FORT HOOD MUNICIPAL SOLID WASTE LANDFILL
III CORPS & FORT HOOD, TEXAS
CORYELL COUNTY, TEXAS

MSW PERMIT NO. 1866

GROUNDWATER SAMPLING & ANALYSIS PLAN

October 14, 2008

REVISED June 19, 2009

Prepared for
Inland Service Corporation
Fort Hood Directorate of Public Works – Environmental Division

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1.0 INTRODUCTION

This Groundwater Sampling and Analysis Plan (GWSAP) has been prepared for the United States Army, Fort Hood, Coryell County, Texas Type I Municipal Solid Waste Landfill (MSWLF) Permit No. 1866. This facility is located approximately 4 miles northeast of Copperas Cove, 2.5 miles north of U.S. 190, and 5.5 miles west of Killeen, Bee County, Texas. This landfill serves only United States Government properties and facilities. This GWSAP is a requirement for groundwater monitoring and is based on the federal guidelines as stated in the Code of Federal Regulations (CFR), 40 CFR Part 258, current Environmental Protection Agency (EPA) guidance documents, the Texas Administrative Code (TAC), Title 30, Chapter 330, Municipal Solid Waste (MSW) Regulations, Subchapter J, Groundwater Monitoring and Corrective Action, specifically 30 TAC §330.405, and the Texas Commission on Environmental Quality (TCEQ), MSW Division, guidance documents.

This plan will be implemented for the Fort Hood landfill upon approval by the Executive Director of the TCEQ and following the design certification approval of the groundwater monitoring system.

1.1 Groundwater Monitoring System

The Fort Hood Landfill's groundwater monitoring system is shown in Figure 1. This groundwater monitoring system meets requirements of 30 TAC §330.403. The landfill's point-of-compliance is shown on Figure 1, but generally lies along the western, northern, and eastern boundaries of the landfill. In compliance with 30 TAC §330.3, the northern point of compliance boundary is located between Active Fill Area 4 and Future Fill Area 5 at the hydraulically downgradient limit of the waste management unit boundary. The point-of-compliance will be adjusted when Fill Areas 5 or 6 are utilized in the future. The point-of-compliance will be adjusted as future waste cells are constructed within the landfill's permitted boundary and additional monitor wells will be installed to meet monitor well spacing requirements. Monitor wells located along the point-of-compliance are located no more than 600 feet from one another. Groundwater samples will be collected from monitor wells located along the point-of-compliance. Groundwater sampling at "interior wells" (i.e. P-5) will be ceased as background monitoring is completed at perimeter wells in accordance with the original approach described in the facility's Groundwater Monitoring System Design Certification (February 19, 1998).

Monitor wells at the landfill are screened in different geologic formations including (from youngest to oldest) the Walnut Formation, the Paluxy Formation, and the Glen Rose Formation. The strata dip gently to the east. The Walnut Formation consists of marl with interbedded hard limestone. The Walnut Formation is underlain by the Paluxy Formation which consists of approximately six to eight feet of calcareous sandy clay, clayey sand, silt, and sand. The Glen Rose Formation consists of alternating beds of clayey marl and hard limestone (EMCON, 2000). Hydraulic conductivities measured during original landfill site investigations were on the order of 10^{-5} cm/sec in each of these formations. The average hydraulic gradient was estimated to be approximately 320 feet per mile (0.06).

Groundwater flow at the site occurs primarily in the Paluxy Formation. The Paluxy Formation receives recharge from precipitation that falls on its outcrop near the site and, where present, from the overlying Walnut Formation. Groundwater found in the Glen

Rose Formation occurs in irregularly distributed fractures and is poorly connected to the groundwater in the overlying Paluxy Formation. Lateral movement of groundwater in the Glen Rose Formation does not appear to occur (EMCON, 2000). Hydraulic gradient maps shown in Appendix 9 are produced for each formation although actual flow may be very limited at this site.

2.0 GROUNDWATER SAMPLING PREPARATION

Detailed procedures for preparing for each groundwater sampling event at Fort Hood's MSWLF are described in this section. The subsections discuss specific tasks involved in preparation for sampling the groundwater through the site monitoring system.

2.1 Groundwater Sampling Event Preparation

The following list of supplies and equipment will be required for each sampling event:

1. Site-specific safety and health plan (SSHP) addressing all applicable regulatory standards for worker health protection.
2. Personal protective equipment: boots, gloves, safety glasses or goggles, respirators, street clothes with optional Tyvek® protective coveralls (modified EPA level D).
3. Safety and medical equipment: 16-unit first-aid kit, fire extinguisher, emergency eyewash, drinking water.
4. Field measurement instruments and monitoring equipment: meter(s) for measuring groundwater temperature, conductivity, pH, and turbidity (e.g., Horiba U-10 Water Quality Checker, or equivalent); water-level measurement device (e.g., Solinst 102 Water Level Meter, or equivalent); oxygen-combustible gas meter (e.g., Bacharach Sentinel 44, or equivalent). Calibration supplies for the above instruments (refer to manufacturers' instructions for the necessary supplies).
5. Sampling equipment and supplies: Groundwater Monitoring Well Sampling Forms (see Appendix 2), power source and flow regulator for submersible pumps, disposable bailers (for backup use only) with Teflon®-coated stainless steel cables, Teflon® tubing, laboratory-grade glass or stainless steel or Teflon® containers or beakers (1 liter, graduated), and plastic containers (1 or 2 gallon, graduated).
6. Sample containers: sample bottles and preservatives per Appendix 3 (sample bottles to be supplied with proper preservative).
7. Sample shipping supplies and documentation: sample container labels, shipping forms, chain-of-custody forms (see Appendix 4) and seals, permanent marking pens, and iced storage chests.
8. General site equipment and supplies: camera and film, field notebook, tool kit, duct tape, plastic trash bags, and cellular phone (optional).
9. Decontamination equipment and supplies: laboratory-grade detergent (e.g., Alconox), 6-mil polyethylene or plastic sheeting, sorbent socks or diking tubes, tap water, reagent-grade water (deionized or distilled), scrub brushes, 5-gallon plastic drip buckets, paper towels, 2- or 3-gallon portable compressed-air water spray tank, and leak-proof corrosion-resistant storage drums.

The analytical laboratory performing the groundwater analysis will supply the necessary shipping coolers, pre-cleaned sample containers, trip blanks, chemical preservatives, sample labels, and custody seals. The laboratory will be notified 10 work days in advance of each scheduled sampling event so that sufficient time is available to ship the required supplies to the sampling team. The sampling team will thoroughly inventory these shipments when received to verify that the requested supplies are available for the sampling event.

2.2 Sample Container Selection

Sample containers are to be constructed of materials compatible and non-reactive with the material sampled. As noted above, the contract analytical laboratory will supply the required containers. In special circumstances, the samplers may be required to obtain containers from a source other than the analytical laboratory. Such purchases will be made only from a laboratory supply company. Metal lids will not be used for any sample containers. A detailed description of the required sample containers, preservation and storage procedures, and holding times is given in *Recommended Sampling, Preservation, and Storage Procedures for Groundwater Monitoring*, Appendix 3. This appendix will be used during all sampling activities.

2.3 Equipment Preparation Prior to Site Arrival

The preparation of the sampling equipment for departure to the site includes an inventory of all equipment items required to complete the sampling program at the landfill. Instruments and meters will be calibrated prior to departure and tested daily while at the site to confirm proper operating status. For those instruments requiring periodic maintenance, that activity should be performed according to manufacturer's specification, or at least quarterly. All personnel operating the instruments will be knowledgeable and experienced with the calibration and operation of the field instruments. All instruments will be accompanied with the manufacturers' operating instructions.

3.0 GROUNDWATER SAMPLING PROCEDURES

Detailed procedures for groundwater sampling at Fort Hood's MSWLF are described in this section. The following subsections discuss specific tasks involved in sampling the groundwater through the site monitoring system. Preparation for the groundwater sampling event will be accomplished according to Section 2 to facilitate a safe, efficient sampling event. The sampling procedures and equipment to be used will be uniform for all wells sampled, unless otherwise noted, in order to eliminate any reasonable possibility that procedural inconsistencies might negatively impact the comparability of sampling events.

3.1 Well Sampling Order

Where contaminant conditions are known at one or more wells, wells with lower levels of contamination will be sampled before wells with higher levels. Where the contaminant condition is not known, sampling will proceed from wells with higher water level elevations to those with lower elevations as determined from prior sampling events.

3.2 Well Inspection

Upon arrival at the site, the samplers will inspect the area around the well and make observations assessing its integrity. The security of each well will be assessed to confirm that the introduction of outside-source constituents to the well has been prevented. Each well will be inspected for any physical damage including: broken or corroded piping or casing; broken concrete pads or damaged bollards; erosion of soil beneath or adjacent to the concrete pad; spillage of water or other liquids; integrity of the padlocks on each well; accumulation of water in the annular space between the protective cover and the well casing that may indicate damaged weather seals; odors; fasteners for any dedicated equipment installed in the well. Any apparent well maintenance activity performed by others since the previous sampling event will be noted. All inspection information, as well as the date and time, general weather conditions, and sampling personnel identification will be documented with notations on the Groundwater Monitoring Well Sampling Form (Appendix 2), and in the field notebook. Requests for corrective action to be taken will also be noted on these forms. If the situation warrants (i.e., broken casing, spillage, etc.), the sampler will notify the Project Manager or the Directorate of Public Works personnel to provide for immediate corrective action. Written notification of the nature of the damage to the well and the corrective action taken will be provided to the TCEQ. Should any well need to be replaced, a request for a permit modification, pursuant to 30 TAC §305.70, will be submitted to the TCEQ in order to update the Site Development Plan.

All monitoring wells will be inspected and the water level elevations in each well will be measured (Section 3.4) prior to any purging or sampling activities.

3.3 Decontamination

After the well inspection, separate sampling and decontamination areas will be set up at the well site. To construct the sampling area, 6-mil polyethylene or plastic sheeting will be placed around the well casing and pad to provide containment for accidental spillage of groundwater. The decontamination area, constructed with the same protective material as the sampling area, should be located at least 10 feet downgradient and down-wind from the sampling area to prevent cross-contamination of groundwater and sampling equipment. The perimeter of each of the two zones should be secured with sorbent socks or diking tubes to prevent liquids from migrating beyond the protective sheeting. All protective sheeting and diking materials will be disposed following use at each well.

Fort Hood intends to use dedicated submersible pumps as the primary means of purging and sampling wells with disposable bailers to serve as backup in the event of primary equipment failure. Dedicated sampling equipment will only need decontamination in the event of contact with a contaminated surface and prior to installation. Non-dedicated sampling equipment (e.g., e-line, field parameter measurement devices) will be thoroughly decontaminated, as described below, before entering the sampling area.

The non-dedicated sampling equipment will be decontaminated both prior to and following sampling at the first well to be sampled each day. Non-dedicated sampling equipment need only be decontaminated following sampling at each successive well, unless intervening contamination of equipment is suspected.

Non-dedicated sampling equipment will be disassembled as much as possible prior to decontamination. Decontamination of sampling equipment and portable instrumentation for field parameter monitoring will be accomplished according to the following procedure:

- Rinse with tap water.
- Wash and scrub with water and laboratory-grade detergent (e.g., Alconox).
- Rinse three times with deionized water.

The use of powder-free latex gloves by field personnel during well purging, field analysis, sampling, and decontamination is required to protect the samplers and to prevent cross-contamination of groundwater samples. Gloves will be discarded and replaced after completing each of the above-mentioned tasks and whenever torn or discolored.

Decontamination will be sufficient to prevent the introduction of any contaminant into a well or the transport of contaminants between wells. Equipment blank samples will be collected during each sampling event to verify the effectiveness of the decontamination procedures (see Subsection 3.7.2). Decontamination water will be collected in storage drums and disposed in the same manner as the well purge water (see Subsection 3.5).

3.4 Static Water Level Measurement

Following the well inspection and any required decontamination activity, the water level elevation in the well will be measured. This measurement will be used to determine the elevation of the groundwater to mean sea level. Because of possible water level fluctuations in a well due to the removal of water in a nearby well, the initial groundwater elevations on all monitoring wells will be measured prior to any purging or sampling activity. All of the wells have been surveyed to establish the elevation of a reference point (survey pin) and the top of the well casing from which all water level measurements will be taken. All water level measurements will be taken from the same point of reference at the top of the riser pipe. This point will be permanently marked; a notch cut in the top of the pipe will be sufficient for this purpose. An electrical probe (e-line) is recommended for measuring the static water level.

The e-line method of measuring the water level operates on the principle that a circuit is completed when two electrodes come into contact with the water surface in the well. An e-line with graduations to 0.01 foot and with auditory and visual alarms will be used for water level measurements. Measurements made with well-maintained electrical probes are reproducible to within ±0.02-foot. Measurements should be adjusted per the probe manufacturer's recommendations to account for the stretch of the suspended tape. An alarm sounds and a light is seen on the reel when the probe contacts the water. The water level measurement is recorded on the Sampling Form and in the field notebook, to the nearest 0.01 foot. Decontamination of the water level measuring instrument will follow the procedures described in Subsection 3.3. The details of water level measuring will vary depending on whether submersible pumps (primary method) or bailers (backup method) are used. Both of these possibilities are discussed in the following subsections.

Upon opening the cap of each monitoring well, the well will be tested for landfill gas that may have accumulated in the well casing since the last sampling event. An oxygen-combustible gas meter will be used to ensure the atmosphere is not combustible during sampling activities. Readings will be recorded in the field log book.

3.4.1 Water Measurement in Wells with Submersible Pumps

In wells with submersible pumps, the following steps will be taken to measure the water levels. Steps 1-5 only will be done to determine the initial water level elevation, and all of the steps will be performed immediately prior to and during purging and sampling activities.

1. After decontamination, shake off all excess water and/or wipe the e-line clean with paper towels.
2. Prior to inserting the e-line into the well, follow the manufacturer's instructions to ensure the device is functioning properly.
3. Leave the dedicated pump and associated fixtures in place, and slowly unreel the e-line into the well, using extreme caution to not have the measurement line contact the pump, associated tubing or the fastening cable suspending the dedicated pump in-place.
4. Slowly raise and lower the e-line or tape to the point where the buzzer and the light just begin to activate. This indicates the static water level. Agitation to the surface of the groundwater may cause inaccurate measurements or excess mixing of the water. Care will be taken to avoid any excess agitation.
5. Using the thumb and index finger, mark this position on the e-line to the permanent reference point at the top of the polyvinyl chloride (PVC) pipe. The water level will be recorded in hundredths of a foot from the e-line. This measurement provides the depth to the top of the water surface, which will be used as a point of reference for monitoring the water level during purging and sampling.
6. During purging and sampling, the water level will be measured every three to five minutes to monitor any drawdown in the water level.
7. After all purging and sampling activities are complete, measure the total depth of the well. Turn the probe off and slowly lower the e-line until slack is sensed in the line. Slowly lift the line back up, stopping when tautness is sensed. Record the measurement as in step #5 above. If the submersible pump does not allow the e-

line to be lowered past the pump, remove the pump and all associated apparatus before measuring the total depth of the well. Be cautious that the pump and associated apparatus do not come into contact with a contaminated surface. Should this occur, decontaminate the equipment according to Section 3.3.

8. When all depth measurements have been completed, reel the cable back into the spool while wiping the line dry with paper towels. Replace the pump and associated apparatus to the proper position in the well.
9. For the purpose of computing the amount of water in the well to be purged for non low-flow purging, calculate the depth of water in the well by subtracting the water level measurement recorded in step #5 from the Total Depth (TD) of the well obtained from the well completion reports or drilling logs. Record this information in the field notebook and the Groundwater Monitoring Well Sampling Form in hundredths of feet.
10. Compare the measured depth of the well as determined in step #7 with the Total Depth (TD) used to calculate the depth of water in the well. Record the difference between these two values in the field notebook and the Groundwater Monitoring Well Sampling Form in hundredths of feet. This figure reflects the degree to which silt has accumulated in the bottom of the well. A significant accumulation could interfere with the performance of the well. This information should be furnished to the Project Manager and to Fort Hood Directorate of Public Works personnel. This information will be evaluated along with the well inspection information discussed in Subsection 3.2 and reported to the TCEQ, if corrective action is required.

All measurements taken in feet and inches will be converted to hundredths of feet. For example: a measurement of 35 feet, 4 inches converts to 35.33 feet.

3.4.2 Static Water Level Measurement in Wells to be Bailed

The following steps will be used to take water level measurements in wells where bailers are used due to failure of the primary equipment.

1. After the e-line is decontaminated, shake off all excess water and/or wipe the cable clean with paper towels.
2. Prior to inserting the e-line into the well, follow the manufacturer's instructions to ensure the device is functioning properly.
3. Slowly unreel the e-line into the well until the buzzing sound can be heard and the red light is observed on the meter.
4. Slowly raise and lower the e-line to the point where the buzzer and the light just begin to activate. This indicates the static water level.
5. Using the thumb and index finger, mark this position on the e-line to the point at the top of the polyvinyl chloride (PVC) pipe. The water level will be recorded in hundredths of a foot from the tape. This measurement provides the depth to the top of the water surface, which will be used to measure the amount of water in the well.
6. To measure the total depth of the well, turn the probe off and slowly lower the e-line until there is slack in the line. Slowly lift the line back up, stopping when tautness is sensed. Record the measurement as in step #5, above.

7. When all depth measurements have been completed, reel the e-line back into the spool while wiping the line dry with paper towels.
8. For the purpose of computing the amount of water in the well, calculate the depth of water in the well by subtracting the water level measurement recorded in step #5 from the Total Depth (TD) of the well obtained from the well completion reports or drilling logs. Record this information in the field notebook and the Groundwater Monitoring Well Sampling Form in hundredths of feet.
9. Compare the measured depth of the well as determined in step #6 with the Total Depth (TD) used to calculate the depth of water in the well. Record the difference between these two values in the field notebook and the Groundwater Monitoring Well Sampling Form in hundredths of feet. This figure reflects the degree to which silt has accumulated in the bottom of the well. A significant accumulation could interfere with the performance of the well. This information should be furnished to the Project Manager and to Fort Hood Directorate of Public Works personnel. This information will be evaluated along with the well inspection information discussed in Subsection 3.2 and reported to the TCEQ, if corrective action is required.
10. All measurements taken in feet and inches will be converted to hundredths of feet. For example: a measurement of 35 feet, 4 inches converts to 35.33 feet.

3.5 Purging the Wells

Following the completion of water level measurements at all wells, each well will be purged prior to sampling to remove stagnant, degassed water that may not be representative of the groundwater. The primary purging method will be performed with adjustable-rate, dedicated submersible pumps, with manual bailing used as the backup method. The submersible pumps will be able to perform low-flow and normal purging. The requirements for purging the wells with submersible pumps or bailers are the same if the pumps are not used in low-flow mode. If the submersible pumps are used for low-flow purging, the requirements for purging differ dramatically. The following subsections address the different possibilities.

Purged water and water from the decontamination procedures will be combined with the leachate from the landfill and disposed in the Bell County W.C.I.D. No. 1 Wastewater Treatment Plant system. The field sampling team will contact the landfill manager at the operations office upon arrival at the landfill for specific instructions regarding disposal of purged and decontamination water.

3.5.1 Low-Flow Purging with Submersible Pumps

Low-flow purging with dedicated, adjustable-rate, submersible pumps will be the primary method used for monitoring wells that, with sustained pumping, exhibit no continuous drawdown. Acceptable pumps will be centrifugal or bladder-type pumps constructed of stainless steel or Teflon®; peristaltic and inertial pumps will not be used. Pumps will be capable of achieving pumping rates less than 0.25 L/min (0.065 Gal/min), and pumping through at least 50 feet of tubing. All pumps and pump apparatus, including tubing, will be permanently installed. Tubing will be Teflon® or Teflon®-lined. In the event that non-dedicated or replacement equipment is used, it must be decontaminated and installed at least 24 hours prior to sample collection in order to minimize mixing of stagnant water from the surface of the well, and the resuspension of settled solids in the well.

Submersible pumps will be installed, utilized, and maintained with strict accordance to the manufacturer's instructions.

During the initial groundwater sampling event, a demonstration using low-flow methods will be conducted at all sampling points to determine the viability of low-flow purging and sampling. The purpose of this demonstration is to identify which wells at the landfill are capable of supporting a low-flow sampling regime, and the specific pumping rates required for each individual well in order that extreme and/or continuous drawdown does not occur. The data gathered from this demonstration would be recorded and presented to the TCEQ for review. Pursuant to this demonstration, those wells which can be purged by low-flow methods will be identified. Those wells that are not capable of supporting low-flow methods will be purged according to Section 3.5.2.

The purge rate will be less than 1.0 L/min (0.26 Gal/min) and preferably be less than 0.3 L/min (0.08 Gal/min), and the optimal purge rate range for each well will be determined and recorded in the field notebook during the initial demonstration. The minimum purge volume will be at least the equivalent of two times the combined volumes of the sample pump and tubing, calculated from the pump manufacturer's specifications and the dimensions of the tubing. The purge process will continue until the geochemical parameters, temperature, specific conductance, turbidity, and pH (see Section 3.6) have stabilized within 10%, or ±0.1 pH units, over the last three consecutive measurements taken three to five minutes apart. Purge water will be collected into a measuring device (1 or 2 gallon graduated plastic container) to determine the volume removed. This volume will be recorded in the field notebook. Sampling will immediately follow stabilization of the geochemical parameters.

During purging, the elevation of the surface of the groundwater in the well will be measured every three to five minutes and recorded in the field notebook (see Sections 3.4 and 3.4.1). If continuous drawdown is noted, the pump rate will be lowered to the point that drawdown does not occur. If this cannot be achieved, purging will follow the procedure discussed in Section 3.5.2. Documentation of all purge data, including volumes of both purged water and sampled water, elapsed times, pump-flow rates, all water level measurements and geochemical parameter measurements will be submitted with sampling results to the TCEQ for review.

3.5.2 Non Low-Flow Purging

If the initial demonstration determines a well is not capable of purging by low-flow methods, or if low-flow methods will not be used for any reason, non low-flow purging will be performed using submersible pumps (with bailers as backup in case of equipment failure). Equipment dedicated to an individual well will be used in order to prevent cross-contamination of groundwater samples between wells.

Regardless of whether submersible pumps or bailers are used, the minimum amount of water to be bailed is the same. The volume of water to be purged prior to sampling is calculated by using the measured depth of water in the well. To calculate the minimum amount of water to purge: subtract the static water level (WL) in the well, as determined on the measuring tape at the top of the casing, from the total depth (TD) of the well (see Subsection 3.4.1, step #9), and multiply that difference by 0.7 gallons/foot for a 4-inch casing, or 0.17 gallons/foot for a 2-inch casing. This converts the depth of water in feet to the volume of water in gallons. Multiply the number of gallons of water in the well by 3 to obtain the minimum volume of water to be purged from the well (3 well casing volumes).

For example, for Monitoring Well No. 1:

TD = 63.4 feet (Obtained from Well Completion Report);

WL from top of casing = 45.25 feet;

(TD-WL) = 63.4 – 45.25 = 18.15 feet of water in the well;

Conversion from feet of water to gallons of water: For a 4-inch well, multiply by 0.7 gallons/foot = 18.15' x 0.7 gal/ft = 12.71 gallons of water in well: multiplied by 3 well casing volumes = 38.13 gallons to purge from well.

To convert the depth of water (ft) to volume (gal) for any diameter well, use the following formula:

Well volume (gal) = depth of water (ft) x $[\text{pipe diameter (in)}]^2$ x 0.0408.

To convert from gallons to liters, multiply gallons by 3.79, and to convert liters to gallons, multiply liters by 0.264.

If a well recharges slowly, purging to dryness is sufficient to remove stagnant water. When dealing with slow-recovery wells, up to seven days should be allowed for groundwater recharge prior to sampling, and the water level should be allowed to recover to an amount sufficient for collecting groundwater samples. After seven days, if the well has not recovered enough water to obtain any groundwater samples, the well may be declared "dry" for that sampling event. TCEQ approval for allowing up to seven days to sample a well is not necessary, although contact with the TCEQ in these instances is encouraged. The volume of water removed from the well and the time required for purging should be recorded in the field log.

3.5.2.1 Non Low-Flow Purging with Submersible Pumps

Purging with dedicated, adjustable-rate, submersible pumps will be the primary method used for monitoring wells, which, with sustained pumping, exhibit continuous drawdown. The requirements for these pumps are identical to the requirements for the pumps described in Section 3.5.1. In the event that non-dedicated equipment is used (such as when dedicated equipment is damaged), it must be decontaminated and installed at least 24 hours prior to sample collection in order to minimize mixing of stagnant water from the surface of the well, and the resuspension of settled solids in the well. To minimize the disturbance of sediments in the bottom of the well during purging, the pump will be installed at least two feet above the bottom of the well.

The flow rate of the submersible pump will be set at 3 L/min (0.78 Gal/min) for purging. Purge water will be collected into a measuring device (1 or 2 gallon graduated plastic container) to determine the volume removed. The volume of water purged will be recorded in the field notebook and on the Groundwater Monitoring Well Sampling Form (Appendix 2). Purging will continue until dryness occurs, or until at least 3 well casing volumes of water have been removed (see Section 3.5.2).

After purging at least three well casing volumes, the purge process will continue until geochemical parameters (pH, temperature, turbidity, and conductivity; see Section 3.6) have stabilized with 10%, or ±0.1 pH units for the last three measurements taken three to five minutes apart. Sampling (Section 3.7) should follow purging immediately, providing there is significant groundwater available to collect all required samples.

3.5.2.2 Purging with Bailers

Bailers with a double-check valve and bottom emptying device will be used in the event of primary equipment (i.e., submersible pump) failure. Bailers will either be stainless steel or single-use disposable, with a Teflon®-coated stainless steel cable used for suspension. The bailer will be lowered slowly to avoid agitating accumulated sediments at the bottom of the well. The bailer should be lowered to the bottom of the screen and removed slowly to the surface. The bailer is then emptied into a measuring device (1 or 2 gallon graduated plastic container) to determine the volume removed. The volume of water purged will be recorded in the field notebook and on the Groundwater Monitoring Well Sampling Form (Appendix 2). Purging will continue until at least 3 well casing volumes have been removed from the well or until the well runs dry.

After purging at least three casing volumes, the geochemical parameters (pH, temperature, turbidity, and conductivity; see Section 3.6) will be measured for stabilization. Stabilization is achieved when the measurements of groundwater taken from three consecutive bailers have stabilized with 10%, or ±0.1 pH units. Sampling (Section 3.7) should follow purging immediately, providing there is significant groundwater available to collect all required samples.

3.6 Measurement of Field Parameters

Recharging groundwater must return to a representative or “stabilized” state before samples can be collected for laboratory analysis. Stabilization is achieved when the field-measured values for groundwater temperature, specific conductance, pH, and turbidity from the last three consecutive measurements taken three to five minutes apart or from separate bailers, exhibit no greater than a 10% difference, or 0.1 pH units, between each consecutive samples. In addition to these parameters, any pertinent physical characteristics, such as color and odor, will be noted in the field notebook. Once stabilization is achieved, the sampling process may be initiated.

Dedicated submersible pumps (with bailers as a backup) will be used to collect groundwater for testing field parameters to determine water stability and for collecting analytical samples once groundwater stability has been confirmed. When using submersible pumps, groundwater stabilization will be tested using an in-line flow-through cell for the parameters of temperature, conductivity, pH, and turbidity.

The in-line cell will connect to the tubing from the well using a non-reducing, Teflon® or stainless steel “tee” junction valve. The tubing from the pump to the surface will attach to one of the inlets of the junction, and a valve will divert flow into one of two directions: to the sample collection discharge, or to the in-line flow-through cell. All tubing not directly connected to the submersible pump will be Teflon®, and will be disposed of after each use. The cell will be composed of inert materials such as Teflon®, stainless steel or laboratory-grade glass (Pyrex or equivalent). The in-line flow-through cell will be thoroughly decontaminated between sampling events (see Section 3.3).

If the backup method is used (bailers), the water removed from the bailers is placed in a beaker for field parameter measurements. A separate bottle or beaker (not a labeled sample bottle) will be used for field parameter testing. These bottles or beakers may be reused if thoroughly decontaminated between sampling events. All results must be recorded in the field notebook and on the sampling form provided in Appendix 2.

The pump should be operated so that the groundwater is withdrawn from the well at a rate of less than 1.0 L/min to avoid agitating and potentially degassing the sample. Samples should be collected as near to the well head as possible, and the flow-through cell or beaker should be shielded from the sun and wind. After the sample to be tested is drawn into the flow-through cell or beaker (in the case of bailers), the water temperature should be measured immediately, followed by measurements for specific conductance, pH, and turbidity. The instrument(s) used to measure field parameters should be calibrated daily, checked against standards before testing at each individual well, and backup equipment should be available should the primary instrument(s) malfunction. Instruments failing standards checks must be re-calibrated prior to use. A single instrument such as the Horiba U-10 Water Quality Checker, or an equivalent device, may be used to measure all four of the field stabilization parameters. If such a device is used, the manufacturer's instructions for calibration and operation should be followed. If individual testing instruments are used, they should be employed according to the discussions presented in the following four subsections describing field parameter measurements, or according to manufacturer's specifications whenever those specifications vary from this discussion.

3.6.1 Temperature

The sampler will measure the water temperature with a calibrated thermometer upon removal of the water from the well. Insert the thermometer into the flow-through cell or beaker and allow the thermometer reading to reach a steady state. Temperature stabilization is achieved when three consecutive samples, taken three to five minutes apart or from separate bailers, read with 10% of each other (for example: 20, 18, 19). Record the stabilized temperature to the nearest °C in the column "TEMP. (Deg. C)" on the sampling form in Appendix 2.

3.6.2 Specific Conductance

The specific conductance of a sample is measured by the use of a self-contained conductivity meter. Instruments are standardized with KCl (Potassium Chloride, 0.01 M) solution before use. The conductivity cell must be kept clean. The sampler will follow the directions of the manufacturer for operation of the instrument. Samples are preferably analyzed at 25°C. If not, temperature corrections are made and results reported at 25°C. If the instrument does not automatically adjust the conductance value for variations in water temperature, then a temperature-related adjustment in the conductivity value will need to be made. To make this correction, determine the temperature of the sample to the nearest 1°C. If the temperature of the sample is not 25°C, make temperature corrections in accordance with these instructions:

3.6.2.1 Procedure

Temperature corrections are based on the standard KCl solution.

1. If the temperature of the sample is below 25°C, add 2% of the reading per degree.

2. If the temperature of the sample is above 25°C, subtract 2% of the reading per degree.

3.6.2.2 Reporting

Results are to be reported as Specific Conductance, umhos/cm. Specific conductance stabilization is achieved when three consecutive samples, taken three to five minutes apart or from separate bailers, read within 10% of each other. Report the stabilized reading on the Sampling Form under the column "SPEC. COND. (umhos/cm)."

3.6.3 pH

The pH is measured with a portable pH meter. The pH meter is calibrated with the pH 7.0 and 4.0 buffer solutions. The pH 10.0 buffer is used as a reference check. If individual instruments (different meters for pH and conductivity) are used, the pH should be measured *after* the conductivity to prevent any false conductivity readings caused by leakage of salts from the pH probe into the sample.

3.6.3.1 Procedure

Rinse the electrodes 2 or 3 times with deionized or distilled water before measuring the pH of samples. Insert the pH probe into the flow-through cell or beaker so the sensing elements are completely submersed and gently stir at a constant rate to provide homogeneity and suspension of solids. Note and record the pH and temperature of the sample. If the sample temperature varies by more than 2°C from the buffer solution (see above), the measured pH values must be corrected. Many instruments are equipped with automatic or manual compensators that electronically adjust for temperature differences. Refer to the manufacturer's instructions for information on compensators or for manual compensating factors. pH stabilization is achieved when three consecutive samples, taken three to five minutes apart or from separate bailers, read within 0.1 pH units of each other.

3.6.3.2 Reporting

pH meters read directly in pH units. Report the stabilized pH value to the nearest 0.1 unit under the column "pH (1-14)" on the sampling form in Appendix 2.

3.6.4 Turbidity

Turbidity is the measurement of suspended matter in water that interferes with the passage of light. There are many different instruments available for the measurement of turbidity. Some instruments require re-calibration as a part of the measurement procedure while others require that the groundwater sample be diluted to achieve a final measurement. In either case an instrument which uses Formazin as a reference standard will be used. Nephelometric Turbidity Units (NTU) are the standard units of measure for turbidity.

3.6.4.1 Procedure

Calibrate the turbidimeter following the manufacturer's operating instructions prior to testing the sample. This initial calibration will establish a turbidity measurement range for the instrument.

The sample should be free of any debris which was not present in the groundwater when it was extracted from the monitoring well. The sample should be agitated so that any suspended solids are evenly dispersed throughout the sample. Depending on the instrument being used, the samples will either remain in the beaker for testing or a portion will be poured into a turbidimeter tube prior to measurement. Regardless of which type of measurement container is used, the sample should be free of air bubbles prior to measuring.

Take turbidity measurements following the instrument manufacturer's instructions. If the turbidity reading falls within the calibration range of the instrument discussed above, record the reading. If the reading falls outside of this range, then adjustments will need to be made and at least one additional measurement will need to be taken. Some instruments, such as the Horiba U-10, require re-calibration to a measurement range that will include the initial turbidity reading. Once this instrument is re-calibrated, a second reading is taken, and if this reading falls within the calibration range, then the reading is recorded. If the reading still falls outside of the calibration range of the instrument, then the re-calibration and re-measurement process is repeated.

Other types of instruments require that the sample be diluted if the initial reading exceeds the calibration range of the instrument. In this case, dilute a sample of the water with turbidity-free deionized or distilled water according to the instrument manufacturer's instructions, and test the diluted sample. When the turbidimeter reading falls within the calibration range of the instrument, note the reading but do not record it. This reading must be adjusted to account for the dilution of the sample. For example, if 5 volumes of turbidity-free water were added to 1 volume of sample, and measurement of the diluted sample indicated a turbidity of 30 units, then the turbidity of the original sample is 180 units [(5+1) volumes x 30 units].

When the final turbidity measurement has been achieved, the results will be recorded on the Sampling Form under the column "TURBIDITY (NTUs)" as follows:

NTU Value	Record to the Nearest:
0.0 – 1.0	0.05
1 – 10	0.1
10 – 40	1
40 – 100	5
100 – 400	10
400 – 1000	50
>1000	100

If the instrument being used requires that groundwater samples be poured into a turbidity tube for placement into the instrument, these tubes must be kept clean, and they must be discarded if they become scratched or etched. Also, the groundwater sample should be agitated to disperse suspended solids prior to each measurement when samples are re-tested following calibration adjustments. Turbidity stabilization is achieved when three consecutive samples, taken three to five minutes apart or from separate bailers, read within 10% of each other.

3.6.4.2 Reporting

Complete notes of all turbidity tests, instrument calibrations, and calculations, if applicable, must be entered in the field notebook. Report the turbidity results under the column "TURBIDITY (NTUs)" on the Sampling Form in Appendix 2.

3.6.5 <u>Physical/Chemical Characteristics</u>

Several physical and chemical characteristics may be evident by observation upon removal of the groundwater from the wells. Color and odors may be present in groundwater samples, which may indicate the presence of contaminants. Odors may indicate the presence of certain contaminants such as volatile organic compounds (VOCs). Another physical evidence of possible problems would be a two-phase (aqueous and non-aqueous) sample. This could indicate an introduction of an organic liquid. The organic phase may be either lighter or heavier than water, depending upon its composition.

Notes describing these observations will be placed in the "COMMENTS" column on the Groundwater Monitoring Well Sampling Form and also recorded in the field notebook. The Project Manager or the Directorate of Public Works will be notified of any unusual observations.

3.7 Sampling, Preservation, and Field QA/QC

Preferably, samples will be collected immediately after the well is stabilized (samples must be collected immediately if low-flow purging is used), otherwise, samples should be collected from a well within 24 hours following purging. If a well is slow to recharge, a maximum of 7 days may be allowed between purging and sampling. If a well has not sufficiently recharged after 7 days, the well may be declared "dry", and no samples may be collected from that well for that sampling event. Except in the case of bailers, all wells will be sampled using the same specifications for the submersible pumps.

Samples collected with submersible pumps will be collected from the pump discharge line before the water enters the flow-through cell. The Teflon or stainless steel "tee" junction valve will be adjusted to divert the flow away from the flow-through cell to the sample discharge line. Before sampling, inspect the sampling line for air bubbles caused by loose connections. If air is introduced into the sampling train through loose connections, the connections should be adjusted to prevent the introduction of air. Additionally, the pump flow rate may be reduced to minimize aeration, bubble formation, or turbulent filling of sample bottles. Do not use reduction valves to reduce flow rate as it may cause a pressure gradient that leads to the volatilization of volatile organic compounds (VOCs). The flow rates for submersible pumps will be less than 0.5 L/min during sampling (preferably less than 0.1 L/min for VOC sampling).

If a bailer is used to collect samples, the bailer will be lowered and retrieved slowly to avoid degassing the groundwater and agitating any sediments in the well. Bailers will be identical to those described in Section 3.5.2.2. The water will be transferred directly into the sample containers.

Sample containers will be rinsed with water pumped or bailed from the well prior to filling unless the sample containers contain preservation agent(s), in which case the container will be filled so that spillage of the preservation agent is avoided and no headspace remains once the cap is in place. Sample containers will be filled in a manner which does not agitate or aerate the sample in order to prevent loss of volatile contaminants and to prevent chemistry changes due to either carbon dioxide (CO_2) loss with pH increase or oxygenation of the samples. All non-dedicated sampling equipment will be thoroughly decontaminated as described in Subsection 3.3.

When filling the sample bottles, the following procedures and precautions are essential:

1. Bottle caps will be removed carefully so that the inside of the cap is not touched. Caps should never be put on the ground. Caps for volatile organic compounds (VOCs) vials contain a Teflon®-lined septum. The Teflon® side of the septum must be facing the sample to prevent contamination of the sample through the septum.
2. Field technicians will wear appropriate gloves (Powder-free PVC or Latex disposable gloves).
3. Ice chests will have ice in them prior to transport to the field to aid in the cooling process for samples.
4. The sample bottles will be filled with a minimal amount of air contact, and without allowing the sampling equipment or personnel to touch the inside of the bottles or bottle caps. Tubing or hoses must not touch or be placed in the sample bottles.
5. Samples for Metals and VOCs will have preservatives in the bottles when received. The analytical laboratory will prepare their bottles before shipment, and will label the bottles accordingly. These bottles will be filled completely with the sample and the bottle cap replaced tightly.
6. Should preservative spill from a bottle before or during sampling, the bottle must not be used.
7. VOC vials must be filled so that they are headspace-free. These sample containers will be filled by allowing the pump discharge to gently flow down the inside of the container with minimal turbulence. These sample bottles need to be slightly overfilled such that a positive meniscus from the water surface extends above the rim of the vial. The caps for these bottles will be replaced gently, to eliminate any air bubbles in the sample. These bottles must be checked by inverting them and tapping them sharply with a finger. If any air bubbles appear, open the bottle, add more water, and repeat this process until all air bubbles are gone. Do not empty the bottle and refill it.
8. All sample bottles will be labeled with non-smearing ink prior to filling. Do not remove the lid on the sampling bottle until the ink has completely dried, inks may contain volatile chemicals that would produce false results. Once sample bottles have been filled and capped, they must immediately be wrapped in “bubble wrap” or a similar material to avoid breakage during shipment. After being wrapped, the containers will be placed in a water-tight resealable plastic bag to prevent contact with melted ice. Next, the bottles will be placed in an ice chest and chilled to 4°C. Dry ice will not be used to chill samples. These procedures must be executed quickly to avoid increasing the temperature of the samples.
9. Samples must be shipped to the analytical laboratory as soon as possible after the sampling day, preferably shipped on the same day to arrive in the laboratory the next morning. Expanded foam ice chests will not be used to ship samples.

Due to the short hold and extraction times involved with some of the analytical methods, it may be necessary to ship the same day as sampling occurs. Therefore, allow time at the end of the day to get the collected samples to the courier.

10. Sample bottles, caps, or septums that fall on the ground before filling will be thoroughly rinsed with sample water before being used. All circumstances regarding dropped caps or bottles, and their subsequent rinsing and use, must be noted on the field notebook and Sampling Form.

Samples will be collected and containerized in the order of the volatilization sensitivity of the parameters being collected. The order of collection will be as follows: VOCs and metals.

Samples to be analyzed for VOCs require 2 – 40 mL glass vials or bottles with Teflon®-lined septa preserved with hydrochloric acid (HCl) to the groundwater to make the pH less than 2 (<2). Samples must be cooled to 4°C after sampling and maintained at that temperature until analysis. Maximum sample holding time by the analytical laboratory is 14 days. VOC samples, including QA/QC samples, should be representative of the same water. Therefore, if samples are collected using a submersible pump, the second vial will be filled immediately after the first vial is filled. If a bailer is used for sampling, all VOC samples should be filled with water from a single bailer.

Groundwater samples to be analyzed for metals are collected in appropriate 1-liter plastic or glass containers. These samples are to be acidified with nitric acid (HNO_3) to a pH<2 after field filtering, and must be maintained at 4°C after sampling. Maximum holding time for metals is 6 months except for mercury, which is 28 days.

3.7.1 Quality Control (QC) Samples

QC samples to be included in the shipment to the laboratory include field duplicates, trip blanks, field blanks, and equipment blanks. These samples will be prepared for each groundwater sampling event.

Field duplicates consist of two samples from the same well, collected consecutively or from the same bailer (if used), but labeled differently (i.e., different sample number) so that the analytical laboratory is unaware that the samples are duplicates. By comparing the analytical results of the two samples, the precision of laboratory techniques may be assessed. Two field duplicates will be submitted for each sampling event. Wells chosen for field duplicates will be identified prior to mobilization for field activities. These wells will be chosen randomly except when:

1. It is determined that a specific well will be studied due to contamination detected by a previous sampling event; or
2. An equipment failure occurs, and one or more wells will need to be purged and sampled with bailers. In such an instance, at least one set of duplicates will be taken from well(s) sampled with bailers, and one set from well(s) using submersible pumps.

Trip blanks are prepared before the sampling event by pouring distilled or deionized water into clean sample containers. The blanks are then transported to and from the site along with the other sample containers. Trip blanks are used to determine if any of the sample bottles or samples collected have been contaminated before or during sampling.

Further, they are used to ensure that the integrity of the samples has been maintained during shipping, handling, and storage. One trip blank for each sampling event will be used.

Field blanks are prepared in the field by pouring distilled or deionized water into sample containers opened in the field, then submitted to the laboratory with the samples to be analyzed. Field blanks are used to check sampling procedures and detect airborne contaminants. Field blanks will be collected when sampling the downgradient wells at the site. One field blank for each sampling day or two field blanks, whichever is greater, will be used.

Equipment blanks are a sample of distilled or deionized water, processed through the sampling equipment in the same manner as the groundwater samples to determine the effectiveness of the decontamination procedures. One equipment blank per sampling event will be used.

The U.S. Army Corps of Engineers (COE) or Fort Hood may require the collection of split samples. Split samples will be collected in the same manner as duplicates. Sample pre-treatment, handling methods, and, as much as possible, the methods of analysis will be the same for both sets of samples. This sample will be sent to a different analytical laboratory for analysis. The analytical results from the two laboratories will then be compared in order to confirm the procedures and assess the quality of data being generated by the primary analytical laboratory. Split samples will be collected at the frequency requested by the COE.

3.8 Chain-of-Custody Records

A groundwater sample chain-of-custody record will be maintained to document sample possession and the handling of individual samples from the time of collection through the completion of laboratory analysis. The chain-of-custody program will include the following:

- Sample labels to prevent misidentification of samples.
- Custody seals to preserve the integrity of the samples from the time they are collected until the shipping containers are opened in the laboratory.
- Field notes to record information about each sample collected during the groundwater monitoring program.
- Chain-of-custody record to document sample possession from the time of collection to analysis.
- Laboratory storage and analysis records, which are maintained at the laboratory and which record pertinent information about each sample.

The various components of this chain-of-custody program are described below:

3.8.1 Sample Labels

Each sample’s identification must be marked clearly on the sample container labels in waterproof ink. The information will be printed on each label and placed on the sample container prior to filling. The labels will be durable and legible even when wet and contain the following information:

- Sample identification number.
- Name and signature of the sampler.
- Date and time of sample collection.
- Well number.
- Analyses requested.

3.8.2 Sample Custody Seal

A custody seal will be placed on a shipping container across the lid and the body of the container in a manner which will cause the seal to break when the container is opened. Laboratory personnel will examine the condition of the seal upon receipt of the container and note any evidence of tampering (i.e., broken seal) in the laboratory records and immediately contact the Project Manager or the Directorate of Public Works to report the status of the shipment.

3.8.3 Field Notebook

The field notebook is to provide documentation of all activities involved in sampling activities. Items to be noted in the notebook are measurements, observations, information about samples including color, turbidity, degassing odor, and surface film or layered sample. Weather conditions will be noted including temperature, humidity, wind, and precipitation. Well purging activities will also be noted. Entries to the field notebook will be made in waterproof ink. Errors will be corrected by striking through the error with a single line so the original text may be read. The correction will then be initialed and dated by the person making the correction. The sampler will document the following information in the field notebook:

- Well number and depth.
- Static water level depth and measurement technique.
- Presence and thickness of immiscible layer, if present, and the detection method.
- Well purging procedure, equipment, and time.
- Well yield (high, same, low) and well recovery after purging (slow, same, fast).
- Collection method for immiscible layers, if needed.
- Sample withdrawal procedure, equipment, date and time, and results.
- Field observations of sampling event, including weather conditions.
- Name of samplers.
- Internal temperature of field and shipping containers.

3.8.4 Sample Analysis Request and Chain-of-Custody Record

The Analysis Request and Chain-of-Custody Record (field chain-of-custody) is included in Appendix 4. This document will be completed in waterproof ink by personnel performing the sampling activity in the field, and submitted along with the sample shipment to the analytical laboratory. The samplers will record all the necessary information on the form, and sign and date the form. Items of information to be recorded include the following:

- Sample numbers; date and time of sample.
- Size and material of sample container (for example: 8-oz. and glass).
- Sample type (aqueous or if immiscible material present).
- Method of preservation.
- Analyses and method numbers to be performed.

When the samples are delivered to the carrier, the samplers must sign in the "Relinquished by" space and record the date and time relinquished on the form. The carrier representative receiving the samples must sign his name adjacent to the person relinquishing the samples in the "Received by" space, record the date and time received, and whether or not the samples were intact. This procedure is repeated each time possession of the sample containers changes, until delivery to the analytical laboratory. The laboratory personnel will sign the field chain-of-custody and take receipt of the sample bottles. An internal laboratory chain-of-custody is maintained at the laboratory. As with the field chain-of-custody, the laboratory custody and transfer of samples must be documented so that the identity and integrity of samples can be established and maintained.

3.8.5 Sample Shipment

After collection, the sample bottles will be wiped clean, enclosed with bubble wrap, sealed in watertight, resealable plastic bags, and placed into an insulated, pre-iced, plastic-shelled ice chest or other suitable container. The temperature of the samples will be recorded when the ice chest arrives at the analytical laboratory to ensure that the appropriate sample temperature was maintained during shipment. All samples included in the ice chests will be packed in such a manner as to minimize the potential for container breakage. The Analytical Request and Chain-of-Custody form will be sealed in a water resistant bag and placed with the appropriate bottle set. A custody seal will be placed on the ice chest in a manner that will cause the seal to break if the ice chest is opened. All shipments will be scheduled for next day delivery to the laboratory. If the laboratory is closed on the day following sampling, the samples will be kept in the possession of the samplers until they can be delivered to the laboratory. The Bill of Lading or receipt for the ice chest(s) shipment will be attached to the Analysis Request and Chain-of-Custody form upon arrival at the analytical laboratory.

4.0 ESTABLISHMENT OF BACKGROUND GROUNDWATER QUALITY

Background groundwater quality will be established for all upgradient and downgradient groundwater monitoring wells to provide a baseline for determining whether a statistically significant change has occurred in the chemical composition of the groundwater during the detection phase of groundwater monitoring. The constituents to be monitored for the establishment of background are listed in Tables 1 and 2 of this GWSAP (See Appendix 1).

4.1 Background Sampling Event Scheduling

To establish a background database, a minimum of eight independent sampling events will be conducted at this facility, during which groundwater samples will be collected from each well in the monitoring system and analyzed for all constituents and parameters listed in Tables 1 and 2 of Appendix 1. Information generated from these eight background sampling events will permit both intrawell and interwell comparisons of sampling data. Background sampling at monitoring wells that are not included in the initial phase of background sampling will begin at least two years prior to the expected date that these wells will be incorporated into the monitoring system. Refer to the approved Fort Hood Groundwater Design Certification document for information regarding the phased monitoring well system.

4.2 Temporal Independence of Samples

The temporal independence of collected samples will be established by ensuring that a sufficient interval of time expires between sampling events. Over the two-year sampling period, the sampling events will be dispersed throughout each year so that two events coincide with each season. Thus, at the end of background sampling, two independent sets of data will have been produced from sampling conducted during each season: spring, summer, fall, and winter. In addition, sampling events will be scheduled so that samples may be collected following periods of both low and high rainfall in order to determine the effect of such variations on groundwater chemistry.

Since only one sampling event will be conducted during each year's season, more than sufficient time will elapse between events to ensure that the samples collected are temporally independent. This passage of time is necessary for the sampled groundwater to completely flow out from the sampling zone of each monitoring well such that samples collected during the subsequent event represent different water.

The time required for a temporal change in groundwater at an individual well can be calculated using Darcy's equation. Using guidance from the TCEQ and site-specific data obtained from the U.S. Army Corps of Engineers (USACE) study conducted in 1987 (See Fort Hood Permit Modification, Volume 2, Appendix IV, September 1994), the horizontal component of groundwater velocity may be calculated using a value of 0.0606 (320 ft/mi) for the hydraulic gradient (I), a value of 0.0283 ft/day (1×10^{-5} cm/sec) for the hydraulic conductivity (K_h), and a value of 0.02 for effective porosity (Ne).

$V_h = K_h * I / Ne$

$V_h = 0.0283 \text{ ft/day} * 0.0606/0.02$

V_h = 0.086 ft/day = 1 in/day

Therefore, in a 4-inch diameter monitoring well in the Fort Hood groundwater system, the water will change completely in approximately four (4) days. A sampling frequency equivalent to once a quarter within a calendar year will be more than sufficient to ensure the temporal independence of consecutive background sampling events.

5.0 DETECTION MONITORING

The Detection Monitoring Program is discussed in the following sections.

5.1 Groundwater Detection Monitoring Methodology

Following completion of the two-year program of background monitoring, the collected data will be statistically evaluated in order to determine the most appropriate method for statistical analysis of analytical data collected during detection monitoring. The objective of detection monitoring is to determine whether a statistically significant change (SSC) has occurred in the quality of the groundwater being sampled. Statistical methodology is discussed in Appendix 5, *Procedures for Selecting Statistical Methods*.

Per 30 TAC §330.407(b), data from detection monitoring events will be compared to background monitoring data within 60 days of each sampling event to determine if statistically significant changes (SSCs) have occurred.

5.2 Groundwater Detection Monitoring Constituents

Groundwater samples will be analyzed for the constituents listed in Tables 1 and 2 of Appendix 1.

5.3 Groundwater Detection Monitoring Frequency

Detection monitoring will begin six months after the completion of background sampling and will continue at a frequency of every six months thereafter. This groundwater sampling and analysis program must be conducted for the active life of the facility and for the duration of its closure and post-closure care periods.

6.0 ASSESSMENT MONITORING

An assessment monitoring program will be initiated at the facility if a SSC is confirmed in at least one downgradient monitor well. An assessment monitoring program must begin within 90 days of determining that a SSC has occurred per 30 TAC §330.409(b).

6.1 Initial Assessment Monitoring Event

In accordance with 30 TAC 330.409(b), if an SSI is verified in a monitor well, assessment monitoring will be initiated at the well(s) exhibiting the SSI, and at the immediately adjacent wells on each side of the monitoring well(s) exhibiting the SSI, unless an alternative subset of wells is designated by the TCEQ executive director. During the initial assessment monitoring event for a monitor well, the sample will be analyzed for constituents listed in Appendix II of 40 CFR 258. Initial assessment monitoring samples will be collected within 90 days of determination that a SSC exists per 30 TAC §330.409(b).

Per 30 TAC §330.409(d), the Owner will submit an assessment monitoring report to the TCEQ within 60 days of the initial assessment monitoring event.

6.2 Subsequent Assessment Monitoring Events

Following review of data obtained during the initial assessment monitoring event, constituents listed in 40 CFR 258, Appendix II that are not detected during the initial assessment monitoring event may be excluded from the constituent list for future assessment monitoring events with the approval of the TCEQ Executive Director. Approval by the TCEQ Executive Director of requests for deletion of 40 CFR 258, Appendix II constituents will be based on lines of evidence including but not limited to data documenting whether or not those constituents are reasonably expected to be in or derived from waste contained in the unit. Historical leachate monitoring data collected at the landfill may be used in this determination.

Subsequent assessment monitoring events will be conducted concurrently with detection monitoring events on a semi-annual basis.

Results from subsequent assessment monitoring events will be reported to the TCEQ on an annual basis in accordance with 30 TAC §330.409(k). An annual assessment monitoring report must be submitted to the TCEQ within 60 days after the landfill's second semi-annual groundwater monitoring event that includes the following information determined since the previously submitted annual report:

1. A statement regarding whether a statistically significant level above a groundwater protection standard has occurred in any well during the previous year and the status of any statistically significant level events;
2. The results of all groundwater monitoring, testing, and analytical work, including a summary of background groundwater quality values, groundwater monitoring analyses, statistical calculations, graphs, and drawings;
3. The groundwater flow rate and direction in the uppermost aquifer and all documentation used to determine the groundwater flow rate and direction of groundwater flow;

4. A contour map of piezometric water levels in the uppermost aquifer and all data or documentation used to establish the contour map; and
5. Recommendations for any changes.

6.3 Requirements for Termination of Assessment Monitoring

If concentrations of all assessment constituents (constituents exhibiting SSCs) at a specific monitor well are at or below background values for two consecutive assessment monitoring events, the facility may return that well to detection monitoring if approved by the TCEQ. If the concentrations of any assessment constituents are above background values but below groundwater protection standards (GWPSs, as determined in accordance with 30 TAC §330.409(h)), the facility will remain in assessment monitoring. If one or more assessment constituents are detected at statistically significant levels above GWPSs, the facility will conduct an assessment of corrective measures in accordance with 30 TAC §330.411.

7.0 ANALYSIS OF RESULTS AND REPORTING

Laboratory data and analyses will be performed and submitted in accordance with Chapter 330 Subchapter F, Analytical Quality Assurance and Quality Control. Additionally, the facility will submit laboratory data and analyses prepared by a TCEQ accredited environmental testing laboratory and in accordance with acceptable accreditation standards (e.g., National Environmental Laboratory Accreditation Conference (NELAC)).

7.1 Practical Quantitation Limits

The practical quantitation limit (PQL) is defined as the lowest concentration reliably achieved within specified limits of precision and accuracy during routine laboratory operating conditions and is analogous to the limit of quantitation definition in the most recent available NELAC Standard (National Environmental Laboratory Accreditation Conference). The PQL is method, instrument, and analyte specific and may be updated as more data becomes available. The PQL must be below the groundwater protection standard established for that analyte as defined by 30 TAC §330.409(h) unless approved otherwise by the Texas Commission on Environmental Quality (TCEQ). The precision and accuracy of the PQL shall be initially determined from the PQLs reported over the course of a minimum of eight groundwater monitoring events. The results obtained from these events shall be used to demonstrate that the PQLs meet the specified precision and accuracy as shown in the table below. The PQL will be supported by analysis of a PQL check sample, which is a laboratory reagent grade sample matrix spiked with chemicals of concern at concentrations equal to or less than the PQL. At a minimum, a PQL check sample will be performed quarterly during the calendar year to demonstrate that the PQL continues to meet the specified limits for precision and accuracy as defined below.

QC Specification Limits for the PQL and Lower Limit of Quantitation Check Samples

COC	Precision (% RSD)	Accuracy (% Recovery)
Metals	10	70-130
Volatiles	20	50-150
Semi-Volatiles	30	50-150

For analytes that the established PQL cannot meet the precision and accuracy requirements in the table above, the owner/operator will ensure the laboratory will submit sufficient documentation and information to the TCEQ for alternate precision and accuracy limits on a case by case basis. Non-detected results will be reported as less than the established PQL limit that meets these precision and accuracy requirements.

7.2 Laboratory Data Package Reporting Requirements

All analytical data submitted under the requirements of this permit will be examined by the owner and/or operator to ensure that the data quality objectives are considered and met prior to submittal for the TCEQ to review. The owner and/or operator will determine if the results representing the sample are accurate and complete. The QC results, supporting data, and data review by the laboratory must be included when the owner/operator reviews the data. Any potential impacts will be reported such as the bias on the quality of the data, footnotes in the report, and anything of concern that was identified in the Laboratory Case Narrative (LCN) summary.

The owner and/or operator will ensure that the laboratory documents and reports all problems and anomalies associated with the analysis. If analysis of the data indicates that the data fails to meet the QC goals for the laboratory's analytical data analysis program, the owner and/or operator will determine if the data is usable. If the owner and/or operator determines the analytical data may be utilized, any and all problems and corrective action that the laboratory identified during the analysis will be included in the report submitted to the TCEQ.

A LCN report for all problems and anomalies observed must be submitted by the owner and/or operator. The LCN will report the following information:

1. The exact number of samples, testing parameters, and sample matrix.
2. The name of the laboratory involved in the analysis. If more than one laboratory is used, all laboratories shall be identified in the case narrative.
3. The test objective regarding samples.
4. Explanation of each failed precision and accuracy measurement determined to be outside of the laboratory and/or method control limits.
5. Explanation if the effect of the failed precision and accuracy measurements on the results induces a positive or negative bias.
6. Identification and explanation of problems associated with the sample results, along with the limitations these problems have on data usability.
7. A statement on the estimated uncertainty of analytical results of the samples when appropriate and/or when requested.
8. A statement of compliance and/or noncompliance with the requirements and specifications. Exceedance of holding times and identification of matrix interferences must be identified. Dilutions shall be identified, and if dilutions are necessary, they must be done to the smallest dilution possible to effectively minimize matrix interferences and bring the sample into control for analysis.
9. Identification of any and all applicable QA/QC samples that will require special attention by the reviewer.
10. A statement on the QC of the analytical method of the permit and the analytical recoveries information shall be provided when appropriate and/or when requested.

In addition to the LCN, the following information must be submitted for all analytical data:

1. A table identifying the field sample name with the sample identification in the laboratory report.
2. Chain-of-Custody.
3. An analytical report that documents the results and methods for each sample and analyte to be included for every analytical testing event. These test reports must document the reporting limit/method detection limit the laboratory used.
4. A release statement must be submitted from the laboratory. This statement must state "I am responsible for the release of this laboratory data package. This data package has been reviewed by the laboratory and is complete and technically compliant with the requirements of the methods used, except where noted by the

laboratory in the attached exception reports. By my signature below, I affirm to the best of my knowledge, all problems/anomalies, observed by the laboratory as having the potential to affect the quality of the data, have been identified by the laboratory in the Laboratory Review Checklist, and no information or data have been knowingly withheld that would affect the quality of the data."

- If it is an in-house laboratory, it must have the following statement: "This laboratory is an in-house laboratory controlled by the person responding to the rule. The official signing the cover page of the rule-required report (for example, the APAR) in which these data are used is responsible for releasing this data package and is by signature affirming the above release statement is true."

5. If the data is from soil and/or sediment samples, it must be reported on a dry weight basis with the percent solids and the percent moisture reported so that any back calculations of the wet analysis may be performed.
6. A laboratory checklist (included as Appendix 8). For every response of "No, NA, or NR" that is reported on the checklist, the permittee will ensure the laboratory provides a detailed description of the "exception report" in the summary of the LCN. The permittee will require that the laboratory use the checklist and do an equivalent of an EPA Level 3 review regarding QC analysis.

7.3 Data Compilation

The analytical results of each event will be maintained in an electronic database designed to facilitate data retrieval and statistical manipulation. The computer software selected to maintain the database should be capable of performing the statistical procedures discussed in Appendix 5.

Each constituent-specific data set will be plotted and assessed to identify anomalies that could be related to possible data entry errors, QC problems, or potential outliers.

7.4 Statistical Analysis

Following completion of background monitoring, the assembled data will be evaluated according to the procedures detailed in Appendix 5. Based upon that evaluation, within 90 days of the completion of background monitoring, Fort Hood will submit a recommendation for the statistical methods to be used in the analysis of data produced during detection monitoring. The methods recommended will be specific to each constituent to be monitored. This recommendation will be submitted to the TCEQ for approval.

7.5 Reporting

In accordance with 30 TAC §330.407(c), an annual detection monitoring report will be submitted to the TCEQ within 90 days after the landfill's last groundwater monitoring event in a calendar year that includes the following information determined since the previously submitted annual report:

1. A statement regarding whether a SSC increase has occurred over background values in any well during the previous year and the status of any SSC increase events;

2. The results of all groundwater monitoring, testing, and analytical work, including a summary of background groundwater quality values, groundwater monitoring analyses, statistical calculations, graphs, and drawings;
3. The groundwater flow rate and direction in the uppermost aquifer and all documentation used to determine the groundwater flow rate and direction of groundwater flow;
4. A contour map of piezometric water levels in the uppermost aquifer and all data or documentation used to establish the contour map; and
5. Recommendations for any changes in the groundwater monitoring system.

If a statistically significant change (SSC) from background concentrations is determined for one or more parameters required to be monitored, Fort Hood will notify the Executive Director in writing of this fact within 14 days after that determination is made per 30 TAC §330.407(b). The report will include all the background information leading to the conclusion that a statistically significant change had occurred, what measures were being taken to determine the source, and the schedule for any verification resampling activities or advise the TCEQ if an Alternate Source Demonstration Report (ASDR) is being prepared in accordance with 30 TAC §330.407(b)(3). The U.S. Army, Fort Hood will also place a notice in the operating record describing the change.

During the time following the initial recognition of a potential SSC, one verification resample may be obtained to confirm the presence/absence of a SSC. If verification resampling is performed, results will be submitted to the TCEQ no later than 60 days following identification of the potential SSC.

Circumstances or events could arise where reasonable cause would indicate a source other than the landfill unit has caused the contamination that resulted in a statistically significant change from background levels of any of the tested constituents, at any of the monitoring wells or that the statistically significant change resulted from error in sampling, analysis, statistical evaluation, or natural variation in groundwater quality. If so, then an ASDR will be prepared and certified by a qualified groundwater scientist providing documentation that the reason for the statistically significant change was a source other than the municipal solid waste landfill facility. The report will be submitted to the Executive Director for review and approval and to the TCEQ within 90 days from the SSC notice. ASDRs will be submitted in accordance with the following schedule:

1. The TCEQ will be notified within 14 days of identification of a SSC of the facility's intent to submit an ASDR.
2. An ASDR will be submitted to the TCEQ within 90 days of identification of a SSC. Per 30 TAC §330.407(b)(4), the Owner must make a satisfactory demonstration within 90 days of the notification to the TCEQ of a SSC or an assessment monitoring program must be initiated. If a satisfactory demonstration is made within this time frame, the facility will continue detection monitoring.