Groundwater Sampling and Analysis Plan
For Developing Baseline Water Quality Parameters In the Vicinity of Hydraulic Fracturing

(Version 1.0 May 2015)
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1.0 INTRODUCTION

Post Oak Savannah Groundwater Conservation District (POSGCD) has the regulatory authority to monitor groundwater quality and develop rules to help protect the groundwater resources in Milam and Burleson County. Since its creation in 2003, POGCD monitoring activities have focused primarily on constructing a well inventory, measuring water levels in wells, and tracking reported pumping. Although POSGCD has occasionally measured water quality parameters in wells such as total dissolved solids, POSGD has not considered monitoring water quality as a primary responsibility. As a result, the increased oil and gas activity associated with hydraulic fracturing in the district along with public concerns regarding the potential impacts of hydraulic fracturing on groundwater quality, the POSGCD has decided to begin to monitor water quality in groundwater wells.

The primary purpose of the POSGCD groundwater monitoring program is to develop a database of baseline water quality parameters that can be used a “pre-hydraulic fracturing” condition. This baseline data needs to be of sufficient quality so that it can be used, if necessary, in the future to help evaluate whether or not hydraulic fracturing (or related oil and gas activity) has contributed to the degradation of the groundwater in the district.

The purpose of the Groundwater Sampling and Analysis Plan (GWSAP) is to document field sampling procedures and laboratory methods that will be used to ensure that consistent and representative water quality data is collected, and that a uniform method of data reporting to the agencies is established. Sampling must be conducted in a way that employs “best practice protocols” designed for the collection of samples that are representative of groundwater at the site. Methods and techniques used in the analysis of the groundwater samples must be capable of providing both accurate and precise measurements and representative aliquots of a groundwater for analysis. It is important to use well documented analytical processes so that different laboratories are capable of producing comparable data.

1.1 Ground Water Sampling and Analysis Objectives

An objective of the GWSAP is to ensure that POSGCD database of measured concentrations is generated using sampling and analytical techniques of known quality and legal defensibility. Such data will provide reproducible results at reporting thresholds that are adequate to evaluate potential changes in water quality. To achieve this objective, the GWSAP has been developed in accordance to the rules and guidelines published by the Texas Commission on Environmental Quality for analytical methods and sampling guidance (http://www.tceq.texas.gov/remediation/analysis.html). One of the important requirements is that except for a few specified exception, the analytical data submitted to TCEQ needs to be generated by a lab that is accredited through the Texas Laboratory Accreditation Program under the NELAP standard for matrices, methods, and parameters of analysis.

Another objective of the GWSAP is to prudently select the concentration and water quality parameters to be measured so that the costs of populating the POSGCD database is reasonable and commensurate with the risks associated with potential contamination. To help manage costs, the GWSAP focuses on sampling ions and chemicals that occur naturally in the subsurface that have been used in peer-reviewed publications (Osborn and others, 2011; Darrah and others, 2013) to indicate possible contamination of groundwater supply by oil & gas production. Chemicals that are unique to the hydraulic fracturing process such as biocides, corrosion inhibitors, or gelling agents will not be
measured. Table 1-1 summarizes the types of samples to be collected during the baseline sampling program and the anticipated uses of the data.

<table>
<thead>
<tr>
<th>Data Parameter</th>
<th>Data Uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Major Cations and Major Anions</td>
<td>- Classify the groundwater based on its hydrochemical facies</td>
</tr>
</tbody>
</table>
| Common anions (Cl, SO4, NO3, NO2, HCO3, CO3, PO4), fluoride (F), bromide (Br), total TAL metals, silica(Si), boron(B), total dissolved solids(TDS), alkalinity | - Identify potential impacts from exploration and production activities  
- Identify potential impacts from well drilling and installation practices  
- Distinguish between the types of groundwater |
| Dissolved gas composition: C1-C5 gases, fixed gases | - Identify (or prevent misidentification) of VOCs detected in groundwater in the gasoline organics range by coupling gas chromatography with mass spectroscopy  
- Source determination |
| Gas composition: C1-C5 gases, fixed gases, benzene, toluene, ethylbenzene, xylenes (BTEX) | - Compare general compositional characteristics to evaluate correlation between gases present in groundwater, natural gas, and well casing headspace.  
- Calculate C1/C2 + C3 ratios to compare between gases and to evaluate the potential for migration of gas  
- Identify wells to be sampled for stable isotope analysis of methane |
| Stable isotopes of methane: 13C and deuterium | - Compare to global meteoric water line and Tertiary meteoric water line to identify sources or mixing of water |
| Stable isotopes of water: 18O and deuterium | |

### 1.2 Baseline Sampling Program

The POSGCD’s baseline sampling program will be continually evaluated and modified as appropriate based on available funding, perceived risks, and data gaps. Currently, the primary source of funding for the program are fees associated with the permitting of rig supply wells for the oil & gas industry. Once a fee is paid, POSGD will develop a list of parameters for analysis at the rig supply well and/or other monitoring wells in the vicinity of the rig supply wells. The parameter list for a well will vary and will be dependent ongeochemical data gaps and perceived risks in the vicinity of the rig supply wells. All wells will be sampled for the major and common ions listed in Table 1-1. Among the gas measurements, methane is considered most important followed by C1-C5 gas composition (note that C1 indicates a molecule with one carbon). Where funding is available, an isotopic analysis of methane will be performed to determine whether its source is thermogenic, bacterial reduction, or bacteria fermentation. Prior to a sampling event, the wells will be identified and each well will be assigned a parameter list.

### 1.3 Organization

The GWSAP is organized into the following sections:

- Section 1 provides introductory project information, including the purpose of the SAP
• Section 2 presents a brief background of hydraulic fracturing, the Eagle Ford Shale, and regulation of groundwater resources in Texas
• Section 3.0 describes procedures for sample handling, documentation, and analysis
• Section 4.0 describes the groundwater sampling procedures
• Section 5.0 discusses laboratory analytical methods and holding times
• Section 6.0 presents quality assurances and quality controls
• Section 7.0 provide the references
2.0 BACKGROUND INFORMATION

2.1 Hydraulic Fracturing Process

Informally called “fracking,” hydraulic fracturing dates back to 1947 when the practice was pioneered for vertical wells in the Hugoton gas field in Grant County, Kansas. In recent years, operators have begun drilling horizontal wells—drilling vertically then turning horizontally through a known oil or gas zone (see Figure 2-1)—then employing hydraulic fracturing. With hydraulic fracturing, fluid is injected into a well under high pressure (up to thousands of pounds per square inch) to fracture rock formations and release oil and gas. The method is nearly ubiquitously used in rocks known to contain oil or gas trapped in unconnected pores and not economically producible without hydraulic fracturing. After a well to be fractured has been drilled and constructed using multi-levels of steel casing and high-quality cement, the well casing is perforated in the target zone, allowing the hydraulic fluid to fracture the rock. Typically, fractures created during the process are the width of a single grain of sand (approximately 1 mm, or 0.04 in) and vary in length up to hundreds of feet (Suchy & Newell, 2011). After the rock is fractured, oil and/or gas released from isolated pores and fractures in the rock can flow freely via steel casing or tubing to surface containment vessels or pipelines.

Experts believe 60 to 80 percent of all wells drilled in the United States in the next ten years will require hydraulic fracturing to remain operating (https://fracfocus.org). Hydraulic fracturing allows for extended production in older oil and natural gas fields. It also allows for the recovery of oil and natural gas from formations that geologists once believed were impossible to produce, such as tight shale formations in the areas shown on the map below. Hydraulic fracturing is also used to extend the life of older wells in mature oil and gas fields.

2.1.1 Stages of Hydraulic Fracturing

Contrary to many media reports, hydraulic fracturing is not a “drilling process.” Hydraulic fracturing is used after the drilled hole is completed. Put simply, hydraulic fracturing is the use of fluid and material to create or restore small fractures in a formation in order to stimulate production from new and existing oil and gas wells. This creates paths that increase the rate at which fluids can be produced from the reservoir formations, in some cases by many hundreds of percent.

Each oil and gas zone across the United States is different and requires a hydraulic fracturing design tailored to the particular conditions of the formation. Therefore, while the process remains essentially the same, the sequence may change depending upon unique local conditions. A hydraulic fracturing job is carried out in predetermined stages that can be altered depending on the site-specific conditions or if necessary during the treatment. In general, these stages can be described as follows.

Pad Stage – The pad is the first stage of the job. The fracture is initiated in the targeted formation during the initial pumping of the pad. From this point forward, the fracture is propagated into the formation. Typically, no proppant is pumped during the pad; however, in some cases, very small amounts of sand may be added in short bursts in order to abrade or fully open the perforations. Another purpose of the pad is to provide enough fluid volume within the fracture to account for fluid leak-off into the targeted formations that could occur throughout the treatment.

Proppant Stage - After the pad is pumped, the next stages will contain varying concentrations of proppant. The most common proppant is ordinary sand that has been sieved to a particular size. Other specialized proppants include sintered bauxite, which has an extremely high crushing strength, and ceramic proppant, which is an intermediate strength proppant.
Displacement for Flushing Stage – The purpose of the displacement is to flush the previous sand laden stage to a depth just above the perforations. This is done so that the pipe is not left full of sand, and so that most of the proppant pumped will end up in the fractures created in the targeted formation. Sometimes called the flush, the displacement stage is where the last fluid is pumped into the well. Sometimes this fluid is plain water with no additives, or it may be the same fluid that has been pumped into the well up to that point in time.

2.1.2 Fluids Used in Hydraulic Fracturing

Hydraulic fracturing fluids typically consist of 90% water, 9.5% proppant (sand or other inert material), and 0.5% additives (Suchy & Newell, 2011). The water carries the sand and additives and delivers the high-pressure energy necessary to fracture the formation. The sand props the fractures open while the various additives reduce friction, thicken the fluid to carry the sand, eliminate bacteria, and reduce pipe corrosion (API, 2009). Once fracturing is completed and injection of the fluid is discontinued, the fluid is pumped to the surface through the wellbore. The fluid, known as “flowback” and “produced water,” contains both fracturing fluids and naturally occurring fluids (formation brine and hydrocarbons) in the rock.

The proppant is a granular material that prevents the created fractures from closing after the fracturing treatment. Types of proppant include silica sand, resin-coated sand, bauxite, and man-made ceramics. The choice of proppant depends on the type of permeability or grain strength needed. In some formations, where the pressure is great enough to crush grains of natural silica sand, higher-strength proppants such as bauxite or ceramics may be used. The most commonly used proppant is silica sand, though proppants of uniform size and shape, such as a ceramic proppant, is believed to be more effective.

The fracturing fluid varies depending on fracturing type desired, and the conditions of specific wells being fractured, and water characteristics. The fluid can be gel, foam, or slickwater-based. Fluid choices are tradeoffs: more viscous fluids, such as gels, are better at keeping proppant in suspension; while less-viscous and lower-friction fluids, such as slickwater, allow fluid to be pumped at higher rates, to create fractures farther out from the wellbore. Important material properties of the fluid include viscosity, pH, various rheological factors, and others.

A typical fracture treatment uses between 3 and 12 additive chemicals. Although there may be unconventional fracturing fluids, typical chemical additives can include one or more of the following:

- A dilute acid solution, as described in the first stage, used during the initial fracturing sequence. This cleans out cement and debris around the perforations to facilitate the subsequent slickwater solutions employed in fracturing the formation.
- A biocide or disinfectant, used to prevent the growth of bacteria in the well that may interfere with the fracturing operation: Biocides typically consist of bromine-based solutions or glutaraldehyde.
- A scale inhibitor, such as ethylene glycol, used to control the precipitation of certain carbonate and sulfate minerals.
- Iron control/stabilizing agents such as citric acid or hydrochloric acid, used to inhibit precipitation of iron compounds by keeping them in a soluble form.
- Friction reducing agents, also described above, such as potassium chloride or polyacrylamide-based compounds, used to reduce tubular friction and subsequently reduce the pressure needed to pump fluid into the wellbore: The additives may reduce tubular friction by 50 to 60%. These friction-reducing compounds represent the “slickwater” component of the fracing solution.
• Corrosion inhibitors, such as N,n-dimethyl formamide, and oxygen scavengers, such as ammonium bisulfite, are used to prevent degradation of the steel well casing.
• Gelling agents, such as guar gum, may be used in small amounts to thicken the water-based solution to help transport the proppant material.
• Occasionally, a cross-linking agent will be used to enhance the characteristics and ability of the gelling agent to transport the proppant material. These compounds may contain boric acid or ethylene glycol. When cross-linking additives are added, a breaker solution is commonly added later in the frac stage to cause the enhanced gelling agent to break down into a simpler fluid so it can be readily removed from the wellbore without carrying back the sand/proppant material.

2.1.3 Eagle Ford Shale

Hydraulic fracturing in Milam and Burleson Counties occurs at a depth between 6,000 and 9,000 feet below ground surface in the Eagle Ford Shale. The Eagle Ford Shale is one of the most significant domestic oil finds in decades and is currently the most active shale play in the world producing oil, natural gas and natural gas liquids. This immense hydrocarbon producing formation in South Texas is considered to be one of the most noteworthy oil and natural gas discoveries ever found in the state.

The Eagle Ford Shale extends approximately 50 miles wide, 400 miles long and has an average thickness of 250 feet (see Figure 2-2). The growth of oil and natural gas extraction in the Eagle Ford Shale region is exponential. Drilling permits tripled in the 14 counties surrounding the Eagle Ford Shale between 2010 and 2011 alone, and experts predict that this type of growth will span for an additional 10-12 years. Experts have also noted that the wells drilled will continue to produce for another 40-50 years beyond.

2.2 Groundwater Regulation in Texas

2.2.1 Texas Commission on Environmental Quality (TCEQ)

The Texas Commission on Environmental Quality (TCEQ) has the responsibility for the majority of the state’s environmental and water quality regulatory programs. The TCEQ implements a variety of programs which address groundwater protection and focus on both prevention of contamination and remediation of existing problems. The major areas of jurisdiction affecting groundwater include the wastewater and storm water permitting, the Edwards Aquifer program, the Petroleum Storage Tank (PST) program, underground injection control, surface water rights permitting, the oversight of public drinking water systems, the on-site waste water program, solid and hazardous waste disposal and remediation programs.

As the state lead agency for water resources and environmental protection, the TCEQ administers both state and federally mandated programs. Federal programs include the Resource Conservation and Recovery Act for the management of municipal and industrial wastes; the Comprehensive Environmental Response, Compensation, and Liability Act or Superfund cleanup program; the Clean Water Act for managing pollutant releases to state waters; the Safe Drinking Water Act for the protection of public drinking water supplies; and the development of pesticide management plans for groundwater under the Federal Insecticide, Fungicide, and Rodenticide Act. TCEQ has responsibilities and authorities under state law provided in the Texas Water Code and the Texas Health and Safety Code for a number of programs addressing water resource management, waste management, and environmental protection.

2.2.2 The Texas Water Development Board (TWDB)

The TWDB is the state agency responsible for statewide water planning, collection and maintenance of water resource information, and administration of financial assistance programs for water supply, water...
quality, flood control and agricultural water conservation projects. The TWDB is responsible for the
development of the State Water Plan to provide for the orderly development, management and
conservation of the state’s water resources. TWDB provides support to regional water planning groups
for the development of regional water plans that serve as the bases for the State Water Plan.

The TWDB, in support of its water planning and data collection responsibilities, conducts an active
groundwater resource assessment program. The TWDB conducts studies to assess the State’s aquifers,
including occurrence, availability, quality and quantity of groundwater present. Major groundwater-
using entities and current and projected demands on groundwater resources are also identified. The
TWDB conducts statewide groundwater level measurements and groundwater quality sampling
programs as a part of its assessment effort. The groundwater quality sampling program permits the
TWDB to 1) monitor changes, if any, in the ambient quality of groundwater over time; and 2) establish,
as accurately as possible, the baseline quality of groundwater occurring naturally in the State’s aquifers.

2.2.3 Groundwater Conservation District

Groundwater conservation districts (GCDs) are a form of local governments authorized by the Texas
Constitution. GCDs are created through the Legislature or through the TCEQ in response to a petition
from area landowners. GCDs have the purpose and duty of preserving, conserving, and protecting
groundwater. State law provides that groundwater conservation districts are the state’s preferred
method of groundwater management. Groundwater conservation districts have the authority to
develop management plans, adopt and enforce rules, require well permits, monitor groundwater quality
and quantity and provide public education. As of February 2015, there were 99 established groundwater
districts in the state.

2.3 Drinking Water Standards

The Environmental Protection Agency (EPA) and the state of Texas regulate public drinking water
supplies. These agencies do not regulate private drinking water wells. The EPA has set primary and
secondary standards for the maximum contaminant level (MCL) of certain substances for public drinking
water supplies. The primary standards are set as a protection to the safety and health of humans, and
are legally enforceable. The secondary standards are those that, when exceeded, may cause aesthetic
effects (taste, color, odor and foaming), cosmetic effects (skin or tooth discoloration), and technical
effects (corrosivity, expensive water treatment, plumbing fixture staining, scaling, and sediment) and are
not legally enforceable. In addition to EPA standards, the TCEQ has established maximum contaminant
levels (MCLs) for primary or secondary drinking water standards. Table 2-1 and Table 2-2 show the
primary and secondary MCLs adopted by TCEQ and EPA. Both agencies share the same primary
standards, but have different secondary MCLs.
Table 2-1  Primary MCLs for Public Drinking Water Supply.

<table>
<thead>
<tr>
<th>Contaminant</th>
<th>MCL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antimony</td>
<td>0.006 mg/L</td>
</tr>
<tr>
<td>Arsenic</td>
<td>0.01 mg/L</td>
</tr>
<tr>
<td>Asbestos</td>
<td>7 million fibers/liter (longer than 10 μm)</td>
</tr>
<tr>
<td>Barium</td>
<td>2 mg/L</td>
</tr>
<tr>
<td>Beryllium</td>
<td>0.004 mg/L</td>
</tr>
<tr>
<td>Cadmium</td>
<td>0.005 mg/L</td>
</tr>
<tr>
<td>Chromium</td>
<td>0.1 mg/L</td>
</tr>
<tr>
<td>Copper</td>
<td>1.3 mg/L</td>
</tr>
<tr>
<td>Cyanide</td>
<td>0.2 mg/L</td>
</tr>
<tr>
<td>Fluoride</td>
<td>4 mg/L</td>
</tr>
<tr>
<td>Lead</td>
<td>0.015 mg/L</td>
</tr>
<tr>
<td>Mercury</td>
<td>0.002 mg/L</td>
</tr>
<tr>
<td>Nitrate</td>
<td>10 mg/L (as N)</td>
</tr>
<tr>
<td>Nitrite</td>
<td>1 mg/L (as N)</td>
</tr>
<tr>
<td>Nitrate &amp; Nitrite (Total)</td>
<td>10 mg/L (as Nitrogen)</td>
</tr>
<tr>
<td>Selenium</td>
<td>0.05 mg/L</td>
</tr>
<tr>
<td>Thallium</td>
<td>0.002 mg/L</td>
</tr>
</tbody>
</table>

Table 2-2  Secondary MCLs for Public Drinking Water Supply.

<table>
<thead>
<tr>
<th>Contaminant</th>
<th>TCEQ MCL</th>
<th>EPA MCL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminum</td>
<td>0.05 to 0.2 mg/L</td>
<td>0.05 to 0.2 mg/L</td>
</tr>
<tr>
<td>Chloride</td>
<td>300 mg/L</td>
<td>250 mg/L</td>
</tr>
<tr>
<td>Color</td>
<td>15 Color Units</td>
<td>15 Color Units</td>
</tr>
<tr>
<td>Copper</td>
<td>1 mg/L</td>
<td>1.0 mg/L</td>
</tr>
<tr>
<td>Corrosivity</td>
<td>Non-Corrosive</td>
<td>Non-Corrosive</td>
</tr>
<tr>
<td>Fluoride</td>
<td>2 mg/L</td>
<td>2.0 mg/L</td>
</tr>
<tr>
<td>Foaming Agents</td>
<td>----</td>
<td>0.5 mg/L</td>
</tr>
<tr>
<td>Hydrogen Sulfide</td>
<td>0.05 mg/L</td>
<td>--</td>
</tr>
<tr>
<td>Iron</td>
<td>0.3 mg/L</td>
<td>0.3 mg/L</td>
</tr>
<tr>
<td>Manganese</td>
<td>0.05 mg/L</td>
<td>0.05 mg/L</td>
</tr>
<tr>
<td>Odor</td>
<td>3 threshold odor number</td>
<td>3 threshold odor number</td>
</tr>
<tr>
<td>pH</td>
<td>&gt;7.0</td>
<td>6.5-8.5</td>
</tr>
<tr>
<td>Silver</td>
<td>0.1 mg/L</td>
<td>0.10 mg/L</td>
</tr>
<tr>
<td>Sulfate</td>
<td>300 mg/L</td>
<td>250 mg/L</td>
</tr>
<tr>
<td>Total Dissolved Solids</td>
<td>1000 mg/L</td>
<td>500 mg/L</td>
</tr>
<tr>
<td>Zinc</td>
<td>5 mg/L</td>
<td>5 mg/L</td>
</tr>
</tbody>
</table>
Figure 2-1  Hydraulic Fracturing Water Cycle from Acquisition to Treatment and Disposal (modified from Fross and Lyle, 2013).
Figure 2-2  Footprint of the Counties Overlying the Eagle Ford Shale (light blue) and the Location of the Oil and Gas Permits in the Eagle Ford Shale as of February 2013 (form http://eaglefordshale.com/news/eagle-ford-shale-well-map-tx-rrc-may-2013/attachment/eagle-ford-shale-well-map-8/).
3.0 PROCEDURES FOR SAMPLE HANDLING AND DOCUMENTATION

3.1 Sample Identification and Labeling

Upon collection, the samples will be appropriately labeled and placed in a chilled cooler for shipment to the analytical laboratories. Appropriate chain-of-custodies procedures will be implemented during sample collection and shipment.

The sample collected at the first sampling location will be the assigned POSGCD registration ID followed sequentially in order of collection. For example, if the sample well has POSGCD ID 198 the sample identification numbers will be:

- 1st sample collected: 198-1
- 2nd sample collected: 192-2
- 3rd sample collected: 198-3
- 4th sample collected: 198-4

Sample IDs and location identification will be recorded on the Groundwater Field Data Sheets. The sample ID numbers generated prior to visiting the well and will be associated with specific event. At a minimum, each label will contain the following information:

- Site location
- Sample identification number
- Date and time of sample collection
- Method of preservation used

3.2 Sample Containers and Preservatives

3.2.1 Sample Containers

Proper sample preparation practices will be observed to minimize sample contamination and potential repeat analyses due to anomalous analytical results. Prior to sampling, commercially cleaned sample containers will be obtained from the analytical laboratory. The bottles will be labeled as described in the previous section to indicate the type of sample and sample matrix to be collected. Sample bottles can be either pre-preserved from the laboratory or preservatives can be added in the field during sample collection.

3.2.2 Sample Preservation

Samples are preserved in order to prevent or minimize chemical changes that could occur during transit and storage. Sample preservation should be performed immediately upon sample collection to ensure that laboratory results are not compromised by improper coordination of preservation requirements and holding times. Samples will be preserved immediately and stored on ice in coolers prior to shipping.

3.3 Sample Preparation and Shipping

After collection, samples will be labeled and prepared as described in the previous section and placed on ice in an insulated cooler. Samples will then be placed right side up in a cooler with ice for delivery to the laboratory. Blue ice will be used if provided by the laboratory. In all other coolers the ice will be double-bagged. The coolers will be taped shut and chain-of-custody seals will be attached to the outside of the cooler to ensure that the cooler cannot be opened without breaking the seal. All samples will be
shipped for laboratory receipt and analysis within the holding times specified in Section 5, “Laboratory Analytical Methods.”

3.4 Sample Documentation and Tracking

This section describes the information that should be provided in field notes and sample chain-of-custody documentation.

3.4.1 Field Notes

Documentation of observations and data acquired in the field provide information on sample acquisition, field conditions at the time of sampling, and a permanent record of field activities. Field observations and data collected during routine monitoring activities will be recorded with waterproof ink in a permanently bound weatherproof field log book with consecutively numbered pages or on the Groundwater Sampling Field Data Sheet. Field notebook and/or data sheet entries will, at a minimum, include the information listed below:

- Project name
- Location of sample
- Data and time of sample collection
- Sample identification numbers
- Description of sample (matrix sampled)
- Sample depth (if applicable)
- Sample methods, or reference to the appropriate SOP
- Field observations
- Descriptions of any photographs taken
- GPS coordinates
- Results of any field measurements, such as depth to water, pH, temperature, specific conductance
- Personnel present

Changes or deletions in the field book or on the data sheets should be recorded with a single strike mark and remain legible. Sufficient information should be recorded to allow the sampling event to be reconstructed without having to rely on the collector's memory. All field books will be signed on a daily basis by the person who has made the entries. Anyone making entries in another person's field book will sign and date those entries.

3.4.2 Sample Chain-of-Custody

During field sampling activities, traceability of the sample must be maintained from the time the samples are collected until laboratory data are issued. Establishment of traceability of data is crucial for resolving future problems if analytical results are called into question and for minimizing the possibility of sample mix-up. Initial information concerning collection of the samples will be recorded in the field log book or on data sheets as described above. Information on the custody, transfer, handling, and shipping of samples will be recorded on a COC form. Figure 3-1, 3-2, and 3-3 are example chain-of-custody forms that are used for San Antonio Testing Laboratory, LCRA Environmental Laboratory, and ZymaX Forensics Isotopes Testing laboratory.

The sampler is responsible for initiating and filling out the COC form. The COC form will be signed by the sampler when he or she relinquishes the samples to anyone else. A COC form will be completed for each set of water quality samples collected, and will contain the following information:
• Sampler's signature and affiliation
• Project number
• Date and time of collection
• Sample identification number
• Sample type
• Analyses requested
• Number of containers
• Signature of persons relinquishing custody, dates, and times
• Signature of persons accepting custody, dates, and times
• Method of shipment
• Shipping air bill number (if the samples are shipped)
• Any additional instructions to the laboratory

The person responsible for delivery of the samples to the laboratory will sign the COC form, retain a copy of the form, document the method of shipment, and send the original form with the samples. Upon arrival at the laboratory, the person receiving the samples will sign the COC form and return a copy to the Project Manager. Copies of all COC documentation will be compiled and maintained in the central files. The original COC forms will remain with the samples until the time of final disposition. After returning samples for disposal, the laboratory will send a copy of the original COC to the Operator. This will then be incorporated into the central files.
Figure 3-1  Chain of Custody form Used by the San Antonio Testing Laboratory
### Figure 3-2  Chain of Custody form Used by the LCRA Environmental Laboratory

The Chain of Custody form used by the LCRA Environmental Laboratory includes fields for Sample ID, Collection Date and Time, Matrix, Container(s) Type/Preservative/Number, Requested Analysis, and more. The form is designed to track the handling and analysis process of environmental samples. Notable fields include those for transferring and receiving the samples, with instructions for proper documentation. The form emphasizes the importance of maintaining a chain of custody to ensure the integrity of the samples and the results of the analysis. The details on the form indicate a systematic approach to managing samples through various stages of the laboratory process.
**Figure 3-3  Chain of Custody form Used by the ZymaX Forensics Isotopes Testing Laboratory**
4.0 GROUNDWATER SAMPLING PROCEDURES

Groundwater sampling will be performed to collect water samples for inorganic and organic analyses, dissolved gases, and isotopic analyses of dissolved gas and dissolved inorganic carbon (DIC). Samples will be collected from water wells located at selected and approved sites. Prior to performing any work in the field, field personnel should review and understand the procedures described in a TWDB field manual (Boghici, 2003) for groundwater sampling.

Sample collection will be completed according to the following procedures (listed in order):

1. Prior to departure equipment required for proper sample identification and documentation will be assembled and inspected per SOP-1 (Sample Identification and Documentation). Laboratories will be contacted to request the bottles for the field collection of samples.

2. All monitoring and sampling equipment will be decontaminated as per SOP-12 (Decontamination And Prevention Of Cross-Contamination) prior to use and between each well.

3. At the well location, the physical condition and location of the well will be documented (e.g., photographs, global positioning system [GPS] position, and existing equipment). Information will be recorded on appropriate Field Data Sheet or in a field log book.

4. Prior to sampling each well, the water level will be recorded per SOP-2 (Water Level Measurement).

5. If possible, static well volume will be determined using the following calculation:

   \[ V = 5.875 \times D^2 \times (TD - WL) \]

   where:
   
   \[ V \] = well volume (gallons)
   \[ D \] = inside well diameter (feet)
   \[ TD \] = total well depth (feet)
   \[ WL \] = state water level (feet)

6. If a pump exists in the well or a dedicated sampling submersible pump can be inserted into the well, then SOP-5 (Purging a Monitoring Well With a Pump) should be used to purge the well. If no pump is available then a bailer can be used to purge the well based on SOP-7 (Purging a Monitoring Well With a Bailer).

7. Toward the end of purging and at the start of pumping, field parameters (pH, specific conductance, and temperature) will be collected. These field measurement will be collected and analyzed in accordance to SOP 3.0 (Measurement Of Field Parameters). After the parameters have stabilized, groundwater sampling will be collected. Generally, pH values within ±0.2 pH unit and conductivity and temperature readings within ±10 percent between consecutive readings indicate good stability of the water chemistry.

8. After purging the well, the groundwater samples will be collected per SOP-6 (Groundwater Sampling Using a Pump) if a pump is used or SOP-8 (Groundwater Sampling Using a Bailer) if a bailer is being used.

9. Water samples for inorganic and organic analyses will be collected using standard accepted sampling methods that are prescribed by the testing laboratory. Samples will be collected in pre-cleaned and pre-preserved containers provided by the analytical laboratory.
10. When possible, the sample will be collected from tubing (poly or silicone) attached to the pump discharge tap or spigot. If tubing cannot be attached to the discharge tap, samples can be filled directly from the tap. A clean temporary container may be filled from which filtered metal samples can be collected. If a water treatment system (e.g., water softener) is used by the homeowner, then the sample will be collected “upstream” of the system. Water samples will be collected by filling containers from the tubing and preserved as per analytical laboratory instructions.

11. Contact information for the analytical labs is provided in Section 5 “Laboratory Analytical Methods”. If any questions should arise regarding sampling, preservation, storage, or shipping the samples, field personnel should check with the analytical labs prior to making modifications to protocols described in this sampling and analysis plan.
5.0 Laboratory Analytical Methods

The analytes to be sampled and analyzed are presented in Table 5-1. All analysis are required to be performed by testing laboratories that are accredited through the Texas Laboratory Accreditation Program under the NELAP standard for matrices, methods, and parameters of analysis.

5.1 Sample Holding Times and Analyses

Sample holding times are established to minimize chemical changes in a sample prior to analysis and/or extraction. A holding time is defined as the maximum allowable time between sample collection and analysis and/or extraction, based on the nature of the analyte of interest and chemical stability factors. Holding times applicable for analytes are listed in Table 5-1. Samples should be sent to the laboratory as soon as possible after collection by hand delivery or an overnight courier service to minimize the possibility of exceeding holding times. For most samples, preservation by cooling to 4°C is required immediately after collection while the samples are held for shipment and during shipment to the laboratory. Table 5-1 summarized the bottle types used for sample collection and storage and preservation techniques by method or type of analyte. Laboratory specific requirements may supersede the procedures summarized in Table 5-1.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Analyte</th>
<th>Analytical Method</th>
<th>Container/Preservation</th>
<th>Maximum Holding Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Dissolved Metals (As, Ba, B, Cd, Cr, Co, Cu, Fe, Pb, Mn, Ni, Se, Ag, Zn, Ca, Mg, Na, K)</td>
<td>3005/6010</td>
<td>250 mL plastic preserved with HNO₃ (if filtered in the field). If not filtered in field then 250 mL unpreserved.</td>
<td>6 months</td>
</tr>
<tr>
<td>2</td>
<td>TDS</td>
<td>SM 2540 C</td>
<td>1 L Nalgene, unpreserved, 4°C</td>
<td>7 days</td>
</tr>
<tr>
<td></td>
<td>Alkalinity</td>
<td>SM 2320 B</td>
<td></td>
<td>14 days</td>
</tr>
<tr>
<td></td>
<td>pH</td>
<td>SM 4500 H +</td>
<td>500 mL Nalgene, unpreserved, 4°C</td>
<td>immediately</td>
</tr>
<tr>
<td></td>
<td>Specific Conductance</td>
<td>SM 2510 B</td>
<td></td>
<td>28 days</td>
</tr>
<tr>
<td></td>
<td>Br, Cl, F, SO₄ (dissolved)</td>
<td>EPA 300.0 (SW9056A)</td>
<td></td>
<td>28 days</td>
</tr>
<tr>
<td>3</td>
<td>Nitrate + Nitrite</td>
<td>EPA 300.0</td>
<td>250 mL Nalgene, preserved with H₂SO₄, 4°C</td>
<td>2 days</td>
</tr>
<tr>
<td>4</td>
<td>H₂S*</td>
<td>H 8131</td>
<td>250 mL Nalgene, preserved with ZnC₂H₃O₂₇, 4°C</td>
<td>As soon as possible</td>
</tr>
</tbody>
</table>
Table 5–1, continued

<table>
<thead>
<tr>
<th>Sample</th>
<th>Analyte</th>
<th>Analytical Method</th>
<th>Container/Preservation</th>
<th>Maximum Holding Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>TOC Dissolved</td>
<td>H 10129</td>
<td>500 mL Nalgene, unpreserved, 4°C</td>
<td>28 days</td>
</tr>
<tr>
<td></td>
<td>Isotope Analysis</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>δC13 of C1, C2</td>
<td></td>
<td>GC-IRMS (EPA, 2008)</td>
<td></td>
<td>6 months</td>
</tr>
<tr>
<td>δD of C1, C2</td>
<td></td>
<td>IRMS (EPA, 2008)</td>
<td></td>
<td>6 months</td>
</tr>
<tr>
<td>δO18 of H2O</td>
<td></td>
<td></td>
<td></td>
<td>6 months</td>
</tr>
<tr>
<td>δD of H2O</td>
<td></td>
<td></td>
<td></td>
<td>6 months</td>
</tr>
<tr>
<td></td>
<td>Hydrocarbon in headspace</td>
<td></td>
<td>Three 1-liter bottles with gas extraction cap., 4°C.</td>
<td>14 days</td>
</tr>
<tr>
<td></td>
<td>Fixed Gases</td>
<td></td>
<td></td>
<td>14 days</td>
</tr>
<tr>
<td></td>
<td>Gas in Water</td>
<td></td>
<td></td>
<td>14 days</td>
</tr>
</tbody>
</table>

* not currently NELAP Certified for these parameters

### 5.2 Laboratory Contact Information and Shipping Information

Prior to a sampling event, field personnel will coordinate the sampling event with the testing laboratory and request appropriate bottles be sent for sampling. In addition, the field personnel will coordinate overnight delivery samples to the laboratory and will work properly consider working around the days when a laboratory are not receiving samples such as some holidays and weekends. Table 5-2 provides the contact and shipping information for the analytical laboratories that POSGCD has approved for analytical work for their groundwater sampling program. Table 5-2 lists the laboratory that will be used by POSGCD at the time of the writing of this sampling and analysis plan. Over time, as the number of approved laboratories could increases, Table 5-2 will be updated to include the contact and shipping information for the additional approved laboratories.

### Table 5-2 Laboratory Contact and Shipping Information

<table>
<thead>
<tr>
<th>Laboratory</th>
<th>Shipping and Contact Information</th>
<th>Analyte Responsibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>ZymaX Forensics Isotope</td>
<td>600 S. Andreasen Drive Suite B</td>
<td>Samples associated with gas in water, fixed gases, and isotope analysis associated in Table 5-1</td>
</tr>
<tr>
<td>Yi Wang</td>
<td>Escondido, CA 92029</td>
<td></td>
</tr>
<tr>
<td><a href="mailto:YiWang@zymaxusa.com">YiWang@zymaxusa.com</a></td>
<td>760-781-3338 x 43</td>
<td></td>
</tr>
<tr>
<td>609-721-2843 (cell)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LCRA Environmental Laboratory</td>
<td>3505 Montopolis Drive P.O. Box 220</td>
<td>All analytes associated with the samples 1 to 5 in Table 5-1</td>
</tr>
<tr>
<td>Services</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Susan Benavidez</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Edward County</td>
<td>Contact Information</td>
<td>Notes</td>
</tr>
<tr>
<td>------------------------</td>
<td>---------------------</td>
<td>-------</td>
</tr>
<tr>
<td>County Engineer</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>County Clerk</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>County Auditor</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>County Surveyor</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**San Antonio Testing Laboratory, LLC**

<table>
<thead>
<tr>
<th>Name</th>
<th>Phone Number</th>
<th>Email Address</th>
<th>Address</th>
<th>Fax Number</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marcela Hawk</td>
<td>210-229-9920</td>
<td><a href="mailto:mhawk@satestinglab.com">mhawk@satestinglab.com</a></td>
<td>1610 S. Laredo Street, San Antonio, TX 78207</td>
<td>210-229-9921</td>
<td>All analytes associated with the samples 1 to 5 in Table 5-1</td>
</tr>
</tbody>
</table>
6.0 QUALITY ASSURANCE AND QUALITY CONTROL

The quality assurance and quality control (QA/QC) program described herein has been developed to ensure the usability and reliability of sampling and analysis data, and provides for routine application of procedures for controlling the measurement process. Standard procedures described in this section ensure that data collected in the field, analyzed by the laboratory, and entered into a POGCD water quality database will be of appropriate quality to meet the data needs and data quality objectives.

Quality control is a system of routine technical activities that accounts for and quantifies as many potential measurement errors as possible in order to evaluate uncertainties associated with any given measurement. Errors that influence environmental measurements can be introduced in the field during sample collection, during shipment, in the laboratory, and during database entry.

6.1 FIELD QUALITY CONTROL

Field quality control consists of collecting quality control samples, decontaminating field sampling equipment, operating/maintaining/calibrating field equipment in accordance with manufacturer’s instructions, using disposable equipment where possible, following standard operating procedures (SOPs – Appendix A), using standard field forms, using trained personnel for sampling, and adherence to this Plan of Study.

The following quality control samples will be collected, on occasion, label in accordance with SOP-4 (Quality Control Samples) (Appendix A) and submitted to the analytical laboratories:

Field Duplicate Sample: Field duplicates are two samples taken from the same media at the same time and under similar conditions, both sets of which are submitted to the same laboratory. The duplicate sample bottles are labeled in a way that does not reveal their identity to the laboratory. Field duplicate samples will be collected at a frequency not least than 1 per 20 natural samples collected.

Field Split Sample: Field split samples are the same as “field duplicate samples”, with the exception that the duplicate sample is submitted to a different laboratory. Field split samples are not planned for this sampling and analysis program, but may be incorporated if a situation arises that warrants their use or if additional funding becomes available.

Field Equipment Blank Sample: Field equipment blank will be prepared in the field by running deionized water through decontaminated reusable sampling equipment (for instance a bailer) and collected in laboratory-supplied sample containers. Equipment blanks will be considered only if multiple wells will be sampled using a bailer during the same sampling event. Equipment blank bottles will be labeled in a manner that does not reveal their status to the laboratory. Equipment blanks will not be used for gas sampling from water supply well casings and production wells, or groundwater sampling for isotope analysis.

Field Blanks: Field blanks will be prepared using deionized water provided by the analytical laboratory and submitted with the natural samples. Field blanks will be collected if there is a high sensitivity with the analyses at a specific well. Field blanks will be labeled in a manner that does not reveal their status to the laboratory.
**Standard Reference Sample:** Standard reference samples are certified liquids with known concentrations of selected constituents that are prepared by an agency or private laboratory. These samples are submitted to the laboratory at the same time as the natural samples. Although the laboratory may be able to recognize the standard reference samples, it would not know the acceptable concentration range for each constituent. Accuracy statements about the analysis can be generated by comparing laboratory results to the acceptable range of each constituent provided by the supplier of the blind standard reference samples. At the time of the preparation of this sampling and analysis plan, no standard reference samples are planned.

### 6.2 LABORATORY QUALITY CONTROL

Laboratories are requested to provide the following information to support analytical results for each parameter:

- Sample preparation method reference
- Analytical method reference
- Method detection limit (MDL)
- Reporting or practical quantitation limit (PQL)
- Units of measure
- Sample collection and analysis dates
- Chain-of-custody record initiated by the sampler
- Sample condition upon receipt, including temperature
- Adherence to designated holding time
- Method blank results
- Laboratory duplicate results and relative percent difference
- Laboratory control standard recovery
- Matrix spike (MS) recovery
- Matrix spike duplicate (MSD) recovery
- Initial and continuing calibration checks

Laboratories are requested to meet and document certain certification, licensing, accreditation, and/or auditing requirements, such as adherence to EPA requirements and/or ISO Standard 17025. The laboratories are also requested to provide documentation for their quality control programs.

Laboratory quality control samples will be prepared and analyzed in accordance with procedures described in the analytical laboratory’s Quality Assurance Manual. At a minimum, these will include:

- Method Blanks
- Matrix Spike / Matrix Spike Duplicate Samples
- Certified Reference Materials or Laboratory Control Samples; and,
- Laboratory Duplicates.

Criteria for acceptance of laboratory data with respect to precision and accuracy include the following:
**Laboratory Method Blank Sample:** No target analytes should be detected in laboratory blanks. The method blank is processed through the entire analytical procedure in a manner identical to the natural samples. Under certain conditions, corrective action will be performed by the laboratory to identify and eliminate the source(s) of contamination and samples shall be re-digested and analyzed, as appropriate. If eliminating the blank contamination is not possible, all impacted analytes in the sample batch will be qualified in accordance with EPA guidance for the Contract Laboratory Program (CLP) (EPA 2004a, 2004b).

**Laboratory Matrix Spike Sample:** The laboratory shall use both pre-digestion and, when warranted, post-digestion matrix spike samples for inorganic analytes, and matrix spike/matrix spike duplicate (MS/MSD) samples for organic analytes to evaluate potential sample matrix interferences. The laboratory shall conform to sample frequencies, control limits, and data qualifiers specified in EPA guidance for the CLP (EPA 2004a, 2004b).

**Certified Reference Materials or Laboratory Control Sample:** These samples contain certified concentrations of the analytes of interest, as determined through replicate analyses by a reputable certifying agency using two independent measurement techniques for verification. Control limits on analyte percent recoveries are lab-specific, and are stated in each laboratory’s Quality Control Manual. As a general requirement, laboratory control limits should meet or exceed those specified by the EPA for the CLP (EPA 2004a, 2004b).

**Laboratory Analytical Duplicate Sample:** Agreement between analytical results for laboratory duplicate samples is evaluated using the relative percent difference (RPD) between the two results. In accordance with EPA CLP guidelines EPA (2004a, 2004b) a RPD of 20 percent or less is considered an acceptable control limit without data qualification if concentrations of both samples are >5x the PQL. If results are <5x the PQL, the PQL will be the control limit.

The RPD is defined by the following equation:

\[
\text{RPD} = \frac{\text{[(sample – duplicate value)}]}{\text{[(sample + duplicate value) ÷ 2]}} \times 100
\]

**Continuing Calibration Checks:** Calibration check solutions traceable to a recognized organization are inserted as part of the sample stream on a routine basis. Source of the calibration check solution shall be independent from the standards used for calibration. Calibration check solutions used for the continuing calibration checks will contain all analytes of interest.

**Participation in Inter-Laboratory Comparison:** These exercises provide a tool for continuous improvement of laboratory measurements by helping the analysts identify and resolve problems of methodology and/or quality control. Results of these exercises are also used to evaluate both the individual and collective performance of the participating analytical laboratories on a continuing basis, and to insure that ongoing measurements are meeting standards. The participating laboratories should initiate corrective action if their performance in the comparison exercises falls below certain predetermined minimal standards.
6.3 DATABASE AND REPORTING

Laboratories report analytical data in paper and electronic formats (database spreadsheet and PDF). Paper copies are placed in appropriate project files, whereas electronic field and laboratory data are stored in a computer database specific for the project. The laboratory method detection limit (MDL) is used to define the analytical limit or sensitivity of detectability. The Code of Federal Regulations (40 CFR Part 136, 1993) provides the following definition:

The MDL is the minimum concentration of a substance that can be measured and reported with 99% confidence that the analyte concentration is greater than zero.

Normally, the MDL is set at three times the standard deviation, or the t-distribution times the standard deviation, of a minimum of seven replicate measurements of a given spiking concentration. Values at the MDL may not reflect a signal much above zero, and therefore, are quantitatively not very meaningful.

The practical quantitation limit (PQL) is considered the lowest concentration that can be reliably measured within specified limits of precision and accuracy during routine laboratory operating conditions. The PQL is determined either through the use of inter-laboratory study data, or through the use of a multiplier times the MDL. Using these definitions, measurements below an MDL are not believable, measurements between the MDL and PQL are semi-quantifiable, and measurements above the PQL have a high degree of confidence.

Some laboratories use the term reporting limit (RL), which is a limit imposed upon the reporting laboratory by a client or regulatory agency. The reporting limit typically is associated with either the MDL or PQL.

Concentrations of chemicals that exceed the MDL but do not exceed the PQL are often reported as “estimates”. A value reported by the laboratory that is less than the detection limit, which is either the MDL or PQL depending on the needs of the end-user, is an estimated concentration. For statistical purposes, non-detect values most commonly are represented as one-half the detection limit. The EPA (2006) specifies guidelines for evaluating data that includes values below the detection limit. The suggested procedures depend upon the amount of data below the detection limit.
7.0 REFERENCES

API, 2009, Hydraulic fracturing operations – well construction and integrity guidelines: API Publishing Services, American Petroleum Institute, Washington, D.C.,


# Appendix A

## List of Standard Operating Procedures

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<th>Standard Operating Procedure</th>
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<td>1 SAMPLE IDENTIFICATION AND DOCUMENTATION</td>
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</tr>
<tr>
<td>3 MEASUREMENT OF FIELD PARAMETERS</td>
</tr>
<tr>
<td>4 QUALITY CONTROL SAMPLES</td>
</tr>
<tr>
<td>5 PURGING A WELL WITH A PUMP</td>
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<td>9 MICRO PURGING A MONITORING WELL</td>
</tr>
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<td>10 GROUNDWATER SAMPLING USING A LOW-FLOW TECHNIQUE</td>
</tr>
<tr>
<td>11 GROUNDWATER SAMPLES FOR VOLATILE ORGANIC COMPOUND (VOC)</td>
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<td>12 DECONTAMINATION AND PREVENTION OF CROSS-CONTAMINATION</td>
</tr>
<tr>
<td>13 SAMPLE HANDLING AND CONTROL</td>
</tr>
</tbody>
</table>
1.0 METHOD SUMMARY
This standard operating procedure (SOP) provides guidance for sample identification and documentation. The purpose of these procedures is to insure that samples are properly labeled and handled.

2.1 EQUIPMENT/APPARATUS/REAGENTS
2.2 Equipment List
- Field logbook;
- Sample labels;
- Indelible pens;
- Digital camera;
- Shipping labels and manifests;
- Chain-of-custody (C-O-C) labels and
- C-O-C documentation records.

3.1 PROCEDURES
FIELD LOGBOOK ENTRIES
All sample locations will be visually inspected, described in the field logbook, and photographed. Information regarding sample collection and all measurements and calculations performed relating to the sample location will be entered into the field logbook in accordance with SOP for Field Activity Documentation and Reporting. At a minimum, the following information will be recorded in the field logbook in indelible ink:
- date and time of sample collection;
- environmental matrix and sample type (e.g., soil composite or groundwater grab);
- sample collection method;
- sample preservation method;
- name of the person who collected the sample;
- sample identification number
- depth and interval sampled (e.g., a three inch soil interval was collected from the three to six inches deep);
- field measurements made on the sample during collection, e.g., photoionization readings using a photoionization detector (PID);
- when low-flow technology used, the flow rate (e.g., mL/min) as the sample was collected;
- GPS file number or latitude and longitude coordinates;
- photograph number, date and time with a description of the purpose of the photograph (e.g., “This photo documents the sample collected at location X of material released to soil from the corroded and leaking drums in the drum storage area observed and documented in photos 2 & 3.”);
- name of photographer and direction of the photograph (e.g., NNW, SE...);
- relevant observations such as soil color, obvious staining, and weather conditions; and
- deviations from the Superfund Quality Assurance Project Plan, Field Sampling Plan, or Superfund SOPs.
1.0 Sample Identification

A unique sample identification numbering system should be used. Samples shall be uniquely identified, labeled, and documented in the field at the time of collection. Samples should be identified with standard sample labels which are affixed to the sample containers. The following information shall be included on the sample label at the time of collection using permanent ink:

- Project number
- Field identification or sample station number
- Date and time of sample collection
- Designation of the sample as a grab or composite
- Whether the sample is preserved or unpreserved
- The types of analyses to be performed
- Any relevant comments (such as readily detectable or identifiable odor, color, or known hazardous properties)
- Signature or initials of the sampler(s)

DOCUMENTATION OF WELL DATA

Well data will be recorded for each sampled drinking water well, monitor well, or other groundwater sampling point. This information includes, but is not limited to:

- well name or number;
- address;
- owner and/or tenant;
- condition of the well, pump, filter system etc;
- total depth of well (when possible);
- water and non-aqueous phase liquid levels (when possible);
- “totalizer” readings;
- purge volumes and times;
- field parameters;
- date; and
- sampling information.

PHOTOGRAPHIC DOCUMENTATION

All sample locations will be photographed. Sample location photographs will include a sign showing date sampled and sample location number and an available landmark, such as a fencepost, tree, or other feature. The field logbook will include a table cross-referencing sample locations and photograph numbers. The photographic log will also identify and describe any salient features in the photographs.

2.0 SAMPLE BOTTLE LABELING

Sample bottles may be temporarily labeled prior to or immediately after sample collection. Sample bottles will be permanently labeled as soon as practical after collection. Sample labels will include:
field sample ID,
- project name and number,
- sampling date and time,
- name of the sample collector,
- method of sample preservation, and
- laboratory analyses required.

3.0 FIELD SAMPLE IDs

Logical and organized sample identification number conventions will be used. Previously established sample identification number conventions for the site will be followed unless requested otherwise by the TCEQ PM. An example sample numbering system is detailed below:

- identify source or waste material samples using the prefix “XX” followed by a sequential number.
- identify soil samples using the prefix “SO” followed by a sequential number.
- identify sediment samples using the prefix “SE” followed by a sequential number.
- identify surface water samples using the prefix “SW” followed by a sequential number.
- identify monitor well samples using the prefix “MWxx” where “xx” refers to the monitor well number) followed by a date sequence number (e.g. 110809 for August 9th, 2011).
- identify drinking water well samples using the prefix “DWxx” where “xx” refers to the well number or other identifying label) followed by a date sequence number.
- identify other groundwater samples using the prefix “GW” followed by a date sequence number.
- identify field duplicate samples with a selected number. Include collection times as a random increment of time after the collection time of the first duplicate sample. The identification of duplicate samples should not include any information the laboratory could use to identify the samples as duplicates. Record duplicate pair samples along with the actual time of collection in the field logbook.
- identify field blanks and equipment rinsate blanks either as groundwater (“GW”) or surface water (“SW”) samples followed by a selected number. The actual identification of these samples should be recorded in the field logbook and should be associated with the prefix “GW” or “SW” according to the actual sample and time of collection.
- identify trip blanks using the prefix “TB” followed by a sequential number.

4.0 CHAIN-OF-CUSTODY (C-O-C) DOCUMENTATION

All sample shipments will be accompanied by the C-O-C record which identifies the contents of the shipment. The original C-O-C record plus copies will accompany the shipment with one copy retained in the project file. Another copy will be returned to the project team with the analytical results.

The samples will be relinquished to representatives of the carrier service (e.g., Federal Express, United Parcel Service) or be delivered directly to the laboratory by the CONTRACTOR. When the samples are relinquished to the carrier service, a notation to that effect will be made on the C-O-C record.
When samples are delivered directly to the laboratory, the C-O-C record will be signed by the receiving laboratory personnel.

Preformatted C-O-C records will be used as the primary documentation mechanism to ensure that information pertaining to each sample is recorded. In addition, field notebooks containing a sample log will be maintained for all samples collected. Copies of the C-O-C records and the field logs will be retained in the project file.

5.0 CAUTIONS AND INTERFERENCES

The C-O-C should be verified against the documentation in the logbook, field data sheets, and FSP to ensure that the sample identification information and requested analyses and turn-around times are correct. Any edits to the C-O-C, sample bottle labels, logbooks, or field data sheets should be made by a single strike through the incorrect information and the initials of the sampler or person having custody of the samples.
1.0 METHOD SUMMARY
An accurate water level measurement is necessary to calculate purge volumes and to create water level surface maps. This SOP describes the steps necessary to collect a water level/sediment level from a monitoring well.

2.0 EQUIPMENT/APPARATUS/REAGENTS
The following is a typical equipment list used for water level/sediment measurement of groundwater monitoring wells.

2.1 Equipment List
- Water level indicator/e-line
- Well keys
- Logbook
- As-built diagrams of monitoring wells
- Calculator
- Plastic sheeting
- Cotton string
- Clear bailers
- Nylon rope
- Weights
- Measurement tape

3.0 PROCEDURES
3.1 Water level
1. Inspect the well for signs of tampering or other damage. If tampering is suspected, (i.e., casing is damaged, lock or cap is missing) this shall be recorded in the field log book and on the well sampling form and reported to the Field Operations Leader.
2. Remove locking well cap, note location, time of day, and date in field notebook or appropriate log form.
3. Remove well casing cap.
4. Record whether a pump is in place and any information regarding recent pumping history in nearby the well.
5. Turn on the water level meter.
6. Press the battery check button (if so equipped). A solid tone will be heard if the battery is good.
7. Lower water level measuring device or equivalent (i.e., permanently installed transducers or airline) into well, unreeling the measuring tape from the spool of the meter as you go.
8. Continue lowering the probe until a continuous tone is heard. This tone indicates that the probe has come in contact with the water.
9. Holding the measuring tape near the measuring reference point, alternately raise and lower the probe across the depth at which the tone sounds. This will ensure that you have an accurate measurement of the depth to water. Record the distance from water surface to the referenced measuring point on well casing in site logbook. Alternatively, if there is no reference point, note that water level measurement is from top of steel casing, top of PVC riser pipe, from ground surface, or some other position on the wellhead, typically on the north edge. Water level measurement should be recorded to the nearest 0.01 foot.

10. Measure total depth of well (at least twice to confirm measurement) and record in the site logbook or field data sheet. Total depth measurements should be recorded to the nearest 0.01 foot.

11. If the field investigator suspects that excessive sediment buildup may be occurring at the bottom of the well, the measured total depth should be compared with the total depth at the time of drilling (from boring log). If the sediment thickness exceeds one foot, or is excessively impeding the flow of groundwater through the well screen, the well shall be redeveloped in accordance with SOP 5.6 (Monitor Well Development/Abandonment).

12. Decontaminate water level probe in accordance with SOP 1.5 (Decontamination).

4.0 CAUTIONS AND INTERFERENCES
Water levels in wells should measured from the least contaminated to the most contaminated or from upgradient to downgradient if chemistry is unknown.
1.0 METHOD SUMMARY
Field parameters are collected during surface water or groundwater sampling events to identify physical/chemical characteristics of the sample that are representative of field conditions as they exist at the time of sample collection. They are also used to indicate when stagnant water has been removed from the well so that sampling may begin. Numerous instruments are commercially available for measuring field parameters. The setup and use of all instruments should follow a basic format to imply consistency of use. Regardless of the brand of meter used, all meters should be properly maintained and operated in accordance with the manufacturer=s instructions and calibrations should be checked prior to use.

2.1 EQUIPMENT/APPARATUS/REAGENTS
The following is a typical equipment list used for measuring field parameters:

2.2 Equipment List

- Logbook
- Field data sheets
- Decontamination solutions
- Tap water
- Field parameter instruments (pH meter, thermometer, conductivity meter)
- Calibration standards
- Tap water
- Non-phosphate soap (Note: Alconox is not considered a non-phosphate soap; rather a low-phosphate soap)
- Glass bulb thermometer

3.1 PROCEDURES
3.2 Temperature
Temperature is a measure of hotness or coldness on a defined scale as measured using a thermometer. Typical types of thermometers include:

- Digital (thermo-couple) thermistor
- Glass bulb mercury filled
- Bi-metal strip/dial indicator

No matter which type of thermometer is used, it should be calibrated prior to use, if possible. Digital thermometers should be calibrated prior to use by comparison with a mercury bulb thermometer and should agree within ± 0.5 °C.

The procedures for measuring temperature are as follows:
1. Clean the probe end with analyte-free water and immerse into sample.
2. Swirl the thermometer in the sample.
3. Allow the thermometer to equilibrate with the sample.
4. Suspend the thermometer away from the sides and bottom to observe the reading.
5. Record the reading in the field log book or on the appropriate sampling log sheet. Units of temperature are degrees Celsius (°C) and should be recorded to the nearest tenth (0.1).

Conversion Formulas:

\[ ^\circ F = (1.8 ^\circ C) + 32^\circ \]  or  \[ ^\circ C = 0.56 (^\circ F - 32^\circ) \]
3.3 pH

Hydrogen ion concentration (pH) is used to express both acidity and alkalinity on a scale which ranges from 0 to 14 with 7 representing neutrality.

The procedures for measuring pH in the field are as follows:

1. Calibrate the instrument in accordance with the manufacturer=s specifications.
2. Collect a sample. Measure the temperature prior to measuring the pH.
3. Immerse the probe in the sample, keeping it away from the sides and bottom of the sample container. Allow ample time for the probe to equilibrate with the sample.
4. While suspending the probe away from the sides and bottom of the sample container, record the pH. Units of pH are standard units and should be recorded in tenths (0.1).
5. Rinse the probe with analyte-free water and store it in an analyte-free water filled container until the next sample is ready.
6. Perform a post calibration at the end of the day and record all findings.

3.4 Conductivity

Conductivity is defined as the quality or power of conducting or transmitting. The procedures for measuring conductivity in the field are as follows:

1. Calibrate the instrument in accordance with the manufacturer=s specifications.
2. Collect the sample and check and record its temperature.
3. Correct the conductivity instruments temperature adjustment to the temperature of the sample (if required).
4. Immerse the probe in the sample keeping it away from the sides and bottom of the container. It is important that the entire portion of the probe be wetted by the sample. This will be evident when some of the sample water is seen coming out of the small weep hole.
5. Record the result in the field log book or field sampling sheet. Units of conductivity are micro ohms per centimeter (μohms/cm) at 25°C. Results should be reported to the nearest 10 units for readings below 1,000 μohms/cm and to the nearest 100 units for readings above 1,000 μohms/cm.
6. Rinse probe.

3.5 Dissolved Oxygen

Dissolved oxygen (DO) should be measured in-situ or adown hole whenever possible. If in-situ measurements are not possible, precautions should be taken to minimize the time the sample is exposed to ambient air. Dissolved oxygen readings should not exceed the saturation limit of oxygen in water (8 to 10 mg/l). If readings greater than 10mg/l are observed, the meter is probably not functioning correctly. The procedures for collecting a DO sample are as follows:

1. Inspect the membrane of the DO meter for air bubbles and/or holes. If air bubbles or holes exist, replace the membrane.
2. Calibrate the DO meter in accordance with the manufacturer=s specifications.
3. Measure the temperature of the sample and adjust the temperature setting of the DO meter, if so equipped.

4. Record the reading in the field log book or field sampling sheet. Dissolved oxygen is measured in units of mg/l. Results should be reported to the nearest tenth of a unit (0.1).

3.6 Turbidity

Turbidity is measured using a nephelometer/turbidimeter. The procedures for measuring turbidity are as follows:

1. Rinse the sample cell with analyte-free water.

2. Follow the manufacturer=s specifications for collecting a turbidity measurement.

3. Record the reading in the field log book or field sampling sheet. The units of turbidity are nephelometric turbidity units or NTUs. Units should be recorded to the nearest whole unit.

4.0 CAUTIONS AND INTERFERENCES

Refer to owner=s manual for instructions on proper calibration methods of all field parameter measuring equipment.
1.0 METHOD SUMMARY
Quality control (QC) samples are collected to determine if sample bottle preparation, shipment, handling, and storage procedures result in contamination or other effects on environmental samples. QC samples include:

- Equipment Blanks.
- Trip Blanks.
- Field Blanks.
- Temperature Blanks.
- Field Duplicate Samples.
- Field Split Samples.
- Matrix Spike/Matrix Spike Duplicates (MS/MSD).

2.0 EQUIPMENT/APPARATUS/REAGENTS
The following equipment is used for collection of QC samples:

- Pre-cleaned sample containers (with preservatives, if required)
- ASTM Type II reagent grade water or Distilled Water
- Other equipment as prescribed for collecting samples

3.0 PROCEDURES
3.1 EQUIPMENT BLANKS
Equipment blanks are used to assess the effectiveness of equipment decontamination procedures. An equipment blank (also known as a rinsate blank) is a sample of ASTM Type II reagent grade water poured into, over, or pumped through the sampling device; collected in a sample container; and transported to the laboratory for analysis. These blanks are collected immediately after the equipment has been decontaminated and are analyzed for all laboratory analyses requested for the environmental samples collected with that equipment.

FREQUENCY
Equipment blanks are not collected from disposable or dedicated (e.g., a monitoring well bailer dedicated to a single well) equipment. They are collected at a frequency of one blank per equipment type, per environmental media, per day.

PROCEDURE
Equipment blanks should be collected using the following procedures:
1. Properly decontaminate the sampling device [see SOP 1.5 (Decontamination)].

2. Select the proper sample containers and an appropriate quantity of ASTM Type II reagent grade water.

3. Complete the sample labels with the appropriate information.

4. Slowly pour the ASTM Type II reagent grade water through or over the sampling device until the sample bottle is filled to the appropriate level.

5. Securely tighten the cap on the bottle.

6. Prepare the bottle for shipment in accordance with SOP 6.4 (Sampling Handling and Control).

**DATA EVALUATION**

Contamination detected in the equipment blank may indicate that contamination was introduced by the sampling equipment. If the same analytes are found in the field samples, these analytes may represent contamination originating from the sampling equipment.

### 3.2 TRIP BLANKS

Samples can be contaminated by diffusion of volatile organic compounds (VOCs) through the septum seal into the sample during storage, shipping, and handling. Contamination may also be present in the bottles used to contain the sample or in the reagent grade water.

Trip blanks are used to assess the potential introduction of VOC contaminants to the sample during sample handling, transportation, and storage. They consist of a VOC sample vial filled in the laboratory with ASTM Type II reagent grade water, transported to the sampling site, handled like an environmental sample, and returned to the laboratory for analysis. The trip blank is shipped and stored with VOC water samples and should not be opened in the field.

**FREQUENCY**

Trip blanks are prepared only when VOC samples are collected and are analyzed only for VOC analytes. One trip blank should be included in each sample cooler containing samples for VOC analysis.

**PROCEDURE**

The procedures for submitting a trip blank are:

1. Prepare the coolers for shipment to the laboratory. If possible, pack all samples for VOC analysis in one cooler so that only one trip blank is required.

2. Identify the trip blank on the chain-of-custody record. If the project will continue for several days, be sure to number trip blanks sequentially so that multiple trip blanks with the same identification number are not submitted to the laboratory.
DATA EVALUATION

Contamination detected in the trip blank may indicate that contamination was present in the sample bottles or was introduced during sample handling. If the same analytes are found in the field samples, these analytes may represent contamination introduced during sample handling, transportation, or storage.

3.3 FIELD BLANKS

Field blanks are used to assess the potential introduction of contaminants from field sources (e.g., gasoline motors in operation) to the samples during sample collection. A field blank consists of ASTM Type II reagent grade water poured into a VOC sample vial at the sampling site (in the same vicinity as the associated samples). Field blanks must be collected downwind of possible VOC sources. The field blank is handled like an environmental sample and transported to the laboratory for analysis.

FREQUENCY

Field blanks are prepared only when VOC samples are collected and are analyzed only for VOC analytes. They are collected at a frequency of one blank per 20 VOC samples for each matrix.

PROCEDURE

The procedures for collecting field blanks are:

1. Select the proper sample containers (VOC vials) and an appropriate quantity of ASTM Type II reagent grade water.

2. Complete the sample labels with the appropriate information.

3. Pour the ASTM Type II reagent grade water into the vial just to overflowing so that there is a meniscus at the top of the vials.

4. Securely tighten the lid on the sample vials.

5. Prepare the sample for shipment in accordance with SOP for Sampling Handling and Control.

DATA EVALUATION

Contamination detected in the field blank may indicate that VOC contamination was introduced from field sources. If the same analytes are found in the field samples, these analytes may represent contamination introduced during sample collection, transportation, or storage.

3.4 TEMPERATURE BLANKS

Temperature blanks are prepared by the analytical laboratory and included in the shipment of sample coolers and containers. They are used to determine the temperature of the environmental samples upon receipt by the laboratory.
FREQUENCY

A temperature blank will be included with each cooler sent to the laboratory with environmental samples.

PROCEDURE

Temperature blanks are typically prepared by the analytical laboratory and included in the shipment of sample coolers and containers. The temperature of temperature blank samples is measured by the laboratory upon receipt of environmental samples.

DATA EVALUATION

Excessive temperature in the blank may indicate the potential for analyte loss or degradation prior to sample analysis.

3.5 FIELD DUPLICATE SAMPLES

Field duplicate samples are collected simultaneously or in immediate succession, using identical recovery techniques, and treated in an identical manner during storage, transportation, and analysis. Locations for field duplicate samples should be designated prior to field work but should be adjusted in the field based on field observations. They are shipped “blind” to the laboratory (the nomenclature used to identify the duplicate sample does not reveal to the laboratory that the sample is part of a field duplicate pair).

3.6 FIELD SPLIT SAMPLES

Field split samples are collected by retrieving double sample volume from the environmental matrix from one location, fully homogenizing the complete volume, and from that homogenized volume collecting two separate aliquots. Each aliquot is given a unique sample number. Field split samples are intended to evaluate laboratory precision if sent “blind” to the same laboratory. Field split samples are intended to evaluate inter-laboratory precision if the samples are sent to separate laboratories and each laboratory performs the same analysis using the same standard operating procedure(s) for the preparation and analysis of the sample.

FREQUENCY

The frequency of collection of field duplicates is specified in the FSP.

PROCEDURE

The procedures for collecting field duplicates are:

1. Select the proper sample containers for collecting two samples.
2. Complete the sample labels with the appropriate information.
3. Specify the locations designated for the collection of field duplicate samples. (If possible, collect field duplicate samples in areas known to be contaminated to assess the laboratory’s ability to measure contamination).

4. Collect the sample as required.
   a. Groundwater Samples
      i. Collect the sample in accordance with the appropriate sampling SOP.
      ii. Fill the first sample bottle half full with the pump or bailer then fill the second sample bottle half full. Fill the remainder of each sample bottle beginning with the first bottle. If a bailer is used, attempt to fill equal quantities from each bailer load into both bottles.
   b. Soil Samples
      i. Collect double the required volume of soil for a normal sample in accordance with the appropriate sampling SOP.
      ii. Place the soil in a stainless steel bowl and mix the sample with a stainless steel spoon. Do not mix samples for VOC analysis as the mixing process may cause a release of VOCs.
      iii. Arrange the soil into quarters within the sample bowl and set aside two of the quarters.
      iv. Mix the sample again.
      v. Fill the appropriate sample jars using the material from the bowl, placing equal portions of soil in each bottle.

5. Securely tighten the caps on the sample bottles.

6. Prepare the sample for shipment in accordance with SOP 6.5 (Sampling Handling and Control).

DATA EVALUATION

Field duplicate sample results may be used to assess total precision, which includes the inherent spatial variability of contaminants in the field, the sample collection process, any mixing process employed, and the laboratory extraction and analysis process. The two largest components of variability (imprecision) are the inherent spatial variability of contaminants in the field and the mixing process. These two components of variability cannot be assessed separately from the other components of variability through the collection of low numbers of field duplicate samples. There are no corrective actions for the failure to achieve duplicate goals.

Field duplicate sample collection and analyses result in two equally valid analytical results (hence the term “duplicate”). Neither the “original” sample nor the “duplicate” sample is more valid than the other. Therefore, both sample results should be considered in environmental projects. As listed below, several options are available depending on the situation and the goal of the project:

1. Use both sample results;
2. Use the mean of the two sample results; or
3. Use the maximum of the two sample results.

3.6 MATRIX SPIKE/MATRIX SPIKE DUPLICATE (MS/MSD)
A matrix spike is a measured, known amount of target analyte which is added to a sample prior to extraction and analysis in order to determine the effects the sample matrix (e.g., soil, waste, or water) has on the recovery of contaminants.

Frequently the sample to be used for spiking is split into three aliquots, two of which are spiked with known concentrations of contaminants. Many laboratories can prepare the MS/MSD samples from the submitted sample volume, while others may require additional (e.g. triplicate) volume. The two spiked aliquots are known as the matrix spike (MS) and the matrix spike duplicate (MSD) sample.

The MS and MSD are spiked at a level less than or equal to the midpoint of the calibration curve for each analyte identified in the FSP. When the contaminants are not identified in the FSP, the MS/MSD are spiked with a subset of the analytes included in the laboratory’s initial calibration standard mixture(s) that are representative of the range and characteristics of the calibrated analytes. All three aliquots are analyzed.

The choice of which sample to select for the MS/MSD analysis is important. If left up to the laboratory, a relatively contaminant-free sample, which is likely to provide good matrix spike recoveries, may be selected. This practice circumvents the primary purpose of the MS/MSD analysis, which is to assess matrix effects that may be associated with samples from a site. Therefore, the sample to be used for the MS/MSD should be designated by the field team from likely contaminated areas; however, source areas or sample locations with known high concentrations should not be selected for the MS/MSD analysis. Only TCEQ project samples should be used for the MS/MSD on Superfund projects.

FREQUENCY
One MS/MSD sample will be designated for every 20 environmental samples per environmental medium.

PROCEDURE
The following procedures apply to MS/MSDs:

1. Contact the laboratory to confirm the necessary volume for MS/MSD samples.
2. Plan which field locations will be appropriate to collect MS/MSD samples.
3. Collect the required volume for the designated sample(s).
4. Identify the MS/MSD and associated parent sample on the chain of custody.
5. Ship the sample with other environmental samples.
6. Confirm that the TCEQ samples were analyzed as the MS/MSD at the required frequency.
DATA EVALUATION

Percent recoveries are calculated for each of the spiked analytes to give an indication of how the matrix is affecting the reported concentrations (i.e. the direction and magnitude of any potential bias to the reported sample results). The relative percent difference (%RSD) between the MS and the MSD is calculated to assess the analytical precision of the laboratory. TCEQ does not use the MS/MSD to control the analytical process.

4.0 CAUTIONS AND INTERFERENCES

The types of QC samples and frequency for collection are outlined in the project Quality Assurance Project Plan (QAPP). It is important to identify the sample frequency in the Field Sampling Plan (FSP). QC samples should be selected to match the sampling program (i.e., it is not necessary to collect trip blanks for sites where only samples for metals analysis are being collected).
1.0 METHOD SUMMARY

Purging is the process of removing stagnant water from a monitoring well, immediately prior to sampling, causing its replacement by groundwater from the adjacent formation, which is representative of actual aquifer conditions. If a monitor well is pumped or bailed dry, it will be allowed to recover to 85 percent of the original water volume before sample collection. If the monitor well does not recover to within 85 percent of the original water volume within 24 hours, but a sufficient volume of water is present to collect a sample, the sample will be collected from the available water and the volume of water will be recorded in the field logbook. If the monitoring well is to be purged and sampled using micro purging and low-flow sampling techniques, refer to SOP for Micro Purging a Monitoring Well.

2.1 EQUIPMENT/APPARATUS/REAGENTS

The following is a typical equipment list used for purging groundwater monitoring wells a pump.

2.2 Equipment List

- Logbook
- As-built diagrams of monitoring wells
- Calculator
- Field data sheets
- 5-gallon buckets
- Plastic sheeting
- Generator, if using pump
- Air compressor for bladder pumps
- Pump
- Gasoline for generator/air compressor
- Discharge tubing for pump
- Control box (if necessary)
- Appropriate pump fittings (e.g., hose clamps, barbed fittings, etc.)
- Drums
- Marking pen for labeling drums
- Wrench for opening/sealing drums
- Appropriate PPE

3.0 PROCEDURES

1. Determine the diameter of the well in inches.

2. Select the "Gallons/Linear Foot of Water Column" from Table 1 corresponding to the diameter of the well.

<table>
<thead>
<tr>
<th>Well Casing Diameter</th>
<th>Gallons/Linear Foot of Water Column</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.041</td>
</tr>
<tr>
<td>2</td>
<td>0.163</td>
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<tr>
<td>9</td>
<td>3.305</td>
</tr>
<tr>
<td>10</td>
<td>4.08</td>
</tr>
</tbody>
</table>
SOP 5 FOR PURGING A WELL WITH A PUMP
[MODIFICATION OF TCEQ SOP 7.3 (8/28/2013)]

3. Measure the water level in the well in feet [as described in SOP for Water Level.
4. Determine the total depth of the well in feet.
5. Determine the height of the water column in the well in feet (H = height of water column (feet), calculated by subtracting the depth to water from the total depth of the well); the volume of water in the well includes the water in the casing and in the annular space.
6. Determine the purge volume using Equation 1 (the purge volume is determined as three times the calculated volume of water in the well).

Equation 1:

\[
\text{Purge Volume} = H \times (\text{selected Gallons/Linear Foot of Water Column}) \times 3
\]

Where \( H \) = height of water column

7. All non-dedicated equipment shall be decontaminated in accordance with SOP 1.5 (Decontamination) prior to sampling activities.
8. Assemble pump, hoses and safety rope, and lower the pump into the well. Make sure the pump is deep enough so all the water is not evacuated; running the pump without water may cause damage.
9. Make connections between the pump and control box if using an air-lift or bladder pump (e.g., Well Wizard).
10. Attach flow meter to the outlet hose to measure the volume of water purged.
11. Use a ground fault circuit interrupter (GFCI) or ground the generator to avoid possible electric shock.
12. Attach power supply, and begin purging the well. The well should be purged at a rate low enough to prevent water from cascading down the sides of the well, if at all possible. Do not allow the pump to run dry.
13. If the pumping rate exceeds the well recharge rate, lower the pump further into the well, reduce the pumping rate to decrease well drawdown, and continue pumping.
14. If using an air-lift or bladder type pump, be sure to adjust flow rate to prevent violent jolting of the hose as sample is drawn in.
15. Purge water should be handled in accordance with SOP 1.4 (Management of Investigation-Derived Waste) and the site-specific field sampling plan.
16. When no sediments are visible in the purge water, begin measuring field parameters in accordance with SOP 7.5 (Measurement of Field Parameters).
17. Purge the well until the purge volume has been achieved and the well parameters have stabilized. As a general rule, all monitoring wells should be pumped or bailed prior to sampling. Purge water should be containerized on site or handled as specified in the site specific project plan. Evacuation of a minimum of one borehole volume, and preferably three to five volumes, is recommended for a representative sample.
4.0 CAUTIONS AND INTERFERENCES

The primary goal in performing groundwater sampling is to obtain a representative sample of the groundwater body. Analysis can be compromised by field personnel in two primary ways: (1) taking an unrepresentative sample, or (2) by incorrect handling of the sample. There are numerous ways of introducing foreign contaminants into a sample, and these must be avoided by following strict sampling procedures and utilizing trained field personnel. While laboratory methods have become extremely sensitive, well controlled and quality assured, they cannot compensate for a poorly collected sample. The collection of a sample should be as sensitive, highly developed and quality assured as the analytical procedures.

In a non-pumping well, there will be little or no vertical mixing of the water, and stratification will occur. The well water in the screened section will mix with the groundwater due to normal flow patterns, but the well water above the screened section will remain isolated, become stagnant, and may lack the contaminants representative of the groundwater. Persons sampling should realize that stagnant water may contain foreign material inadvertently or deliberately introduced from the surface resulting in an unrepresentative sample. To safeguard against collecting nonrepresentative stagnant water, the following guidelines and techniques should be adhered to during sampling:

1. Water level and sediment thickness measurements should be taken prior to beginning the purging activities.
2. As a general rule, all monitoring wells should be pumped (preferred) or bailed prior to sampling. Purge water should be containerized on site or handled as specified in the site specific project plan.
3. A non-representative sample can result from excessive pre-pumping of the monitoring well. Stratification of the leachate concentration in the groundwater formation 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 of interest.

Materials of construction for samplers and evacuation equipment (bladders, pump, bailers, tubing, etc.) should be limited to stainless steel, Teflon, and glass in areas where concentrations are expected to be at or near the detection limit. The tendency of organics to leach into and out of many materials makes the selection of materials critical for trace analyses. The use of plastics, such as PVC or polyethylene, should be avoided when analyzing for organics. However, PVC may be used for evacuation equipment as it will not come in contact with the sample, and in highly contaminated wells, disposable equipment (e.g., polypropylene bailers) may be appropriate to avoid cross-contamination.
1.0 METHOD SUMMARY
Most hazardous waste site investigations utilize some form of a groundwater sampling or monitoring program to fully characterize the nature and extent of groundwater contamination. In order to obtain a representative groundwater sample for chemical analysis it is important to remove stagnant water in the borehole or pump tubing before collection of the sample. This may be achieved using a variety of instruments including pumps and bailers. Once purging is completed and the correct laboratory-cleaned sample containers have been prepared, sampling may proceed. Sampling may be conducted with any of the above instruments, and need not be the same as the device used for purging. During sampling, a field data sheet should be completed, a chain of custody form prepared, and all pertinent data recorded in the site logbook. This SOP describes the procedures used for sampling a monitoring well with a pump.

2.1 EQUIPMENT/APPARATUS/REAGENTS
The following is a typical equipment list used for sampling groundwater monitoring wells using a pump.

- Field data sheets and sample jar labels
- Chain-of-custody forms/Custody seals
- Sample containers
- Knife or scissors
- 5-gallon buckets
- Plastic sheeting
- Shipping containers
- Packing materials
- Ziploc-type plastic bags
- Field parameter instruments (pH meter, thermometer, conductivity meter)
- Calibration standards
- Non-phosphate soap (Note: Alconox is not considered a non-phosphate soap; rather a low-phosphate soap)
- Generator, if using pump
- Air compressor for bladder pumps
- Pump
- Gasoline for generator
- Discharge tubing for pump
- Control box (if necessary)
- Appropriate pump fittings (e.g., hose clamps, barbed fittings, etc.)
- Appropriate PPE

3.0 PROCEDURES
This section outlines the procedures for collecting representative groundwater samples using the following steps: Each step in the procedure is covered in a separate SOP. The reference SOP is in parenthesis.

1. Refer to SOP for Documentation, for Collection of VOCs, for Sample Handling and Control, and For Collection of QC Samples.
2. Water level/sediment measurement will be taken in accordance with SOP for Water Level Measurement
3. Measurement of field parameters will be done in accordance with SOP for Measurements of Monitor Well Field Parameters.
4. Purging will be done in accordance with SOP for Purging a Monitoring Well with a Bailer or SOP For Purging a Monitoring Well with a Pump.
5. Allow well to recharge after purging to 90% of the static water level.
6. Assemble and label the appropriate bottles.
7. Set the pump height so that the intake is near the center of the screened interval.
8. Adjust the flow rate of the pump to minimize aeration and bubble formation. A flow rate of <0.5 L/min is typically appropriate. The pump discharge should produce a thin, continuous stream of water when filling the sample container.
9. Begin using the pump to fill the appropriate container. Samples should be collected in the following order:
   - Volatile organic compounds (VOCs)
   - Semi-volatile organic compounds (SVOCs); including polyaromatic hydrocarbons (PAHs)
   - Inorganic constituents (metals)
   - Mercury
   - Cyanide
   - Total organic carbon (TOC)
   - Total organic halogen (TOX)
   - Samples requiring field filtration
   - Samples for field parameter measurement
   - Samples for nutrient anion determinations
10. Filter and preserve samples as required by sampling plan.
11. Cap the sample container tightly and place pre-labeled sample container in a pre-chilled cooler.
12. Replace the well cap.
13. Log all samples in the site logbook and on the chain-of-custody form and label all samples in accordance with SOP for Documentation.
14. Package samples and complete necessary paperwork in accordance with 6.4 for Sample Handling and Control.
15. Transport sample to decontamination zone for preparation for transport to analytical laboratory.

4.0 CAUTIONS AND INTERFERENCES

Before sampling, monitoring wells shall be allowed to stabilize for a minimum period of 24 hours after development.

The primary goal in performing groundwater sampling is to obtain a representative sample of the groundwater body. Analysis can be compromised by field personnel in two primary ways: (1) taking an unrepresentative sample, or (2) by incorrect handling of the sample.
There are numerous ways of introducing foreign contaminants into a sample, and these must be avoided by following strict sampling procedures and utilizing trained field personnel. While laboratory methods have become extremely sensitive, well controlled and quality assured, they cannot compensate for a poorly collected sample. The collection of a sample should be as sensitive, highly developed and quality assured as the analytical procedures.

Sample withdrawal methods require the use of pumps, compressed air, bailers, and samplers. Ideally, sample withdrawal equipment should be completely inert, economical to manufacture, easily cleaned, sterilized, reusable, able to operate at remote sites in the absence of power sources, and capable of delivering variable rates for sample collection. Wells should be sampled as soon as possible after purging (certainly no more than 24 hours) and should be sampled in order from least contaminated to most contaminated or from upgradient to downgradient if chemistry is unknown. Water levels shall be allowed to recover to 90% of the static water level before sampling. All non-dedicated equipment shall be decontaminated in accordance with SOP 1.5 (Decontamination) prior to use or upon completion of the sampling activities.
1.0 METHOD SUMMARY

Purging is the process of removing stagnant water from a monitoring well, immediately prior to sampling, causing its replacement by groundwater from the adjacent formation, which is representative of actual aquifer conditions. If a monitor well is pumped or bailed dry, it will be allowed to recover to 85 percent of the original water volume before sample collection. If the monitor well does not recover to within 85 percent of the original water volume within 24 hours, but a sufficient volume of water is present to collect a sample, the sample will be collected from the available water and the volume of water will be recorded in the field logbook.

2.0 EQUIPMENT/APPARATUS/REAGENTS

The following is a typical equipment list used for purging groundwater monitoring wells with a bailer.

2.1 Equipment List

- Logbook
- As-built diagrams of monitoring wells
- Calculator
- Field data sheets
- 5-gallon buckets
- Plastic sheeting
- Nylon rope
- Bailers
- Drums
- Marking pen for labeling drums
- Wrench for opening/sealing drums
- Appropriate PPE

3.0 PROCEDURES

The procedures for purging the well with a bailer are as follows:

1. Determine the diameter of the well in inches.
2. Select the “Gallons/Linear Foot of Water Column” from Table 1 corresponding to the diameter of the well.

<table>
<thead>
<tr>
<th>Table 1 Well Casing Diameter versus Volume of Water</th>
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<tbody>
<tr>
<td><strong>Well Casing Diameter</strong></td>
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</table>
3. Measure the water level in the well in feet (as described in SOP for Water Level/Sediment Measurement).
4. Determine the total depth of the well in feet.
5. Determine the height of the water column in the well in feet ($H = \text{height of water column (feet)}$), calculated by subtracting the depth to water from the total depth of the well); The volume of water in the well includes the water in the casing and in the annular space.
6. Determine the purge volume using Equation 1 (the purge volume is determined as three times the calculated volume of water in the well).

**Equation 1:**

\[ \text{Purge Volume} = H \times (\text{selected Gallons/Linear Foot of Water Column}) \times 3 \]

Where $H = \text{height of water column}$

7. All non-dedicated equipment shall be decontaminated in accordance with SOP 1.5 (Decontamination) prior to sampling activities.
8. Attach a new piece of nylon rope to the bailer and slowly lower until the bailer is completely submerged, being careful not to drop the bailer to the water, causing turbulence and the possible loss of volatile organic contaminants. The well should be purged at a rate low enough to prevent water from cascading down the sides of the well, if at all possible.
9. Pull bailer out ensuring that the rope either falls onto a clean area of plastic sheeting or never touches the ground.
10. Empty the bailer into a pail until full to determine the number of bails necessary to achieve the required purge volume.
11. When no sediments are visible in the purge water, begin measuring field parameters in accordance with SOP 7.5 (Measurement of Field Parameters).
12. Continue purging the well and repeat measurement of field parameter after each purged well volume.
13. Thereafter, pour the water into a container and dispose of purge waters as specified in the site specific sampling plan.
14. Purge the well until the purge volume has been achieved and the well parameters have stabilized. As a general rule, all monitoring wells should be purged prior to sampling. Purge water should be containerized on site or handled as specified in the specific project plan. Evacuation of a minimum of one borehole volume of water, and preferably three to five volumes, is recommended for a representative sample.

### 4.1 CAUTIONS AND INTERFERENCES

In a non-pumping well, there will be little or no vertical mixing of the water, and stratification will occur. The well water in the screened section will mix with the groundwater due to normal flow patterns, but the well water above the screened section will remain isolated, become stagnant, and may lack the contaminants representative of the groundwater. Persons sampling should realize that stagnant water may contain foreign material inadvertently or deliberately introduced from the surface resulting in an unrepresentative sample. To safeguard against collecting stagnant water, the following guidelines and techniques should be adhered to during sampling:
SOP 7  FOR PURGING A MONITORING WELL WITH A BAILER
[MODIFICATION OF TCEQ SOP 7.2 (8.28.3013)]

- Water level and sediment thickness measurements should be taken prior to beginning the purging activities.
- As a general rule, all monitoring wells should be pumped (preferred) or bailed prior to sampling.
- Purge water should be handled in accordance with SOP 1.4 (Management of Investigation-Derived Waste) and the site-specific field sampling plan.

Materials of construction for samplers and evacuation equipment (bladders, pump, bailers, tubing, etc.) should be limited to stainless steel, Teflon, and glass in areas where concentrations are expected to be at or near the detection limit. The tendency of organics to leach into and out of many materials makes the selection of materials critical for trace analyses. The use of plastics, such as PVC or polyethylene, should be avoided when analyzing for organics. However, PVC may be used for evacuation equipment as it will not come in contact with the sample, and in highly contaminated wells, disposable equipment (e.g. polypropylene bailers) may be appropriate to avoid cross-contamination.
SOP 8 FOR GROUNDWATER SAMPLING USING A BAILER
[MODIFIED FROM TCEQ SOP 7.6 (8/28/2013)]

1.0 METHOD SUMMARY
Most hazardous waste site investigations utilize some form of a groundwater sampling or monitoring program to fully characterize the nature and extent of groundwater contamination. In order to obtain a representative groundwater sample for chemical analysis it is important to remove stagnant water in the borehole or pump tubing before collection of the sample. This may be achieved using a variety of instruments including pumps and bailers. Once purging is completed and the correct laboratory-cleaned sample containers have been prepared, sampling may proceed. Sampling may be conducted with any of the above instruments, and need not be the same as the device used for purging. During sampling, a field data sheet should be completed, a chain of custody form prepared, and all pertinent data recorded in the site logbook.

If a monitor well is pumped or bailed dry, it will be allowed to recover to 85 percent of the original water volume before sample collection. If the monitor well does not recover to within 85 percent of the original water volume within 24 hours, but a sufficient volume of water is present to collect a sample, the sample will be collected from the available water and the volume of water will be recorded in the field logbook. This SOP describes the methods used to sample monitoring wells with a bailer.

2.0 EQUIPMENT/APPARATUS/REAGENTS
The following is a typical equipment list used for sampling groundwater monitoring wells using a bailer.

- Field data sheets and sample jar labels
- Chain-of-custody forms/Custody seals
- Sample containers
- Knife or scissors
- 5-gallon buckets
- Plastic sheeting
- Shipping containers
- Packing materials
- Ziploc-type plastic bags
- Field parameter instruments (pH, DO meters, thermometer)
- Calibration standards
- Non-phosphate soap (Note: Alconox is not considered a non-phosphate soap; rather a low-phosphate soap)
- Nylon rope
- Bailers
- Appropriate PPE

3.0 PROCEDURES
This section outlines the procedures for collecting representative groundwater samples using the following steps. Each step in the procedure is covered in a separate SOP. The reference SOP is in parenthesis.

1. Prepare for sampling using: SOP 6.1 (Documentation), 6.3 (Collection of VOCs), 6.4 (Sample Handling and Control), and 6.5 (Collection of QC Samples).
2. Water level/sediment measurement will be taken in accordance with SOP 7.1 (Water Level Measurement)
3. Measurement of field parameters will be done in accordance with SOP 7.5 (Measurements of Monitoring Well Field Parameters).
4. Purge the well in accordance with SOP for Monitoring Well Purging with a Bailer or SOP for Monitoring Well Purging with a Pump.

5. Assemble and label appropriate sample containers.

6. Attach a new piece of nylon rope to a dedicated bailer, a disposable bailer, or a clean, decontaminated non-dedicated bailer.

7. Lower the bailer slowly and gently into the well, taking care not to shake the casing sides or to splash the bailer into the water. Stop lowering at a point adjacent to the screen.

8. Allow bailer to fill and then slowly and gently retrieve the bailer from the well avoiding contact with the casing, so as not to knock flakes of rust or other foreign material into the bailer.

9. Remove the cap from the sample container and place it on the plastic sheet or in a location where it won't become contaminated or disturbed.

10. Begin pouring slowly from the bailer into the appropriate container. Samples should be collected in the following order:
    - Volatile organic compounds (VOCs)
    - Semi-volatile organic compounds (SVOCs); including polyaromatic hydrocarbons (PAHs)
    - Inorganic constituents (metals)
    - Mercury
    - Cyanide
    - Total organic carbon (TOC)
    - Total organic halogen (TOX)
    - Samples requiring field filtration
    - Samples for field parameter measurement
    - Samples for nutrient anion determinations

11. Filter and preserve samples as required by the sampling plan.

12. Cap the sample container tightly and place pre-labeled sample container in a pre-chilled cooler.

13. Replace the well cap.

14. Log all samples in the site logbook and on the chain-of-custody form and label all samples in accordance with SOP 6.1 for Documentation.

15. Package samples and complete necessary paperwork in accordance with SOP for Sampling Handling and Control.

16. Transport samples to decontamination zone for preparation for transport to analytical laboratory.

4.0 CAUTIONS AND INTERFERENCES

Before sampling, monitoring wells shall be allowed to stabilize for a minimum period of 24 hours after development.
SOP 8 FOR GROUNDWATER SAMPLING USING A BAILER
[MODIFIED FROM TCEQ SOP 7.6 (8/28/2013)]

The primary goal in performing groundwater sampling is to obtain a representative sample of the groundwater body. Analysis can be compromised by field personnel in two primary ways: (1) taking an unrepresentative sample, or (2) by incorrect handling of the sample. There are numerous ways of introducing foreign contaminants into a sample, and these must be avoided by following strict sampling procedures and utilizing trained field personnel. While laboratory methods have become extremely sensitive, well controlled and quality assured, they cannot compensate for a poorly collected sample. The collection of a sample should be as sensitive, highly developed and quality assured as the analytical procedures.

Sample withdrawal methods require the use of pumps, compressed air, bailers, and samplers. Ideally, sample withdrawal equipment should be completely inert, economical to manufacture, easily cleaned, sterilized, reusable, able to operate at remote sites in the absence of power sources, and capable of delivering variable rates for sample collection. Wells should be sampled as soon as possible after purging (certainly no more than 24 hours) and should be sampled in order from least contaminated to most contaminated or from up-gradient to down-gradient if chemistry is unknown. Water levels shall be allowed to recover to 90% of the static water level before sampling. All non-dedicated equipment shall be decontaminated in accordance with SOP 1.5 (Decontamination) prior to use or upon completion of the sampling activities.
SOP 9 FOR MICRO PURGING A MONITORING WELL
[MODIFICATION OF TCEQ SOP 7.4(8/28/2013)]

1.0 METHOD SUMMARY
Micro purging is an approach to purging based on the observation that groundwater flows through the well screen in most formations with sufficient velocity to maintain an exchange with formation water surrounding the well screen. By placing a pump within the screen interval and pumping at a low-flow rate which does not induce drawdown of the water column, a representative sample of formation groundwater can be collected with minimal withdrawal of stagnant water. Ideally micro purging should be conducted in wells in which dedicated pumps have been installed. It is possible to use non-dedicated pumps if a sufficient amount of time is allowed for the water level to equilibrate following insertion of the pump. Whenever possible, micro purging and low-flow sampling methods are preferred for use at Superfund sites. If a monitor well is pumped or bailed dry, it will be allowed to recover to 85 percent of the original water volume before sample collection. If the monitor well does not recover to within 85 percent of the original water volume within 24 hours, but a sufficient volume of water is present to collect a sample, the sample will be collected from the available water and the volume of water will be recorded in the field logbook.

2.0 EQUIPMENT/APPARATUS/REAGENTS
The following is a typical equipment list used for micro purging groundwater monitoring wells.

Equipment List

2.1.1 Logbook
2.1.2 As-built diagrams of monitoring wells
2.1.3 Field data sheets
2.1.4 Plastic sheeting
2.1.5 Generator, if using pump
2.1.6 Air compressor for bladder pumps
2.1.7 Pump
2.1.8 Gasoline for generator or an electrical source
2.1.9 Discharge tubing for pump
2.1.10 Control box (if necessary)
2.1.11 Appropriate pump fittings (e.g., hose clamps, barbed fittings, etc.)
2.1.12 Drums
2.1.13 Marking pen for labeling drums
2.1.14 Wrench for opening/sealing drums
2.1.15 Appropriate PPE

3.0 PROCEDURES
The procedures for micro purging are as follows:

1. All non-dedicated equipment shall be decontaminated in accordance with SOP 1.5 (Decontamination) prior to sampling activities.

2. Assemble pump, hoses and safety cable, and, if using a non-dedicated pump, lower the pump into the well. The pump intake should be set in the middle or slightly above the middle of the screened interval. Alternatively, the pump may be located adjacent to the zone of highest contamination, if well-documented for reproducibility; however, placement of the pump too close to the bottom of the well may result in increased entrainment of solids which have accumulated in the well over time.
SOP 9 FOR MICRO PURGING A MONITORING WELL
[MODIFICATION OF TCEQ SOP 7.4(8/28/2013)]

Placement of the pump at the top of the water column, just below the air/water interface is only recommended in unconfined aquifers where the water table straddles the screen or where this is the desired sampling point.

3. If using a non-dedicated pump, allow sufficient time for the water level to equilibrate to obtain a representative sample.

4. Make connections between the pump and control box if using an air-lift or bladder pump (i.e., Well Wizard).

5. Use a ground fault interrupter (GFCI) or ground the generator to avoid possible electric shock.

6. Attach power supply and begin micro purging the well. A well should be purged at or below its recovery rate, ideally less than 0.2 to 0.3 L/min.

7. Monitor the drawdown in the well. If the drawdown exceeds 0.3 ft, then reduce the pumping rate to ensure that drawdown does not exceed 0.3 ft.

8. Connect the water quality meters to the discharge hose and measure field parameters in accordance with Section 7.5 (Measurements of Monitor Well Field Parameters).

9. Repeat the measurements at a regular interval (i.e., every minute). Record the values in the field log book. Continue purging until the measured parameters stabilize for 3 successive readings.

10. If field parameters have not stabilized after 3 successive readings, continue taking measurements at 3 minute intervals up to a maximum of 5 successive readings. If, after 5 successive readings, the parameters have not stabilized, an entry shall be made in the field logbook indicating that sampling will be conducted without stabilized parameters.

11. Purge water should be containerized on site or handled as specified in the site specific project plan.

4.0 CAUTIONS AND INTERFERENCES

The primary goal in performing groundwater sampling is to obtain a representative sample of the groundwater body. Analysis can be compromised by field personnel in two primary ways: (1) taking an unrepresentative sample, or (2) by incorrect handling of the sample. There are numerous ways of introducing foreign contaminants into a sample, and these must be avoided by following strict sampling procedures and utilizing trained field personnel. While laboratory methods have become extremely sensitive, well controlled and quality assured, they cannot compensate for a poorly collected sample. The collection of a sample should be as sensitive, highly developed and quality assured as the analytical procedures.

In a non-pumping well, there will be little or no vertical mixing of the water, and stratification will occur. The well water in the screened section will mix with the groundwater due to normal flow patterns, but the well water above the screened section will remain isolated, become stagnant, and may lack the contaminants representative of the groundwater. Persons sampling should realize that stagnant water may contain foreign material inadvertently or deliberately introduced from the surface resulting in an unrepresentative sample. To safeguard against collecting stagnant water, the following guidelines and techniques should be adhered to during sampling:

1. Water level and sediment thickness measurements should be taken prior to beginning the purging activities.
2. As a general rule, all monitoring wells should be pumped (preferred) or bailed prior to sampling. Purge water should be containerized on site or handled as specified in the site specific project plan.

3. For wells that can be easily pumped or bailed to dryness, micro purging and low-flow sampling methods shall be used.

Materials of construction for samplers and evacuation equipment (bladders, pump, bailers, tubing, etc.) should be limited to stainless steel, Teflon, and glass in areas where concentrations are expected to be at or near the detection limit. The tendency of organics to leach into and out of many materials makes the selection of materials critical for trace analyses. The use of plastics, such as PVC or polyethylene, should be avoided when analyzing for organics. However, PVC may be used for evacuation equipment as it will not come in contact with the sample, and in highly contaminated wells, disposable equipment (i.e., polypropylene bailers) may be appropriate to avoid cross-contamination.
SOP 10 FOR GROUNDWATER SAMPLING USING A LOW-FLOW TECHNIQUES
[MODIFICATION OF TCEQ SOP 7.8 (4/28/2013)]

1.0 METHOD SUMMARY
Most hazardous waste site investigations utilize some form of a groundwater sampling or monitoring program to fully characterize the nature and extent of groundwater contamination. In order to obtain a representative groundwater sample for chemical analysis it is important to remove stagnant water in the borehole or pump tubing before collection of the sample. This may be achieved using a variety of instruments including pumps and bailers. Once purging is completed and the correct laboratory-cleaned sample containers have been prepared, sampling may proceed. Sampling may be conducted with any of the above instruments, and need not be the same as the device used for purging. During sampling, a field data sheet should be completed, a chain of custody form prepared, and all pertinent data recorded in the site logbook. This SOP describes the procedures for sampling a monitoring well using low-flow techniques. Low-flow methods are typically used in conjunction with micropurging.

2.0 EQUIPMENT/APPARATUS/REAGENTS
The following is a typical equipment list used for sampling groundwater monitoring wells using a pump.

- Field data sheets and sample jar labels
- Chain-of-custody forms/Custody seals
- Sample containers
- Knife or scissors
- 5-gallon buckets
- Plastic sheeting
- Shipping containers
- Packing materials
- Ziploc-type plastic bags
- Field parameter instruments (pH meter, thermometer, conductivity meter)
- Calibration standards
- Non-phosphate soap (Note: Alconox is not considered a non-phosphate soap; rather a low-phosphate soap)
- Generator, if using pump
- Air compressor for bladder pumps
- Pump
- Gasoline for generator
- Discharge tubing for pump
- Control box (if necessary)
- Appropriate pump fittings (e.g., hose clamps, barbed fittings, etc.)
- Appropriate PPE

3.0 PROCEDURES
This section outlines the procedures for collecting representative groundwater samples using the following steps: Each step in the procedure is covered in a separate SOP. The reference SOP is in parenthesis.
Low-flow sampling procedures should be used whenever pumps are used for groundwater sampling. These procedures should be used in conjunction with micropurging techniques.

1. Prepare for sampling using: SOP 6.1 for Documentation, for Collection of VOCs, for Sample Handling and Control, and for Collection of QC Samples.

2. Water level/sediment measurements will be taken in accordance with SOP for Water Level Measurement
3. Measurement of field parameters will be done in accordance with SOP for Measurements of Monitoring Well Field Parameters.

4. Purging will be done in accordance with SOP for Micro Purging.

5. Allow well to recharge after purging to 90% of the static water level.

6. Disconnect flow-through cells.

7. Assemble and label the appropriate bottles.

8. Set the pump height so that the intake is near the center of the screened interval.

9. Adjust the flow rate of the pump to minimize aeration and bubble formation. A flow rate of $<0.5$ L/min is typically appropriate. The pump discharge should produce a thin, continuous stream of water when filling the sample container.

10. Begin using the pump to fill the appropriate container. Samples should be collected in the following order:
    - Volatile organic compounds (VOCs)
    - Semi-volatile organic compounds (SVOCs); including polyaromatic hydrocarbons (PAHs)
    - Inorganic constituents (metals)
    - Mercury
    - Cyanide
    - Total organic carbon (TOC)
    - Total organic halogen (TOX)
    - Samples requiring field filtration
    - Samples for field parameter measurement
    - Samples for nutrient anion determinations

11. Filter and preserve samples as required by sampling plan.

12. Cap the sample container tightly and place pre-labeled sample container in a pre-chilled cooler.

13. Replace the well cap.

14. Log all samples in the site logbook and on the chain-of-custody form and label all samples in accordance with SOP 6.1 for Documentation.

15. Package samples and complete necessary paperwork in accordance with SOP for Sample Handling and Control.

16. Transport sample to decontamination zone for preparation for transport to analytical laboratory.

4.0 CAUTIONS AND INTERFERENCES

Before sampling, monitoring wells shall be allowed to stabilize for a minimum period of 24 hours after development.

The primary goal in performing groundwater sampling is to obtain a representative sample of the groundwater body. Analysis can be compromised by field personnel in two primary ways: (1) taking an
unrepresentative sample, or (2) by incorrect handling of the sample. There are numerous ways of introducing foreign contaminants into a sample, and these must be avoided by following strict sampling procedures and utilizing trained field personnel. While laboratory methods have become extremely sensitive, well controlled and quality assured, they cannot compensate for a poorly collected sample. The collection of a sample should be as sensitive, highly developed and quality assured as the analytical procedures.

Sample withdrawal methods require the use of pumps, compressed air, bailers, and samplers. Ideally, sample withdrawal equipment should be completely inert, economical to manufacture, easily cleaned, sterilized, reusable, able to operate at remote sites in the absence of power sources, and capable of delivering variable rates for sample collection. Wells should be sampled as soon as possible after purging (certainly no more than 24 hours) and should be sampled in order from least contaminated to most contaminated or from upgradient to downgradient if chemistry is unknown. Water levels shall be allowed to recover to 90% of the static water level before sampling. All non-dedicated equipment shall be decontaminated in accordance with SOP for Decontamination prior to use or upon completion of the sampling activities.
1.0 METHOD SUMMARY
The objective of this standard operating procedure (SOP) is to provide guidance for the sampling of volatile organic compounds (VOCs).

2.0 EQUIPMENT/APPARATUS/REAGENTS
Typical equipment required for groundwater and soil sampling includes:
• 40-mL glass vials with a PTFE-lined septum that can be hermetically sealed.
• Bailers (stainless steel or disposable)

3.0 PROCEDURES
3.1 Water Sample Collection
The following procedures shall be followed for the collection of groundwater VOC samples. The sample volume shall be dictated in the Field Sampling Plan:
1. The 40-mL glass sample vials must be pre-cleaned and/or be certified free of VOCs.
2. Wells shall be purged in accordance with one of the following SOPs: SOP for Monitor Well Purging with a Bailier, SOP for Monitor Well Purging with a Pump, or SOP for Monitor Well Micro Purging.
3. Label sample vials in accordance with SOP for Sample Handling and Control.
4. Carefully fill a 40-mL vial with a slow, steady stream of water down the side of the vial to minimize aeration of the sample.
5. Fill the vial with water to the top so that a meniscus is formed. Allow any air bubbles to rise to the surface. Carefully and quickly screw the cap onto the container and finger tighten.
6. Invert the vial and tap it gently, looking for any air bubbles. If the sample contains air bubbles, discard the sample and repeat the sampling process with a new sampling container.
7. Refer to the site-specific field sampling plan for the site-specific sample volume. The typical sample volume for a regular water sample is three 40-mL vials. Six additional 40-mL vials are typically needed for the sample identified as the matrix spike/matrix spike duplicate (MS/MSD).
8. Preserve to a pH of 2 with HCl and cool to 4°C (±2°C) immediately after collection. DO NOT FREEZE water samples. Samples collected for determining concentrations of highly reactive VOCs, (e.g., vinyl chloride, styrene, 2-chlorovinylether, or acrylamide) will not be acid preserved and must be analyzed within seven days.
9. Package sample for shipment in accordance with SOP for QC Samples
10. During sample shipment, all conditions relating to the isolation/segregation of the samples from potential contaminants (gasoline/diesel engines or generators, highly contaminated samples, etc.) must be observed.
11. Decontaminate all non-disposable sampling equipment prior to moving to new sampling point and in accordance with SOP for Decontamination

12. Groundwater and surface water samples for VOC analysis that are not acid preserved will be cooled in the field for transport and storage and analyzed within seven days of collection.

3.2.1 Field procedures

This recommended sample collection technique does not require preservative.

1. The 40-mL amber glass sample vials must be pre-cleaned and/or be certified free of VOCs.

2. Sample vials should be prepared in a fixed laboratory or other controlled environment. The tare weight of the sample vial including cap, septum, and label must be determined and recorded on the label prior to shipping the vials to the field for sample collection. Clean gloves should be worn when handling tared vials.

3. Exposure to air must be minimized by obtaining the sample directly from the source media using a coring device or a commercially designed sampling device and by transferring the sample as quickly as possible to a vial (or sealing the sample borer/hermetically sealed sample container immediately). The vial should be quickly wiped free of any particulate matter that would compromise the integrity of the vial seal. Fingers should be used to minimize exposure to air by forming a temporary seal between the vial and the sampling device.

4. Sample containers remain unopened from the time of collection until analysis.

5. All samples must be properly packaged (SOP 6.4) and put on ice immediately upon collection.

6. During sample shipment, all conditions relating to the isolation/segregation of the samples from potential contaminants (gasoline/diesel engines or generators, highly contaminated samples, etc.) must be observed.

7. Decontaminate all non-disposable sampling equipment prior to moving to another well and/or at the end of the day.

3.2.2 Quality Control

The laboratory quality control measures specified throughout Method 5035 must be followed. Field quality control measures should include a trip blank in every sample shuttle that contains samples for volatile analysis regardless of the sample collection technique.

4.0 CAUTIONS AND INTERFERENCES

Make sure that there are no air bubbles in the sample bottle. Be careful not to agitate the sample. The sample bottle should be quickly sealed, put on ice and shipped to the laboratory.
1.0 METHOD SUMMARY

This standard operating procedure (SOP) provides 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 used during hazardous waste operations. This SOP does not address detailed personnel decontamination; however, all disposable Personal Protective Equipment (PPE) will be decontaminated such that it can be disposed of as Class 3 waste. Non-dedicated sampling equipment and tools will be decontaminated prior to use and between sample locations. Dedicated sampling equipment will be decontaminated prior to first use, unless certified free of contaminants by the manufacturer. The TCEQ Project Manager (PM) may modify the decontamination frequency, as appropriate.

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.

2.0 EQUIPMENT/APPARATUS/REAGENTS

2. non-phosphate detergent
3. tap water
4. distilled or deionized water
5. long and short handled brushes
6. bottle brushes
7. paper towels
8. plastic or galvanized tubs or buckets
9. aluminum foil
10. re-sealable bags
11. trash bags
12. face shield (for hard hat)
13. landscape timbers, 4 x 4’s, or 2 x 4’s

3.0 PROCEDURES

3.1 Decontamination

Decontamination of drilling equipment, well construction materials, sampling equipment, tools, etc. shall be described in the project work plan or field sampling plan. All samples and equipment leaving the contaminated area of a site must be decontaminated to remove any contamination that may have adhered to equipment. This includes casing, drill bits, auger flights, the portions of drill rigs that stand above boreholes, sampling devices, and instruments, such as slugs and sounders. In addition, the contractor shall take care to prevent the sample from coming into contact with potentially contaminating substances, such as tape, oil, engine exhaust, corroded surfaces, and dirt.
The following procedures shall be used to decontaminate equipment used in the sampling.

1. rinse all equipment with potable water;
2. clean equipment with a brush in a solution of laboratory grade detergent (Liquinox, Alconox, or equivalent);
3. rinse with potable water;
4. rinse with 10% nitric acid solution (trace metals grade);
5. rinse with distilled or deionized water;
6. Place the equipment on clean plastic sheeting and allow to air dry; and

If a particular contaminant fraction is not present at the site, the ten (10) step decontamination procedure specified above may be modified for site specificity. For example, 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.

4.0 CAUTIONS AND INTERFERENCES

5. The use of distilled/deionized water commonly available from commercial vendors is typically acceptable for decontamination of sampling equipment.
6. 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.
7. If solvents are utilized in decontamination they raise health and safety, and waste disposal concerns.
8. Damage can be incurred by solvent washing of complex and sophisticated sampling equipment.
1.0 METHOD SUMMARY

This SOP presents procedures for maintaining control of environmental samples following collection through shipment to the analytical laboratory. In addition, this SOP describes standard chain-of-custody protocols which should be followed to document the possession of samples from the time of collection until the laboratory report is submitted.

2.0 EQUIPMENT/APPARATUS/REAGENTS

Equipment needed for use in this SOP includes:

- Pre-cleaned sample containers
- Preservatives (if not in containers)
- Sturdy cooler, in good repair
- Fiberglass strapping tape
- Duct tape
- Clear tape
- Bubble wrap or other packing material
- Ziploc-type bags
- Trash bags
- Ice
- Shipping labels
- Pens, markers, etc.

3.0 PROCEDURES

3.1 Sample Packaging

Environmental samples should be packed prior to shipment using the following procedures:

7. Allow sufficient headspace (approximately 10 percent of the volume of the container) in all bottles (except volatile organic analysis (VOA) vials with a septum seal) to compensate for any pressure and temperature changes which may occur during shipment.

8. Ensure that the lids on all bottles are tight.

9. Select a sturdy cooler in good repair. Secure and tape the drain plug with fiberglass strapping tape or duct tape. Line the cooler with a heavy duty plastic garbage bag.

10. Place glass sample bottles into bubble wrap bags or wrap a layer of bubble wrap around glass containers. Many laboratories provide bubble wrap bags for sample shipment. Place two to three VOA vials in a single bag.

11. Place the bottles in the cooler with larger bottles on the bottom inside the garbage bag. Insert polyethylene bottles between glass bottles for cushion. Put VOA vials (in bubble wrap bags) on their side on top of the larger sample containers.

12. Ensure that a trip blank has been included as appropriate for VOA samples and that a temperature blank (if supplied) is included as outlined in SOPs for VOC Samples and QC Samples.

13. Place ice that has been double bagged® on top of and/or between the samples. Fill remaining void space in the cooler with bubble wrap. Ensure that a sufficient quantity of ice has been placed into the cooler to maintain VOC samples at 4°C. In summer months, it may be necessary to fill as much as 50 percent of the cooler volume with ice to properly cool warm samples.

14. Securely fasten the top of the garbage bag with tape.
15. Place the Chain-of-Custody record into a Ziploc-type bag and tape the bag to the inside of the cooler lid.

16. Close the cooler and securely tape (preferably with fiberglass strapping tape) the top of the cooler shut. Chain-of-custody seals (preferably two) should be affixed to the cooler with clear tape so that the cooler can not be opened without breaking the seals.

17. Place the shipping label in a sealed pouch on the lid of the cooler for shipment. A label containing the name and address of the shipper and the destination should be placed on the outside of each additional cooler included in the shipment.

3.2 Sample Shipping

Samples collected in the field shall be transported to the laboratory or field testing site as expeditiously as possible (within 24 hours of sampling) to avoid hold time exceedances and to ensure that samples remain properly preserved. Samples for VOC analysis must be maintained at a temperature of 4°C by placing samples on ice.

In general environmental samples include drinking water, most ground water and ambient 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. Regulations for packing marking, labeling, and shipping of dangerous goods by air transport are promulgated by the International Air Transport Authority (IATA), which is equivalent to United Nations International Civil Aviation Organization (UN/ICAO). It is the responsibility of the shipper to ensure that shipments are made in accordance with all applicable laws, including contents and labeling.

3.3 Sample Chain-of-Custody

Procedures to ensure the custody and integrity of the samples should begin at the time of sampling and continue through transport, sample receipt, preparation, analysis and storage, data generation and reporting, and sample disposal. Records concerning the custody and condition of the samples are maintained in field laboratory records.

The contractor shall maintain chain-of-custody records for all field and field QC samples. A sample is defined as being within a person’s custody if any of the following conditions exist:

- It is in their possession,
- It is in their view,
- It was in their possession and they secured it in a locked area, or
- It is in a designated secured area.

All sample containers shall be sealed in a manner that shall prevent or provide detection of tampering if it occurs. In no case shall tape be used to seal sample containers. Samples shall not be packaged with activated carbon unless prior approval is obtained from TCEQ.

The following minimum information concerning the sample shall be documented on the TCEQ chain-of-custody form (Attachment 1):

- Unique sample identification
- Date and time of sample collection
• Source of sample (including name, location, and sample type)
• Designation of matrix spike/matrix spike duplicate (MS/MSD)
• Preservative used
• Analyses required
• Number of sample containers
• Pertinent field data (pH, temperature, elevated headspace results or contaminant concentrations)
• Serial numbers of custody seals and transportation cases (if used)
• Name(s) of person(s) collecting the samples
• Custody transfer signatures and dates and times of sample transfer from the field to transporters and to the laboratory or laboratories
• Transporter tracking number (if applicable) or courier receipts

2.1 CAUTIONS AND INTERFERENCES
This section is not applicable to this SOP.
**SOP FORM SAMPLE HANDLING AND CONTROL**

**CHAIN OF CUSTODY FORM**

Received for Laboratory by:  

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Project Location | Project Manager |

Sampler(s)

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