Attachment 15

THERMAL TREATMENT UNIT AND LANDFILL 5 GROUNDWATER SAMPLING AND ANALYSIS PLAN

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1.0 INTRODUCTION

This Sampling and Analysis Plan (SAP) describes the groundwater sampling methodology for the Thermal Treatment Unit (TTU) and Landfill 5 sites located at the Utah Test and Training Range-North (UTTR-North). The SAP has been prepared to fulfill requirements of Module III and Module IV of the Permit for the TTU and Landfill 5. The SAP was developed to guide field sampling to ensure the collection of representative and defensible groundwater samples that are sufficient to draw statistical conclusions concerning potential contamination. Where applicable, the procedures and quality assurance/quality control (QA/QC) techniques in the current version of the Basewide Quality Assurance Project Plan (Basewide QAPP), which is based on United States Environmental Protection Agency (USEPA) test methods for evaluating groundwater contamination, are used.

Figure 1

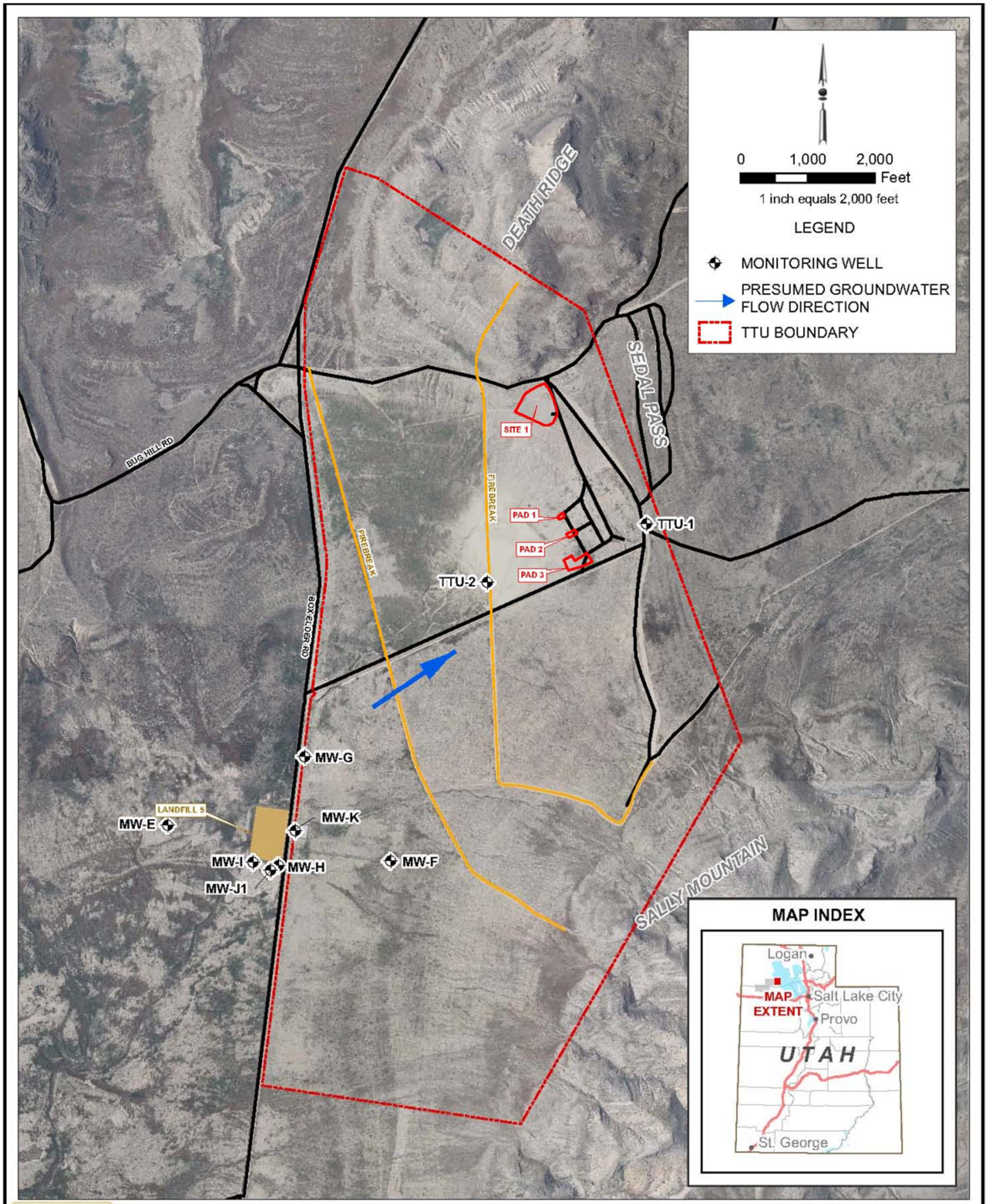

FIGURE 1-1

THERMAL TREATMENT UNIT AND LANDFILL 5 SAMPLING LOCATIONS

THERMAL TREATMENT UNIT AND LANDFILL 5 SAMPLING AND ANALYSIS PLAN
UTAH TEST AND TRAINING RANGE, UTAH

2.0 THERMAL TREATMENT UNIT AND LANDFILL 5 DESCRIPTION

2.1 Site History

2.1.1 Thermal Treatment Unit Site History

Hill Air Force Base (AFB) has been treating solid Pyrotechnics, Energetics, and Propellants (PEP) items at the TTU for more than 30 years using both Open Burn (OB) and Open Detonation (OD) thermal treatment processes. Historically, the TTU has primarily been used to treat large rocket motors. Other materials permitted for treatment at the TTU are listed in Module III of the RCRA Permit. The frequency of treatment varies according to the quantity of munitions declared unserviceable or excess during any given time period.

2.1.2 Landfill 5 Site History

Landfill 5 is a hazardous waste disposal facility that was operated under interim status guidelines in compliance with Chapter 7 of the Utah Hazardous Waste Management Rules [now Rule R315, Utah Administrative Code (UAC)]. The official closure permit for Landfill 5 was issued to Hill AFB by the Utah Department of Environmental Quality (UDEQ) on July 15, 1988. Landfill 5 is currently undergoing post-closure groundwater monitoring. A wide variety of wastes generated at Hill AFB including chlorinated and non-chlorinated solvents, heavy metals, polychlorinated biphenyls (PCBs), paints and paint strippers, Industrial Wastewater Treatment Plant (IWTP) sludge, cadmium-contaminated blast media, mercury, asbestos, and many other wastes were deposited in the landfill between 1976 and 1983. Landfill 5 was operated prior to land disposal restrictions (LDR), which now prohibit the disposal of liquid hazardous waste in landfills.

2.2 Site Description

Figure 1 shows the location of the TTU and Landfill 5. The TTU occupies approximately two square miles at the north end of the Sink Valley, which slopes gently to the southwest, near Sedal Pass. Landfill 5 is located immediately southwest of the TTU. The TTU area is located approximately five miles northeast of the UTTR-North support facility (Oasis) and 20 miles north of Utah Exit 62 on Interstate 80. Access to the TTU is provided via Box Elder County Road, which runs from Interstate 80 northward to the Union Pacific Railroad work site at Lakeside.

The TTU contains four sites used for treating waste ordnance by OB and/or OD. Sites 1 and 4 are the rocket motor and scrap propellant OB pads. Site 2 consists of three pads used as staging areas for munitions treated by OB/OD in areas adjacent to those pads. Actual OB/OD operations take place on the grounds immediately to the west of each pad. Site 3 is the munitions burn pan where small arms ammunition, flares, cartridge actuated devices (CADs), and propellant-actuated devices (PADs) are demilitarized by OB.

All the OB and/or OD operations performed at Sites 1, 2 and 4 are conducted by placing waste munitions items on ground level and initiating or detonating the materials to be treated using explosive charges. There are no engineered structures or containment facilities in place at these three sites. All OB operations at Site 3 are conducted in a burn pan.

Landfill 5 consists of six cells, which are 90 feet wide by 150 feet long by 15 deep. These cells were excavated into a light-gray alkaline silty-clay loam. The location of the landfill was chosen because of the low soil permeability, low annual precipitation, high evapotranspiration, and remoteness of the site.

3.0 REQUIRED PROGRAMS

Groundwater monitoring at the Landfill 5 and TTU wells are governed by either detection monitoring or compliance monitoring programs as outlined in R315-8-6.9 and R315-8-6.10 respectively. Individual wells at both sites are monitored under either program, as specified in Table 1, depending on whether or not contaminants of concern or statistical increases in concentrations of contaminants of concern have been detected at each well.

3.1 Detection Monitoring

Detection monitoring programs are required at the TTU (Permit section III.3.G) and Landfill 5 (Permit Section V.J). Detection monitoring programs at both sites require annual sampling of contaminants of concern as specified in Table 2.

The TTU detection monitoring program requires statistical evaluation of data to determine if concentrations of background parameters or contaminants of concern are increasing (section III.G.3.d). Comparison of analyte concentrations to a list of concentration limits or action levels is also required (section III.G.3.a.iii). Exceedances of these action levels may trigger compliance monitoring (section III.dG.3.d.ii).

The Landfill 5 detection monitoring program requires statistical evaluation of background quality parameters (sections V.I.1.g and V.J.2) and comparison of monitoring results to analytical method detection limits. Detection of contaminants of concern (section V.G.2 and V.J. 1.d) or statistical increases in background parameters (V.J.2.e) trigger a compliance monitoring program for the wells where detections or increases were observed.

3.2 Compliance Monitoring

A compliance monitoring program is initiated on a well by well basis depending on the results of detection monitoring. Compliance monitoring requires analysis of the constituents and contaminants of concern listed in Table 2 on a semi-annual basis or other frequency specified by the Executive Secretary as described in R315-8-6.10. Statistical increases of constituents or exceedances of concentration limits listed in Table 3 may trigger corrective action as required by R315-8-6.2.

Concentration limits were developed based on site specific industrial screening levels following the USEPA regional screening level guidance (USEPA, 2011). Specific inputs and parameters are listed in Table 4. The screening levels were calculated using the USEPA “RSL Calculator” (USEPA, 2011).

Table 1. Monitoring Program Summary and Schedule*

Well	Monitoring Program	Basis	Sampling Frequency
TTU-1	Detection Monitoring	No statistical increases or exceedances	annual
TTU-2	Detection Monitoring	No statistical increases or exceedances	annual
MW-E	Detection Monitoring	No statistical increases or detections	annual
MW-F	Detection Monitoring	No statistical increases or detections	annual
MW-G	Detection Monitoring	No statistical increases or detections	annual
MW-H	Compliance Monitoring	Detections of Toluene, MIBK, and MEK in 2008 and 2009	semi-annual
MW-I	Compliance Monitoring	Toluene detection in 2009	semi-annual
MW-J1	Compliance Monitoring	Proximity to wells MW-H & MW-I	semi-annual
MW-K	Compliance Monitoring	Detection s of 1,1-DCE, Methylene Chloride, 1,1,1-TCA, TCE, Toluene, and PCE in 2011	semi-annual

*Modification of Table 1 will be considered a Class 1 permit modification with prior approval of the Executive Secretary as outlined in 40 CFR 270.42 Appendix I (C)(2).

4.0 GROUNDWATER SAMPLING LOCATIONS

Groundwater samples will be collected from two monitoring wells (TTU-1 and TTU-2) at the TTU and seven monitoring wells (MW-E, MW-F, MW-G, MW-H, MW-I, MW-J1, and MW-K) at Landfill 5 as shown in Figure 1. The wells are screened to monitor the uppermost water-bearing zone beneath the TTU and Landfill 5. The direction of groundwater flow is difficult to determine in this area due to a very low groundwater gradient, a low number of sampling points (two at the TTU and seven at Landfill 5), possible completion of the TTU and Landfill 5 wells in different hydrogeologic units, and significant depth to groundwater below the TTU and Landfill 5 (CH2M HILL, 2004) which imposes a significant amount of error into the measurement of groundwater depth due to the application of inclination correction factors (URS, 2010). Although the direction of groundwater flow is very difficult to determine in this area, historical groundwater data collected from the TTU and Landfill 5 wells suggest that local groundwater flows to the east and north beneath the TTU and Landfill 5, respectively (USGS, 2004).

The Great Salt Lake and the Great Salt Lake Desert are the two major groundwater discharge basins in the region surrounding the TTU and Landfill 5 (Price and Bolke, 1970). The Great Salt Lake is located to the east and north of the TTU and Landfill 5, while the Great Salt Lake Desert is located to the west. Price and Bolke (1970) suggest that groundwater in the Sink Valley flows from the surrounding mountains toward the axis of the valley and then flows in a north-northwest direction toward the Great Salt Lake Desert. Sedal Pass acts as a surface drainage divide between Sink Valley to the southwest and the Great Salt Lake to the east, but it does not appear that there is a similar groundwater divide at Sedal Pass. Groundwater flow beneath the TTU appears to flow toward the Great Salt Lake to the east, while groundwater flow beneath Landfill 5 appears to flow northeast toward Sedal Pass.

Wells TTU-1 and TTU-2 are situated approximately up and downgradient of the TTU, respectively. Based on the low groundwater gradient in the area of Landfill 5, any of the wells may be control or compliance wells for Landfill 5.

5.0 HAZARDOUS CONSTITUENTS/INDICATOR PARAMETERS TO BE MONITORED

Hazardous constituents of concern at the TTU are listed in Appendix VIII of 40 Code of Federal Regulations (CFR) 261. Table 2 provides the list of constituents that will be monitored under this SAP. The Table 2 constituents have been selected based on:

- Knowledge of past operations at the TTU and Landfill 5;
- The types, quantities, and concentrations of constituents likely to be present in the wastes at the TTU and Landfill 5; and
- Mobility of waste constituents during vadose zone transport with inclusion of constituents that would be likely to reach groundwater first.

Table 3 lists the maximum laboratory method detection limits for each analyte.

Table 2. Monitored Constituents and Methods. Numbers of samples to be collected for detection and compliance monitoring events are shown.

Analysis (water)	**Primary Samples (LF5 Wells: MW-E, MW-F, MW-G, MW-H*, MW-I*, MW-J1*, MW-K*)**	**Primary Samples (TTU Wells: TTU-1, TTU-2)**	**Primary Samples Total**	**QA/QC (field dup, MS/MSD)**
Volatiles 8260B	7(4)*	0	**7(4)**	3(3)
Volatiles-EDB, DBCP, 123TCP 504.1/8260B	7(4)	0	**7(4)**	3(3)
Explosives 8330	0	2	**2**	3
Dissolved Metals-ICP (Al, As, Ba, Be, Cd, Cr, Fe, Pb, Ni, Se, Ag, V, Zn) 6010B	7(4)	2	**9(4)**	3(3)
Dissolved Metals-Hg 7470A	7(4)	2	**9(4)**	3(3)
General Chemistry-alkalinity 310.1	7(4)	2	**9(4)**	3(3)
General Chemistry-anions 300.0A/SW9056A (Cl, SO4, F)	7(4)	2	**9(4)**	3(3)
General Chemistry-nitrate/nitrite 353.2	7(4)	2	**9(4)**	3(3)
General Chemistry-phosphate 365.4/SW9056A	7(4)	2	**9(4)**	3(3)
General Chemistry-TDS 160.1	7(4)	2	**9(4)**	3(3)
Perchlorate (6850) IC/MS/MS	7(4)	2	**9(4)**	3(3)

*Indicated wells are sampled more frequently under a compliance monitoring program as described in section 3.2. Parenthesis indicate the number of samples to be collected during compliance monitoring rounds.

Table 3. Method Detection Limits and Concentration Limits

Explosives Residues		**MDL**	**Conc. Limit**[†]	**units**
1,3,5-Trinitrobenzene	SW-846 8330	0.30	3.07E+03 nc	ug/L
1,3-Dinitrobenzene	SW-846 8330	0.10	1.02E+01 nc	ug/L
2,4,6-Trinitrotoluene	SW-846 8330	0.10	5.11E+01 nc	ug/L
2,4-Dinitrotoluene	SW-846 8330	0.10	9.23E+01 ca	ug/L
2,6-Dinitrotoluene	SW-846 8330	0.10	1.02E+02 nc	ug/L
2-Amino-4,6-Dinitrotoluene	SW-846 8330	0.10	2.04E+02 nc	ug/L
2-Nitrotoluene	SW-846 8330	0.10	9.20E+01 nc	ug/L
3-Nitrotoluene	SW-846 8330	0.10	1.02E+01 nc	ug/L
4-Amino-2,6-Dinitrotoluene	SW-846 8330	0.10	2.04E+02 nc	ug/L
4-Nitrotoluene	SW-846 8330	0.30	4.09E+02 nc	ug/L
HMX	SW-846 8330	0.10	5.11E+03 nc	ug/L
Nitrobenzene	SW-846 8330	0.10	5.69E+01 nc	ug/L
RDX	SW-846 8330	0.10	2.60E+02 ca	ug/L
Tetryl	SW-846 8330	0.10	4.09E+02 nc	ug/L
Dissolved Metals		**MDL**	**Conc. Limit**	**units**
Aluminum	SW-846 6010B	20.0	N/A[††]	ug/L
Arsenic	SW-846 6010B	10.0	N/A[††]	ug/L
Barium	SW-846 6010B	2.0	N/A[††]	ug/L
Beryllium	SW-846 6010B	1.0	N/A[††]	ug/L
Cadmium	SW-846 6010B	1.0	N/A[††]	ug/L
Chromium	SW-846 6010B	3.0	N/A[††]	ug/L
Iron	SW-846 6010B	25.0	N/A[††]	ug/L
Lead*	SW-846 6010B	3.0	N/A[††]	ug/L
Mercury	SW-846 7470A	0.10	N/A[††]	ug/L
Nickel*	SW-846 6010B	10.0	N/A[††]	ug/L
Selenium	SW-846 6010B	15.0	N/A[††]	ug/L
Silver	SW-846 6010B	3.0	N/A[††]	ug/L
Vanadium*	SW-846 6010B	3.0	N/A[††]	ug/L
Zinc	SW-846 6010B	5.0	N/A[††]	ug/L
General Chemistry		**MDL**	**Conc. Limit**	**units**
Total Alkalinity	EPA 310.1	2.0	N/A[††]	mg/L
Bicarbonate Alkalinity	EPA 310.1	2.0	N/A[††]	mg/L
Carbonate Alkalinity	EPA 310.1	2.0	N/A[††]	mg/L
Chloride	EPA 300.0A	0.50	N/A[††]	mg/L
Fluoride	EPA 300.0A	0.10	N/A[††]	ug/L
Nitrate+Nitrite	EPA 353.2	0.050	N/A[††]	ug/L
Total Phosphorus	EPA 365.4	0.010	N/A[††]	mg/L
Sulfate	EPA 300.0A	0.30	N/A[††]	mg/L
Total Dissolved Solids	EPA 160.1	5.0	N/A[††]	mg/L
Perchlorate	SW-846 6850	0.050	N/A[††]	ug/L

Volatiles		MDL	Conc. Limit†	units
Chloromethane	SW-846 8260B	0.40	7.88E+02 nc	ug/L
Vinyl Chloride	SW-846 8260B	0.50	2.04E+01 ca	ug/L
Bromomethane	SW-846 8260B	0.50	3.35E+01 nc	ug/L
Chloroethane (Ethyl Chloride)	SW-846 8260B	0.50	8.76E+04 nc	ug/L
Acetone	SW-846 8260B	2.0	6.86E+04 nc	ug/L
Carbon Disulfide	SW-846 8260B	0.50	3.83E+03 nc	ug/L
Methylene Chloride	SW-846 8260B	0.50	2.20E+03 ca	ug/L
1,1-Dichloroethene	SW-846 8260B	0.20	1.30E+03 nc	ug/L
trans-1,2-Dichloroethene	SW-846 8260B	0.20	4.18E+02 nc	ug/L
cis-1,2-Dichloroethene	SW-846 8260B	0.20	2.04E+02 nc	ug/L
2-Butanone (MEK)	SW-846 8260B	2.0	2.56E+04 nc	ug/L
Chloroform	SW-846 8260B	0.20	9.56E+01 ca	ug/L
1,1,1-Trichloroethane	SW-846 8260B	0.20	3.61E+04 nc	ug/L
Carbon Tetrachloride	SW-846 8260B	0.20	2.04E+02 ca	ug/L
1,1-Dichloroethane	SW-846 8260B	0.20	1.17E+03 ca	ug/L
1,2-Dichloroethane	SW-846 8260B	0.20	5.57E+01 nc	ug/L
Benzene	SW-846 8260B	0.20	1.60E+02 nc	ug/L
Trichloroethene	SW-846 8260B	0.20	8.76E+01 nc	ug/L
1,2-Dichloropropane	SW-846 8260B	0.20	3.49E+01 nc	ug/L
Bromodichloromethane	SW-846 8260B	0.20	5.80E+01 ca	ug/L
cis-1,3-Dichloropropene	SW-846 8260B	0.20	1.66E+02 nc[1]	ug/L
trans-1,3-Dichloropropene	SW-846 8260B	0.20	1.66E+02 nc[1]	ug/L
4-Methyl-2-Pentanone (MIBK)	SW-846 8260B	1.50	6.24E+03 nc	ug/L
Toluene	SW-846 8260B	0.20	6.89E+03 nc	ug/L
1,1,2-Trichloroethane	SW-846 8260B	0.50	1.74E+00 nc	ug/L
Tetrachloroethene	SW-846 8260B	0.20	4.70E+01 ca	ug/L
2-Hexanone	SW-846 8260B	1.50	1.74E+02 nc	ug/L
Dibromochloromethane	SW-846 8260B	0.20	7.17E+01 ca	ug/L
Chlorobenzene	SW-846 8260B	0.20	3.61E+02 nc	ug/L
1,1,2,2-Tetrachloroethane	SW-846 8260B	0.20	3.26E+01 ca	ug/L
Ethylbenzene	SW-846 8260B	0.20	7.12E+02 ca	ug/L
m&p-Xylene	SW-846 8260B	0.50	8.40E+02 nc	ug/L
o-Xylene	SW-846 8260B	0.20	8.40E+02 nc	ug/L
Styrene	SW-846 8260B	0.20	6.13E+03 nc	ug/L
Bromoform	SW-846 8260B	0.20	2.04E+03 nc	ug/L
1,2-Dibromoethane	SW-846 504.1	0.010	3.18E+00 ca	ug/L
1,2-Dibromo-3-Chloropropane	SW-846 504.1	0.010	8.42E-01 ca	ug/L
1,2,3-Trichloropropane	SW-846 8260B	1.0	1.99E+00 ca	ug/L

†Concentration limits are based on site specific industrial screening levels following the USEPA regional screening level guidance found at http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm. Inputs are listed in Table 4. "ca" indicates the screening level is based on carcinogenic risk and "nc" indicates a non-carcinogenic basis.

††As a potential background parameter (see Permit sections III.G.3.a.iv and V.J.2), this analyte is subject to the background/trend analysis described in section 10.1 of this attachment.

*No EPA drinking water standard (MCL) has been established for lead, nickel, or vanadium. Therefore, aqueous concentrations of these metals can be determined by either method SW-846 6010B or 6020A, but SW-846 6010B is considered sufficient.

[1] Concentration limit based on screening level for 1,3-Dichloropropene

Table 4. Inputs† Used to Develop Groundwater Concentration Limits Based on Industrial Groundwater Screening Levels.

Variable	Value
Target cancer risk (TR) - unitless	0.0001
Target hazard quotient (THQ) - unitless	1
Averaging time (AT) - days	365
Exposure frequency (EF) - days	250
Exposure duration (ED) - years	25
Mutagenic Exposure duration ($ED_{0\text{-}2}$) - years	0
Mutagenic Exposure duration ($ED_{2\text{-}6}$) - years	0
Mutagenic Exposure duration ($ED_{6\text{-}16}$) - years	0
Mutagenic Exposure duration ($ED_{16\text{-}30}$) - years	12
Life Time (LT)	70
Exposure Time (ET) hours/day	8
Body Weight - adult (BW_a) - kg	70
Body Weight - children 1-6 yr (BW_c) - kg	15
Exposure duration - child (ED_c) - years	0
Water Ingestion - adult (IRW_a) - L/day	1
Water Ingestion - child (IRW_c) - L/day	0
Volatilization factor of Andelman (K) - L/m^3	0.5
Ingestion Factor - L-year/kg-day	0.357142857
Mutagenic Ingestion Factor - L-year/kg-day	0.171428571

† These inputs were used in the USEPA RSL Calculator (http://epa-prgs.ornl.gov/cgi-bin/chemicals/csl_search) using the chronic, site specific, resident, tap water exposure selections to calculate the Landfill 5 industrial concentration limits.

6.0 SCHEDULE

Groundwater sampling will be conducted annually at the TTU and Landfill 5 for wells under the detection monitoring program and semi-annually for wells under the compliance monitoring program as specified in Table 1. Semi-annual compliance sampling rounds will occur in the Spring/Summer and Fall/Winter each year.

7.0 PROCEDURES

This section describes the procedures that will be used for groundwater measurement, sampling, and analysis. Sample collection and measurement with the associated field and analytical procedures are described in this section. All procedures outlined in this SAP will be performed in accordance with the Hill AFB Basewide QAPP. Standard Operating Procedure 20 (SOP-20) from the Basewide QAPP outlines groundwater sampling procedures at Hill AFB facilities and is presented in Appendix A.

7.1 Installation/Site Access

At least one week prior to sampling activities, the field sampling contractor will submit a Visit Request Form to the 388th Range Squadron safety officer or CEV project manager. The Visit Request Form will list all of the required information for each member of the sampling team. A copy of the Visit Request Form is presented in Appendix C. The CEV Project Manager will contact Range Security, Range Control, and the appropriate regulatory agencies before sampling is conducted.

All field sampling personnel will be required to sign in at the guard post upon arrival and departure. The sampling team will have a Hill AFB issued radio with them at all times while on the Range. One person familiar with radio procedures at the UTTR will be present with the sampling team.

7.2 Documentation

Field documentation serves as the primary foundation for all field data collected that will be used to evaluate the site. All field documentation shall be accurate, legible, and written in indelible ink. Incorrect entries in the field books, logs, or on forms that need to be deleted shall be crossed out with one line, initialed, and dated. Skipped pages or blank sections at the end of a page shall be crossed out with an "X" covering the entire page or blank section. The responsible field team member shall write his/her signature, date, and time after the day's last entry.

To further assist in the organization of the field books, logs, or forms, the date shall be recorded on top of each page along with the significant activity description (e.g., well location). In addition, all original field documentation shall be retained in the project files. The descriptions of field data documentation given below serve as an outline.

7.2.1 Field Logbooks

The field logbook shall be a bound, weatherproof book with numbered pages and shall serve primarily as a daily log of the activities carried out during the investigation. The logbook shall serve as a diary of the events of the day. The groundwater sampling team members shall be responsible for recording the following information.

- Health and safety activities;
- Personnel contamination prevention and decontamination procedures;
- Record of daily tailgate safety meetings;
- Weather;
- Calibration of field equipment;
- Equipment decontamination procedures;
- Personnel on job site and time spent on the site;
- Disposal of contaminated wastes, including personal protective equipment (PPE), paper towels, etc.;
- Site name/well number;
- Water levels, including time and datum that water levels are measured (i.e., top of casing);
- Well purging information with the following information:
    - Visual and olfactory observations,

  - Measured field parameters (temperature, pH, and specific conductance),
  - Amount of water purged,
  - Purge water disposal/containment (Baker tank/drums, number used, identification, etc.); and
- Well sampling information:
  - Number of samples collected and type of containers used,
  - Date and time of sample collection,
  - Type of analyses requested,
  - QA/QC samples collected, including names given to blind samples,
  - Field observations,
  - Problems encountered and corrective actions taken,
  - Deviations from the sampling plan,
  - Site visitors.

7.2.2 Sampling Field Forms

The groundwater sampling field forms shall be used any time that a well is sampled. An example copy of the groundwater sampling field form is presented in Appendix B.

The following information should be recorded on the field form.

- Project name, project number, and site;
- Well identification number;
- Date and time of sampling;
- Water level and reference elevation;
- Volume of water to be purged;
- Pertinent well construction information (e.g., total depth, well diameter, etc.);
- Measurement of field parameters, including pH, specific conductance, and temperature, as well as the time of each of the readings;
- Type of purging and sampling equipment used;
- Type of samples collected; and
- Name of sampler.

7.3 Pre-Sampling Procedures

Upon arrival at the well and prior to groundwater measurement, purging, or sampling, the sampling personnel shall document any signs of tampering or well deterioration. A depth to groundwater measurement shall be taken using a non-dedicated electronic water level indicator. Electronic water level indicators consist of a spool of graduated tape or small-diameter cable with a weighted probe attached to the end. When the probe comes in contact with the water, an electrical circuit is closed and a meter, light, and/or buzzer attached to the spool signals the contact. A depth to water measurement is read directly off the markings on the cable or tape. To prevent potential cross-contamination between measuring points, the water level indicator will be decontaminated prior to use at each location with paper towels and a solution of Alconox™ (or equivalent) detergent and water, followed by a triple rinse with deionized water. Field personnel will don a new pair of clean nitrile gloves prior to measuring the groundwater elevation at each location.

The following method will be used to measure groundwater elevation:

- Verify well identification (ID). Check and ensure proper operation of measurement equipment aboveground. Prior to opening the well, don PPE as required.
- Record well number, top of casing elevation, and surface elevation if available.
- Lower the probe slowly into the well. Upon contact with water, the buzzer should sound and the indicator light should glow. Raise and lower the probe slightly about the water level a few times to determine accurate point of contact.
- Measure and record static water level and total depth to the nearest 0.01 foot (0.3 cm) from the surveyed reference mark on the top edge of the monitoring well. If no reference mark is present, record in the logbook where the measurement was taken from (e.g., from the north side of the inner casing) and record the depth to groundwater.
- Record the time and day of the measurement.
- Raise the water level probe on the spool and decontaminate.

7.4 Equipment Calibration

The accuracy, precision, and usefulness of field measurements are dependent on the proper use and care of the field instruments. The instruments shall be handled carefully at the well site and during transport to the field and between sampling sites. Field equipment shall never be left unsecured where it can be lost, stolen, or tampered with. Equipment shall not be left at the UTTR between jobs without the project or equipment manager’s approval and a secure area for storage.

All meters shall be calibrated prior to use in accordance with the manufacturer’s directions and the Basewide QAPP. All information regarding meter calibration shall be described in the field logbook or field forms. An example copy of the equipment calibration log is presented in Appendix B. All meters shall be used in accordance with the manufacturer’s direction, and no meters shall be used unless they are functioning properly. Equipment calibration procedures are outlined in the Basewide QAPP.

Table 5
TTU and Landfill 5 Monitoring Well Completion Data

Well Location ID	Date Drilled (feet)	Total Depth (feet)	Local NGVD 29 US Foot Elevation[1]	Approx. Water Level (feet)	Inclination Correction Factor (ft)	Boring Diameter (inches)	Screen Interval (feet)	Casing/ Screen Diameter (inches)	Casing/ Screen Type	Pump Type	Intake Depth (feet)	Discharge Piping	Water Level Access Piping	Control Box	Last Pump Replace-ment
TTU-1	1990	706	4859.91	650	-1.33	10-12	680-690	6	Stainless Steel	Grundfos 5S20-39	687	1-inch Type 304 SS	1 1/2-inch Flush Threaded Sch. 80 PVC	Yes	March 1997
TTU-2	1990	609	4722.11	510	-0.38	10-12	574-584	6	Stainless Steel	Grundfos 10S20-27	583	1-inch Type 304 SS	1 1/2-inch Flush Threaded Sch. 80 PVC	Yes	December 2007
MW-E	October 1986	454	4616.19	395	-2.32	8-5/8	425-445	4	Sch. 40 PVC	Grundfos 5S15-26	432	1-inch Sch. 80 PVC, NPT Thread	3/4-inch Flush Threaded Sch. 80 PVC	Yes	July 1998
MW-F	October 1986	514	4673.48	455	-2.15	8-5/8	485-505	4	Sch. 40 PVC	QED P1101HM	495	3/8-inch OD Teflon-lined Polyethylene	3/4-inch Flush Threaded Sch. 80 PVC	Yes; QED MP10H	December 2009
MW-G	January 1988	466	4632.41	415	-4.78	8-5/8	435-455	4	Sch. 40 PVC	Grundfos 5S15-26	452	3/4-inch Sch. 80 PVC, NPT Thread	3/4-inch Flush Threaded Sch. 80 PVC	Yes	January 1998
MW-H	January 1988	444	4609.95	390	-0.89	8-5/8	414-434	4	Sch. 40 PVC	QED P1101HM	424	3/8-inch OD Teflon-lined Polyethylene	1-inch Flush Threaded Sch. 80 PVC	Yes; QED MP10H	December 2009
MW-I	February 1988	454	4604.9	385	-2.01	8-5/8	425-445	4	Sch. 40 PVC	QED P1101HM	435	3/8-inch OD Teflon-lined Polyethylene	3/4-inch Flush Threaded Sch. 80 PVC	Yes; QED MP10H	December 2009
MW-J1	September 1996	443	4607.44	385	-0.45	7-7/8	420-440	4	Sch. 40 PVC	Grundfos 5S15-26	425	3/4-inch Type 304 SS	1-inch Flush Threaded Sch. 80 PVC	Yes	September 1996
MW-K	December 2010	502	4617.011	395	-0.07	10	450-470	5	Sch. 80 PVC	QED P1101HM	460	3/8-inch OD Teflon-lined Polyethylene	None Required	Yes; QED MP10H	December 2010

[1] Surveyed by Robinson, Biehn & Biehn, Inc. on December 16, 2009 and Jan 7, 2011 (MW-K). Elevation marked as "X" on North side top of monument casing.

7.5 Groundwater Purging

All TTU and Landfill 5 groundwater monitoring wells will be purged prior to sampling to remove stagnant water in the well casing. Purging facilitates the collection of representative groundwater samples by promoting the movement of formation water into the well casing by removing stagnant water within the well. Once purging is complete, formation water will be collected for analysis. Dedicated pump discharge tubing shall be decontaminated prior to purging and sampling.

Because of the potential for spreading environmental contamination, proper purge water disposal is a necessary part of well monitoring. All purge water shall be contained in aboveground portable storage tanks. Purge water collected from the TTU and Landfill 5 monitoring wells may be temporally stored in aboveground storage tanks at the site pending the results of the analytical work. If the analytical results indicate that the samples are contaminated, the purge water shall be disposed into the permitted Oasis wastewater treatment system; otherwise, the stored water shall be discharged onto the ground.

Water level measurements and water quality parameters, including pH, specific conductance, and temperature shall be collected in the field during groundwater purging and sampling. The water quality parameter measurements shall be conducted in a flow-through cell attached to the discharge line of the pump system.

Table 5 summarizes well construction and equipment information for the TTU and Landfill 5 monitoring wells. As indicated in Table 5, both wells at the TTU (TTU-1 and TTU-2) are equipped with dedicated four-inch Grundfos submersible sampling pumps with dedicated pump discharge assemblies. Submersible pumps are commonly used in deep monitoring wells for compliance sampling, and prior to 2009, submersible pumps were used in all of the TTU and Landfill 5 wells. The submersible pumps were removed from Landfill 5 wells starting in December, 2008, and were replaced with dedicated two-inch QED bladder pumps designed for low-flow sampling.

Two different groundwater purging protocols shall be followed for the two different types of pumps installed at TTU and Landfill 5. For wells that have dedicated QED bladder pumps installed, purging and sampling will be conducted according to the procedures for low-flow sampling outlined in Section 4.5 of SOP-20 of the Basewide QAPP (HAFB, 2010) and included in Appendix A. Pertinent low-flow sampling procedures are summarized below, with more detailed information provided in SOP-20 in Appendix A. Purging volumes for wells with dedicated bladder pumps will be calculated by adding the volume of purge water in the tubing and pump and multiplying the total volume by two. Calculations and the total purge volumes shall be entered in the field logbook or groundwater sampling log. The following equation can be used to calculate the volume of purge water for the wells with bladder pumps:

Total Purge Volume: $V_t = 2 \times ((L_t \times \pi \times (D_t/24)^2 + V_p) \times 28.32 \text{ liters/ft}^3)$

Where:

V_t = Total Purge Volume (mL)

L_t = Length of Tubing (ft)
D_t = Inner Diameter of Tubing (inches)
V_p = Volume of Pump (ft^3)

Protocol for purging these wells is as follows:

- The static groundwater level will be measured.
- The volume of water in the pump and tubing will be calculated. The minimum volume to be purged from the well is two times the volume of the tubing and pump. See equation above.
- The criteria that must be met before sampling include stabilized water quality parameters at each monitoring point. Initial purging rates will be set and adjusted to meet the BQAPP drawdown criterion of less than 0.3 foot. If these criteria are met, the monitoring point will be sampled when the water quality parameters stabilize, as discussed in following step.
- During purging, measure the following groundwater quality parameters for stabilization: pH, temperature, electrical conductivity. The parameters shall be considered stable when three consecutive readings, collected at intervals of at least five minutes, are within:
  - Conductivity ±10%
  - pH ±0.2 units
  - Temperature ±1 degree Celsius
- Dissolved oxygen, ORP, and turbidity are measured in the field and recorded, but are not used to determine stabilized conditions.
- If the monitoring point drawdown cannot be limited to 0.3 foot, the purging will be stopped long enough to allow the monitoring point to recharge, and the purge rate will be lowered, if possible. Following recharge to a level above 0.2 foot of drawdown, purging will restart. This procedure will continue as long as a minimum of 1 liter of groundwater is removed every 20 minutes (approximately 50 milliliters per minute [mL/min]). The monitoring point will then be sampled when the water quality parameters stabilize, as discussed in bullet 5.
- If one liter of groundwater cannot be removed every 20 minutes or it is apparent that one liter of groundwater will not be able to be purged from the monitoring point in 20 minutes, the monitoring point will be pumped at the lowest flow rate possible (at least 50 mL/min) and the drawdown measured and documented at the same time the water quality parameters are measured, or as often as necessary to determine drawdown stabilization. Because the flow from a bladder pump is cyclical, the drawdown will be measured just before the pump is pressurized. This is the period when the recharge is considered to be at the maximum level. These measurements will be used to determine whether the drawdown has stabilized. Drawdown will be considered stabilized when three consecutive measurements are within 0.1 foot and a stable trend is observed. Purging rates may be able to be increased once drawdown stabilizes due to an increased hydraulic gradient. Following drawdown stabilization, the monitoring point will be sampled when the water quality parameters stabilize for three consecutive readings, as discussed in bullet 5.
- The monitoring point will be considered ready for sampling when a minimum of two purge volumes (two times the volume of the pump and tubing) have been removed and

the purge water measurements for temperature, pH, and specific conductivity are within a range of ±10 percent for the last three consecutive readings. If these conditions are not met, purging will continue until a maximum of two additional purge volumes are removed. If any of the parameters are not stabilized after removing the additional purge volumes, the contractor Project Manager will be consulted to determine whether further purging is necessary or whether sampling can be initiated. If the monitoring point is sampled without meeting the parameter stabilization criteria, the reason for not meeting the criteria will be assessed and documented in the field book in each case. In addition, a discussion of all such instances will be provided in the individual sampling data validation reports.

- The monitoring point will be sampled at the same flow rate at which the monitoring point was purged or lower. At a minimum, monitoring points will be sampled at a flow rate that generates enough volume to fill a 40-milliliter sample vial in a single cycle approximately 50 mL/min).

For wells that have dedicated Grundfos submersible pumps installed, purging and sampling will be conducted according to the procedures for electric submersible pumps outlined in Section 4.4 of SOP-20 of the Basewide QAPP (HAFB, 2010) and included in Appendix A. Pertinent sampling procedures are summarized below, with more detailed information provided in SOP-20. Borehole volumes shall be calculated as described below. Calculations and the total purge volumes shall be entered in the field logbook or groundwater sampling log.

- Obtain all available information on well construction (e.g., location, casing, screen, total depth; see Table 3).
- Determine well or casing diameter.
- Measure and record static water level (depth below surveyed measuring point).
- Calculate the purge water volume using the following formula:

Total Purge Volume: $V_t = 3(V_c + V_a n) \times 7.48\ \text{gal/ft}^3$

where:
V_t = Total Purge Volume (gals)
V_c = Volume of water in well casing (ft^3)
V_a = Volume of water in well annulus (ft^3)
n = Estimated porosity of sand pack (usually 30%)
7.48 = Conversion factor from cubic feet to gallons

Casing Volume: $V_c = \pi r_1^2 h_1$

where:
V_c = Casing Volume (ft^3)
r_1 = Inside radius of monitoring well casing (ft)
h_1 = Height of water column (i.e., total well depth minus static water level depth) (ft)

Annular Volume: $V_a = \pi(r_2^2 - r_1^2)\ h_2$

where:
V_a = Annular Volume (ft^3)
r_2 = Radius of borehole (ft)

r_1 = Outside radius of well casing (ft)
h_2 = Total vertical saturated thickness of sand pack (ft)

Pre-sampling purging will be considered complete for wells that have dedicated Grundfos submersible pumps when **three** borehole volumes have been evacuated from the well, and when three consecutive measurements (collected at least one-half a borehole volume apart) do not change by more than the following:

– pH	±0.2 units
– Specific conductance	±10%
– Temperature	±1 degree Celsius

When evacuating low yield wells (wells that pump or bail dry), the well shall be evacuated to dryness once (USEPA, 1986). Sampling shall be conducted when the well recovers to 90 percent of the pre-purge water column. If, under special circumstances, the well does not recover to 90 percent within a normal workday, the well may be allowed to recover overnight and be sampled the following morning.

7.6 Sample Collection

Groundwater sampling will be conducted after the purging of the well is complete. All purging and sampling equipment shall be decontaminated prior to purging and sampling and between sampling locations (non-dedicated equipment). Temperature, pH, and specific conductance shall be measured immediately prior to sample collection. All groundwater sample data and information collected in the field shall be recorded in the field logbook or on a sampling log.

If applicable, the pump discharge shall be reduced to minimize agitation or aeration of the sample. The sample containers shall be filled in order from the least to the most stable compounds. Sufficient volume shall be collected so that the scheduled analysis can be performed. The sample containers do not need to be filled to eliminate headspace, except for volatiles that must be sampled with no headspace. Based on USEPA guidance (USEPA, 1986), sample bottles shall be filled in the following order:

- Volatiles and Explosives
- Dissolved Metals
- General Chemistry (including Perchlorate)

Groundwater samples for dissolved metals shall be filtered in the field using a disposable 0.45-micron (µm) filter prior to filling the sample containers. As the samples will be collected with a pump, an in-line disposable filter shall be placed on the pump discharge line, and the groundwater sample shall be collected directly into the sample container from the filter discharge. All filtered groundwater samples shall be collected in pre-preserved containers prepared by the laboratory. The samples shall not be preserved prior to filtering, and the filters shall be discarded after each use.

7.7 Sample Handling and Transport

7.7.1 Sample Containers

The sample containers to be used shall be dependent on the sample matrix and analyses desired. Containers to be used for various analyses are described in Table 6. Once opened, the containers shall be used immediately. When storing before and after sampling, the containers shall remain separate from solvents and other volatile organic materials. Containers shall be kept in a cool, dry place until taken to the job site.

Table 6. Containers, Preservatives, and Holding Times for TTU and Landfill 5 Groundwater Sampling

Site	Analytical Method	Container*	Preservative	Holding Time
Landfill 5	Volatiles, 8260B	2-40 ml VOAs	Cool, 4° C, HCl, pH<2, No headspace	14 days
Landfill 5	Volatiles (EDB, DBCP, 123TCP), 504.1/8260B	2-40 ml VOAs	Cool, 4° C, HCl, pH<2, No headspace	14 days
TTU	Explosives, 8330	2-1 L amber	4° C, dark	7 days
Landfill 5/ TTU	Dissolved Metals-ICP (Al, As, Ba, Be, Cd, Cr, Fe, Pb, Ni, Se, Ag, V, Zn) 6010B	500 ml plastic	HNO_3 filtered	180 days
Landfill 5/ TTU	Dissolved Metals (Hg), 7470A	250 ml plastic	pH<2, HNO_3	28 days
Landfill 5/ TTU	General Chemistry-alkalinity, 310.1	500 ml plastic	Cool, 4° C	14 days
Landfill 5/ TTU	General Chemistry-anions (Cl, SO_4, F), 300.0/SW9056A	500 ml plastic	Cool, 4° C	28 days (2 days for NO_3, NO_2, PO_4)
Landfill 5/ TTU	General Chemistry-nitrate/nitrite, 353.2	250 ml plastic	Cool, 4° C, H_2SO_4, pH<2	28 days
Landfill 5/ TTU	General Chemistry Phosphate, 365.4/SW9056A	125 ml plastic	Cool, 4° C, H_2SO_4, pH<2	28 days
Landfill 5/ TTU	General Chemistry-TDS, 160.1	500 ml plastic	Cool, 4° C	7 days
Landfill 5/ TTU	Perchlorate, 6850	500 ml plastic	Cool, 4° C	28 days

*Container volumes may vary depending on laboratory preference

7.7.2 Numbering and Labeling

A unique sample identification number shall be developed for all groundwater samples submitted for analysis. A sample label shall be affixed to all sample containers. Labels provided by the laboratory or another supplier may be used, and at a minimum shall include the following information:

- Sample identification number;
- Date and time of sample collection;
- Type of sample (grab or composite);
- Initials of sampler;
- Preservative used; and

- Sample Analysis Method.

This information shall be written in indelible ink. After labeling, each sample shall be refrigerated or placed in a cooler containing ice to chill and maintain samples at a temperature of approximately four degrees Celsius.

7.7.3 Chain-of-Custody

Chain-of-Custody (COC) procedures allow for the tracking of possession and handling of individual samples from the time of field collection through to laboratory analysis. Documentation of custody is accomplished through a COC record that lists each sample and the individuals responsible for sample collection, transport, and receipt. A sample is considered in custody if it is:

- In a person's possession;
- In view after being in physical possession;
- Locked or sealed so that no one can tamper with it after it has been in an individual's physical custody;
- In a secured area, restricted to authorized personnel.

A COC record is used to record the samples taken and the analyses requested. Information recorded by field personnel on the COC record shall include the following:

- Client name;
- Project name;
- Project location;
- Sample location;
- Signature of sampler(s);
- Sample identification number;
- Date and time of collection;
- Sample designation (grab or composite);
- Sample matrix;
- Signature of individuals involved in custody transfer (including date and time of transfer);
- Type of analysis and laboratory method number; and
- Any comments regarding individual samples (e.g., organic vapor meter readings, special instructions).

When the sample(s) are transferred, both the receiving and relinquishing individuals shall sign the record. The sampler shall retain copies of the COC record. If the COC records are sequentially numbered, the record number shall be cross-referenced in the field logbook.

7.7.4 Sample Preservation/Storage

The requirements for sample preservation are dependent on the desired analyses and the sample matrix. Sample preservation requirements will be performed as required by the analytical method and as presented in Table 5.

7.7.5 Custody Seals

Custody seals shall be used on each shipping container to ensure custody. Custody seals consist of security tape placed over the lid of each cooler containing samples, with the initials of the sampler and the date written on the tape. The tape shall be affixed such that the seal must be broken to gain access to the contents. Custody seals shall be placed on coolers prior to the sampling team's release to a second or third party (e.g., delivery to the laboratory).

7.7.6 Sample Transport

Groundwater samples will be shipped by overnight carrier to the analytical laboratory. The following procedures will be followed for sample transport to the analytical laboratory:

- Sample labels shall be completed and attached to sample containers as described in Section 7.7.2.
- The samples shall be placed upright in a waterproof plastic ice chest or cooler.
- Wet ice in double Ziploc™ bags (to prevent leakage) shall be placed around, among, and on top of the sample bottles. Enough ice shall be used to chill and maintain samples at four degrees Celsius (± two degrees Celsius) during transport to the laboratory. Dry ice shall not be used.
- To prevent the sample containers from shifting inside the cooler, the remaining space in the cooler shall be filled with inert cushioning material, such as shipping peanuts, additional bubble pack, or cardboard dividers.
- The original copy of the completed COC record shall accompany the samples to the laboratory.
- A copy of the COC record shall be retained for the project files.

7.8 Equipment Decontamination

The following procedure will be used to decontaminate non-dedicated sampling equipment that may come into contact with groundwater samples. To minimize decontamination procedures in the field, dedicated equipment shall be used wherever feasible. The following procedure will be used to decontaminate non-dedicated equipment:

- Wash and scrub equipment with phosphate-free laboratory-grade detergent (e.g. Alconox™ or equivalent), steam cleaning may also be performed if possible;
- Triple-rinse with distilled water;
- Personnel involved in decontamination activities shall wear appropriate PPE, including nitrile gloves.

8.0 DATA MANAGEMENT

Data management tasks associated with this project will include the transfer of electronic data between analytical laboratories and the data manager, the data manager and the data validation staff, and the data manager and the Hill AFB Project Manager, Wayne Downs. To facilitate efficient data flow, the Air Force Environmental Resources Program Information Management System (ERPIMS) will be used as the basis for data management. The ERPIMS format provides a set of codes and structure for data deliverables. Data management will be performed in the following sequence:

- The field sampling team will obtain samples according to the Basewide QAPP.
- The samples obtained during the day will be continuously logged on a COC form.
- The COCs will be delivered to the data manager who will enter the data from the COCs to the database. The data manager will then track the status of the analytical samples.

Water level measurements will be corrected using correction factors determined from inclination surveys conducted in each well. These data are provided in *Inclination Survey of Landfill 5 Monitoring Wells and Cap Maintenance Report* (CH2M HILL, 1999), *Inclination Survey of Thermal Treatment Unit Monitoring Wells TTU1 and TTU2* (CH2M HILL, 2001), and *Summary of New Groundwater Monitoring Well MW-K at Landfill 5, Utah Test and Training Range Technical Memorandum (CH2M HILL, 2011).*

9.0 DATA VALIDATION

Data validation will follow the requirements as specified in the Hill AFB Basewide QAPP and the following USEPA documents:

- Contract Laboratory Program National Functional Guidelines for Organic Data Review, October 1999.

A USEPA Level III QA/QC review of all analytical data will be performed to ensure that data quality objectives are met. Validation of the laboratory reports and sample custody documentation will be performed for all of the laboratory data. The laboratory reports will be reviewed for the following:

- Calibration,
- Sample hold times,
- Target analyte list,
- Reporting limits,
- Field and laboratory blanks,
- Field duplicates,
- Surrogate spikes (organics),
- Laboratory control samples, and
- Matrix spikes.

A report that summarizes the quality control efforts and the results of data validation for this project. The report will evaluate the effect of the quality control data on the project samples and the overall quality and usability of the data.

In addition, validation flags will be entered directly into the ERPIMS database.

10.0 REPORTING

Upon receipt of the validated data, a sampling and analysis report will be prepared that describes the activity and presents the analytical data. Comparisons will be made with previous sampling events, and conclusions and recommendations will be presented as described below.

10.1 Statistical Approach for Groundwater Analysis

As a test of background exceedance, the Mann-Kendall statistical test will be applied to the analytical data to determine the occurrence of increasing concentrations over time. The Mann-Kendall test is a non-parametric test that is suitable for non-normal data sets. The test will be performed at the 95-percent confidence level and will be applied to both the control and compliance well data sets.

10.2 Contaminant Concentration Limits and Reporting

Concentration limits for individual analytes are listed in Table 3. As specified in Modules III.G.3.d and V.j.2.c of the Permit, the Executive Secretary will be notified of any statistically significant increase or concentration limit exceedance of a monitored contaminant of concern.

10.3 Cumulative Risk Analysis

The cumulative excess lifetime cancer risk (ELCR) and hazard index (HI) will be calculated and reported for groundwater from each well where non-background constituents are detected based on the site specific industrial risk parameters listed in Table 4 for each well under compliance monitoring. ELCR and HI will be calculated using methodologies described in Parts A, B, and F of *Risk Assessment Guidelines for Superfund Volume I-Human Health Evaluation Manual* (USEPA, 1989, 1991, and 2009) using toxicity values based on the most recent UTTR human health risk assessment evaluation required by Permit section II.F.2.

11.0 REFERENCES

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Appendix A

SOP-20 from the Basewide QAPP

1.0 INTRODUCTION

This standard operating procedure (SOP) is intended to serve as a reference for the proper equipment and techniques for collecting groundwater samples for chemical analysis for Hill Air Force Base (AFB). The purpose of this SOP is to enable the user to collect representative and defensible groundwater samples, and to plan the field sampling effort. The techniques presented shall be followed whenever applicable, although site-specific conditions or project-specific requirements may warrant adjustments in methodology.

To be valid, a groundwater sample must represent the water-bearing unit being sampled. The physical, chemical, and bacteriological integrity of the sample must be maintained from collection to analysis in order to minimize changes in water quality. Acceptable equipment for sample collection from completed wells includes bailers and various types of pumps. In order to obtain a representative sample of the groundwater, the sampler must accomplish the following:

- avoid collecting stagnant (standing) water in the well;
- avoid physically or chemically altering the water due to improper sampling techniques, sample handling, or transport; and;
- document that proper sampling procedures have been followed.

This SOP describes groundwater sample collection methods only. Sample handling and shipping procedures are described in SOP-15. Field documentation procedures are presented in SOP-4.

2.0 DEFINITIONS

Annular Space: The space between the casing or well screen and the wall of the drilled hole, or between the drill pipe and casing, or between two separate strings of casing. The annular space may also be referred to as the annulus.

Aquifer: A geologic formation, group of formations, or part of a formation that is capable of yielding economic quantities of water to a well or spring.

Bailer: A long, narrow, tubular device with an open top and a bottom check valve that is used to remove water from a well during purging or sampling. Bailers may be made of Teflon®, polyethylene, or stainless steel. Disposable bailers are available and are made of polyethylene.

Barcads™ System: An in-well, gas-driven device used for sampling groundwater.

Bladder Pump: A pump consisting of a flexible bladder usually made of Teflon® contained within a rigid cylindrical body (commonly made of stainless steel or PVC) that is operated using compressed air and a pump controller. The lower end of the bladder is connected through a check valve to the intake port, while the upper end is connected through a second check valve to a sampling line that leads to the ground surface. A second line, the gas line, leads from the compressed air source to the space between the bladder and the outer body of the pump. After filling under hydrostatic pressure, application of gas pressure forces the groundwater to the surface through the sample line. An air compressor or compressed air tank provides gas pressure. The pump controller automatically switches the gas pressure off and on at specific intervals.

Centrifugal Water-Supply Pump: A pump that creates a vacuum and moves liquid by accelerating it radially outward and upward in an impeller to a discharge line.

Chain-of-Custody: Method for documenting the history and possession of a sample from the time of its collection through its analysis, data reporting and final disposition.

Check Valve: Ball and spring valves on bailers and pumps that are used to allow water to flow in one direction only.

Conductivity (electrical): A measure of the quantity of electricity transferred across a unit area, per unit potential gradient, per unit time. It is the reciprocal of resistivity.

Darcy's Law: States that the rate of flow through a porous medium is proportional to the loss of head, and inversely proportional to the length of the flow path, or (eq. 1) $v = K(dh/dl)$

Where:

v = Q/A, which is the specific discharge, also known as the Darcy velocity or Darcy flux, (length/time),

Q = the volume rate of flow (length^3/time),

A = the cross sectional area normal to flow direction (length^2),

dh/dl = describes the aquifer hydraulic gradient (length/length) and,

K = describes the hydraulic conductivity of the aquifer.

Equation 1 may be rewritten as:

(eq. 2) $Q = K(dh/dl)A$

It should be noted that the specific discharge is in velocity units of length/time. It is important to also note that this is a macroscopic concept, and must be differentiated from microscopic (real) flow velocities, which consider the porosity of the medium, as:

(eq. 3) $$v = \frac{K(dh/dl)}{n}$$

where "n" is the effective porosity of the media.

Datum: An arbitrary surface (or plane) used in the measurement of heads (i.e., National Geodetic Vertical Datum [NGVD], commonly referred to as mean sea level [msl]).

Decontamination: A variety of processes used to clean equipment that contacted formation material or groundwater that is known to be or suspected of being contaminated.

Directional Isotropy: Constant horizontal conductivity through soil.

Discharge: the volume of water moving through a unit cross-section area within a given unit of time (i.e., ft^3/min). Discharge may include any sediment or other solids that may be dissolved in, or mixed within the water.

Dissolved Oxygen (DO): A measure of the quantity of oxygen dissolved in groundwater. DO data is collected in the field using direct measure probes. DO is used to assess the balance between oxygen-consuming and oxygen-producing processes.

Downgradient: In the direction of decreasing hydrostatic head.

Drawdown: The lowering of the potentiometric or piezometric surface in a well and aquifer due to the discharge of water from the well.

Electric Submersible Pump: A pump that consists of a rotor contained within a chamber and driven by an electric motor. The entire device is lowered into the well with the electrical cable and discharge tubing attached. A portable power source and control box remain at the surface. Electrical submersible pumps used for groundwater sampling are constructed of inert materials such as stainless steel, and are sealed to prevent sample contamination by lubricants.

Filter-Pack: Sand or gravel that is generally uniform, clean, and well rounded that is placed in the annulus of the well between the borehole wall and the well screen to prevent formation material from entering the well screen, and to stabilize the adjacent formation.

Groundwater Sample: A sample collected from an aquifer for chemical analysis to support remedial investigation, feasibility studies, treatability studies, remediation design and performance assessment, waste characterization, etc.

Head-Space: The empty volume in a sample container between the water level and the cap.

Hydraulic Conductivity: This property is a constant of proportionality that describes fluid flow through a porous media discovered by Henry Darcy, a French hydraulic engineer, in 1856. Hydraulic conductivity ("K" by convention) is a function of the permeability of the media and of the physical properties of the fluid. Hydraulic conductivity has the units of length/time. In a normal groundwater setting, where the physical properties of the water are considered relatively constant, hydraulic conductivity can be considered a function of the porous media. For this reason, the terms permeability and hydraulic conductivity are often used interchangeably for aquifer properties. Because hydraulic conductivity varies over 13 orders of magnitude for earth materials (Freeze and Cherry, 1979), order-of-magnitude approximations are generally considered appropriate for evaluation of aquifer properties.

Hydropunch®: An in-situ groundwater sampling system in which a hollow steel rod is driven into the saturated zone and a groundwater sample is collected.

Inert Gas: An unreactive gas.

In Situ: In the natural or original position; in place.

Low-flow Method: Method to minimize the velocity/stress on the sample water as it exits the formation into the screened interval of the well and as it enters the pump.

Monitoring Well: A well that is constructed by one of a variety of techniques for the purpose of extracting groundwater for physical, chemical, or biological testing, or for measuring water levels.

Oxidation-Reduction Potential (ORP): ORP is a measurement of the potential of a given system to oxidize or reduce. ORP data are collected in the field using direct measure probes. Positive potentials indicate the system is oxidizing, while negative potentials indicate the system is reducing.

Packer: A transient or dedicated device placed in a well or borehole that isolates or seals a portion of the well, well annulus, or borehole at a specific level.

Passive Diffusion Sampler: Technology designed to utilize passive sampling techniques that eliminate the need for well purging.

Peristaltic Pump: A low-volume suction pump. The compression of a flexible tube by a rotor results in the development of suction.

pH: A measure of the acidity or alkalinity of a solution, numerically equal to 7 for neutral solutions, increasing with increasing alkalinity and decreasing with increasing acidity.

Piezometer: A non-pumping well, generally of small diameter, that is used to measure the elevation of the water table or potentiometric surface.

Preservative: An additive (usually an acid or a base) used to protect a sample against decay or spoilage, or to extend the holding time for a sample.

Slug: A solid pipe used to displace water by insertion or withdrawal from a well. Bailers may also be used for water withdrawal only. The slug volume should be maximized based on field conditions. Different length slugs, capable of being threaded together, should be brought to the field to provide flexibility to the program. A typical slug used for a 2-inch-diameter monitoring well may be 1.5 inches in diameter and 6 to 10 feet in length. The volume of the slug or the water withdrawn from the well for each test must be recorded in the field notes.

Sonde: Device for testing physical conditions.

Static Water Level: The elevation of the top of a column of water in a monitoring well or piezometer that is not influenced by pumping or conditions related to well installation, hydrologic testing, or nearby groundwater extraction.

Temperature: A measure of the thermal energy contained in a solid or fluid.

Turbidity: Cloudiness in water due to suspended and colloidal organic and inorganic material.

Upgradient: In the direction of increasing hydrostatic head.

3.0 RESPONSIBILITIES

This section presents a brief definition of field roles, and the responsibilities generally associated with them. This list is not intended to be comprehensive and often, additional personnel may be involved. Project team member information shall be included in project-specific plans (e.g., work plan, field sampling plan, quality assurance plan, etc.), and field personnel shall always consult the appropriate documents to determine project-specific roles and responsibilities. In addition, one person may serve in more than one role on any given project.

Project Manager: Develops the groundwater sampling program with input from Hill AFB personnel and other key project staff.

Quality Control Manger: Performs project audits. Ensures that the project-specific data quality objectives are met.

Field Team Leader (FTL) and/or Geologist, Hydrogeologist, or Engineer: Implements the groundwater sampling program and supervises other sampling personnel. Insures that proper chain-of-custody procedures are observed and that samples are collected, packaged, transported, and shipped in a correct and timely manner. Prepares daily logs of field activities.

Field Sampling Technician (or other designated personnel): Assists the FTL and/or geologist, hydrogeologist, or engineer in the implementation of tasks and is responsible for the proper use, and maintenance of groundwater sampling equipment.

4.0 MONITORING WELL SAMPLE COLLECTION PROCEDURES

4.1 SAMPLING EQUIPMENT

There are several types of equipment available for well purging and sampling. Several factors that shall be considered when choosing purging and sample collection equipment include the depth and diameter of the well, the recharge capacity of the well, and the analytical parameters of interest. Few sampling devices are suitable for the complete range of groundwater parameters. Table 20-1 provides a summary of the groundwater sampling equipment that is appropriate for a specific parameter or group of parameters. For example, a peristaltic pump is acceptable for collecting major ion and trace metal samples, but it may lead to erroneous analytical results if used for the collection of samples for volatile organics analysis or dissolved gases.

Hill AFB prefers the use of positive displacement pumps such as bladder and electric submersible pumps for sample collection. These pumps minimize the aeration of the groundwater as it is sampled, and therefore provide the most representative samples. The use of other types of sample collection equipment, such as bailers or gas lift pumps, is not recommended, especially when analyzing for parameters that are sensitive to geochemical changes that can occur due to the aeration of the water within the well. In addition, the use of these sampling devices may entrain suspended materials, such as fine clays and colloids that are not representative of mobile chemical constituents in the formation of interest (Puls and Barcelona, 1989).

4.2 PRE-SAMPLING PROCEDURES

Well Inspection: Upon arrival at the well, prior to groundwater purging or sampling, sampling personnel shall document any signs of tampering or well deterioration. These observations shall be recorded in the field logbook or on a field form. A plastic sheet shall be placed around the well head to prevent contamination of the surface around the well during purging/sampling, and to keep decontaminated sampling equipment from contacting the ground surface. The following procedures are proper placement and use of plastic:

- Prior to sampling any monitoring point, the area surrounding the monitoring point will be swept clear of debris.

- Sampling equipment that may come in contact with the sample that is sent to the analytical laboratory will be kept off the ground surface.

- The tailgate of the truck will be covered with a small sheet of plastic. In addition, a small, approximately 2-foot by 4–foot, piece of plastic will be placed under the flow-through cell and sampling tubing to protect sampling equipment from contact with the ground surface. The plastic will be used to provide a clean surface for sampling. Depending on the monitoring well completion layout, the plastic may be placed surrounding the monitoring well completion or adjacent to one-side of the completion. New pieces of plastic will be used for each monitoring point.

- Any sampling equipment that falls on the ground surface will be thoroughly decontaminated by a triple-rinse with distilled water.

- At the conclusion of sampling, any water that is present on the plastic will be drained into a bucket and disposed of with the purge water.

- A larger sheet of plastic may be placed surrounding the monitoring well head during sampling of a monitoring point, as necessary based on monitoring well contamination concentrations and the work being performed. For example, if the monitoring point contains LNAPL, a larger sheet of plastic will be needed.

- The plastic will be placed on the ground surface such that the personnel performing the sampling will minimize walking or standing on the plastic.

- All plastic will be properly disposed of after sampling in accordance with the PPE disposal procedure defined in this letter.

Field Measurements — Water Level and Water-Quality Parameters: Water level measurements and water-quality parameters including pH, conductivity, temperature, turbidity, ORP, and DO shall be collected in the field during groundwater purging and sampling. The sensitivity of the water-quality parameters to changes as a result of exposure of groundwater to surface level conditions (e.g., changes in the partial pressure of dissolved gases or the conditions of the purging system) make in-situ monitoring desirable. If possible, water-quality parameter measurements should be conducted in a closed, flow-through cell attached to the discharge line of the pump system.

The accuracy, precision, and usefulness of these measurements are dependent on the proper use and care of the field instruments. All meters shall be calibrated in accordance with the manufacturer's directions. The instruments shall be handled carefully at the well site and during transport to the field and between sampling sites. All information regarding meter calibration shall be described in the field log book or field log form. All meters shall be used in accordance with the manufacturer's directions and no meters shall be used unless they are functioning properly. Equipment calibration procedures are outlined in SOP-2. The following paragraphs describe the general procedures for field parameter measurement.

Water Level: Water levels shall be measured in all wells prior to purging to calculate the purge volumes, and during and after sampling if following low flow sampling procedures. Groundwater elevation measurement procedures are described in detail in SOP-24.

pH: pH shall be measured during purging and immediately prior to sample collection using a meter with an accuracy of ± 0.1 pH units. A detailed description of pH meter calibration is provided in SOP-2. Prior to use of the pH meter, it shall be established that the meter is providing accurate measurements. All information regarding meter calibration shall be described in the field log book or field log form. All meters shall be used in accordance with the manufacturer's directions and no meters shall be used unless they are functioning properly. The following procedures shall be followed for field measurement of pH:

1. Immerse the probe in the sample. Allow for sufficient flow past the probe membrane either by stirring the sample or placing the probe in a flow-through cell.
2. Allow the meter to stabilize and record the pH to the nearest 0.1 pH units in the field logbook or on the field form.

Specific Conductivity: Specific conductivity shall be measured during purging and immediately prior to sample collection. A detailed description of specific conductivity meter calibration is provided in SOP-2. Prior to use of the specific conductivity meter, it shall be established that the meter is providing accurate measurements. All information regarding meter calibration shall be described in the field log book or field log form. All meters shall be used in accordance with the manufacturer's directions and no meters shall be used unless they are functioning properly. The following procedures shall be followed for field measurement of specific conductivity:

1. Immerse the specific conductivity probe in the sample. Allow for sufficient flow past the probe membrane either by stirring the sample or placing the probe in a flow-through cell.
2. Allow the meter to stabilize and record the specific conductivity and unit of measurement (e.g. micromhos/centimeter [µm/cm] or millimhos/cm).

Temperature: Temperature shall be measured during purging and immediately prior to sample collection with either a mercury or electronic thermometer capable of accurately reading to 0.1 degrees Celsius (°C). A detailed description of temperature meter calibration is provided in SOP-2. Prior to use of the temperature meter, it shall be established that the meter is providing accurate measurements. All temperature meters shall be used in accordance with the manufacturer's directions and no meters shall be used unless they are functioning properly. The following procedures shall be followed for field measurement of specific temperature:

1. Immerse the temperature probe or thermometer in the sample.
2. Allow the temperature to stabilize and record the temperature and unit of measurement (e.g. degrees Fahrenheit or Celsius) to the nearest 0.1 degrees in the field log book or on the field form.

Dissolved Oxygen: Dissolved oxygen shall be measured during purging and immediately prior to sample collection. Whenever possible, in-situ measurements of DO shall be collected to minimize sample handling. If this is not possible, care shall be taken during DO measurement to minimize turbulence that may lead to increased oxygen solubilization in the sample and unreliable results. Non-in-situ DO measurements should be indicated as such in field log books. A detailed description of DO meter calibration is provided in SOP-2. Prior to use of the DO meter, it shall be established that the meter is providing accurate measurements. All DO meters shall be used in accordance with the manufacturer's directions and no meters shall be used unless they are functioning properly. The following procedures shall be followed for field measurement of DO:

1. Immerse the probe in the sample and allow sufficient time for the meter to stabilize.
2. Read and record the dissolved oxygen content and unit of measurement to the nearest 0.1% for percent oxygen readings or 0.1 milligrams per liter (mg/l) for mg/l readings in the field logbook or on the field form. Note that DO is affected by temperature and it is important that the associated temperature measurements are accurate.

Oxidation-Reduction Potential: Oxidation reduction potential shall be measured during purging and immediately prior to sample collection using direct measure instruments. A detailed description of ORP meter calibration is presented in SOP-2. Prior to use of the ORP meter, it shall be established that the meter is providing accurate measurements. All ORP meters shall be used in accordance with the manufacturer's directions and no meters shall be used unless they are functioning properly. The following procedures shall be followed to obtain ORP readings:

1. Immerse the probe in the sample. Allow for sufficient flow past the membrane either by stirring the sample or placing the probe in a flow-through cell.
2. Allow the meter to stabilize and record the reading (in millivolts) in the field log book or on the field form. Apply correction (based on pH and temperature) to the ORP as required based on the manufacturer's directions.

Turbidity: Turbidity shall be measured during purging and immediately prior to sample collection using a direct read meter. Turbidity is a measure of the interaction of light with suspended solid particles in the sample, and is reported in Nephelometric Turbidity Units (NTUs). A detailed description of turbidimeter calibration is presented in SOP-2. Prior to use of the turbidimeter, it shall be established that the meter is providing accurate measurements. All turbidimeters shall be used in accordance with the manufacturer's directions and no meters shall be used unless they are functioning properly. The following provides general guidance for collecting turbidity data:

1. Place the meter probe into the sample, or place the cuvette containing the sample into the measuring chamber of the meter. Note that if a Hydrolab® meter is used, the cell must not be exposed to direct light during turbidity measurements. Exposure to direct light interferes with the turbidity probe, resulting in unreliable data. This problem can be avoided by placing the flow-through in a black plastic garbage bag while collecting turbidity measurements or covering the flow-through cell with duct-tape.
2. Allow the meter to stabilize and record the turbidity measurement in the field log-book or on the field form.

Pre-Sampling Purging Criteria: The chemical composition of the water within the well casing and in close proximity to the screened interval does not represent the overall groundwater chemistry in the target aquifer. Chemical changes occur due to the possible presence of drilling materials near the well and because certain environmental conditions, such as ORP, in the immediate vicinity of the well may differ from the conditions in the surrounding water-bearing materials. For these reasons it is necessary to purge the well until it is thoroughly flushed of stagnant water and contains water from the aquifer. The recommended amount of purging before sampling is dependent on many factors including the characteristics of the well, the hydrogeological properties of the aquifer, the type of sampling equipment being used, and the proposed analytical parameters.

For all standard sampling techniques, except low-flow sampling, determination of the total pre-sampling purge volume shall be volume-based (low-flow purging and sampling procedures are discussed in Section 4.5). A minimum of three borehole volumes shall be purged prior to sampling for all wells that do not bail or pump dry at a purge rate of ≥ 1 liter per minute. It is recommended that a flow rate as close to the actual groundwater recharge rate as possible be used to avoid further well development, well damage, or the disturbance of accumulated corrosion or reaction products in the well (Puls and Barcelona, 1989).

During purging, water-quality parameters including pH, turbidity, specific conductivity, temperature, DO, and ORP shall be measured. Pre-sampling purging will be considered complete when three borehole volumes have been removed from the well, and the final three consecutive measurements (collected at time intervals equal to or greater than the required time to purge ½ of the borehole volume) do not change by more than the following:

Conductivity	±10%
pH	±0.2 units
Temperature	±1 degree Celsius
Dissolved Oxygen	±0.2 milligrams per liter (mg/l)
ORP	±10 millivolts
Turbidity	<5 NTU

Experience at Hill AFB indicates that turbidity requirements may not be met for some wells, or if methods other than pumps are used for groundwater evacuation. If the turbidity exceeds 5 NTUs after 3 borehole volumes have been removed and the turbidity is continuing to decrease, purging should continue until turbidity stabilizes. If the stable turbidity measurements (i.e., three measurements within ±10%) exceed 5 NTUs, the Hill AFB Project Manager shall be contacted to determine what corrective actions, if any, shall be taken prior to sampling.

Borehole volumes shall be calculated following the steps described below. Calculations and the total purge volumes shall be entered in the field logbook or groundwater sampling log form.

1. Obtain all available information on well construction (e.g., casing diameter, borehole diameter, screened interval, total well depth, etc.).

2. Measure and record static water level (depth below ground level or top of casing reference point).
3. Determine depth of well by sounding using a clean, decontaminated weighted tape measure or an electronic water-level probe.
4. Calculate the purge water volume using the following formula:

Total Purge Volume: $V_t = 3(V_c + V_a n) \times 7.48 \text{ gal/ft}^3$

where: V_t = Total Purge Volume (gals)
V_c = Volume of water in well casing (ft^3)
V_a = Volume of water in well annulus (ft^3)
n = Estimated porosity of sand pack (usually 30%)
7.48 = Conversion factor from cubic feet to gallons

Casing Volume: $V_c = \pi r_1^2 h_1$

where: V_c = Casing Volume (ft^3)
r_1 = Inside radius of monitoring well casing (ft)
h_1 = Height of water column (i.e., total well depth minus static water level depth) (ft)

Annular Volume: $V_a = \pi(r_2^2 - r_1^2) h_2$

where: V_a = Annular volume (ft^3)
r_2 = Radius of borehole (ft)
r_1 = Outside radius of well casing (ft)
h_2 = Total vertical saturated thickness of sand pack (ft)

Alternatively, the casing volume can be calculated by multiplying the linear feet of water in the well by the volume per linear foot taken from Table 20-2, Table 20-3, or other similar tables. The units used for all calculations shall be consistent.

When evacuating low yield wells (wells that pump or bail dry at a purge rate $\geq$ 1 liter per minute) the well shall be purged to dryness once (USEPA, 1986, 1992). Sampling shall be conducted when the well recovers to 90 percent of the pre-purge water column thickness. If under special circumstances the well does not recover to 90 percent within a normal workday, the well may be allowed to recover overnight and be sampled the following morning. When a well is to recover overnight, the Hill AFB Project Manager shall be notified. At no time shall the well be pumped or bailed dry if the recharge rate causes the formation water to vigorously cascade down the sides of the screen, which may cause the loss of volatiles.

4.3 GENERAL CRITERIA FOR SAMPLE COLLECTION

As discussed in Section 4.1, several types of equipment may be used for groundwater sample collection. Regardless of the type of equipment used, the following procedures shall be observed during groundwater sampling:

- When using non-dedicated sampling equipment, monitoring wells shall be sampled in the order of increasing contamination.
- After well development, adequate time must be allowed for the formation to equilibrate before the well should be sampled. The length of time between well development and sampling depends on the hydraulic conductivity and gradient of the formation around the well. For wells with higher hydraulic conductivities and/or gradients, one to two days may be sufficient for the formation to return to equilibrium. Wells with lower hydraulic conductivities and/or gradients may require significantly more time to come to equilibrium. The amount of time between development and sampling will be determined by the contractor with Hill AFB Project Manager approval.
- All monitoring wells shall be sampled in a continuous sequence with no breaks between sampling greater than two consecutive calendar days, unless otherwise approved by the Hill AFB Project Manager.
- All purging and sampling equipment shall be decontaminated prior to purging and sampling, and between sampling locations (non-dedicated equipment), as outlined in SOP-3.
- All samples for dissolved metals analysis shall be field filtered and preserved.

- Temperature, pH, specific conductance, DO, ORP, and turbidity shall be measured immediately prior to sample collection.
- Preserved sample bottles shall be checked daily or weekly for the proper pH using litmus paper test strips tests of a single sample vial are adequate. Each individual sample vial can be visually checked to make sure it contains an adequate volume of preservative. When checking VOA vials, a vial shall be filled with sample water and a strip of litmus paper shall be used to test the solution; the test vial shall not be used for sample collection. The pH of other preserved bottles can be checked by pouring a drop of sample solution out of the cap onto the litmus test strip; the bottle can be used for sample collection. Acids shall have a pH of less than or equal to 2 and bases shall have a pH of greater than or equal to 13. Checks shall be performed at least once per day for each preserved sample type.
- In accordance with EPA guidance given to Hill AFB in August 2001, powder-free gloves and "low-particulate" and "suitable for clean room use" paper towels shall be used by personnel during sample collection.
- All groundwater sample data and information collected in the field shall be recorded in the field log book or on a field form. An example of a groundwater sampling field form is included as Figure 20-1.
- Sample bottles shall be filled in order of the volatility of the analytes to be tested so that containers for analysis of volatile organic compounds (VOCs) will be filled first, and those for analyses that are not pH-sensitive or subject to loss of volatile or semi-volatile components shall be filled thereafter. The sample collection order that shall be followed is based on U.S. EPA guidance (U.S. EPA, 1986) and is as follows:

    - VOCs
    - Total petroleum hydrocarbons (TPH)
    - Total organic halogens (TOX)
    - Total organic carbon (TOC)
    - Extractable organics (e.g., semi-volatile organic compounds, pesticides, herbicides, explosives)
    - Total metals
    - Dissolved metals

  - Phenols
  - Cyanide
  - Sulfate and chloride
  - Nitrate and ammonia
  - Radionuclides.

- After discussion with the EPA, sample collection into a beaker and then transferring required volume to the corresponding sample containers is no longer an approved method.

Dissolved Metals Filtering Procedures: Groundwater samples for dissolved metals shall be filtered in the field using a disposable 0.45-micron (µm) filter prior to filling the sample containers. If the samples are collected with a pump, an in-line disposable filter shall be placed on the pump discharge line and the groundwater sample shall be collected directly into the sample container from the filter discharge. If the samples are collected with a bailer, the sample shall first be transferred to a clean container. This sample shall then be filtered using either a peristaltic pump equipped with Teflon® tubing and an in-line 0.45 µm disposable filter or a hand vacuum filtration system (e.g., Nalgene ™ disposable filtration units). The inlet of the pump tubing shall be placed in the groundwater sample and the sample shall be pumped through the filter and collected into the sample container from the filter discharge. All filtered groundwater samples shall be field preserved with nitric acid to a pH of <2. Note that the samples shall not be preserved prior to filtering. The filters shall be discarded after each use.

VOC Sample Collection Procedures: Regardless of the sampling equipment type, the following procedures shall be used for VOC sample collection. It should be noted that bailers are not recommended for the collection of VOC samples (see Table 20-1). Bailers should only be used as a last resort in the collection of VOC samples and approval from the Hill AFB Project Manager must be obtained prior to using a bailer to collect samples for VOC analysis.

- If a pump is used for sampling, the pump discharge rate shall be reduced to 50 milliliters per minute (ml/min) to 100 ml/min. The flow rate should be a long and gentle flow, if possible. The pump volume and flow rate shall be adjusted to attempt to fill a VOC or methane sample vial (40 milliliters) in a single pump pulse, while minimizing the aeration of the sample. Larger sample bottles will not be filled in a single pump pulse. It is unnecessary to fill non-VOC sample bottles in a single pump pulse because non-VOC samples are not generally affected by volatilization. If a VOC or methane sample vial cannot be filled in a single pump pulse, the contractor and HAFB Project Managers will be contacted to determine if the monitoring well can be sampled using a less than 40 milliliter per cycle flow rate. If a bailer is used for sampling, a VOC sampler shall be attached to the bottom of the bailer. The VOC sampler shall be inserted in such a manner as to allow a streamlined flow of water into the sample bottle. The contents of the bailer shall be discharged slowly through the VOC sampler to the sample container to minimize aeration of the sample. During direct-push groundwater sampling, sample water may be slowly poured from the top of the stainless steel bailer, thus reducing the amount of sediment collected in the vial.
- The sample container shall be completely filled so that a convex meniscus forms over the neck of the opening to eliminate head-space.
- Position the Teflon® side of the septum (in the vial cap) against the meniscus, and screw the cap on tightly.
- Invert the sample bottle and tap lightly to check for air bubbles. The absence of an air bubble indicates an airtight seal. If an air bubble is observed, recollect the sample following the procedures described above using a new sample vial. This process shall be continued until the VOC sample vials contain no head space.
- Collected VOC samples shall be checked for effervescence (sparging). If sparging is observed, the VOC sample shall be recollected in unpreserved volatile organic analysis (VOA) vials to prevent the loss of VOCs from the sample.

Non-VOC Sample Collection Procedures: The following procedures shall be followed for the collection of samples for analyses other than VOCs or dissolved metals:

- If a pump is used, the pump discharge shall be reduced to minimize agitation or aeration of the sample. If a bailer is used for sampling, a VOC sampler shall be attached to the bottom of the bailer. The VOC sampler shall be inserted in such a manner as to allow a streamlined flow of water into the sample bottle. The contents of the bailer shall be transferred slowly through the VOC sampler to the sample container to minimize aeration of the sample. At no time should groundwater be discharged from the top of the bailer.
- The sample containers shall be filled in order from the least to the most stable compounds as described previously.
- Sufficient volume shall be collected so that the scheduled analysis can be performed. The sample containers do not need to be filled so that there is no head-space.

4.4 MONITORING WELL PURGING AND SAMPLING EQUIPMENT

Several types of equipment may be used for purging and sampling. Equipment that may be used for purging includes bailers, and bladder, electric submersible, water supply, and peristaltic pumps. The types of equipment that may be used for sampling include bailers, and bladder, electric submersible and peristaltic pumps. Centrifugal water-supply pumps shall not be used for sample collection. Specific instructions for the use of several types of equipment for purging and for sample collection are presented in the paragraphs that follow.

Bailers: Bailers represent the simplest method of purging or collecting a sample from a well. However, they may not be suitable for the collection of samples for certain analyses (see Table 20-1). The advantages associated with bailer use are:

- Relatively inexpensive to purchase and use.
- Disposable bailers minimize decontamination and potential for cross-contamination.

The limitations associated with bailer use are:

- Labor-intensive, particularly in deep wells (> 30 ft)
- Rope used to lower and raise bailer may introduce surface contaminants into well.
- Bailers are not preferable for the collection of samples for VOC analysis, but in some cases (e.g., small-diameter piezometer) are the only means available for collecting a sample. A properly decontaminated, non-dedicated pump is a more acceptable method for VOC sampling. If a bailer is necessary for collecting VOC samples, the Hill AFB Project Manager will be contacted and the reason(s) for using the bailer will be discussed. The Hill AFB and individual Project Managers will approve using a bailer for sampling VOCs on an individual monitoring point basis. The reasons for using a bailer will be documented in the field book and discussed in each of the individual data validation summary reports for the OUs.

The following general procedures shall be followed when using a bailer for well purging and sampling:

- Non-disposable bailers shall be decontaminated prior to use and between sampling each subsequent well.
- Stainless steel, Teflon®-coated stainless steel wire, or disposable nylon rope is recommended for lowering and retrieving the bailer from the well. At no time should the bailer or the line touch the ground during the sampling process. This can be done by coiling the line in a bucket or on a sheet of polyethylene. Polypropylene line may be substituted for the stainless steel wire, but should be discarded after each use. Nylon rope should be discarded and wire should be decontaminated after use.
- When lowering the bailer into the well, care should be taken to minimize agitation in the well, such as when the bailer contacts the water-table surface. The bailer should be lowered to a depth below the top of the screened interval during purging and sampling to ensure that the collected sample water is obtained directly from the screened interval of the well.

- Once pre-sampling purging criteria have been met, lower the bailer slowly into the well and fill with groundwater. Retrieve the bailer to the surface and attach a VOC sampler to the bottom of the bailer. The VOC sampler should be inserted in such a manner as to allow a streamlined flow of water into the sample bottle. Sample groundwater shall be dispensed from the bottom of the bailer, through the VOC sampler, into the sample container. Care shall be taken to minimize aeration of the sample during filling. As previously mentioned, direct-push groundwater samples may be dispensed from the top of the bailer, thus reducing the amount of sediment collected in the vial.
- If VOC samples are scheduled for collection, fill sample vials so that there is no head-space, following the guidance under Section 4.3 VOC Sample Collection Procedures.
- Collect the remaining sample fractions by discharging the contents of the bailer into the sample containers. The sample bottles need to be filled so that there is sufficient volume for the scheduled analysis; However, the sample containers do not need to be filled so that there is no head-space.

Peristaltic/Centrifugal Water-Supply Pumps: Peristaltic and centrifugal water-supply pumps are widely used for purging wells with shallow water levels (less than 30 feet). Peristaltic pumps are only suitable for the collection of certain environmental samples (see Table 20-1). Centrifugal water-supply pumps shall not be used for sample collection. The advantages associated with these pumps are:

- They are light, portable and easily adaptable.
- Minimal downhole equipment is required.
- They are capable of delivering large quantities of water against low head conditions.
- Disposable tubing minimizes lengthy decontamination procedures.

The limitations associated with the use of these pumps are:

- Centrifugal water-supply pumps cannot be used for sample collection.

- Peristaltic pumps cannot be used for pH, redox, dissolved gasses, VOC, TOC, and TOX sample collection
- Both pumps are not suitable for purging wells deeper than 30 feet.
- If new tubing is not available, decontamination may be time consuming.

After meeting pre-sampling purging criteria, the following procedures shall be followed when sampling with a peristaltic pump:

1. Reduce the flow of the peristaltic pump to minimize aeration of the groundwater sample.
2. Collect the sample fractions into the appropriate sample containers. The sample bottles need to be filled so that there is sufficient volume for the scheduled analysis; however, the sample containers do not need to be filled so that there is no head-space.

Electric Submersible Pumps: Electric submersible pumps may be used for both purging and sampling, and along with bladder pumps, are Hill AFB's preferred method of groundwater sample collection. Submersible pumps take in the sample and push the sample up a discharge tube to the surface. The power source for these pumps is electricity. Electric submersible pumps are available for 2-inch-diameter wells and larger, and can lift water up to two hundred feet. These pumps should be dedicated, wherever possible, and used in wells with high purge volume requirements.

The advantages of these pumps are:

- They allow for collection of low turbidity samples.
- They are easy to install as dedicated systems.

Limitations of these pumps are:

- Certain models may be expensive.
- Electricity is needed.

- Sediment in water may cause clogging of the pump and deterioration of the impellers.
- Decontamination of non-dedicated electric submersible pumps may be difficult and time consuming.

The procedures outlined below shall be followed for purging with electric submersible pumps.

For wells with high recharge rates (≥ 1 liter per minute), purge as follows:

1. Set the pump intake in the middle of the screened interval.
2. Record water level and potential subsequent drawdown continuously with an electric water level indicator.
3. If the static water level prior to purging is above the screened interval, acceptable drawdown shall be defined as the lowering of the water level to the top of the screened interval. If continued drawdown occurs below the top of the screened interval, the pump rate shall be decreased to stabilize the water level to prevent atmospheric contact with the filter pack and formation.
4. If the static water level prior to purging is within the screened interval, the drawdown due to purging shall not exceed a distance of 25 percent of the length of the saturated screened interval. This will prevent cascading and the potential loss of volatiles, excessive turbidity, and entrapment of air in the filter pack. The well should not be pumped dry.
5. If the pump seizes up during purging, the pump may be jiggled within the well in an attempt to free clogged sediment and resume pump operation.

For wells with low recharge rates (≤ 1 liter per minute), the following procedures shall be used to purge the wells:

1. Set the pump intake at approximately two feet above the bottom of the well. Measure the depth to water.
2. Purge the well at a rate of approximately one liter per minute (this flow rate may not be possible in deeper wells) until the water level drops to the pump intake.

3. Allow the static water level to recover to 90 percent of the original static level. If under special circumstances the well does not recover to 90 percent within a normal workday, the well may be allowed to recover overnight and be sampled the following morning. When a well is to recover overnight, the Hill AFB Project Manager shall be notified. At no time shall the well be pumped or bailed dry if the recharge rate causes the formation water to vigorously cascade down the sides of the screen, which may cause the loss of volatiles.
4. After sufficient recharge has occurred, pump at a low flow rate (e.g., 100 ml/min.) and collect water-quality parameter measurements if adequate water volume is present. Continue purging and monitoring until three consecutive readings meet the stabilization criteria. The drawdown shall be monitored continuously to ensure the water level does not drop to a level less than one foot above the pump intake. If adequate water volume is not present, sample without field parameter stabilization.

The following procedures shall be followed when collecting groundwater samples using a submersible pump:

1. Once purging requirements have been met, adjust the flow rate to maintain a steady streamlined flow from the discharge tube into the sample container. Sample collection flow rates shall be approximately 100 ml/min. In between filling containers, care shall be taken to ensure that well water does not flow onto the ground.
2. Collect samples in order of volatility. Samples for VOC analysis shall always be collected first.
3. Fill VOC sample bottles so that there is no head-space, following the guidance under Section 4.3 VOC Sample Collection Procedures.
4. Collect the remaining sample fractions. The sample bottles need to be filled so that there is sufficient volume for the scheduled analysis. However, the sample containers do not need to be filled so that there is no head-space.

Bladder Pumps: Bladder pumps are positive displacement pumps that can be used for both purging and sample collection, and along with electric submersible pumps, are preferred by Hill AFB for sample collection. Groundwater is displaced and forced up the pump discharge line by an inflatable bladder. The advantages of these pumps are:

- They allow for the collection of low turbidity samples.
- They are adjustable to very low flow rates.
- They are relatively inexpensive and easy to install as dedicated systems.

Limitations of these pumps are:

- An air compressor or another source of compressed air are required to operate the pumps
- They cannot be used at depths greater than 150 feet below ground surface unless specially designed pumps are used.
- Pump efficiency decreases with depth.
- Sediment in water may cause clogging of the valves in the pump.

For wells with <u>high recharge rates (≥ 1 liter per minute)</u>, purge as follows:

1. Set the pump intake one foot from the bottom of the screened interval for low yield wells or in the middle of the screened interval for high yield wells. Begin purging at approximately one liter per minute.
2. Once purging requirements have been met, adjust the flow rate to maintain a steady streamlined flow from the tube into the sample container during each discharge cycle of the bladder pump. Sample collection flow rates shall be 100 ml/min or less for VOC samples. VOC sample vials shall be filled completely during a bladder pump discharge cycle. In between filling containers, care shall be taken to ensure that well water does not flow onto the ground.

For wells with <u>low recharge rates (≤ 1 liter per minute)</u>, the following procedures shall be used to purge the wells:

1. Set the pump intake at approximately two feet above the bottom of the well. Measure the depth to water.
2. Purge the well at a rate of approximately one liter per minute (this flow rate may not be possible in deeper wells) until the water level drops to the pump intake.
3. Allow the static water level to recover to 90 percent of the original static level. If under special circumstances the well does not recover to 90 percent within a normal workday, the well may be allowed to recover overnight and be sampled the following morning. When a well is to recover overnight, the Hill AFB Project Manager shall be notified. At no time shall the well be pumped or bailed dry if the recharge rate causes the formation water to vigorously cascade down the sides of the screen, which may cause the loss of volatiles.
4. After sufficient recharge has occurred, pump at a low flow rate (e.g., 100 ml/min.) and collect water-quality parameter measurements. Continue purging and monitoring until three consecutive readings meet the stabilization criteria. The drawdown shall be monitored continuously to ensure the water level does not drop to a level less than one foot above the pump intake. If adequate water volume is not present, sample without field parameter stabilization.

4.5 MONITORING WELL LOW-FLOW SAMPLING

To limit the disposal of large volumes of purged water, monitoring wells can be sampled with bladder pumps using lower flow rates. Studies have shown that groundwater in the screened interval of a standard monitoring well can be representative of groundwater in the formation, even though stagnant water lies above in the casing. This occurs when flow is generally horizontal and naturally purges the screened interval. However, the insertion of a sampling device, such as a bailer or pump, can disrupt this equilibrium and cause mixing of the screened and cased interval waters. The mixture of stagnant and screened interval water can even be forced into the aquifer, resulting in chemical and microbiological effects that may affect data quality. Therefore, low-flow sampling techniques are most accurate using dedicated sampling devices that can be left in place within a monitoring well. Considerations also need to be made for switching between standard purge volume and low-flow sampling methods. If a dedicated pump has not been installed in the monitoring point, a pump is being replaced, or a pump is being repaired, the monitoring point boring log will be reviewed by the project engineer or geologist to determine well construction characteristics (i.e., total depth, length/location of the screened interval, etc.) and the depth of the main water-bearing zone. The main water-bearing zone is considered the layer that recharges the monitoring point and is normally assumed to be a sand layer, or the layer with the highest hydraulic conductivity within the screened interval. These zones are generally noted on the exploration log for the monitoring point.

The objective of low-flow sampling is to minimize the velocity/stress on the sample water as it exits the formation into the screened interval of the well and as it enters the pump. Flow rates from 0.1 to 0.5 liter/minute (l/min) are typical for this sampling procedure. When performed correctly, water sampled using the low-flow technique is produced from the screened interval without disturbing stagnant water in the well casing. By using low flow rates to stabilize drawdown at less than the goal of 0.30 feet, only screened interval water will be sampled. Project-specific work plans should be developed in cases where low-flow sampling with less than 0.30 feet of drawdown cannot be achieved. Under these cases, the individual Hill AFB Project Manager must approve of alternative sampling methods prior to sampling.

The following procedures shall be used while performing low-flow purging and sampling:

1. If a dedicated pump has not been installed in the monitoring point, a pump is being replaced, or a pump is being repaired, the monitoring point boring log will be reviewed by the project engineer or geologist to determine well construction characteristics (i.e., total depth, length/location of the screened interval, etc.) and the depth of the main water-bearing zone. The main water-bearing zone is considered the layer that recharges the monitoring point and is normally assumed to be a sand layer, or the layer with the highest hydraulic conductivity within the screened interval. These zones are generally noted on the exploration log for the monitoring point.

2. The monitoring point dedicated pump intake will be adjusted to the depth of the middle of the main water-bearing zone. If a dedicated pump is not installed in the monitoring point, a pump will be installed. Following pump installation, replacement, or repair, the monitoring point will be allowed to equilibrate for 1 week before sampling.

3. The static groundwater level will be measured.

4. The volume of water in the pump and tubing will be calculated. The minimum volume to be purged from the well is two times the volume of the tubing and pump (available from the manufacturer). The tubing volume shall be determined by multiplying the volume per foot of tubing (available from the manufacturer) by the total length of tubing.

5. For situations where the water level is above the top of the screened interval, the volume of water in the casing will also be calculated. The monitoring point water level will be continuously monitored during purging to determine whether recharge is occurring. For a 2-inch casing, the purge volume should be less than approximately 610 milliliters per foot (mL/ft) of drawdown to indicate recharge to the monitoring point. Purge volumes greater than or equal to 610 mL/ft of drawdown indicate the removal of only stagnant water within the casing and the lack of recharge to the monitoring point

6. The criteria that must be met before sampling include stabilized water quality parameters and stabilized drawdown at each monitoring point. Initial purging rates will be set and adjusted to meet the *BQAPP* drawdown criterion of less than 0.3 foot. If these criteria are met, the monitoring point will be sampled when the water quality parameters stabilize, as discussed in following step (Step 7)

7. During purging, measure the following groundwater quality parameters: pH, temperature, electrical conductivity, turbidity, DO, and ORP. The parameters shall be considered stable when three consecutive readings, collected at intervals of at least five minutes, are within:

Conductivity	±10%
pH	±0.2 units
Temperature	±1 degree Celsius
Dissolved Oxygen	±0.2 mg/l
ORP	±10 millivolts
Turbidity	<5 NTU.

Samplers will meet the DO reading requirement of ±10 percent for three consecutive readings before the monitoring well can be sampled whenever possible. However, after removing the required purge volumes and stabilizing the remaining water quality measurements, DO readings not meeting the requirement may not preclude the sampling of the monitoring point. Samples may be collected in this instance following an assessment on a case-by-case basis. Every reasonable effort will be made to allow DO readings to stabilize before sampling. If the DO readings have not stabilized after the required purge volumes have been removed, additional groundwater will be purged in an attempt to meet stabilization requirements. If the stabilization criterion has not been met after removing one additional borehole volume for standard purging or two additional purge volumes for low-flow purging, the Hill AFB Project Manager and/or the Project Manager will be consulted to determine whether further purging is necessary or whether sampling can be initiated. If the monitoring well is sampled without meeting the DO reading criteria, the reason for the lack of stabilization will be assessed and documented in the field book in each case. In addition, a discussion of all such instances will be provided in the individual sampling data validation reports for the OUs.

Additionally, if the turbidity is not ≤5 NTU, but is stable (within ± 10 percent between readings) within the three previously consecutive readings, and all other parameters are stable, the samples shall be collected. Once parameters have stabilized, collect the samples. Every reasonable effort will be made to allow turbidity readings to decline below 5 NTUs before sampling. If turbidity readings are near the 5 NTU criterion and declining, additional groundwater will be purged from the monitoring well to attempt to meet the 5 NTU criterion. In these instances, if the 5 NTU criterion has not been met after removing one additional borehole volume for standard purging or two additional purge volumes for low-flow purging, the Hill AFB Project Manager and/or the contractor Project Manager will be consulted to determine whether further purging is necessary or whether sampling can be initiated. If the monitoring well is sampled without meeting the 5 NTU turbidity criterion, the reason for not meeting the criteria will be assessed and documented in the field book in each case. In addition, a discussion of all such instances will be provided in the individual sampling data validation reports for the OUs.

8. If the monitoring point drawdown cannot be limited to 0.3 foot, the purging will be stopped long enough to allow the monitoring point to recharge, and the purge rate will be lowered, if possible. Following recharge to a level above 0.2 foot of drawdown, purging will restart. This procedure will continue as long as a minimum of 1 liter of groundwater is removed every 20 minutes (approximately 50 milliliters per minute [mL/min]). The monitoring point will then be sampled when the water quality parameters stabilize, as discussed in Step 7.

9. If one liter of groundwater cannot be removed every 20 minutes or it is apparent that one liter of groundwater will not be able to be purged from the monitoring point in 20 minutes, the monitoring point will be pumped at the lowest flow rate possible (at least 50 mL/min) and the drawdown measured and documented at the same time the water quality parameters are measured, or as often as necessary to determine drawdown stabilization. Because the flow from a bladder pump is cyclical, the drawdown will be measured just before the pump is pressurized. This is the period when the recharge is considered to be at the maximum level. These measurements will be used to determine whether the drawdown has stabilized. Drawdown will be considered stabilized when three consecutive measurements are within 0.1 foot and a stable trend is observed. Purging rates may be able to be increased once drawdown stabilizes due to an increased hydraulic gradient. Following drawdown stabilization, the monitoring point will be sampled when the water quality parameters stabilize for three consecutive readings, as discussed in Step 7.

10. If drawdown does not stabilize, the monitoring point will be sampled using a normal purge method as described in the *BQAPP* until three borehole volumes are removed or the drawdown reaches the top of the pump, whichever occurs first. The monitoring point will be sampled in the first case when the water quality parameters (1) stabilize as discussed in Section 2.5.2.16 or (2) are allowed to recharge to 90 percent of the initial static water level and sampled in accordance with the *BQAPP* SOP 20, Section 4.4.3 without regard to parameter stabilization. This is the least favorable condition for sampling and should only be used as a last resort. Based on previous experience, few if any Hill AFB monitoring points will need to be sampled using this method.

11. The monitoring point will be considered ready for sampling when a minimum of two purge volumes (two times the volume of the pump and tubing) have been removed and the purge water measurements for temperature, pH, specific conductivity, DO, and oxidation-reduction potential are within a range of ±10 percent for the last three consecutive readings. If these conditions are not met, purging will continue until a maximum of two additional purge volumes are removed. If any of the parameters are not stabilized after removing the additional purge volumes, the contractor Project Manager will be consulted to determine whether further purging is necessary or whether sampling can be initiated. If the monitoring point is sampled without meeting the parameter stabilization criteria, the reason for not meeting the criteria will be assessed and documented in the field book in each case. In addition, a discussion of all such instances will be provided in the individual sampling data validation reports.

12. During purging, water quality parameters will be measured in accordance with the *BQAPP*. The readings will be recorded no less than three times per purge volume.

13. The monitoring point will be sampled at the same flow rate at which the monitoring point was purged or lower. At a minimum, monitoring points will be sampled at a flow rate that generates enough volume to fill a 40-milliliter sample vial in a single cycle (approximately 50 mL/min).

5.0 HYDROPUNCH® GROUNDWATER- SAMPLING SYSTEM

5.1 BACKGROUND

The Hydropunch® allows for the collection of in-situ groundwater samples by using a specially designed sample tool to provide a hydraulic connection with the adjacent water table. Both groundwater and floating layer hydrocarbons may be sampled using the Hydropunch®. Two types of Hydropunch® are available: Hydropunch® I and Hydropunch® II. The Hydropunch® I allows for only one sample of very low volume to be collected while the Hydropunch® II allows for the withdrawal of as much groundwater as is required for the analyses being conducted.

In the Hydropunch® I Groundwater Sampling System, the sample tool is pushed to the desired sampling interval (at least 5 feet of submergence) and then retracted several feet to expose an inlet screen. The interior of the sample tool fills with water. As the Hydropunch® is recovered, check valves keep the sample from draining. Discharge to sample containers is accomplished through a stopcock.

The Hydropunch® II uses the same type of system as the Hydropunch® I to collect groundwater samples except the sampler is lowered and pushed into the groundwater on hollow push rods. The rods are then retracted to expose a stainless steel inlet screen. A bailer or peristaltic pump can be used to collect groundwater samples. Typically, a stainless steel bailer is lowered down the hollow push rods and into the exposed screened interval of the Hydropunch® II. The bailer can be lowered to the water table as many times as required to obtain a sufficient volume of water for analyses.

Both systems may be pushed through as much as 200 feet of soft sediments to collect groundwater samples. In coarse sand, gravel, consolidated rock, or at depths greater than 60 feet, a pilot hole may be drilled prior to driving the Hydropunch® into the saturated zone.

The advantages of Hydropunch® include:

- Low cost
- The ability to collect a relatively undisturbed in-situ groundwater sample.
- The relative speed with which a sample can be collected when compared to drilling, installing, developing, purging, and sampling a monitoring well.

The disadvantages of Hydropunch® include:

- Data collected using this sampling method is considered screening level, and data use is limited.
- An accurate water level cannot be obtained.
- Sampling cannot be repeated if problems occur with the samples after they are collected.
- It does not allow for long-term groundwater monitoring.

The Hydropunch® is ideal for screening for contaminants or defining a contaminant plume without installing a large number of monitoring wells.

5.2 HYDROPUNCH® SAMPLE COLLECTION PROCEDURES

The Hydropunch® groundwater system was discussed in detail in Section 6.1. The procedures outlined below shall be followed when sampling using the Hydropunch® I or II. A maximum of two hours should be allowed for formation groundwater to fill the inside of the screen.

1. For samples collected using bailers, lower a bailer with check valves to the water table. Allow the bailer to fill with groundwater. Retrieve the bailer to the surface and transfer the sample directly into a sample container. Check valves keep the water from draining as the bailer is retrieved. Collect the scheduled sample fractions by displacing the valve at the bottom of the bailer. If the check valve is clogged with sediment, sample water collected in the bailer may be slowly poured

from the top of the stainless steel bailer, thus reducing the amount of sediment collected in the vial.

2. If a peristaltic pump is used, the inlet end of the tubing is lowered down the hollow push rods to the exposed screened interval (Hydropunch® II). A peristaltic pump shall not be used to collect VOC samples and the maximum depth at which a peristaltic pump can be used is approximately 30 feet for other sample fractions. When project-specific pre-sampling purging criteria have been met, reduce the flow rate of the pump and transfer the sample to the sample containers following the procedures described under Section 4.3 VOC Sample Collection Procedures for VOC samples and Section 4.3 non-VOC Sample Collection Procedures for non-VOC samples.
3. To prevent sparging of VOCs, all samples collected for VOC analysis using the Hydropunch® groundwater system shall be collected in unpreserved (i.e., no hydrochloric acid) vials.

6.0 PASSIVE DIFFUSION GROUNDWATER SAMPLING PROCEDURE

6.1 BACKGROUND

This standard operation procedure (SOP) is intended to serve as a reference for choosing the appropriate passive diffusion groundwater (DG) sampling devise and utilizing the proper equipment and techniques for collecting DG samples for chemical analysis for Hill Air Force Base (AFB). The purpose of this SOP is to enable the user(s) to collect representative and defensible DG samples and to plan the field sampling effort. The techniques presented shall be followed whenever applicable, although site-specific conditions or project-specific requirements may warrant adjustment in methodology.

Although there are several types of diffusion samplers which offer individual advantages, the overall advantages of passive DG samplers include:

- Passive diffusion samplers have the potential to eliminate or substantially reduce the amount of purge water associated with sampling.

- Passive diffusion samplers are relatively inexpensive.
- Passive diffusion samplers are easy to deploy and recover.
- A minimal amount of field equipment is required.
- Multiple passive diffusion samplers, distributed vertically along with the screened or open interval, may be used to evaluate the movement of contaminants into and out of the monitoring well (MW) screen or open interval or to profile the zone of highest concentration in the MW.
- Proven sampling method.

The limitations of these methods include:

- Passive diffusion samplers rely on the free movement of water through the well screen.
- In well screens transecting zones of different permeability, concentrations of analytes in water could represent concentrations in a part of the aquifer not adjacent to the diffusion sampler.

To be valid, a passive DG sample must represent the water bearing zone being sampled. The physical and chemical integrity of the sample must be maintained from collection to analysis to minimize changes in water quality. To obtain a representative sample of the groundwater, the sampler(s) must accomplish the following:

- Avoid collecting stagnant water in the MW.
- Avoid physically or chemically altering the water due to improper sampling techniques, sample handling, or transport.
- Document that proper sampling procedures have been followed.

This SOP describes passive DG sample collection methods only. Sample handling and shipping procedures are described in SOP-15. Field documentation procedures are presented in SOP-4.

6.2 PASSIVE DIFFUSION GROUNDWATER SAMPLING DEVICES

There are several types of samplers available for DG sampling. Several factors that shall be considered when choosing a DG sampling device include; the diameter of the MW, screened interval, and analytical parameters of interest. Diffusion groundwater sampling devices are not suitable for measuring all groundwater parameters. Table 20-4 provides a summary of DG samplers that are appropriate for a specific parameter or group of parameters.

Passive Diffusion Bag (PDB) Sampler: Passive diffusion bag samplers have the potential to be used for cost-effective long-term monitoring of most volatile organic compounds (VOCs) in groundwater. The sampler consists of a semi-permeable membrane tube made from low density polyethylene (LDPE) that is filled with laboratory grade deionized water. The pore size of the LDPE is approximately 0.001 micron, which does not permit the flux of water molecules. The groundwater sample obtained constitutes a point sample that represents ambient conditions better than conventional methods because there is little to no mixing of groundwater within the MW. The PDB sampler eliminates or substantially reduces the amount of water removed from the well and the amount of decontamination waste generated.

Samplers are not susceptible to matrix interferences caused by turbidity because the membrane used is not permeable to colloids or other particles larger in diameter than approximately 0.001 micron. The samplers are also not subject to volatilization loss by effervescence when the samples are acidified for preservation because the turbidity containing carbonate minerals is excluded. Passive Diffusion Bag samplers can only be used in 2-inch MWs or larger with screened intervals equal to or grater than 3 feet. The PDB samplers are not appropriate for all compounds. The following VOCs have not shown a good correlation in laboratory testing between PDB samplers and other sampling techniques (standard purging and low flow):

- acetone
- methyl tert-butyl ether (MTBE)
- styrene

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- methyl iso-butyl ketone (MIBK)

Rigid Porous Polyethylene (RPP) Sampler: Rigid porous polyethylene samplers have recently been tested in a laboratory setting by the United States Geological Survey (USGS). The sampler consists of a rigid polyethylene tube having a pore size of 6 to 15 microns. Given the relatively large pore size, the RPP samplers could potentially be used to sample for volatile and non-volatile analytes. Bench-scale tests results indicate the sampler can be used for VOCs (including MTBE), chromium, and chloride (Vroblesky, 2004). Limitations of RPP samplers are:

- The porous polyethylene sampler pores will retain air even when submerged. The entrapped air reduces the permeability of the samplers and should be removed prior to use by flushing the sampler with water.
- Tests performed to date indicate that the maximum feasible sampler dimensions are approximately 1.5 inches outside diameter (OD) by 7.5 inches long. Use of a longer sampler would result in leakage of water out of the sampler due to higher head pressure present in the sampler (Vroblesky, 2004).
- The sampler can only be in 2-inch MWs or larger with screen intervals equal to or greater than 3 feet.

Polysulfone Membrane (PsM) Sampler: Testing of PsM samplers in a laboratory setting at Texas Tech University has indicated that dissolved concentrations of non-volatile groundwater constituents can pass through a polysulfone (e.g., HT® Tuffryn) membrane having a sufficient pore size (Jackson, 2003). The PsM sampler appears to be a viable method for monitoring hexavalent chromium, metals, and anions in the groundwater. A PsM sampler may be constructed by following the steps below:

- Cut a 2-inch OD PVC pipe 2 inches long.
- Cover one end of the tube with flexible polysulfone membrane with a pore size of 0.2 micron. Hold the membrane in place by sliding a 2-inch PVC coupling over the end of the tube.

- Before deploying, fill the tube with deionized water (approximately 108 ml). Cover the other end with flexible polysulfone membrane with the same pore size. Place a 2-inch coupling over the end of the tube to hold the membrane in place.
- The tube(s) should be deployed such that the membrane is positioned orthogonally to horizontal groundwater flow.

Due to the lack of field- or bench-scale testing of PsM samplers, the potential advantages or disadvantages of this sampler have not been completely evaluated. The PsM sampler can only be used in 3-inch MWs or larger with screen intervals equal to or greater than 1 foot.

Regenerated Cellulose (RC) Sampler: Regenerated cellulose samplers have been successfully tested in MWs for inorganic and volatile organic constituents in groundwater (Vroblesky, 2002; Ehlke, 2004). The sampler consists of perforated PVC pipe inside a sleeve of high-grade regenerated cellulose tubular dialysis membrane with an outer protective LDPE mesh. A RC sampler may be constructed by following the steps below:

1. Cut the cellulose tubular dialysis membrane to a length of 2 feet.
2. Thoroughly decontaminate the membrane with deionized water.
3. Tie one end of the tube in a knot.
4. Cut a PVC perforated pipe to a length long enough to fit inside the dialysis tube. Slide the pipe into the dialysis tube for structural support.
5. Fill the sampler with deionized water at the time of sampler deployment. Ensure that there are no bubbles remaining inside the tube.
6. Tie the other end of the tube into a knot.
7. Slide the sampler into a LDPE mesh long enough to protect it from abrasion.

During short term deployment, the susceptibility of the cellulose membrane to biodegradation does not significantly affect the sampler's usefulness in at least some groundwater environments; however, the sampler may begin to biodegrade in some groundwater systems (Vroblesky and Pravecek, 2002). The maximum length of time a RC sampler(s) shall be deployed will be two weeks because of potential biodegradation of the cellulose membrane. The RC sampler can only be used in 2-inch MWs or larger with screen intervals equal to or greater than 3 feet.

Nylon-Screen (NS) Sampler: Nylon-screen samplers are capable of obtaining concentrations of inorganic solutes and VOCs in groundwater that closely correspond to low-flow sampling. Particular care must be taken when sampling for iron and other metals, because of the potential for iron precipitation by oxygenation, and when dealing with chemically stratified sampling intervals. Concentrations of oxygen-sensitive inorganic solutes in a MW may be underestimated due to rainwater infiltration. The NS sampler can only be used in 2-inch MWs or larger with screen intervals equal to or greater than 3 feet. A NS sampler may be constructed by following the steps below:

1. Cut three or four 2- by 2-inch sections of 125- to 250-micron nylon screen.
2. Remove the caps to each of the 30-ml polyethylene wide-mouth open top jars.
3. Before deployment, fill each of the wide-mouth open top jars with deionized water. To ensure the removal of all bubbles, the jars shall be filled in a bucket of deionized water.
4. Place the nylon-screens on each of the wide-mouth bottles while they are under deionized water.
5. Secure the cap to the wide-mouth jars with the nylon-screen in between the cap and jar while under deionized water.
6. When the samplers are to be filled with anaerobic water, helium will be bubbled through the deionized water in the bucket until the dissolved-oxygen concentration is reduced to less than 0.5 mg/l. Anaerobic deionized water will be used when groundwater conditions are known to be anaerobic also.
7. Place the three or four samplers into a 2-inch flexible LDPE mesh with the cap facing downwards for 2-inch MWs. Space the jars approximately 0.5 to 1 inch apart. The jars may be secured in place with nylon cable ties threaded through the

LDPE mesh and around the jars. For 4-inch or larger MWs the caps can be either facing downwards or orthogonal to the direction of groundwater flow.

8. Close both ends of the LDPE mesh with cables ties to ensure that the jars do not slip out of the mesh.

6.3 REQUIRED SAMPLING EQUIPMENT

The following equipment will be needed for DG sampling:

- Stainless-steel weights: These weights are reusable, but must be decontaminated in accordance with SOP 3.0 before first use or before using in a different MW.
- Nylon cable ties, to attach diffusion samplers to the weighted line.
- Fishing line (50 pound test or higher), stainless steel cable (1/32-inch diameter or larger), or 0.25-inch LDPE tubing may be used to hang samplers

6.4 PREDEPLOYMENT PROCEDURES

Well Inspection: Upon arrival at the MW, prior to diffusion sampler deployment and retrieval, sampling personnel shall document any signs of tampering or well deterioration. These observations shall be recorded in the field log book or on a field form. A plastic sheet shall be placed around the wellhead to prevent contamination of the surface around the well during deployment, sampling, retrieval, and to keep decontaminated sampling equipment from contacting the ground surface.

Water Level: Water levels shall be measured in all MWs prior to deployment and retrieval of diffusion sampler. This information will be used to determine how much of the MW screen is in the saturated zone.

Total Depth: Total depth of the well shall be measured and compared to the well construction data in all MWs prior to deployment of diffusion samplers. This will provide information on whether sediment has accumulated in the bottom of the well.

Saturated Monitoring Well Screen Length: The saturated MW length shall be calculated following the steps described below. Calculations and saturated MW length shall be entered in the field log book or groundwater sampling log form.

If the water level is above the top of the MW screen, then the saturated MW screen length is calculated as follows:

$L_{sat} = D_{se} – D_{sb}$

where:

L_{sat} = Saturated MW screen length (ft)

D_{se} = Depth to bottom of MW screen or top of sediment, whichever is higher (ft bgs)

D_{sb} = Depth to top of MW screen (ft bgs)

If the water level is lower then the top of the MW screen, then the saturated MW screen length is calculated as follows:

$L_{sat} = D_{se} – WL$

where:

L_{sat} = Saturated MW screen length (ft)

D_{se} = Depth to bottom of MW screen or top of sediment, whichever is higher (ft bgs)

WL = Water level in the MW (ft bgs)

Maximum Number of Diffusion Samplers: The maximum number(s) of diffusion samplers that can be installed in a MW can be calculated by follow the steps below.

Maximum Diffusion Samplers = $(L_{sat} – DS_l)/DS_l$

where:

L_{sat} = Saturated MW screen length (ft)

DS_l = Diffusion sampler length (ft)

Round the calculated value down to the next whole number. This is the maximum number of diffusion samplers that can be installed.

Number of Diffusion Samplers: Determine the number and intervals of diffusion samplers to be installed in the MW. The value shall not be greater than the maximum number of diffusion samplers.

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6.5 GENERAL CRITERIA FOR DIFFUSION SAMPLER DEPLOYMENT

The following procedures shall be followed during diffusion sampler deployment:

- After well development, adequate time must be allowed for the formation to equilibrate before deployment of diffusion sampler. The length of time between well development and deployment depends on the hydraulic conductivity and gradient of the formation around the MW. For wells with high groundwater flow rates, one to two days may be sufficient for the formation to return to equilibrium. Wells with slow groundwater flow rates may require significantly more time to come to equilibrium. The amount of time between development and deployment will be determined by the contractor with Hill AFB Project Manager approval.
- All equipment shall be decontaminated prior to deployment, sampling, and between deployment locations, as outlined in SOP-3.
- In accordance with EPA guidance given to Hill AFB in August 2001, powder-free gloves and “low-particulate” paper towels shall be used by personnel during sample collection.
- All groundwater data and information collected in the field shall be recorded in the field log book or on a field form.

6.6 DIFFUSION SAMPLER DEPLOYMENT PROCEDURE

This section shall be used to install diffusion sampler(s) in a MW.

1. Tie knot at bottom of the line for attachment of the stainless steel weight. Calculate the distance from the bottom of the MW, or top of the sediment in the MW, up to the point where the shallowest diffusion sampler is to be installed.
2. Move up the line placing loops (stainless steel cable), knots (fishing line), or drilling holes (LDPE pipe) at the top of each sampling interval.
3. Record in the field book the depths at which each sampler is to be installed. The samplers will be labeled from the shallowest to the deepest in accordance with SOP-5.

4. Tie a stainless steel weight to the end of the line. This weight should rest on the bottom of the MW or on the sediment in the MW when installed.
5. Immediately prior to placing the line and weight down the MW, the diffusion samplers should be attached to the knots. They are attached using the following procedure:

   - Insert the cable ties through the loops, knots, or holes in the line.
   - Weave the ends of the cable ties through the diffusion sampler attachment holes and tighten the cable ties. Ensure that the diffusion sampler is securely attached to the knot.
   - Trim the excess from the cable tie.
6. Lower the weight and rope down the well until the weight rests on the bottom. The diffusion samplers should now be positioned at the targeted depth.
7. Secure the assembly in this position. A suggested method is to attach the line to the bolt running through the locking compression cap on the inside of the cap. Reattach well cap and lock the MW.
8. Allow the MW system to remain undisturbed as the diffusion sampler(s) equilibrate. Equilibrium time is the sum of the time required by the diffusion sampler to equilibrate with ambient groundwater and for the well to recover from the disturbance caused by diffusion sampler installation. The recommended equilibration time for the sampler is two weeks, but may be longer or shorter depending on site specific conditions.

6.7 DIFFUSION SAMPLER RECOVERY PROCEDURES

This section shall be used to recover diffusion sampler(s) in a MW.

1. Remove, by pulling to the surface, the weighted line and diffusion sampler(s) from the MW. Ensure that the samplers are not exposed to extreme heat or agitated when brought to the ground surface.
2. Record in the field book or field form the time when the sampler line was recovered.

3. Cut the cable ties to remove the diffusion samplers from the line. Examine the surface of the diffusion sampler membrane for evidence of any type of film, such as algae, oil, discoloration, etc., that may have affected the performance of the diffusion membrane. Record observations in the sampler's field log book or field form.
4. Depending on the type of diffusion sampler deployed, a decontaminated scissor shall be used to cut open the sampler.
5. The samples shall be collected in accordance with the following section.
6. All samples should be documented in accordance with SOP-4.
7. Excess groundwater shall be collected and contained in accordance with Section 6.9.
8. Repeat this process until all sampler(s) are removed from the MW.

6.8 DIFFUSION SAMPLER SAMPLE COLLECTION

The following procedures shall be followed during diffusion sampler recovery and sample collection:

- All samples for dissolved metals analysis shall be field filtered and preserved.
- In accordance with EPA guidance given to Hill AFB in August 2001, powder-free gloves and "low-particulate" paper towels shall be used by personnel during sample collection.
- All groundwater sample data and information collected in the field shall be recorded in the field log book or on a field form.
- All groundwater samples shall be placed in a cooler with ice at a temperature of 4 degrees Celsius.

1. Sample bottles shall be filled in order of the volatility of the analytes to be tested so that containers for analysis of VOCs will be filled first, and those for analyses that are not pH-sensitive or subject to loss of volatile or semi-volatile components shall be filled thereafter. The sample collection that shall be followed is based on EPA guidance (U.S. EPA, 1986) in Section 4.3

Minimum amounts of water required for each analysis can be found in Table 20-5.

VOC Sample Collection Procedures: Regardless of the sampling equipment type, the following procedures shall be used for VOC sample collection.

- If a diffusion sampler is used, the contents of the diffusion sampler shall be discharged slowly through the diffusion sampler into the sample container to minimize aeration of the sample. All VOC samples shall be collected in preserved VOA vials.
- The sample container shall be completely filled so that a convex meniscus forms over the neck of the opening to eliminate head-space.
- Position the Teflon® side of the septum against the meniscus, and screw the cap on tightly.
- Invert the sample bottle and tap lightly to check for air bubbles. The absence of an air bubble indicates an airtight seal. Due to the small amounts of water collected from diffusion samplers, if an air bubble is observed, do not recollect the sample. Unscrew the cap and fill the bottle to form a convex meniscus over the neck and re-screw on the cap. Check for bubbles again. If problem persists call the FTL.

Non-VOC Sample Collection Procedures: The following procedures shall be followed for the collection of samples for analyses other than VOCs or dissolved metals:

- If a diffusion sampler is used the contents of the sampler shall be discharged slowly through the diffusion sampler into the sample container to minimize aeration of the sample.
- The sample containers shall be filled in order from least to the most stable compounds as described previously.
- Sufficient volume shall be collected so that the scheduled analysis can be performed.

Dissolved Metals Filtering Procedures: Groundwater samples for dissolved metals shall be filtered in the field using a disposable 0.45 micron filter prior to filling the sample containers. If the samples are collected with a diffusion sampler, the sample shall be first transferred to a clean container. The sample from the diffusion sampler shall than be filtered using either a peristaltic pump equipped with Teflon® tubing and an in-line 0.45 micron disposable filter or a hand vacuum filtration system. The inlet of the pump tubing shall be placed in the groundwater sample and the sample shall be pumped through the filter and collected into the sample container from the filter discharge. All filtered groundwater samples shall be field preserved with nitric acid to a pH of <2. Note that the samples shall not be preserved prior to filtering. The filters shall be discarded after each use.

6.9 EXTRA GROUNDWATER HANDLING AND DISPOSAL

Because of the potential for spreading environmental contamination, proper purge groundwater disposal is a necessary part of groundwater sample collection. All purge water shall be contained in either an above-ground portable storage tank or a fixed above-ground storage tank. It is acceptable to contain small amounts of purged groundwater in small sampling containers (e.g., covered 5 gallon buckets, 5-gallon plastic distilled water bottles). For most groundwater sampling activities at Hill AFB, purge water shall be disposed of at the Industrial Wastewater Treatment Plant (IWTP) as specified in the *Final Basewide Investigation-Derived Waste Work Plan* (Radian, 1995), unless otherwise stipulated in project-specific plans.

7.0 BARCAD GROUNDWATER SAMPLING PROCEDURE

7.1 BACKGROUND

Current monitoring well sampling procedures that are used at OU 10 are outlined in the *Basewide Quality Assurance Project Plan* (*BQAPP*) and in the *Calendar Year 2003 Basewide Groundwater Monitoring Workplan (Work Plan)* (CH2M HILL, 2003). Existing monitoring wells at OU 10 consist of either 2 or 4-inch diameter wells equipped with 500-milliliter bladder pumps that are sampled using a low-flow method. The low-flow sampling procedures are outlined in the *Work Plan.*

Because of the inherent mechanical differences between the bladder pumps and the Barcads™, different sampling procedures are necessary. Groundwater sampling procedures have been developed for the Barcads™ by BESST Inc. and will be used as the initial standard operating procedures (SOPs) for collecting groundwater samples from the Barcads™. These procedures will be used in conjunction with the *BQAPP* and the *Work Plan* procedures for the collection, handling, and shipping of groundwater samples at OU 10. Upon further experience and use with the Barcads™, additional procedures may be developed and recommended for efficiency and to ensure quality assurance throughout the groundwater sampling process. Outlined below are the operating procedures that will be used to sample the Barcads™ and procedures for measuring groundwater levels and performing slug tests. Additionally, a reference list is attached that describes case studies where the Barcads™ have been installed.

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- Siegrist, R.L. and Jenssen, P.D., 1990, Evaluation of Sampling Method Effects on Volatile Organic Compound Measurements in Contaminated Soils, Environmental Science Technology, v. 24, no. 9, pgs 1387-1392

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7.2 PROCEDURE FOR PURGING AND SAMPLING THE BARCAD SYSTEM

The process includes the application of an inert gas, under pressure, to the top of the water column inside the riser pipe. This application allows water in the riser pipe to return through the sample return tube. The inert gas is typically nitrogen.

To begin the process, the nitrogen tank valve is opened (typically one 360-degree turn is satisfactory). The typical tank volume used for most Barcad applications is 55 cubic-feet. When starting with a full tank of nitrogen gas, the typical starting tank pressure is about 2,200 PSI – as indicated by the tank gauge. Next, the tank regulator is slowly opened by rotating the regulator T-handle clockwise. This action depresses a spring inside of the regulator which slowly opens the regulator valve. As the regulator T-handle is opened, the line gauge needle will begin to climb to the required pressure needed to lift the groundwater to the surface from the riser pipe. To calculate the groundwater threshold lift pressure needed to accomplish this, simply use the following equation:

$$\frac{\text{(depth to top of Barcad from ground surface [ft])(1.1)}}{\text{2.31 (psi/ft)}} = \text{lift pressure (psi)}$$

As an example, if the depth to the top of the Barcad from the ground surface is 50 feet, then 24 PSI of pressure from the nitrogen tank is required to return the groundwater from the riser pipe to the ground surface. If the depth to the top of the Barcad from the ground surface is 1600 feet, then 762 PSI is required to return the groundwater in the riser pipe to the ground surface.

Once the lift pressure is reached, a two-way ball valve (connected between the tank regulator and the sampler head) is opened by rotating the valve handle 180 degrees. When this is done correctly, the pointed end of the valve handle points towards the sampler head. At this point, the line pressure will be released all at once and drive the groundwater from the riser pipe to the ground surface via the sample return tube. The rate at which the water exits the sample return line can be controlled with the T-handle of the regulator. The maximum discharge rate from the sample return tube is 2 to 3 liters per minute. The slowest rate possible is about 0.05 liters (50 milliliters [ml]) per minute.

When the water from the riser pipe is completely discharged, the nitrogen gas that was used to drive the water out follows behind the groundwater stream. This transition makes a distinct gurgling sound that is diagnostic of having removed one complete riser tube volume (the length of water column from the top of the Barcad to the potentiometric surface inside the riser pipe). Once the nitrogen gas begins to exit the sample discharge tube, the two-way ball valve is rotated 180 degrees such that the pointed end of the valve handle points away from the sampler head and points towards the exhaust muffler at the freely opened end of the two-way valve. This allows the residual nitrogen to bleed off from the riser pipe and sample discharge tube – returning the pipe and tube pressure to ambient pressure. Water from the formation can then hydrostatically reenter the riser pipe through the one-way valve at the top of the Barcad.

The first well volume that is removed from the riser pipe is typically sufficient to clean out the system of any stagnant water. Once the purging has been completed, the well will be allowed to recover to a volume to provide sufficient groundwater to fill the sample containers for the required analysis and to fill the water-quality meter cup for water-quality parameters measurements. Barcad wells that recharge slowly and provide a low volume, approximately less than 1 gallon, may be allow to recover overnight and may not provide enough groundwater volume to fill all sample containers and collect water-quality parameters. Project Manager approval will be obtained on a case by case basis for sampling wells that require deviations from the sampling plan and SOPs. The rate at which the water is removed from the riser pipe during sampling can be controlled with the regulator T-handle or with a metering valve supplied by BESST, Inc. Therefore, if it is desired to slow the discharge rate from the sample return tube, the T-handle (or metering valve) on the regulator is rotated counter clockwise to narrow the gas pathway in the regulator valve. Prior to sampling, the first 10 to 20 ml of water will be discharged into a bucket or other containment device from the sample return tube first, then the groundwater samples can be collected into the appropriate containers. This practice is similar to that used with submersible pumps. Immediately following sample collection, the water-quality meter cup will be filled with groundwater from the sample return line and water-quality parameters measurements will be recorded.

7.3 PROCEDURES FOR MEASURING WATER LEVELS

With single and nested borehole installations and single well retrofits, water level measurements can be made by first removing the plastic dust cover that snugly sits on top of the riser pipe – inside the monitoring well completion. A standard water level sensor and spool set-up can be used for Barcad set-ups with ½ or 1-inch riser pipe. In the case of a Barcad set-up with 1-inch inside diameter (ID) riser pipe, a standard water level sensor with a ¾-inch outside diameter (OD) Sonde can be used. In the case of riser pipe with ½-inch ID riser pipe, a standard water level sensor with a ¼-inch OD Sonde is recommended.

It is important to note that even though there is a one-way valve in the Barcad, the potentiometric surface of groundwater in the riser pipe will always adjust up and down according to seasonal and induced fluctuations in the groundwater potential. This is due to the Teflon O-ring seal beneath the one-way valve being deliberately severed prior to installation below the one-way valve. The O-ring gap allows continual back and forth communication between formation water in the riser pipe and the adjacent groundwater in the adjacent formation. It is also important to note that the O-ring gap will not allow groundwater in the riser pipe to be back-flushed into the formation when inert gas pressure is applied to drive groundwater from the riser pipe to the ground surface. This is due to back pressurization with the inert gas which compresses the O-ring gap to the point of closure.

7.4 PROCEDURES FOR PERFORMING SLUG TESTS USING THE BARCAD SYSTEM

A rising-head slug test is used to calculate the hydraulic conductivity within the screened interval of the well. The following equation is used for the calculation:

- $$k_h = \frac{d_2 * \ln(2mL/D)}{8 * L * (t_2 - t_1)} * \ln(H_1/H_2),\ \textit{for } mL/D > 4$$

Definitions:

d = 1.0” (2.54cm) Inside Diameter for Barcad groundwater cell

L = 1.0’ (7.5cm) (Height of Barcad filter stone)

D = 1.5” (7.5cm) (Diameter of Barcad filter stone)

k_h = horizontal conductivity through soil (cm/s)

k_v = vertical conductivity through soil (cm/s)

m = k_h/k_v ; assume $k_h \cong (2.0 \text{ to } 4.0)*k_v$ for uniform sands. Therefore, m=(1.4 to 2.0) for uniform sands. This number is unitless.

Use the above permeability equation for mL/D > 4 even though it is only 1.4 to 2.0 for case where L=D=3” (7.5cm) since the Barcad filter is only open on the sides and not the bottom.

H_1= piezometric head for $t=t_1$ (cm)

H_2=piezometric head for $t=t_2$ (cm)

Assumptions:

1. Soil at intake is uniform.
2. Infinite depth.
3. Directional isotropy (k_h constant).
4. No disturbance, segregation, swelling or consolidation of soil.
5. No sedimentation or leakage.
6. No air or gas in soil, well point or pipe.
7. Hydraulic losses in pipes, well point, or filters are negligible.

Procedures:

1. Top of water table or piezometric surface must be approximately known.
2. The approximate distance (length) between H_1 (at t_1) and the top of the water table or piezometric surface must be known (Figure 20-3). This would equate to the distance between the bottom of the Barcad reservoir and the top of the water table or piezometric surface.
3. The approximate distance (length) between H_2 (at t_2) and the top of the water table or piezometric surface must be known. This would equate to the distance

between the bottom of the Barcad reservoir and the top of the water table or piezometric surface.

4. Use a clear, one-liter plastic bottle to monitor fill of formation water into the Barcad reservoir. Remember, the pre-fill for the Barcad cell is 200 ml. Therefore, all groundwater entering the Barcad reservoir after 200 ml of pre-fill is water that has crossed over the top of the one-way valve at the base of the Barcad reservoir. Therefore, it is from this point that a stop watch should be started to time the rise of head from the bottom of the Barcad reservoir to the top of the Barcad reservoir (the H_2, t_2 position). When the groundwater has reached the H_2, t_2 position in the Barcad reservoir, the rising head test has ended.

8.0 GROUNDWATER SAMPLE COLLECTION PROCEDURES FOR EXTRACTION OR PRODUCTION WELLS

Municipal Production/Private Wells. Domestic water supply wells shall be sampled in a similar manner to monitoring wells, although allowances must be made for the type of pumping equipment already installed in the well. The following steps shall be taken in collecting samples from extraction or production wells:

1. Inspect the well, including storage tanks and any treatment systems nearby.
2. Choose a sample access point as close to the well as possible prior to where the water enters any storage tank or treatment system. Sample from a cold water source tap as close to the pump as practical. Domestic supply samples shall not be taken from locations delivering chlorinated, aerated, softened, or filtered water.
3. Remove faucet aerators if possible before sampling. Turn on the water tap and run for at least 30 minutes. If the water tap is directly adjacent to the well head, allow the water to run for no less than 10 minutes before collecting samples to flush stagnant water from the system. If the well is used for production, note the pumping rate.

4. Prior to collecting samples intended for VOC analyses, reduce the tap flow rate to approximately 100 ml/min. Measure and record all field parameters as described in Section 4.2 Pre-Sampling Procedures.
5. Fill sample containers with water directly from the tap as described under Section 4.3 VOC Sample Collection Procedures for VOC samples and Section 4.3 Non-VOC Sample Collection Procedures for non-VOC samples. Note the components of the plumbing system to assist in data interpretation.

9.0 PURGE WATER HANDLING AND DISPOSAL

Because of the potential for spreading environmental contamination, proper purge water disposal is a necessary part of well monitoring. All purge water shall be contained in either an above-ground portable storage tank (water wagon) or fixed above-ground storage tank (e.g., Baker Tank). It is acceptable to contain small amounts of purge water in small sampling containers (e.g., covered 5-gallon buckets, 5-gallon plastic distilled water bottles). For most groundwater sampling activities at Hill AFB, purge water shall be disposed of at the Industrial Wastewater Treatment Plant (IWTP) as specified in the *Final Basewide Investigation-Derived Waste Work Plan* (Radian, 1995), unless otherwise stipulated in project-specific plans.

10.0 REFERENCES

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Appendix B

Sampling Field Forms

Operable Unit: Monitoring Point: Date: Sampler:

Weather: Visitors:

Boring Dia. Casing Dia. DTW: TD: Pump Intake Depth: Pump Top Depth:

Purge/Sampling Method: Vial pH: Depth to Water @Sampling:

Low Flow:
Calculated Purge Volume

Tubing Leng. (ft) X Tubing Dia. Factor + Pump Volume X 2 = Purge Volume (ml) = Rounded Purge Volume (Rounded up to nearest 100 ml)

Tubing Diameter Factors: 3/8"= 13 ml/ft 1/2"= 20 ml/ft

Casing Volume Above Screen

Screen Volume

Standard Method:
Calculated Purge Volume

TD (ft) - DTW (ft) = Water Column (ft) - Scr. Leng. (ft) = Casing Leng. X Casing Factor X 3 = Casing Vol. + (Scr. Leng. (ft) X Scr. Factor) = Purge Volume (gal) (0.0)

Casing Volume Factors (gal/ft): 2"= 0.17; 4"=0.66; 5"=0.95 Screen Interval Volume Factors (Cas.Dia/Bor.Dia.)(in): 2/8"= 2.15 gal/ft; 4/10"= 2.93 gal/ft; 4/12"= 4.55 gal/ft; 5"/10"=2.54 gal/ft

Site Safety: PPE Disposal: Disposition of Purge Water: 90% Recharge Level: ft Sampling Flow Rate ≤ 100 ml/min?

Time	**Purge Vol specify ml or gal**	**Temp (C) (0.0)**	**pH (0.0)**	**Specific Cond. (mS/cm) (0.000)**	**Turbidity (NTU) (0.0)**	**DO (mg/l) (0.0)**	**ORP (mV) (0.0)**	**Chloride (YSI) (mg/l) (0.00)**	**Ammonia (YSI) (mg/l) (0.000)**	**Nitrate (YSI) (mg/l) (0.000)**	**GW Level (ft below MP)**	**Comments (Color/Odor)**	**Other Parameters**
													Sulfide (mg/l) (0.00)
													Sulfate (mg/l) (0.00)
													DO (mg/l) (0.00)
													Total Iron (Fe) (mg/l) (0.00)
													Ferrous Iron (Fe+2) (mg/l) (0.00)
													Purge Flow Rate (ml (0) or gal per min (0.0))

Time	Purge Vol specify ml or gal	Temp (C) (0.0)	pH (0.0)	Specific Cond. (mS/cm) (0.000)	Turbidity (NTU) (0.0)	DO (mg/l) (0.0)	ORP (mV) (0.0)	Chloride (YSI) (mg/l) (0.00)	Ammonia (YSI) (mg/l) (0.000)	Nitrate (YSI) (mg/l) (0.000)	GW Level (ft below MP)	Comments (Color/Odor)	Other Parameters
Field parameters stable?		Y N	Y N	Y N	Y N	Y N	Y N						

	Sample ID	Time	Date	Analysis	Number of Bottles
Normal					
Duplicate					
MS/SD					
Trip Blank					
Equipment Blank					

Flow-through Cell Calibration Meter: ______________________________

Parameter	Calibration	Check	Date	Time	Calibration Standards	Initial Reading	Final Reading	Calibration within Specifications
pH								
Turbidity								
ORP								
Spec Cond								
DO								
Ammonia								
Chloride								
Nitrate								

General Notes: ______________________________

Well Condition: ______________________________

Monitoring Point Information

Monitoring Point: ______________________ Date/Time: ______________________ Sampler: ______________________

Aboveground Completion:

I.D. Tag Intact: Yes No   Point Locked: Yes No   Point Lockable: Yes No   Need New Lock: Yes No

Completion Size: 4"x4" / 6"x6" / 8"x8" / 6" Round / 8" Round / Other: ______________________

Completion Condition: Clean / Dirty / Rusty / Leaks   Needs Replacement: Yes No

Bollard Size: 2" / 4" / 6"   Number of Bollards: __________   Bollards Damaged: Yes No   Bollard Caps Needed: Yes No

Pad Condition and Size: Pad OK / Pad Damaged   Pad Needs Replacement: Yes No

Pad Size: 2'x2' / 3'x3' / 4'x4' / Other: ______________________

Paint Color: Brown / Yellow   Paint Condition: Fresh / Faded / Cracked / Peeling   Needs Repainting: Yes No

Describe Damage & Repairs Needed: ______________________

Flush Mount Completion:

Completion Type: Round Bolt on Lid: 6" / 8" / 10" / 12"   12" Square   M. Augustyn Inc.   8" Robco

I.D. Tag Intact: Yes No   Point Locked: Yes No   Point Lockable: Yes No   Need New Lock: Yes No

Completion Condition: Clean / Dirty / Rusty / Leaks   Needs Replacement: Yes No

Pad Condition and Size: Pad OK / Pad Damaged   Pad Needs Replacement: Yes No

Pad Size: 2'x2' / 3'x3' / 4'x4' Other: ______________________

Lid Damaged: Yes No   Coating Condition: Good / Fair / Poor   Lid Needs Replacement: Yes No

Needs Inner Security Lid: Yes No   Needs Center Compression Bolt: Yes No   Needs Lid Gasket: Yes No   Needs Bolts: Yes No

Well & Pump Information:

Casing Diameter: 2" / 2.5" / 3" / 4" / 5" / 6" / 8" / 10" / 12"   Type: PVC / S. Steel / Other: ______________________

Pump Type: Bladder / Electric / Peristaltic / Other: ______________________

Pump Size: 1.6" / 2" / 2.5" / Barcad / Other: ______________________

Describe Damage & Repairs Needed on Pump or Other Sampling Equipment: ______________________

Other Comments: ______________________

Landfill 5 and TTU Groundwater Level Measurements

Location ID	Monitoring Point (North edge of casing)	Date (mm-dd-year)	Time (military)	Depth to Groundwater (0.01 feet)	Comments
TTU-1					
TTU-2					
MW-E					
MW-F					
MW-G					
MW-H					
MW-I					
MW-J1					
MW-K					
Please contact the project manager immediately if a monitoring point depth to groundwater cannot be taken.					

Appendix C

Visit Request Form

UTAH TEST AND TRAINING RANGE (UTTR) VISIT REQUEST

This form is subject to the Privacy Act of 1974. Authority: Executive Orders 9397; 9838; 10450; and 11652; 10 U.S.C. 8013 Secretary of the Air Force. System of records notice F205 AFSCO C. Purpose: This form is used to validate clearances, verify need-to-know, and ensure safety of visitors to the UTTR. Routine Uses: Information provided will not be released without the written consent of provider. Disclosure: Voluntary. Failure to provide requested information could delay or prevent access.

TO: 388RANS/SF
6067 Boxelder Lane
Hill Air Force Base, UT 84056-5811

Commercial Phone: (801) 777-2313
DSN: 777-2313
FAX: 775-4226

FROM (Organization, address, phone number):

1. Visit approval is requested for the personnel listed below. Visit will be considered approved unless otherwise notified.

Name, Grade, SSAN, and Position/Title	Citizenship, Date and Place of Birth	Office Symbol/Activity	Clearance/Date of Clearance (Classified visits only)	CAGE Code and Facility Clearance (Contractors Only)

2. Area(s) to be Visited (check all that apply):

☐ Bldg 1274 (MCC)
☐ Diddles Knoll
☐ Wig
☐ TS-2
☐ Bldg 1A
☐ Eagle Range
☐ TAC WSEP (TS-3)
☐ CALCM
☐ Oasis
☐ Craners Complex
☐ Baker Strong Point
☐ Wendover
☐ Grassy Mountain
☐ Dugway
☐ PGM Complex
☐ Cedar Peak
☐ HAG
☐ Granite Peak
☐ Sand Island (TS-4)
☐ Wildcat
☐ Kittycat
☐ Industrial Complex
☐ TS-5
☐ Other:

3. Purpose of Visit: **(RANGE ACCESS BRIEFINGS AND RADIOS REQUIRED BEFORE ENTERING ANY NUMBERED RANGE)**

4. Date(s) of Visit	**5. Name(s) of Person(s) to be Visited**	**6. Name, Grade, and Title of Certifying Official**	**7. Certifying Official Signature/Date**

388RANS USE

☐ **ACCESS APPROVED** ☐ **ACCESS APPROVED WITH ESCORT** **NAME OF ESCORT:** ☐ **ACCESS DISAPPROVED**

Name, Grade, and Title of Approving Authority:

Approving Authority Signature/Date

POC for radios on R6402, R6406, and R6407 is 388RANS at Dugway, Commercial (435) 522-5343, or DSN 789-5343
POC for radios on R6404 is 75RANS at Oasis, Commercial (801) 777-1522 or DSN 777-1522

Call Sign(s):

☐ **Security Briefing** ☐ **Safety Briefing** ☐ **EOD Briefing** **Briefed by:** **Date Briefed:**

Remarks: