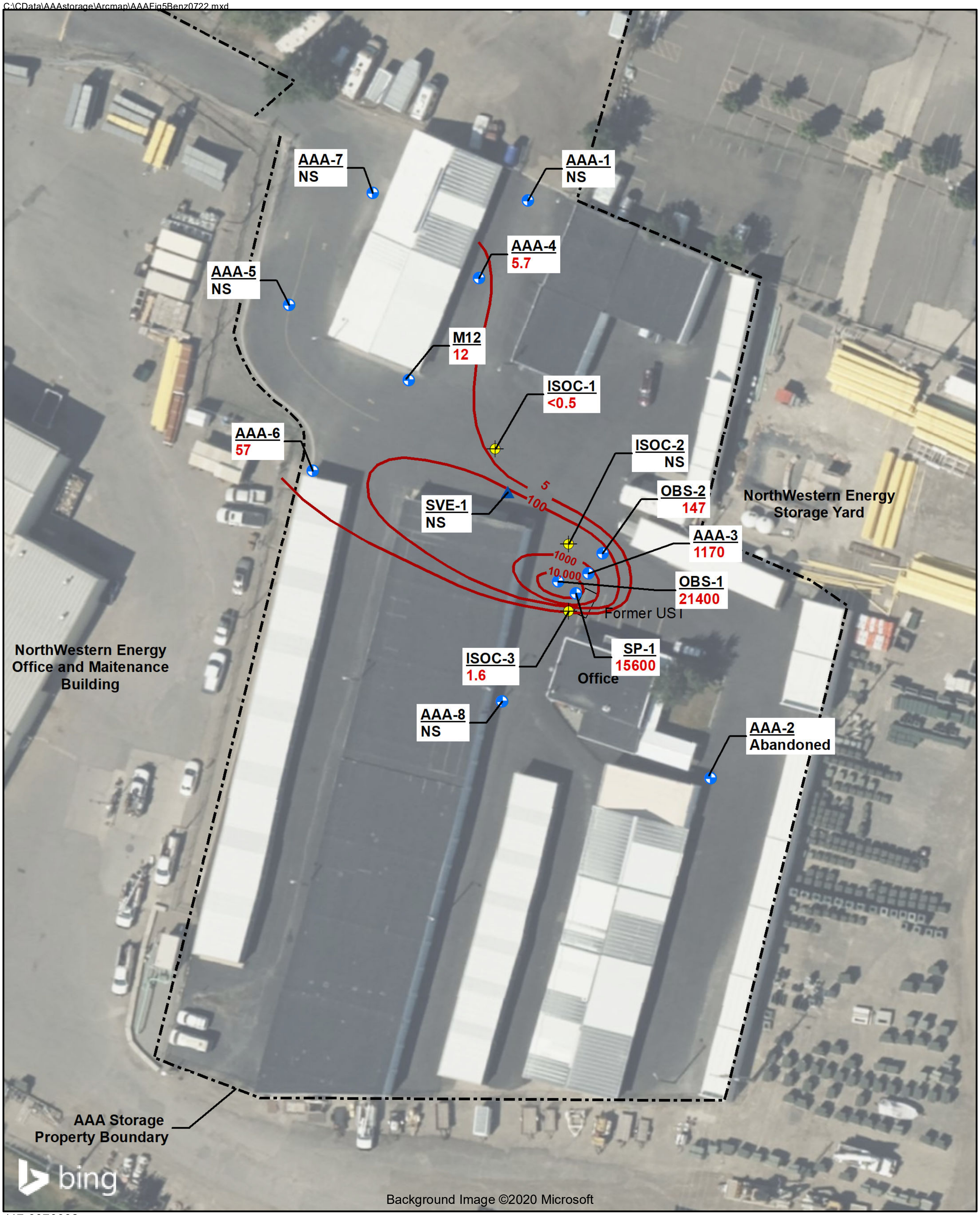
N

Feet
0 1:720 60

- Monitoring Well
- Soil Vapor Extraction Well
- ISOC Well
- Groundwater Elevation Contour (dashed where inferred)
- 3940.64 Groundwater Elevation (feet)
- * Not used in groundwater surface calculations

Potentiometric Surface Map
July 2022
AAA Storage
1530 Columbia Avenue
Helena, Montana
Figure 3

C:\CData\AAAstorage\Arcmap\AAAFig5Benz0722.mxd



117-8070002
4/3/2023

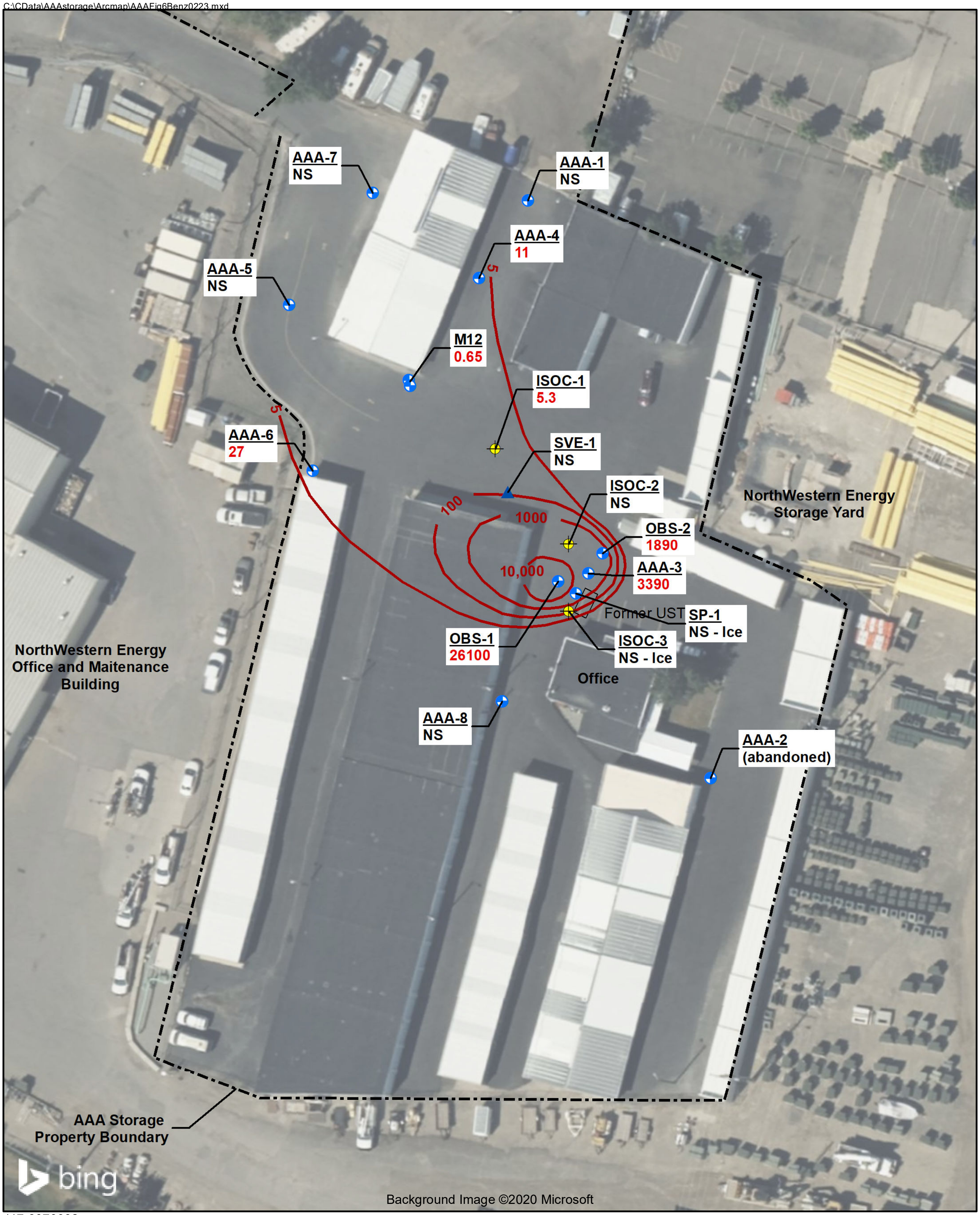
N

Feet
0 1:720 60

●	Monitoring Well
▲	Soil Vapor Extraction Well
⊕	ISOC Well
<0.5	Benzene Concentration (µg/L)
NS	Not Sampled
100 ——	Estimated Benzene Isopleth

Benzene Concentration Map
July 2022
AAA Storage
1530 Columbia Avenue
Helena, Montana
Figure 5

C:\CData\AAAstorage\Arcmap\AAAFig6Benz0223.mxd



117-8070002
4/4/2023

N

Feet
0 1:720 60

(symbol)	Monitoring Well
(symbol)	Soil Vapor Extraction Well
(symbol)	ISOC Well
<0.5	Benzene Concentration (µg/L)
NS	Not Sampled
100	Estimated Benzene Isopleth

Benzene Concentration Map
February 2023
AAA Storage
1530 Columbia Avenue
Helena, Montana
Figure 6

ATTACHMENT B – DATA SUMMARY

TABLE 2
HISTORICAL GROUNDWATER ELEVATION AND HYDROCARBON ANALYTICAL DATA

AAA Storage
1530 Columbia Avenue
Helena, Montana

Location		Sample Date	Water Level Data: Depth to Water (feet) [1]	Water Level Data: Ground-water Elevation (feet) [2]	Water Level Data: Free Product Thickness (feet)	Benzene (µg/L)	Toluene (µg/L)	Ethyl-benzene (µg/L)	Total Xylenes (µg/L)	Naph-thalene (µg/L)	MTBE (µg/L)	TPH (µg/L)	C5-C8 Aliphatics (µg/L)	C9-C12 Aliphatics (µg/L)	C9-C10 Aromatics (µg/L)	1,2-dibromo-methane	1,2-dichloro-ethane
						Laboratory Parameters — Volatile Petroleum Hydrocarbons											
DEQ Tier 1 RBSLs**						**5**	**1,000**	**700**	**10,000**	**100**	**30**	**NE**	**650**	**1,400**	**1,100**	**0.017**	**4**
AAA-1	N	09/12/00	--	--	0	< 1	< 1	< 1	5	< 2	< 1	< 500	< 240	< 100	< 60	--	--
	N	05/24/01	31.63	3933.32	0	< 1	< 1	< 1	< 3	< 2	< 2	< 500	< 240	< 100	< 60	--	--
	N	09/14/01	28.32	3936.63	0	< 1	< 1	< 1	< 3	< 2	< 2	< 300	< 150	< 150	< 20	--	--
	N	12/10/01	30.60	3934.35	0	< 1	< 1	< 1	< 3	6	< 20	< 300	< 150	< 150	< 20	--	--
	N	03/13/02	32.79	3932.16	0	< 1	< 1	< 1	4	< 2	< 2	< 300	< 150	< 150	< 20	--	--
	N	06/05/03	27.91	3937.04	0	< 0.5	< 0.5	< 0.5	4.1	< 1	< 1	38	23	19	< 20	--	--
	N	06/22/04	29.17	3935.78	0	< 1	< 1	< 1	< 3	< 5	< 2	< 200	< 100	< 100	< 20	--	--
	N	05/10/06	28.29	3936.46	0	< 0.5	< 0.5	< 0.5	< 0.5	< 1	< 1	< 20	< 20	< 20	< 20	--	--
	N	12/07/06	29.80	3934.95	0	< 0.5	< 0.5	< 0.5	< 0.5	< 1	< 1	< 20	< 20	< 20	< 20	--	--
	N	06/20/07	26.52	3938.23	0	< 0.5	< 0.5	< 0.5	< 0.5	< 1	< 1	< 20	< 20	< 20	< 20	--	--
	N	11/26/07	30.48	3934.27	0	< 0.5	< 0.5	< 0.5	< 0.5	< 1	< 1	< 20	< 20	< 20	< 20	--	--
	N	02/23/16	29.31	3935.44	0	< 0.5	< 0.5	< 0.5	< 0.5	< 1	< 1	< 20	< 20	< 20	< 20	--	--
	N	07/18/22	29.65	3939.52	--	--	--	--	--	--	--	--	--	--	--	--	--
	N	02/13/23	29.32	3939.85	--	--	--	--	--	--	--	--	--	--	--	--	--
AAA-2	N	09/12/00	--	--	0	< 1	< 1	< 1	< 3	< 2	< 1	< 500	< 240	< 100	< 60	--	--
	N	05/09/06	36.26	3934.16	0	--	--	--	--	--	--	--	--	--	--	--	--
	N	12/07/06	36.30	3934.12	0	--	--	--	--	--	--	--	--	--	--	--	--
	N	06/20/07	35.75	3934.67	0	--	--	--	--	--	--	--	--	--	--	--	--
	N	11/26/07	37.05	3933.37	0	--	--	--	--	--	--	--	--	--	--	--	--
	N	02/23/16	35.42	3935.00	0	< 0.5	< 0.5	< 0.5	< 0.5	< 1	< 1	< 20	< 20	< 20	< 20	--	--
AAA-3	N	09/12/00	--	--	0	18000	27000	2000	13000	180	< 20	93000	24000	< 5000	4500	--	--
	N	05/24/01	34.79	3934.27	0	15000	26000	2300	15000	< 2000	< 2000	126000	48000	15000	10000	--	--
	N	09/14/01	30.47	3938.59	0	17000	26000	1700	12000	370	< 50	123000	46000	< 15000	9500	--	--
	N	12/10/01	32.19	3936.87	0.13	--	--	--	--	--	--	--	--	--	--	--	--
	N	03/13/02	19.55	3949.51	0	12000	15000	2700	17000	850	< 100	167000	81000	18000	23000	--	--
	N	12/05/02	28.52	3940.54	0.12	--	--	--	--	--	--	--	--	--	--	--	--
	N	06/05/03	26.93	3942.13	0	3020	12200	1500	12200	560	< 10	73800	38100	13300	10500	--	--
	N	06/22/04	31.79	3937.27	0	3200	8900	1100	10000	600	< 20	49000	18000	< 1000	7900	--	--
	N	05/23/06	33.01	3936.05	0	7510	20300	3400	23900	1510	< 125	149000	59100	34600	33800	--	--

TABLE 2
HISTORICAL GROUNDWATER ELEVATION AND HYDROCARBON ANALYTICAL DATA
AAA Storage
1530 Columbia Avenue
Helena, Montana

Location		Sample Date	Depth to Water (feet) [1]	Ground-water Elevation (feet) [2]	Free Product Thickness (feet)	Benzene (µg/L)	Toluene (µg/L)	Ethyl-benzene (µg/L)	Total Xylenes (µg/L)	Naph-thalene (µg/L)	MTBE (µg/L)	TPH (µg/L)	C5-C8 Aliphatics (µg/L)	C9-C12 Aliphatics (µg/L)	C9-C10 Aromatics (µg/L)	1,2-dibromo-methane	1,2-dichloro-ethane
			Water Level Data			Laboratory Parameters – Volatile Petroleum Hydrocarbons											
DEQ Tier 1 RBSLs**						**5**	**1,000**	**700**	**10,000**	**100**	**30**	**NE**	**650**	**1,400**	**1,100**	**0.017**	**4**
AAA-3	N	12/07/06	32.78	3936.28	0.34	--	--	--	--	--	--	--	--	--	--	--	--
	N	06/21/07	33.44	3935.62	0.28	--	--	--	--	--	--	--	--	--	--	--	--
	N	11/26/07	33.85	3935.21	0.41	--	--	--	--	--	--	--	--	--	--	--	--
	N	02/24/16	32.51	3936.55	0.11	--	--	--	--	--	--	--	--	--	--	--	--
	N	11/07/19	23.43	3950.08	--	298	505	102	3020	151	d< 45	18800	3610	9140	6790	10	H 1.8
	N	06/05/20	26.85	3946.66	--	128	128	42	1560	60	d< 27	6920	1060	3040	2820	11	< 1.8
	N	12/10/20	28.92	3944.59	--	840	402	202	5330	221	< 58	27500	5460	9020	10600	60	< 1.8
	N	06/17/21	32.06	3941.45	--	28	28	26	439	14	d< 14	6720	2370	2360	2100	0.67	< 0.5
	N	07/19/22	35.58	3937.93	--	1170	1280	791	12200	317	d< 234	38700	8190	12600	10600	37	< 2.5
	D	07/19/22	35.58	3937.93	--	1040	1080	636	10100	253	d< 189	34200	7910	11700	8860	38	< 2.5
	N	02/13/23	32.49	3941.02	--	3390	4060	955	11700	342	d< 254	51600	15700	14600	10300	146	< 12
AAA-4	N	05/10/06	30.15	3935.93	0	274	103	74	5800	190	< 50	18100	7110	6300	3250	--	--
	N	12/07/06	31.18	3934.90	0	100	343	257	10000	351	< 50	29500	10200	8190	5940	--	--
	N	06/21/07	28.43	3937.65	0	260	117	40	8960	297	< 50	21000	6970	4720	3160	--	--
	N	11/26/07	32.00	3934.08	0	72	108	51	4270	300	< 26	19900	9150	5760	3540	--	--
	N	02/24/16	30.70	3935.38	0	6.3	3.5	< 2.5	594	170	< 5	9900	4600	4890	3830	--	--
	N	03/14/18	30.02	3936.06	--	7	3.7	0.83	101	118	d< 25	5630	3310	953	1520	--	--
	N	11/05/19	23.11	3947.39	--	< 0.5	< 0.5	< 0.5	< 0.5	< 1	< 1	< 20	< 20	< 20	< 20	< 0.01	< 0.5
	N	06/04/20	27.83	3942.67	--	1.1	1.8	< 0.5	7.2	16	d< 5	780	304	81	414	< 0.01	< 0.5
	N	12/09/20	28.12	3942.38	--	J 0.48	0.84	< 0.5	5.2	4.2	1.1	437	168	95	218	< 0.01	<H 0.5
	N	06/15/21	28.30	3942.20	--	3.9	3.7	< 0.5	26	14	d< 10	1970	1070	233	740	< 0.01	< 0.5
	N	07/18/22	31.57	3938.93	--	5.7	3.1	< 0.5	27	3.7	d< 5	1470	598	389	662	< 0.01	< 0.5
	N	02/13/23	30.71	3939.79	--	11	3	J 0.3	8.2	3.7	d< 4	1110	618	277	392	< 0.01	< 0.5
	D	02/13/23	30.71	3939.79	--	9.7	2.6	< 0.5	6.8	3.1	d< 5	1010	569	248	362	< 0.01	< 0.5
AAA-5	N	05/10/06	32.85	3934.37	0	38	7360	297	10400	393	< 50	41800	19400	8740	4420	--	--
	N	12/07/06	33.21	3934.01	0	< 25	1420	192	7300	221	< 50	24600	9920	6180	3770	--	--
	N	06/21/07	31.35	3935.87	0	15	5670	1040	8270	276	< 27	31700	11900	4370	4610	--	--
	N	02/23/16	32.48	3934.74	0	0.66	0.59	< 0.5	1.7	3.6	< 1	301	182	68	67	--	--
	N	05/09/18	26.59	3940.63	--	< 0.5	< 0.05	< 0.05	< 0.05	< 1	< 1	< 20	< 20	< 20	< 20	--	--

TABLE 2

HISTORICAL GROUNDWATER ELEVATION AND HYDROCARBON ANALYTICAL DATA

AAA Storage
1530 Columbia Avenue
Helena, Montana

Location		Sample Date	Water Level Data: Depth to Water (feet) [1]	Water Level Data: Ground-water Elevation (feet) [2]	Water Level Data: Free Product Thickness (feet)	Benzene (µg/L)	Toluene (µg/L)	Ethyl-benzene (µg/L)	Total Xylenes (µg/L)	Naph-thalene (µg/L)	MTBE (µg/L)	TPH (µg/L)	C5-C8 Aliphatics (µg/L)	C9-C12 Aliphatics (µg/L)	C9-C10 Aromatics (µg/L)	1,2-dibromo-methane	1,2-dichloro-ethane
						Laboratory Parameters — Volatile Petroleum Hydrocarbons											
DEQ Tier 1 RBSLs**						**5**	**1,000**	**700**	**10,000**	**100**	**30**	**NE**	**650**	**1,400**	**1,100**	**0.017**	**4**
AAA-5	N	11/04/19	26.14	3945.48	--	< 0.5	< 0.5	< 0.5	< 0.5	< 1	< 1	< 20	< 20	< 20	< 20	< 0.01	< 0.5
	N	06/03/20	29.97	3941.65	--	< 0.5	< 0.5	< 0.5	< 0.5	< 1	< 1	< 20	< 20	< 20	< 20	< 0.01	< 0.5
	N	12/08/20	29.80	3941.82	--	< 0.5	< 0.5	< 0.5	< 0.5	< 1	< 1	< 20	< 20	< 20	< 20	< 0.01	< 0.5
	N	06/15/21	30.54	3941.08	--	< 0.5	J 0.31	< 0.5	0.95	2.3	d< 1.5	124	87	J 5.9	22	< 0.01	< 0.5
	N	07/19/22	34.09	3937.53	--	--	--	--	--	--	--	--	--	--	--	--	--
	N	02/14/23	32.57	3939.05	--	--	--	--	--	--	--	--	--	--	--	--	--
AAA-6	N	05/09/06	36.81	3934.00	0	219	1310	619	6790	269	< 25	24800	9860	4400	5240	--	--
	N	12/07/06	36.35	3934.46	0	56	1320	1410	7370	212	< 40	35400	15000	10900	6040	--	--
	N	06/21/07	35.61	3935.20	0	200	1520	1320	7530	326	< 35	29300	11700	5060	6440	--	--
	N	11/26/07	37.42	3933.39	0	171	594	1240	6710	326	< 20	28900	12100	7290	5120	--	--
	N	02/24/16	35.83	3934.98	0	J 9.4	252	98	5200	239	20	19300	6390	11600	4680	--	--
	N	05/09/18	30.93	3939.88	--	< 0.5	< 0.05	< 0.05	< 0.05	< 1	< 1	< 20	< 20	< 20	< 20	--	--
	N	11/04/19	29.04	3946.18	--	< 0.5	< 0.5	< 0.5	< 0.5	< 1	< 1	< 20	< 20	< 20	< 20	< 0.01	< 0.5
	N	06/03/20	33.90	3941.32	--	20	11	d< 2.5	1600	201	d< 20	5850	1700	2140	1520	0.019	< 0.5
	N	12/09/20	33.18	3942.04	--	1.3	1.4	J 0.23	191	10	< 1	520	119	151	135	< 0.01	< 0.5
	N	06/15/21	34.65	3940.57	--	7	15	3.3	2810	223	d< 21	8370	2420	1500	2640	d< 0.08	< 0.5
	N	07/20/22	38.05	3937.17	--	57	15	< 5	2640	330	d< 35	15000	5380	4020	5300	d< 0.2	< 0.5
	N	02/14/23	36.23	3938.99	--	27	8.9	22	1520	214	d< 16	9860	2770	2810	2950	< 0.01	< 1.2
AAA-7	N	06/21/07	28.47	3937.88	0	< 0.5	< 0.5	< 0.5	< 0.5	< 1	< 1	< 20	< 20	< 20	< 20	--	--
	N	11/26/07	32.69	3933.66	0	< 0.5	< 0.5	< 0.5	< 0.5	< 1	< 1	< 20	< 20	< 20	< 20	--	--
	N	02/23/16	31.31	3935.04	0	< 0.5	< 0.5	< 0.5	< 0.5	< 1	< 1	< 20	< 20	< 20	< 20	--	--
	N	07/20/22	31.84	3938.92	--	--	--	--	--	--	--	--	--	--	--	--	--
	N	02/14/23	31.84	3938.92	--	--	--	--	--	--	--	--	--	--	--	--	--
AAA-8	N	11/05/19	29.05	3946.80	--	< 0.5	< 0.5	< 0.5	< 0.5	< 1	< 1	J 7.4	< 20	< 20	< 20	< 0.01	< 0.5
	N	06/04/20	33.85	3942.00	--	< 0.5	< 0.5	< 0.5	< 0.5	< 1	J 0.58	< 20	< 20	< 20	< 20	--	--
	N	12/09/20	33.80	3942.05	--	< 0.5	< 0.5	< 0.5	< 0.5	< 1	< 1	< 20	< 20	< 20	< 20	< 0.01	< 0.5
	N	06/15/21	Dry	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	N	07/20/22	34.84	3941.01	--	--	--	--	--	--	--	--	--	--	--	--	--
	N	02/13/23	34.54	3941.31	--	--	--	--	--	--	--	--	--	--	--	--	--

TABLE 2

HISTORICAL GROUNDWATER ELEVATION AND HYDROCARBON ANALYTICAL DATA

AAA Storage
1530 Columbia Avenue
Helena, Montana

Location		Sample Date	Water Level Data: Depth to Water (feet) [1]	Water Level Data: Ground-water Elevation (feet) [2]	Water Level Data: Free Product Thickness (feet)	Benzene (µg/L)	Toluene (µg/L)	Ethyl-benzene (µg/L)	Total Xylenes (µg/L)	Naph-thalene (µg/L)	MTBE (µg/L)	TPH (µg/L)	C5-C8 Aliphatics (µg/L)	C9-C12 Aliphatics (µg/L)	C9-C10 Aromatics (µg/L)	1,2-dibromo-methane	1,2-dichloro-ethane
						Laboratory Parameters – Volatile Petroleum Hydrocarbons											
DEQ Tier 1 RBSLs**						**5**	**1,000**	**700**	**10,000**	**100**	**30**	**NE**	**650**	**1,400**	**1,100**	**0.017**	**4**
ISOC-1	N	07/20/22	33.80	3938.44	--	< 0.5	J 0.41	< 0.5	0.77	< 1	< 1	J 9.9	< 20	< 20	< 20	< 0.01	< 0.5
	N	02/15/23	31.73	3940.51	--	5.3	8.2	0.91	6.4	< 1	< 1	45	J 19	J 12	< 20	0.34	< 0.5
ISOC-2	N	07/19/22	34.49	3938.94	--	--	--	--	--	--	--	--	--	--	--	--	--
	N	02/13/23	32.40	3941.03	--	--	--	--	--	--	--	--	--	--	--	--	--
ISOC-3	N	07/19/22	24.44	3949.80	--	1.6	5.5	0.87	7.9	J 0.38	< 1	39	J 5.5	23	< 20	0.12	< 0.5
	N	02/15/23	Ice	--	--	--	--	--	--	--	--	--	--	--	--	--	--
OBS-1	N	05/09/06	34.11	3935.25	0	25800	34100	2470	14800	598	< 400	156000	80900	10400	8580	--	--
	N	05/23/06	33.33	3936.03	0	16000	25000	3210	20600	1510	< 200	170000	86400	26800	27200	--	--
	N	02/24/16	33.45	3935.91	0.17	--	--	--	--	--	--	--	--	--	--	--	--
	N	03/14/18	32.65	3936.71	--	26200	36400	2620	17100	d< 2000	d< 30	147000	55300	J 18500	< 40000	--	--
	N	11/06/19	26.41	3947.39	--	19600	33000	2370	18200	377	d< 424	120000	25900	13700	10400	1280	H 1480
	N	06/04/20	30.28	3943.52	--	22100	30700	1980	13800	436	d< 839	119000	29200	16800	6460	1230	3750
	N	12/10/20	30.17	3943.63	--	22700	34500	2960	22000	796	< 644	161000	51200	25400	20000	1200	< 50
	N	06/17/21	31.92	3941.88	--	25100	34600	2680	18000	468	d< 640	133000	35000	9530	9750	1150	3970
	N	07/19/22	35.44	3938.36	--	21400	28100	2080	13800	374	d< 912	131000	43200	18500	J 7310	1160	4770
	N	02/13/23	33.19	3940.61	--	26100	35900	2700	18500	541	d< 420	154000	59200	25000	11200	1360	4380
OBS-2	N	05/09/06	33.20	3935.54	0	15100	16400	421	10800	370	< 200	79000	36800	5550	4520	--	--
	N	05/23/06	32.54	3936.20	0	11600	15900	1190	11500	741	< 150	66400	24300	6350	9040	--	--
	N	02/24/16	32.09	3936.65	0	2910	745	302	1440	106	< 30	21400	9450	5500	2720	--	--
	N	05/09/18	24.41	3944.33	--	3.7	4.3	0.52	4.7	< 1	< 1	52	J 11	J 19	J 13	--	--
	N	11/06/19	21.75	3951.54	--	J 0.28	1.7	2.3	21	J 0.91	< 1	88	J 20	J 18	32	< 0.01	< 0.5
	N	06/05/20	22.98	3950.31	--	< 0.5	< 0.5	< 0.5	< 0.5	< 1	< 1	< 20	< 20	< 20	< 20	< 0.01	< 0.5
	N	12/10/20	28.43	3944.86	--	10	5.4	J 0.3	15	J 0.82	< 2	217	117	29	49	0.13	< 0.5
	N	06/17/21	29.12	3944.17	--	< 0.5	< 0.5	< 0.5	< 0.5	< 1	< 1	< 20	< 20	< 20	< 20	< 0.01	< 0.5
	N	07/19/22	34.69	3938.60	--	147	42	1.9	45	4.4	< 1	1550	797	205	279	3.9	< 0.5
	N	02/13/23	32.17	3941.12	--	1890	150	28	192	23	d< 169	8260	3490	550	538	17	< 0.5
SP-1	N	05/09/06	34.51	3935.14	0	16600	18900	1680	10100	327	< 200	90700	45500	5800	4530	--	--
	N	02/24/16	33.81	3935.84	0	22900	27900	2470	12800	310	< 200	134000	73600	28200	8750	--	--
	N	11/07/19	27.60	3946.56	--	625	646	22	328	7	d< 31	3300	1060	457	158	16	121

TABLE 2

HISTORICAL GROUNDWATER ELEVATION AND HYDROCARBON ANALYTICAL DATA

AAA Storage
1530 Columbia Avenue
Helena, Montana

Location		Sample Date	Water Level Data: Depth to Water (feet) [1]	Water Level Data: Ground-water Elevation (feet) [2]	Water Level Data: Free Product Thickness (feet)	Benzene (µg/L)	Toluene (µg/L)	Ethyl-benzene (µg/L)	Total Xylenes (µg/L)	Naph-thalene (µg/L)	MTBE (µg/L)	TPH (µg/L)	C5-C8 Aliphatics (µg/L)	C9-C12 Aliphatics (µg/L)	C9-C10 Aromatics (µg/L)	1,2-dibromo-methane	1,2-dichloro-ethane
						Laboratory Parameters – Volatile Petroleum Hydrocarbons											
DEQ Tier 1 RBSLs**						**5**	**1,000**	**700**	**10,000**	**100**	**30**	**NE**	**650**	**1,400**	**1,100**	**0.017**	**4**
SP-1	N	06/04/20	32.12	3942.04	--	549	559	17	227	J 4.4	d< 27	2510	753	226	116	16	148
	N	12/10/20	31.45	3942.71	--	J 0.25	< 0.5	< 0.5	< 0.5	< 1	< 1	< 20	< 20	< 20	< 20	0.89	3.6
	N	06/17/21	32.98	3941.18	--	188	201	17	94	2.3	d< 9	861	235	58	62	5.9	38
	N	07/18/22	35.95	3938.21	--	15600	17500	1840	8310	153	d< 908	78100	24600	8900	5780	303	3150
	N	02/13/23	Ice	--	--	--	--	--	--	--	--	--	--	--	--	--	--
M10	N	09/02/98	39.16	3937.59	<0.1	--	--	--	--	--	--	--	--	--	--	--	--
	N	03/29/99	43.15	3933.13	0.17	--	--	--	--	--	--	--	--	--	--	--	--
	N	03/23/00	44.10	3932.18	0.32	--	--	--	--	--	--	--	--	--	--	--	--
	N	06/14/00	43.48	3932.80	0.28	--	--	--	--	--	--	--	--	--	--	--	--
	N	10/05/00	43.92	---3932.36	0.28	--	--	--	--	--	--	--	--	--	--	--	--
	N	01/03/01	44.05	3932.23	0.15	--	--	--	--	--	--	--	--	--	--	--	--
	N	03/15/01	44.80	3931.48	0.23	--	--	--	--	--	--	--	--	--	--	--	--
M12	N	03/29/99	34.26	3933.42	0	8310	14900	551	10900	--	< 1000	49000	--	--	--	--	--
	N	07/08/99	31.60	3936.08	0	3760	18350	1120	14270	--	< 10	53000	--	--	--	--	--
	N	12/21/99	34.06	3933.62	0	10450	30920	2150	7362	< 1	4120	150510	82900	8010	4800	--	--
	N	03/23/00	35.34	3932.34	0	--	--	--	--	--	--	--	--	--	--	--	--
	N	06/14/00	35.77	3931.91	0	--	--	--	--	--	--	--	--	--	--	--	--
	N	08/25/00	--	--	0	--	--	--	--	--	--	--	--	--	--	--	--
	N	09/12/00	--	--	0	9000	19000	1200	10000	< 1700	< 330	129000	76000	8500	5200	--	--
	N	09/25/00	35.49	3932.19	0	--	--	--	--	--	--	--	--	--	--	--	--
	N	10/05/00	35.69	3931.99	0	--	--	--	--	--	--	--	--	--	--	--	--
	N	01/03/01	35.48	3932.20	0	--	--	--	--	--	--	--	--	--	--	--	--
	N	03/15/01	36.42	3931.26	0	--	--	--	--	--	--	--	--	--	--	--	--
	N	05/24/01	34.33	3933.35	0	5800	11000	1300	8600	< 2000	< 2000	101000	48000	23000	12000	--	--
	N	06/13/01	33.64	3934.04	0	--	--	--	--	--	--	--	--	--	--	--	--
	N	09/14/01	31.56	3936.12	0	3300	10000	420	9900	400	< 50	56000	13000	< 15000	12000	--	--
	N	09/28/01	31.58	3936.10	0	--	--	--	--	--	--	--	--	--	--	--	--
	N	12/10/01	33.13	3934.55	0	6080	15000	1300	14000	610	< 100	79000	31000	< 3000	10000	--	--
	N	03/13/02	35.24	3932.44	0	5200	7500	940	8100	400	< 10	54000	21000	< 7500	7700	--	--

TABLE 2
HISTORICAL GROUNDWATER ELEVATION AND HYDROCARBON ANALYTICAL DATA
AAA Storage
1530 Columbia Avenue
Helena, Montana

Location		Sample Date	Water Level Data			Laboratory Parameters											
						Volatile Petroleum Hydrocarbons											
			Depth to Water (feet) [1]	Ground-water Elevation (feet) [2]	Free Product Thickness (feet)	Benzene (µg/L)	Toluene (µg/L)	Ethyl-benzene (µg/L)	Total Xylenes (µg/L)	Naph-thalene (µg/L)	MTBE (µg/L)	TPH (µg/L)	C5-C8 Aliphatics (µg/L)	C9-C12 Aliphatics (µg/L)	C9-C10 Aromatics (µg/L)	1,2-dibromo-methane	1,2-dichloro-ethane
DEQ Tier 1 RBSLs**						**5**	**1,000**	**700**	**10,000**	**100**	**30**	**NE**	**650**	**1,400**	**1,100**	**0.017**	**4**
M12	N	08/09/02	28.41	3939.27	0	--	--	--	--	--	--	--	--	--	--	--	--
	N	12/05/02	31.08	3936.60	0	--	--	--	--	--	--	--	--	--	--	--	--
	N	01/21/03	32.27	3935.41	0	--	--	--	--	--	--	--	--	--	--	--	--
	N	03/20/03	33.27	3934.41	0	--	--	--	--	--	--	--	--	--	--	--	--
	N	06/05/03	30.65	3937.03	0	2940	12900	1450	12200	412	< 10	57300	24200	8270	8620	--	--
	N	06/22/04	32.17	3935.51	0	4600	12000	1700	11000	490	< 25	56000	21000	< 5000	10000	--	--
	N	05/09/06	32.67	3935.01	0	4270	8900	1740	8630	442	< 100	52500	25600	3910	5720	--	--
	N	12/07/06	32.79	3934.89	0	1730	3010	1400	8170	343	< 100	44700	22700	6590	6280	--	--
	N	05/24/07	34.94	3932.74	--	--	--	--	--	--	--	--	--	--	--	--	--
	N	06/21/07	30.91	3936.77	0	261	9840	1960	10100	397	< 100	44800	15700	2830	5980	--	--
	N	11/26/07	33.84	3933.84	0	942	1250	1390	4790	344	< 40	34700	20800	4630	4290	--	--
	N	11/05/19	24.89	3942.79	--	< 0.5	< 0.5	< 0.5	J 0.5	< 1	< 1	J 9.3	< 20	J 7.7	< 20	< 0.01	< 0.5
	N	06/04/20	29.99	3937.69	--	1.7	2.3	35	467	88	d< 2	1680	219	800	672	d< 0.02	< 0.5
	N	12/09/20	29.53	3938.15	--	0.86	2.9	25	268	38	< 1	1110	173	335	474	< 0.03	< 0.5
	N	06/15/21	30.30	3937.38	--	6.4	3.5	34	411	46	d< 2	1400	308	249	586	< 0.01	< 0.5
	N	07/18/22	33.97	3933.71	--	12	4.2	20	482	61	< 5	2370	779	631	788	< 0.01	< 0.5
	N	02/15/23	32.99	3934.69	--	0.65	1.6	4.4	61	5.4	< 1	226	80	67	56	< 0.01	< 0.5
SVE-1	N	02/13/23	30.97	3942.31	--	--	--	--	--	--	--	--	--	--	--	--	--

Notes:

- -- - Field data or laboratory sample not collected/analyzed
- 1 - Depth to water is measured in feet below monitoring well measuring point
- 2 - Measuring point elevation and groundwater elevation are relative to North American Vertical Datum (NAVD) 1988
- µg/L - micrograms per liter
- D - Duplicate sample
- N - Natural sample
- NE - Not established
- MTBE - Methyl tertiary butyl ether
- TPH - Total purgeable hydrocarbons
- < - Not detected above laboratory Practical Quantitation Limit (PQL)
- J - Estimated value. The analyte was present but less than the reporting limit.
- d - RL increased due to sample matrix
- ** - DEQ Tier 1 Risk Based Screening Levels (RBSLs) and Human Health Standards (HHSs), May 2018
- Ice - Well not sampled due to ice
- [shaded box] - Shading indicates results above Montana's RBSL.

ATTACHMENT C – COST PROPOSAL

ATTACHMENT D – STANDARD OPERATING PROCEDURES

SOP-16

STANDARD OPERATING PROCEDURE

QUALITY CONTROL (QC) SAMPLES

Quality Control (QC) samples are submitted along with natural samples to provide supporting laboratory data to validate laboratory results. QC samples typically are submitted blind, and do not have any unique identifying codes that would enable the lab or others to bias these samples in any way. Usually, the time or sampling location is modified in a way which will separate blank and standard samples from the rest of the sample train. QC samples are identified only on field forms and in field notebooks. The following codes are typically used:

N - Natural Sample	Soil, water, air, or other material from a field site
SP - Split Sample	A portion of a natural sample collected for independent analysis; used in calculating laboratory precision
D - Duplicate Sample	Two samples taken from the same media under similar conditions; also used to calculate laboratory precision
BB - Bottle Blank	Distilled water collected in sample bottle; used to detect contamination in sample containers
CCB - Cross Contamination Blank	Distilled water run through decontaminated equipment and analyzed for residual contamination, also known as a Rinsate blank
BFS - Blind Field Standard	Certified chemical constituent(s) of known concentration; used to determine laboratory accuracy
TB - Travel or Trip Blank	Inert material (deionized water or diatomaceous earth) included in sample cooler; sent by the lab, the sample is used to determine if contamination by volatiles is present during collection or shipping

In general, selected QC samples will be inserted into the sample train within a group of 10 to 20 samples. Unless otherwise specified, QC samples will be prepared in the field. Distilled water for bottle blanks and cross-contamination blanks will be collected from carboys and cubitainers used in the field. An exception to field preparation of QC samples is some blind field standards. Since the analytes in some blind field standards are to be mixed according to specific manufacturer's instructions, field conditions may not provide the needed laboratory atmosphere. This is especially true for volatile organic compounds, which need to be prepared just before analyzing. Under these circumstances, such blind field standards will be shipped to the laboratory for preparation, keeping the concentration or manufacturer's QC Lot Number as blind as possible.

The number and types of samples submitted for each group of natural samples will be determined by the project manager and others, including state or Federal agencies, and will be defined in the project work plan. Each field crew leader will be responsible for all QC samples prepared in the field.

Methods for computing data validation statements can be found in EPA documents or obtained from the laboratory.

SOP-17

STANDARD OPERATING PROCEDURE

FIELD FORMS / FIELD NOTES

All pertinent field investigations and sampling information shall be recorded on a field form or in a hard bound field book during each day of the field effort and at each sample site. The field crew leader shall be responsible for ensuring that sufficient detail is recorded on the field forms. No general rules can specify the extent of information that must be entered on the field form. However, field forms shall contain sufficient information so that someone can reconstruct all field activities without relying on the memory of the field crew. All entries shall be made in indelible ink, weather conditions permitting. Each day's or site's entries will be initialed and dated by the author. At the end of each day, field notes will be finalized, with field personnel’s signature and date at the bottom of the page. Field forms, field notes, and photographs will be scanned into the project directory on the project server as soon as possible upon return to the office.

At a minimum, entries on the field sheet or in field notebook shall include:

- Project name and type/project number
- Purpose/objective of site visit
- Date and time of starting work and weather conditions
- Names of field crew leader and team members
- Subcontractors present or other visitors
- Health and safety tailgate topics
- Location of sample site, including map reference, if relevant
- Description of site conditions and any unusual circumstances
- Equipment ID numbers or serial numbers, including equipment calibration information (standards used, verification reading values, drift check values, or reference to location of calibration information. Date/time of calibration shall be recorded in the field book or designated field form)
- Details of actual work effort, particularly any deviations from the field work plan or standard operating procedures
- Chronologic description of observations and events
- Persons contacted and topics discussed
- Field observations
- Any field measurements made (e.g., pH) with time entry of measurement and units of measurement, or reference in field book to standardized field form

For sampling efforts, specific details for each sample should be recorded using Tetra Tech standardized field forms. Surface water and groundwater field forms contain fill-in-the-blank type information in order that all pertinent information shall be recorded. In addition to the items listed above, the following information is recorded on field forms during sampling efforts:

- Time and date samples were collected
- Number and type (natural, duplicate, QA/QC) of samples collected
- Analysis requested
- Sampling method, particularly deviations from standard operating procedures
- Observations of sampling point conditions

Strict custody procedures shall be maintained with the field forms. Field forms shall remain with the field team at all times, while being used in the field. Upon completion of the field effort, photocopies of the original field forms will be made and used as working documents; original field forms shall be filed in an appropriately secure manner.

Photographs

Photographs should be taken using a camera lens similar to the naked eye. Wide angle and telephoto photos are not legal representation. Some clients do not permit these on site photographs. Confirm with project manager or site representative whether photographs are allowed. Reference each photograph in the field book or field form noting the direction and object of view. Photographs are to be uploaded to the project directory after the work is completed.

Corrections

In the event an error is made on the field form or in the field notebook, corrections will be made by drawing a single line through the error then enter the correct information. All corrections will be initialed and dated.

SOP-18

STANDARD OPERATING PROCEDURE

SAMPLE DOCUMENTATION

Sample documentation is an important step to ensure the laboratory, project manager, and field personnel are informed on the status of field samples. Depending on the specifics required for each project, a number of forms will need to be filled out. Some sample documentation forms are preprinted carbonless triplicates, enabling copies to be filed or mailed from labs or offices. The forms will be completed by field personnel, who have custody of the samples. The office copy will be kept in the project file and subsequent copies sent to the laboratory, or other designated parties. The responsibility for the completion of these forms will be with each field crew leader. It is important the field crew leader is certain field personnel are familiar with the completion process for filling out forms, and the expected information is included.

Potential documents to be completed clearly using indelible ink for each sample generated include:

- Sample Labels

  Sample identification are required on all sample containers. Labels should contain the following:
  - Sample identification
  - Date and time of sample collection
  - Analysis to be performed
  - Preservative
  - Project name
  - Sampler's initials

  Note: when sampling for volatile organic compounds, tape should not be used to cover any label due to potential for volatile organics in the tape adhesive to contaminate the sample. Care should also be taken to use Sharpie pens in well ventilated areas due to possible toluene contamination of the sample.

- Field Form

  Complete appropriate forms to document information associated with sample or sample site conditions. All form blanks are to be completed.

- Chain-of-Custody (COC)

  The intent of COC is to apply traceability of sample from the time it is collected until its derived information is used. COC information includes the following:
  - Sample identification
  - Sample matrix
  - Number of containers
  - Sample date and time
  - Preservation
  - Project name
  - Samplers name
  - Date, time, and person responsible for sample integrity
  - Contact information of project manager or person responsible for sample results

- Custody Seal, signed and dated by the person relinquishing custody

If working on Superfund activities, the following additional forms will also be prepared:

- EPA Sample Tags
- SAS Packing Lists
- Sample Identification Matrix Forms
- Organic Traffic Report (if applicable)
- Inorganic Traffic Report (if applicable)

STANDARD OPERATING PROCEDURE

EQUIPMENT DECONTAMINATION

The purpose of this SOP is to describe general decontamination procedures for field equipment in contact with mine/mill tailings, soil, or water. During field sampling activities, sampling equipment has potential to become contaminated through use. Sampling equipment must be decontaminated between sample collection points if it is not disposable. Field personnel must wear disposable nitrile or vinyl gloves and eye protection while decontaminating equipment at the project site. Change gloves between every sample. Every precaution must be taken by personnel to prevent contaminating themselves with the wash water and rinse water used in the decontamination process.

Table A-1 lists equipment and liquids necessary to decontaminate field equipment.

TABLE A-1. EQUIPMENT LIST FOR DECONTAMINATION

5-gallon plastic tubs	Liquinox (soap)
5-gallon plastic water-container	Hard bristle brushes
5-gallon carboy DI water	Garbage bags
1-gallon cube of 10% HNO_3	Latex or nitrile gloves
1-gallon container or spray bottle of 10% Methanol for organics	Spray or squeeze bottles
	Paper Towels

Distilled water may be purified through a distilling process or a reverse osmosis (RO) process. The RO process is preferred if sampling for metal contaminates.

The following should be done in order to complete thorough decontamination:

1. Set up the decontamination zone upwind from the sampling area to reduce the chances of windborne contamination.

2. Visually inspect sampling equipment for contamination; use stiff brush to remove visible material.

3. The general decontamination sequence for field equipment includes: wash exterior of non-dedicated equipment with Liquinox or an equivalent non-phosphate degreasing detergent; follow with a distilled water rinse; follow with 10% dilute nitric acid rinse (if sampling for metals) or 10% methanol solution (if sampling for organics); follow with a distilled water rinse.

4. Wash interior of sample equipment with the same sequence as above. For pumps, pump decontamination solutions through the device and purge decontamination solutions with the next sample water prior to collecting the next sample.

Alternatively, field equipment can be decontaminated by steam cleaning, rinsing with 10% dilute nitric acid (if sampling for metals) or 10% dilute methanol (if sampling for organics), and rinsing with distilled water.

All disposable items (e.g., paper towels, latex gloves) should be deposited into a garbage bag and disposed of in a proper manner. Contaminated wash water does not have to be collected, under most circumstances.

If vehicles used during sampling become contaminated, wash both inside and outside as necessary.

SOP-23

STANDARD OPERATING PROCEDURE

FIELD MEASUREMENT OF GROUND WATER LEVEL

1. Check well probe prior to leaving for field for defects by placing probe in water and testing buzzer and light. Repair as necessary.

2. Measure all wells (monitoring and domestic) from the top of the well casing in the north quadrant or from a designated measuring point, as appropriate. Measure and record distance from measuring point to ground level. Make sure measuring point is labeled on well, so future measurements can be made from the same location.

3. Obtain a depth to water from measuring point to the nearest hundredth of a foot by lowering the probe until the buzzer or light activates. Record data on appropriate field forms.

   To avoid potential for introducing foreign constituents or entanglement with existing pump wiring on domestic wells, a sonic water level probe can be used following individual equipment instructions.

4. Decontaminate well probe between each measurement by rinsing with deionized water. (Note, sonic well probe does not need decontamination,) Additional decontamination, such as liquinox scrubbing, may be required for certain wells; consult the project work plan.

5. Measure all assigned project wells within a 24-hour period. Measure all assigned project wells prior to well purging/sampling activities are initiated.

STANDARD OPERATING PROCEDURE

DETERMINATION OF LIQUID HYDROCARBON THICKNESS IN WATER TABLE AQUIFER USING MONITORING WELL GAGING MEASUREMENTS

This procedure is used for estimating the actual thickness of a liquid hydrocarbon layer in a near-surface aquifer, using apparent liquid hydrocarbon thicknesses measured in a monitoring well under static conditions. The well must be screened throughout the entire interval from the uppermost liquid hydrocarbon level to a depth at which the liquid hydrocarbon level could potentially fall when the liquid hydrocarbon layer is bailed from the well, allowing for depression of the water level as some groundwater is inadvertently bailed from the well with the liquid hydrocarbon layer.

EQUIPMENT REQUIRED

1. A bailer with a diameter slightly smaller than the well to be tested, plus bailer cord.

2. A stopwatch.

3. A well gauging probe which can detect both water and liquid hydrocarbons, and which is accurate to at least 0.01 feet.*

4. A 5 gallon bucket, funnel and a D.O.T. approved 55 gallon drum.

5. Decontamination equipment.

6. Regular arithmetic graph paper, pencils and eraser, a scratch pad, field notebook, and a straight edge.

NOTE:* This technique requires accurate depth to water and liquid hydrocarbon measurements. The rapidity of these measurements requires a well gauging probe which is both fast and accurate, and does not present awkward or time consuming operating techniques. The dual interface probe design provides the degree of accuracy needed, while permitting the use of a single probe to gauge hydrocarbons and water. Use of two measurement devices can disturb liquid levels and will demand time for managing equipment at the expense of data collection. Since water level probes only provide half the data needed, another device would be needed to gauge liquid hydrocarbons. Tape and paste can serve this purpose but is awkward, slow and less accurate than an interface probe. Measurement techniques which disturb or affect the thickness or elevation of water or liquid hydrocarbons such as a clear acrylic bailer or a "plopper" well gauge are not acceptable.

PROCEDURE

1. Decontaminate bailer and well probe as per SOP-20, or use a new disposable bailer.

2. Prepare a graph for recording measurements. The abscissa (X, or horizontal axis) will be used to record time of measurement. The ordinate (Y, or vertical axis) will be used to record depth to groundwater and depth to the liquid hydrocarbon layer.

3. Gradually lower the interface probe until the liquid hydrocarbon signal activates. Note this depth. Continue lowering the interface probe until the water signal activates. Note this depth. Gradually raise the interface probe until the hydrocarbon signal deactivates. This should be the same as the first reading. Plot the hydrocarbon and water readings at the Time Zero position on the Y axis of the graph

paper. The interval between the two readings is the Apparent Liquid Hydrocarbon Thickness in the monitoring well.

4. Bail the liquid hydrocarbon layer from the well. Bail as rapidly as possible. Take care to remove as little water as practical to avoid causing the water level in the well to fall significantly below the liquid hydrocarbon level in the aquifer. Attempt to remove all liquid hydrocarbons from the well. If this is not possible, bail until the no further reduction in liquid hydrocarbon thickness can be achieved. Place bailed hydrocarbons and water in the 5 gallon bucket for later transfer to the 55 gallon D.O.T. approved drum.

5. Immediately upon the cessation of bailing begin to measure and record depth to product, depth to water and time of measurement. Water and liquid hydrocarbon levels will change rapidly at first, then begin to slow with time. During the initial period of rapid liquid level change it will be necessary to take as many measurements as possible. An assistant who may record data as the individual gauging the well calls out measurements would be beneficial at this time.

   As the rate at which changes in the thickness of the liquid hydrocarbon layer begins to slow, it will be possible to reduce the rate at which these measurements are taken. For example, after five minutes you may be able to take a reading every thirty seconds, after ten minutes the measurement rate may be reduced to once per minute, after fifteen minutes once per every five minutes may be sufficient etc...

6. The test is considered complete when the liquid levels in the well have stabilized for three consecutive readings, or when a significant amount of time has elapsed and liquid hydrocarbon thickness readings have approached 90 percent of the original liquid hydrocarbon layer thickness.

7. Plot the depth to water and depth to product measurements against the time elapsed since bailing was ended on the graph paper. Connect data points representing depth to water with a line. Connect depth to liquid hydrocarbon data points with a second line.

8. As the liquid level versus time data are plotted on the graph paper, certain trends will become apparent. The depth to water and depth to liquid hydrocarbon data plots will record the recovery of these fluids as lines (or curves) with a positive slope.

   Initially, the thickness of the liquid product in the well will increase rapidly. After about one half to two hours, the rate of liquid hydrocarbon accumulation will decrease noticeably. Both of the lines connecting depth to water and depth to liquid hydrocarbon data points will then describe a less steep positive slope, or will become flat. This will be apparent as breaks in slope for each of the two lines representing fluid recovery rates. The liquid hydrocarbon thickness at the time of this break in slope is considered to represent the minimum estimated thickness of the liquid hydrocarbon layer in the aquifer.

   A second break in slope will occur at a later time when the rate at which liquid hydrocarbons are accumulating in the well begins to increase again. At this time, the slope of the two lines will increase. The thickness of liquid hydrocarbons at this time represents the maximum theoretical thickness of liquid hydrocarbons in the aquifer.

The actual thickness of liquid hydrocarbons in the aquifer is therefore considered to range between the theoretical minimum and maximum hydrocarbon layer thicknesses represented by the earlier and later breaks in slope of the two lines depicting depth to groundwater versus time and depth to the liquid hydrocarbon layer versus time.

9. If these breaks in slope are not apparent following completion of the test, an alternate interpretation of the data may be used to estimate the true thickness of the liquid hydrocarbon layer. At the time when liquid hydrocarbons begin to accumulate in the well beyond the true thickness of the liquid hydrocarbon layer in the aquifer, the over accumulation of liquid hydrocarbons begins to depress the water table. This is represented by the generation of a negative slope in the line representing depth to groundwater readings. The thickness of the liquid hydrocarbon layer in the well at this time is considered to equal the true thickness of the liquid hydrocarbon layer in the aquifer.

10. Transfer bailed fluids from the 5 gallon bucket to the 55 gallon drum. Secure the 55 gallon D.O.T. approved drum for safe storage of recovered liquid hydrocarbons.

11. Decontaminate five gallon bucket, funnel, bailer and well probe as per SOP-20.

12. Complete field documentation of site activities before leaving the site.

SOP-25

STANDARD OPERATING PROCEDURE

GROUNDWATER SAMPLING

SUPPLIES – All Methods:

Five gallon bucket graduated in gallons	Decontamination equipment and fluids
Purge water containers – if required	- Liquinox or Alconox solution
Sample coolers and Ice	- 10% methanol solution (if sampling organics)
Preservatives (from laboratory, dependent on requested analysis)	- 10% nitric acid solution (if sampling for metals)
Filter apparatus (.45 micron)– if sampling for dissolved metals	- Distilled water
Field sampling forms and field log book	Personal Protective Equipment (PPE) – as required
Chain of custody (CoC)	- Nitrile gloves
Custody seals and packaging tape	- Safety glasses
Temperature blank – one per cooler	- Safety toe boots
Trip blanks for VOC or VPH	- Hardhat
Water level probe	Calibration fluids
Oil/Water interface probe (optional for hydrocarbons)	- 1413 mS common for specific conductance
pH meter[1]	- pH 4, 7, and 10
~~Thermometer~~Temperature probe[1]	- Zobell solution or Quinhydrone (ORP)
Specific Conductance meter1	Tools
Oxidation Reduction Potential (ORP) meter1 (optional)	- Hose clamps, scissors,
Indelible marker	- screwdrivers, wrenches, duct tape, etc.
Garbage bags	

1 – Industry standard is use of a multiparameter meter containing all four parameters (temp, pH, SC, ORP, DO), and/or turbidity.

Method Specific Equipment

Calculator	500 mL poly bottle marked in 50 mL increments
Stopwatch	Pump control box with appropriate lines (tubing) and fittings
Bailer(s)	Air compressor or compressed nitrogen gas cylinder
Bailer rope/twine or teflon coated reel	Appropriate tubing air/nitrogen and water
Purge pump(s)	Tubing/reel rod apparatus
Discharge hose or tubing	Multi-parameter meter (pH, SC, temp, DO, ORP)
Generator	Turbidity meter and calibration standards
Fuel	Flow through cell

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The intention of groundwater sample collection is to retrieve a representative sample of the aqueous portion of the aquifer at the time of collection. Numerous methods have been developed over time to retrieve as representative a sample as possible. Each method has advantages and disadvantages and specific equipment needs. The purpose of this SOP is to present how to collect groundwater samples using the various methods not the selection of the most appropriate method.

All sampling equipment shall be inspected for damage, and repaired if necessary, prior to arriving on-site. Pump and non-dedicated down-hole equipment is to be cleaned and decontaminated according to SOP-20 before use and between wells.

Follow manufacturer instructions to calibrate field meters before sampling.

GENERAL PROCEDURE

The General procedure for groundwater sampling is as follows

1) Wells shall be sampled from the least contaminated to more contaminated, if known.
2) Measure depth to water (SOP-23) - regardless of purge or sample collection method, measure static water level prior to initiating any purging or collection of samples. Puls and Barcelona (1995) recommend well depth be obtained from well logs. Measuring the bottom of the well casing will cause re-suspension of settled solids from the formation and require longer purging times for stabilization. Measure the well depth, if necessary, should be completed after sampling is completed. If sampling for hydrocarbons compounds, wells shall be checked for the presence of free product prior to purging and sampling (SOP-24).
3) Decontaminate non-dedicated down-hole equipment per SOP-20. The following is a summary of SOP-20: wash with ~~liquinox~~Liquinox® detergent and tap water solution, followed with 10% volumetric methanol and distilled water solution (if sampling for organics) or a 10% volumetric nitric acid and distilled water solution (if sampling for metals), and finally distilled water rinses. Distilled water may be purified through a distilling process or a reverse osmosis (RO) process, or purchased from the grocery store. ~~The RO process is preferred if sampling for metal contaminates.~~
4) Where possible and if known, sample wells in the order from least contaminated to most contaminated.
5) Purge well prior to sample collection by the method specified in the work plan or sampling and analysis plan (SAP);
6) Filter, containerize, and preserve as necessary groundwater samples for laboratory analyses.

The following table provides a brief summary of common purging and sampling methods, common application, advantages and disadvantages for general introduction of the methods presented in this SOP.

Method	**Common Application**	**Advantages**	**Disadvantages**
Purge 3-5 Casing Volumes	- Metals, inorganics - Inaccessible by other equipment - Insufficient water for submersible pump - Traditional historic	- May be faster/less expensive depending on purge method, volume, and depth - Some methods able to retrieve water from	- May produce large volumes of purge water - May affect chemistry of samples by surging, increased turbidity,

	method	minimal water column - Minimal training needed	mixing, excessive drawdown
Purge to field parameter stabilization	- Metals, inorganics, organics with care - Inaccessible by other equipment - Insufficient water for submersible	- May be faster/less expensive depending on purge method, volume, and depth - Some methods able to retrieve water from minimal water column	- May produce large volumes of purge water, - May affect chemistry of samples by surging, increased turbidity, mixing, excessive drawdown.
Low-flow purge and sample	- Volatile organic compounds - Low-medium yield wells	- Improved sample accuracy, - Reduced purge volume - Isolates stagnant water above screen - Samples represent naturally mobile contaminants	- May take more than one hour per well to purge - Large amounts of disposable tubing consumed - Tubing and controls may freeze during cold weather. - High conductivity zones contribute more water may affect results - Will not work for very low yield wells - Bottle fill time may be lengthy - Equipment and process training needed
Passive – No purge sample	- Remote inaccessible locations - Stratification investigations - Selective organic sampling (diffusion sampling)	- Minimal equipment and waste - Easy to use except on deep wells - Dedicated systems = no decontamination between wells - No purge water disposal - Can provide contaminant stratification data	- Some systems have higher initial capital cost for dedicated systems - Some regulatory agencies may not accept - If sample absent during retrieval due to water level change, equipment or operation failure, may be days or weeks before resample. - Susceptible to vertical flow mixing in well

Three – Five Casing Volume Purge

If sampling for hydrocarbon compounds, wells shall be checked for the presence of free product prior to purging and sampling.

Purging must be performed prior to sample collection. Field parameters pH, specific conductivity, temperature will be measured on first purge water, after each casing volume is evacuated, and at the time of sample collection. Field parameters and purge volume values will be entered on Field Sampling Forms during the purge process. Additional field parameters to be measured such as oxidation reduction potential (ORP) may be identified in the work plan. Well purging may be achieved using bailers, inertial pumps, peristaltic pumps, bladder pumps, and submersible electric pumps. The specific purging method shall be chosen based on depth to groundwater, diameter of well, existing well configuration and contaminant(s) of concern. If using a pump, pump intake placement is dependent upon many variables such as the specific characteristics of the contaminant(s) targeted for sample analysis, contaminant(s) source and subsurface lithology to name a few. Review the site specific SAP for clarification of specific sampling protocols. The pump intake depth should meet the following criteria;

- Pump intake **must** be in the screened interval of the well casing;
- The pump should be placed to a depth that will ensure sufficient head is maintained for bladder recharge and DTW measurements;
- Pump intake should be placed at a depth consistent with previous monitoring activities;
- Pump should never be lowered to the bottom of the well; maintain 1-2 feet above well bottom minimum.

A minimum of three and up to five volumes of groundwater in the well casing shall be withdrawn prior to sample collection. The well is ready to be sampled when the specified number of casing volumes have been evacuated. The volume of water present in each well shall be computed using the length of water column and monitoring well casing inside diameter. The total volume of water in the well (gallons) can be approximated using the following formula (depth and water level measurements in feet; casing diameter in inches):

$$\mathbf{(1/25)(Total\ Depth - Measured\ Water\ Level)(Casing\ Diameter)^2 = gallons}$$

If the recovery of a low-yield well exceeds two hours after purging, the sample shall be extracted as soon as sufficient volume is available in the well for a sample to be extracted. At no time will a monitoring well be purged dry if the recharge rate causes formation water to cascade down the well casing causing an accelerated loss of volatiles and change in pH.

During sample collection, sample directly from the bailer or pump tubing without altering pumping rate. Note: Pumping rate may be decreased if the pumping rate is too high to allow gentle non-turbulent flow into the container. If field filtering, install an in-line filter to the bailer or pump tubing and pre-rinse the filter with purge water prior to sample collection without stopping the purge process or follow SOP-14 as appropriate.

Complete sample documentation as necessary following SOP-17 and SOP-18.

Purge to Field Parameter Stabilization

If sampling for hydrocarbon compounds, wells shall be checked for the presence of free product prior to purging and sampling.

If specified by the project work plan, field parameters will be measured periodically during well purging. Field parameters, depth to water, purge volume values, and time, will be entered on Field Sampling Forms during the purge process. Well purging may be achieved using bailers, inertial pumps, peristaltic pumps, bladder pumps, and submersible electric pumps. The specific purging method shall be chosen based on depth to groundwater, diameter of well, existing well configuration and contaminant(s) of concern. If using a pump, pump intake placement is dependent upon many variables such as the specific characteristics of the contaminant(s) targeted for sample analysis, contaminant(s) source and subsurface lithology to name a few. Review the site specific SAP for clarification of specific sampling protocols. The pump intake depth should meet the following criteria;

- Pump intake **must** be in the screened interval of the well casing;
- The pump should be placed to a depth that will ensure sufficient head is maintained for bladder recharge and DTW measurements;
- Pump intake should be placed at a depth consistent with previous monitoring activities;
- Pump should never be lowered to the bottom of the well; maintain 1-2 feet above well bottom minimum.

The well is ready for sampling when measured field parameters stabilize at plus or minus five percent over three successive readings.

If the recovery of a low-yield well exceeds two hours after purging, the sample shall be extracted as soon as sufficient volume is available in the well for a sample to be extracted. At no time will a monitoring well be purged dry if the recharge rate causes formation water to cascade down the well casing causing an accelerated loss of volatiles and change in pH.

During sample collection, sample directly from the bailer or pump tubing without altering pumping rate. Note: Pumping rate may be decreased if the pumping rate is too high to allow gentle non-turbulent flow into the container. If field filtering, install an in-line filter to the bailer or pump tubing and pre-rinse the filter with purge water prior to sample collection without stopping the purge process or follow SOP-14 as appropriate.

Complete sample documentation as necessary following SOP-17 and SOP-18.

Low-Flow Purge and Sample

Groundwater samples collected using a low-flow (low stress) sampling system are completed accordance with U.S. EPA Standard Operating Procedure EQASOP-GW-001, last revised January 19, 2010. The low-flow method emphasizes the need to minimize hydraulic stress at the well-aquifer interface by maintaining low water-level drawdowns, and by using low pumping rates during purging and sampling operations (EPA 2010). The use of either a bladder pump or an adjustable rate electric submersible pump is recommended to purge and sample the wells while minimizing aeration and subsequent volatilization of constituents. Peristaltic pumps and other vacuum based pumps are not recommended but may be used with caution because they may cause degassing, pH modification, and loss of volatile compounds. The bladder pump method includes use of an air compressor or nitrogen compressed gas cylinder, controller and stainless steel bladder pump equipped with disposable down-well tubing to bring the water to the surface. The electric submersible pump includes use of a controller (with battery or portable generator), variable speed stainless steel submersible pump with disposal down-well tubing to bring the water to the surface. No matter which equipment is used to purge and sample, the discharge for each must go through a flow through cell to measure SC, ORP, pH, DO, and temp. The only field parameter that can be taken without a flow through cell is turbidity.

1) Wells shall be sampled from the least contaminated to more contaminated, if known.
2) Measure static water level prior to placing the pump in the well or collecting any samples (SOP-23). Puls and Barcelona (1995) recommend that well depth be obtained from well logs. Measuring the bottom of the well casing will cause re-suspension of settled solids from the formation and require longer purging times for stabilization. Measure the well depth, if necessary, should be completed after sampling is completed.
3) All non-disposable down-hole equipment will be decontaminated prior to sampling and between wells according to SOP-20. The following is a summary of SOP-20: wash with liquinox® detergent and tap water solution, followed with 10% volumetric methanol and distilled water solution (if

sampling for organics) or a 10% volumetric nitric acid and distilled water solution (if sampling for metals), and finally distilled water rinses. Distilled water may be purified through a distilling process or a reverse osmosis (RO) process. The RO process is preferred if sampling for metal contaminates.

4) The bladder pump intake will be lowered to a specific sampling depth that is selected for each well. Pump placement is dependent upon many variables such as the specific characteristics of the contaminate(s) targeted for sample analysis, contaminate(s) source and subsurface lithology to name a few. Review the site specific SAP for clarification of specific sampling protocols. The sampling depth should meet the following criteria;

   - Pump intake **must** be in the screened interval of the well casing;
   - The pump should be placed to a depth that will ensure sufficient head is maintained for bladder recharge and DTW measurements;
   - Pump intake should be placed at a depth consistent with previous monitoring activities;
   - Pump should never be lowered to the bottom of the well; maintain 1-2 feet above well bottom minimum.

5) Secure the pump/pump tubing to maintain a consistent pump intake level. Pump tubing should be dedicated, disposable tubing unless the well is fitted with a permanent, dedicated pump and tubing system.

6) Lower the electronic water level probe to 0.3 feet below the water table to monitor drawdown. Secure the probe to maintain a consistent monitoring level.

7) Connect the pump tubing to the flow-through cell and attach the multi-parameter meter probes.

8) Turn on the pump adjust the flow rate to minimize water level drawdown in the well (less than 0.3 feet). If the minimal drawdown that can be achieved exceeds 0.3 feet but remains stable, continue to purge. Measure or record pumping rate and collect water in a 5 gallon bucket to measure the total volume removed.

9) Use a 500 mL beaker or a 500 mL poly bottle marked off in 50 mL increments to measure mL/cycle.

10) Field parameters including pH, specific conductivity (SC), temperature, dissolved oxygen (DO), and oxidation-reduction potential (ORP) will be measured every 3 to 5 minutes during the purge process and at the time of sample collection using a multi-meter and flow-through cell. These parameters are used in the field to assess chemical stability prior to sampling. Measure water level at time of each parameter reading.

11) Stabilization is considered to be achieved when three consecutive readings, taken three to five minutes, apart are within a predetermined range as outlined below (summary of EPA's field parameter stabilization requirements).

EPA SOP GW-001 Requirements for Field Parameter Stabilization

Parameter	Field Parameters Stabilization Requirements
Turbidity*	<5 NTU or ±10% when turbidity is greater than 5 NTUs
Dissolved Oxygen	10%, or values < 0.5 mg/l
Specific Conductance	±3%
Temperature	±3%
pH	±0.1 unit
Oxidation Reduction Potential	±10 mV

* - Turbidity levels of less than 5 NTU and stable drawdowns of less than 0.3 feet are preferred but

not mandatory.

12) Field measurement data and notes will be recorded on groundwater sampling field forms. Record all field parameters, start time, flow rate, pump depth, water levels, time of parameters, water levels and the total volume removed from wells.
13) If field parameters have not stabilized with 90 minutes indicate such on the groundwater sampling field forms, and collect groundwater samples.
14) During sample collection, remove the flow through cell, and sample directly from the pumps tubing without altering the pumping rate. Note: Pumping rate may be decreased while collecting samples for VOC analyses if the pumping rate is too high to allow gentle non-turbulent flow into the container.
15) If Field filtering, install an in-line filter and pre-rinse the filter with purge water prior to sample collection without stopping the purge process or follow SOP-14 as appropriate.
16) Place samples in a cooler containing doubled, re-sealable bags filled with ice. Replenish ice as needed during the day, during transport, and prior to shipping to the laboratory.
17) Decontaminate all sampling equipment as per SOP-20.
18) Place disposable field sampling supplies in an approved waste receptacle for disposal at a sanitary landfill, unless specified otherwise in the work plan.
19) Complete sample documentation as necessary following SOP-17 and SOP-18.

Passive – No purge sample

There are several manufacturers of passive groundwater samplers. Passive samplers are generally classified as *Diffusion Samplers, Equilibrated Grab Samplers, or Accumulation Samplers*. In general, passive samplers are deployed by lowering and suspending the sampler at a specified depth. After a period of equilibration (days, weeks, months) the sampler is brought back to the surface to retrieve the sample. Some systems require decanting the sample from sampler in to laboratory supplied bottles, while other systems ship the disposable sampler to the laboratory. Follow manufacture instructions to deploy samplers and retrieve samples.

Domestic Well Sampling

1) Turn-on household fixture closest to well (preferably an outside faucet) that is on the well-side of any household water conditioning device. Use a hose to direct the discharge to an appropriate location if necessary.
2) Using the above equation, calculate the volume of water to be evacuated. Measure the discharge rate from the faucet in a graduated 5 gallon bucket, or other suitable container, to compute the rate of discharge. Calculate the time needed to evacuate the predicted volume from the well. Record all measurements and calculations on field forms.
3) If specified by the project work plan, measure field parameters. Continue monitoring field parameters periodically during purging process. The well is ready for sampling when either or both of the following conditions are met: 1) the purged volume is equal to three to five casing volumes and/or, 2) measured field parameters are within plus or minus five percent ($\pm$ 5%) over three successive readings.
4) Samples should be collected directly from hydrant or faucet and prior to entry of the water through any water conditioning devices. Do not collect samples through rubber hoses. For inorganics samples, rinse sample containers, without preservatives, three times with sample water before final collection. Do not rinse containers for organics analysis.
5) If sampling for dissolved metals or metals speciation, field filter sample according to SOP-14.

6) If sampling for volatile analyses gently fill vials; form positive meniscus over vial brim, add preservative, and cap. After capping, invert vial, gently tap and look for air bubbles. If bubbles are present, un-cap vial, add more water and repeat procedure.
7) Add preservatives as necessary in accordance with SOP-15 or as directed by the laboratory.
8) Complete sample documentation as necessary following SOP-17 and SOP-18.

REFERENCES:

Puls, R.W. and Barecelona, M.J., 1995. Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures. USEPA Office of Research and Development, Office of Solid Waste and Emergency Response. EPA/540/S-95/504, December.

U.S. EPA Standard Operating Procedure No. GW-0001, Revision 3, Revised January 19, 2010. Note, next revision anticipated in 2017 or 2018.