Quality Assurance Project Plan

Lower Yakima Valley
Dairy Investigation

Yakima County, Washington

December 2012

Prepared for:

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1 PROJECT MANAGEMENT ELEMENTS

1.1 Project/Task Organization

Table 1 identifies the personnel involved in the Lower Yakima Valley Dairy Investigation including monitoring well installation, sampling, and analytical activities, and defines their respective responsibilities in the process. Personnel listed on Table 1 should receive copies of the signed QAPP.

Table 1 – Project Personnel, Roles, and Contact Information

Name	Affiliation	Role	Contact Information
Michael Boykin	USEPA Region 10	Federal On-Scene Coordinator – manages START Contractor, Ecology and Environment (ENE)	206-553-6362 Cell: boykin.michael@epa.gov
Erin Lynch, R.G.	Ecology and Environment	START Hydrogeologist and Project Manager – oversees drilling subcontractor well installation, well development, and conducts sampling.	503-248-5600 Ext. 4607 Cell: elynch@ene.com
Brian Ciecko	Ecology and Environment	START Geologist – oversees drilling subcontractor well installation, well development, and conducts sampling.	503-248-5600 Ext. 4602 Cell: bciecko@ene.com
Mark Woodke	Ecology and Environment	QA Officer – responsible for subcontracting laboratory for nitrate analysis. Receives data from subcontracted lab and passes onto EPA.	206-624-9537 mwoodke@ene.com
Renee Nordeen	Ecology and Environment	Sample Manager & Scribe Project File Manager – responsible for sample packing and shipping as well as creating and maintaining project Scribe files.	rnordeen@ene.com
Rene Fuentes, P.E., PHG.	USEPA Region 10	Lead Project Hydrogeologist – identifies drilling locations, determines whether actual drilling locations need to be moved from proposed locations; determines the order in which the wells will be drilled and determines whether a borehole should be abandoned rather than completed as a monitoring well. Assists with report preparation.	206-553-1599 fuentes.rene@epa.gov
Brent Richmond	USEPA Region 10	EPA Field Sampling Manager – responsible for well security (locks), sample collection, handling, packing, shipping, and chain of custody documentation.	360-871-8711 Cell: richmond.brent@epa.gov

Name	Affiliation	Role	Contact Information
Donald Brown	USEPA Region 10	EPA Quality Assurance Chemist – reviews and approves QAPP; responds to questions on QA; data validation.	206-553-0717 brown.donaldm@epa.gov
Jennifer Crawford	USEPA Region 10	EPA Regional Sample Control Coordinator (RSCC) – responsible for analytical scheduling and communication with EPA Manchester Environmental Laboratory (MEL). Provides the regional sample tracking numbers, project code, sample tags, and custody seals.	206-553-6261 crawford.jennifer@epa.gov
Eric Winiecki	USEPA Region 10	EPA Project Coordinator – provides overall direction on the project and manages Office of Water and Watersheds Contractor (SAIC).	206-553-6904 winiecki.Eric@epa.gov
Dianne Stewart	SAIC	Senior Environmental Scientist – prepares QAPP/SAP.	650-417-8900 stewartd@saic.com
Gerald Dodo	USEPA Region 10	MEL Supervisory Chemist – main contact at the laboratory responsible for accepting work to be conducted by MEL.	360-871-8728 dodo.gerald@epa.gov
Karen Norton	MEL ESAT contractor	Laboratory sample custodian.	360-871-8760 norton.karen@epa.gov
Kristine Allen	Test America Laboratory	START subcontractor - Answers questions about lab capability and capacity. Receives samples at the lab.	253-922-2310 kristine.allen@testamericainc.com
Josh Burrows	Environmental West	START subcontractor - Operates drill rig and installs and develops monitoring wells. Prepares traffic control plans and implements traffic control as appropriate. Submits traffic control plans to Yakima County for approval.	509-534-2740 joshb@environmentalwest.com
Jesse Garner	Pioneer Surveying and Engineering, Inc.	Surveys well locations and elevations.	(509) 773-4945

1.2 Problem Definition/Background

1.2.1 BACKGROUND

From February through April 2010, EPA conducted sampling of drinking water wells and potential sources of nitrate contamination in the Lower Yakima Valley, which is in Yakima County in central Washington State. The primary purpose of this study was to investigate the contribution from various land uses to the high nitrate levels measured in groundwater and residential drinking water wells, which is the predominant source of drinking water for many residents in the Lower Yakima Valley.

The study included sampling residential drinking water wells, dairy supply water wells, and three sources of nitrate: dairies; irrigated cropland; and residential septic systems. In addition to nitrate and other forms of nitrogen, EPA analyzed samples for a variety of chemicals to evaluate whether chemicals other than nitrate can be used to identify likely sources of the nitrate contamination in the groundwater and drinking water wells.

One of the conclusions reached in the study is that, given the historic and current volumes of wastes generated and stored by dairies, and the application by the dairies of nitrogen-rich fertilizers including dairy waste, it is expected that dairies are a likely source of high nitrate levels in downgradient drinking water wells in the Lower Yakima Valley (EPA 2012). Drinking water well samples were collected only from existing wells; no new wells were installed for the study. One of the limitations noted in the study is that information on the depths and screened intervals of the water wells for about two-thirds of the wells that were sampled was not available. Designations of upgradient and downgradient wells were based on regional groundwater flow data from the United States Geological Survey (USGS). The lack of complete information for the wells sampled in this study limited EPA's ability to verify if the wells upgradient and downgradient of the sources draw water from the same water bearing zone.

1.2.2 OBJECTIVES/SCOPE

This investigation includes installing and sampling monitoring wells in locations that are upgradient and downgradient of dairies that were sampled in the study conducted by EPA in 2010. New monitoring wells will be completed in the alluvial drinking water aquifer and, if encountered, the shallow perched aquifer. The objectives of this investigation are to:

- Confirm the direction of flow in the alluvial drinking water aquifer in the immediate vicinity of the dairies;
- Increase understanding about the concentrations of nitrate in the alluvial drinking water aquifer upgradient and downgradient of the dairies.
- Evaluate whether a shallow, perched aquifer exists at selected location, above the alluvial drinking water aquifer, and if encountered, also install a well and sample the perched aquifer for nitrate.

The newly installed wells will be surveyed and groundwater elevations will be measured to confirm the direction of ground water flow in the immediate vicinity of the dairies.

Monitoring wells will be sampled for nitrate and analytical results will be compared to the maximum contaminant level (MCL) for nitrate of 10 mg/L. Nitrate concentrations that exceed the MCL pose an acute threat to human health. In addition, field test strips will be used to screen for ammonia in the newly installed monitoring wells. If ammonia is detected, a sample will be collected for laboratory analysis of ammonia. Ammonia is converted to nitrite and then nitrate in soil and groundwater through a microbial process known as nitrification. The presence of ammonia in groundwater can indicate a nearby source of nitrogen contamination.

1.3 Project/Task Description and Schedule

1.3.1 PROJECT/TASK DESCRIPTION

Approximately thirteen boreholes will be drilled into the alluvial drinking water aquifer. The approximate locations of the 13 proposed well sites, and several alternative sites, are shown in Figures 1 and 2 as well as Table 2. Alternative sites may be used in the event that a proposed site is inaccessible or otherwise determined to be inappropriate for well installation. More or fewer boreholes may be drilled depending on access limitations or conditions encountered in the field. The boreholes will be drilled using the air-rotary casing hammer and/or sonic drilling methods. Drilling will be done to install shallow monitoring wells in the alluvial drinking water aquifer, and in selected locations in the perched aquifer if one exists at those locations. Monitoring wells will be installed within the borings and developed as described in the Work Plan (Appendix A).

Groundwater samples will be collected from the newly installed monitoring wells. Two teams (EPA Region 10 and a Superfund Technical Assessment & Response Team (START)) will collect the samples using a low flow sample collection technique (Appendix B) to minimize aquifer disturbance and minimize investigation derived waste from sampling. The following parameters may be measured in the field: pH, temperature, dissolved oxygen, conductivity, oxidation reduction potential (ORP), turbidity, nitrate, and ammonia. A sample will be collected from each well and submitted for nitrate analysis to Test America Laboratory in Tacoma, WA. If ammonia is detected during field screening, a sample will be collected and sent to EPA's Manchester Environmental Laboratory (MEL) for analysis of ammonia.

Wells will be left in place for future monitoring needs. A professional land surveyor, licensed in the State of Washington, will survey the locations, ground surface elevation and elevation of top of well casing elevation for all newly installed monitoring wells.

For any monitoring wells that are to be installed within the Yakima County right-of-way, the surveyor will survey the center line of the roadway using existing monuments that are located every half mile along the major roads (the roads laid out on a one-mile grid), and measure the right-of-way from the center of the road.

The driller will provide a traffic control plan to Yakima County for review and approval for each well drilling location that is in the county right-of-way. Traffic control plans should be sent to Joe McWalters at Yakima County. Joe can be reached at 509-574-2336 or email address: joe.mcwalters@co.yakima.wa.us. If Joe cannot be reached, an alternative contact is Gary Ekstedt at (509) 574-2300 and email address: gary.ekstedt@co.yakima.wa.us.

Table 2 - Monitoring Well Summary

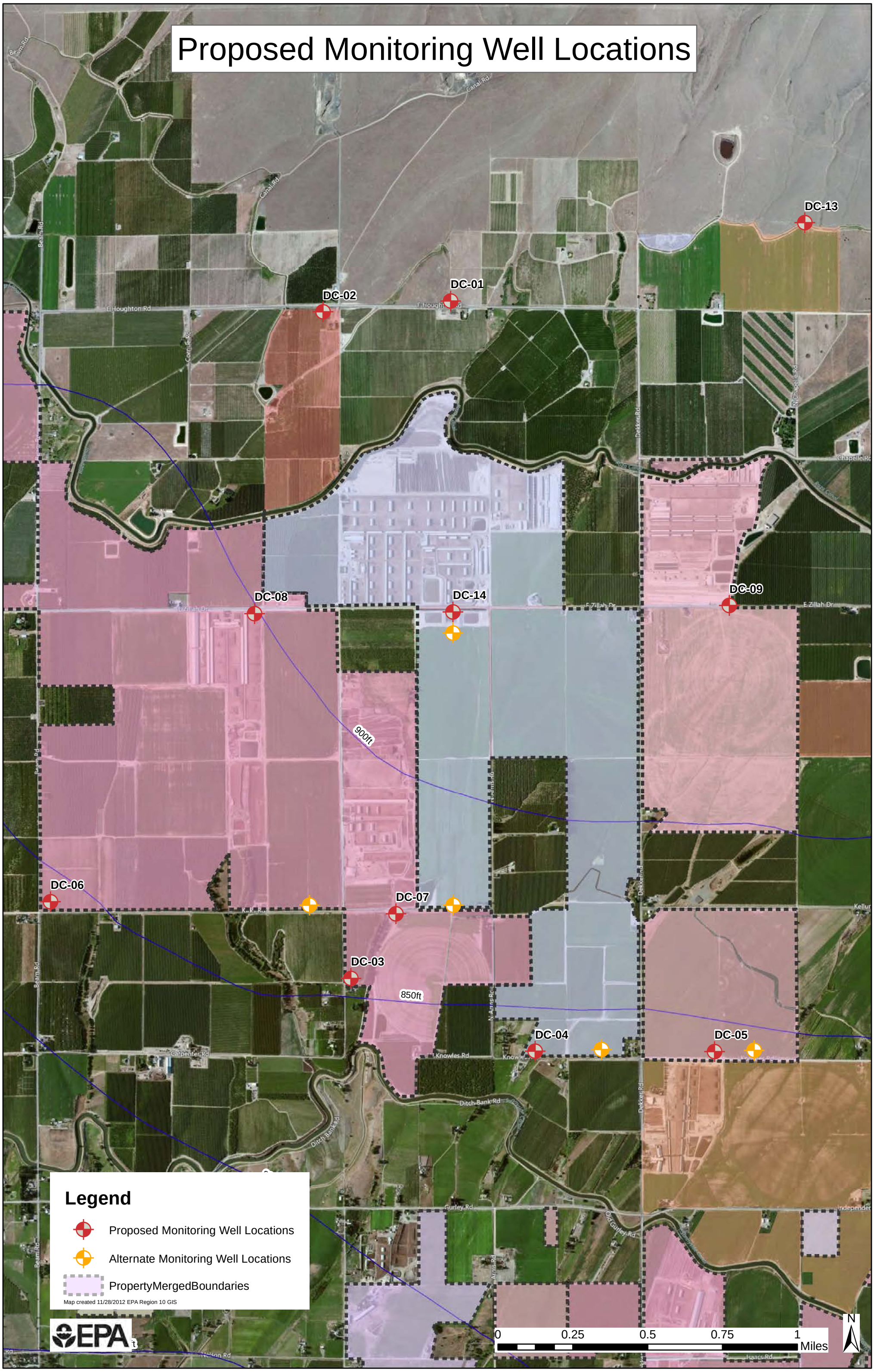
Order of Drilling[1]	General Area	Comment	Road	Well ID and Location (see maps)	County Right-of-Way	Well Screen Location	Approx. Total Depth (feet)
First or later in drilling order	Dairy Cluster	**ONE** upgradient well along East Houghton Road in the vicinity of Well # 1 and #2	East Houghton	DC-01	35'from CL	Drinking water aquifer	200' +
				DC-02	28' from CL		
Second	Dairy Cluster	Downgradient well	North Liberty	DC-03	30' from CL	Drinking water aquifer	150'
Third	Dairy Cluster	Downgradient well	Kirks	DC-07-S DC-07-D	25' from CL	Well Pair[2]	180'
Fourth	Dairy Cluster	Downgradient well	East Zillah	DC-14-S DC-14-D	30' from CL	Well Pair[2]	180'
Fifth	Dairy Cluster	Downgradient well	Knowles Road	DC-04-S DC-04-D	25' from CL	Well Pair[2]	150'
Sixth	Dairy Cluster	Downgradient well	East Zillah	DC-09-S DC-09-D	30' from CL	Well Pair[2]	150'
Seventh	R&M Haak Dairy	Upgradient well	Washout Road	HK-10	25' from CL	Drinking water aquifer	100'
Eighth	R&M Haak Dairy	Downgradient well	Independence Road	HK-11	25' from CL	Drinking water aquifer	100'
Ninth	R&M Haak Dairy	Move this downgradient well from its current location on a private property road to the southwest and install along Independence Road south of center pivot sprayfield	Private Property	HK-12	N/A	Drinking water aquifer	100'
After other wells are installed and at the direction of EPA Hydrogeologist	Dairy Cluster	Downgradient well	Knowles Road	DC-05-S DC-05-D	25' from CL	Well Pair[2]	150'

Order of Drilling[1]	General Area	Comment	Road	Well ID and Location (see maps)	County Right-of-Way	Well Screen Location	Approx. Total Depth (feet)
After other wells are installed and at the direction of EPA Hydrogeologist	Dairy Cluster	Downgradient well	Beam	DC-06	25' from CL	Drinking water aquifer	100’
After other wells are installed and at the direction of EPA Hydrogeologist	Dairy Cluster	Downgradient well	East Zillah	DC-08	30' from CL	Drinking water aquifer	100’
DO NOT DRILL unless dairy provides access	Dairy Cluster	Upgradient well	Private Property	DC-13	NA	Drinking water aquifer	200’ +

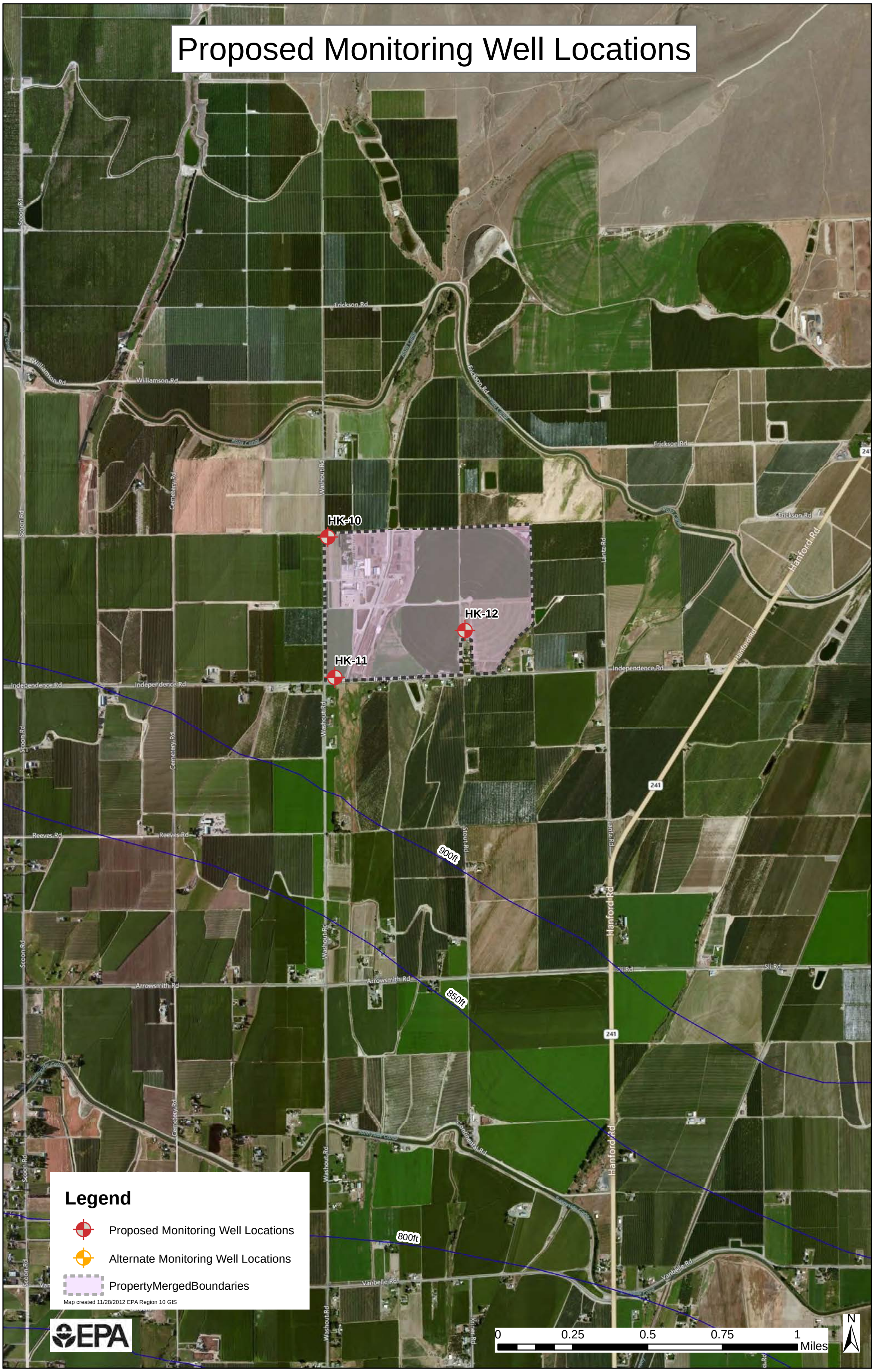
[1] Drilling locations or order of well drilling may be altered in the field at the direction of the EPA Hydrogeologist.

[2] Well pair to include a well in shallow aquifer, if encountered, and a well in the alluvial drinking water aquifer.

Proposed Monitoring Well Locations



Proposed Monitoring Well Locations



1.3.2 Schedule of Tasks

The proposed schedule is shown in Table 3.

Table 3 – Activity Schedule and Tentative Start and Completion Dates

Task	Start Date	Completion Date
Develop QAPP	November 8, 2012	November 21, 2012
Review QAPP	November 23, 2012	December 5, 2012
Approve and Sign QAPP	After QAPP review is complete	December 7, 2012
Right-of-way Pre-survey	December 6, 2012	December 12, 2012
Drilling/monitoring well installation	December 10, 2012	December 19, 2012
Well development	December 10, 2012	December 19, 2012
Collection of samples	December 18, 2012	December 22, 2012
Monitoring Well Survey	December 19, 2012	December 22, 2012
Laboratory Nitrate Analysis	December 19, 2012	December 28, 2012
Laboratory Ammonia Analysis and Verification	December 19, 2012	January 16, 2013
Nitrate Data Validation	December 31, 2012	January 9, 2013
Report Preparation	January 7, 2013	January 21, 2013

1.4 Quality Objectives and Criteria for Measurement Data

Data Quality Objectives (DQOs) are the quantitative and qualitative criteria used to describe the data needed in order to meet the project's objectives. These criteria include: when, where, and how to collect samples or measurements; determination of tolerable decision error rates; and the number of samples or measurements that should be collected.

DQOs for measurement data (referred to here as data quality indicators) are precision, accuracy, representativeness, completeness, comparability, and measurement range.

The overall QA objective for analytical data is to ensure that data of known and acceptable quality are provided. To achieve this goal, data must be reviewed for 1) representativeness, 2) comparability, 3) precision, 4) accuracy (or bias), and 5) completeness. Precision, accuracy, completeness, sample representativeness and data comparability are necessary attributes to ensure that analytical data are reliable, scientifically sound, and legally defensible. Each analytical result or set of results generated should be fully defensible in any legal action, whether administrative, civil, or criminal.

Precision: Samples in duplicate will be analyzed on at least a 10% frequency (1 per 10 samples collected). The precision is evaluated using the Relative Percent Difference (RPD) values between the duplicate sample results.

$$RPD = \frac{ABS(R1 - R2)}{\left(\frac{R1 + R2}{2}\right)} \times 100$$

R1 = Recovery for MS or duplicate 1
R2 = Recovery for MSD or duplicate 2

Accuracy: For parameters analyzed in the fixed laboratory, accuracy will be evaluated by the use percent recovery (%R) of the target analyte in spiked samples and also the recoveries of the surrogates in all samples and QC samples.

$$\%Recovery = \frac{SSR - SR}{SA} \times 100$$

SSR = Spiked Sample Result
SR = Sample Result
SA = Spike Added

Representativeness is the degree to which data from the project accurately represent a particular characteristic of the environmental matrix that is being tested. Representativeness of samples is ensured by adherence to standard field sampling protocols and standard laboratory protocols. The design of the sampling scheme and number of samples should provide a representativeness of each matrix or product of the chemical processes being sampled.

Comparability is the measurement of the confidence in comparing the results of one sampling event with the results of another achieved by using the same matrix, sample location, sampling techniques and analytical methodologies. Data comparability will be maintained using defined procedures and the use of consistent methods and consistent units.

Completeness: Completeness is the percentage of valid results obtained compared to the total number of samples taken for a parameter. Since sampling from inspections are usually grab and limited in number of samples, the number of valid results obtained from the analyses are expected to be equal or better than 85%.

The QA objectives outlined above will be evaluated in conjunction with the data validation process.

1.5 Documentation and Records

The driller will be responsible for completing and submitting geologic well construction logs that contain the information required by the Washington Department of Ecology (Ecology) *Water Well Report* form.

The sampling teams will complete the following items in the field and submit them to the field sampling manager or project hydrogeologist:

- Boring Log (one per well)
- Chain of custody forms,
- Sample container labels, and
- Additional information (e.g. photographs, sketches, and logbook notes)

The field sampling manager will provide the records to the project coordinator.

All laboratory analytical data generated during this project will be processed, stored, and distributed according to the laboratory's SOPs and subcontract Statement of Work (SOW). Stored data will include all sample receipt, sample login, extraction/preparation, and laboratory instrument printouts and other analytical documentation.

All project documentation will be kept in a case file and submitted to the EPA Project Coordinator for inclusion in the final narrative report.

1.6 Health and Safety

Personnel participating in this project will follow their own organization's Health and Safety Plan.

2 DATA GENERATION AND ACQUISITION

2.1 Monitoring Well Installation and Development

The procedures for drilling and developing the monitoring wells and handling investigation derived wastes are described in the Work Plan (Appendix A).

2.2 Sample Collection

Groundwater samples will be collected from the newly installed and developed monitoring wells. Two teams (EPA Region 10 and a Superfund Technical Assessment & Response Team (START)) will collect one sample from each well. The sample will be analyzed for nitrate at Test America Laboratory in Tacoma, WA. If ammonia is detected during field screening, a second sample will be collected from the well and sent to MEL for ammonia analysis. Groundwater samples will be collected using the low-flow sample collection method. Low flow sample collection is a method that minimizes the impact the purging process has on the groundwater chemistry and the volume of water that is being purged and disposed of during sample collection.

Sample collection activities will follow the low flow sample collection procedures described in the Standard Operation Procedure (SOP) for Low-Stress (Low Flow)/Minimum Drawdown Groundwater Sample Collection (Appendix B). The SOP describes the steps in the sample collection process as summarized in the following subsections.

The low flow sample collection method requires water-quality-indicator parameters and water levels to be measured during purging, prior to sample collection. Stabilization of the water-quality-indicator parameters, as well as monitoring water levels, is a prerequisite to sample collection. The water quality indicator parameters to be measured are: specific electrical conductance, dissolved oxygen, turbidity, oxidation-reduction potential, pH, and temperature. Stabilizatoin criteria are included in the SOP (Appendix B).

A list of suggested field and sampling equipment is presented in Table 4. EPA field equipment will be managed in accordance with OEAFieldSOP-001 titled *Inventory and Management of Field Equipment and Chemical Standards and Reagents* (Appendix C), which describes procedures on equipment tracking/maintenance, the check-in and check-out procedures, and the training requirements for staff using the equipment and supplies.

Table 4 – Suggested Sample Equipment for Monitoring Well Sampling

Copy of this QAPP and Health and Safety Plan
EPA or Contractor ID
Field Data Sheets and notebooks ; waterproof pens and markers
Camera
Clipboard, calculator
Flashlight
Sample bottles and preservation supplies
Test strips for nitrate and ammonia
Ice Chests for sample shipping plus extras for equipment transport
Trimble Geo-XH GPS Pocket PC
Depth-to-water measuring device
Industrial Scientific Multi-Gas Monitor (detects O_2, CO, H_2S, & LEL), Photovac 2020 Portable Photoionization Detector (PID), or equivalent
Sample Pro Mini Bladder Pump with MP50 Controller/12 VDC Compressor, or equivalent
Flow measurement supplies (flow meter, graduated cylinder, stop watch)
2 Horiba U-53G Multi Water Quality Checkers
Flow-Through Cell and disposable tubing, plumbing connections and clamps
Calibration Solutions
Decontamination supplies (distilled water, buckets, decontamination tubes for pumps, brushes, non-phosphate soap)
Custody Sheets/Custody Seals/blank labels/shipping labels
Polyethylene sheeting, container for purged water
Tool kit

2.3 Sampling Equipment Decontamination Procedure

Decontamination of sampling equipment will follow the procedures outlined below in accordance with EPA SOP No. 2006 titled *Sampling Equipment Decontamination* (Appendix D).

The decontamination procedure for the electronic water level indicator probe/steel tape and the water-quality field parameter sensors are as follows:

1. The water level meter will be hand washed with phosphate-free detergent and a scrubber, then thoroughly rinsed with distilled water.
2. Water quality field parameter sensors and flow through cell will be rinsed with distilled water between sampling locations. No other decontamination procedures are necessary or recommended for these probes since they are sensitive. After the sampling event, the flow cell and sensors must be cleaned and maintained per the manufacturer's requirements.

The decontamination procedure for the sampling pump is as follows:

1. Upon completion of the groundwater sample collection, the sampling pump must be properly decontaminated between monitoring wells. The pump and discharge line including support cable and electrical wires that were in contact with the groundwater in the well casing must be decontaminated by the following procedure:
2. The outside of the pump, tubing, support cable and electrical wires must be pressure-sprayed with soapy water, tap water, and distilled water. Spray outside of tubing and pump until water is flowing off of tubing after each rinse. Use bristle brush to help remove visible dirt and contaminants.
3. Place the sampling pump in a bucket or in a short PVC casing (4-in. diameter) with one end capped. The pump placed in this device must be completely submerged in the water. A small amount of phosphate-free detergent must be added to the potable water (tap water).
4. Remove the pump from the bucket or 4-in. casing and scrub the outside of the pump housing and cable.
5. Place pump and discharge line back in the 4-in. casing or bucket, start pump and recirculate this soapy water for 2 minutes (wash).
6. Re-direct discharge line to the ground surface or a container. Continue to add 5 gallons of potable water (tap water) or until soapy water is no longer visible.
7. Turn pump off and place pump into a second bucket or 4-in. casing that contains tap water. Continue to add 5 gallons of tap water (rinse).
8. Turn pump off and place pump into a third bucket or 4-in. casing which contains distilled/deionized water, continue to add 3 to 5 gallons of distilled/deionized water (final rinse).

2.4 Sample Handling

This subsection summarizes sample handling procedures that will be used for this investigation. The purpose of these procedures is to ensure that the quality of the samples is maintained during collection, transportation, storage, and analysis. All sample control and chain-of-custody procedures will follow the *Sample and Evidence Management* SOP (Appendix E) except where noted.

2.4.1 SAMPLE NUMBERING

An eight-digit EPA Sample number will be assigned to each individual sample from the RSCC-assigned block of project sample numbers. These are tracking numbers required by the laboratory and will be used to track each sample from the field through the laboratory analysis. These sample numbers and other information pertinent to the collection of each sample will be recorded in the field logbook or on the field record forms.

Scribe will be used to generate the sample labels and chain-of-custody forms. Scribe is a software tool developed by the USEPA's Environmental Response Team (ERT) to assist in the process of managing environmental data. Scribe is used to document field sample collection information, capture spatial data, generate sample labels and chain-of-custody forms, and track field samples to laboratories, import field and laboratory results, and produce tables from the data. Scribe also supports handheld extensions to capture and import sampling and monitoring data collected on handheld instruments. All use of Scribe data management software must adhere to EPA Region 10 requirements. All final validated laboratory data must be imported into the Scribe project file and published on Scribe.net at the completion of this project.

2.4.2 CUSTODY SEALS

Custody seal procedures will adhere to the *Sample and Evidence Management* SOP (Appendix E).

2.4.3 CHAIN-OF-CUSTODY RECORDS AND TRAFFIC REPORTS

The primary objective of chain-of-custody procedures is to provide an accurate written or computerized record that can be used to trace the possession and handling of a sample from collection to completion of all required analyses. Chains-of-custody will be generated by Scribe and will follow the *Sample and Evidence Management* SOP (Appendix E).

Original and duplicate custody records, together with the delivery note(s), constitute a complete custody record. It is the Field Sampling Manager's responsibility to ensure that all records are consistent. It is the project coordinator's responsibility to ensure that they become part of the project file.

2.4.4 FIELD LOGBOOKS AND DATA FORMS

Field logbooks and data forms are necessary to document daily activities and observations. Documentation will be sufficient to enable participants to reconstruct events that occurred during the project accurately and objectively at a later time. Data entry for sample collection, field measurements, and field equipment should follow the approach provided in the field logbook SOP (Appendix F). Deviations from the QAPP or other referenced procedures should be noted in the field log book.

2.4.5 PHOTOGRAPHS

Photographs will be taken as directed by the team leaders. Documentation of a photograph is crucial to its validity as a representation of an existing situation. The following information will be noted in the project or task log concerning photographs:

- Date and time
- Photographer (initials)
- EPA Camera identification number
- Description of photograph taken
- Sequential number of the photograph
- Camera lens system used
- Direction of photograph

2.5 Sample Shipping and Laboratory Custody

This subsection describes sample shipping procedures that will be used for the Lower Yakima Valley Dairy Investigation field activities. The purpose of these procedures is to ensure that the quality of the samples is maintained during shipping to the laboratories.

2.5.1 SAMPLE SHIPPING

Sample shipping are described in the the SOP in Appendix G. Also refer to the Sample and Evidence Management SOP in Appendix E.

Samples will be transported from the site to the UPS customer center for shipping. The address is as follows:

UPS Customer Center – Union Gap
501 W. Valley Mall Blvd
Union Gap, WA 98903
800.742.5877
Drop-off deadline 4:00 PM Mon.-Fri.

Nitrate samples have a short holding time (48-hours holding time on Method 300.0). Nitrate samples must be transported either the day they are collected or very early the next morning, if they are collected late in the day. The nitrate samples should be shipped to the following address:

Test America Seattle
5755 8th Street East
Tacoma, WA 98424
253.922.2310

Ammonia samples will be shipped to MEL and received by Karen Norton, ESAT MEL Contractor. Notify the RSCC, Jennifer Crawford, on the day of shipment to MEL, via email or phone (206-553-6261; crawford.jennifer@epa.gov). The laboratory address is as follows:

Manchester Environmental Laboratory
7411 Beach Drive East
Port Orchard, WA 98366
360-871-8700

2.5.2 LABORATORY CUSTODY PROCEDURES

The laboratory will follow its internal chain-of-custody procedures as stated in the laboratory QA manual. The laboratory will check the temperature blank inside the cooler (if that is used) and document it in the sample log-in form. Should the temperature be greater than what is required by the Statement of Work (SOW) or the method, the sample custodian will inform the region and proceed to follow the course of actions stipulated in the SOW or specified by the regional QA Coordinator.

2.6 Laboratory Quality Assurance & Quality Control

Components of quality assurance and quality control include data quality objectives, equipment calibration, analytical procedures and reporting levels, quality control procedures, data reduction, validation, and reporting, performance and systems audits, data assessment, corrective action, and quality assurance reports. The laboratory will follow its written QA/QC Plan to assure data quality. Guidelines for minimum samples for field QA/QC sampling and laboratory analysis are summarized in Table 5.

Table 5 – QA/QC Samples for Field Sampling and Laboratory Analysis

Matrix	Analytical Parameters	QA/QC Samples				Total Samples (Estimated)		
		Trip Blank	Field Duplicate	Equipment Blank	Field Blank	Field	QA/QC	Total
Water	Nitrate	2	2	2	2	17	8	25
Water	Ammonia	2	2	2	2	17	8	25

Field duplicates to be collected at a rate of 1 for every 10 samples. Like sample containers will be filled one after the other (co-sampled), from a continuous flow from the well being sampled for each analyte of interest.

A matrix spike and matrix spike duplicate will be analyzed per batch of samples. The spike recoveries and the relative percent differences (RPDs) are calculated and reported for each parameter. The required precision and accuracy for this project is 20% relative percent difference (RPD) and accuracy, as measured by recovery of spikes is expected to be 80-120%.

Equipment blanks will be collected when non-disposable equipment is used for sampling at a rate of 1 blank for every 20 samples per sampling team (i.e., EPA or ENE). The equipment blank will consist of the deionized water used to rinse the sampling equipment after decontamination. Rinse water will be placed into 500-milliliter polyethylene bottles and will be analyzed for the analytes of interest.

Field blanks will be collected at a rate of 1 blank for every 20 samples per sampling team (i.e., EPA or ENE). A field blank consists of deionized water poured into a sampling container (500-milliliter polyethylene bottle) in the field and will be analyzed for the analytes of interest.

One trip blank will be included in every cooler containing samples to be analyzed. A trip blank consists of placing deionized water into a 500-milliliter polyethylene bottle. The trip blank will be provided by one of the analytical laboratories and will be analyzed for the analytes of interest.

2.7 Laboratory Analytical Methods Requirements

The laboratories performing the sample analysis for this program will be Safe Drinking Water Act (SDWA) certified and/or accredited. Scientists performing the analytical work for this project will have appropriate knowledge, skill and demonstrated experience in the execution of the analytical methods being requested.

Table 6 lists the requested analytes, methods, containers, preservation methods and holding times. The primary contaminant of concern is nitrate, therefore these samples are considered non-hazardous.

2.8 Instrument Calibration and Frequency

The Horiba U-53G Series Multi Water Quality Checker will be used to collect measurements during well purging and sampling. It features an integrated control unit and sensors. It is capable of making a maximum of eleven simultaneous measurements for various parameters (i.e. pH, temperature, dissolved oxygen, conductivity, total dissolved solids, salinity, turbidity, oxidation reduction potential, depth and GPS position). The U-53G is composed of the sensor unit that is lowered into the water, and the hand held monitor, which allows the user to view and log sensor readings. The field instruments will be calibrated daily or as recommended by the manufacturer using the manual calibration procedures specified in the SOP (Appendix H). In addition, instrument drift measurements will be calculated daily.

2.9 Inspection/Acceptance Requirements for Supplies and Consumables

All sample containers used for chemical analysis in this project will be new and pre-cleaned by the manufacturer.

3 ASSESSMENT AND OVERSIGHT

The EPA Field Sampling Manager will be responsible for reviewing field log notebooks for accuracy and completeness. Sample results provided to the Sampling Manager by the laboratory will be assembled for a sampling report. The EPA Field Sampling Manager will compare the sample information on the field data sheets with the analytical results to ensure that no transcriptions errors have occurred.

Laboratories routinely perform performance checks using different program specific quarterly blind and double blind check standards. Each method of analysis requires specific QA/QC runs that must be complied with by the laboratory performing the analysis. The appropriate supervisors and the Laboratory QA Coordinator will routinely conduct an internal assessment of the data and results. No additional audits will be performed on the laboratory for this project.

3.1 Reports to Management

3.1.2 Project Report

The project team will prepare a report that, at a minimum, includes a brief summary of field activities; tabulation of validated analytical results, map(s) illustrating well locations and potentiometric contours of the groundwater surface in the aquifer(s) where monitoring wells are installed; and documentation of deviations from the approved QAPP.

3.1.1 Analytical Data Reporting

The analytical laboratories associated with this project should submit sufficient laboratory documentation such that the sample results are traceable to the field samples, and the analytical data can be verified and validated by an indpenedent third-party reviewer. The TestAmerica Laboratory will submit the nitrate data packages with the following information specified below through the subcontract manager (Mark Woodke, ENE) to the EPA Region 10 QA Staff for data review and validation.

I. Case Narrative
- Case Narrative per batch of samples per suite of parameters – a summary of samples received, extraction techniques (if applicable) and analytical method used with focus on problems encountered during analysis, corrective action taken, data limitations (if any), example of calculations and definitions of laboratory qualifiers applied.

II. QC data
- Matrix Spike/Matrix spike duplicate recoveries
- Fortified blank recovery results (at least 1 per batch)
- Method blanks and list of samples associated with the method blanks
- Calibration summary
- Continuing calibration summary

III. Sample Data
- Summary of Analytical results. Analytical Results should also include a sample specific reporting limit.
- Instrument Raw Data (Chromatograms, Mass Spectra, etc.)

IV. Miscellaneous Data
- Copy of method SOP
- Sample receipt documentation and sample control
- Extraction Logs (if applicable)
- Instrument Run Log
- Other analytical runs (screens, clean-up, etc.)

If, for any reason, the procedures described in this QAPP cannot be followed, the EPA Field Sampling Manager will complete a Sample Alteration Form (SAF) or a Corrective Action Form (CAF), as appropriate (Appendix I). The SAF shall be reviewed and approved by the project QA chemist. A copy of the approved SAF will be provided to the laboratory for reference.

Table 6 – Analytes, Methods, Holding Times and Preservation

Analyte	Analytical Method	Reporting Limit or Range	Container Type	Bias (accuracy)	Variability (precision)	Hold time	Preservation
Laboratory Measurements							
Nitrate	EPA 300.0	0.9 mg/L	500ml polyethylene	80-120%	+/- 20%*	48 hours	< 6 deg. C
Ammonia	EPA 350.1	0.5 mg/L	500ml polyethylene	90-110%	+/- 20%*	28 Days	H_2SO_4 to pH < 2, < 6 deg. C
Field Measurements							
Ammonia	Hach Ammonia (Nitrogen) Test Strip	0-6.0 mg/L	N/A	N/A	N/A	N/A	N/A
Nitrate	Hach Nitrate Test Strip	0-50 mg/L	N/A	N/A	N/A	N/A	N/A

*Field duplicates to be collected at a rate of 1 for every 10 samples.

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3.2 Data Validation and Usability

3.2.1 Data Review, Validation, and Verification Requirements

Data validation and review services provide a method for determining the usability and limitations of data and provide a standardized data quality assessment. Data for all parameters (except MEL data) will undergo two levels of review and validation: (1) at the laboratory data review and verification, and (2) outside the laboratory by third-party independent data verification and validation. Subcontracted laboratory-generated data will be verified and validated by the EPA R10 Quality Staff. The data generated by the regional EPA laboratory (MEL) is reviewed and verified internally at MEL and is not considered 'external validation' although validation qualifiers are applied as needed.

3.2.2 Validation and Verification Methods

All data generated shall be validated in accordance with the QA/QC requirements specified in the methods, and the technical specifications outlined in the QAPP. The summary of all analytical results will be reported to the EPA Project Coordinator. Laboratories should submit analytical results with all proper quality control and analytical raw data for each analysis and sample. The laboratory shall maintain the raw data for this project.

All Field Forms and Sample Custody & Analysis Required Forms will be reviewed by the EPA Field Sampling Manager for completeness and correctness. Any discrepancies in the records will be reconciled to the EPA Project Coordinator.

Initial data reduction, validation, and reporting at the laboratory will be performed as described in the laboratory standard operating procedures. Independent data validation by EPA or their designee will follow EPA *Contract Laboratory Program National Functional Guidelines for Inorganic/Organic Data Review* (EPA 2010), as applicable. Validation of subcontracted data will follow EPA guidance as applicable to method QC parameters, and an equivalent level of effort as prescribed in the guidance will be implemented.

3.2.3 Reconciliation with User Requirements

All data and related information obtained during the course of this project will be included in a data report package. Non-detected nitrate results will be assessed to determine if they meet the reporting limit requirements set forth in the QAPP and the drinking water standards (e.g., MCLs, MCLGs)

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APPENDICES

Lower Yakima Valley Dairy Investigation

Quality Assurance Project Plan December 2012

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Appendix A – START Work Plan
Yakima Valley Nitrate Site
TDD: 12-11-0001

FINAL WORK PLAN

Yakima Valley Nitrate Site
Sunnyside Washington
TDD: 12-11-0001

November 2012

Prepared for:

U.S. Environmental Protection Agency, Region 10
1200 Sixth Avenue
Seattle, Washington 98101

Prepared by:

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List of Abbreviations and Acronyms

ARCH	Air Rotary Casing Hammer
bgs	below ground surface
CAFO	Confined Animal Feeding Operation
DOT	Department of Transportation
E & E	Ecology and Environment, Inc.
EPA	United States Environmental Protection Agency
IDW	Investigation Derived Waste
lbs	pounds
mg/L	milligrams per liter
NAD 83	North American Datum of 1983
NAVD 88	North American Vertical Datum of 1988
NSF	National Sanitation Foundation
NTU	nephelometric turbidity unit
PPE	personal protective equipment
PVC	polyvinyl chloride
QAPP	Quality Assurance Project Plan
RA	Removal Assessment
Site	Yakima Valley Nitrate Site
SOP	Standard Operating Procedure
SSSP	Site Specific Sampling Plan
START	Superfund Technical Assessment & Response Team
USGS	United States Geological Survey

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1 Introduction

Ecology and Environment, Inc. (E & E), under Superfund Technical Assessment and Response Team (START) contract number EP-S7-06-02 with the United States Environmental Protection Agency (EPA), has prepared this Work Plan to document anticipated drilling, monitoring well construction, and development activities for a Removal Assessment (RA) at the Yakima Valley Nitrate Site (Site). Activities described in this Work Plan are intended to be implemented in November and December 2012.

The Site is part of the Yakima River Basin Aquifer System in the Lower Yakima Valley, in Central Washington State. Numerous studies conducted over the last 30 years have shown elevated nitrate concentrations in shallow groundwater. These elevated nitrate concentrations are commonly above the EPA maximum contaminant level of 10 milligrams per liter (mg/L). This Work Plan describes the installation of monitoring wells to supplement data collected in previous investigations in the area. The monitoring wells will be used to establish groundwater flow directions and gradients as well as provide additional data points for nitrate concentrations in groundwater. As potential sources of nitrates are addressed, the monitoring well network will be used to assess improvements, if any, on nitrate concentrations in groundwater.

This Work Plan includes the following sections: Site Description and Background, Monitoring Well Drilling and Installation, Monitoring Well Development, Location/Elevation Survey, and References. Appendix A includes Standard Operating Procedures (SOP's).

Additional information pertaining to groundwater sampling and laboratory analysis can be found in the Quality Assurance Project Plan (QAPP) (SAIC 2012).

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2 Site Description and Background

The Site is located in the Toppenish Basin within the south-central part of the Yakima Basin and is focused on the Dairy Cluster and Haak Dairy which are located just south of the Rattlesnake Hills in Yakima County, Washington, approximately 10 road miles and 4 road miles, respectively, from Sunnyside, Washington. The Dairy Cluster is located within Sections 025, 026, 027, 034, 035, and 036 of Township 11 North, Range 21 East; Sections 030 and 031 of Township 11 North, Range 22 East; Section 006 of Township 10 North, Range 22 East; and Township 10 North Range 21 East; Willamette Meridian. The Haak Dairy is located within Section 006, Township 10 North, Range 23 East; Willamette Meridian. Figure 1 shows the location of the dairies and general topography of the study area.

The topography of the study area consists of gently rolling hills. Land use in the study area is predominantly large dairy farms, which are concentrated animal feeding operations or CAFOs, and irrigated cropland including apple, cherry and grape orchards/vineyards. There are some residences as well. Residences depend on private well water for drinking. All of these land uses could potentially contribute to nitrates in groundwater through improper management of animal waste, application of animal waste to croplands, and through septic systems. The current target of the monitoring well network is nitrates in shallow groundwater. Existing groundwater data from wells in the area, in some cases, shows concentrations of nitrate greater than 50 mg/L or over 5 times that of the EPA Maximum Contaminant Level of 10 mg/L.

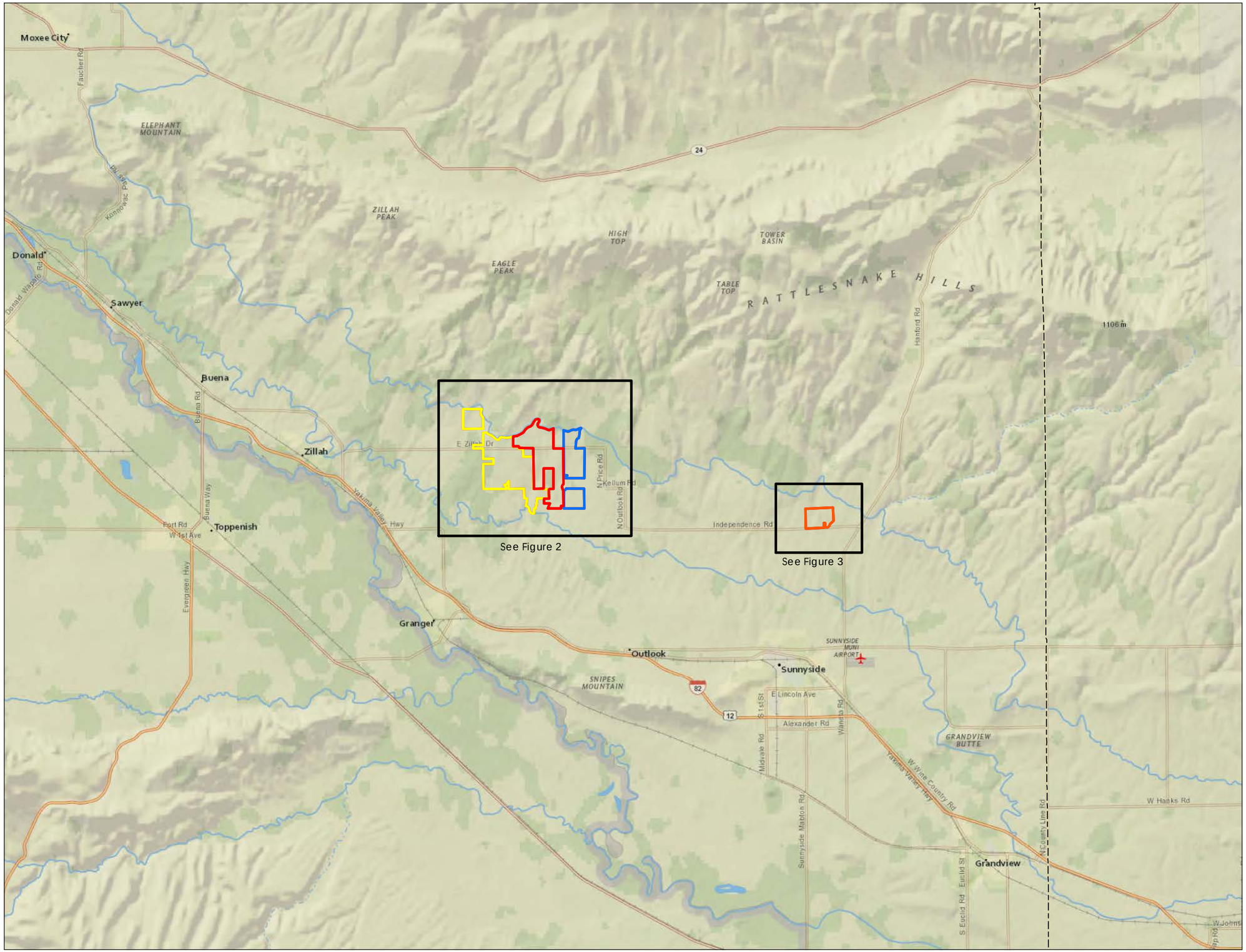
A more detailed Site description and background can be found in the project QAPP (SAIC 2012).

Figure 1
Yakima Valley Nitrate Project
Sunnyside, Washington

Legend

Project Boundaries

- Property 1
- Property 2
- Property 3
- Property 4



N

0 2.5 5 Miles
0 4 8 Kilometers

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3 Monitoring Well Drilling and Installation

The following information pertains to monitoring well drilling and installation activities.

3.1 Pre-Drilling Activities

For monitoring wells installed in county road right-of-ways, a subcontracted surveyor will meet with EPA and START at the Site. During this meeting the proposed well location will be marked with a lathe stake. The surveyor will verify that each marked location is within the Yakima County road right-of-way (ROW). All surveying work will be under the responsible charge of a professional surveyor currently licensed in the State of Washington.

Due to an anticipated high density of underground utilities near the drill sites, the drilling subcontractor will use a Vac-Truck/Air Knife capable of clearing materials to a minimum depth of 5 feet below ground surface (bgs) at each location prior to drilling. Two alternate drilling locations, within 30 feet of the original location, will be selected by EPA and START. One of these locations will be used if the Vac-Truck/Air Knife exposes underground utilities in the first location. If after the three locations, underground utilities cannot be avoided, the drill site will be abandoned until a decision is made (by EPA) on where an alternate, suitable location will be. Abandoned Vac-truck/Air knife holes shall be backfilled in a way that complies with all local, state, and federal regulations for borehole abandonment.

3.2 Monitoring Well Drilling

Approximately 13 monitoring wells will be installed to approximately 100 feet bgs[1] or 20 feet below the water table using Air Rotary Casing Hammer drilling and/or Sonic drilling methods. The field crew will consist of one START field geologist and one EPA oversight staff. The number of field crews may be increased to two if it is determined that a second drilling rig should be mobilized to the site to shorten the number of days in the field needed to complete drilling.

[1] The upgradient/background well locations may require drilling to depths greater than 100 feet bgs based on an anticipated deeper water table at these locations.

Depth to groundwater will vary throughout the site, but generally, it is anticipated that the depth to groundwater will be greater in the northern reaches of the Site and shallower to the south. Upon encountering groundwater at the target depth, drilling will be ceased and 15 to 30 minutes will be allowed for water levels to equilibrate. At that time a static water level will be collected in accordance with Standard Operating Procedure (SOP) 2043 contained in the QAPP (SAIC 2012).

Boreholes will be drilled in unconsolidated alluvial material and therefore will require the use of temporary drive casing in order to keep the borehole open. Boreholes will be drilled until groundwater is encountered or until EPA hydrogeologist directs the driller to stop drilling and abandon. Once groundwater is encountered, or observed in drill cuttings, drilling shall continue for 5 feet, at which point drilling will cease in order to collect depth-to-water measurements. The START field geologist shall record lithologic characteristics of drill cuttings in a form similar to that of Appendix A of SOP #2048 Monitoring Well Installation contained in Appendix A of this work plan. A depth-to-water measurement shall be collected as soon as possible after drilling has ceased, and then in 5 minute intervals as the water level re-equilibrates for maximum duration of 30 minutes. The START field geologist shall record the depth at which groundwater is first encountered and subsequent measurements.

Figures 2 and 3 show the proposed monitoring well locations. Details of the drilling methods and monitoring well installation are described herein.

3.2.1 Air Rotary Casing Hammer (ARCH) Drilling

Air rotary drilling, the ideal method for advancing boreholes into consolidated bedrock formations, uses a rotary-driven drill bit and high-pressure, high-flow air. Typically, either a "tricone" cutting bit or a downhole percussion hammer is used to penetrate the rock surface and grind the rock into small particles. High-flow air is injected through the drill string, cooling the bit, evacuating rock cuttings from the borehole and stabilizing the borehole during drilling.

The air-rotary technique is much more efficient than other rock drilling techniques (ie cable tool) because the high-flow air constantly cleans the bottom of the boreholes, which allows for consistent contact between the drill bit and intact bedrock.

This method can also be used in unconsolidated materials and is especially useful when large boulders are encountered.

3.2.2 Sonic (Rotary Vibratory) Drilling

A sonic drill is more precisely identified as a rotary vibratory drill. The drill head, which is slightly larger than a standard rotary head, contains the mechanism necessary for rotary motion, as well as an oscillator, which causes a high frequency force to be superimposed on the drill string. The drill bit is

physically vibrating up and down in addition to being pushed down and rotated. These three combined forces allow drilling to proceed rapidly through most geological formations including most types of rock.

In overburden, the vibratory action causes the surrounding soil particles to fluidize, thereby allowing penetration. In rock, the drill bit causes fractures at the rock face, creating rock dust and small rock particles, which facilitates advancement of the drill bit. In many instances the drilling and coring of rock and earth can be accomplished without the use of any drilling fluid whatsoever. Compressed air, drill mud, or plain water can be utilized to remove the cuttings and speed up the operation further, depending on the application that the machine is used for.

The oscillator is driven by a hydraulic motor and uses out of balance weights to generate high sinusoidal forces that are transmitted to the drill bit. An air spring is also incorporated in order to confine the alternating forces to the drill string. The frequency can be varied to suit operation conditions and is generally between 50 and 120 hertz (cycles per second). This frequency range falls within the lower range of sound vibrations that the human ear is capable of hearing. Thus the term "sonic drill" has been applied to this class of rotary-vibratory drilling machine. The driller chooses a frequency that gives him the best drilling rate or best core recovery, as the case may be.

3.3 Decontamination Procedures

The purpose of decontamination is to prevent the cross-contamination of samples, control spread of contaminants to uncontaminated areas, and to prevent chemical exposure to the site personnel. Prior to the mobilization of the drill rig on site and following project completion, the rig and all associated equipment (including sampling devices) shall be thoroughly cleaned to remove all oil, grease, mud, tar, etc. This cleaning process shall consist of a high-pressure steam cleaning as indicated in SOP # 2048, Monitor Well Installation (Appendix A). START personnel will inspect all equipment to ensure sufficient cleaning. The Subcontractor must provide all equipment necessary for this cleaning process. Prior to drilling at each location, all cutting bits, drive casing, and drill rod will be pressure washed or steam cleaned and air-dried.

A decontamination pad will be constructed or a decontamination trailer for steam cleaning down-hole tools, well materials, and sampling and other equipment will be provided by the driller. All contaminated wash water, and related materials will be collected by the driller. Decontamination water can be discharged to the land surface at the drill site so long as it does not enter surface water and result in cloudy/turbid water or other water quality criteria exceedance.

Proper personal protective equipment (PPE) will be worn by personnel during equipment decontamination. The driller will be responsible for proper disposal of disposable PPE. Non-disposable protective clothing will be washed

with a water and Liquinox detergent solution, and will be rinsed with potable water.

3.4 Monitoring Well Installation

New monitoring wells will be installed within borings in accordance with Chapter 173-1 60 WAC, Minimum Standards for Construction and Maintenance of Wells and as described below. Additional information relevant to monitoring well installation is included in SOP # 2048, Monitor Well Installation (Appendix A).

Each well will be constructed of 2-inch inner diameter, Schedule 40, National Sanitation Foundation (NSF)-approved, polyvinyl chloride (PVC) flush-threaded casing. The wells will be screened with one 20-foot section of 2-inch, 0.010-inch continuous slot PVC screen, or equivalent.

A 2.5-foot, 2-inch, Schedule 40, matching thread, NSF-approved sump will be attached to the base of the well screen. The monitoring wells will be completed to ground surface using Schedule 40 PVC riser. All PVC casing joints will be of matching flush-threaded design with Viton O-rings and will be screwed together without the use of glues, epoxies, or petroleum-based lubricants. All materials will be cleaned and placed in polyethylene bags at the factory; the bags will remain sealed until the time of installation.

A minimum annular space of 2 inches between the borehole and well casing will be maintained. Centralizers shall be installed below the well screen and within 4 feet of the top of the well screen and every 20 feet up the riser until a maximum depth of 20-feet bgs.

The filter pack will extend from the bottom of the borehole to at least 2 feet above the top of the screen. A filter pack of 20 - 40 Colorado (or equal) silica sand will be placed in the annular space around the well screen from the bottom of the borehole to approximately 4 feet above the top of the screen. The well screen will then be surged in 5-foot intervals for 5 minutes in each interval. This will assure that the filter sand is settled and that the seal will not sink into the screen. The field geologist will pre-determine the volume of filter pack expected to fill the annular space in the filter pack interval and record this in a field logbook. Before the bentonite seal is placed, the filter pack will be carefully re-measured to ensure correct installation of the sand pack. Additional material will be added to ensure that the position of the sand pack is correct.

Bentonite chips will be placed on top of the sand pack to within 3 feet of the land surface. The bentonite chips will be added to the borehole annulus within temporary drive casing in 2.5 foot increments and hydrated. As bentonite chips are added and hydrated the temporary drive casing will be withdrawn in equal increments. The bentonite chips will be hydrated after placement only if they are above the water table. . The remainder of the borehole annulus, up to 3 feet bgs, will be backfilled with cement-bentonite grout. Cement-bentonite grout shall consist of approximately 5 pounds (lbs) of bentonite powder mixed with 94

lbs of cement and no more than 8 gallons of water. The above ground surface completion will not be installed within 24 hours of grout placement.

Flush-mount completions: Each new monitoring well that is completed at the ground surface will be finished with a traffic rated flush-mount monument. Inner well casings will be fitted with a locking interior watertight cap. A 2- by 2-foot concrete apron will be constructed around the well monument and sloped away from the well.

Above Ground Surface Completions: Each new monitoring well that is completed above ground will have an 8 to 10-inch protective "stovepipe" casing set in a 2-foot by 2-foot by 4-inch sloping concrete apron surrounded by 3 bollards. In order to minimize the effects of frost action, the concrete pads will be constructed with galvanized steel-reinforcing fibers which will impart a greater durability to the well pad. The outer protective casing will be 3.5 feet above grade. The monitoring well will be centered within the protective casing and placed about 3 feet above grade. Concrete or 20- 40 Colorado silica sand will be placed between the casing and the stovepipe and rodded to settle the concrete and lock the joint in place. The casing, stovepipe and Sonotube shall be supported until the concrete has hardened. The outer protective casing shall have a lockable steel plate as the cover. The monitoring well will have a lockable well cap inside the protective casing. The outer and inner casing shall be vented near the top to prevent potential gas accumulation. Three 4-inch diameter by 5-foot long cement filled steel guard posts (bollards) will be installed radially around the well. The guard posts will be recessed approximately two feet into the ground and set in concrete. The post will be placed around, but not in, the concrete pad placed at the well base.

Water used in the drilling process, to prepare grout mixtures and to hydrate the bentonite will be from a clean, uncontaminated water source of known chemistry as determined by an START and/or EPA representative.

Geologic well construction logs shall be completed by the driller and submitted to the appropriate regulatory agencies within the appropriate time frame.

Each monitoring well shall be assigned a permanent identifier or name, which will be permanently marked on the well by stamping the metal surface of the well casing, clearly marking the protective surface pad, or some other means acceptable to START's field Geologist.

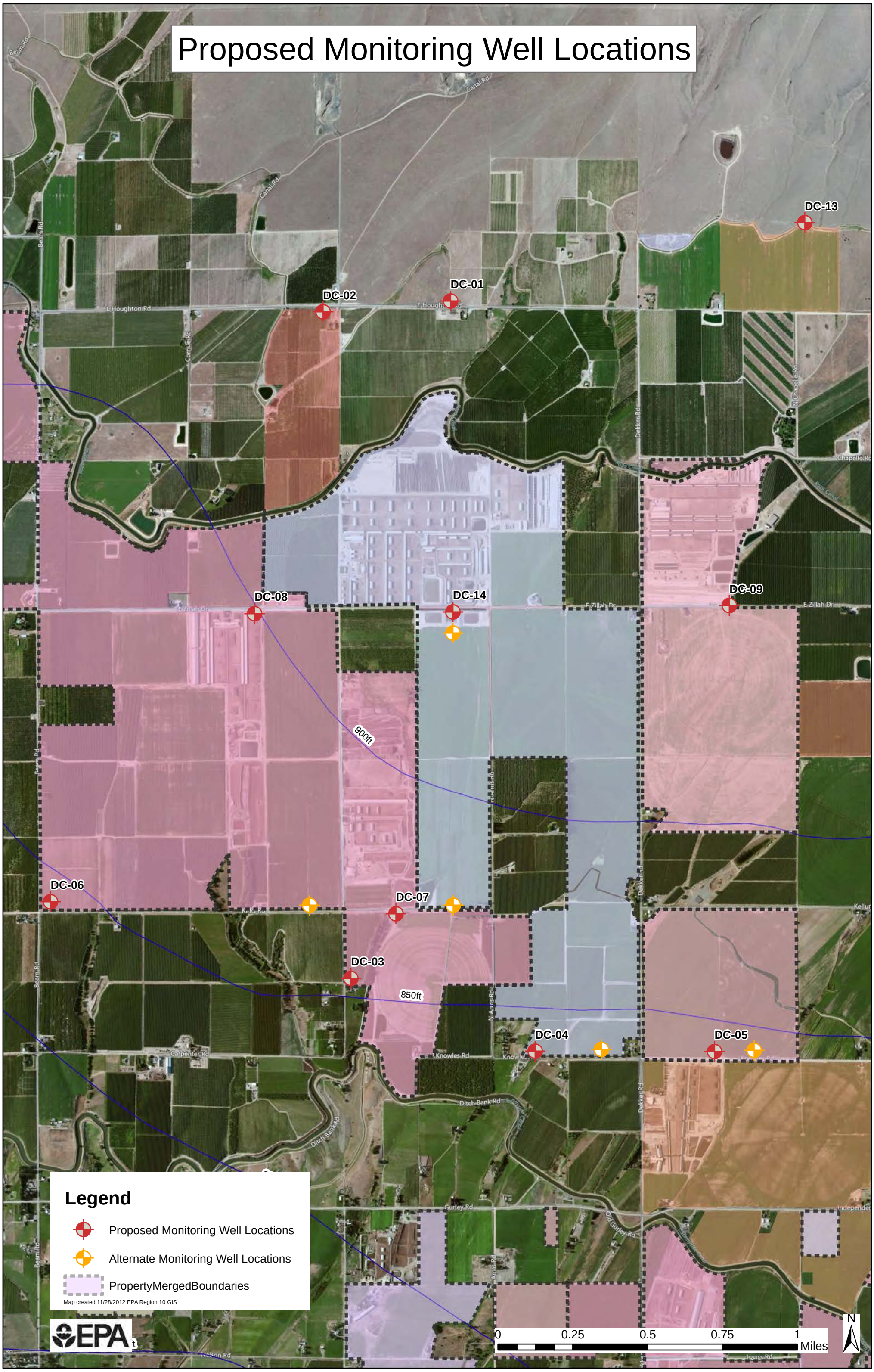
3.5 Underground Utility Location

The driller will be responsible for calling the appropriate dig line and for the procurement of a private utility locator to verify the positions of all resulting underground utilities identified within proximity of the proposed boring locations.

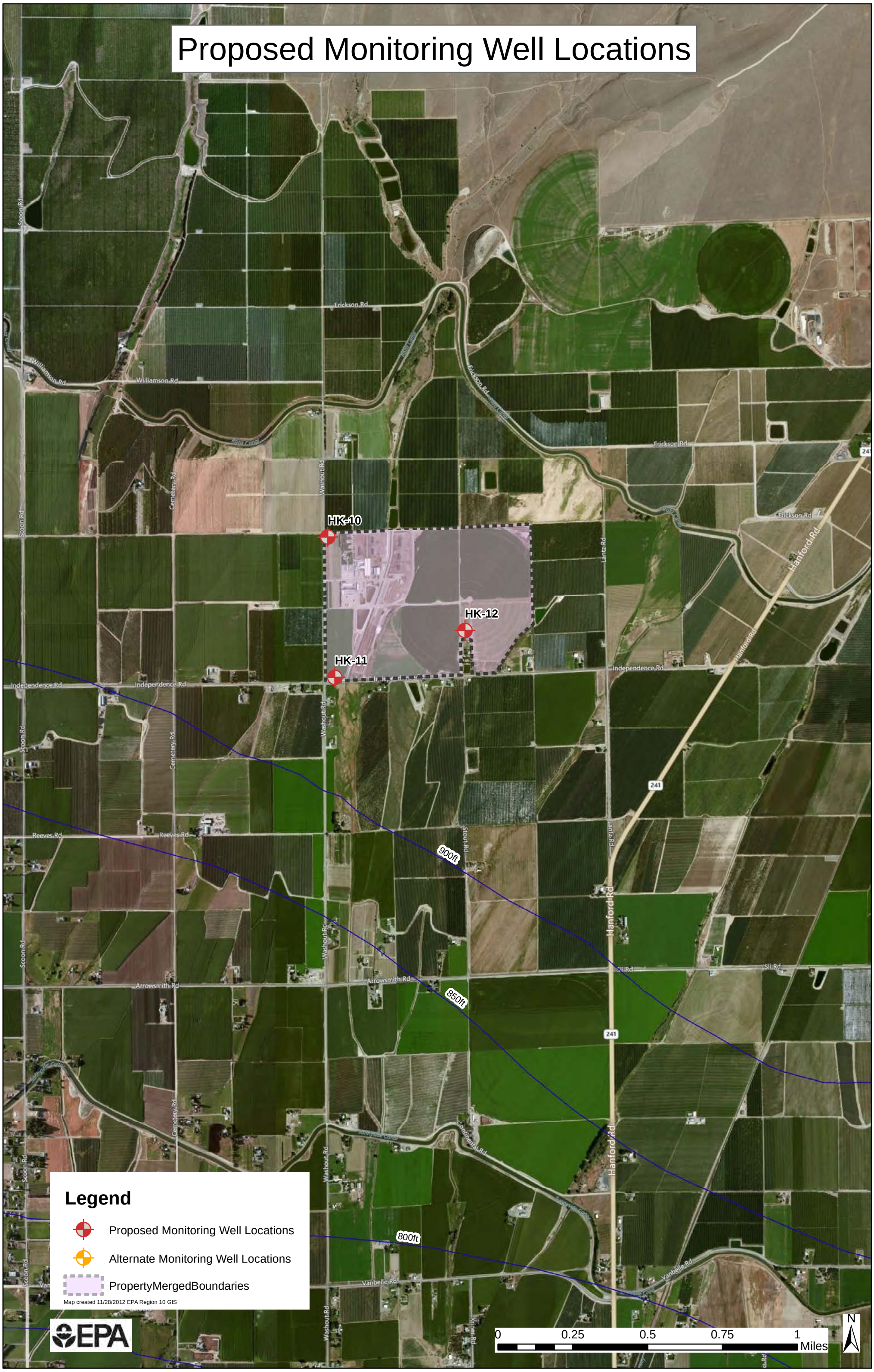
3.6 Traffic Control

The driller will be responsible for providing traffic control for all drill sites. It is anticipated that up to 7 drill sites will require the closure of one lane of traffic and will require the use of flaggers. It is anticipated up to 5 locations will partially obstruct one lane of traffic and require the use of cones and signs, but not the use of flaggers. The remaining locations will not affect traffic. The locations that are assumed to require a flagger include: 1, 2, 3, 4, 5, and 7. Locations anticipated to require cones and signs include: 6, 8, 9, 10, and 14. These locations are likely to change some depending on utility locations and access to the proposed locations. See Figures 2 and 3.

Proposed Monitoring Well Locations



Proposed Monitoring Well Locations



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4 Monitoring Well Development

Newly completed monitoring wells should be developed as soon as practical, but no sooner than 48 hours after grouting is completed. Well development should comply with the general requirements of SOP #2044, Monitor Well Development, included in Appendix A. For the Yakima Nitrate site, the following steps[2] should be followed for well development:

- Measure the depth to water and the total depth of the well.
- Measure the initial pH, temperature, turbidity, and specific conductance of the groundwater from the first groundwater that comes out of the well. Note the time, the water color, clarity, and odor.
- Develop the well using the methods described below. Continue to record observations and water quality readings. Record these observations and all results in a field logbook or on a well development form.
- The wells shall be developed using a combination of a surge block and pumping techniques until the water produced is relatively sand-free and clear, has a reading of less than 10 nephelometric turbidity units (NTU) and until each water quality parameter is stable to within 10 percent or until further development will not improve water clarity in the opinion of START's field geologist. The surge block should be lowered into the water column above the well screen. The water column will effectively transmit the action of the block to the filter pack and hydrologic unit adjacent to the well screen. Development should begin above the screen and move progressively downward to prevent the surge block from becoming sand locked in the well. The initial surging action should be relatively gentle, allowing any material blocking the screen to break up, go into suspension, and then move into the well. As water begins to move easily both in and out of the screen, the surge block is usually lowered in increments to a level just above the screen. As the block is lowered, the force of the surging movement should be increased. Since these monitoring wells are equipped with relatively long screens, it may be more effective to operate the surge block in the screen to concentrate its actions at various levels.

[2] Note site specific steps are contained in this work plan in addition to steps outlined in SOP #2044.

- A pump or bailer should be used periodically to remove dislodged sediment that may have accumulated at the bottom of the well during the surging process. The pump or bailer should be moved up and down at the bottom of the well to suspend and collect as much sediment as possible.
- All development purge water will be discharged to the land surface at the drill site so long as it does not enter surface water and result in cloudy/turbid water or other water quality criteria exceedance.

The pump, tubing, and all other equipment used during development will be decontaminated between each use as specified in SOP #2006, Sampling Equipment Decontamination (Appendix A).

5 Investigation Derived Waste

The IDW generated during field activities will be treated as specified below. IDW is expected to consist of the following waste types:

- Drill cuttings from extractions and monitoring wells,
- Groundwater from well development,
- Wastewater from well development activities,
- Wastewater from drilling operations, and
- Decontamination fluids.

Drill cuttings generated within Yakima County Right-of-Way may be spread at the drill site so long as it does not enter surface water and result in cloudy/turbid water or other water quality criteria exceedance. IDW wastewater will be containerized, sampled and discharged to the City of Sunnyside Wastewater Treatment Plant, in accordance with all local, state and federal laws. IDW generated on other, private property will be addressed on an individual basis depending on the property owner's wishes for handling. In some cases IDW generated during drilling operations may be placed in subcontractor supplied 55 -gallon Department of Transportation (DOT)-approved drums and/or Baker Tanks and relocated as designated by the site manager.

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6 Location/Elevation Survey

A surveying subcontractor will survey all newly installed monitoring wells along with ground surface control points across the Site. All surveying work will be under the responsible charge of a professional surveyor currently licensed in the State of Washington.

The surveyor will measure the latitude, longitude (Northings and Eastings), and elevation at the top of the riser and ground surface for each of the wells installed. Horizontal locations will be measured to an accuracy of +/- 0.1 foot and elevations will be established to an accuracy of +/-0.01 foot. A permanent notch will be made on the north side of the riser. The top of the riser and ground surface will be surveyed with respect to:

- Vertical Accuracy and Datum: All points shall have relative accuracy to within 0.01 feet vertically. Vertical datum for topographic survey shall be North American Vertical Datum of 1988 (NAVD 88), Units in Feet. See attached Figure for basis of elevation information at United States Geological Survey (USGS) Monument Designation H 39.
- Horizontal coordinates of the monitoring wells and other locations shall be established to the closest 0.1 foot and referenced to the State Plane Coordinate System North American Datum of 1983 (NAD 83).

The surveyor will provide elevations and horizontal coordinates of the ground surface and top of inner casing for each well within 2 weeks of completing the surveying in digital and a report format.

All data obtained during the survey will be permanently recorded. A field notebook will be maintained noting location, survey-crew members, dates, times, weather, field sketches, and other pertinent data (e.g. computer calculations or coordinates used to verify survey accuracy, closure notes, etc.).

Data recorded electronically will be preserved on a compact disc. A hard copy of all electronically obtained data will be maintained.

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7 References

SAIC 2012, Yakima Valley Dairy Investigation, Quality Assurance Project Plan for the United States Environmental Protection Agency, Region 10. November 2012.

A Standard Operating Procedures

MANUAL WATER LEVEL MEASUREMENTS

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A - Example Field Data Sheet

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SUPERCEDES: SOP #2043; Revision 0.0, 02/11/00; U.S. EPA Contract 68-C99-223

1.0 SCOPE AND APPLICATION

The purpose of this Standard Operating Procedure (SOP) is to set guidelines for the determination of the depth to water measurements in an open borehole, a cased borehole, a monitor well, or a piezometer.

Generally, water-level measurement data from boreholes, piezometers, or monitor wells are used to construct water table or potentiometric surface maps, and to determine groundwater flow direction, groundwater level recovery following a pumping event, or to determine other aquifer characteristics. Therefore, all water level measurements at a given site should be collected within a 24-hour period. However, certain situations may produce rapidly changing groundwater levels that necessitate taking measurements within a condensed time frame. Rapid groundwater level changes may occur due to:

- Atmospheric pressure changes;
- Tidal influences;
- Changes in river stage, impoundments levels, or flow in unlined ditches;
- Pumping of nearby wells;
- Precipitation.

2.0 METHOD SUMMARY

A permanent survey mark should be placed on the top of the riser pipe or casing as a reference point for groundwater level measurements. If the lip of the riser pipe is not flat, the reference point may be located on the grout apron or the top of the outer protective casing (if present). If using a measurement reference point, it must be documented in the site logbook, the sampler's personal log book, or on field data sheets (Figure 1, Appendix A). All field personnel must be informed of the measurement reference point used in order to ensure the collection of comparable data. NOTE: All data recorded in the sampler's personal log book must be photocopied and retained in the project files.

Before measurements are made, water levels in piezometers and monitor wells should be allowed to stabilize for a minimum of 24 hours after well construction and development. In low yield situations, recovery of water levels to static equilibrium may take longer. All measurements should be recorded to one hundredth (0.01) of a foot. Water level measuring equipment must be decontaminated prior to and after each use at each measuring location. When possible, measurements should be taken from the least to the most contaminated borehole, well, or piezometer.

Open the well and monitor the head space with an appropriate air monitoring instrument to determine the presence of volatile organic compounds (VOCs). For electrical sounders, ground the measuring equipment, and then lower the water level probe into the well until the water surface is SERAShed, as indicated by a tone or meter deflection. Record the distance from the water surface to the reference point. (Measurement with a chalked tape will necessitate lowering the tape below the water level and holding a convenient foot marker at the reference point. Record the water level as indicated on the chalked tape section and the depth mark held at the reference point. The depth to water is the difference between these two readings.) Remove the water level probe, replace the riser pipe cap, and decontaminate the equipment as necessary. Note: If a separate phase product is present, a product/water interface probe is required for the measurement of product thickness and water level.

3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING AND STORAGE

This section is not applicable to this SOP.

4.0 INTERFERENCES AND POTENTIAL PROBLEMS

- Cascading water, particularly in open-hole or rock wells and especially during aquifer pumping tests, may interfere with the water level measurement.
- Some older types of electric sounders are only marked at 5-foot intervals. A surveyor's tape is necessary to extrapolate between the 5-foot marks.
- Oil or other product floating on the water column can insulate the contacts of the probe on an electric sounder and give false readings. For accurate level measurements in wells containing separate phase product, a special product/water level indicator is required.
- Tapes (electrical or surveyor) may have damaged or missing sections, or may be spliced inaccurately. Always examine the tape for continuity and completeness.
- An air line may be the only available means to take measurements in sealed production wells, and is not described here. The method is generally accurate to approximately two-tenths (0.2) of a foot.
- When using a chalked steel tape, it is necessary to lower the tape below the water level in order to take a measurement. This method is more successful when the operator has knowledge of the approximate groundwater level.

5.0 EQUIPMENT/APPARATUS

- Electric water level indicator, marked in increments of 0.01-foot
- Steel tape, chalked, marked in increments of 0.01-foot
- Appropriate air monitoring equipment [photoionization detector (PID) and/or flame ionization detector (FID)]
- Product/water interface probe
- Chalk
- Ruler/Measuring tape
- Site logbook, personal logbook, and/or field data sheets
- Decontamination supplies
- Paper towels and trash bags

6.0 REAGENTS

No chemical reagents are used in this procedure; however, decontamination solutions may be necessary. If decontamination of equipment is required, refer to Environmental Response Team/Scientific, Engineering, Response and Analytical Services (ERT/SERAS) SOP #2006, *Sampling Equipment Decontamination*, and the approved site Work Plan (WP).

7.0 PROCEDURES

7.1 Preparation

1. Determine the number of measurements needed, the methods to be employed, and the equipment and supplies needed.

2. Decontaminate or pre-clean equipment, and ensure that it is in working order.

3. Coordinate sampling schedule with staff, clients, and regulatory agency, if appropriate.

4. If this is an initial visit, perform a general site survey prior to site entry in accordance with the current approved site specific Health and Safety Plan (HASP).

5. Identify sampling locations.

7.2 Water Level Determination

1. If possible, and when applicable, measure those wells that are least contaminated and proceed to those most contaminated.

2. Clean all the equipment used to measure water levels (which enters the well) by the following decontamination procedure:

   - Rinse equipment with deionized water.

   - Wash the equipment with an Alconox solution, followed by a deionized water rinse.

   - Rinse the equipment with an appropriate solvent suitable for the type and material composition (e.g., methanol, isopropyl alcohol, acetone) as per the WP, if organic contamination is suspected.

   - Triple rinse the equipment with deionized water.

   - Place the equipment on clean surface such as a Teflon or polyethylene sheet to air dry.

3. Remove the (locking) well cover, note the well identification (ID), the date and time of day, and the participating field personnel in the site logbook, a personal logbook, and/or on a field data sheet.

4. Remove well cap.

5. If organic contaminants are suspected, monitor the head space of the well with a photoionization detector (PID) or flame ionization detector (FID). Record the results in the site logbook, personal logbook, and/or on a field data sheet.

6. Lower a water-level measuring device into the well. Electrical tapes are lowered to the water surface. Chalked steel tapes are lowered generally a foot or more below the water surface; steel tapes are generally chalked so that a 1- to 5-foot long section will fall below the expected water level. Record all measurements in the site logbook, the sampler's personal log book, and/or on field data sheets. NOTE: All data recorded in a personal log book must be photocopied and retained in the project files.

7. For electrical tapes, record the distance from the water surface, as determined by the audio signal or meter, to the reference measuring point. For chalked tapes, an even foot mark is held at the reference point, once the chalked section of the tape is below the water level. Both the water level on the tape and the foot mark held at the reference point is recorded. The depth to the water is the difference between the two readings. In addition, note the reference point used (top of the outer casing, top of the riser pipe, ground surface, or some other permanent reproducible position on the well head). Repeat the measurement to ensure reproducibility and accuracy. Preferably the same person and level measurement equipment should be used to eliminate any sources of error related to the measurement readings.

8. Remove all water level measuring equipment, replace the well cap and the locking steel caps.

9. Decontaminate all equipment as outlined in Step 2 (above), and store for transport to the next sampling location.

10. Note any physical changes, such as erosion or cracks in protective concrete pad or variation in the total depth of the well, in a site logbook, a personal logbook, and/or on a field data sheet.

8.0 CALCULATIONS

To determine groundwater elevation above mean sea level, use the following equation:

$$E_w = E - D$$

where:

$\boldsymbol{E_W}$ = Elevation of water above mean sea level (feet) or local datum
$\boldsymbol{E}$ = Elevation above sea level or local datum at point of measurement (feet)
$\boldsymbol{D}$ = Depth to water (feet)

9.0 QUALITY ASSURANCE/QUALITY CONTROL

The following general quality assurance/quality control (QA/QC) procedures apply:

1. All data must be documented in site logbooks, personal logbooks, and/or field data sheets.

2. All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the WP.

3. Each well must be tested at least twice in order to compare results. If results do not agree within 0.02 of a foot, a third measurement must be taken and the readings averaged. Consistent failure of consecutive readings to agree suggests that levels are changing because of one or more conditions, as indicated in Section 1.

10.0 DATA VALIDATION

This section is not applicable to this SOP.

11.0 HEALTH AND SAFETY

When working with potential hazardous materials, follow U.S. EPA, Occupational Safety and Health Administration (OSHA) and corporate health and safety procedures.

If the FID/PID results obtained while monitoring the head space and breathing zones indicate that VOCs are present, the personal protection level may need to be upgraded from that denoted in the HASP.

12.0 REFERENCES

Driscoll, F.G. 1986. Groundwater and Wells. *Collection and Analysis of Pumping Test Data*. 2nd ed. Chapter 16. St. Paul, Minnesota: Johnson Filtration Systems Inc. pp 534-579.

U.S. Environmental Protection Agency, 1986. *RCRA Groundwater Monitoring Technical Enforcement Guidance Document*. p. 207.

U.S. Environmental Protection Agency, Office of Emergency and Remedial Response. 1987. *A Compendium of Superfund Field Operations Methods.* EPA/540/p-87/001.

APPENDIX A
Example Field Data Sheet
SOP #2043
December 2002

FIGURE 1. EXAMPLE FIELD DATA SHEET

PAGE __ OF

SITE NAME: _____ LOGGER NAME: _____

SITE LOCATION: _____ ERTC WAM: _____

LOG DATE: _____ WBS #: RIA _____

Well I.D.	Time	Elevation of well(1) (TOC)	Depth to bottom of well (feet)	Depth to Water (feet)	Depth to product (feet)	COMMENTS (pH, temperature, specific conductance)

TOC: top of casing (1) feet above mean sea level

MEASUREMENT REFERENCE POINT FROM_____GROUND SURFACE OR_____TOP OF CASING

Weather Conditions: Temperature (^{o}C):_____ Rain: Heavy: ____Medium:____ Light:____(Circle one)

Other significant observations:

MONITOR WELL INSTALLATION

SOP#: 2048
DATE: 03/18/96
REV. #: 0.0

1.0 SCOPE AND APPLICATION

The purpose of this standard operating procedure (SOP) is to provide an overview of the methods used for groundwater monitor wells. Monitor well installation create permanent access for collection of samples to assess groundwater quality and the hydrogeologic properties of the aquifer in which contaminants may exist. Such wells should not alter the medium which is being monitored.

The most commonly used drilling methods are: the hollow-stem auger, cable tool, and hydraulic rotary. Rotary drilling can utilize mud rotary or air rotary methods.

These are standard (i.e., typically applicable) operating procedures which may be varied or changed as required, depending on site conditions, equipment limitations, or limitations imposed by the procedures themselves. In all instances, the ultimate procedures employed should be documented and described in the final report as well as in logbooks.

Mention of trade names or commercial products does not constitute United States Environmental Protection Agency (U.S. EPA) endorsement or recommendation for use.

2.0 METHOD SUMMARY

There is no ideal monitor well installation method for all conditions therefore, hydrogeologic conditions at the site as well as project objectives must be considered before deciding which drilling method is appropriate.

2.1 Hollow-Stem Augering

Outside diameters of hollow-stem augers generally range from 6 1/4 inches to 22 inches with corresponding inner diameters ranging from 2 1/4 inches to 13 inches. Auger lengths are usually 5 feet which allows easy handling. However, lengths of 10 or 20 feet may be used for deeper holes drilled with machines capable of handling the extended lengths. Formation samples can be taken in a number of ways, depending on the accuracy required. Cuttings may suffice for shallow depths but become less representative with depth, particularly below the water table. The most accurate samples are obtained with various coring devices, such as split spoons or shelby tubes which can be used inside the augers. Continuous cores can also be taken with a thin-walled tube which is inserted into the lowest auger and locked in place. The tube is retracted with a wire line and hoist after the hole has been advanced the length of the auger. A bottom plug in the cutting head or bit prevents cuttings from entering the augers until the first core sample is taken and the plug is knocked out.

In unconsolidated material, the augers serve as a temporary casing and gravel-packed wells can be constructed inside the augers and then the augers withdrawn. Well development is usually less difficult than with wells drilled by the mud rotary method because a bentonite drilling fluid is not normally used.

2.2 Cable Tool Drilling

Cable tool drilling is a percussion method in which a bit, attached to a drilling string, is lifted and dropped. The drilling string, consists (bottom to top) of the bit, drill stem, drilling jars, socket, and wire cable. A walking beam on the drilling rig provides the lifting and dropping motion to the wire cable and hence to the drilling string. The repeated action breaks or loosens the formation material which mixes with formation water or water added to the hole by the operator to form a slurry. The slurry facilitates removal of the cuttings which are periodically removed from the hole with a bailer. In unconsolidated formations, steel casing must be driven or pushed into the ground as the drilling progresses in order to prevent hole collapse. A hardened steel drive shoe on the bottom end of the

casing prevents damage during driving. A well may then be constructed inside the steel casing and the casing pulled back. In consolidated formations, the casing may be driven through the weathered zone, and seated in solid rock. The hole below the casing may remain open or may be fitted with a smaller diameter inner casing and screen, depending on the sampling requirements. Depending on formation material, extensive well development may often not be necessary.

2.3 Rotary Drilling

2.3.1 Mud Rotary Method

In the mud rotary method the drill bit is rotated rapidly to cut the formation material and advance the borehole. The drill bit is attached to hollow drilling rods which transfer power from the rig to the bit. In conventional rotary drilling, cuttings are removed by pumping drilling fluid (water, or water mixed with bentonite or other additives) down through the drill rods and bit, and up the annulus between the borehole and the drill rods. The drilling fluid flows into a mud pit where the cuttings settle out and then is pumped back down the drill rods. The drilling fluid also cools the bit and prevents the borehole from collapsing in unconsolidated formations.

Sampling may be done from the cuttings but samples are generally mixed and the amount of fine material may not be accurately represented. Coring may be done through the drill rods and bit if a coring bit (with a center opening big enough to allow passage of the coring tube) is used. When drilling unconsolidated formations, a temporary surface or shallow casing may have to be installed in order to prevent cross-contamination, hole collapse, or wall erosion by the drilling fluid. Casing (riser pipe), screen, and gravel pack are usually installed in the open hole or through the surface casing. Once the well is constructed, extensive well development may be necessary in order to remove drilling fluid from the formation.

2.3.2 Air Rotary Method

The air rotary method uses air as the drilling fluid. Air is forced down the drill rods by an air compressor, escapes out of the bit and returns to the surface in the annular space between the hole wall and the drill string. Cuttings are moved out of the hole by the ascending air and collect around the rig. Cuttings are mixed and may not always be representative of the depth currently being drilled. In the conventional air rotary method, the drill string operates in a manner similar to that described for the mud rotary system. In a "hammer" or "down-the-hole" air rotary method, the bit is pneumatically driven rapidly against the rock in short strokes while the drilling string slowly rotates. The use of air rotary methods are generally limited to consolidated and semi-consolidated formations. Casing is often used in semi-consolidated formations and through the weathered portion of consolidated formations to prevent hole collapse. In environmental work, the air supply must be filtered to prevent introduction of contamination into the borehole.

3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

Often, a primary objective of the drilling program is to obtain representative lithologic or environmental samples. The most common techniques for retrieving samples are:

In unconsolidated formations:

- Split spoon sampling, carried out continuously or at discrete intervals during drilling, as summarized in ASTM Method D-1586-84, Split Barrel Sampling
- Shelby tube sampling when an undisturbed sample is required from clayey or silty soils, especially for geotechnical evaluation or chemical analysis
- Cutting collection when a general lithologic description and approximate depths are sufficient

In consolidated formations:

- Rock coring at continuous or discrete intervals
- Cutting collection when a general lithologic description and approximate depths are sufficient

When collecting environmental samples, the amount of sample to be collected and the proper sample container type (i.e., glass, plastic), chemical preservation, and storage requirements are dependent on the matrix being sampled and the parameter(s) of interest. Sample preservation, containers, handling

and storage for air and waste samples are discussed in the specific SOPs for the technique selected.

4.0 INTERFERENCES AND POTENTIAL PROBLEMS

Advantages and disadvantages of the various drilling methods are summarized below.

4.1 Auger Drilling

The advantages of auger drilling are:

- Relatively fast and inexpensive
- Because augers act as temporary casing, drilling fluids are not used resulting in reduced well development

The disadvantages of auger drilling are:

- Very slow or impossible to use in coarse materials such as cobble or boulders
- Cannot be used in consolidated formations and is generally limited to depths of approximately 100 feet in order to be efficient

4.2 Cable Tool Drilling

The advantages of cable tool drilling are:

- Relatively inexpensive with minimum labor requirements
- The water table and water bearing zones are easily identified
- Driven casing stabilizes borehole and minimizes potential for cross-contamination
- Especially successful in drilling caving formations or formations containing boulders
- Accurate formation samples can usually be obtained from cuttings

The disadvantages of cable tool drilling are:

- Extremely slow rate of drilling
- Necessity to drive casing may limit depth in large diameter holes.

4.3 Rotary Drilling

4.3.1 Mud Rotary Drilling

The advantages of mud rotary drilling are:

- Fast, more than 100 feet of borehole advancement per day is common
- Provides an open borehole, necessary for some types of geophysical logging and other tests

The disadvantages of mud rotary drilling are:

- Potential for cross-contamination of water-bearing zones
- Drill cuttings may be mixed and not accurately represent lithologies at a given drilling depth
- Drilling mud may alter the groundwater chemistry
- Water levels can only be determined by constructing wells
- Drilling mud may change local permeability of the formation and may not be entirely removed during well development
- Disposal of large volumes of drilling fluid and cuttings may be necessary if they are contaminated

4.3.2 Air Rotary Drilling

The advantages of air rotary drilling are:

- Fast, more than 100 feet of borehole advancement a day is possible
- Preliminary estimates of well yields and water levels are often possible
- No drilling fluid to plug the borehole

The disadvantages of air rotary drilling are:

- Generally cannot be used in unconsolidated formations

- In contaminated zones, the use of high-pressure air may pose a significant hazard to the drill crew because of transport of contaminated material up the hole

- Introduction of air to the groundwater could reduce concentration of volatile organic compounds

5.0 EQUIPMENT

The following equipment is necessary for the site geologist:

- Metal clipboard box case (container for well logs)
- Ruler
- Depth sounder
- Water level indicator
- All required health and safety gear
- Sample collection jars
- Trowels
- Description aids (Munsell color chart, grain size charts, etc.)
- Geolis® Logbooks (Appendix A)
- Field Logbook

Equipment and tools to install the well are normally provided by the drilling contractor.

6.0 REAGENTS

Reagents are not required for preservation of soil samples. Samples should, however, be cooled to 4 °C and protected from sunlight in order to minimize any potential reaction due to the light sensitivity of the sample. Decontamination of drilling equipment should follow the Sampling Equipment Decontamination SOP and the site-specific work plan.

7.0 PROCEDURES

7.1 Preparation

All drilling and well installation programs must be planned and supervised by a professional geologist/hydrogeologist.

The planning, selection and implementation of any monitor well installation program should include the following:

- Review of existing data on site geology and hydrogeology including publications, air photos, water quality data, and existing maps. These may be obtained from local, state or federal agencies

- Assesment of the site to determine potential access problems for drill rig, locate water supply sources, establish equipment storage area, and observe outcrops

- Perform utilities check, note location of underground utilities and of overhead electrical wires

- Preparation of a Site Safety Plan

- Select drilling, sampling and well development methods

- Determination of well construction specifications (i.e., casing and screen materials, casing and screen diameter, screen length and screen interval, filter pack and screen slot size)

- Determination of the need for containing drill cuttings and fluids and their method of disposal

- Preparation of work plan including all of the above

- Preparation of and execute the drilling contract

7.2 Field Preparation

Prior to mobilization, the drill rig and all associated equipment should be thoroughly decontaminated by a steam/pressure washer to remove all oil, grease, mud, etc. Before drilling each boring, all the "down-the-hole" drill equipment should be steam cleaned and rinsed with potable water to minimize cross-contamination. Special attention should be given to the threaded section of the casings, and to the drill rods. All drilling equipment should be steam-cleaned at completion of the project to ensure that no contamination is transported to or from the sampling site.

7.3 Well Construction

The well casing material should not interact with the groundwater. Well casings for environmental projects are usually constructed of polyvinyl chloride (PVC), Teflon™, fiberglass, or stainless steel. Details of the construction methods are given in Sections 7.3.1 and 7.3.2.

7.3.1 Bedrock Wells

Wells completed in bedrock will be drilled using the air or mud rotary method. Crystalline rock wells are usually drilled most efficiently with the air rotary method while consolidated sedimentary formations are drilled using either the air rotary or mud rotary method. The compressed air supply will be filtered prior to introduction into the borehole to remove oil or other contaminants. Bedrock wells may be completed as an open-hole, providing that borehole cave-in is not a possibility.

Bedrock wells will be advanced with air or mud rotary methods until a minimum of 5 feet of competent rock has been drilled. Minimum borehole diameter will be 8 inches. The drill string will then be pulled from the borehole and 6-inch I.D. Schedule 80 or 40 PVC casing inserted. Portland cement/bentonite grout will be pumped into the hole and up the annular space outside the casing. After the grout has set (minimum of 24 hours), the cement will be drilled out and the borehole advanced to the desired depth. Figure 1 (Appendix B) shows typical construction details for an open-hole bedrock well.

The preferred method of well completion for the bedrock wells will be open-hole. However, if the open borehole is subject to cave-in, the well(s) will be completed as screened and cased sand-packed wells. For details of completion see Section 7.3.2.

7.3.2 Overburden Well Construction

Any of the drilling methods discussed in this SOP can be used to drill or set a well in the overburden. The hollow-stem method is the preferred choice for shallow (<100 ft.) overburden wells because the well can be constructed inside of the augers. Details of the construction are provided below and are shown in Figure 2 (Appendix B).

1. The screen slot size will be determined by the site hydrologist, based upon sand-pack size. The length of screen used will be site-dependent. Casing sections will be flush-threaded. Screw-threaded bottom plugs will be used. To prevent introduction of contaminants into the well, no glue-connected fittings will be used. Each piece of PVC pipe, screen, and the bottom plug will be steam-cleaned before lowering into the borehole. The site hydrogeologist is responsible for the supervision of all steam cleaning procedures.

2. The annular space between the well screen and the borehole wall will be filled with a uniform gravel/sand pack to serve as a filter media. For wells deeper than approximately 50 feet, or when recommended by the site geologist, the sand pack will be emplaced using a tremie pipe. A sand slurry composed of sand and potable water will be pumped through the tremie pipe into the annulus throughout the entire screened interval, and over the top of the screen. Allowance must be made for settlement of the sand pack.

3. The depth of the top of the sand will be determined using the tremie pipe, thus verifying the thickness of the sand pack. Additional sand shall be added to bring the top of the sand pack to approximately 2 to 3 feet above the top of the well screen. Under no circumstances should the sand pack extend into any aquifer other than the one to be monitored. In most cases, the well design can be modified to allow for a sufficient sand pack without threat of crossflow between producing zones through the sand pack.

4. In materials that will not maintain an open hole using hollow-stem augers, the temporary or outer casing will be withdrawn gradually during placement of sand pack/grout. For example, after filling two feet with sand pack, the outer casing should be withdrawn 2 feet. This step of placing more gravel and withdrawing the outer casing should be repeated until the level of the sand pack is approximately 3 feet above the top of the well screen. This ensures that there is no locking of the permanent (inner) casing in the outer casing.

5. A bentonite seal of a minimum 2-foot vertical thickness will be placed in the annular space above the sand pack to separate the sand pack from the cement surface seal. The bentonite will be placed through a tremie pipe or poured directly into the annular space, depending upon the depth and site conditions. The bentonite will be pourable pellets. The hydrogeologist will record the start and stop times of the bentonite seal emplacement, the interval of the seal, the amount of bentonite that was used, and problems that arise. The type of bentonite and the supplier will also be recorded.

   A cap placed over the top of the well casing before pouring the bentonite pellets will prevent pellets from entering the well casing.

6. If a slurry of bentonite is used as annular seal, it is prepared by mixing powdered or granular bentonite with potable water. The slurry must be of sufficiently high specific gravity and viscosity to prevent its displacement by the grout to be emplaced above it. As a precaution (regardless of depth) and depending on fluid viscosity, a few handfuls of bentonite pellets may be added to solidify the bentonite slurry surface.

7. Cement and/or bentonite grout is placed from the top of the bentonite seal to the ground surface.

   Only Type I or II cement without accelerator additives may be used. An approved source of potable water must be used for mixing grouting materials. The following mixes are acceptable:

- Neat cement, a maximum of 6 gallons of water per 94 pound bag of cement

- Granular bentonite, 1.5 pounds of bentonite per 1 gallon of water

- Cement-bentonite, 5 pounds of pure bentonite per 94 pound bag of cement with 7-8 gallons of water

- Cement-bentonite, 6 to 8 pounds of pure bentonite per 94 pound bag of cement with 8-10 gallons of water, if water mixed

- Non-expandable cement, mixed at 7.5 gallons of water to one half (1/2) teaspoon of Aluminum Hydroxide, 94 pounds of neat cement (Type I) and 4 pounds of bentonite

- Non-expandable cement, mixed at 7 gallons of water to one half (1/2) teaspoon of Aluminum Hydroxide, 94 pounds of neat cement (Type I and Type II)

8. Grout is pumped through a tremie pipe (normally a 1.25-inch PVC or steel pipe) to the bottom of the annulus until undiluted grout flows from the annulus at the ground surface

9. In materials that will not maintain an open hole, the temporary steel casing should be withdrawn in a manner that prevents the level of grout from dropping below the bottom of the casing.

10. Additional grout may be added to compensate for the removal of the temporary casing and the tremie pipe to ensure that the top of the grout is at or above ground surface. After the grout has set (about 24 hours), any depression due to settlement is filled with a grout mix similar to that described above.

11. The protective casing should now be set. Casing may be a 5 foot minimum length of black iron or galvanized pipe extending about 1.5 to 3 feet above the ground surface, and set in concrete or cement grout. The protective casing diameter should be 4 inches greater than the well casing. A 0.5-inch drain hole may be installed near ground level. A flush-mount protective casing may also be used in areas of high traffic or where access to other areas would be limited by a well stick-up.

12. A protective steel cap, secured to the protective casing by a padlock, should be installed.

13. Steel guard posts should be installed around the protective casing in areas where vehicle traffic may be a problem. Posts should have a minimum diameter of 3 inches and be a

minimum of 4 feet high.

14. All monitor wells should be labelled and dated with paint or steel tags.

7.4 Well Development

Well development is the process by which the aquifer's hydraulic conductivity is restored by removing drilling fluids, and fine-grained formation material from newly installed wells. Two methods of well development that are commonly used are surging and bailing, and overpumping. A well is considered developed when the pH and conductivity of the groundwater stabilizes and the measured turbidity is <50 nephelometric turbidity units (NTUs).

Surging and bailing will be performed as follows:

1. Measure the total depth (TD) of the well and depth to water (DTW).

2. Using an appropriately sized surge block, surge 5-foot sections of well screen, using 10-20 up/down cycles per section. Periodically remove the surge block and bail accumulated sediment from the well, as required.

3. For open-hole wells, a 6-inch surge block will be used inside the cased portion of the well. Sediments will be bailed periodically, as required. Overpumping may be used in combination with surging and bailing for development of bedrock wells. The method(s) used will be based on field conditions encountered, and will be determined by the site hydrogeologist. However, sediment will initially be removed from the wells by bailing in order to minimize the volume of development water generated.

The pump used must be rated to achieve the desired yield at a given depth. The pump system should include the following:

- A check valve to prevent water from running back into the well when the pump is shut off
- Flexible discharge hose
- Safety cable or rope to remove the pump from the well
- Flow meter monitoring system (measuring bucket or inline flow meter)
- Generator
- Amp meter, to measure electrical current (load)

The amp meter is used to monitor pump performance. If the pump becomes clogged, the current will increase due to stress on the pump. If the water level drops below the intake ports, the current will drop due to decreased resistance on the pump.

8.0 CALCULATIONS

To maintain an open borehole during rotary drilling, the drilling fluid must exert a pressure greater than the formation pore pressure. Typical pore pressures for unconfined and confined aquifers are 0.433 define (psi/ft) and 0.465 psi/ft, respectively.

The relationship for determining the hydrostatic pressure of the drilling fluid is:

Hydrostatic Pressure (psi) = Fluid Density (lb/gal) x Height of Fluid Column (ft) x 0.052

The minimum grout volume necessary to grout a well can be calculated using:

Grout Vol (ft^3) = Vol of Borehole (ft^3) - Vol of Casing (ft^3) = $L (r_B^2 - r_C^2)$

where:

L	=	length of borehole to be grouted (ft)
r_B	=	radius of boring (ft)
r_C	=	radius of casing (ft)

9.0 QUALITY ASSURANCE/ QUALITY CONTROL

There are no specific quality assurance activities that apply to the implementation of these procedures. However, the following general QA procedures apply:

1. All data must be documented on standard well completion forms, field data sheets or within field/site logbooks. Descriptive logs, pump tests, and well completion date are entered on Geolis® forms. The Geolis® forms are used to ensure data is collected uniformly by all Site Geologists and provide

input to a standardized computer well file. Appendix A contains examples of Geolis® forms used to record descriptions of geologic samples.

2. All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan. Equipment checkout and calibration activities must occur prior to sampling/operation and must be documented.

10.0 DATA VALIDATION

This section is not applicable to this SOP.

11.0 HEALTH AND SAFETY

Drilling rigs and equipment present a variety of safety hazards. REAC personnel working around drilling rigs should know the position of the emergency "kill" switch. Wirelines and ropes should be inspected and frayed or damaged sections discarded. Swivels and blocks should turn freely. Gages should be operational and controls clearly marked. All underground utilities should be clearly marked, and drillers should be aware of any overhead hazards such as power lines. Avoid drilling in these areas. Ear protection should be worn when working around drilling equipment for extended periods of time, particularly air rotary equipment. Failure to follow safety procedure or wear the proper personal protection gear on the part of either the drilling crew or REAC personnel may result in dismissal from the job.

When working with potentially hazardous materials, follow U.S. EPA, OSHA, and corporate health and safety practices.

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APPENDIX A

Geolis Forms

Form 1. Geolis® Borehole Logging Form

GEOLIS® Borehole Logging Form

COMPANY: _____ LOCATION ID: _____
CLIENT: _____ DATE: _____
PROJECT: _____ LOGGER: _____
SITE / AREA: _____ SIGNATURE: _____

SAMPLING METHOD: SPS - CSS - STB - CTS - CUT - COR - NS
OTHER: _____
SAMPLING INTERVAL: _____ TO _____ FT/M BGS
RECOVERY: _____ / _____ FT/M NA
BLOW COUNT: [ ] [ ] [ ] [ ] / [ ] IN/CM NA
RQD: _____ % NA

FLUID ENTRY/ LOSS ZONES: _____ FT/M BGS _____ GPM
_____ FT/M BGS _____ GPM
ANALYTICAL SAMPLE ID INTERVAL (FT/M BGS)
_____ _____ - _____
TYPE / LAB : UND - DIS - CMP / MOB - GEO - CHM - _____
/ _____ _____ - _____
TYPE / LAB : UND - DIS - CMP / MOB - GEO - CHM - _____

SAMPLING INTERVAL No.: _____
LITHOLOGIC INTERVAL No.: _____
LITHOLOGIC INTERVAL: _____ TO _____ FT/M BGS
LITHOLOGY ARCHIVED? YES - NO
NO RECOVERY

MATERIAL: NATURAL - FILL - UNCERTAIN
OBSERVED: STN - SHN - ODR - PRD - NA - OTHER: _____
INSTRUMENT 1 TYPE: _____ READING: _____
INSTRUMENT 2 TYPE: _____ READING: _____

OVERBURDEN

SECONDARY TYPE: NA - BED - CLS - MIX — SECONDARY
COLOR: MUN - GSA _____
COLORATION: UNI - STN - MOT - VAR
BOULDERS: _____ % MAX DIAM: _____ IN
COBBLES: _____ % MAX DIAM: _____ IN
TEXTURE: C - M - F
GRAVEL: __ __ __ _____ % _____ %
SAND: __ __ __ _____ % _____ %
SILT: _____ % _____ %
CLAY: _____ % _____ %
ORGANIC: _____ % _____ %
ROUNDNESS:
GRAVEL: FAC - STR - ANG - SUB - RND - NA
SAND: ANG - SUB - RND - NA
SORTING: WEL - MOD - POR - NA
PLASTICITY: NON - LOW - MOD - HGH - NA
MOISTURE: DRY - MST - WET - SAT - NA
CEMENTATION: NON - SLT - MOD - WEL - NA
GRAIN TYPE: QTZ - FRG - FOS - BIO - NA _____
MATRIX: MSM - CSM - CAL - OXD - ARG - SIL - NA
STRENGTH:
COHESIVE: VSF - SFT - FRM - STF - VST - HRD
NONCOHESIVE: VDN - DEN - FIR - LSE - NA
UPPER CONTACT: SHP - GRD - DIF - SME - NA
BEDDING THICK: _____ IN/CM No.: _____
TYPE: XBD - RPL - HOR - INC - NA
MAS - LNS - LAM - GRU - GRD

GRAPHIC LOG

BEDROCK

SECONDARY TYPE: NA - BED - VEN - MIX — SECONDARY
COLOR: MUN - GSA _____
ROCK TYPE: OTHER: _____
SED: SHL - SLT - SST - CGL - LST - DOL - COL
MET: SLA - PHY - SHS - GNS - HRN - QZT - MBL
IGN: GRN - RHY - BSL - GBR - TUF - BRC
TEXTURE: C - M - F NA
GRAVEL: __ __ __ _____ % _____ %
SAND: __ __ __ _____ % _____ %
SILT: _____ % _____ %
CLAY/LIME MUD: _____ % _____ %
GRAIN TYPE: QTZ - FRG - FOS - BIO - NA
MATRIX: CAL - MIC - OXD - ARG - SIL - ORG - NA
STRENGTH: EWK - VWK - WEK - MOD STR - VST - EST
UPPER CONTACT: SHP - GRD - DIF - SAM - NA
SECONDARY POROSITY: VUG - FRC - BED - NA - OTHER HGH - MOD - LOW
WEATHERING: FRS - SLT - MOD - HGH - CPL - NA

NATURAL FRACTURE SETS

INTERVAL (FT/M BGS)	#/FT-M	DIP	DIR	FILL/SHAPE/ROUGH/SURFACE
-				FILL: OPN - PRT - FUL SHAPE: PLN - CUR - UND - STP - IRR ROUGH: SMH - MOD - RGH SURFACE: CLN - MIN - OXD - STN - WTH
-				FILL: OPN - PRT - FUL SHAPE: PLN - CUR - UND - STP - IRR ROUGH: SMH - MOD - RGH SURFACE: CLN - MIN - OXD - STN - WTH
-				FILL: OPN - PRT - FUL SHAPE: PLN - CUR - UND - STP - IRR ROUGH: SMH - MOD - RGH SURFACE: CLN - MIN - OXD - STN - WTH
-				FILL: OPN - PRT - FUL SHAPE: PLN - CUR - UND - STP - IRR ROUGH: SMH - MOD - RGH SURFACE: CLN - MIN - OXD - STN - WTH

STRAT UNIT: [ ]
NOTE LINE : [ ]

NEXT INTERVAL: SAMP/LITH No. _____ / _____ DEPTH INTERVAL _____ TO _____ NOT SAMPLED NO RECOVERY

COMMENTS: (1) _____
(2) _____

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APPENDIX A (Cont'd)

Geolis Forms

Form 2. Geolis® Well Construction Form

GEOLIS® Well Construction Form

Sheet ____ of ____

COMPANY: _____ LOCATION ID: _____
PROJECT: _____ DATE: _____
PROPERTY: _____ LOGGER: _____
SITE/AREA: _____ / _____ SIGNATURE: _____

START DATE: _____
COMPLETION DATE: _____
WELL STATUS: PMP - ABN - COL - NOR
STATUS DATE: _____

SURVEYED ELEVATIONS (MSL)		DEPTH TO WATER	DATE / TIME
GROUND LEVEL: _____	FT/M	_____ FT/M(TOC)	_____
MEASURING POINT: (TOP OF CASING) _____	FT/M	_____ FT/M(TOC)	_____
		_____ FT/M(TOC)	_____

WELL DIAGRAM - NOT TO SCALE	DEPTH (FT. BGS)	WELL CODE
	0	GRS

WELL TYPE: SCREEN - MULTIPLE SCREEN - OPEN HOLE - NESTED - PROBE
CASING: SINGLE - DOUBLE - TRIPLE COMPLETION: FLUSH - PROT - VAULT - CAP - NA
TOTAL NO. OF SCREENS/WELLS: _____ SCREEN/WELL NO.: _____
WELL USE: DOM - PUB - IRR - FIR - MON - HYD - EXT - DEW - RCH - VEW - INJ - OTH: _____

WELL DESIGN CONSTRUCTION

CASING #1: (INNERMOST) DIAMETER: _____ IN/CM INTERVAL: _____ TO _____ FT/M BGS
TYPE: PVC - STN - LCS - GAL - ____ SCHEDULE: 5 - 10 - 20 - 40 - 80 - ____
CASING JOINTS: FLT - BUT - EUT - SOL - WLD - SCW - CAM - OTH: _____

CASING #2: DIAMETER: _____ IN/CM INTERVAL: _____ TO _____ FT/M BGS
TYPE: PVC - STN - LCS - GAL - ____ SCHEDULE: 5 - 10 - 20 - 40 - 80 - ____

CASING #3: (OUTERMOST) DIAMETER: _____ IN/CM INTERVAL: _____ TO _____ FT/M BGS
TYPE: PVC - STN - LCS - GAL - ____ SCHEDULE: 5 - 10 - 20 - 40 - 80 - ____

STICK UP: INNER CASING: _____ FT/M OUTER CASING: _____ FT/M

GROUT: TYPE: CMT - C/B - BEN - HSB - OTH: _____
INTERVAL: _____ TO _____ FT/M BGS
PLACEMENT: TRM - PRS - GRV CENTRALIZERS: NON - 1 - 2 - 3 - OTH: ____

SEAL: TYPE 1: _____ INTERVAL: _____ TO _____ FT/M BGS
TYPE 2: _____ INTERVAL: _____ TO _____ FT/M BGS

SAND PACK: TYPE: _____ INTERVAL: _____ TO _____ FT/M BGS

SCREEN OR DEVICE: DIAMETER: _____ IN/MM INTERVAL: _____ TO _____ FT/M BGS
TYPE: PVC - STN - LCS - TEF - CER - HDP - OTH: _____
SLOTS: CON - SLH - SLV - BRG - CUT - OTH: _____
SLOT SIZE: 6 - 10 - 20 - 30 - 40 - _____ SLOT

STRAT UNIT MONITORED: _____
ESTIMATED WELL YIELD: _____ GPM/LPM DRAWDOWN: _____ FT/M BMP
WATER SAMPLING SYSTEM: NON - PMP - PKR - MLS TYPE: _____
SEAL INTERVAL: _____ TO _____ FT/M BGS INTAKE DEPTH: _____ FT/M BGS
NOTES: _____

OPEN HOLE: DIAMETER 1: _____ IN/CM INTERVAL: _____ TO _____ FT/M BGS
DIAMETER 2: _____ IN/CM INTERVAL: _____ TO _____ FT/M BGS

SILT TRAP/SUMP: YES - NO INTERVAL: _____ TO _____ FT/M BGS
INSIDE WELL T.D.: _____ FT/M BGS COLLAPSE/BACKFILL: COL - BFL - BTH - NON
COLLAPSE INTERVAL: _____ TO _____ FT/M BGS
BACKFILL INTERVAL: _____ TO _____ FT/M BGS TYPE: _____

COMMENTS: _____

WELL CONSTRUCTION CODES

GRS = GROUND SURFACE	TSC = TOP OF SCREEN
BPC = BOTTOM OF PROTECTIVE CASING	TST = TOP OF SILT TRAP
TBS = TOP OF BENTONITE SEAL	WTD = TOTAL DEPTH INSIDE WELL
TBR = TOP OF BEDROCK	BTD = BOREHOLE TOTAL DEPTH
BOC = BOTTOM OF OUTER CASING	TOC = TOP OF CASING (INNER)
TSP = TOP OF SAND PACK	BGS = BELOW GROUND SURFACE

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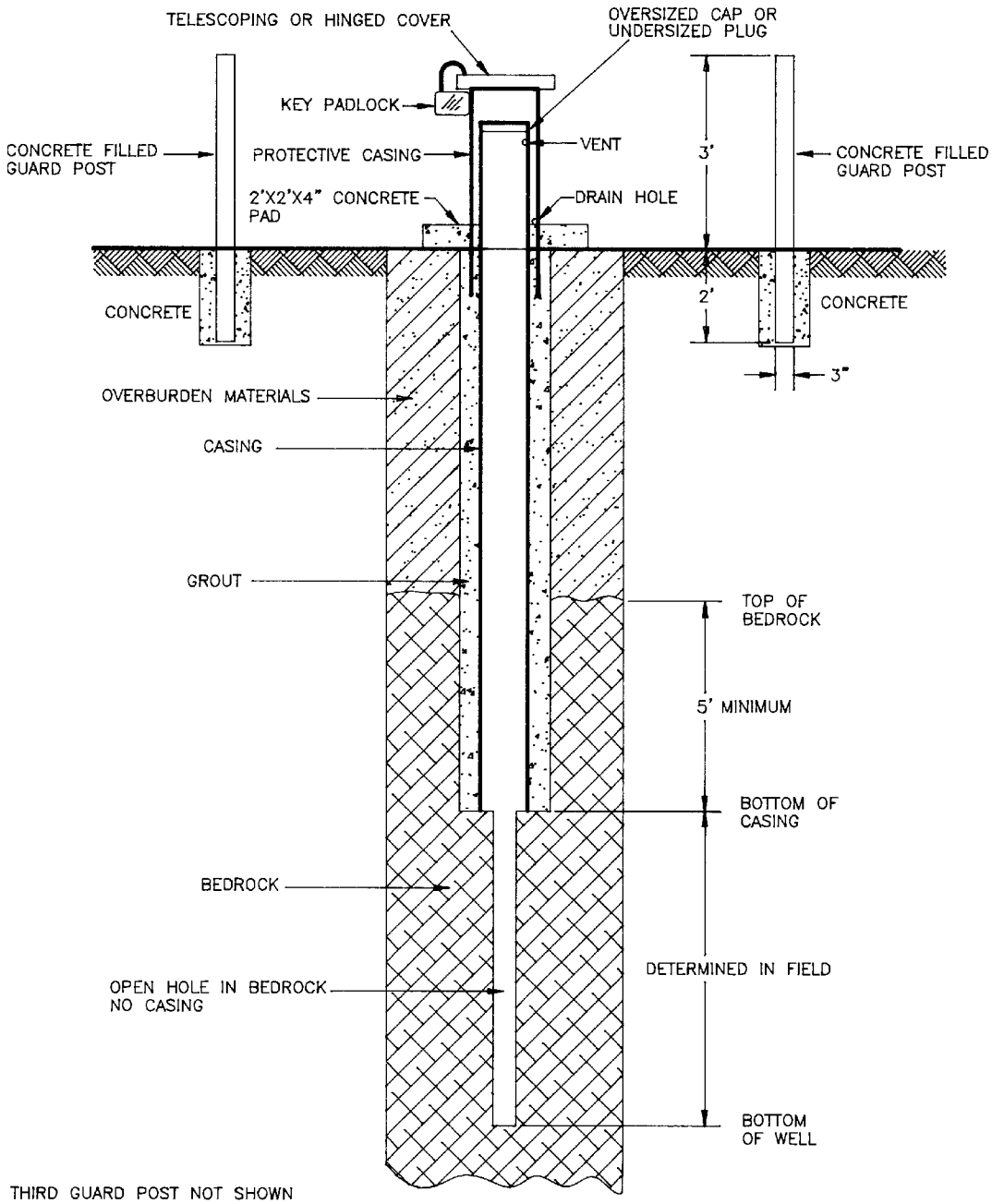
APPENDIX B

Figures

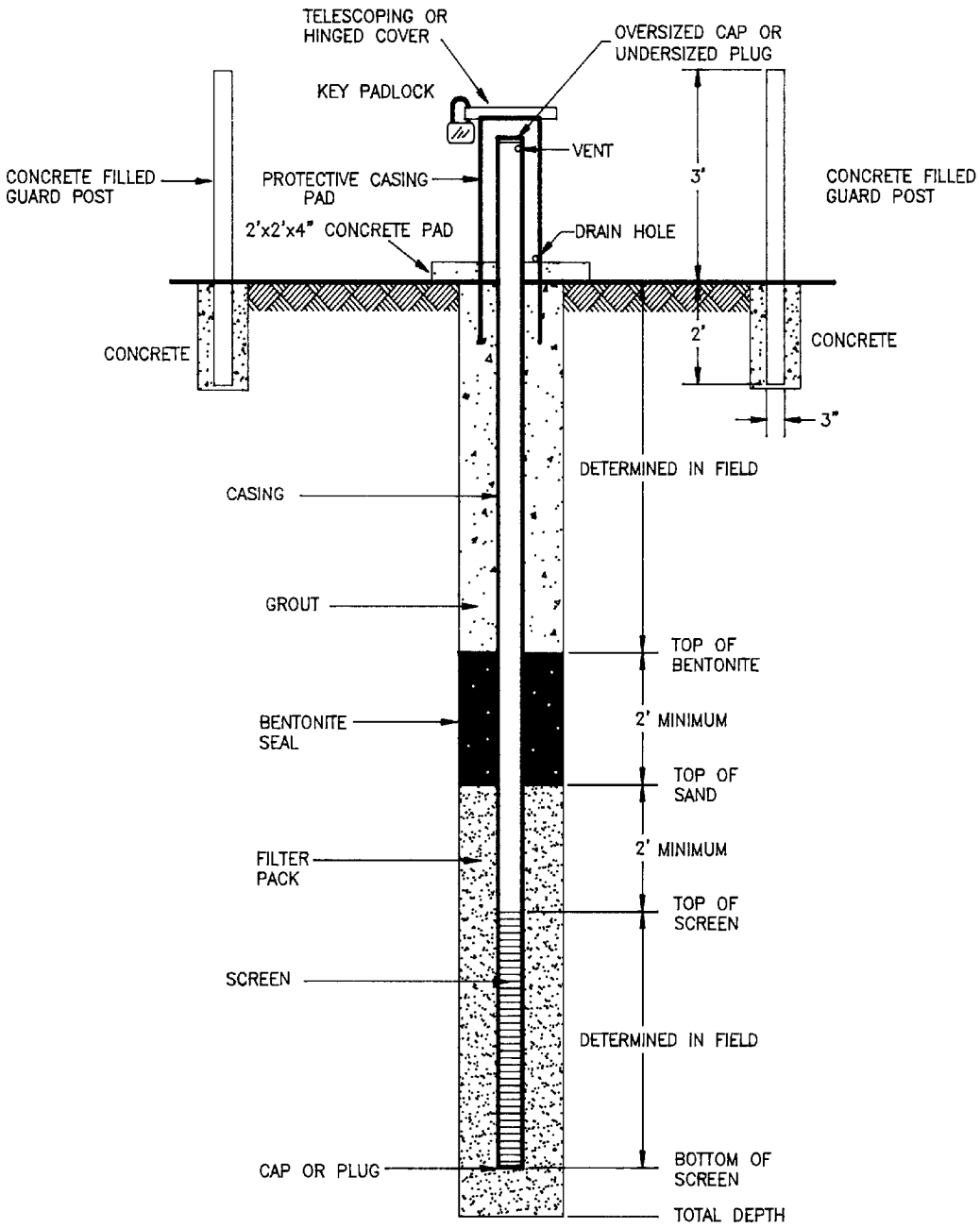
FIGURE 1. Typical Bedrock Well Construction



APPENDIX B (Cont'd)

Figures

FIGURE 2. Typical Overburden Well Construction



U. S. EPA ENVIRONMENTAL RESPONSE TEAM

STANDARD OPERATING PROCEDURES

MONITOR WELL DEVELOPMENT

CONTENTS

1.0 SCOPE AND APPLICATION*

2.0 METHOD SUMMARY*

3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

4.0 INTERFERENCES AND POTENTIAL PROBLEMS*

5.0 EQUIPMENT/APPARATUS*

6.0 REAGENTS

7.0 PROCEDURES

- 7.1 Preparation
- 7.2 Operation*
- 7.3 Post-Operation

8.0 CALCULATIONS*

9.0 QUALITY ASSURANCE/QUALITY CONTROL*

10.0 DATA VALIDATION

11.0 HEALTH AND SAFETY

12.0 REFERENCES*

13.0 APPENDICES*

*These sections affected by Revision 0.1.

SUPERCEDES: SOP #2044; Revision 0.0; 2/18/00; U.S. EPA Contract 68-C99-223.

1.0 SCOPE AND APPLICATION

The purpose of this standard operating procedure (SOP) is to provide an overview of monitor well development practices. The purpose of monitor well development is to ensure removal of fine grained sediments (fines) from the vicinity of the well screen. This allows the water to flow freely from the formation into the well, and also reduces the turbidity of the water during sampling. The most common well development methods are: surging, jetting, overpumping, and bailing.

Surging involves raising and lowering a surge block or surge plunger inside the well. The resulting surging motion forces water into the formation and loosens sediment, pulled from the formation into the well. Occasionally, sediments must be removed from the well with a sand bailer to prevent sand locking of the surge block. This method may cause the sand pack around the screen to be displaced to a degree that damages its value as a filtering medium. Channels or voids may form near the screen if the filter pack sloughs away during surging (Keel and Boating, 1987).

Surging with compressed air is done by injecting a sudden charge of compressed air into the well with an air line so that water is forced through the well screen. The air is then turned off so that the water column falls back into the well and the process is repeated. Periodically, the air line is pulled up into a pipe string (educator) and water is pumped from the well using air as the lifting medium (air-lift pumping). The process is repeated until the well is sediment free. Method variations include leaving the air line in the pipe string at all times or using the well casing as the educator pipe.

Jetting involves lowering a small diameter pipe into the well and injecting a high velocity horizontal stream of water or air through the pipe into the screen openings. This method is especially effective at breaking down filter cakes developed during mud rotary drilling. Simultaneous air-lift pumping is usually used to remove fines.

Overpumping involves pumping at a rate rapid enough to draw the water level in the well as low as possible, and then allowing the well to recharge to the original level. This process is repeated until sediment-free water is produced.

Bailing includes the use of a simple manually operated check-valve bailer to remove water from the well. The bailing method, like other methods, should be repeated until sediment free water is produced. Bailing may be the method of choice in a shallow well or well that recharges slowly.

These are standard (i.e., typically applicable) operating procedures which may be varied or changed as required, dependent on site conditions, equipment limitations or limitations imposed by the procedure. In all instances, the ultimate procedures employed should be documented and associated with a final report.

Mention of trade names or commercial products does not constitute United States Environmental Protection

Agency (U.S. EPA) endorsement or recommendation for use.

2.0 METHOD SUMMARY

After installation, development of a well should occur as soon as it is practical. It should not occur any sooner than 48 hours after grouting is completed, especially if a vigorous well development method (i.e. surging) is being used. If a less vigorous method (i.e bailing) is used, it may be initiated shortly after installation. The method used for development should not interfere with the setting of the well seal.

Several activities must take place prior to well development. First, open the monitor well, take initial measurements (i.e., head space air monitoring readings, water level, total depth of the well) and record results in the site logbook. Develop the well by the appropriate method to accommodate site conditions and project objectives. Continue until the development water is clear and free of sediments, or until parameters such as pH, temperature, and specific conductivity stabilize. Containerize all purge water from wells with known or suspected contamination. Record final measurements in the site logbook. Decontaminate equipment as appropriate prior to use in the next well.

3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

This section is not applicable to this SOP.

4.0 INTERFERENCES AND POTENTIAL PROBLEMS

The following problems may be associated with well development:

1. Overpumping is not as vigorous as surging and jetting, and is probably the most desirable method for monitor well development. The possibility of disturbing the filter pack is greatest with surging and jetting well development methods.

2. The introduction of external water or air by jetting may alter the hydro chemistry of the aquifer.

3. Surging with air may produce “air locking” in some formations, preventing water from flowing into the well.

4. The use of surge blocks in formations containing clay may cause plugging of the screen.

5. Small (2-inch nominal diameter) submersible pumps that will fit in 2-inch diameter well casing are especially susceptible to clogging if used in well development applications.

6. Chemicals/reagents used during the decontamination of drilling equipment may complicate well development.

5.0 EQUIPMENT/APPARATUS

The type of equipment used for well development is dependent on the diameter of the well and the development method. For example, the diameter of most submersible pumps is too large to fit into a two-inch inner diameter (I.D.) well, and other development methods should be used. Obtaining the highest possible yield is not usually an objective in developing monitor wells and vigorous development is not always necessary. Many monitor wells are constructed in fine-grained formations that would not normally be considered aquifers. Specifications for the drilling contract should include the necessary well development equipment (air compressors, pumps, air lines, surge blocks, generators).

6.0 REAGENTS

The use of chemicals in developing wells that will be used to monitor groundwater quality should be avoided if possible; however, polyphosphates (a dispersing agent), acids, or disinfectants are often used in general well development. Polyphosphates should not be used in thinly bedded sequences of sands and clays. The use of decontamination solutions may also be necessary. If decontamination of equipment is required at a well, refer to Environmental Response Team/Response Engineering and Analytical Contract (ERT/REAC) SOP #2006, *Sampling Equipment Decontamination* and the site specific work plan.

7.0 PROCEDURES

7.1 Preparation

1. Coordinate site access and obtain keys to well locks.

2. Obtain information on each well to be developed (i.e., drilling method, well diameter, well depth, screened interval, anticipated contaminants).

3. Obtain a water level meter, a depth sounder, air monitoring instruments, materials for decontamination, and water quality instrumentation capable of measuring, at a minimum, pH, specific conductivity, temperature, and turbidity. Dissolved oxygen (DO) and salinity are also useful parameters.

4. Assemble containers for temporary storage of water produced during well development. Containers must be structurally sound, compatible with anticipated contaminants, and easy to manage in the field. The use of truck-mounted or roll-off tanks may be necessary in some cases; alternately, a portable water treatment unit (i.e., activated carbon) may be used to decontaminate the purge water.

7.2 Operation

Development should be performed as soon as it is practical after the well is installed, but no sooner than 48 hours after well completion.

1. Assemble necessary equipment on a plastic sheet surrounding the well.

2. Record pertinent information in the site or personal logbook (personnel, time, location ID, etc.).

3. Open monitor well, take air monitor reading at the top of casing and in the breathing zone as appropriate.

4. Measure depth to water and the total depth of the monitor well. Calculate the water column volume of the well (Equation 1, Section 8.0).

5. Begin development and measure the initial pH, temperature, turbidity, and specific conductivity of the water and record in the site logbook. Note the initial color, clarity, and odor of the water.

6. Continue to develop the well and periodically measure the water quality parameters indicated in step 5 (above). Depending on project objectives and available time, development should proceed until these water quality parameters stabilize, or until the water has a turbidity of less than 50 nephelometric turbidity units (NTUs).

7. All water produced by development of contaminated or suspected contaminated wells must be containerized or treated. Each container must be clearly labeled with the location ID, date collected, and sampling contractor. Determination of the appropriate disposal method will be based on the analytical results from each well.

8. No water shall be added to the well to assist development without prior approval by the appropriate U.S. EPA ERT Work Assignment Manager (WAM) and/or appropriate state personnel. In some cases , small amounts of potable water may be added to help develop a poor yielding well. It is essential that at least five times the amount of water injected must be recovered from the well in order to assure that all injected water is removed from the formation.

9. Note the final water quality parameters in the site or personal logbook along with the following data:

   - Well designation (location ID)
   - Date(s) of well installation
   - Date(s) and time of well development

- Static water level before and after development
- Quantity of water removed, and initial and completion time
- Type and capacity of pump or bailer used
- Description of well development techniques

7.3 Post-Operation

1. Decontaminate all equipment;

2. Secure holding tanks or containers of development water;

3. Review analytical results and determine the appropriate water disposal method. Actual disposal of the purge water is generally carried out by the On-Scene Coordinator (OSC).

8.0 CALCULATIONS

To calculate the volume of water in the well, the following equation is used:

$$\textbf{Well Volume (V)} = Br^2 h \text{ (cf)} \quad \textbf{[Equation 1]}$$

where:

B	=	pi (3.14)
r	=	radius of monitoring well in feet (ft)
h	=	height of the water column in ft. [This may be determined by subtracting the depth to water from the total depth of the well as measured from the same reference point.]
cf	=	conversion factor in gallons per cubic foot (gal/ft^3) = 7.48 gal/ft^3. [In this equation, 7.48 gal/ft^3 is the necessary conversion factor.]

Monitor well diameters are typically 2-, 3-, 4-, or 6-inches. A number of standard conversion factors can be used to simplify the above equation using the diameter of the monitor well. The volume, in gallons per linear foot, for various standard monitor well diameters can be calculated as follows:
where:

$$\textbf{V (gal/ft)} = Br^2 \text{ (cf)} \quad \textbf{[Equation 2]}$$

B	=	pi
r	=	radius of monitoring well (feet)
cf	=	conversion factor (7.48 gal/ft^3)

For example, a two inch diameter well, the volume per linear foot can be calculated as follows:

$$\mathbf{V\ (gal/ft) = \pi r^2\ (cf) \quad [Equation\ 2]}$$
$$\mathbf{= 3.14\ (1/12\ ft)^2\ \ 7.48\ gal/ft^3}$$
$$\mathbf{= 0.1631\ gal/ft}$$

NOTE: The diameter must be converted to the radius in feet as follows:

$$\mathbf{\frac{Well\ Diameter\ (inches)}{12} \times 0.5 = Well\ Radius\ (feet) \quad [Equation\ 3]}$$

The volume in gallons/feet for the common size monitor wells are as follows:

Well diameter (inches)	2	3	4	6
Volume (gal/ft)	0.1631	0.3670	0.6524	1.4680

If you utilize the volumes for the common size wells above, Equation 1 is modified as follows:
where:

$$\mathbf{Well\ volume = (h)(f) \quad [Equation\ 4]}$$

h = height of water column (feet)
f = the volume in gal/ft calculated from Equation 2

9.0 QUALITY ASSURANCE/QUALITY CONTROL

There are no specific quality assurance activities, which apply to the implementation of these procedures. However, the following general quality assurance/quality control (QA/QC) procedures apply:

1. All data must be documented in site and/or personal logbooks.

2. All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer, unless otherwise specified in the work plan. Equipment checkout and calibration activities must occur prior to sampling/operation and must be documented.

10.0 DATA VALIDATION

This section is not applicable to this SOP.

11.0 HEALTH AND SAFETY

When working with potentially hazardous materials, follow U.S. EPA, Occupational Safety and Health (OSHA), and corporate health and safety practices.

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13.0 APPENDICES

This section is not applicable to this SOP.

Appendix B– SOP for Low-Flow Sampling

Ground-Water Sampling Guidelines for Superfund and RCRA Project Managers

GROUND WATER FORUM ISSUE PAPER

Douglas Yeskis* and Bernard Zavala**

BACKGROUND

The Ground Water, Federal Facilities and Engineering Forums were established by professionals from the United States Environmental Protection Agency (USEPA) in the ten Regional Offices. The Forums are committed to the identification and resolution of scientific, technical, and engineering issues impacting the remediation of Superfund and RCRA sites. The Forums are supported by and advise OSWER's Technical Support Project, which has established Technical Support Centers in laboratories operated by the Office of Research and Development (ORD), Office of Radiation Programs, and the Environmental Response Team. The Centers work closely with the Forums providing state-of-the-science technical assistance to USEPA project managers.

This document provides sampling guidelines primarily for ground-water monitoring wells that have a screen or open interval with a length of ten feet or less and which can accept a sampling device. Procedures that minimize disturbance to the aquifer will yield the most representative ground-water samples. This document provides a summary of current and/or recommended ground-water sampling procedures. This document was developed by the Superfund/RCRA Ground Water Forum and incorporates comments from ORD, Regional Superfund hydrogeologists and others. These guidelines are applicable to the majority of sites, but are not intended to replace or supersede regional and/or project-specific sampling plans. These guidelines are intended to assist in developing sampling plans using the project-specific goals and objectives. However, unusual and/or site-specific circumstances may require approaches other than those specified in this document. In these instances, the appropriate Regional hydrologists/geologists should be contacted to establish alternative protocols.

ACKNOWLEDGMENTS

A document of this scope involved significant participation from a number of people, such that any omission in these acknowledgments is purely unintentional. We thank all of the participants involved in the development of this document! The authors acknowledge the active participation and valuable input from the committee from the Ground Water Forum of Dick Willey, Region 1; Ruth Izraeli and Kevin Willis, Region 2; Kathy Davies, Region 3; Robert Puls, ORD-NRMRL; and Steve Gardner, ORD-NERL. In addition, valuable input from former members of the committee are gratefully acknowledged. And finally, the peer reviews of the document completed by Franceska Wilde of the Water Division of the U.S. Geological Survey, Reston, VA; Richard Duwelius and Randy Bayless of the Indiana District of the U.S. Geological Survey, Indianapolis, IN; Steve White of the Omaha District of the U.S. Army Corps of Engineers, Omaha, NE and Karl Pohlmann of the Desert Research Institute, Las Vegas, NV are gratefully acknowledged.

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INTRODUCTION

The goal of ground-water sampling is to collect samples that are “representative” of in-situ ground-water conditions and to minimize changes in ground-water chemistry during sample collection and handling. Experience has shown that ground-water sample collection and handling procedures can be a source of variability in water-quality concentrations due to differences in sampling personnel, sampling procedures, and equipment (U.S. Environmental Protection Agency, 1995).

Several different ground-water sampling procedures can be used, which vary primarily through the criteria used to determine when a sample is representative of ground-water conditions. No single method or procedure is universally applicable to all types of ground-water-sampling programs; therefore, consideration should be given to a variety of factors when determining which method is best suited to site-specific conditions. These site-specific conditions include sampling objectives, equipment availability, site location, and physical constraints. This paper will discuss each of these conditions and how they may contribute to the decision in choosing the appropriate sampling methodology and equipment to be used during ground-water sampling.

This paper focuses on ground-water sampling procedures for monitoring wells only where separate, free-phase, Non-Aqueous Phase Liquids (NAPLs) are not present in the monitoring well. Residential and/or municipal-production wells where special sampling procedures and considerations need to be implemented are not discussed in this document. The recommendations made in this paper are based on findings presented in the current literature, and will be subject to revision as the understanding of ground-water-sampling procedures increases.

SAMPLING OBJECTIVES

The objective of a good sampling program should be the collection of a "representative" sample of the current ground-water conditions over a known or specified volume of aquifer. Ideally to meet this objective, sampling equipment, sampling method, monitoring well construction, monitoring well operation and maintenance, and sample handling procedures should not alter the chemistry of the sample. A sample that is obtained from a poorly constructed well, or using improper sampling equipment, or using poor sampling techniques, or which has been preserved improperly, can bias the sampling results. Unrepresentative samples can lead to misinterpretations of ground-water-quality data. Generally, the costs of obtaining representative ground-water samples are insignificant when compared to potential remedial responses that may be implemented based on erroneous data or when considering the overall monitoring program costs over the life of the program (Nielson, 1991).

The data quality objectives (DQOs) of the sampling program should be thoroughly developed, presented and understood by all parties involved. To develop the DQOs, the purpose of the sampling effort and data use(s) should be clearly defined. The sampling guidelines presented here can be used for a variety of monitoring programs, these include site assessment, contaminant detection, site characterization, remediation, corrective action and compliance monitoring.

For example DQOs for a site characterization sampling effort might vary from those of a remediation monitoring sampling effort. This difference could be in how much of the screen interval should be sampled. A site characterization objective may be to collect a sample that represents a composite of the entire (or as close as is possible) screened interval of the monitoring well. On the other hand, the monitoring objective of a remediation monitoring program may be to obtain a sample that represents a specific portion of the screened interval.

Additionally, the site characterization may require analyses for a broad suite of contaminants, whereas, the remediation monitoring program may require fewer contaminants to be sampled. These differences may dictate the type of sampling equipment used, the type of information collected, and the sampling protocol.

In order to develop applicable DQOs, a site conceptual model should be developed. The site conceptual model should be a dynamic model which is constantly revised as new information is collected and processed. The conceptual model, as it applies to the DQOs, should focus on contaminant fate and transport processes, such as contaminant pathways, how the geologic materials control the contaminant pathways (depositional environments, geologic structure, lithology, etc.), types of contaminants present (i.e., hydrophobic versus hydrophilic), and the processes that influence concentrations of the contaminants present such as dilution, biodegradation, and dispersion. The detail of the conceptual model will depend greatly on the availability of information, such as the number of borings and monitoring wells and the amount of existing analytical data. Clearly, a site that is being investigated for the first time will have a much simpler conceptual model compared to a site that has had a Remedial Investigation, Feasibility Study, and Remedial Design, (or, within the RCRA Program, a RCRA Facility Assessment, a RCRA Facility Investigation, and a Corrective Measures Study), and is currently in remediation/corrective action monitoring. Specific parameters that a conceptual model should describe that may impact the design of a ground-water-sampling program include:

a) The thickness, lateral extent, vertical and horizontal flow direction, and hydraulic conductivity contrasts of the geologic materials controlling contaminant transport from the site (thick units versus thin beds versus fractures, etc.)

b) The types of contaminants to be sampled (volatile organic compounds, semi-volatile organic compounds, metals, etc.) and factors that could bias sampling results (turbidity for metals, co-solvation effects on PCBs, etc.)

c) Lateral and vertical distribution of contamination (contaminants distributed throughout an entire unit being monitored versus localized distribution controlled by small scale features, etc.)

Vertical aquifer characterization is strongly recommended prior to the completion of a ground-water monitoring well installation program. A detailed vertical aquifer characterization program should include field characterization of hydraulic conductivities, determination of vertical and horizontal flow directions, assessment of lithologic and geologic variations, and determination of vertical and horizontal contaminant distributions. The successful aquifer characterization program provides detailed information to guide the technical and cost-effective placement, vertically and areally, of monitoring wells.

INFORMATION NEEDED PRIOR TO SAMPLING

To ensure appropriate methodology and expedient collection of water-quality samples, information is needed before a sample is collected. Some information should be obtained prior to the start of field activities such as well condition, construction, water-level information, contaminant types and concentrations, and direction(s) of ground-water flow. Field measurements, such as depth to water and total well depth will be needed prior to purging. Before commencement of all field activities, the field health and safety plan should be consulted under the direction of the site health and safety officer.

BACKGROUND DATA

Well construction and maintenance information are needed to better plan the sampling program, optimize personnel, and obtain more representative samples. Prior to field activities, personnel should have specific information including well casing diameter, borehole diameter, casing material, lock number and keys, physical access to wells, and length of and depth to well screen. The diameter of each well casing is used to select the correct equipment and technique for purging and sampling the well. A site map with possible physical barriers and description of access is necessary to allow for the selection of proper equipment based on several factors, such as portability, ease of repair, power sources, containment of purge water, and well accessibility. The length and depth of each well screen and depth to water is important when placing a sampling device's intake at the proper depth for purging and sampling and for choosing a sampling device. Well development information is needed to ensure that purging and sampling rates will not exceed well development extraction rates. Previous sampling information should be provided and evaluated to determine the nature and concentrations of expected contaminants. This will be useful in determining the appropriate sampling method and quality assurance/quality control (QA/QC) samples (for example, field duplicates, equipment blanks, trip blanks). Attachment 1 is an example of a sampling checklist for field personnel. This information should be kept in the field for easy access during sampling activities.

When evaluating previous sampling information, consideration should be given to the amount of time that has expired between the last sampling effort and the planned sampling effort. If this time exceeds one year, the need for redevelopment of the monitoring wells should be evaluated. The necessity of redevelopment can be evaluated by measuring constructed depth compared to the measured depth. If the depth measurement indicates siltation of the monitoring well screen, or evidence exists that the well screen is clogged, the well should be redeveloped prior to sampling. The assessment of the condition of the monitoring wells should be completed several weeks prior to sampling activities in order to allow the proper recovery of the developed wells. This is especially important in wells where prior sampling has indicated high turbidity. The time for a well to re-stabilize after development is dependent on site-specific geology and should be specified in the site sampling plan. The development method, if necessary, should be consistent with the sampling objectives, best technical criteria and USEPA guidelines (Aller et al., 1991; Izraeli et al., 1992; Lapham et al., 1997).

REFERENCE POINT

Each well should be clearly marked with a well identifier on the outside and inside of the well casing. Additionally, each well should have a permanent, easily identified reference point from which all depth measurements are taken. The reference point (the top of the inner casing, outer casing, or security/protective casing) should remain constant through all measurements, should be clearly marked on the casing and its description recorded. Whenever possible, the inner casing is recommended as a reference point, because of the general instability of outer casings due to frost heaving, vehicular damage, and other phenomena which could cause movement of casings. The elevation of this reference point should be known and clearly marked at the well site (Nielson, 1991).

This reference point should also have a known latitude and longitude that are consistent with the Regional and National Minimum Data Elements requirements. The elevation of the reference point should be surveyed relative to Mean Sea Level (MSL) using the NAVD 88 datum.

TOTAL WELL DEPTH

The depth of the well is required to calculate the volume of standing water in the well and to document the amount of siltation that may have occurred. Moreover, measuring the depth to the bottom of a well provides checks for casing integrity and for siltation of the well screen. Corrosion can cause leaking or collapse of the well casing, which could lead to erroneous or misleading water-level measurements. Corrosion, silting, and biofouling can clog well screens and result in a sluggish response or no response to water-level changes, as well as changes in ground-water chemistry. Well redevelopment or replacement may be needed to ensure accurate collection of a representative water-quality sample.

Total well depths should be measured and properly recorded to the nearest one-tenth of a foot using a steel tape with a weight attached. The steel tape should be decontaminated before use in another well according to the site specific protocols. A concern is that when the steel tape and weight hit the bottom of the well, sediment present on the bottom of a well may be stirred up, thus increasing turbidity which will affect the sampling results. The frequency of total well depth measurements varies, with no consensus for all hydrogeologic conditions. The United States Geological Survey (USGS) recommends a minimum of once a year (Lapham et al., 1997). USEPA also recommended one measurement per year (Barcelona et al., 1985) but later recommended a total well depth be taken every time a water-quality is collected or a water-level reading taken (Aller et al., 1991). Therefore, when possible, the total depth measurements should be taken following the completion of sampling (Puls and Barcelona, 1996). When total-well-depth measurements are needed prior to sampling, as much time as possible should be allowed prior to sampling, such as a minimum of 24 hours. The weight of electric tapes are generally too light to determine accurate total well depth. If the total well depth is greater than 200 feet, stretching of the tape must be taken into consideration.

DEPTH TO WATER

All water levels should be measured from the reference point by the use of a weighted steel tape and chalk or an electric tape (a detailed discussion of the pros and cons of the different water level devices is provided in Thornhill, 1989). The steel tape is a more accurate method to take water levels, and is recommended where shallow flow gradients (less than 0.05 foot/feet or 0.015 meter/meters) or deep wells are encountered. However, in those cases where large flow gradients or large fluctuations in water levels are expected, a calibrated electric tape is acceptable. The water level is calculated using the well's reference point minus the measured depth to water. At depths approximately greater than 200 feet, the water-level-measuring device should be chosen carefully, as some devices may have measurable stretching.

The depth-to-water measurement must be made in all wells to be sampled prior to activities in any single well which may change the water level, such as bailing, pumping, and hydraulic testing. All readings are to be recorded to the nearest one-hundredth of a foot.

The time and date of the measurement, point of reference, measurement method, depth-to-water level measurement, and any calculations should be properly recorded. In addition, any known, outside influences (such as tidal cycles, nearby pumping effects, major barometric changes) that may affect water levels should be noted.

GROUND-WATER SAMPLING METHODS

The ground-water sampling methods to be employed should be dependent on site-specific conditions and requirements, such as data-quality objectives and well accessibility. Ground-water sampling methods vary based on the type of device used, the position of the sampler intake, the purge criteria used, and the composition of the ground water to be sampled (e.g., turbid, containing high volatile organics, etc.). All sampling methods and equipment should be clearly documented, including purge criteria, field readings, etc. Examples of appropriate documentation are provided in Attachment 2 of this document and Appendix E of the U.S. Environmental Protection Agency, 1995 document.

The water in the screen and filter pack is generally in a constant state of natural flux as ground water passes in and out of the well. However, water above the screened section remains relatively isolated and become stagnant. Stagnant water is subject to physio-chemical changes and may contain foreign material, which can be introduced from the surface or during well construction, resulting in non-representative sample data. To safeguard against collecting a sample biased by stagnant water, specific well-purging guidelines and techniques should be followed.

A non-representative sample also can result from excessive pumping of the monitoring well. Stratification of the contaminant concentrations in the aquifer may occur, or heavier-than-water compounds may sink to the lower portions of the aquifer. Excessive pumping can dilute or increase the contaminant concentrations from what is representative of the sampling point.

PURGING AND SAMPLING DEVICES

The device used to purge and sample a well depends on the inner casing diameter, depth to water, volume of water in the well, accessibility of the well, and types of contaminants to be sampled. The types of equipment available for ground-water sampling include hand-operated or motor-driven suction pumps, peristaltic pumps, positive displacement pumps, submersible pumps, various in-situ devices and bailers made of various materials, such as PVC, stainless steel and Teflon®. Some of these devices may cause volatilization and produce high pressure differentials, which could result in variability in the results of pH, dissolved oxygen concentrations, oxidation-reduction potential, specific electrical conductance, and concentrations of metals, volatile organics and dissolved gases. Therefore, the device chosen for well purging and sampling should be evaluated for the possible effects it may have on the chemical and physical analyses. In addition, the types of contaminants, detection levels, and levels of concern as described by the site DQOs should be consulted prior to the selection of a sampling device. The same device used for purging the monitoring well should be used for sampling to minimize agitation of the water column (which can increase turbidity, increase volatilization, and increase oxygen in the water).

In general, the device used for purging and sampling should not change geochemical and physical parameters and/or should not increase turbidity. For this reason, low-flow submersible or positive-displacement pumps that can control flow rates are recommended for purging wells. Dedicated sampling systems are greatly preferred since they avoid the need for decontamination of equipment and minimize turbulence in the well. If a sampling pump is used, the pump should be lowered into the well as slowly as possible and allowed to sit as long as possible, before pumping commences. This will minimize turbidity and volatilization within the well.

Sampling devices (bladders, pumps, bailers, and tubing) should be constructed of stainless steel, Teflon®, glass, and other inert materials to reduce the chance of these materials altering the ground water in areas where concentrations of the site contaminants are expected to be near detection limits. The sample tubing thickness should be maximized and the tubing length should be minimized so that the loss of contaminants through the tubing walls may be reduced and the rate of stabilization of ground-water parameters is maximized. The tendency of organics to sorb into and out of many materials makes the appropriate selection of sample tubing materials critical for these trace analyses (Pohlmann and Alduino, 1992; Parker and Ranney, 1998). Existing Superfund and RCRA guidance suggest appropriate compatible materials (U.S. Environmental Protection Agency, 1992). Special material considerations are important when sampling for non-routine analyses, such as age-dating and biological constituents.

Preferably, wells should be purged and sampled using a positive-displacement pump or a low-flow submersible pump with variable controlled flow rates and constructed of chemically inert materials. If a pump cannot be used because the recovery rate is so slow (less than 0.03 to 0.05 gallons per minute or 100 to 200 milliliters per minute) and the volume of the water to be removed is minimal (less than 5 feet (1.6 meters) of water), then a bailer with a double check valve and bottom-emptying device with a control-flow check valve may be used to obtain the samples. Otherwise, a bailer should not be used when sampling for volatile organics because of the potential bias introduced during sampling (Pohlmann, et al., 1990; Yeskis, et al., 1988; Tai, et al., 1991). A peristaltic

pump also may be used under these conditions, unless the bias by a negative pressure may impact the contaminant concentrations of concern (generally at depths greater than 15 to 20 feet (4.5 to 6 meters) of lift). Bailers should also be avoided when sampling for metals due to increased turbidity that occurs during the deployment of the bailer, which may bias inorganic and strongly hydrophobic parameters. Dedicated sampling pumps are recommended for metals sampling because the pumps avoid the generation of turbidity from frequent sampler deployment (Puls et al., 1992). A number of alternate sampling devices are becoming available, including passive diffusion samplers (Vroblesky and Hyde, 1997; Vroblesky, 2001a and b) and other in-situ sampling devices. These devices may be particularly useful to sampling low-permeability geologic materials, assuming the device is made of materials compatible with the analytical parameters, meet DQOs, and have been properly evaluated. However, the site investigator should ensure the diffusion membrane materials are selected for the contaminants of concern (COCs) present at the site. Comparison tests with an approved sampling method and diffusion samplers should be completed to confirm that the method is suitable for the site.

POSITION OF SAMPLE INTAKE

Essentially there are two positions for placement of the sample pump intake, within the screen and above the screen. Each of the positions offers advantages and disadvantages with respect to the portion of the well screen sampled, data reproducibility and potential purge volumes.

When the sampling pump intake is set above the well screen, the pump generally is set just below the water level in the well. The sampling pump then is pumped until a purge criterion is reached (commonly either stabilization of purge parameters or a set number of well volumes). If the distance between the water level and the top of the screen is long, there is concern that the water will be altered geochemically as it flows along the riser pipe, as water flows between the well screen and the sampling pump intake. This is especially a concern if the riser pipe is made of similar material as the COC (such as a stainless steel riser with nickel as a COC, or PVC with organics as a COC). Keely and Boateng (1987) suggested that to minimize this potential influence, the sample pump be lowered gradually while purging, so that at the time of the sampling the pump intake is just above the screen. This would minimize contact time between the ground water and the well construction materials while sampling, as well as ensure the evacuation of the stagnant water above the screen.

With the final location of the sampling pump intake just above the well screen, the sample results may be more reproducible than those collected by positioning the pump intake within the well screen. Results may be more reproducible because the sampler can ensure that the ground water is moving into the well with the same portions of the aquifer being sampled each time assuming the same pump rate. If the pump is placed into different portions of the screen each time, different portions of the aquifer may be sampled. Of course, this can be avoided by the use of dedicated, permanently installed equipment. Additionally, the placement of the pump at the same vertical position within the screen can be ensured by the use of calibrated sampling pump hose, sounding with a weighted tape, or using a pre-measured hose.

The placement of the pump above the screen does not guarantee the water-quality sample represents the entire well screen length. Any bias in the pump placement will be consistently towards the top of the well screen and/or to the zone of highest hydraulic conductivity. Another possible disadvantage, or advantage, depending on the DQOs, of the placement of the pump above the well screen is that the sample may represent a composite of water quality over the well screen. This may result in dilution of a portion of the screen that is in a contaminated portion of an aquifer with another portion that is in an uncontaminated portion of the aquifer. However, shorter well screens would minimize this concern.

When the pump intake is positioned within the well screen, its location is recommended to be opposite the most contaminated zone in the well screen interval. This method is known as the low-flow, low-stress, micropurge, millipurge, or minimal drawdown method. The well is then purged with a minimal drawdown (usually 0.33 feet (0.1 meters) based on Puls and Barcelona, 1996) until selected water-quality-indicator parameters have stabilized. Use of this method may result in the vertical portion of the sampled aquifer being smaller than the well screen length. This method is applicable primarily for short well-screen

lengths (less than 5 feet (1.6 meters)) to better characterize the vertical distribution of contaminants (Puls and Barcelona, 1996). This method should not be used with well-screen lengths greater than 10 feet (3 meters). By using this method, the volume of purge water can be reduced, sometimes significantly, over other purging methods.

However, two potential disadvantages of this method exist. The first potential disadvantage may involve the lower reproducibility of the sampling results. The position of the sampling pump intake may vary between sampling rounds (unless adequate precautions are taken to lower the pump into the exact position in previous sampling rounds, or a dedicated system is used), which can result in potentially different zones within the aquifer being sampled. This potential problem can be overcome by using dedicated sampling pumps and the problem may be minimized by the use of short well screens. The second potential disadvantage, or advantage, depending on the DQOs, may be that the sample which is collected may be taken from a small portion of the aquifer volume.

PURGE CRITERIA

"Low-Stress Approach"

The first method for purging a well, known as the low-stress approach, requires the use of a variable-speed, low-flow sampling pump. This method offers the advantage that the amount of water to be containerized, treated, or stored will be minimized. The low-stress method is based on the assumption that pumping at a low rate within the screened zone will not draw stagnant water down, as long as drawdown is minimized during pumping. Drawdown should not exceed 0.33 feet (0.1 meters) (Puls and Barcelona, 1996). The pump is turned on at a low flow rate approximating the estimated recovery rate (based on the drawdown within the monitoring well during sampling). This method requires the location of the pump intake to be within the saturated-screened interval during purging and sampling. The water-quality-indicator parameters (purge parameters), pH, specific electrical conductance, dissolved oxygen concentration, oxidation-reduction potential, temperature and turbidity, are monitored at specific intervals. The specific intervals will depend on the volume within the tubing (include pump and flow-through cell volumes), pump rate and drawdown; commonly every three to five minutes. These parameters should be recorded after a minimum of one tubing volume (include pump and flow-through-cell volumes) has been purged from the well. These water-quality-indicator parameters should be collected by a method or device which prevents air from contacting the sample prior to the reading, such as a flow-through cell (Barcelona et al., 1985; Garske and Schock, 1986; Wilde et al., 1998). Once three successive readings of the water-quality-indicator parameters provided in Table 1 have stabilized, the sampling may begin. The water-quality-indicator parameters that are recommended include pH and temperature, but these are generally insensitive to indicate completion of purging since they tend to stabilize rapidly (Puls and Barcelona, 1996). Oxidation-reduction potential may not always be an appropriate stabilization parameter, and will depend on site-specific conditions. However, readings should be recorded because of its value as a double check for oxidizing conditions, and for some fate and transport issues. When possible, especially when sampling for contaminants that may be biased by the presence of turbidity, the turbidity reading is desired to stabilize at a value below 10 Nephelometric Turbidity Units (NTUs). For final dissolved oxygen measurements, if the readings are less than 1 milligram per liter, they should be collected with the spectrophotometric method (Wilde et al., 1998, Wilkin et al., 2001), colorimetric or Winkler titration (Wilkin et al., 2001). All of these water-quality-indicator parameters should be evaluated against the specifications of the accuracy and resolution of the instruments used.

During purging, water-level measurements must be taken regularly at 30-second to five-minute intervals (depending on the hydraulic conductivity of the aquifer, diameter of the well, and pumping rate) to document the amount of drawdown during purging. The water-level measurements will allow the sampler to control pumping rates to minimize drawdown in the well.

"Well-Volume Approach"

The second method for purging wells is based on proper purging of the stagnant water above the screened interval and the stabilization of water-quality-indicator parameters prior to sampling. Several considerations in this method need to be evaluated before purging. For monitoring wells where the water level is above the screens, the pump should be set

near the top of the water column, and slowly lowered during the purging process. For water columns within the well screen, the pump should be set at a sufficient depth below the water level where drawdown during pumping does not allow air to enter the pump. The pump should not be allowed to touch or draw sediments from the bottom of the well, especially when sampling for parameters that may be impacted by turbidity. The well-purging rate should not be great enough to produce excessive turbulence in the well, commonly no greater than one gallon per minute (3.8 liters per minute) in a 2-inch well. The pump rate during sampling should produce a smooth, constant (laminar) flow rate, and should not produce turbulence during the filling of bottles. As a result, the expected flow rate for most wells will be less than one gallon per minute (3.8 liter per minute), with expected flow rates of about one-quarter gallon per minute (500 milliliter per minute).

The stabilization criteria for a “well-volume approach” may be based on the stabilization of water-quality-indicator parameters or on a pre-determined well volume. Various research indicates that purging criteria based on water-quality-indicator parameter stabilization may not always correlate to stabilization of other parameters, such as volatile organic compounds (Gibs and Imbrigiotta, 1990; Puls et al., 1990). A more technically rigorous sampling approach that would yield more consistent results over time would be a time-sequential sampling program at regular well-volume intervals while measuring water-quality-indicator parameters. However, the cost would be prohibitive for most sites. For comparison of water-quality results, by sampling under the same conditions (same purge volume and rate, same equipment, same wells, etc.) temporal evaluations of trends may be considered.

The stabilization requirements of the water-quality-indicator parameters are consistent with those described above for the low-stress approach. The parameters should be recorded approximately every well volume; when three successive readings have reached stabilization, the sample(s) are taken (Barcelona et al., 1985). If a ground-water monitoring well has been sufficiently sampled and characterized (at least several rounds of water-quality samples obtained, including the field parameters, during several seasonal variations), and if water-quality-indicator parameters are no longer needed as a part of site characterization and/or monitoring, then samples could be obtained based on a specific number of well volumes at the previous pumping rates.

LOW-PERMEABILITY FORMATIONS

Different procedures must be followed in the case of slow-recovery wells installed in low hydraulic conductivity aquifers. The following procedures are not optimum, but may be used to obtain a ground-water sample under less than ideal conditions. One suggested procedure is to remove the stagnant water in the casing to just above the top of the screened interval, in a well screened below the water table, to prevent the exposure of the gravel pack or formation to atmospheric conditions (McAlary and Barker, 1987). At no point should the pump be lowered into the screened interval. The pumping rate should be as low as possible for purging to minimize the drawdown in the well. However, if a well has an open interval across the water table in a low permeability zone, there may be no way to avoid pumping and/or bailing a well dry (especially in those cases with four feet of water or less in the well and at a depth to water greater than 20 to 25 feet (which is the practical limit of a peristaltic pump)). In these cases, the well may be purged dry. The sample should be taken no sooner than two hours after purging and after a sufficient volume for a water-quality sample, or sufficient recovery (commonly 90%) is present (Herzog et al., 1988). In these cases, a bailer with a double check valve with a flow-control, bottom-emptying device may be used, since many sampling pumps may have tubing capacities greater than the volume present within the well. If the depth of well and water column are shallow enough, consideration of a very low-flow device, such as a peristaltic pump, should be considered, especially if constituents are present that are not sensitive to negative pressures that may be created with the use of the peristaltic pump. If such constituents are present and sampled with a peristaltic pump, a negative bias may be introduced into the sampling results. To minimize the bias, thick-walled, non-porous tubing should be used, except for a small section in the pump heads, which require a greater degree of flexibility. As stated earlier in this paper, the DQOs for the sampling should be consulted to consider the potential impact of the sampling device on the potential bias versus the desired detection levels.

Another method to be considered for low-permeability conditions is the use of alternative sampling methods, such as passive diffusion samplers and other in-situ samplers. As more sites are characterized with these alternative sampling methods and devices, the potential bias, if any, can be evaluated with regard to the sampling DQOs. Regional hydrologists/geologists and Regional quality-assurance specialists should be consulted on the applicability of these methods for the site-specific conditions.

DECISION PROCESS FOR DETERMINING APPLICABLE SAMPLING METHODOLOGY

Once the project team has determined the sampling objectives and DQOs, reviewed the existing data, and determined the possible sampling devices that can be used, the team must decide the appropriate sampling methodology to be used. Table 2 provides a summary of considerations and rationale to be used in establishing the proper ground-water-sampling program using site-specific conditions and objectives.

POTENTIAL PROBLEMS

The primary objective is to obtain a sample representative of the ground water moving naturally (including both dissolved and particulate species) through the subsurface. A ground-water sample can be compromised by field personnel in two primary ways: taking an unrepresentative sample and handling the (representative) sample incorrectly. There are numerous ways of introducing foreign contaminants into a sample. These must be avoided by following strict sampling protocols and transportation procedures, and utilizing trained personnel. Common problems with sampling include the use of inappropriate sample containers and field composites, and the filtration of turbid samples.

SAMPLE CONTAINERS

Field samples must be transferred from the sampling equipment to the container that has been specifically prepared for that given parameter. Samples must not be composited in a common container in the field and then split in the lab. The USEPA Regional policy on sample containers should be consulted to determine the appropriate containers for the specified analysis.

FIELD FILTRATION OF TURBID SAMPLES

The USEPA recognizes that in some hydrogeologic environments, even with proper well design, installation, and development, in combination with the low-flow purging and sampling techniques, sample turbidity cannot be reduced to ambient levels. The well construction, development, and sampling information should be reviewed by the Regional geologists or hydrologists to see if the source of the turbidity problems can be resolved or if alternative sampling methodologies should be employed. If the water sample is excessively turbid, the collection of both filtered and unfiltered samples, in combination with turbidity, Total Suspended Solids (TSS), Total Dissolved Solids (TDS), pumping rate, and drawdown data is recommended. The filter size used to determine TSS and TDS should be the same as used in the field filtration. An in-line filter should be used to minimize contact with air to avoid precipitation of metals. The typical filter media size used is 0.45 µm because this is commonly accepted as the demarcation between dissolved and non-dissolved species. Other filter sizes may be appropriate but their use should be determined based on site-specific criteria (examples include grain-size distribution, ground-water-flow velocities, mineralogy) and project DQOs. Filter sizes up to 10.0 µm may be warranted because larger size filters may allow particulates that are mobile in ground water to pass through (Puls and Powell, 1992). The changing of filter media size may limit the comparability of the data obtained with other data sets and may affect their use in some geochemical models. Filter media size used on previous data sets from a site, region or aquifer and the DQOs should be taken into consideration. The filter media used during the ground-water sampling program should be collected in a suitable container and archived because potential analysis of the media may be helpful for the determination of particulate size, mineralogy, etc.

The first 500 to 1000 milliliters of a ground-water sample (depending on sample turbidity) taken through the in-line filter will not be collected for a sample in order to ensure that the filter media has equilibrated to the sample (manufacturer's recommendations also should be consulted). Because bailers have been shown to increase turbidity while purging and sampling, bailers should be avoided when sampling for trace element, metal, PCB, and pesticide constituents. If portable sampling pumps are used, the

pumps should be gently lowered to the sampling depth desired, carefully avoiding lowering it to the bottom of the well, and allowed to sit in order to allow any particles mobilized by pump placement to settle. Dedicated sampling equipment installed in the well prior to the commencement of the sampling activities is one of the recommended methods to reduce turbidity artifacts (Puls and Powell, 1992; Kearl et al., 1992; Puls et al., 1992; Puls and Barcelona, 1996).

SAMPLER DECONTAMINATION

The specific decontamination protocol for sampling devices is dependent on site-specific conditions, types of equipment used and the types of contaminants encountered. Once removed from the well, non-dedicated sampling equipment should be decontaminated to help ensure that there will be no cross-contamination between wells. Disposable items such as rope and low-grade tubing should be properly disposed between wells. Cleaning thoroughly that portion of the equipment that is going to come into contact with well water is especially important. In addition, a clean plastic sheet should be placed adjacent to or around the well to prevent surface soils from coming in contact with the purging and sampling equipment. The effects of cross-contamination can be minimized by sampling the least contaminated well first and progressing to the more contaminated ones. Equipment blanks should be collected on a regular basis from non-dedicated equipment, the frequency depending on the sampling plan and regional protocols, to document the effectiveness of the decontamination procedures.

The preferred method is to use dedicated sampling equipment whenever possible. Dedicated equipment should still be cleaned on a regular basis to reduce biofouling, and to minimize adsorption effects. Dedicated equipment should have equipment blanks taken after every cleaning.

POST-SAMPLING ACTIVITIES

Specific activities should be completed at monitoring wells at regular intervals to ensure the acquisition of representative ground-water samples. Activities include hydraulic conductivity testing to determine if a monitoring well needs redeveloping and/or replacing. Another activity that needs to be completed is regular surveying of well measuring points impacted by frost heaving and site activities. The schedules of these activities are to be determined on a site-by-site basis in consultation with regional geologists or hydrologists, but at a minimum, should be every five years.

CONCLUSION

This document provides a brief summary of the state-of-the-science to be used for Superfund and RCRA ground-water studies. As additional research is completed, additional sampling experience with other sampling devices and methods and/or additional contaminants are identified, this paper may be revised to include the new information/concerns. Clearly there is no one sampling method that is applicable for all sampling objectives. As new methods and/or equipment are developed, additional standard operating procedures (SOPs) should be developed and attached to this document. These SOPs for ground-water sampling should include, at a minimum: introduction, scope and application, equipment, purging and sampling procedures, field quality control, decontamination procedures and references. Example SOP's for the low-stress/minimal-drawdown and well-volume sampling procedures have been included as Attachments 3 and 4. These example SOPs are to be considered a pattern or starting point for site-specific ground-water-sampling plans. A more detailed discussion of sampling procedures, devices, techniques, etc. is provided in various publications by the USEPA (Barcelona et al., 1985; U.S. Environmental Protection Agency, 1993) and the U.S. Geological Survey (Wilde et al., 1998).

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TABLES:

Stablization Criteria with References for Water-Quality-Indicator Parameters

and

Applicability of Different Approaches for Purging and Sample Monitoring Wells

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TABLE 1: Stabilization Criteria with References for Water-Quality-Indicator Parameters

Parameter	Stabilization Criteria	Reference
pH	+/- 0.1	Puls and Barcelona, 1996; Wilde et al., 1998
specific electrical conductance (SEC)	+/- 3%	Puls and Barcelona, 1996
oxidation-reduction potential (ORP)	+/- 10 millivolts	Puls and Barcelona, 1996
turbidity	+/- 10% (when turbidity is greater than 10 NTUs)	Puls and Barcelona, 1996; Wilde et al., 1998
dissolved oxygen (DO)	+/- 0.3 milligrams per liter	Wilde et al., 1998

TABLE 2: Applicability of Different Approaches for Purging and Sampling Monitoring Wells

	Low-Stress Approach	**Well-Volume Approach**	**Others** (such as passive diffusion samplers, in-situ samplers, and other non-traditional ground-water sampling pumps)
Applicable Geologic Materials[1]	Materials with moderate to high hydraulic conductivities. May be applicable to some low hydraulic conductivities, if can meet minimal drawdown criteria.	Materials with low to high hydraulic conductivities	Materials with very low to high hydraulic conductivities
Aquifer/Plume Characterization Data Needs prior to Choosing Sampling Method [2]	High definition of vertical hydraulic conductivity distribution and vertical contaminant distribution	Plume and hydraulic conductivity distributions are less critical	May need to consider the degree of hydraulic and contaminant vertical distribution definition dependent on Data Quality Objectives and sampler type.
Constituent Types Method is Applicable	Mainly recommended for constituents which can be biased by turbidity in wells. Applicable for most other contaminants.	Applicable for all sampling parameters. However, if turbidity values are elevated, low-stress approach may be more applicable if constituents of concern are turbidity sensitive.	Constituents of concern will be dependent on the type of sampler.
Data Quality Objectives	1) High resolution of plume definition both vertically and horizontally. 2) Reduce bias from other sampling methods if turbidity is of concern. 3) Target narrow sections of aquifer.	1) Basic site characterization 2) Moderate to high resolution of plume definition (will be dependent on screen length). 3) Target sample composition to represent entire screened/open interval	1) Can be applicable to basic site characterization, depending on sampler and methodology used. 2) Can reduce bias from other sampling methods. 3) May yield high resolution of plume definition.

[1]Hydraulic conductivities of aquifer materials vary from low hydraulic conductivities (clays, silts, very fine sands) to high conductivities (gravels, sands, weathered bedrock zones). This term for the use on this table is subjective, and is more dependent on the drawdown induced in a monitoring well when sampled with a ground-water sampling pump. For instance, in a well being pumped at 4 liters per minute (l/min) with less than 0.1 feet of drawdown, can be considered to have high hydraulic conductivity. A well that can sustain a 0.2 to 0.4 l/min pumping rate, but has more than 0.5 feet of drawdown can be considered to have low hydraulic conductivity. To assign absolute values of hydraulic conductivities to well performance and sustainable pumping rates cannot be completed because of the many factors in monitoring well construction, such as well diameter, screen open area, and length of screen.

[2] See last paragraph under the SAMPLING OBJECTIVES section.

ATTACHMENT 1
Example Sampling Checklist

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SAMPLING CHECKLIST

Well Identification:_____

Map of Site Included: Y or N
Wells Clearly Identified with Roads: Y or N
Well Construction Diagram Attached: Y or N

Well Construction:

Diameter of Borehole:_____ Diameter of Casing:_____
Casing Material:_____ Screen Material:_____
Screen Length:_____ Total Depth:_____

Approximate Depth to Water:_____
Maximum Well Development Pumping Rate:_____
Date of Last Well Development:_____

Previous Sampling Information:

Was the Well Sampled Previously: Y or N
(If Sampled, Fill Out Table Below)

Table of Previous Sampling Information

Parameter	Previously Sampled	Number of Times Sampled	Maximum Concentration	Notes (include previous purge rates)

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ATTACHMENT 2
Example Ground-Water Sampling Field Sheets

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GROUND-WATER SAMPLING RECORD

Well ID:_____

Station #:_____

Facility Name: Date:____/____/____

Well Depth:_____ Depth to Water:_____ Well Diameter:_____

Casing Material.:_____ Volume Of Water per Well Volume:_____

Sampling Crew:_____,_____,_____,_____

Type of Pump:_____ _____ Tubing Material:_____ Pump set at _____ ft.

Weather Conditions:_____ NOTES:_____ _____

_____

GROUND-WATER SAMPLING PARAMETERS

Time	Water Level	Volume Pumped	Pumping Rate	DO (mg/l)	Temp. (°C)	SEC (µS/cm)	pH	ORP (mV)	Turbidity (NTU)

Other Parameters: _____

Sampled at:_____ Parameters taken with :_____

Sample delivered to _____ by _____ at_____.

Sample CRL #:_____ OTR #:_____ ITR #:_____ SAS #:_____

Parameters Collected	Number of Bottles	Bottle Lot Number

Ground Water Sampling Log

Site Name: **Well #:** **Date:**
Well Depth(Ft-BTOC[1]): **Screen Interval**(Ft):

Well Dia.: **Casing Material:** **Sampling Device:**

Pump placement(Ft from TOC[2]):

Measuring Point: **Water level (static)**(Ft):

Water level (pumping)(Ft): **Pump rate**(Liter/min):

Sampling Personnel:

Other info: (such as sample numbers, weather conditions and field notes)

Water Quality Indicator Parameters

Time	Pumping rates (L/Min)	Water level (ft)	DO (mg/L)	ORP (mv)	SEC[3]	Turb. (NTU)	pH	Temp. (C^0)	Volume pumped (L)

Type of Samples collected:

1 casing volume was:
Total volume purged prior to sample collection:
[1]BTOC-Below Top of Casing
[2]TOC-Top of Casing
[3]Specific Electrical Conductance

Stabilization Criteria

D.O.	+/- 0.3 mg/l
Turb.	+/- 10%
S.C.	+/- 3%
ORP	+/- 10 mV
pH	+/- 0.1 unit

ATTACHMENT 3
Example Standard Operating Procedure:

Standard Operating Procedure for Low-Stress (Low Flow)/Minimal Drawdow Ground-Water Sample Collection

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Standard Operating Procedure for Low-Stress (Low-Flow)/ Minimal Drawdown Ground-Water Sample Collection

INTRODUCTION

The collection of "representative" water samples from wells is neither straightforward nor easily accomplished. Ground-water sample collection can be a source of variability through differences in sample personnel and their individual sampling procedures, the equipment used, and ambient temporal variability in subsurface and environmental conditions. Many site inspections and remedial investigations require the sampling at ground-water monitoring wells within a defined criterion of data confidence or data quality, which necessitates that the personnel collecting the samples are trained and aware of proper sample-collection procedures.

The purpose of this standard operating procedure (SOP) is to provide a method that minimizes the impact the purging process has on the ground-water chemistry and the volume of water that is being purged and disposed of during sample collection. This will take place by placing the pump intake within the screen interval and by keeping the drawdown at a minimal level (0.33 feet) (Puls and Barcelona, 1996) until the water quality parameters have stabilized and sample collection is complete. The flow rate at which the pump will be operating will depend upon both hydraulic conductivity of the aquifer and the drawdown with the goal of minimizing the drawdown. The flow rate from the pump during purging and sampling will be at a rate that will not compromise the integrity of the analyte that is being sampled. This sampling procedure may or may not provide a discrete ground-water sample at the location of the pump intake. The flow of ground-water to the pump intake will be dependent on the distribution of the hydraulic conductivity (K) of the aquifer within the screen interval. In order to minimize the drawdown in the monitoring well, a low-flow rate must be used. "Low-Flow" refers to the velocity with which water enters the pump intake from the surrounding formation in the immediate vicinity of the well screen. It does not necessarily refer to the flow rate of water discharged at the surface, which can be affected by flow regulators or restrictions (Puls and Barcelona, 1996). This SOP was developed by the Superfund/RCRA Ground Water Forum and draws from an USEPA's Ground Water Issue Paper, Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedure, by Robert W. Puls and Michael J. Barcelona. Also, available USEPA Regional SOPs regarding Low-Stress (Low-Flow) Purging and Sampling were used for this SOP.

SCOPE AND APPLICATION

This SOP should be used primarily at monitoring wells that have a screen or an open interval with a length of ten feet or less and can accept a sampling device that minimizes the disturbance to the aquifer or the water column in the well casing. The screen or open interval should have been optimally located to intercept an existing contaminant plume(s) or along flowpaths of potential contaminant releases. Knowledge of the contaminant distribution within the screen interval is highly recommended and is essential for the success of this sampling procedure. The ground-water samples that are collected using this procedure are acceptable for the analyses of ground-water contaminants that may be found at Superfund and RCRA contamination sites. The analytes may be volatile, semi-volatile organic compounds, pesticides, PCBs, metals, and other inorganic compounds. The screened interval should be located within the contaminant plume(s) and the pump intake should be placed at or near the known source of the contamination within the screened interval. It is critical to place the pump intake in the exact location or depth for each sampling event. This argues for the use of dedicated, permanently installed, sampling devices whenever possible. If this is not possible, then the placement of the pump intake should be positioned with a calibrated sampling pump hose sounded with a weighted-tape or using a pre-measured hose. The pump intake should not be placed near the bottom of the screened interval to avoid disturbing any sediment that may have settled at the bottom of the well.

Water-quality-indicator parameters and water levels must be measured during purging, prior to sample collection. Stabilization of the water-quality-indicator parameters as well as monitoring water levels are a prerequisite to sample collection. The water-quality-indicator parameters that are recommended include the following: specific electrical conductance, dissolved oxygen, turbidity, oxidation-reduction potential, pH, and temperature. The latter two parameters are useful data, but are generally insensitive as purging parameters. Oxidation-reduction potential may not always be appropriate stabilization parameter, and will depend on site-specific conditions. However, readings

should be recorded because of its value as a double check for oxidation conditions and for fate and transport issues.

Also, when samples are collected for metals, semi-volatile organic compounds, and pesticides, every effort must be made to reduce turbidity to 10 NTUs or less (not just the stabilization of turbidity) prior to the collection of the water sample. In addition to the measurement of the above parameters, depth to water must be measured during purging (U.S. Environmental Protection Agency, 1995).

Proper well construction, development, and maintenance are essential for any ground-water sampling procedure. Prior to conducting the field work, information on the construction of the well and well development should be obtained and that information factored into the site specific sampling procedure. The Sampling Checklist at the end of this attachment is an example of the type of information that is useful.

Stabilization of the water-quality-indicator parameters is the criterion for sample collection. But if stabilization is not occurring and the procedure has been strictly followed, then sample collection can take place once three (minimum) to six (maximum) casing volumes have been removed (Schuller et al., 1981 and U.S. Environmental Protection Agency., 1986; Wilde et al., 1998; Gibs and Imbrigiotta., 1990). The specific information on what took place during purging must be recorded in the field notebook or in the ground-water sampling log.

This SOP is not to be used where non-aqueous phase liquids (NAPL) (immiscible fluids) are present in the monitoring well.

EQUIPMENT

- Depth-to-water measuring device - An electronic water-level indicator or steel tape and chalk, with marked intervals of 0.01 foot. Interface probe for determination of liquid products (NAPL) presence, if needed.
- Steel tape and weight - Used for measuring total depth of well. Lead weight should not be used.
- Sampling pump - Submersible or bladder pumps with adjustable rate controls are preferred. Pumps are to be constructed of inert materials, such as stainless steel and Teflon®. Pump types that are acceptable include gear and helical driven, centrifugal (low-flow type), and air-activated piston. An adjustable rate, peristaltic pump can be used when the depth to water is 20 feet or less.
- Tubing - Teflon® or Teflon®-lined polyethylene tubing is preferred when sampling for organic compounds. Polyethylene tubing can be used when sampling inorganics.
- Power source - If a combustion type (gasoline or diesel-driven) generator is used, it must be placed downwind of the sampling area.
- Flow measurement supplies - flow meter, graduated cylinder, and a stop watch.
- Multi-parameter meter with flow-through cell - This can be one instrument or more contained in a flow-through cell. The water-quality-indicator parameters that are monitored are pH, ORP/Eh, (ORP) dissolved oxygen (DO), turbidity, specific conductance, and temperature. Turbidity readings must be collected before the flow cell because of the potential for sediment buildup, which can bias the turbidity measurements. Calibration fluids for all instruments should be NIST-traceable and there should be enough for daily calibration throughout the sampling event. The inlet of the flow cell must be located near the bottom of the flow cell and the outlet near the top. The size of the flow cell should be kept to a minimum and a closed cell is preferred. The flow cell must not contain any air or gas bubbles when monitoring for the water-quality-indicator parameters.
- Decontamination supplies - Including a reliable and documented source of distilled water and any solvents (if used). Pressure sprayers, buckets or decontamination tubes for pumps, brushes and non-phosphate soap will also be needed.
- Sample bottles, sample preservation supplies, sample tags or labels, and chain-of-custody forms.
- Approved Field Sampling and Quality Assurance Project Plan.
- Well construction, field, and water quality data from the previous sampling event.
- Well keys and map of well locations.
- Field notebook, ground-water sampling logs, and calculator. A suggested field data sheet (ground-water sampling record or ground-water sampling log) are provided at the end of this attachment.

- Filtration equipment, if needed. An in-line disposable filter is recommended.
- Polyethylene sheeting placed on ground around the well head.
- Personal protective equipment as specified in the site Health and Safety Plan.
- Air monitoring equipment as specified in the Site Health and Safety Plan.
- Tool box - All needed tools for all site equipment used.
- A 55-gallon drum or container to contain the purged water.

Construction materials of the sampling equipment (bladders, pumps, tubing, and other equipment that comes in contact with the sample) should be limited to stainless steel, Teflon®, glass, and other inert material. This will reduce the chance that sampling materials alter the ground-water where concentrations of the site contaminants are expected to be near the detection limits. The sample tubing diameter should be maximized and the tubing length should be minimized so that the loss of contaminants into and through the tubing walls may be reduced and the rate of stabilization of ground-water parameters is maximized. The tendency of organics to sorb into and out of material makes the appropriate selection of sample tubing material critical for trace analyses (Pohlmann and Alduino, 1992; Parker and Ranney, 1998).

PURGING AND SAMPLING PROCEDURES

The following describes the purging and sampling procedures for the Low-Stress (Low-Flow)/ Minimal Drawdown method for the collection of ground-water samples. These procedures also describe steps for dedicated and non-dedicated systems.

Pre-Sampling Activities (Non-dedicated and dedicated system)

1. Sampling must begin at the monitoring well with the least contamination, generally up-gradient or farthest from the site or suspected source. Then proceed systematically to the monitoring wells with the most contaminated ground water.

2. Check and record the condition of the monitoring well for damage or evidence of tampering. Lay out polyethylene sheeting around the well to minimize the likelihood of contamination of sampling/purging equipment from the soil. Place monitoring, purging and sampling equipment on the sheeting.

3. Unlock well head. Record location, time, date, and appropriate information in a field logbook or on the ground-water sampling log (See attached ground-water sampling record and ground-water sampling log as examples).

4. Remove inner casing cap.

5. Monitor the headspace of the monitoring well at the rim of the casing for volatile organic compounds (VOC) with a photo-ionization detector (PID) or flame ionization detector (FID) and record in the logbook. If the existing monitoring well has a history of positive readings of the headspace, then the sampling must be conducted in accordance with the Health and Safety Plan.

6. Measure the depth to water (water level must be measured to nearest 0.01 feet) relative to a reference measuring point on the well casing with an electronic water level indicator or steel tape and record in logbook or ground-water sampling log. If no reference point is found, measure relative to the top of the inner casing, then mark that reference point and note that location in the field logbook. Record information on depth to ground water in the field logbook or ground-water sampling log. Measure the depth to water a second time to confirm initial measurement; measurement should agree within 0.01 feet or re-measure.

7. Check the available well information or field information for the total depth of the monitoring well. Use the information from the depth of water in step six and the total depth of the monitoring well to calculate the volume of the water in the monitoring well or the volume of one casing. Record information in field logbook or ground-water sampling log.

Purging and Sampling Activities

8A. Non-dedicated system - Place the pump and support equipment at the wellhead and slowly lower the pump and tubing down into the monitoring well until the location of the pump intake is set at a predetermined location within the screen interval. The placement of the pump intake should be positioned

with a calibrated sampling pump hose, sounded with a weighted-tape, or using a pre-measured hose. Refer to the available monitoring well information to determine the depth and length of the screen interval. Measure the depth of the pump intake while lowering the pump into location. Record pump location in field logbook or ground-water sampling log.

8B. Dedicated system - Pump has already been installed, refer to the available monitoring well information and record the depth of the pump intake in the field logbook or ground-water sampling log.

9. Non-dedicated system and dedicated systems - Measure the water level (water level must be measured to nearest 0.01 feet) and record information on the ground-water sampling log, leave water level indicator probe in the monitoring well.

10. Non-dedicated and dedicated systems - Connect the discharge line from the pump to a flow-through cell. A “T” connection is needed prior to the flow-through cell to allow for the collection of water for the turbidity measurements. The discharge line from the flow-through cell must be directed to a container to contain the purge water during the purging and sampling of the monitoring well.

11. Non-dedicated and dedicated systems - Start pumping the well at a low flow rate (0.2 to 0.5 liter per minute) and slowly increase the speed. Check water level. Maintain a steady flow rate while maintaining a drawdown of less than 0.33 feet (Puls and Barcelona, 1996). If drawdown is greater than 0.33 feet, lower the flow rate. 0.33 feet is a goal to help guide with the flow rate adjustment. It should be noted that this goal may be difficult to achieve under some circumstances due to geologic heterogeneities within the screened interval, and may require adjustment based on site-specific conditions and personal experience (Puls and Barcelona, 1996).

12. Non-dedicated and dedicated systems - Measure the discharge rate of the pump with a graduated cylinder and a stop watch. Also, measure the water level and record both flow rate and water level on the ground-water sampling log. Continue purging, monitor and record water level and pump rate every three to five minutes during purging. Pumping rates should be kept at minimal flow to ensure minimal drawdown in the monitoring well.

13. Non-dedicated and dedicated systems - During the purging, a minimum of one tubing volume (including the volume of water in the pump and flow cell) must be purged prior to recording the water-quality indicator parameters. Then monitor and record the water-quality- indicator parameters every three to five minutes. The water-quality indicator field parameters are turbidity, dissolved oxygen, specific electrical conductance, pH, redox potential, and temperature. Oxidation-reduction potential may not always be an appropriate stabilization parameter, and will depend on site-specific conditions. However, readings should be recorded because of its value as a double check for oxidizing conditions. Also, for the final dissolved oxygen measurement, if the readings are less than 1 milligram per liter, it should be collected and analyze with the spectrophotometric method (Wilde et al., 1998 Wilkin et al., 2001), colorimetric or Winkler titration (Wilkin et al., 2001). The stabilization criterion is based on three successive readings of the water quality field parameters; the following are the criteria which must be used:

Parameter	Stabilization Criteria	Reference
pH	+/- 0.1 pH units	Puls and Barcelona, 1996; Wilde et al., 1998
specific electrical conductance (SEC)	+/- 3% S/cm	Puls and Barcelona, 1996
oxidation-reduction potential (ORP)	+/- 10 millivolts	Puls and Barcelona, 1996
turbidity	+/- 10% NTUs (when turbidity is greater than 10 NTUs)	Puls and Barcelona, 1996; Wilde et al., 1998
dissolved oxygen	+/- 0.3 milligrams per liter	Wilde et al., 1998

Once the criteria have been successfully met indicating that the water quality indicator parameters have stabilized, then sample collection can take place.

14. If a stabilized drawdown in the well can't be maintained at 0.33 feet and the water level is approaching the top of the screened interval, reduce the flow rate or turn the pump off (for 15 minutes) and allow for recovery. It should be noted whether or not the pump has a check valve. A check valve is required if the pump is shut off. Under no circumstances should the well be pumped dry. Begin pumping at a lower flow rate, if the water draws down to the top of the screened interval again, turn pump off and allow for recovery. If two tubing volumes (including the volume of water in the pump and flow cell) have been removed during purging, then sampling can proceed next time the pump is turned on. This information should be noted in the field notebook or ground-water sampling log with a recommendation for a different purging and sampling procedure.

15. Non-dedicated and dedicated systems - Maintain the same pumping rate or reduce slightly for sampling (0.2 to 0.5 liter per minute) in order to minimize disturbance of the water column. Samples should be collected directly from the discharge port of the pump tubing prior to passing through the flow-through cell. Disconnect the pump's tubing from the flow-through cell so that the samples are collected from the pump's discharge tubing. For samples collected for dissolved gases or VOC analyses, the pump tubing needs to be completely full of ground water to prevent the ground water from being aerated as it flows through the tubing. The sequence of the samples is immaterial unless filtered (dissolved) samples are collected and they must be collected last (Puls and Barcelona, 1996). All sample containers should be filled with minimal turbulence by allowing the ground water to flow from the tubing gently down the inside of the container. When filling the VOC samples, a meniscus must be formed over the mouth of the vial to eliminate the formation of air bubbles and head space prior to capping. In the event that the ground water is turbid, (greater then 10 NTUs), a filtered metal (dissolved) sample also should be collected.

If filtered metal sample is to be collected, then an in-line filter is fitted at the end of the discharge tubing and the sample is collected after the filter. The in-line filter must be pre-rinsed following manufacturer's recommendations and if there are no recommendations for rinsing, a minimum of 0.5 to 1 liter of ground water from the monitoring well must pass through the filter prior to sampling.

16A. Non-dedicated system - Remove the pump from the monitoring well. Decontaminate the pump and dispose of the tubing if it is non-dedicated.

16B. Dedicated system - Disconnect the tubing that extends from the plate at the wellhead (or cap) and discard after use.

17. Non-dedicated system - Before locking the monitoring well, measure and record the well depth (to 0.1 feet).

Measure the total depth a second time to confirm initial measurement; measurement should agree within 0.01 feet or re-measure.

18. Non-dedicated and dedicated systems - Close and lock the well.

DECONTAMINATION PROCEDURES

Decontamination procedures for the water level meter and the water quality field parameter sensors.
The electronic water level indicator probe/steel tape and the water-quality field parameter sensors will be decontaminated by the following procedures:

1. The water level meter will be hand washed with phosphate-free detergent and a scrubber, then thoroughly rinsed with distilled water.

2. Water quality field parameter sensors and flow-through cell will be rinsed with distilled water between sampling locations. No other decontamination procedures are necessary or recommended for these probes since they are sensitive. After the sampling event, the flow cell and sensors must be cleaned and maintained per the manufacturer's requirements.

Decontamination Procedure for the Sampling Pump

Upon completion of the ground water sample collection the sampling pump must be properly decontaminated between monitoring wells. The pump and discharge line including support cable and electrical

wires which were in contact with the ground water in the well casing must be decontaminated by the following procedure:

1. The outside of the pump, tubing, support cable and electrical wires must be pressure-sprayed with soapy water, tap water, and distilled water. Spray outside of tubing and pump until water is flowing off of tubing after each rinse. Use bristle brush to help remove visible dirt and contaminants.
2. Place the sampling pump in a bucket or in a short PVC casing (4-in. diameter) with one end capped. The pump placed in this device must be completely submerged in the water. A small amount of phosphate-free detergent must be added to the potable water (tap water).
3. Remove the pump from the bucket or 4-in. casing and scrub the outside of the pump housing and cable.
4. Place pump and discharge line back in the 4-in. casing or bucket, start pump and recirculate this soapy water for 2 minutes (wash).
5. Re-direct discharge line to a 55-gallon drum. Continue to add 5 gallons of potable water (tap water) or until soapy water is no longer visible.
6. Turn pump off and place pump into a second bucket or 4-in. casing that contains tap water. Continue to add 5 gallons of tap water (rinse).
7. Turn pump off and place pump into a third bucket or 4-in. casing which contains distilled/deionized water, continue to add 3 to 5 gallons of distilled/deionized water (final rinse).
8. If a hydrophobic contaminant is present (such as separate phase, high levels of PCBs, etc.), an additional decontamination step, or steps, may be added. For example, an organic solvent, such as reagent-grade isopropanol alcohol may be added as a first spraying/bucket prior to the soapy water rinse/bucket.

FIELD QUALITY CONTROL

Quality control (QC) samples must be collected to verify that sample collection and handling procedures were performed adequately and that they have not compromised the quality of the ground-water samples. The appropriate EPA program guidance must be consulted in preparing the field QC sample requirements for the site-specific Quality Assurance Project Plan (QAPP).

There are five primary areas of concern for quality assurance (QA) in the collection of representative ground-water samples:

1. Obtaining a ground-water sample that is representative of the aquifer or zone of interest in the aquifer. Verification is based on the field log documenting that the field water-quality parameters stabilized during the purging of the well, prior to sample collection.
2. Ensuring that the purging and sampling devices are made of materials, and utilized in a manner that will not interact with or alter the analyses.
3. Ensuring that results generated by these procedures are reproducible; therefore, the sampling scheme should incorporate co-located samples (duplicates).
4. Preventing cross-contamination. Sampling should proceed from least to most contaminated wells, if known. Field equipment blanks should be incorporated for all sampling and purging equipment, and decontamination of the equipment is therefore required.
5. Properly preserving, packaging, and shipping samples.

All field QC samples must be prepared the same as regular investigation samples with regard to sample volume, containers, and preservation. The chain-of-custody procedures for the QC samples will be identical to the field ground-water samples. The following are QC samples that must be collected during the sampling event:

Sample Type	Frequency
● Field duplicates	1 per 20 samples
● Matrix spike	1 per 20 samples
● Matrix spike duplicate	1 per 20 samples
● Equipment blank	per Regional requirements or policy
● Trip blank (VOCs)	1 per sample cooler
● Temperature blank	1 per sample cooler

HEALTH AND SAFETY CONSIDERATIONS

Depending on the site-specific contaminants, various protective programs must be implemented prior to sampling the first well. The site Health and Safety Plan should be reviewed with specific emphasis placed on the protection program planned for the sampling tasks. Standard safe operating practices should be followed, such as minimizing contact with potential contaminants in both the liquid and vapor phase through the use of appropriate personal protective equipment.

Depending on the type of contaminants expected or determined in previous sampling efforts, the following safe work practices will be employed:

Particulate or metals contaminants

1. Avoid skin contact with, and incidental ingestion of, purge water.
2. Use protective gloves and splash protection.

Volatile organic contaminants

1. Avoid breathing constituents venting from well.
2. Pre-survey the well head space with an appropriate device as specified in the site Health and Safety Plan.
3. If monitoring results indicate elevated organic constituents, sampling activities may be conducted in level C protection. At a minimum, skin protection will be afforded by disposable protective clothing, such as Tyvek®.

General practices should include avoiding skin contact with water from preserved sample bottles, as this water will have pH less than 2 or greater than 10. Also, when filling pre-acidified VOA bottles, hydrochloric acid fumes may be released and should not be inhaled.

POST-SAMPLING ACTIVITIES

Several activities need to be completed and documented once ground-water sampling has been completed. These activities include, but are not limited to the following:

1. Ensuring that all field equipment has been decontaminated and returned to proper storage location. Once the individual field equipment has been decontaminated, tag it with date of cleaning, site name, and name of individual responsible.
2. Processing all sample paperwork, including copies provided to the Regional Laboratory, Sample Management Office, or other appropriate sample handling and tracking facility.
3. Compiling all field data for site records.
4. Verifying all analytical data processed by the analytical laboratory against field sheets to ensure all data has been returned to sampler.

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SAMPLING CHECKLIST

Well Identification:_____

Map of Site Included: Y or N
Wells Clearly Identified with Roads: Y or N
Well Construction Diagram Attached: Y or N

Well Construction:

Diameter of Borehole:_____ Diameter of Casing:_____
Casing Material:_____ Screen Material:_____
Screen Length:_____ Total Depth:_____

Approximate Depth to Water:_____
Maximum Well Development Pumping Rate:_____
Date of Last Well Development:_____

Previous Sampling Information:

Was the Well Sampled Previously: Y or N
(If Sampled, Fill Out Table Below)

Table of Previous Sampling Information

Parameter	Previously Sampled	Number of Times Sampled	Maximum Concentration	Notes (include previous purge rates)

Ground Water Sampling Log

Site Name: **Well #:** **Date:**
Well Depth(Ft-BTOC[1]): **Screen Interval**(Ft):

Well Dia.: **Casing Material:** **Sampling Device:**

Pump placement(Ft from TOC[2]):

Measuring Point: **Water level (static)**(Ft):

Water level (pumping)(Ft): **Pump rate**(Liter/min):

Sampling Personnel:

Other info: (such as sample numbers, weather conditions and field notes)

Water Quality Indicator Parameters

Time	Pumping rates (L/Min)	Water level (ft)	DO (mg/L)	ORP (mv)	Turb. (NTU)	SEC[3] (S/cm)	pH	Temp. (C^0)	Volume pumped (L)

Type of Samples collected:

1 casing volume was:

Total volume purged prior to sample collection:

[1]**BTOC-Below Top of Casing**
[2]**TOC-Top of Casing**
[3]**Specific Electrical Conductance**

Stabilization Criteria

D.O.	+/- 0.3 mg/l
Turb.	+/- 10%
S.C.	+/- 3%
ORP	+/- 10 mV
pH	+/- 0.1 unit

ATTACHMENT 4
Example Standard Operating Procedure:

Standard Operating Procedure for the Standard/Well-Volume Method for Collecting a Ground-Water Sample

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Standard Operating Procedure for the Well-Volume Method for Collecting a Ground-Water Sample

INTRODUCTION

The collection of “representative” water samples from wells is neither straightforward nor easily accomplished. Ground-water sample collection can be a source of variability through differences in sampling personnel and their individual sampling procedures, the equipment used, and ambient temporal variability in subsurface and environmental conditions. Many site inspections and remedial investigations require the sampling at ground-water monitoring wells within a defined criterion of data confidence or data quality, which necessitates that the personnel collecting the samples are trained and aware of proper sample-collection procedures.

The objectives of the sampling procedures described in this document are to minimize changes in ground-water chemistry during sample collection and transport to the laboratory and to maximize the probability of obtaining a representative, reproducible ground-water sample. Sampling personnel may benefit from a working knowledge of the chemical processes that can influence the concentration of dissolved chemical species.

The well-volume method described in this standard operating procedure (SOP) provides a reproducible sampling technique with the goal that the samples obtained will represent water quality over an entire open interval of a short-screened (ten feet or less) well. This technique is appropriate for long-term and detection monitoring of formation water quality. The resulting sample generally represents a composite of the screened interval, and thus integrates small-scale vertical heterogeneities of ground-water chemistry. This sampling technique also is useful for screening purposes for detection monitoring of contaminants in the subsurface. However, the detection of a low concentration of contaminant in a thin contaminated zone or with long well screens may be difficult and should be determined using detailed vertical profiling techniques.

This method may not be applicable for all ground-water-sampling wells, such as wells with very low yields, fractured rock, and some wells with turbidity problems. As always, site-specific conditions and objectives should be considered prior to the selection of this method for sampling.

SCOPE AND APPLICATION

The objective of a good sampling program should be the collection of a representative sample of the current ground-water conditions over a known or specified volume of aquifer. To meet this objective, the sampling equipment, the sampling method, the monitoring well construction, monitoring well operation and maintenance, and sample-handling procedures should not alter the chemistry of the sample.

An example of how a site’s Data Quality Objectives (DQOs) for a characterization sampling effort might vary from those of a remediation monitoring sampling effort could be a difference of how much of the screened interval or aquifer should be sampled. A site characterization objective may be to collect a sample that represents a composite of the entire (or as close as is possible) screened interval of the monitoring well.

Additionally, the site characterization may require a large suite of contaminants to be sampled and analyzed, whereas, the remediation monitoring program may require fewer contaminants sampled and analyzed. These differences may dictate the type of sampling equipment used, the type of information collected, and the sampling protocol.

This sampling method described is for monitoring wells. However, this method should not be used for water-supply wells with a water-supply pump, with long-screened wells in complex hydrogeologic environments (such as fractured rock), or wells with separate phases of liquids (such as a Dense or Light Non-Aqueous Phase Liquids) present within the screened interval.

EQUIPMENT

- Depth-to-water measuring device - An electronic water-level indicator or steel tape and chalk, with marked intervals of 0.01 foot. Interface probe for measuring separate phase liquids, if needed. Pressure transducer and data logger optional for frequent depth-to-water measuring in same well.
- Steel tape and weight - Used for measuring total depth of well. Lead weights should not be used.
- Sampling pump - Submersible or bladder pumps with adjustable rate controls are preferred. Pumps

are to be constructed of inert materials, such as stainless steel and Teflon®. Pump types that are acceptable include gear and helical driven, centrifugal (low-flow type), and air-activated piston. Adjustable rate, peristaltic pumps can be used when the depth to water is 20 feet or less.

- Tubing - Inert tubing should be chosen based on the types and concentrations of contaminants present, or expected to be present in the monitoring well. Generally, Teflon®-based tubing is recommended when sampling for organic compounds. Polyethylene or Teflon® tubing can be used when sampling for inorganic constituents.
- Power source - If a combustion type (gasoline or diesel-driven) device is used, it must be located downwind of the point of sample collection. If possible, it should also be transported to the site and sampling location in a different vehicle from the sampling equipment.
- Flow-measurement equipment - Graduated cylinder or bucket and a stop watch, or a flow meter that can be disconnected prior to sampling.
- Multi-parameter meter with flow-through cell - This can be one instrument or multiple probes/instruments contained in a flow-through cell. The water-quality-indicator parameters that are measured in the field are pH, oxidation/reduction potential (ORP, redox, or Eh), dissolved oxygen (DO), turbidity, specific electrical conductance (SEC), and temperature. Calibration standards for all instruments should be NIST-traceable, within expiration dates of the solutions, and sufficient for daily calibration throughout the sampling collection.
- Decontamination supplies - A reliable and documented source of distilled water and any solvents (if used). Pressure sprayers, buckets or decontamination tubes for pumps, brushes and non-phosphate soap also will be needed.
- Sample bottles, sample preservation supplies and laboratory paperwork. Also, several coolers, and sample packing supplies (absorbing packing material, plastic baggies, etc.).
- Approved plans and background documents - Approved Field Sampling Plan, Quality Assurance Project Plan, well construction data, field and water-quality data from the previous sampling collection.
- Site Access/Permission documentation for site entry.
- Well keys and map showing locations of wells.
- Field notebook, field data sheets and calculator. A suggested field data sheet is provided at the end of this attachment.
- Filtration equipment - If needed, this equipment should be an in-line disposable filter used for the collection of samples for analysis of dissolved constituents.
- Polyethylene sheeting - Used for decontamination stations and during sampling to keep equipment clean.
- Site Health and Safety Plan and required equipment - The health and safety plan along with site sign-in sheet should be on site and be presented by the site health and safety officer. Personnel-protective and air-monitoring equipment specified in the Site Health and Safety Plan should be demonstrated, present and in good working order on site at all times.
- Tool box - All needed tools for all site equipment used.
- A 55-gallon drum or container to contain the purged water.

Construction materials of the sampling equipment (bladders, pump, bailers, tubing, etc.) should be limited to stainless steel, Teflon®, glass, and other inert materials when concentrations of the site contaminants are expected within the detection limit range. The sample tubing thickness and diameter should be maximized and the tubing length should be minimized so that the loss of contaminants absorbed to and through the tubing walls may be reduced and the rate of stabilization of ground-water parameters is maximized. The tendency of organics to sorb into and out of many materials makes the appropriate selection of sample tubing materials critical for these trace analyses (Pohlmann and Alduino, 1992; Parker and Ranney, 1998).

Generally, wells should be purged and sampled using the same positive-displacement pump and/or a low-flow submersible pump with variable controlled flow rates and constructed of chemically inert materials. If a pump cannot be used because the recovery rate of the well is so low (less than 100 to 200 ml/min) and the volume of the water to be removed is minimal (less than 5 feet of water in a small-diameter well), then a Teflon® bailer, with a double check valve and bottom-emptying device with a control-flow check

valve may be used to obtain the samples. Otherwise, a bailer should not be used when sampling for volatile organics because of the potential bias introduced during sampling (Yeskis et al., 1988; Pohlmann et al., 1990; Tai et al., 1991). Bailers also should be avoided when sampling for metals because repeated bailer deployment has the potential to increase turbidity, which biases concentrations of inorganic constituents. Dedicated sampling pumps are recommended for metals sampling (Puls et al., 1992).

In addition, for wells with long riser pipes above the well screen, the purge volumes may be reduced by using packers above the pumps. The packer materials should be compatible with the parameters to be analyzed. These packers should be used only on wells screened in highly permeable materials, because of the lack of ability to monitor water levels in the packed interval. Otherwise, if pumping rates exceed the natural aquifer recovery rates into the packed zone, a vacuum or negative pressure zone may develop. This may result in a failure of the seal by the packer and/or a gaseous phase may develop, that may bias any sample taken.

PURGING AND SAMPLING PROCEDURE

WATER-LEVEL MEASUREMENTS

The field measurements should include total well depth and depth to water from a permanently marked reference point.

TOTAL WELL DEPTH

The depth of each well should be measured to the nearest one-tenth of a foot when using a steel tape with a weight attached and should be properly recorded. The steel tape should be decontaminated before use in another well according to the site specific protocols. A concern is that when the steel tape and weight hit the bottom of the well, sediment present on the bottom of a well is stirred up, thus increasing turbidity, which will affect the sampling results. In these cases, as much time as possible should be allowed prior to sampling, such as a minimum of 24 hours. If possible, total well depth measurements can be completed after sampling (Puls and Barcelona, 1996). The weight of electric tapes is generally too light to determine accurate total well depth. If the total well depth is greater than 200 feet, stretching of the tape must be taken into consideration.

DEPTH TO WATER

All water levels should be measured from the reference point by use of a weighted steel tape and chalk or an electronic water-level indicator (a detailed discussion of the pros and cons of the different water level devices is provided in Thornhill, 1989). The steel tape is a more accurate method to take water levels, and is recommended where shallow flow gradients (less than 0.05 feet/feet) or deep wells are encountered. However, in those cases where large flow gradients or large fluctuations in water levels are expected, a calibrated electric tape is acceptable. The water level is calculated using the well's surveyed reference point minus the measured depth-to-water and should be measured to the nearest one hundredth of a foot.

The depth-to-water measurement must be made in each well to be sampled prior to any other activities at the well (such as bailing, pumping, and hydraulic testing) to avoid bias to the measurement. All readings are to be recorded to the nearest one hundredth of a foot. When possible, depth-to-water and total well depth measurements should be completed at the beginning of a ground-water sampling program, which will allow any turbidity to settle and allow a more synoptic water-level evaluation. However, if outside influences (such as tidal cycles, nearby pumping effects, or major barometric changes) may result in significant water-level changes in the time between measurement and sampling, a water-level measurement should be completed immediately prior to sampling. In addition, the depth-to-water measurement during purging should be recorded, with the use of a pressure transducer and data logger sometimes more efficient (Barcelona et al., 1985, Wilde et al., 1998).

The time and date of the measurement, point of reference, measurement method, depth-to-water measurement, and any calculations should be properly recorded in field notebook or sampling sheet.

STATIC WATER VOLUME

From the information obtained for casing diameter, total well depth and depth-to-water measurements, the volume of water in the well is calculated. This value is one criteria that may be used to determine the volume of water to be purged from the well before the sample is collected.

The static water volume may be calculated using the following formula:

$$V = r^2h(0.163)$$

Where:

V	=	static volume of water in well (in gallons)
r	=	inner radius of well casing (in inches)
h	=	length of water column (in feet) which is equal to the total well depth minus depth to water.
0.163	=	a constant conversion factor that compensates for the conversion of the casing radius from inches to feet for 2-inch diameter wells and the conversion of cubic feet to gallons, and pi (π). This factor would change for different diameter wells.

Static water volumes also may be obtained from various sources, such as Appendix 11.L in Driscoll (1986).

WELL PURGING

PURGE VOLUMES

In most cases, the standing water in the well casing can be of a different chemical composition than that contained in the aquifer to be sampled. Solutes may be adsorbed or desorbed from the casing material, oxidation may occur, and biological activity is possible. Therefore, the stagnant water within the well must be purged so that water that is representative of the aquifer may enter the well.

The removal of at least three well volumes is suggested (USEPA, 1986; Wilde et al., 1998). The amount of water removed may be determined by collecting it in a graduated pail of known volume to determine pumping rate and time of pumping. A flow meter may also be used, as well as capturing all purged water in a container of known volume.

The actual number of well volumes to be removed is based on the stabilization of water-quality-indicator parameters of pH, ORP, SEC, DO, and turbidity. The water initially pumped is commonly turbid. In order to keep the turbidity and other probes from being clogged with the sediment from the turbid water, the flow-through cell should be bypassed initially for the first well volume. These measurements should be taken and recorded every ½ well volume after the removal of 1 to 1 ½ well volume(s). Once three successive readings of the water-quality-indicator parameters provided in the table have stabilized, sampling may begin. The water-quality-indicator parameters that are recommended include pH and temperature, but these are generally insensitive to indicate completion of purging since they tend to stabilize rapidly (Puls and Barcelona, 1996). ORP may not always be an appropriate stabilization parameter, and will depend on site-specific conditions. However, readings should be recorded because of its value as a double check for oxidizing conditions, and for some fate and transport issues. When possible, especially when sampling for contaminants that may be biased by the presence of turbidity, the turbidity reading is desired to stabilize at a value below 10 Nephelometric Turbidity Units (NTUs). For final DO measurements, if the readings are less than 1 milligram per liter, they should be collected with the spectrophotometric method (Wilde et al., 1998, Wilkin et al., 2001), colorimetric or Winkler titration (Wilkin et al., 2001). All of these water-quality-indicator parameters should be evaluated against the specifications of the accuracy and resolution of the instruments used. No more than six well volumes should be purged, to minimize the over pumping effects described by Gibs and Imbrigiotta (1990).

Purging Methods

In a well that is not being pumped, there will be little or no vertical mixing in the water column between sampling events, and stratification may occur. The water in the screened section may mix with the ground water due to normal flow patterns, but the water above the screened section will remain isolated and become stagnant. Persons sampling should realize that stagnant water may contain foreign material inadvertently or deliberately introduced from the surface, resulting in unrepresentative water quality. To safeguard against collecting nonrepresentative stagnant water in a sample, the following guidelines and techniques should be adhered to during sample collection:

Table of Stabilization Criteria with References for Water-Quality-Indicator Parameters

Parameter	Stabilization Criteria	Reference
pH	+/- 0.1	Puls and Barcelona, 1996; Wilde et al., 1998
specific electrical conductance (SEC)	+/- 3%	Puls and Barcelona, 1996
oxidation-reduction potential (ORP)	+/- 10 millivolts	Puls and Barcelona, 1996
turbidity	+/- 10% (when turbidity is greater than 10 NTUs)	Puls and Barcelona, 1996; Wilde et al., 1998
dissolved oxygen (DO)	+/- 0.3 milligrams per liter	Wilde et al., 1998

1. As a general rule, monitoring wells should be pumped or bailed (although bailing is to be strongly avoided) prior to collecting a sample. Evacuation of a minimum of three volumes of water in the well casing is recommended for a representative sample. In a high-yielding ground-water formation where there is no stagnant water in the well above the screened section (commonly referred to as a water-table well), evacuation prior to sample withdrawal is not as critical but serves to field rinse and condition sampling equipment. The purge criteria has been described previously and will be again in the SAMPLING PROCEDURES section on the following page. The rate of purging should be at a rate and by a method that does not cause aeration of the water column and should not exceed the rate at which well development was completed.

2. For wells that can be pumped or bailed to dryness with the sampling equipment being used, the well should be evacuated to just above the well screen interval and allowed to recover prior to sample withdrawal. (Note: It is important not to completely dewater the zone being sampled, as this may allow air into that zone which could result in negative bias in organic and metal constituents.) If the recovery rate is fairly rapid and time allows, evacuation of more than one volume of water is preferred.

3. A non-representative sample also can result from excessive prepumping of the monitoring well. Stratification of the contaminant concentrations in the ground-water formation may occur or heavier-than-water compounds may sink to the lower portions of the aquifer. Excessive pumping can decrease or increase the contaminant concentrations from what is representative of the sampling point of interest, as well as increase turbidity and create large quantities of waste water.

The method used to purge a well depends on the inner diameter, depth-to-water level, volume of water in the well, recovery rate of the aquifer, and accessibility of the well to be sampled. The types of equipment available for well evacuation include hand-operated or motor-driven suction pumps, peristaltic pumps, submersible pumps, and bailers made of various materials, such as stainless steel and Teflon®. Whenever possible, the same device used for purging the well should be left in the well and used for sampling, generally in a continual manner from purging directly to sampling without altering position of the sampling device or turning off the device.

When purging/sampling equipment must be reused in other wells, it should be decontaminated consistent with the decontamination procedures outlined in this document. Purged water should be collected and screened with air-monitoring equipment as outlined in the site health and safety plan, as well as water-quality field instruments. If these parameters and/or the facility background data suggest that the water is hazardous, it should be contained and disposed of properly as determined on a site-specific basis.

During purging, water-level measurements should be recorded regularly for shallow wells, typically at 15- to 30-second intervals. These data may be useful in

computing aquifer transmissivity and other hydraulic characteristics, and for adjusting purging rates. In addition, these data will assure that the water level doesn't fall below the pump intake level

SAMPLING PROCEDURES

Ground-water sample collection should take place immediately following well purging. Preferably, the same device should be used for sample collection as was used for well purging, minimize further disturbance of the water column, and reduce volatilization and turbidity. In addition, this will save time and avoid possible contamination from the introduction of additional equipment into the well, as well as using equipment materials already equilibrated to the ground water. Sampling should occur in a progression from the least to most contaminated well, if known, when the same sampling device is used.

The sampling procedure is as follows:

1) Remove locking well cap. Note location, time of day, and date in field notebook or on an appropriate log form.
2) Note wind direction. Stand upwind from the well to avoid contact with gases/vapors emanating from the well.
3) Remove well casing cap.
4) If required by site-specific conditions, monitor headspace of well with appropriate air-monitoring equipment to determine presence of volatile organic compounds or other compounds of concern and record in field logbook.
5) If not already completed, measure the water level from the reference measuring point on the well casing or protective outer casing (if inner casing not installed or inaccessible) and record it in the field notebook. Alternatively, if no reference point exists, note that the water level measurement is from the top of the outer protective casing, top of inside riser pipe, ground surface, or some other position on the well head. Have a permanent reference point established as soon as possible after sampling. Measure at least twice to confirm measurement; the measurement should agree within 0.01 feet or re-measure. Decontaminate the water-level-measuring device.
6) If not already completed, measure the total depth of the well (at least twice to confirm measurement; the measurement should agree within 0.01 feet or re-measure) and record it in the field notebook or on log form. Decontaminate the device used to measure total depth. If the total well depth has been measured recently (in the past year), then measure it at the conclusion of sampling.
7) Calculate the volume of water in the well and the volume to be purged using the formula previously provided.
8) Lay plastic sheeting around the well to minimize the likelihood of contamination of equipment from soil adjacent to the well.
9) Rinse the outside of sampling pump with distilled water and then, while lowering the pump, dry it with disposable paper towels.
10) Lower the pump (or bailer) and tubing down the well. The sampling equipment should never be dropped into the well because this will cause degassing of the water upon impact. This may also increase turbidity, which may bias the metals analysis. The lowering of the equipment should be slow and smooth!
11) The pump should be lowered to a point just below the water level. If the water level is above the screened interval, the pump should be above the screened interval for the reasons provided in the purging section.
12) Turn the pump on. The submersible pumps should be operated in a continuous, low-flow manner so that they do not produce pulsating flows, which cause aeration in the discharge tubing, aeration upon discharge, or resuspension of sediments at the bottom of the well. The sampling pump flow rates should be lower than or the same as the purging rates. The purging and sampling rates should not be any greater than well development rates.
13) Water levels should be monitored during pumping to ensure that air does not enter the pump and to help determine an appropriate purging rate.
14) After approximately one to two well volumes are removed, a flow-through cell will be hooked up to the discharge tubing of the pump. If the

well discharge water is not expected to be highly turbid, contain separate liquid phases, or minimal bacterial activitiy that may coat or clog the electrodes within the flow-through cell, then the cell can be immediately hooked up to the discharge tubing. This cell will allow measurements of water-quality-indicator parameters without allowing contact with the atmosphere prior to recording the readings for temperature, pH, ORP, SEC, DO and turbidity.

15) Measurements for temperature, pH, ORP, SEC, DO, and turbidity will be made at each one-half well volume removed. Purging may cease when measurements for all five parameters have stabilized (provided in the earlier table) for three consecutive readings.

16) If the water level is lowered to the pump level before three volumes have been removed, the water level will be allowed to recover for 15 minutes, and then pumping can begin at a lower flow rate. If the pump again lowers the water level to below the pump intake, the pump will be turned off and the water level allowed to recover for a longer period of time. This will continue until a minimum of two well volumes are removed prior to taking the ground-water sample.

17) If the water-quality-indicator parameters have stabilized, sample the well. Samples will be collected by lowering the flow rate to a rate that minimizes aeration of the sample while filling the bottles (approximately 300 ml/min). Then a final set of water-quality-indicator parameters is recorded. The pump discharge line is rapidly disconnected from the flow-through cell to allow filling of bottles from the pump discharge line. The bottles should be filled in the order of volatile organic compounds bottles first, followed by semi-volatile organic compound's/pesticides, inorganics, and other unfiltered samples. Once the last set of samples is taken, if filtering is necessary, an in-line disposable filter (with appropriately chosen filter size) will be added to the discharge hose of the pump. Then the filtered samples will be taken. If a bailer is used for obtaining the samples, filtering occurs at the sampling location immediately after the sample is obtained from the bailer by using a suction filter. The first one-half to one liter of sample taken through the filter will not be collected, in order to assure the filter media is acclimated to the sample. If filtered samples are collected, WITHOUT EXCEPTION, filtering should be performed in the field as soon as possible after collection, and not later in a laboratory.

18) All appropriate samples that are to be cooled, are put into a cooler with ice immediately. All of the samples should not be exposed to sunlight after collection. Keep the samples from freezing in the winter when outside temperatures are below freezing. The samples, especially organics, cyanide, nutrients, and other analytes with short holding times, are recommended to be shipped or delivered to the laboratory daily. Ensure that the appropriate samples that are to be cooled remain at 4°C, but do not allow any of the samples to freeze.

19) If a pump cannot be used because the recovery rate is slow and the volume of the water to be removed is minimal (less than 5 feet of water), then a Teflon® bailer, with a double check valve and bottom-emptying device with a control-flow check valve will be used to obtain the samples. The polypropylene rope used with the bailer will be disposed of following the completion of sampling at each well.

20) The pump is removed from the well and decontaminated for the next sampling location.

Additional precautions to ensure accurate and representative sample collection are as follows:

- Check valves on bailers, if bailers are used, should be designed and inspected to ensure that fouling problems do not reduce delivery capabilities or result in aeration of the sample.
- The water should be transferred to a sample container in a way that will minimize agitation and aeration.
- If the sample bottle contains no preservatives, the bottle should be rinsed with sample water, which is discarded before sampling. Bottles for sample analyses that require preservation should be prepared before they are taken to the well. Care should be taken to avoid overfilling bottles so that the preservative is not lost. The pH should be checked and more preservatives added to inor-

ganic sample bottles, if needed. VOA bottles that do not meet the ph requirements need to be discarded and new sample bottles with more preservative added should be prepared immediately.

- Clean sampling equipment should not be placed directly on the ground or other contaminated surfaces either prior to sampling or during storage and transport.

Special Consideration for Volatile Organic Compound Sampling

The proper collection of a sample for dissolved volatile organics requires minimal disturbance of the sample to limit volatilization and therefore a loss of volatiles from the samples. Preferred retrieval systems for the collection of un-biased volatile organic samples include positive displacement pumps, low-flow centrifugal pumps, and some in-situ sampling devices. Field conditions and other constraints will limit the choice of appropriate systems. The principal objective is to provide a valid sample for analysis, one that has been subjected to the least amount of turbulence possible.

1) Fill each vial to just overflowing. Do not rinse the vial, nor excessively overflow it, as this will effect the pH by diluting the acid preservative previously placed in the bottle. Another option is to add the acid at the well, after the sample has been collected. There should be a convex meniscus on the top of the vial.
2) Do not over tighten and break the cap.
3) Invert the vial and tap gently. Observe the vial closely. If an air bubble appears, discard the sample and collect another. It is imperative that no entrapped air remains in the sample vial. Bottles with bubbles should be discarded, unless a new sample cannot be collected, and then the presence of the bubble should be noted in the field notes or field data sheet. If an open sample bottle is dropped, the bottle should be discarded.
4) Orient the VOC vial in the cooler so that it is lying on its side, not straight up.
5) The holding time for VOCs is 14 days. It is recommended that samples be shipped or delivered to the laboratory daily. Ensure that the samples remain at 4°C, but do not allow the samples to freeze.

Field Filtration of Turbid Samples

The USEPA recognizes that in some hydrogeologic environments, even with proper well design, installation, and development, in combination with the low-flow rate purging and sampling techniques, sample turbidity cannot be reduced to ambient levels. The well construction, development, and sampling information should be reviewed by the Regional geologists or hydrologists to see if the source of the turbidity problems can be resolved or if alternative sampling methods should be employed. If the water sample is excessively turbid, the collection of both filtered and unfiltered samples, in combination with turbidity, Total Suspended Solids (TSS), Total Dissolved Solids (TDS), pumping rate, and drawdown data is recommended. The filter size used to determine TSS and TDS should be the same as used in the field filtration. An in-line filter should be used to minimize contact with air to avoid precipitation of metals. The typical filter media size used is 0.45 µm because this is commonly accepted as the demarcation between dissolved and non-dissolved species. Other filter sizes may be appropriate, but their use should be determined based on site-specific criteria (examples include grain-size distribution, ground-water flow velocities, mineralogy) and project DQOs. Filter sizes up to 10.0 µm may be warranted because larger size filters may allow particulates that are mobile in ground water to pass through (Puls and Powell, 1992). The changing of filter media size may limit the comparability of the data obtained with other data sets and may affect their use in some geochemical models. Filter media size used on previous data sets from a site, region, or aquifer and the DQOs should be taken into consideration. The filter media used during the ground-water sampling program should be collected in a suitable container and archived because potential analysis of the media may be helpful for the determination of particulate size, mineralogy, etc.

The first 500 to 1000 milliliters of sample taken through the filter, depending on sample turbidity, will not be collected for a sample, in order to ensure that the filter media has equilibrated to the sample. Manufacturers' recommendations also should be consulted. Because bailers have been shown to increase

turbidity while purging and sampling, they should be avoided when sampling for trace element, metal, PCB, and pesticide constituents. If portable sampling pumps are used, the pumps should be gently lowered to the sampling depth desired, carefully avoiding being lowered to the bottom of the well. The pumps, once placed in the well, should not be moved to allow any particles mobilized by pump placement to settle. Dedicated sampling equipment installed in the well prior to the commencement of the sampling activities is one of the recommended methods to reduce turbidity artifacts (Puls and Powell, 1992; Kearl et al., 1992; Puls et al., 1992; Puls and Barcelona, 1996).

DECONTAMINATION PROCEDURES

Once removed from the well, the purging and sampling pumps should be decontaminated by scrubbing with a brush and a non-phosphate soapy-water wash, rinsed with water, and rinsed with distilled water to help ensure that there is no cross-contamination between wells. The step-by-step procedure is:

1) Pull pump out of previously sampled well (or out of vehicle) and use three pressure sprayers filled with soapy water, tap water, and distilled water. Spray outside of tubing and pump until water is flowing off of tubing after each rinse. Use bristle brush to help remove visible dirt, contaminants, etc.
2) Have three long PVC tubes with caps or buckets filled with soapy water, tap water and distilled water. Run pump in each until approximately 2 to 3 gallons of each decon solution is pumped through tubing. Pump at low rate to increase contact time between the decon solutions and the tubing.
3) Try to pump decon solutions out of tubing prior to next well. If this cannot be done, compressed air may be used to purge lines. Another option is to install a check valve in the pump line (usually just above the pump head) so that the decon solutions do not run back down the well as the pump is lowered down the next well.
4) Prior to lowering the pump down the next well, spray the outside of the pump and tubing with distilled water. Use disposable paper towels to dry the pump and tubing.
5) If a hydrophobic contaminant is present (such as separate phase, high levels of PCBs, etc.), an additional decon step, or steps, may be added. For example, an organic solvent such as reagent-grade isopropanol alcohol may be added as a first rinse prior to the soapy water rinse.

If the well has been sampled with a bailer that is not disposable, the bailer should be cleaned by washing with soapy water, rinsing with tap water, and finally rinsing with distilled water. Bailers are most easily cleaned using a long-handled bottle brush.

It is especially important to clean thoroughly the portion of the equipment that will be in contact with sample water. In addition, a clean plastic sheet should be placed adjacent to or around the well to prevent surface soils from coming in contact with the purging equipment. The effects of cross-contamination also can be minimized by sampling the least contaminated well first and progressing to the more contaminated ones. The bailer cable/rope (if a bailer is used) and plastic sheet should be properly discarded, as provided in the site health and safety plan, and new materials provided for the next well.

FIELD QUALITY CONTROL

The quality assurance (QA) targets for precision and accuracy of sampling programs are based on accuracy and precision guidelines established by the USEPA. When setting targets, keep in mind that all measurements must be made so that the results are representative of the sample water and site-specific conditions. Various types of blanks are used to check the cleanliness of the field-handling methods. These are known as field blanks, and include field equipment blanks and transport blanks. Other QA samples include spike samples and duplicates.

There are five primary areas of concern for QA in the collection of representative ground-water samples:

1. Obtaining a sample that is representative of water in the aquifer or targeted zone of the aquifer. Verify log documentation that the well was purged of the required volume or that the temperature, pH, ORP, SEC, DO and turbidity stabilized before samples were extracted.

2. Ensuring that the purging and sampling devices are made of materials and utilized in a manner that will not interact with or alter the analyses.
3. Generating results that are reproducible. Therefore, the sampling scheme should incorporate co-located samples (duplicates).
4. Preventing cross-contamination. Sampling should proceed from least to most contaminated wells, if known. Field equipment blanks should be incorporated for all sampling and purging equipment; decontamination of the equipment is therefore required.
5. Ensuring that samples are properly preserved, packaged, and shipped.

FIELD EQUIPMENT BLANKS

To ensure QA and quality control, a field equipment blank must be included in each sampling run, or for every twenty samples taken with the sampling device. Equiptment blanks allow for a cross check and, in some cases, quantitative correction for imprecision that could arise due to handling, preservation, or improper cleaning procedures.

Equipment blanks should be taken for each sample bottle type that is filled. Distilled water is run through the sampling equipment and placed in a sample bottle (the blank), and the contents are analyzed in the lab like any other sample. Following the collection of each set of twenty samples, a field equipment blank will be obtained. It is generally desirable to collect this field equipment blank after sampling a relatively highly contaminated well. These blanks may be obtained through the following procedure:

a) Following the sampling event, decontaminate all sampling equipment according to the site decontamination procedures and before collecting the blank.
b) VOA field blanks should be collected first, prior to water collected for other TAL/TCL analyses. A field blank must be taken for all analyses.
c) Be sure that there is enough distilled water in the pump so that the field equipment blank can be collected for each analysis.
d) The water used for the field equipment blank should be from a reliable source, documented in the field notebooks, and analyzed as a separate water-quality sample.

TRIP BLANKS

A trip blank should be included in each sample shipment and, at a minimum, one per 20 samples. Bottles, identical to those used in the field, are filled with reagent-grade water. The source of the reagent-grade water should be documented in the field notebooks, including lot number and manufacture. This sample is labeled and stored as though it is a sample. The sample is shipped back to the laboratory with the other samples and analysis is carried out for all the same constituents.

DUPLICATE SAMPLES

Duplicate samples are collected by taking separate samples as close to each other in time and space as practical, and should be taken for every 20 samples collected. Duplicate samples are used to develop criteria for acceptable variations in the physical and chemical composition of samples that could result from the sampling procedure. Duplicate results are utilized by the QA officer and the project manager to give an indication of the precision of the sampling and analytical methods.

HEALTH AND SAFETY CONSIDERATIONS

Depending on the site-specific contaminants, various protective programs must be implemented prior to sampling the first well. The site health and safety plan should be reviewed with specific emphasis placed on the protection program planned for the sampling tasks. Standard safe operating practices should be followed, such as minimizing contact with potential contaminants in both the liquid and vapor phases through the use of appropriate personal protective equipment.

Depending on the type of contaminant expected or determined in previous sampling efforts, the following safe work practices will be employed:

Particulate or metals contaminants

1. Avoid skin contact with, and accidental ingestion of, purge water.
2. Wear protective gloves and splash protection.

Volatile organic contaminants

1. Avoid breathing constituents venting from well.
2. Pre-survey the well head space with an appropriate device as specified in the Site Health and Safety Plan.
3. If air monitoring results indicate elevated organic constituents, sampling activities may be conducted in Level C protection. At a minimum, skin protection will be afforded by disposable protective clothing, such as Tyvek®.

General practices should include avoiding skin contact with water from preserved sample bottles, as this water will have pH less than 2 or greater than 10. Also, when filling, pre-preserved VOA bottles, hydrochloric acid fumes may be released and should not be inhaled.

POST-SAMPLING ACTIVITIES

Several activities need to be completed and documented once ground-water sampling has been completed. These activities include, but are not limited to:

- Ensuring that all field equipment has been decontaminated and returned to proper storage location. Once the individual field equipment has been decontaminated, tag it with date of cleaning, site name, and name of individual responsible.
- Processing all sample paperwork, including copies provided to Central Regional Laboratory, Sample Management Office, or other appropriate sample handling and tracking facility.
- Compiling all field data for site records.
- Verifying all analytical data processed by the analytical laboratory against field sheets to ensure all data has been returned to sampler.

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GROUND-WATER SAMPLING RECORD

Well ID:_____

Station #:_____

Facility Name: Date:____/____/____

Well Depth:_____ Depth to Water:_____ Well Diameter:_____

Casing Material.:_____ Volume Of Water per Well Volume:_____

Sampling Crew:_____,_____,_____,_____

Type of Pump:_____ _____ Tubing Material:_____ Pump set at _____ ft.

Weather Conditions:_____ NOTES:_____ _____

_____

GROUND-WATER SAMPLING PARAMETERS

Time	Water Level	Volume Pumped	Pumping Rate	DO (mg/l)	Temp. (^{0}C)	SEC (µS/cm)	pH	ORP (mV)	Turbidity (NTU)

Other Parameters: _____

Sampled at:_____ Parameters taken with :_____

Sample delivered to _____ by _____ at_____.

Sample CRL #:_____ OTR #:_____ ITR #:_____ SAS #:_____

Parameters Collected	Number of Bottles	Bottle Lot Number

Appendix C – SOP for Inventory and Management of Field Equipment and Chemical Standards and Reagents

U.S. EPA REGION 10 Office of Environmental Assessment
Field Standard Operating Procedure

Title: Inventory and Management of Field Equipment and Chemical Standards and Reagents

Effective Date: November 1, 2010

Document Number: OEAFIELDSOP-001

Review and Approvals

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1 General Information

1.1 Purpose/Background

Field activities often require the use of equipment and supplies such as chemical standards and reagents which are stored at the field equipment storage warehouse at the EPA Region 10 Laboratory.

1.2 Scope and Application

This procedure is intended for use by the Office of Environmental Assessment, Environmental Services Unit (OEA/ESU) equipment managers and EPA Region 10 personnel engaged in field activities for which the equipment and supplies can be used. It describes procedures for managing field equipment and supplies including how they are tracked and maintained, the check-in and check-out procedures, and the training requirements for staff using the equipment and supplies.

2 Equipment Inventory and Management

2. 1 Equipment Tracking

The equipment inventory will be tracked using an electronic database maintained at the EPA Region 10 Laboratory by OEA/ESU personnel. Each piece of equipment will be assigned a unique barcode which will be recorded in the database. The data base will also include information such as the make and model of the equipment; the version of the software used, if applicable; the location of the equipment; maintenance records; service interval; SOP's, instruction manual's, and qualified users authorized to check out the equipment. Electronic information such as SOP's or instruction manuals will be linked to the database and/or and explanation of the location that the paper copies are keep, (e.g. field services file cabinet).

2. 2 Chemical Standards and Reagents

Chemical standards and reagents will be tracked using an electronic database maintained by OEA/ESU personnel. A printed copy of the standards and reagents inventory will be kept in the Material Safety Data Sheet (MSDS) binder located in the field equipment storage warehouse. Information in the standards and reagents database will include the following: chemical name, manufacturer/distributor, CAS#, MSDS number, lot number, amount w/units, expiration date, and location. The MSDS binder will also contain copies of the certifications for the chemical standards and reagents. If the chemical standard or reagent is older than the expiration date printed on the product label or if product is 3 years past the manufacture date, it should be disposed of in accordance with the MSDS and relevant EPA Region 10 Laboratory waste disposal procedures.

2. 3 In and Out of Service

All equipment will be considered "in service" unless tagged out by a yellow "out of service" tag. The out of service tag will describe the condition of the equipment and steps necessary for the equipment to be placed into service. Long term storage of electronic equipment shall have an out of service tag placed on the equipment. The out of service tags can be placed on the equipment by anyone with notification given to the equipment managers as to the problem or status. A logbook entry for the equipment shall be made detailing the why the equipment has been placed in out of service status. Once placed back into service, the out of service tag shall be stapled or taped into the equipments log book with an entry of the back in service date and a description of what was done (e.g. sensor replacement) to correct the problem with the equipment. In service equipment shall have a performance check, which may include calibration, prior to becoming available for redeployment to the field.

2. 4 Logbook Entry Information

Logbook entries should be made in accordance with SOP OEAFIELDSOP-012. Generally, equipment log books track who uses the equipment, the site where it was used, results of calibration, and any potential problems that are evident during equipment use.

2.5 Maintenance and Calibration

All equipment should be maintained and calibrated in accordance with guidelines found in either EPA Region 10 SOPs or in field equipment instruction manuals. Maintenance and calibration shall be performed by properly trained field personnel and/or a manufacturer's authorized repair facility. Documentation including certificates of calibration and/or repair reports should be obtained from the repair facilities each time the equipment is serviced. All paper records shall be maintained in the field equipment storage warehouse filing cabinets and the factory calibration date should be logged into the inventory database. Calibration stickers shall be applied to equipment showing the date of last manufacturers calibration and due date of the next calibration.

The EPA Region 10 Laboratory maintains liquid-in-glass thermometers that are traceable to the National Institute of Standards and Technology (NIST) and the American Society for Testing and Materials (ASTM). Field instruments with temperature measuring capability will be checked yearly to verify the thermometer is within operational specifications of the instrument (Region 10 Laboratory, Inorganic Chemistry Support Equipment Monitoring SOP, Document # In_G940A).

2.6 Equipment Check In/Out

Requests for equipment can be sent to equipment managers via telephone, fax, or email. A field equipment checkout sheet (Attachment A) shall be completed for equipment and supplies required for projects. The checkout sheet should contain the ESU Barcode, date, equipment name, condition, and signature of the person assuming responsibility of the equipment. This information will be entered into the equipment inventory database by

equipment managers to show the equipment as checked out. Checkout forms can be obtained in person, email, fax or via the Region 10 intranet site in the Office of Compliance and Enforcement, Tools to prepare, conduct, and follow up on inspection page and then the Regional Field Equipment Link.

Equipment managers will check in and verify equipment is serviceable and cleaned prior to storage. The field equipment checkout form should be reviewed to determine that all equipment was returned. The equipment inventory database will then be updated to show the equipment was returned and will describe its operational status.

2.7 Training

All field personnel checking out equipment and supplies from the field equipment storage warehouse must demonstrate their proficiency for use of equipment. Training can be arranged by contacting one of the equipment managers prior to checking equipment out. Training can be conducted by any qualified field personnel deemed competent by the equipment managers. Training will consist of a combination of review of equipment manuals, SOP's, and other equipment specific documentation plus hands-on demonstration of procedures. Completion of training will be tracked in the equipment inventory database.

2.8 Sampling Bottles

Sampling bottle requests should be made via Attachment A and in accordance with Region 10 Laboratory Technical Standard Operating Procedure titled "Preparation of Sample Containers for the Field" document number QMS.005. Sample bottles are specific to the sample being taken. Field samplers should specify the exact bottle on Attachment A. Samplers should specify: Size, poly or glass, wide or narrow mouth, amber or clear and quantity. Additionally, the Quality Assurance Plan should contain this information and can be submitted with Attachment A. Coordination with the laboratory, chemist conducting the analysis or the OEA Quality Assurance Team will greatly aid the sampler in selection of the correct bottle and preservative.

3 Change History

No changes under current version.

Attachment A

Field Support Center
Short Term Equipment Loan Form

This form is to be completed by Region 10 employees requesting equipment to support official EPA work for a period not exceeding 30 days. Please allow at least 2 weeks between request and delivery of equipment.

The requestor agrees to the following:

1. Use the equipment solely for official work relative to the site identified in the application below.
2. Refrain from transferring any rights for the equipment to a third party.
3. Maintain the equipment in good operating condition and return in to the field support center upon termination of the loan period or when the equipment is no longer needed, whichever is sooner.
4. Decontaminate the equipment prior to its return to the field support center.
5. Be responsible for transportation or shipment of the equipment.
6. The U.S. EPA reserves the right to terminate this loan agreement at any time requiring the immediate return of any or all loaned equipment.

Signature of Requestor:_____ Date:_____

Office:_____ Phone:_____

Field Site Location:_____

Project Supported:_____

Account Number (if Superfund):_____

Equipment Requested:

Item Description	**Decal Number**	**Date taken**	**Date Returned**	**Condition upon return**	
				S	**U**

Comments:

Appendix D – SOP for Sampling Equipment Decontamination

SAMPLING EQUIPMENT DECONTAMINATION

SOP#: 2006
DATE: 08/11/94
REV. #: 0.0

1.0 SCOPE AND APPLICATION

The purpose of this Standard Operating Procedure (SOP) is to provide a description of the methods used for preventing, minimizing, or limiting cross-contamination of samples due to inappropriate or inadequate equipment decontamination and to provide general guidelines for developing decontamination procedures for sampling equipment to be used during hazardous waste operations as per 29 Code of Federal Regulations (CFR) 1910.120. This SOP does not address personnel decontamination.

These are standard (i.e. typically applicable) operating procedures which may be varied or changed as required, dependent upon site conditions, equipment limitation, or limitations imposed by the procedure. In all instances, the ultimate procedures employed should be documented and associated with the final report.

Mention of trade names or commercial products does not constitute U.S. Environmental Protection Agency (U.S. EPA) endorsement or recommendation for use.

2.0 METHOD SUMMARY

Removing or neutralizing contaminants from equipment minimizes the likelihood of sample cross contamination, reduces or eliminates transfer of contaminants to clean areas, and prevents the mixing of incompatible substances.

Gross contamination can be removed by physical decontamination procedures. These abrasive and non-abrasive methods include the use of brushes, air and wet blasting, and high and low pressure water cleaning.

The first step, a soap and water wash, removes all visible particulate matter and residual oils and grease. This may be preceded by a steam or high pressure water wash to facilitate residuals removal. The second step involves a tap water rinse and a distilled/deionized water rinse to remove the detergent. An acid rinse provides a low pH media for trace metals removal and is included in the decontamination process if metal samples are to be collected. It is followed by another distilled/deionized water rinse. If sample analysis does not include metals, the acid rinse step can be omitted. Next, a high purity solvent rinse is performed for trace organics removal if organics are a concern at the site. Typical solvents used for removal of organic contaminants include acetone, hexane, or water. Acetone is typically chosen because it is an excellent solvent, miscible in water, and not a target analyte on the Priority Pollutant List. If acetone is known to be a contaminant of concern at a given site or if Target Compound List analysis (which includes acetone) is to be performed, another solvent may be substituted. The solvent must be allowed to evaporate completely and then a final distilled/deionized water rinse is performed. This rinse removes any residual traces of the solvent.

The decontamination procedure described above may be summarized as follows:

1. Physical removal
2. Non-phosphate detergent wash
3. Tap water rinse
4. Distilled/deionized water rinse
5. 10% nitric acid rinse
6. Distilled/deionized water rinse
7. Solvent rinse (pesticide grade)
8. Air dry
9. Distilled/deionized water rinse

If a particular contaminant fraction is not present at the site, the nine (9) step decontamination procedure specified above may be modified for site specificity. For example, the nitric acid rinse may be eliminated if metals are not of concern at a site. Similarly, the solvent rinse may be eliminated if organics are not of

concern at a site. Modifications to the standard procedure should be documented in the site specific work plan or subsequent report.

3.0 SAMPLE PRESERVATION, CONTAINERS, HANDLING, AND STORAGE

The amount of sample to be collected and the proper sample container type (i.e., glass, plastic), chemical preservation, and storage requirements are dependent on the matrix being sampled and the parameter(s) of interest.
More specifically, sample collection and analysis of decontamination waste may be required before beginning proper disposal of decontamination liquids and solids generated at a site. This should be determined prior to initiation of site activities.

4.0 INTERFERENCES AND POTENTIAL PROBLEMS

- The use of distilled/deionized water commonly available from commercial vendors may be acceptable for decontamination of sampling equipment provided that it has been verified by laboratory analysis to be analyte free (specifically for the contaminants of concern).

- The use of an untreated potable water supply is not an acceptable substitute for tap water. Tap water may be used from any municipal or industrial water treatment system.

- If acids or solvents are utilized in decontamination they raise health and safety, and waste disposal concerns.

- Damage can be incurred by acid and solvent washing of complex and sophisticated sampling equipment.

5.0 EQUIPMENT/APPARATUS

Decontamination equipment, materials, and supplies are generally selected based on availability. Other considerations include the ease of decontaminating or disposing of the equipment. Most equipment and supplies can be easily procured. For example, soft-bristle scrub brushes or long-handled bottle brushes can be used to remove contaminants. Large galvanized wash tubs, stock tanks, or buckets can hold wash and rinse solutions. Children's wading pools can also be used. Large plastic garbage cans or other similar containers lined with plastic bags can help segregate contaminated equipment. Contaminated liquid can be stored temporarily in metal or plastic cans or drums.

The following standard materials and equipment are recommended for decontamination activities:

5.1 Decontamination Solutions

- Non-phosphate detergent
- Selected solvents (acetone, hexane, nitric acid, etc.)
- Tap water
- Distilled or deionized water

5.2 Decontamination Tools/Supplies

- Long and short handled brushes
- Bottle brushes
- Drop cloth/plastic sheeting
- Paper towels
- Plastic or galvanized tubs or buckets
- Pressurized sprayers (H_2O)
- Solvent sprayers
- Aluminum foil

5.3 Health and Safety Equipment

Appropriate personal protective equipment (i.e., safety glasses or splash shield, appropriate gloves, aprons or coveralls, respirator, emergency eye wash)

5.4 Waste Disposal

- Trash bags
- Trash containers
- 55-gallon drums
- Metal/plastic buckets/containers for storage and disposal of decontamination solutions

6.0 REAGENTS

There are no reagents used in this procedure aside from the actual decontamination solutions. Table 1 (Appendix A) lists solvent rinses which may be required for elimination of particular chemicals. In

general, the following solvents are typically utilized for decontamination purposes:

- 10% nitric acid is typically used for inorganic compounds such as metals. An acid rinse may not be required if inorganics are not a contaminant of concern.
- Acetone (pesticide grade) [1]
- Hexane (pesticide grade) [1]
- Methanol [1]

[1] - Only if sample is to be analyzed for organics.

7.0 PROCEDURES

As part of the health and safety plan, a decontamination plan should be developed and reviewed. The decontamination line should be set up before any personnel or equipment enter the areas of potential exposure. The equipment decontamination plan should include:

- The number, location, and layout of decontamination stations.
- Decontamination equipment needed.
- Appropriate decontamination methods.
- Methods for disposal of contaminated clothing, equipment, and solutions.
- Procedures can be established to minimize the potential for contamination. This may include: (1) work practices that minimize contact with potential contaminants; (2) using remote sampling techniques; (3) covering monitoring and sampling equipment with plastic, aluminum foil, or other protective material; (4) watering down dusty areas; (5) avoiding laying down equipment in areas of obvious contamination; and (6) use of disposable sampling equipment.

7.1 Decontamination Methods

All samples and equipment leaving the contaminated area of a site must be decontaminated to remove any contamination that may have adhered to equipment. Various decontamination methods will remove contaminants by: (1) flushing or other physical action, or (2) chemical complexing to inactivate contaminants by neutralization, chemical reaction, disinfection, or sterilization.

Physical decontamination techniques can be grouped into two categories: abrasive methods and non-abrasive methods, as follows:

7.1.1 Abrasive Cleaning Methods

Abrasive cleaning methods work by rubbing and wearing away the top layer of the surface containing the contaminant. The mechanical abrasive cleaning methods are most commonly used at hazardous waste sites. The following abrasive methods are available:

<u>Mechanical</u>

Mechanical methods of decontamination include using metal or nylon brushes. The amount and type of contaminants removed will vary with the hardness of bristles, length of time brushed, degree of brush contact, degree of contamination, nature of the surface being cleaned, and degree of contaminant adherence to the surface.

<u>Air Blasting</u>

Air blasting equipment uses compressed air to force abrasive material through a nozzle at high velocities. The distance between nozzle and surface cleaned, air pressure, time of application, and angle at which the abrasive strikes the surface will dictate cleaning efficiency. Disadvantages of this method are the inability to control the amount of material removed and the large amount of waste generated.

<u>Wet Blasting</u>

Wet blast cleaning involves use of a suspended fine abrasive. The abrasive/water mixture is delivered by compressed air to the contaminated area. By using a very fine abrasive, the amount of materials removed can be carefully controlled.

7.1.2 Non-Abrasive Cleaning Methods

Non-abrasive cleaning methods work by forcing the contaminant off a surface with pressure. In general, the equipment surface is not removed using non-abrasive methods.

Low-Pressure Water

This method consists of a container which is filled with water. The user pumps air out of the container to create a vacuum. A slender nozzle and hose allow the user to spray in hard-to-reach places.

High-Pressure Water

This method consists of a high-pressure pump, an operator controlled directional nozzle, and a high-pressure hose. Operating pressure usually ranges from 340 to 680 atmospheres (atm) and flow rates usually range from 20 to 140 liters per minute.

Ultra-High-Pressure Water

This system produces a water jet that is pressured from 1,000 to 4,000 atmospheres. This ultra-high-pressure spray can remove tightly-adhered surface films. The water velocity ranges from 500 meters/second (m/s) (1,000 atm) to 900 m/s (4,000 atm). Additives can be used to enhance the cleaning action.

Rinsing

Contaminants are removed by rinsing through dilution, physical attraction, and solubilization.

Damp Cloth Removal

In some instances, due to sensitive, non-waterproof equipment or due to the unlikelihood of equipment being contaminated, it is not necessary to conduct an extensive decontamination procedure. For example, air sampling pumps hooked on a fence, placed on a drum, or wrapped in plastic bags are not likely to become heavily contaminated. A damp cloth should be used to wipe off contaminants which may have adhered to equipment through airborne contaminants or from surfaces upon which the equipment was set.

Disinfection/Sterilization

Disinfectants are a practical means of inactivating infectious agents. Unfortunately, standard sterilization methods are impractical for large equipment. This method of decontamination is typically performed off-site.

7.2 Field Sampling Equipment Decontamination Procedures

The decontamination line is setup so that the first station is used to clean the most contaminated item. It progresses to the last station where the least contaminated item is cleaned. The spread of contaminants is further reduced by separating each decontamination station by a minimum of three (3) feet. Ideally, the contamination should decrease as the equipment progresses from one station to another farther along in the line.

A site is typically divided up into the following boundaries: Hot Zone or Exclusion Zone (EZ), the Contamination Reduction Zone (CRZ), and the Support or Safe Zone (SZ). The decontamination line should be setup in the Contamination Reduction Corridor (CRC) which is in the CRZ. Figure 1 (Appendix B) shows a typical contaminant reduction zone layout. The CRC controls access into and out of the exclusion zone and confines decontamination activities to a limited area. The CRC boundaries should be conspicuously marked. The far end is the hotline, the boundary between the exclusion zone and the contamination reduction zone. The size of the decontamination corridor depends on the number of stations in the decontamination process, overall dimensions of the work zones, and amount of space available at the site. Whenever possible, it should be a straight line.

Anyone in the CRC should be wearing the level of protection designated for the decontamination crew. Another corridor may be required for the entry and exit of heavy equipment. Sampling and monitoring equipment and sampling supplies are all maintained outside of the CRC. Personnel don their equipment away from the CRC and enter the exclusion zone through a separate access control point at the hotline. One person (or more) dedicated to decontaminating equipment is recommended.

7.2.1 Decontamination Setup

Starting with the most contaminated station, the decontamination setup should be as follows:

Station 1: Segregate Equipment Drop

Place plastic sheeting on the ground (Figure 2, Appendix B). Size will depend on amount of

equipment to be decontaminated. Provide containers lined with plastic if equipment is to be segregated. Segregation may be required if sensitive equipment or mildly contaminated equipment is used at the same time as equipment which is likely to be heavily contaminated.

Station 2: Physical Removal With A High-Pressure Washer (Optional)

As indicated in 7.1.2, a high-pressure wash may be required for compounds which are difficult to remove by washing with brushes. The elevated temperature of the water from the high-pressure washers is excellent at removing greasy/oily compounds. High pressure washers require water and electricity.

A decontamination pad may be required for the high-pressure wash area. An example of a wash pad may consist of an approximately 1 1/2 foot-deep basin lined with plastic sheeting and sloped to a sump at one corner. A layer of sand can be placed over the plastic and the basin is filled with gravel or shell. The sump is also lined with visqueen and a barrel is placed in the hole to prevent collapse. A sump pump is used to remove the water from the sump for transfer into a drum.

Typically heavy machinery is decontaminated at the end of the day unless site sampling requires that the machinery be decontaminated frequently. A separate decontamination pad may be required for heavy equipment.

Station 3: Physical Removal With Brushes And A Wash Basin

Prior to setting up Station 3, place plastic sheeting on the ground to cover areas under Station 3 through Station 10.
Fill a wash basin, a large bucket, or child's swimming pool with non-phosphate detergent and tap water. Several bottle and bristle brushes to physically remove contamination should be dedicated to this station. Approximately 10 - 50 gallons of water may be required initially depending upon the amount of equipment to decontaminate and the amount of gross contamination.

Station 4: Water Basin

Fill a wash basin, a large bucket, or child's swimming pool with tap water. Several bottle and bristle brushes should be dedicated to this station. Approximately 10-50 gallons of water may be required initially depending upon the amount of equipment to decontaminate and the amount of gross contamination.

Station 5: Low-Pressure Sprayers

Fill a low-pressure sprayer with distilled/deionized water. Provide a 5-gallon bucket or basin to contain the water during the rinsing process. Approximately 10-20 gallons of water may be required initially depending upon the amount of equipment to decontaminate and the amount of gross contamination.

Station 6: Nitric Acid Sprayers

Fill a spray bottle with 10% nitric acid. An acid rinse may not be required if inorganics are not a contaminant of concern. The amount of acid will depend on the amount of equipment to be decontaminated. Provide a 5-gallon bucket or basin to collect acid during the rinsing process.

Station 7: Low-Pressure Sprayers

Fill a low-pressure sprayer with distilled/deionized water. Provide a 5-gallon bucket or basin to collect water during the rinsate process.

Station 8: Organic Solvent Sprayers

Fill a spray bottle with an organic solvent. After each solvent rinse, the equipment should be rinsed with distilled/deionized water and air dried. Amount of solvent will depend on the amount of equipment to decontaminate. Provide a 5-gallon bucket or basin to collect the solvent during the rinsing process.

Solvent rinses may not be required unless organics are a contaminant of concern, and may be eliminated from the station sequence.

Station 9: Low-Pressure Sprayers

Fill a low-pressure sprayer with distilled/deionized water. Provide a 5-gallon bucket or basin to collect water during the rinsate process.

Station 10: Clean Equipment Drop

Lay a clean piece of plastic sheeting over the bottom

plastic layer. This will allow easy removal of the plastic in the event that it becomes dirty. Provide aluminum foil, plastic, or other protective material to wrap clean equipment.

7.2.2 Decontamination Procedures

Station 1: Segregate Equipment Drop

Deposit equipment used on-site (i.e., tools, sampling devices and containers, monitoring instruments radios, clipboards, etc.) on the plastic drop cloth/sheet or in different containers with plastic liners. Each will be contaminated to a different degree. Segregation at the drop reduces the probability of cross contamination. Loose leaf sampling data sheets or maps can be placed in plastic zip lock bags if contamination is evident.

Station 2: Physical Removal With A High-Pressure Washer (Optional)

Use high pressure wash on grossly contaminated equipment. Do not use high- pressure wash on sensitive or non-waterproof equipment.

Station 3: Physical Removal With Brushes And A Wash Basin

Scrub equipment with soap and water using bottle and bristle brushes. Only sensitive equipment (i.e., radios, air monitoring and sampling equipment) which is waterproof should be washed. Equipment which is not waterproof should have plastic bags removed and wiped down with a damp cloth. Acids and organic rinses may also ruin sensitive equipment. Consult the manufacturers for recommended decontamination solutions.

Station 4: Equipment Rinse

Wash soap off of equipment with water by immersing the equipment in the water while brushing. Repeat as many times as necessary.

Station 5: Low-Pressure Rinse

Rinse sampling equipment with distilled/deionized water with a low-pressure sprayer.

Station 6: Nitric Acid Sprayers (required only if metals are a contaminant of concern)

Using a spray bottle rinse sampling equipment with nitric acid. Begin spraying (inside and outside) at one end of the equipment allowing the acid to drip to the other end into a 5-gallon bucket. A rinsate blank may be required at this station. Refer to Section 9.

Station 7: Low-Pressure Sprayers

Rinse sampling equipment with distilled/deionized water with a low-pressure sprayer.

Station 8: Organic Solvent Sprayers

Rinse sampling equipment with a solvent. Begin spraying (inside and outside) at one end of the equipment allowing the solvent to drip to the other end into a 5-gallon bucket. Allow the solvent to evaporate from the equipment before going to the next station. A QC rinsate sample may be required at this station.

Station 9: Low-Pressure Sprayers

Rinse sampling equipment with distilled/deionized water with a low-pressure washer.

Station 10 : Clean Equipment Drop

Lay clean equipment on plastic sheeting. Once air dried, wrap sampling equipment with aluminum foil, plastic, or other protective material.

7.2.3 Post Decontamination Procedures

1. Collect high-pressure pad and heavy equipment decontamination area liquid and waste and store in appropriate drum or container. A sump pump can aid in the collection process. Refer to the Department of Transportation (DOT) requirements for appropriate containers based on the contaminant of concern.

2. Collect high-pressure pad and heavy equipment decontamination area solid waste and store in appropriate drum or container. Refer to the DOT requirements for appropriate containers based on the contaminant of concern.

3. Empty soap and water liquid wastes from basins and buckets and store in appropriate

drum or container. Refer to the DOT requirements for appropriate containers based on the contaminant of concern.

4. Empty acid rinse waste and place in appropriate container or neutralize with a base and place in appropriate drum. pH paper or an equivalent pH test is required for neutralization. Consult DOT requirements for appropriate drum for acid rinse waste.

5. Empty solvent rinse sprayer and solvent waste into an appropriate container. Consult DOT requirements for appropriate drum for solvent rinse waste.

6. Using low-pressure sprayers, rinse basins, and brushes. Place liquid generated from this process into the wash water rinse container.

7. Empty low-pressure sprayer water onto the ground.

8. Place all solid waste materials generated from the decontamination area (i.e., gloves and plastic sheeting, etc.) in an approved DOT drum. Refer to the DOT requirements for appropriate containers based on the contaminant of concern.

9. Write appropriate labels for waste and make arrangements for disposal. Consult DOT regulations for the appropriate label for each drum generated from the decontamination process.

8.0 CALCULATIONS

This section is not applicable to this SOP.

9.0 QUALITYASSURANCE/ QUALITY CONTROL

A rinsate blank is one specific type of quality control sample associated with the field decontamination process. This sample will provide information on the effectiveness of the decontamination process employed in the field.

Rinsate blanks are samples obtained by running analyte free water over decontaminated sampling equipment to test for residual contamination. The blank water is collected in sample containers for handling, shipment, and analysis. These samples are treated identical to samples collected that day. A rinsate blank is used to assess cross contamination brought about by improper decontamination procedures. Where dedicated sampling equipment is not utilized, collect one rinsate blank per day per type of sampling device samples to meet QA2 and QA3 objectives.

If sampling equipment requires the use of plastic tubing it should be disposed of as contaminated and replaced with clean tubing before additional sampling occurs.

10.0 DATA VALIDATION

Results of quality control samples will be evaluated for contamination. This information will be utilized to qualify the environmental sample results in accordance with the project's data quality objectives.

11.0 HEALTH AND SAFETY

When working with potentially hazardous materials, follow OSHA, U.S. EPA, corporate, and other applicable health and safety procedures.

Decontamination can pose hazards under certain circumstances. Hazardous substances may be incompatible with decontamination materials. For example, the decontamination solution may react with contaminants to produce heat, explosion, or toxic products. Also, vapors from decontamination solutions may pose a direct health hazard to workers by inhalation, contact, fire, or explosion.

The decontamination solutions must be determined to be acceptable before use. Decontamination materials may degrade protective clothing or equipment; some solvents can permeate protective clothing. If decontamination materials do pose a health hazard, measures should be taken to protect personnel or substitutions should be made to eliminate the hazard. The choice of respiratory protection based on contaminants of concern from the site may not be appropriate for solvents used in the decontamination process.

Safety considerations should be addressed when using abrasive and non-abrasive decontamination

equipment. Maximum air pressure produced by abrasive equipment could cause physical injury. Displaced material requires control mechanisms.

Material generated from decontamination activities requires proper handling, storage, and disposal. Personal Protective Equipment may be required for these activities.

Material safety data sheets are required for all decontamination solvents or solutions as required by the Hazard Communication Standard (i.e., acetone, alcohol, and trisodiumphosphate).

In some jurisdictions, phosphate containing detergents (i.e., TSP) are banned.

12.0 REFERENCES

Field Sampling Procedures Manual, New Jersey Department of Environmental Protection, February, 1988.

A Compendium of Superfund Field Operations Methods, EPA 540/p-87/001.

Engineering Support Branch Standard Operating Procedures and Quality Assurance Manual, USEPA Region IV, April 1, 1986.

Guidelines for the Selection of Chemical Protective Clothing, Volume 1, Third Edition, American Conference of Governmental Industrial Hygienists, Inc., February, 1987.

Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities, NIOSH/OSHA/USCG/EPA, October, 1985.

APPENDIX A

Table

Table 1. Soluble Contaminants and Recommended Solvent Rinse

TABLE 1 Soluble Contaminants and Recommended Solvent Rinse		
SOLVENT [1]	EXAMPLES OF SOLVENTS	SOLUBLE CONTAMINANTS
Water	Deionized water Tap water	Low-chain hydrocarbons Inorganic compounds Salts Some organic acids and other polar compounds
Dilute Acids	Nitric acid Acetic acid Boric acid	Basic (caustic) compounds (e.g., amines and hydrazines)
Dilute Bases	Sodium bicarbonate (e.g., soap detergent)	Acidic compounds Phenol Thiols Some nitro and sulfonic compounds
Organic Solvents [2]	Alcohols Ethers Ketones Aromatics Straight chain alkalines (e.g., hexane) Common petroleum products (e.g., fuel, oil, kerosene)	Nonpolar compounds (e.g., some organic compounds)
Organic Solvent [2]	Hexane	PCBs

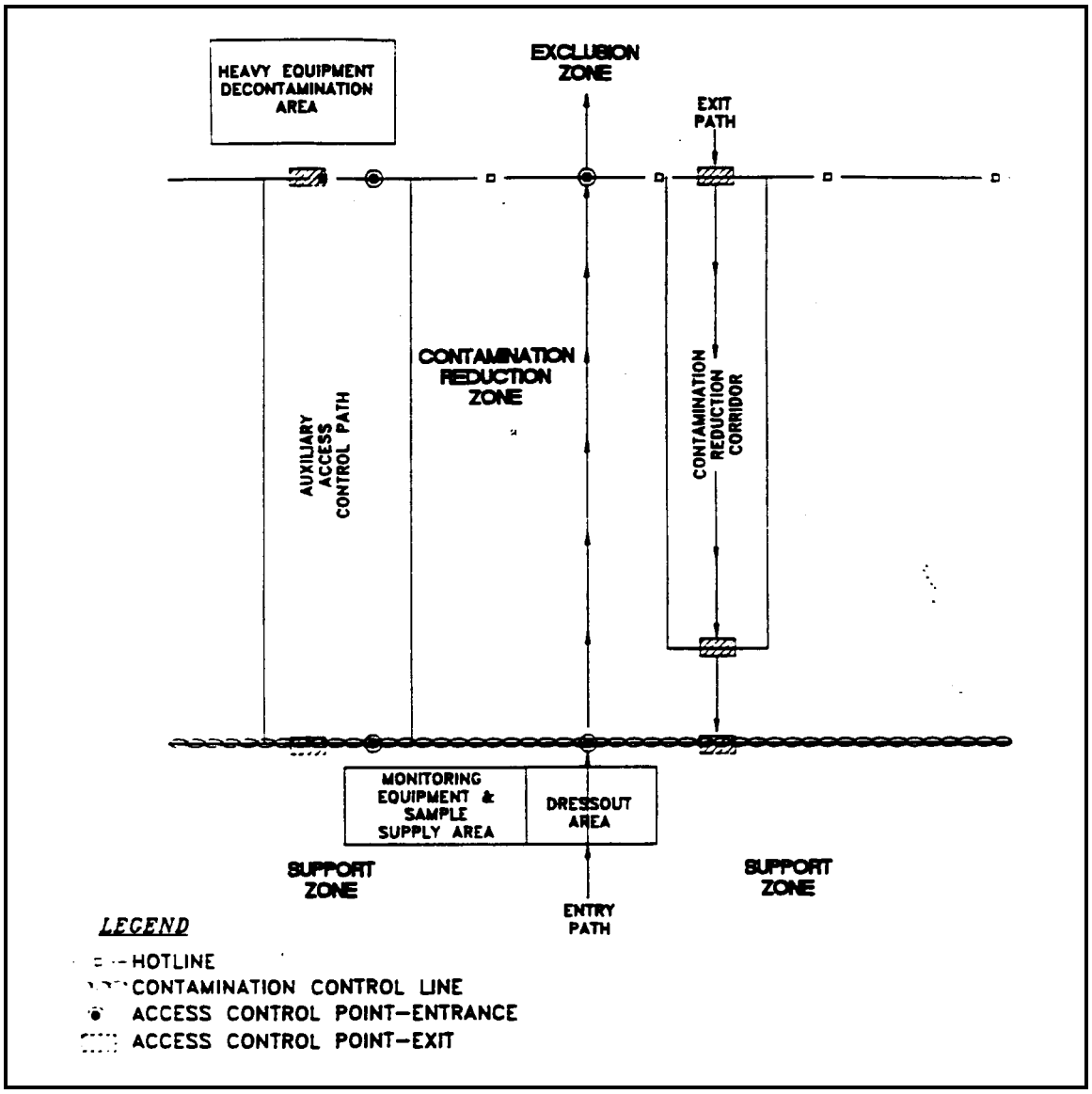
[1] - Material safety data sheets are required for all decontamination solvents or solutions as required by the Hazard Communication Standard

[2] - WARNING: Some organic solvents can permeate and/or degrade the protective clothing

APPENDIX B

Figures

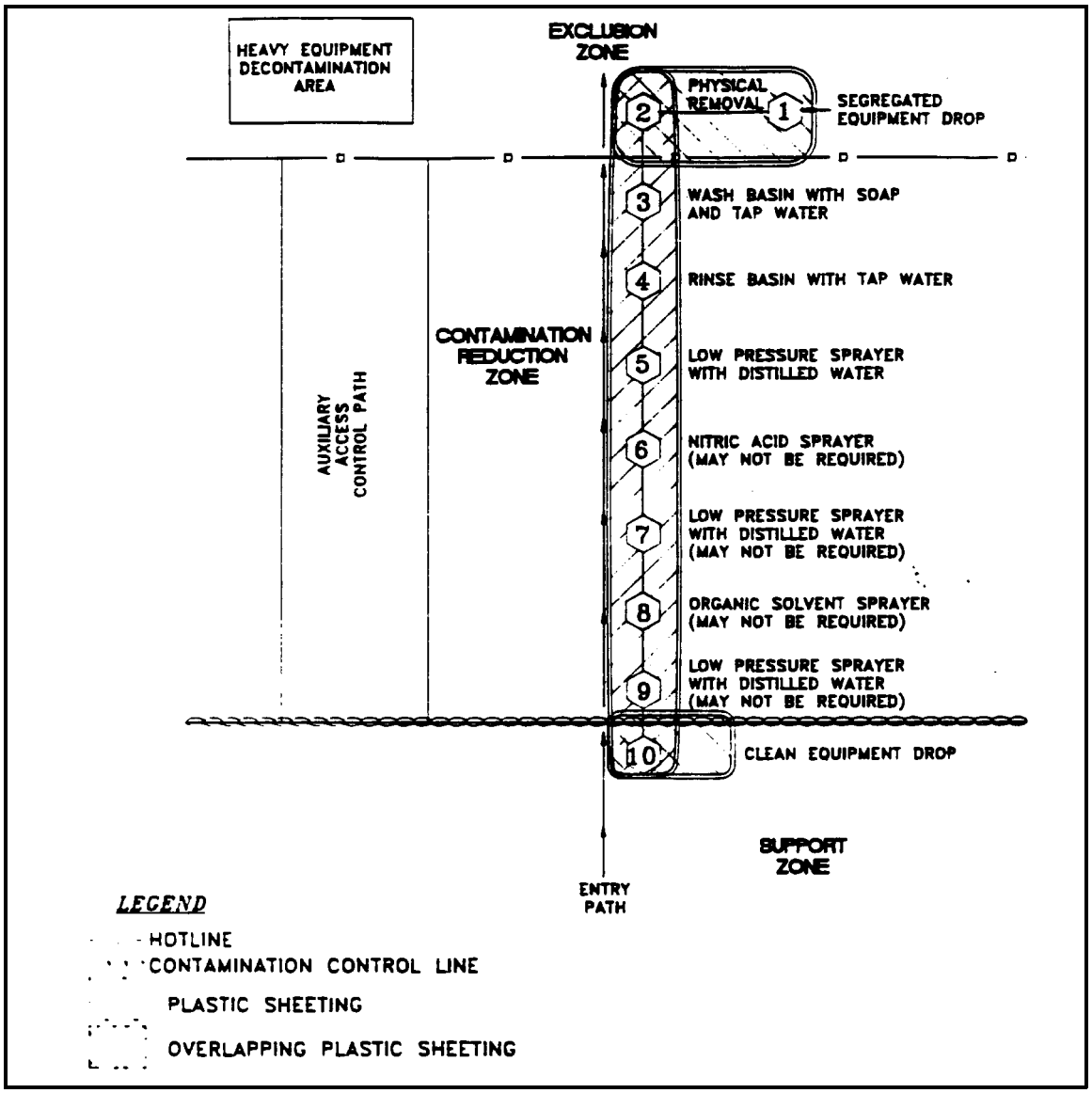
Figure 1. Contamination Reduction Zone Layout



APPENDIX B (Cont'd.)

Figures

Figure 2. Decontamination Layout



Appendix E – SOP for Sample and Evidence Management

U. S. EPA REGION 10 Office of Environmental Assessment
Field Standard Operating Procedure

Title: Sample and Evidence Management

Effective Date: July 27, 2010

Document Number: OEAFIELDSOP-018

Review and Approvals

Signature _____ Date 8/3/2010
Prepared by: Don Matheny, Senior Chemist
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Signature _____ Date 7/28/2010
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1.0 General Information

1.1 Purpose

A sample and evidence management procedure for environmental data collection activities is critical to establishing the integrity and usability of the information derived from these efforts. This document describes the general procedures, methods and considerations to be used and observed by staff in the Environmental Services Unit (ESU) Field Support Program when handling and managing environmental samples and other relevant evidence.

1.2 Scope/Application

The procedures contained in this document are to be used by field staff when handling and managing samples and other evidence collected by the ESU Field Support Program. On occasion ESU field staff may determine that any of the procedures described in this section are inappropriate, inadequate or impractical and that another procedure must be used, the variant procedure will be documented in the field log book, along with a description of the circumstances requiring its use.

1.3 Documentation/Verification

This procedure was prepared by persons deemed technically competent by ESU management, based on their knowledge, skills and abilities and have been tested in practice and reviewed in print by a subject matter expert. The official copy of this procedure resides on the OEA user share drive of the Region 10 local area network under the QA/RSCC sub-directory. ESU QA staff members are responsible for ensuring the most recent version of the procedure is placed on the user share drive and for maintaining records of review conducted prior to its issuance.

1.4 References

USEPA Region 10 Quality Management Plan, January, 2009

USEPA OECA, Conducting Environmental Compliance Inspections Inspector's Field Manual International Edition, 2002

Procedure for Digital Camera Use, OEAFIELDSOP-022, current version

Procedure for Packaging and Shipping of Environmental Samples, OEAFIELDSOP-002, current version

2.0 Sample and Evidence Identification

2.1 Introduction

Proper identification of samples and evidence helps to establish the representativeness of these artifacts in conjunction with all other relevant field information at the time of their collection. Sample identification, chain-of-custody records, receipt for sample records, and evidentiary related field descriptions and entries should be legible and recorded with

waterproof, indelible ink, unless otherwise specified. If errors are made in any hand written documents, corrections will be made by crossing a single line through the error and entering the correct information. All corrections must be initialed and dated. If possible, all corrections should be made by the individual who originated the error.

Following are definitions of terms used in this section:

Field Sampler

Any individual that performs field sample collection, observation and/or measurements.

Project Leader

Any individual that has the overall responsibility for overseeing a field data collection effort.

Field Sample Custodian

Any individual that is responsible for identifying sample containers and maintaining custody of the samples and establishing the Chain-of-Custody Record.

Sample Team Leader

Any individual designated by the project leader to be present during and responsible for all activities related to the collection of samples by a specific sampling team.

Transferee

Any individual that receives custody of samples subsequent to release by the field sample custodian.

Laboratory Sample Custodian

Any individual that receives custody of samples subsequent to delivery at the laboratory.

2.2 Sample and Evidence Identification Procedures

2.2.1 Sample Identification

The method of sample identification used depends on the type of sample collected. Field measurement samples are those collected for specific field analysis or measurement where the data are recorded directly by the field instrument, computer, in field logbooks or on the Chain-of-Custody Record. Examples of field measurements and analyses include X-Ray Fluorescence (XRF), pH, temperature, dissolved oxygen and conductivity. Samples collected for laboratory analysis will be identified by using a stick-on label which is attached to the sample container or by writing directly on the sample container with an indelible ink marker. In some cases such as biological samples, the label may have to be affixed to a bag containing the sample. The following information should be included on the sample label and/or accompanying chain of custody form(s) and entered with indelible ink:

- Project code if assigned by the Regional Sample Control Center (RSCC);
- Regional sample number (assigned by the EPA Region 10 Laboratory or RSCC);
- Station Location
- Date and time of sample collection;
- Designation of the sample as a grab or composite;
- Whether the sample is preserved or unpreserved;
- The general types of analyses to be performed; and
- Relevant comments (such as readily detectable or identifiable odor, color, or known toxic properties).

2.2.2 Digital Still Images and Video Identification

Digital Still Images

When digital images are taken for purposes of documenting and supporting a field activity, a record of each image should be kept in a bound field logbook. The following information will be recorded in the logbook:

- An accurate description of what the photograph or image shows, including orientation, if applicable and relevant;
- The date and time that the image was taken;
- The name of the individual who took the digital image.

When digital images are obtained in the field, an electronic copy and a printed copy of the unaltered images will be placed in the official file. For enforcement cases, it is imperative that the individual who took the image be identified in the field logbook in the event that testimony is required. Refer to "*Digital Camera Use*" (OEAFIELDSOP-022) for more information.

Video

When a video recording is used as evidence in an enforcement case, the following information should be recorded in a bound field logbook:

- The date and time that the video was recorded.
- A brief description of the subject of the video.
- The person recording the video.

An audio recording may also be included in the video tape with the same information, as well as a narrated description of the video record. A label or ink entry will be placed on the video media with the appropriate identifying information (i.e., project name, project code, date, location, etc.). In the event testimony regarding a video recording is required, one individual should be responsible for recording the video. The original, unaltered recording will be placed in the official file.

2.2.3 Identification of Physical Evidence

Physical evidence, other than samples, will be identified, when possible, by recording the necessary information describing the evidence. When samples are collected from vessels or containers which can be moved (drums for example), the vessel or container should be marked with the field identification or sample station number for future identification. The vessel or container may be labeled with an indelible marker (e.g., paint stick or spray paint). The vessel or container need not be marked if it already has a unique marking; however, these markings will be recorded in the bound field logbooks. In addition, it is suggested that photographs of any physical evidence (markings, etc.) be taken and the necessary information recorded in the field logbook.

Occasionally, it is necessary to obtain copies of recorder and/or instrument charts from facility owned analytical equipment, flow recorders, etc., during field investigations and inspections. Record the following information on copies of the charts:

- Starting and ending time(s) and date(s) for the chart;
- An instantaneous measurement of the media being measured by the recorder will be taken and entered at the appropriate location on the chart along with the date and time of the measurement; and
- A description of the location being monitored and other information required to interpret the data such as type of flow device, chart units, factors, etc.

The field sampler will indicate who the chart (or copy of the chart) was received from and enter the date and time, as well as the field sampler's initials.

Documents such as technical reports, laboratory reports, etc., should be marked with the field sampler's signature, the date, the number of pages, and from whom they were received. Documents that are claimed by a facility to be “confidential” and, therefore, potentially subject to the Confidential Business Information requirements, will be handled accordingly.

3.0 Sample Custody and Chain-of-Custody Procedures

3.1 Introduction

Sample custody and chain-of-custody procedures establish and support the authenticity of the samples and evidence that is collected. Combined, these procedures are comprised of the following elements:

1) maintaining custody of samples or other evidence, and
2) documentation of the chain-of-custody for such evidence.

To document chain-of-custody, an accurate record must be maintained to trace the possession of each sample, or other evidence, from the moment of collection to its introduction into evidence.

3.2 Sample Custody

A sample or other physical evidence is in custody if:

- It is in the actual possession of the sampler;
- It is in plain view of the sampler, after being in their physical possession;
- It was in the physical possession of the sampler and then secured to prevent tampering; and/or is placed in a designated secure area.

3.3 Documentation of Chain-of-Custody

The following are used to identify and demonstrate how sample integrity and custody are maintained.

3.3.1 Sample Identification

A stick-on sample label or a tag should be completed for each sample container using waterproof, non-erasable ink as specified in Section 2.2.1.

3.3.2 Sample Seals

If appropriate, sam ples should be sealed as soon as possible following collection using a custody seal with EPA identification. The sample custodian or project leader will write the date and their initials on the seal. Except for criminal investigations, the use of custody seals may be waived if field personnel maintain custody of samples as defined in Section 3.2, from the time of collection until the samples are delivered to the laboratory analyzing the samples. Custody seals must always be used for criminal investigations.

3.3.3 Field Sample Custodian

The field sample custodian is the person designated by th e project leader to receive and manage custody of samples while in the field, including labeling and custody sealing.

3.3.4 Chain-of-Custody Record

The field Chain-Of-Custody record is used to document the custody of all samples or other physical evidence collected and maintained by investigators. All physical evidence or samples will be accompanied by a Chain-Of-Custody Record. This form may be generated by the FORMS computer program (Section 5) or it may be a pre-printed multi-sheet carbonless f orm for hand entry of required information. The Chain-Of-Custody Record documents transfer of custody of samples from the sample custodian to another person, to the laboratory, or other or ganizational elements. The Chain-of-Custody Record will not be used to docum ent the collection of split samples where there is a legal requ irement to provide a receipt for samples (see Section 4, Receipt for Samples Form under CERCLA, RCRA, FIFRA & TSCA). The Chain-Of-Custody Record also serves as a sample logging mechanism for the laboratory sample custodian. A separate Chain-of-Custody Record should be used for each final destination or laboratory used during the investigation. All information necessary to fully and c ompletely document the sam ple collection and required

analyses must be recorded in the appropriate spaces to complete the field Chain-Of-Custody Record. Tag numbers are not required unless numbered "Criminal Tags" are used during an investigation. The following requirements apply to Chain-Of-Custody records generated by either the FORMS system or by hand entry on pre-printed forms:

• All sampling team leaders must sign in the designated signature block.

• One sample should be entered on each line and not be split among multiple lines.

• If multiple sampling teams are collecting samples, the sampling team leader's name should be clearly indicated for each sample.

• The total number of sample containers for each sample must be listed in the appropriate column. Required analyses should be entered in the appropriate location on the Chain-of-Custody Record.

• The field sample custodian, project leader or other designee, and subsequent transferee(s) should document the transfer of the samples listed on the Chain-of-Custody Record. Both the person relinquishing the samples and the person receiving them must sign the form. The date and time that this occurs should be documented in the proper space on the Chain-of-Custody Record. The exception to this requirement would be when packaged samples are shipped with a common carrier. Even though the common carrier accepts the samples for shipment, they do not sign the Chain-of-Custody Record as having received the samples.

• The last person receiving the samples or evidence will be the laboratory sample receipt custodian or their designee(s).

The Chain-of-Custody Form is a uniquely identified document. Once the Form is completed, it becomes an official record and must be maintained in the project file. The suitability of any other form for chain-of custody should be evaluated based upon its inclusion of all of the above information in a legible format. If chain-of-custody is required for documents received during investigations, the documents should be placed in large envelopes, and the contents should be noted on the envelope. The envelope will be sealed and an EPA custody seal placed on the envelope such that it cannot be opened without breaking the seal. A Chain-Of-Custody Record will be maintained for the envelope. Any time the EPA seal is broken, that fact will be noted on the Chain-Of-Custody Record and a new seal affixed, as previously described in this section.

Physical evidence such as video tapes or other small items will be placed in an evidence bag or envelope and an EPA custody seal should be affixed so that they cannot be opened without breaking the seal. A Chain-Of-Custody Record will be maintained for these items. Any time the EPA seal is broken, that fact will be noted on the Chain-of-Custody Record and a new seal affixed. EPA custody seals can be used to maintain custody of other items when necessary by using similar procedures as those previously outlined in this section. Samples should not be accepted from other sources unless the sample collection procedures used are known to be acceptable, can be documented, and the sample chain-of-custody can be

established. If such samples are accepted, a standard sample label containing all relevant information and the Chain-Of-Custody Record will be completed for each set of samples.

3.4 Transfer of Custody with Shipment

Transfer of custody is accomplished by the following:

Samples will be properly packaged for shipment in accordance with the procedures outlined in ESU Operating Procedure for Packing, Marking, Labeling and Shipping of Environmental and Waste Samples (OEAFIELDSOP-002).

- All samples will be accompanied by the laboratory copy of the Chain-Of-Custody Record.
- If pre-printed forms are used, the white and pink sheets will be sent.
- If FORMs generating software is used to generate the Chain-Of-Custody Record, the laboratory copy is identified with an “L” in the upper right corner.
- If multiple coolers are needed for shipment to a particular laboratory, the laboratory copy of the Chain-Of-Custody Record for the entire shipment is placed in a sealed plastic bag in one of the coolers.
- When samples are shipped via a common carrier, the "Relinquished By" box should be filled in; however, the "Received By" box should be left blank.
- The laboratory sample custodian is responsible for receiving custody of the samples and will fill in the "Received By" section of the Chain-of-Custody Record.
- One copy of the Record will be provided to and retained by the project leader.
- After samples have been received and accepted by the laboratory, a copy of the Chain of Custody Record, with sample identification numbers, will be transmitted to the project leader. This copy will become a part of the project file.

If sent by U.S. Mail, the coolers will be registered with return receipt requested. If sent by common carrier, an Air Bill should be used. Receipts from post offices and Air Bills will be retained as part of the documentation of the chain-of custody. The Air Bill number or registered mail serial number will be recorded in the remarks section of the Chain-Of-Custody Record.

4.0 Receipt for Samples Form (CERCLA/RCRA/TSCA)

4.1 Introduction

Section 3007 of the Resource Conservation and Recovery Act (RCRA) of 1976 and Section 104 of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund) of 1980 require that a "receipt" for all facility samples collected during inspections and investigations be given to the owner/operator of each facility before the field sampler departs the premises. The Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) and Toxic Substances Control Act (TSCA) contain similar provisions. The laws do not require that homeowners or other off-site property owners be given this form.

4.2 Receipt for Samples Form

A Receipt for Samples Form, using either the pre-printed form or one generated by the FORMS system, is to be used to satisfy the receipt for samples provisions of CERCLA, RCRA, FIFRA and TSCA.

The Receipt for Samples form is an official document after it is completed. A copy of the form is provided to the facility or site owner/operator. The original form must be maintained in the project file.

5.0 Computer Generated Sample Documentation

Container labels and Chain-of-Custody records should be computer generated with programs such as FORMS II Lite or SCRIBE. These were designed to stream line the documentation required by the Superfund Contract Laboratory Program (CLP) for sample identification and chain-of-custody. By loading sample collection information into the system prior to mobilization, project leads can save time and eliminate hand writing errors onto field forms. When possible, these programs should be used during all field sample collection activities. Once the appropriate information is entered into the computer, the program will generate stick-on labels for the sample containers, sample receipt forms and chain-of-custody records for the appropriate laboratory.

6.0 Change History

This is the original document. Changes to revisions have not occurred.

Appendix F – SOP for Field Log Books

U.S. EPA REGION 10 Office of Environmental Assessment
Field Standard Operating Procedure

Title: Field Logbooks

Effective Date: June 24, 2010

Document Number: OEAFIELDSOP-012

Review and Approvals

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1 General Information

1.1 Background

Field logbooks are used to record observations or relevant information during field activities in order to assist in the development of a comprehensive and factual report. Because field logbooks serve as records of fact, whether for supporting scientific observations or regulatory oversight functions, there is a need to follow certain standards in order for the information to maintain a level of integrity, accountability, organization and relevancy.

1.2 Purpose

This procedure is intended for use by field personnel for the purpose of documenting pertinent and factual information in field logbooks involving sample collection, measurements and other relevant field activities. The purpose of this procedure is to provide users with minimal set of standards to follow while recording information in the field such that there is sufficient documentation available that would enable and support the construction of a comprehensive report at a later time.

1.3 Scope/Application

This document describes the general requirements for field logbooks and the types of information that should be included for various types of field activities. While not comprehensive for all field activities, the information outlined here should be used in concert with other procedural requirements related to the recording of field measurements, sample collection and relevant observations.

2 Field Logbooks and Documentation Procedures

2. 1 General

Field logbooks should be dedicated to a specific project and not used on other projects. Logbooks should be durable and portable, maintain the sequence of observations and be organized in a way that maintains relevant information. Logbook entries should be timely, objective, factual, and free of bias or other non-relevant information. All aspects of measurement, sample collection and handling, as well as visual observations, should be documented. Significant deviations from a QA Project Plan or relevant procedures should also be noted.

Logbook entries that may be considered privileged or confidential need to be handled in accordance with the relevant sections of OEA Operating Procedure(s) for managing such information. Logbooks will be placed in the project file upon completion of the final report.

2. 2 Field Logbook Information Integrity and Accountability

The following practices are designed to demonstrate and preserve the integrity and accountability of information recorded in field logbooks. By implementing these steps, field notations more readily withstand the burden of outside scrutiny and challenge.

- Field logbooks should be bound with sequentially numbered pages.
- Observations should be recorded at the time they are made. Unless prohibited by weather, pens with permanent ink should be used. When conditions do not allow the use of ink, entries may be made using a non-smear lead pencil (e.g., 2H or 3H) and over written with ink at a later time.
- Logbook entries should be legible and contain pertinent, accurate and inclusive documentation of project activities.
- A diagonal line should be drawn and initialed to indicate the conclusion of an entry at: 1) the end of last entry for each day, and 2) at the end of unfilled pages.
- Upon completion of the project, the final entry in the logbook should be indicated (e.g., enter "End" on the last page, date and initial the notation).
- In order to demonstrate the continuity and integrity of the observations, pages should never be removed from bound logbooks.
- Errors in logbook entries are corrected by drawing a line through the incorrect entry and **initialing or signing and dating** the strikeout. An errant entry is not erased, made illegible or obscured such that it cannot be read.
- When pre-printed information is attached to the logbook, the field observer should enter their initials on the edge of the attachment and crossing over to the logbook page such that the attachment cannot be removed without detection.

2. 3 Bound Forms

In order to facilitate the collection of accurate and complete documentation of many field sampling and measurement activities, bound forms may be used. The information in section 2.4 below should be included with bound forms. These forms should be numbered using a "*page x of y*" format and bound prior to use in the field. At the conclusion of the project, the sample team leader should strike through any unused forms with a diagonal line that covers the entire page, and initial and date the page.

2. 4 Logbook Entry Information

2. 4. 1 General Logbook Information

The following information needs to be included either on the front cover or the first page of **all field logbooks**:

1. Project name
2. Project location
3. Project Code (where assigned by the Regional Sample Control Center)
4. Project leader (full name) and initials.
5. Team member(s) (full name) and initials.

2. 4. 2 Information for Sample Collection

In addition to the information listed in Section 2. 4. 1, the following information will be included in all logbooks when **samples** are collected:

1. Date and time of collection
2. Sample station identification
3. Method of collection
4. Number and type of containers
5. Sample collection equipment
6. OEA-ESU equipment identification number, if applicable
7. Physical description of sample
8. Matrix sampled
9. Sample team member duties (calibration, collection, deployment, etc.)
10. Sample preservation (including ice), if applicable
11. Indication of sample team member duties
12. Conditions that may adversely impact quality of samples, if applicable (rain, wind, smoke, dust, extreme temperature, etc.)
13. GPS coordinates (Non-logging GPS units), if applicable
14. Location of electronic data file backups, if applicable
15. Monitoring of condition of ice in coolers or sampler
16. Other pertinent information.

2. 4. 3 Information for Field Measurements

In addition to the information listed in Section 2. 4. 1, the following general information should be included in logbooks when **measurements** are conducted as indicated by the relevant standard operating procedure for each instrument:

1. Date and time of measurement or deployment
2. Sample station identification information
3. Type of measurement/analysis conducted
4. Measurement equipment identification number
5. Manufacturer name, lot number and expiration date of all buffers and standards*
6. Calibration information, including before and after calibration readings*
7. Post measurement/deployment verification check readings
8. Measurement/Deployment depth and total depth (as applicable)
9. Data/time of deployment and retrieval for deployed equipment (as applicable)
10. Physical description of matrix
11. Sample team member duties (calibration, collection, deployment, etc.)
12. Measurement values for non-logging equipment
13. GPS coordinates (non-logging GPS units), if applicable

14. Location of electronic data file backups, if applicable
15. Ambient air temperature, where applicable
16. Conditions that may adversely impact quality of measurement (e. g. , temp. extremes)
17. Maintenance performed/required
18. Instrument check deviations and/or malfunctions
19. Other pertinent information

* Entry of calibration information in logbooks is only required for calibrations conducted in the field. All calibrations conducted at the Field Equipment Warehouse or OEA Manchester laboratory will be recorded in the appropriate equipment logbook.

2. 4. 4 Field Equipment Logbooks

Field equipment logbooks shall remain with the equipment. They are used for maintenance and use information only. Projects should duplicate this information and log into project specific logbooks as described in this SOP. Field Equipment that is accompanied by a logbook should include the following entries.

1. Date and User Name
2. Location of use and project code
3. Calibration and calibration check data
4. Malfunctions that may have occurred, describe what the equipment did
5. Any and all maintenance performed
6. Any other applicable information as it pertains to the equipments operation

2. 4. 5 Additional Information

The following information may be included in logbooks as appropriate:
1. Maps/sketches
2. Photographic or video-graphic log
3. Process diagrams

3 Change History

No changes under current version.

Appendix G – SOP for Packaging and Shipping of Environmental Samples

U.S. EPA REGION 10 Office of Environmental Assessment
Field Standard Operating Procedure

Title: Packaging and Shipping of Environmental Samples

Effective Date: December 03, 2012

Document Number: OEAFIELDSOP-002

Review and Approvals

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1.0 Scope/Application

This standard operating procedure (SOP) provides guidance for the packaging, marking, labeling, and shipping of environmental samples and dangerous goods by Environmental Services Unit (ESU) Field Support Personnel.

2.0 Background

This document describes the procedures, methods and considerations to be used and observed by ESU Field Support Personnel when packing, marking, labeling and shipping environmental samples and hazardous materials to insure that all shipments are in compliance with applicable regulations and guidance. Regulations for packing, marking, labeling, and shipping of dangerous goods by air transport are promulgated by Department of Transportation under 49 CFR, Subchapter C, Hazardous Materials Regulations, and the International Air Transport Authority (IATA). Transportation of hazardous materials (dangerous goods) by EPA personnel is covered by EPA Order 1000.18.

Samples collected during field investigations or in response to a hazardous materials incident need to be classified prior to shipment, as either environmental or hazardous materials (dangerous goods) samples.

In general, environmental samples include drinking water, groundwater, surface water, soil, sediment, treated municipal and industrial wastewater effluent, biological specimens, or any samples not expected to be contaminated with high levels of hazardous materials. Samples collected from process wastewater streams, drums, bulk storage tanks, soil, sediment, or water samples from areas suspected of being highly contaminated may require shipment as dangerous goods. EPA field staff transporting environmental samples or hazardous materials (i.e., preservatives or waste samples) in government vehicles are not subject to the requirements of this section (49 CFR 171.1(d)(5)). EPA contractors, however, are not covered by this exemption and may not transport these materials without full compliance with the regulation.

3.0 Documentation/Verification

This procedure was prepared by persons deemed technically competent by ESU management, based on their knowledge, skills and abilities and has been tested in practice and reviewed in print by a subject matter expert. The official copy of this procedure resides on the OEA user share drive of the Region 10 local area network under the QA/RSCC sub-directory. ESU QA staff members are responsible for ensuring the most recent version of the procedure is placed on the user share drive and for maintaining records of review conducted prior to its issuance.

4.0 References

Title 40 Code of Federal Regulations (CFR), Pt. 136.3, Identification of Test Procedures, Table II, Footnote 3, current version

USEPA, 2007. Contract Laboratory Program Guidance for Field Samplers, EPA 540-R-07-06

ESU Operating Procedure for Preparation of Sample Containers for the Field, OEAFIELDSOP-023, current version

5.0 Safety

Proper safety precautions must be observed when preserving, packing, marking, labeling, and shipping environmental or waste samples. See OEAFIELDSOP-023 for precautions on sample preservation.

6.0 Shipment of Dangerous Goods

The project leader is responsible for determining if samples collected during a specific field investigation meet the definitions for dangerous goods. If a sample is collected of a material that is listed in the Dangerous Goods List, Section 4.2, IATA, that sample must be identified, packaged, marked, labeled, and shipped according to the instructions given for the material. If the composition of the collected sample(s) is unknown, and the project leader knows or suspects that it is a regulated material (dangerous goods), the sample may not be offered for air transport. If the composition and properties of the waste sample or highly contaminated soil, sediment, or water sample are unknown, or only partially known, the sample may not be offered for air transport. In addition, the shipment of pre-preserved sample containers or bottles of preservatives (e.g., NaOH pellets, HCL, etc.) which are designated as dangerous goods by IATA is regulated. Air shipment of nitric acid is strictly forbidden. Consult the IATA Dangerous Goods Regulations for guidance. ***Dangerous goods must not be offered for air transport by any personnel except those trained and certified by IATA in dangerous goods shipment.***

7.0 Supplies and Materials

The following supplies and materials should be gathered prior to mobilization to the field.

- Coolers for storage and/or shipment (various sizes depending on need)
- Bubble Wrap
- Sample containers
- Access to Scribe software for creating labels and TR/COC Records
- Custody Seals
- Evidence bags
- Large plastic bag (30 gal) for lining coolers
- Clear tape (cover sample labels)
- Shipping tape (fiber)
- Ziplock bags (2 gallon) for ice

- Sampling Equipment (mixing bowls, spoons, augers, etc.)
- Ballpoint and marker pens
- Bagged Ice

8.0 Shipment of Environmental Samples

Guidance for the shipment of environmental laboratory samples by personnel is provided in a memorandum dated March 6, 1981, subject "Final National Guidance Package for Compliance with Department of Transportation Regulations in the Shipment of Laboratory Samples". By this memorandum, the shipment of the following unpreserved samples is not regulated:

• Drinking water
• Treated effluent
• Biological specimens
• Sediment
• Water treatment plant sludge
• POTW sludge

In addition, the shipment of preserved drinking water, waste water and ambient water samples is not regulated, provided the amount of preservative used does not exceed the amounts found in 40 CFR 136.3 (Table II) or the relevant USEPA Region 10 Laboratory SOP, (current version). It is the shippers' (individual signing the air waybill) responsibility to ensure that proper amounts of preservative are used.

Samples determined to be in these categories are to be shipped using the following procedure.

Untreated wastewater and sludge from POTW's are considered to be "diagnostic specimens" (not environmental laboratory samples). However, because they are not considered to be etiologic agents (infectious) they are not restricted and may be shipped using the procedures outlined below. Environmental samples shipped by air should also use the following procedures:

1. Allow sufficient headspace in all bottles (except VOC containers with a septum seal) to compensate for any pressure and temperature changes (approximately 10 percent of the volume of the container).

2. Ensure that the lids on all bottles are tight (will not leak).

3. Place bottles in separate and appropriately sized polyethylene bags and seal the bags with tape (preferably plastic electrical tape). Up to three VOC bottles may be packed in one bubble wrap bag.

4. Optionally, place VOC vials in foam holders.

5. Select a sturdy cooler in good repair. Secure and tape the drain plug with fiber or duct tape. Line the cooler with a large heavy duty plastic bag.

6. Place bubble wrap in the bottom of the cooler and then place the bottles and cans in the cooler with sufficient space to allow for the additional bubble wrap between the bottles and cans.

7. Put ice that has been "double bagged" in heavy duty polyethylene bags and properly sealed underneath, on top of and/or between the samples. Fill all remaining space between the bottles or cans with bubble wrap. **Do not use vermiculite or kitty litter**.

8. Securely fasten the top of the large garbage bag with tape (preferably plastic electrical tape) and add custody seal. Custody seal on the bag maintains the custody if cooler is opened during security inspections during shipments by agencies such as TSA.

9. Place the Chain-of-Custody Record into a plastic bag, and tape the bag to the inner side of the cooler lid.

10. Close the cooler and securely tape (preferably with fiber tape) the top of the cooler shut. Chain-of-custody seals should be affixed to the top and sides of the cooler within the securing tape so that the cooler cannot be opened without breaking the seal.

11. Shipping containers should be properly labeled in accordance with shipping company's, IATA or DOT requirements. A label containing the name and address of the shipper should be placed on the outside of the container. Labels used in the shipment of hazardous materials (e.g., Cargo Only Air Craft, Flammable Solids, etc.) are not permitted to be on the outside of containers used to transport environmental samples.

9.0 Change History

This is an original procedure. No changes have occurred.

Appendix H - SOP for Calibration and Use of the Horiba U-53G Multi Water Quality Checker

U.S. EPA REGION 10 Office of Environmental Assessment
Field Standard Operating Procedure

Title: Calibration and Use of the Horiba U-53G Multi Water Quality Checker

Effective Date: April 13, 2010

Document Number: OEAFIELDSOP-100

Review and Approvals

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1.0 Scope and Application

This standard operating procedure (SOP) provides guidance for the calibration and use of the Horiba U-53G Multi Water Quality Checker (U-53G) by qualified field inspectors, investigators, or other field personnel.

2.0 Summary of Test method

Following guidance from applicable analytical methods, regulations and publications, field personnel prepare a Quality Assurance Project Plan (QAPP) which includes specifications for appropriate field parameters to be measured by the U-53G. Based on the information in the QAPP, a service request is received by Field Support Center personnel and the instrument(s) are prepared and packed for shipment or pickup. Within OEA, selected members of the Environmental Services Unit on-site with Region 10 Manchester Environmental Laboratory provide this service. The U-53G is a multi-meter instrument that can simultaneously measure: pH, Temperature, Dissolved Oxygen, Conductivity, Total Dissolved Solids, Salinity, Turbidity, Oxidation Reduction Potential, Depth and GPS position. The U-53G is composed of the sensor unit, that is lowered into the water, and the hand held monitor, which allows the user to view and log sensor readings. The U-53G is calibrated using the methods below. It is designed for field use and applications include: rivers, lakes, and ground or tap water using a flow through cell.

3.0 Acronyms

COND - Conductivity
DO – Dissolved Oxygen
DOT – United States Department of Transportation
IATA – International Air Transport Association
NIST – National Institute of Standards and Technology
NTU – Nephelometric Turbidity Unit
OEA – Office of Environmental Assessment
ORP – Oxidation Reduction Potential
QA – Quality Assurance
QAPP – Quality Assurance Project Plan
SOP – Standard Operating Procedure
TDS – Total Dissolved Solids
TURB- Turbidity

4.0 Interferences and Precautions

- Do not use instrument in magnetic fields. Measurement errors will occur.
- Do not immerse in alcohol, organic solvent, strong acid, strong alkaline or other similar solutions.
- Does not support measurement of samples containing fluorine.
- Do not subject to strong shocks. Do not drop.
- Ensure all calibration solutions are the same temperature as ambient air temperature.

- Holding the probe while calibrating may cause the internal probe temperature to rise causing a Dissolved Oxygen (DO) calibration error
- Do not drop instrument into water lower gently dropping will cause sensors to fail and my produce false readings or instrument failure.
- Do not use below depths of 30 meters. Sensor probes are only resistant to 30 meters. Below these depths may give false reading or instrument failure.
- Unit must be turned on for 20 minutes prior to calibrating or using DO measurements.
- For non-flowing water slowly move instrument up and down to induce flow over DO membrane.
- Oxidation Reduction Potential (ORP) standard solutions must be used within one hour at which point it may be transformed. For this reason ORP standard solutions may not be stored.
- When measuring ORP with low concentration of oxidants and reductants such as tap water, well water, or water that underwent treatment there may less repeatability and stability, in general.
- Always use the calibration cup provided. Other containers may create effects from ambient light that cause incorrect turbidity calibrations.
- Avoid turbidity measurement in direct sunlight, since the readout may be affected.

5.0 Safety

Use appropriate personal protective equipment including gloves and safety glasses when using calibration solutions.

6.0 Equipment and Supplies

1. U-53G multi Water Quality Checker, Control Unit and Sensor Probe
   a. pH Sensor
   b. ORP Sensor
   c. Reference electrode
   d. DO Sensor
   e. Turbidity Sensor

2. Calibration Cup(s) or appropriate containers as specified in sensor calibration section
3. pH reference internal solution
4. DO sensor internal solution set
5. DO Membrane spare parts set
6. Spanner wrench for DO sensor
7. Cleaning Brush
8. Back pack
9. Strap
10. Silicone Grease
11. Instruction Manuel
12. De-ionized water (DI water)
13. Bubbler
14. pH 4,7,10 Calibration Standard
15. Sodium Sulfite (zero DO)
16. ORP Solution (ORP Standard)
17. Auto Cal Solutions (0 NTU, pH 4, 4.40 mS/cm)

18. Level Two Solution (40 NTU, pH 6.86, 53.0 mS/cm)
19. Conductivity Calibration Solutions
20. Turbidity Calibration Solutions
21. Sensor Guard and Cap
22. LR14 alkaline dry cell batteries, C-size
23. Coin battery, CR-2032
24. Protective caps for DO, and pH Storage
25. Flow Cell assembly w/ appropriate size tubing
26. Scale
27. Beakers
28. Graduated Cylinders
29. Calibration Solution Disposal Container

7.0 Calibration Solutions and Standards

7.1 pH

- pH standard 4, 7, and 10, NIST traceable with expiration date.
- Auto Cal Solution, NIST traceable with expiration date

7.2 DO

- Zero DO solution is a Sodium Sulfite salt mixed with water (DI or Tap) at a ratio of 50g of sodium sulfite to 1000 ml of water.
- Span DO solution is water saturated with air. This is done by using a bubbler in a bath of water.
- Each solution shall be made fresh just prior to calibration or drift measurement.

7.3 ORP

- ORP standard powder (quinhydrone) mixed with 250 ml of deionized water and/or premixed ORP standard, NIST traceable with expiration date.

7.4 Conductivity

- Auto Cal Solution, NIST traceable with expiration date.
- Conductivity Standards, range of mS/cm, NIST traceable with expiration date.

7.5 Turbidity

- Auto Cal Solution, Referenced to Formazin, with expiration date.
- Turbidity Solutions, Range of NTU's, Auto Cal Solution, referenced to Formazin with expiration date.

8.0 Shipment and Storage

All equipment and calibration standards or solutions shall be shipped in compliance with the appropriate IATA or DOT requirements.

Calibration solutions and standards should be placed in Ziploc bags with taped caps and placed upright in the shipping container to minimize spilling during shipping.

If the equipment will be shipped or delivered, it will be placed into ice chests, cardboard boxes, or other appropriate containers with adequate cushioning material to prevent breakage and custody sealed to confirm not tapering of the standards has take place during shipment.

8.1 Storage For Short Term Use Only

- Prior to use inspect DO and pH for sensor caps are present and remove. DO is a white cap, the pH is a black cap.

- Replace caps filled with DI water between uses and for short term storage of less than two months. Note: Any water may be used in the field to ensure sensors remain wet. Replace water with DI water once available.

- Follow instruction manual for long term storage, which is defined as storage of longer than 2 months.

9.0 Quality Control and Documentation

Calibration and drift measurements (see section 10) should be conducted for each sampling event at a frequency outlined in the QAPP.

The calibration of the instrument sets each parameter to a given standard or solution.

Drift measurements should also be done at the end of each sampling event. Drift is the measurement of the standards or solutions used for calibration. This measurement will indicate if the instrument has “drifted” during the course instrument use. It is used as an indicator to ensure the probes are in good working order and the readings obtained during the sampling event are accurate.

All calibration solutions and standards shall be made fresh prior to use or be used within the labels expiration date.

All commercial standards or solutions shall be NIST traceable with expiration date or referenced to Formazin in the case of Turbidity.

Documentation of the measurements can occur by two methods: electronically by saving the measurements in the instrument for downloading after the sampling event and/or by logging readings manually into a log book. In either case follow the project specific QAPP or SOP. For example: Inspection type activities require a logbook with numbered pages and must be bound.

An equipment log book accompanies the U-53G. Each user shall enter users name, location of equipment use, date equipment used, calibrations that occurred, and other applicable information or failures. This log book remains with the U-53G and should not be used as the data log for the project.

10.0 Calibration and Standardization

The U-53G offers two methods to calibrate. Selection of the calibration method depends on how accurate and the quality of data needed. For general screening the Auto Calibration generally will meet the needs. The second method each parameter is manually calibrated with a zero and a span(s) standard. It is the operator's responsibility to know the limitations of this instrument, any EPA standard methods that apply, and the quality of data required by the project and/or QAPP. Operators should become familiar with the instruction manual for the U-53G. This outline will not duplicate the instruction manual verbatim.

10.1 Auto Calibration

- **PRIOR TO USE REMOVE DO AND pH SENSOR STORAGE CAPS**
- Turn unit on using the power button. For DO sensors the unit must remain on for 20 minutes to stabilize and prior to calibration.
- Using the auto cal solution and fill calibration cup to the "with TURB" line located on the side of the cup.
- Place calibration cup into black calibration cup to eliminate light sources.
- Press the CAL button or right arrow to the Calibration Tab.
- Press the down arrow to Auto Calibration
- Press Enter and follow instructions on screen.
- Instructions should then direct you to place sensors into calibration cup.
- Monitor values of the sensors once stabilized press ENTER to start calibration
- Do not remove the unit from calibration solution the will display "-----"until finished.
- The display will direct you to press MEAS to exit to measurement screen.
- If error occurs make note of error code and refer to instruction manual, Section 4.6 Troubleshooting.

10.2 Manual Calibration

Manual Calibration is used to individually calibrate sensors. It is used to ensure good measurement precision throughout all measurement ranges. It should be noted the temperature calibration should follow the most current version of the Inorganic Chemistry Support Equipment Monitoring SOP along with procedures outlined below. Since the H-53G allows temperature calibration, the temperature obtained from the Inorganic Chemistry Support Equipment Monitoring SOP can be entered directly into the H-53G and no correction factor is necessary.

- **PRIOR TO USE REMOVE DO AND pH SENSOR STORAGE CAPS**
- Turn unit on using the power button. For DO sensors the unit must remain on for 20 minutes to stabilize and prior to calibration.
- Press the CAL button or right arrow to the Calibration Tab.

10.2.1 Temperature (Performed yearly or as needed)

- Following the Inorganic Chemistry Support Equipment Monitoring SOP
- Press the CAL button or right arrow to the Calibration Tab.
- Press the down arrow to Manual Calibration
- Move the cursor to Temp and press ENTER
- Press the up and down arrow to adjust value
- Once value is stable press ENTER to start calibration
- When calibration is finished press ENTER for measurement mode

10.2.2 pH

- Calibrate the zero point (pH 7) first, rinse calibration cup 2-3 times with DI water,
- then fill with pH 7 standard solution to the w/TURB reference line.
- Rinse the senor probe 2-3 times with DI water to remove any dirt and then submerge into calibration cup
- Press CAL or from the Calibration Tab and press the down arrow to “Manual Calibration”
- Move the cursor to pH and press ENT
- Set the number of calibration points for two
- Press the up and down to set the pH value of 7.00 for the pH 7 standard, reference temperature vs. pH standard value chart
- Check that the value has stabilized then press ENTER to start calibration.
- Once complete press Enter to continue to span cal.
- Rinse calibration cup 2-3 times with DI water
- Fill cup with pH 4 or pH 10 to the w/TURB reference line. Place sensor into calibration cup.
- Check that the value has stabilized, reference temperature vs. pH standard value chart, press ENTER to start calibration.
- When calibration complete press ENTER to return to calibration parameter menu.

10.2.3 ORP

- Rinse the sensor probe and calibration cup 2 to 3 times with DI water
- Place sensor probe into solution.
- Fill calibration cup with ORP standard to the w/TURB reference line.
- Press the units CAL key to set calibration mode
- Press down arrow to Manual Calibration and press ENTER
- Move the cursor to ORP and press ENTER
- Press the up or down arrow to adjust the mV to match the standard mV for the given standard temperature.
- Check the measurement value has stabilized and press ENTER
- Once complete press ENTER to return to the calibration selection screen.

10.2.4 Conductivity (COND)

- Rinse the sensor probe 2 to 3 times with DI water to remove any dirt
- Remove as much moisture from the sensor, the zero calibration is done in air.
- Press the units CAL key to set calibration mode
- Press the down arrow to Manual Calibration and press ENTER
- Move the cursor to COND and press ENTER
- Press up or down arrow to select number of calibration points (2 or 4) press ENTER. Depending on the number of calibration points proceed and stop with the number of steps below. The solutions can be modified to bracket the waters being tested.
- Press up or down arrow to set COND to 0.00 mS/cm
- Check the measurement value has stabilized and press ENTER
- Once complete press ENTER to proceed to first span calibration procedure
- Wash the sensor probe and calibration cup 2 to 3 times with DI water.
- Fill calibration cup to the w/TURB reference line with a 0.00 to 0.999mS/cm standard.
- Place sensor probe into solution.
- Press up or down to set value to standard.
- Check to ensure measurement value has stabilized and press ENTER
- Once complete press ENTER to proceed to the second span calibration procedure.
- Wash the sensor probe and calibration cup 2 to 3 times with DI water.
- Fill calibration cup to the w/TURB reference line with a 1.00 to 9.99 mS/cm standard.
- Place sensor probe into solution.
- Press up or down to set value to standard.
- Check to ensure measurement value has stabilized and press ENTER
- Once complete press ENTER to proceed to the third span calibration procedure.
- Wash the sensor probe and calibration cup 2 to 3 times with DI water.
- Fill calibration cup to the w/TURB reference line with a 10.0 to 100.0 mS/cm standard.
- Place sensor probe into solution.
- Press up or down to set value to standard.
- Check to ensure measurement value has stabilized and press ENTER
- Once complete press ENTER to proceed to the calibration parameter screen.

10.2.5 Turbidity (TURB)

- Rinse the sensor probe and calibration cup 2 to 3 times with DI water
- Fill calibration cup with zero standard to the w/TURB reference line.
- Place calibration cup into black calibration cup to eliminate light sources.
- Place the sensor probe into calibration cup with standard.
- Press the units CAL key to set calibration mode
- Press down arrow to Manual Calibration and press ENTER
- Move the cursor to TURB and press ENTER
- Press the up or down arrow to select number of calibration points

- Press up or down to set value to the 0.00 standard.
- Check to ensure measurement value has stabilized and press ENTER
- Once complete press ENTER to proceed to the first span calibration procedure.
- Wash the sensor probe and calibration cup 2 to 3 times with DI water.
- Fill calibration cup to the w/TURB reference line with a 0.1 to 10.0 NTU standard.
- Place sensor probe into solution.
- Press up or down to set value to standard.
- Check to ensure measurement value has stabilized and press ENTER
- Once complete press ENTER to proceed to the second span calibration procedure.
- Wash the sensor probe and calibration cup 2 to 3 times with DI water.
- Fill calibration cup to the w/TURB reference line with a 10.0 to 100.0 NTU standard.
- Place sensor probe into solution.
- Press up or down to set value to standard.
- Check to ensure measurement value has stabilized and press ENTER
- Once complete press ENTER to proceed to the third span calibration procedure.
- Wash the sensor probe and calibration cup 2 to 3 times with DI water.
- Fill calibration cup to the w/TURB reference line with a 100 to 1000 NTU standard.
- Place sensor probe into solution.
- Press up or down to set value to standard.
- Check to ensure measurement value has stabilized and press ENTER
- Once complete press ENTER to proceed to the calibration parameter screen.

10.2.6 Dissolved Oxygen (DO)

- Prepare standard solutions
    - Add 50 g of sodium sulfite to 1000 ml of water and stir to dissolve. Generally, 1000 ml of solution is not needed for one calibration. Use the ratios 12.5 per 250 ml or 25 g per 500 ml depending on number of instruments that will be calibrated.
    - Pour 1 to 2 liters of water into a suitable container and feed air into water using a bubbler or air pump until it is oxygen saturated.

- Rinse the sensor probe 2 to 3 times with DI water
- Place sensor into zero standard into the calibration cups (black and clear).
- Fill solution over the DO sensor slot in the cup, this is the area between the black cup and the clear cup.
    - Press the units CAL key to set calibration mode.
    - Press down arrow to Manual Calibration and press ENTER.

- Move the cursor to %DO and press ENTER.

- Press the up or down arrow to selecting two (2) for the number of calibration points.
- Press the up or down arrow to adjust the %DO to match zero.
- Check to ensure the measurement value has stabilized and then press ENTER.
- Once complete press ENTER to proceed to span calibration procedure.
- Place sensor guard on sensor unit to protect sensors.
- Place sensor probe into oxygen saturated bath solution.
- Press up or down to set value to 100%.
- Check to ensure measurement value has stabilized and press ENTER.
- Once complete press ENTER to return to the calibration selection screen.

10.2.7 Water Depth (DEPTH)

- Rinse the sensor probe 2 to 3 times with DI water
- Press the CAL button or right arrow to the Calibration Tab.
- Press the down arrow to “Manual Calibration”
- Move the cursor to Depth and press ENTER.
- Press the up and down arrow to adjust value to 0.00 meters
- Once value is stable press ENTER to start calibration
- When calibration if finished press ENT for measurement mode

10.3 Drift Measurements

- Turn unit on using the power button. For DO sensors the unit must remain on for 20 minutes to stabilize and prior to calibration.
- Using the calibration cup or appropriate container with each successive standard or solution and measure the value by pressing the MEAS button.
- Record and compare to the standard or solution value. The difference is the drift value.
- A percentage of drift can be calculated by subtracting the drift measurement from the standard and dividing by the standard value. This percentage can be used to monitor the equipments sensors and to ensure data quality and repeatability.

11.0 Measurement and Data Collection

Any instrument requests should be made to Field Services staff via phone or email with **AT LEAST TWO WEEKS** notice to ensure adequate standards are available and equipment is serviceable.

- **PRIOR TO USE, REMOVE DO AND pH SENSOR STORAGE CAPS**

11.1 Single Measurement

- Turn unit on using the power button. For DO sensors the unit must remain on for 20 minutes to stabilize, use the internal clock and DO reading, and prior to calibration.

- Check that each sensor and sensor guard is mounted.
- Press the right or left arrow to the Single Measurement tab or screen.
- **NOTE: DO NOT** press MEAS key while unit in the air, this will cause turbidity wiper failure.
- Submerge sensor probe in the sample, gently shake them to remove air bubbles form sensors.
- For non-flowing water gently move sensor probe up and down at a rate of 20 to 30 cm a second.
- When non-turbidity values are stable press MEAS to acquire values.
- Press ENTER to save the values or write values in logbook.
- Press ESC to cancel operation.
- Continue to next measurement or press and hold PWR button to power off.

11.3 GPS Information

- Press the right arrow to the Data Operations tab or screen.
- Press the down arrow to move the cursor to GPS Information then press ENTER.
- When position data exists it will be displayed, if no data is displayed data has not been received.

11.4 Data Operations

- Press the right arrow to the Data Operations tab or screen.
- Press the down arrow to move the cursor to View Data then press ENTER.
- Move the cursor to Site/Date/All and then press ENTER. The Site name or Date will need to be entered depending on your selection. All data will display with the most recent first.
- Press the up or down arrow to scroll though data.
- To delete data from the Data Operation tab or screen cursor to Delete Data and press ENTER.
- Press the left arrow to confirm Yes and press ENTER. All data will be deleted.
- It is the operator's responsibility to save data obtained during the sampling event. The unit may be cleared of all data upon return either by the ESU personnel or the next user.

11.5 Calibration Record Check

- Press the right arrow to the Data Operations tab or screen.
- Press the down arrow to move the cursor to Calibration Record then press ENTER
- The latest calibration record will be displayed. Scroll by pressing the down arrow

11.6 Sensor Information

- Press the right arrow to the Information tab or screen.
- When sensor probe is normal "All sensors are available." will appear.

- When a sensor has a problem a message will be generated. Refer to the instruction manual for troubleshooting information. (Section 4.6 pages 89 to 94)

12.0 Calculations

Principals of measurements for each parameter are outlined in the instruction manual for the instrument. Refer to pages 100-109 or Sections 6.3 thru 6.11

Some of the calibrations solutions need to be mixed. Refer to the calibration section of the instruction manual or section 10 above for mixture ratios.

Refer to appropriate calibration chart for standard value for a given temperature. Usually located on the bottle and/or U-53G instruction manual. There may be a need to interpolate between temperature readings to obtain the correct standard value.

Percentage of Drift = (Calibration Standard – Drift Measurement) / Calibration Standard

13.0 Waste Management and Pollution Prevention

Recycle used containers when possible both in the field and in accordance with Manchester Environmental Laboratory's Waste Management and Pollution Prevention Programs when at the Manchester Lab Facility. Disposal of calibration solution should only occur in an appropriate manner, i.e. not on the ground or in a body of water. All waste solutions should be saved and disposed of once you have returned from the field.

14.0 References

Horiba U-50 series, Multi Water Quality Checker, Instruction Manual, April 2009.

Test Methods for Evaluating Solid Waste, Physical/Chemical Methods (SW-846), current version.

Standard Methods for the Examination of Water and Wastewater, Joint Editorial Board, American Public Health Association, American Water Works Association and Water Environment Federation, latest edition.

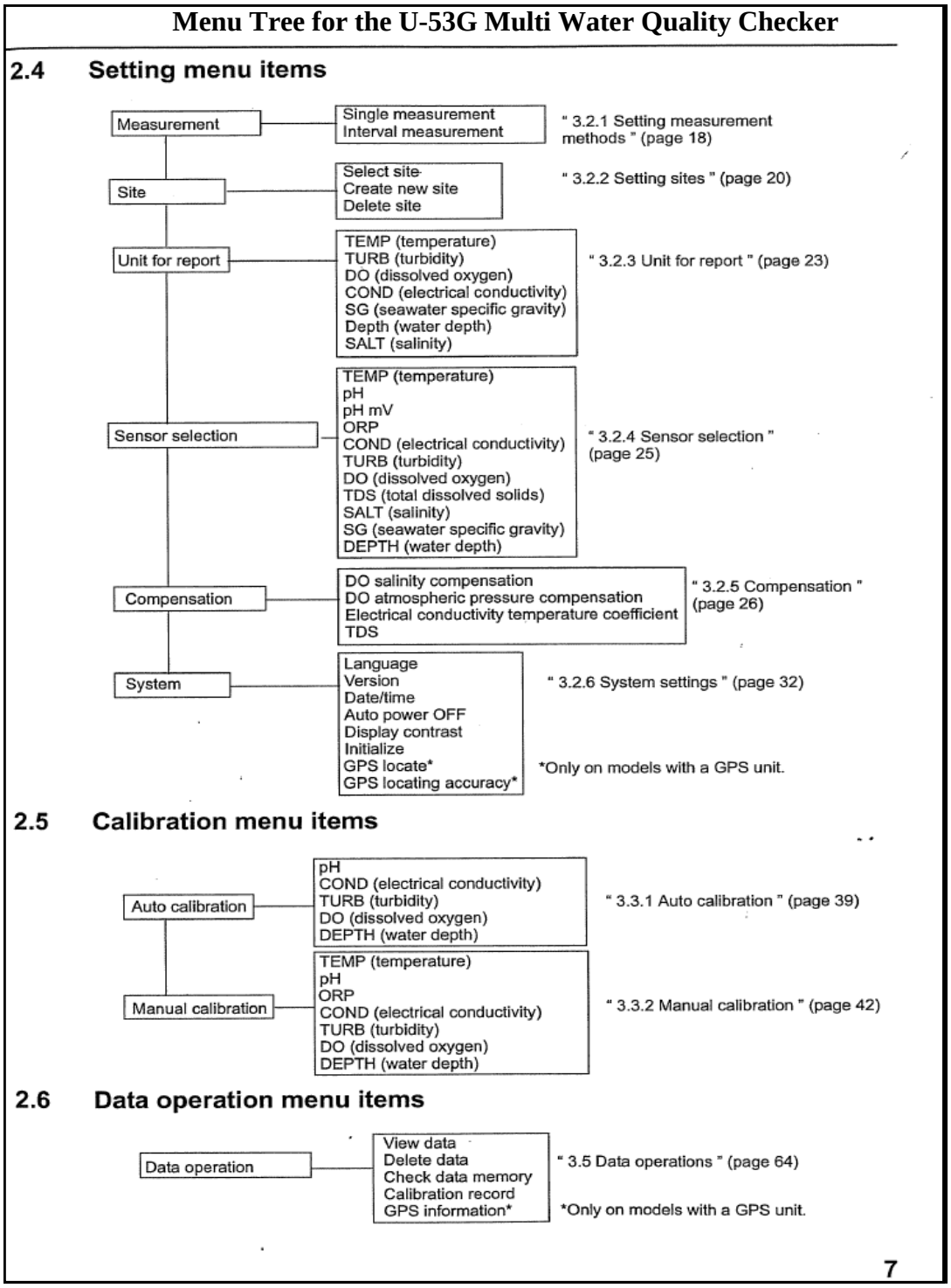
Code of Federal Regulations, Title 40 (40 CFR), Part 136.3, Table IB.

Pollution Prevention Plan of the Manchester Environmental Laboratory," USEPA Region 10,current version.

Manchester Environmental Laboratory Dangerous Waste Disposal Manual," USEPA Region 10, current version.

15.0 Diagram

15.1 Menu Tree for the U-53G



16.0 Change History

Original revision. No changes to date.

Appendix I – Sample Alteration and Corrective Action Forms

Sample Alteration Form

Project Name and Number: _____

Material to be Sampled: _____

Measurement Parameter: _____

Standard Procedure for Field Collection & Laboratory Analysis (cite reference):

_____

Reason for Change in Field Procedure or Analysis Variation:

_____

Variation from Field or Analytical Procedure:

_____

Special Equipment, Materials or Personnel Required:

_____

Initiators Name: _____ Date: _____

Project Officer: _____ Date: _____

QA Officer: _____ Date: _____

CORRECTIVE ACTION FORM

Project Name and Number: _____

Sample Dates Involved: _____

Measurement Parameter: _____

Acceptable Data Range: _____

Problem Areas Requiring Corrective Action:

_____

_____

Measures Required to Correct Problem:

_____

_____

Means of Detecting Problems and Verifying Correction:

_____

_____

Initiators Name: _____ Date: _____

Project Officer: _____ Date: _____

QA Officer: _____ Date: _____