United States Department of Energy

Savannah River Site

H-Area Tank Farm Groundwater Monitoring Plan and Sampling and Analysis Plan (U)

SRNS-RP-2012-00146

Revision 1

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LIST OF ACRONYMS AND ABBREVIATIONS

Acronym	Meaning
ALARA	As Low As Reasonably Achievable
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CLSM	Controlled Low Strength Material
cm	centimeter
CMCOC	Contaminant Migration Constituents of Concern
COC	Constituent of Concern
CRDL	Contract Required Detection Limit
CSM	Conceptual Site Model
CTS	Concentrate Transfer System
DQD	Decision Quality Data
DQI	Data Quality Indicator
DQO	Data Quality Objective
ERDMS	Environmental Restoration Data Management System
FFA	Federal Facility Agreement
ft	feet
FTF	F-Area Tank Farm
GAU	Gordon Aquifer Unit
GCP	General Closure Plan
GWMP	Groundwater Monitoring Plan
GSA	General Separations Area
HTF	H-Area Tank Farm
IDW	Investigation Derived Waste
in	inches
km^2	square kilometers
L	liters
LAZ	Lower Aquifer Zone
LLC	Limited Liability Company
m	meter
MCL	Maximum Contaminant Level
mg	milligrams
mi^2	square miles
mL	milliliters
OU	Operable Unit
PA	Performance Assessment
pCi	pico curies
PQO	Project Quality Objective
PRG	Preliminary Remediation Goal
PVC	polyvinyl chloride
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control

LIST OF ACRONYMS AND ABBREVIATIONS

Acronym	**Meaning**
RCRA	Resource Conservation and Recovery Act
RFI	RCRA Facility Investigation
RI	Remedial Investigation
RPD	Relative Percent Difference
RSL	USEPA Regional Screening Level
SCDHEC	South Carolina Department of Health and Environmental Control
SRNS	Savannah River Nuclear Solutions, LLC
SRR	Savannah River Remediation, LLC
SRS	Savannah River Site
ssEQL	Sample Specific Estimated Quantitation Limit
TAL	Target Analyte List
TCL	Target Compound List
UAZ	Upper Aquifer Zone
UCL	Upper Control Limit
USDOE	United States Department of Energy
USEPA	United States Environmental Protection Agency
UTRA	Upper Three Runs Aquifer
VV	Verified and Validated
WSRC	Westinghouse Savannah River Company, LLC prior to December 8, 2005; Washington Savannah River Company, LLC after December 8, 2005

1.0 INTRODUCTION

This Groundwater Monitoring Plan (GWMP) for the H-Area Tank Farm (HTF) was prepared using the approved template for Sampling and Analysis Plans. The Sample and Analysis Plan template was prepared in accordance with the United States Environmental Protection Agency (USEPA) *Uniform Federal Policy for Quality Assurance Project Plans* (USEPA et al 2005) and the *Area Completion Projects Programmatic Quality Assurance Project Plan for Environmental Data Collection and Management* (SRNS 2012a). Project- or task-specific information for groundwater monitoring of the HTF is documented in this GWMP and refers to the program level Quality Assurance Program Plan (QAPP) (SRNS 2012a) for the program level quality objectives, standard operating procedures, and quality assurance/quality control procedures.

1.1 Sampling Unit Name and Purpose for Sampling

As required by the *Industrial Wastewater General Closure Plan for H-Area Waste Tank Systems* (SRR 2012) (hereinafter referred to as the General Closure Plan [GCP]), monitoring of the groundwater beneath the HTF will continue as requested by SCDHEC in support of Industrial Wastewater Construction Permit # 17,424-IW. The monitoring will be conducted in accordance with an HTF GWMP during the interim period from the time the individual waste tanks and ancillary structures are removed from service until the time of final closure of the HTF Operable Unit (OU). There are currently two monitoring programs in place [i.e., F-Area Tank Farm (FTF)/HTF Groundwater Monitoring and General Separations Area (GSA) Groundwater OU] that utilize data from wells at and around the HTF to document current groundwater conditions at the HTF and surrounding area.

In support of groundwater monitoring at the HTF pursuant to the GCP, a scoping meeting was conducted on May 16, 2012 among the South Carolina Department of Health and Environmental Control (SCDHEC), United States Department of Energy (USDOE), and the USEPA, in which the three parties (i.e., the 2012 Core Team) discussed and agreed to the elements of the HTF GWMP which include a description of the existing groundwater monitoring network and any proposed new groundwater wells, sampling frequency, constituents to be analyzed and associated detection limits, reporting frequency, and triggers for evaluation of corrective action (SRNS 2012d).

As an outcome of that meeting, the following were agreed to (SRNS 2012d):

- Inclusion of an existing background well location (i.e., HAA 1) which comprises three (3) wells installed in the Upper Aquifer Zone (UAZ) and Lower Aquifer Zone (LAZ) of the Upper Three Runs Aquifer (UTRA) and the Gordon Aquifer Unit (GAU);
- Installation of ten (10) wells at five (5) two (2)-well clusters. At each well cluster a well will be installed in the UAZ and LAZ;
- Sampling to be conducted twice-a-year at ten (10) new wells and at existing well clusters HAA 1, HAA 2, HAA 4, and HAA 7 through 15 to include the analyte list as shown on Table 2;
- No GAU monitoring will be conducted except at the background well location (i.e., HAA 1A). However, GAU groundwater monitoring will be conducted in compliance with GSA Eastern Groundwater OU;
- No inner H-Area Tank Farm wells will be monitored (i.e., HTF and HC well series);
- Groundwater beneath the HTF currently contained within the GSA Eastern Groundwater OU would be incorporated into the HTF OU; and
- *Annual Groundwater Monitoring Report for the F- and H-Area Radioactive Liquid Waste Tank Farms* to be submitted on March 31 starting in 2013.

1.2 Sampling Unit Location

H Area occupies 395 acres in the north-central portion of the Savannah River Site (SRS) within an area commonly referred to as the GSA (Figure 1). The GSA is located atop a ridge running southwest to northeast that forms the drainage divide between Upper Three Runs Creek to the north, Fourmile Branch to the south, and McQueen Branch to the east and encompasses approximately 39 km^2 (15 mi^2). The HTF is located within H Area and occupies 45 acres (Figure 2).

The HTF is an active facility and is heavily developed. The HTF site was chosen because of its favorable terrain and its proximity to the H-Canyon Separations Facility (the major waste generation source), which was located near the center of the site, away from the SRS boundaries.

1.3 Statement of Broad Objectives for the Sampling Plan

The primary objective of this GWMP is to develop a detection monitoring program that consists of a sufficient number of wells and appropriate analytes to support the evaluation of groundwater conditions at the HTF. Specifically, this GWMP is being developed, as per the 2012 Core Team agreements from the May 16, 2012 scoping meeting as follows:

- Install additional groundwater wells to support monitoring of groundwater conditions at the HTF boundary;
- Identify existing groundwater wells to be used in groundwater monitoring at the HTF;
- Identify list of constituents and sample frequency for groundwater monitoring; and
- Identify reporting requirements.

2.0 SAMPLING UNIT BACKGROUND

2.1 Sampling Area Physical and Geographical Description

2.1.1 Physical Setting

Surface elevations at the HTF range from approximately 82 to 96 m (270 to 315 ft) above mean sea level. Ground cover at the HTF is predominantly asphalt paving with less than 23% of the surface exposed to infiltration (WSRC 1997). Surface runoff is predominantly to the south and west to tributaries of Fourmile Branch and Upper Three Runs Creek. Surface runoff on the eastern portion of the HTF is to McQueen Branch, a tributary to Upper Three Runs Creek.

2.1.2 Climate

Rainfall at the site tends to be evenly distributed throughout the year. The average annual precipitation at SRS is 121.9 cm (48 in). The evaporation rate is approximately 76.2 cm (30 in) per year. The most severe weather is limited to frequent thunderstorms and infrequent tornadoes and hurricanes. Additional details concerning the climatology and meteorology of SRS can be found in the Performance Assessment (PA) for the HTF (SRR 2011).

2.1.3 Hydrostratigraphy

The SRS lies in the Atlantic Coastal Plain, a southeast-dipping wedge of unconsolidated and semi-consolidated sediment, which extends from its contact with the Piedmont Province at the Fall Line to the continental shelf edge. Sediments range in geologic age from Late Cretaceous to Recent and include sands, clays, limestones, and gravels. This sedimentary sequence ranges in thickness from essentially zero at the Fall Line to more than 1,219 m (4,000 ft) at the Atlantic Coast. At SRS, coastal plain sediments thicken from approximately 213 m (700 ft) at the northwestern boundary to approximately 430 m (1,410 ft) at the southeastern boundary of the site and form a series of aquifers and confining and semi-confining units. Aquifer systems include the Floridan, Dublin, and Midville systems.

Groundwater within the Floridan Aquifer system flows toward streams and swamps and into the Savannah River at rates ranging from inches to several hundred feet per year. The depth to which nearby streams cut into sediments, the lithology of the sediments, and the orientation of the sediment formations control the horizontal and vertical movement of the groundwater. The valleys of smaller perennial streams, such as Fourmile Branch, McQueen Branch, and Crouch Branch in the GSA, allow discharge from the shallow saturated geologic formations. With the release of water to the streams, the hydraulic head of the aquifer unit releasing the water can become less than that of the underlying unit. If this occurs, groundwater has the potential to migrate upward from the lower unit to the overlying unit.

The hydrogeology at the HTF resides on coastal plain sediments consisting of alternating sequences of sands, silts, and clays. The UTRA is the shallowest aquifer beneath the GSA. A semi-continuous confining unit (i.e., commonly referred to as the "tan clay" confining zone) divides the UTRA into the UAZ and LAZ. A more continuous aquitard, the Gordon Confining Unit (commonly referred to as the "green clay") underlies the LAZ and confines the underlying GAU. Figure 3 depicts the regional lithologic units and their corresponding hydrostratigraphic units (i.e., aquifers and confining units) at SRS (Aadland et al 1995).

Current water level data indicate depth to shallow groundwater averages approximately 18 m (59 ft) below land surface. Because the HTF resides on a topographic high within the GSA, shallow groundwater flow mirrors the topography and is radially outward towards nearby streams and swamps which eventually flow to the Savannah River (Figure 4). The rate of flow in the shallow groundwater varies from inches to several feet per year.

The depth of which nearby streams cut in to sediments, the lithology of the sediments, and the orientation of the sediment formations control the horizontal and vertical movement of the groundwater. Figure 5 depicts a conceptual diagram of surface and groundwater flow at the GSA.

2.2 Operational History

The HTF was constructed to receive waste generated by various SRS production, processing, and laboratory facilities. The HTF consists principally of three control rooms, approximately 74,800 ft (14.2 miles) of transfer lines, 10 pump pits, two concentrate transfer system pump pits, one catch tank, three evaporators, and 29 waste tanks. There are four major waste tank types (Type I through IV) in HTF built of carbon steel and reinforced concrete, but of varying designs: Type I tanks with capacity of 750,000 gallons, Type II tanks with capacity of 1,030,000 gallons, and Type III/IIIA and Type IV tanks with capacities of 1,300,000 gallons. The differing waste tank types have varying degrees of secondary containment (except Type IV tanks which have none) and intra-tank interference, such as cooling coils and columns. Each of the tank types were constructed at different times during which design features were greatly improved upon.

The waste tanks are designated new style or old style based on type of containment, type of leak detection and/or leakage. The old style tanks do not meet current standards for secondary containment and/or leak detection or have leaked. Even though the HTF is still in the operational period, the USDOE is in the process of removing wastes from tanks to achieve operational closures under the Savannah River Site's *Federal Facility Agreement* (FFA). As required by SCDHEC Regulation 61-67, *Standards for Wastewater Facility Construction* and SCDHEC Regulation 61-82, *Proper Closeout of Wastewater Treatment Facilities* and the Construction Permit #17,424-IW a closure plan has been prepared to support the removal from service of the HTF underground radioactive waste tanks and ancillary equipment.

Facilities are in place to pretreat the accumulated sludge and salt solutions (supernate) to enable the management of these wastes within other SRS facilities (i.e., Defense Waste Processing Facility and Saltstone Production Facility). These treatment facilities convert the sludge and supernate to more stable forms suitable for permanent disposal in a federal repository or the Saltstone Disposal Facility, as appropriate. The Effluent Treatment Project, located southeast of the HTF, collects and treats wastewater and evaporator overheads from FTF and HTF operations.

USDOE's anticipated schedule for removal of the waste tank systems from service was developed in accordance with federal and state agreements. The FFA provides dates for bulk waste removal efforts and completion of operational closures of Type I, Type II and Type IV tanks (i.e., waste tanks that do not meet the standards set forth in Appendix B of the FFA). Type III and Type IIIA tanks will remain in service until there is no longer a need for them to support waste treatment, as described in the Savannah River Site approved *Site Treatment Plan*, 2010 Update (SRNS 2011).

During the waste tank operational closure period, at-tank leak detection is conducted by automatic surveillance of sump monitoring systems. Daily inspections are conducted with monitoring of secondary containment piping, routine direct visual camera surveys in the annular spaces and non-routine direct visual camera surveys in primary tanks through opened access risers and/or inspection ports in the roof. The leak detection and tank inspection program conducted in accordance with the annual HLW Tank Farm Inspection Plan will continue until agreement is reached to cease waste removal operations. Results of the inspection program are reported annually on or before July 01 of each year as required by Section IX.A.2 of the FFA and Permit 17,424-IW.

2.3 Previous Investigations/Regulatory Actions

The following sections provide a summary of operations investigative work completed at the HTF. Additionally, because the groundwater at the HTF was formerly included within a larger FFA OU (i.e., GSA Eastern Groundwater OU), a summary of other OU groundwater investigations performed in the area is also provided to illustrate previous conditions of the groundwater system. It is not the intent of this document to address all known sources to the groundwater or to address potential soil contamination areas from previous known spills or releases. This will be addressed as part of the HTF OU and GSA Eastern Groundwater OU investigations.

2.3.1 Operational Investigations and Monitoring

Two notable releases have occurred within the HTF at Tank 16 and the Tank 37 Concentrate Transfer System (CTS) that have impacted local subsurface soil and groundwater. Other spills/releases have occurred at the HTF. However, these spills were less significant than that which occurred at Tanks 16 and 37 and were cleaned up immediately (WSRC 1992a).

2.3.1.1 Tank 16 Release and Investigation

In 1960, Tank 16 sustained a leak of liquid waste which overflowed containment structures. The amount of liquid waste which may have been introduced into the soil and groundwater is estimated to have been between 16 and 700 gallons, containing 7.4 curies of radionuclides (predominantly cesium-137) per gallon (WSRC 1992a). Other nonradionuclide hazardous constituents present in the liquid waste may have included silver, chromium, mercury, and lead (WSRC 1992a).

Investigation of the soil and groundwater at Tank 16 revealed impact to these media. It is estimated that approximately 1,600 to 70,000 cubic feet of soil may be contaminated with metals and radionuclides (principally cesium-137) (Poe 1974). Results from groundwater collected near Tank 16 did not indicate impact to groundwater downgradient from the tank. It was determined that the leaked material remained immediately adjacent to the tank and construction pad on which it rests. The lack of movement of the released material was attributed to low groundwater flow rates and the ion exchange property of the local soils at the HTF (Poe 1974). To reduce further impact to the environment, waste removal from Tank 16 was initiated in 1972 (Miles 1992).

Historical data from wells (HTF 5 – 8, 34) near Tanks 13-16 have indicated the presence of tritium in exceedance of the maximum contaminant level (MCL) (20 pCi/mL). Results from groundwater samples collected since the mid-1990s have indicated tritium activities below the MCL (20 pCi/mL). A peak in tritium activities was observed in these wells in the 1980s, but the levels have since decreased. Currently, no groundwater plume above the MCL is observed at the HTF. Tritium activities are still observed within the HTF but are below the MCL.

2.3.1.2 Tank 37 CTS Line Leak and Investigation

In 1989, radioactive contamination was detected on asphalt near Tank 37. Subsequent investigation determined the soil beneath the asphalt to also be contaminated. Further investigation into the source of the contamination found it to be related to a leaking radioactive waste transfer line (i.e., CTS line). It was estimated that up to 500 pounds of material was released (WSRC 1992b). The primary constituents include cesium-137, silver, chromium, mercury, and lead. The leaking line was emptied, flushed, and removed from service.

Approximately 115,000 pounds of contaminated soil was excavated and placed in 24 B-12 metal boxes (WSRC 1992b) and disposed of. Some contaminated soil remains at the excavation site because it is too highly radioactive to be removed without unacceptable worker exposure and conflicting with As Low As Reasonably Achievable (ALARA) principles (WSRC 1992b). Additionally, the contamination is confined in dry compact soil and is localized to within a few feet of the release. Closure of the excavation consisted of placing lead shielding at the release site, followed by the placement of Controlled Low Strength Material (CLSM) to within two feet of the surface. The CLSM was topped with concrete, crushed stone (gravel), carbon steel plate, and asphalt (WSRC 1992c).

No impact to groundwater has been identified in association with this release (WSRC 1992b).

2.3.1.3 H-Area Tank Farm Groundwater Monitoring

The HTF groundwater monitoring program is currently being conducted according to the *Groundwater Monitoring Plan for the High Level Waste Tank Farms* (WSRC 2005). The program is designed to monitor groundwater quality associated with the tank systems and to detect any future impacts to groundwater that may occur. The results are reported annually in the *Annual Groundwater Monitoring Report for the F- and H-Area Radioactive Liquid Waste Tank Farms* (hereinafter referred to as the FTF/HTF groundwater report) and include a discussion of any trends and/or changes in the groundwater quality conditions.

2.3.2 FFA Operable Unit Investigations

USDOE currently has an active groundwater monitoring program for monitoring groundwater impacts from historical releases and spills within H Area and HTF (including the waste tanks). These spill sites were previously listed on the FFA Appendix G (Site Evaluation Areas) at the time of FFA approval and have subsequently been placed on Appendix C (Resource Conservation and Recovery Act [RCRA]/ Comprehensive Environmental Response, Compensation and Liability Act [CERCLA] Units List) as part of the HTF OU for evaluation and possible remediation (FFA 1993). Sources of contamination present in groundwater at the HTF are derived from historical releases from these spill sites and are depicted on Figure 6.

Although various historical spills and leaks have been recorded at the HTF, only two (Tank 16 and the Tank 37 CTS) had the potential to impact groundwater. To address the potential for environmental impact, a RCRA Facility Investigation (RFI)/Remedial Investigation (RI) was completed for both Tank 16 and the Tank 37 CTS (WSRC 1992a and 1992b). No additional surface or groundwater investigation was conducted at the tanks or release sites, however, it was identified that additional groundwater monitoring was needed to monitor groundwater quality at the HTF due to the releases and analysis of existing groundwater data. To provide for additional groundwater monitoring, 40 groundwater monitoring wells at nine (9) well clusters were installed at various times around the HTF and subsequently sampled (WSRC 1996).

In an effort to address the complexity of the tank farm, representatives from SCDHEC, USEPA, and USDOE agreed that the investigation and characterization of these two surface OUs independently of the remainder of the tank farm would not be feasible because of environmental and safety concerns (USDOE 1994). Therefore, the Tank 16 and the Tank 37 CTS Line Leak OUs were consolidated and renamed the H-Area Tank Farm Groundwater OU.

A RFI/RI Work Plan was prepared for the HTF Groundwater OU and it was determined that results from groundwater obtained from wells within the HTF and surrounding area indicated the presence of groundwater contaminants (principally tritium). However, the presence of the contaminants was detected in upgradient as well as downgradient wells. This suggested additional sources of contamination other than the HTF could be contributing to groundwater contamination (WSRC 1996). The prior Core Team acknowledged that no discernible groundwater plume exists at the HTF and that tritium was the only constituent of concern (COC) (WSRC 1999). In 1998, an additional 40 wells were installed to support Phase II characterization of the H-Area Tank Farm Groundwater Operable Unit (WSRC 1998a and 1998b).

In an effort to adequately monitor groundwater at H Area associated with multiple potential sources, the prior Core Team in 2000 agreed to change the HTF Groundwater OU to the H-Area Groundwater OU (the name was subsequently changed later to the GSA Eastern Groundwater OU) (WSRC 2004). This new OU encompassed the HTF, H Area, and selected surrounding OUs into one comprehensive groundwater OU (WSRC 2001). Groundwater monitoring is being performed at a predetermined sampling frequency and number of wells as well as for specific analytes. A Scoping Summary for the GSA Eastern Groundwater OU is prepared, and a Core Team meeting is held annually to discuss the monitoring data and make any changes to the groundwater monitoring program, as needed.

As noted in previous sections, there is no discernible tritium plume within the HTF; even though there are still detectable activities of tritium below the MCL (20 pCi/mL). Tritium activities in the groundwater have been decreasing over time. Figure 7 shows the current location of tritium contamination in the groundwater north of the HTF.

2.4 Summary of Existing Data

Wells interior to the HTF near the waste tanks include the older HTF well series and the HC 1 well cluster. These wells have been monitored for a number of years and a subset of these wells is currently monitored in support of the FTF/HTF annual groundwater report. Currently there are a total of 31 HTF wells of which 30 are located within the HTF. The one well not located within the HTF (HTF 17) is located outside and downgradient of the HTF. All the HTF well series monitor the UAZ. The HC 1 well cluster is comprised of five (5) wells installed in the UAZ and LAZ of the UTRA and the GAU. This well cluster was installed in 1965 and the wells are constructed of iron. Approximately half of the HTF well series were installed in 1973 and are constructed with steel while the remaining were installed in 1985 and are constructed with polyvinyl chloride (PVC). Two newer wells were installed as replacements in 1998 and are constructed with PVC.

The older HTF and HC wells in the tank farm interior and adjacent to the tank farm were constructed to standards that are currently recognized as insufficient for environmental monitoring (due to for example the filter packs, seals, grouting, casing materials, pump components, etc.). Because of this situation, the 2012 Core Team is deleting these wells from the HTF monitoring network.

Downgradient monitoring at the HTF is performed at the HAA well series that were installed as an outcome of previous OU investigations. These wells are comprised of multi-well clusters that monitor groundwater quality in the UAZ and LAZ of the UTRA and the GAU. These wells are constructed of PVC and were installed in various times from 1993 to 1998.

Figures 8 through 10 depict the location of the wells at the HTF per aquifer. Two monitoring programs (i.e., FTF/HTF Groundwater Monitoring and GSA Eastern Groundwater OU) are currently in place which utilizes data from these wells to document current groundwater conditions at the HTF and larger surrounding area. A subset of the HTF well series are monitored and reported in the annual FTF/HTF groundwater report.

As described in Section 2.3, spills and releases have occurred at the HTF. Investigation of these spills/releases has noted impact to subsurface soil and groundwater. However, impact to groundwater has been limited in extent. Historical groundwater monitoring of the UAZ within the HTF has been performed at the HTF well series (wells interior to the HTF). As described earlier, these wells are not constructed to current well standards and as such monitoring conducted at these wells has been limited to various metals and radionuclides.

Based on prior Core Team agreements from previous scoping meetings associated with the GSA Eastern Groundwater OU and current HTF GWMP agreements, the principal groundwater contaminants at the HTF are nitrate/nitrite, cadmium, chromium, manganese, sodium, tritium, and technetium-99. The selection of these groundwater contaminants is based on process knowledge of HTF operations, spills/releases, and groundwater data. In addition, radionuclide indicators, gross alpha and nonvolatile beta, are also of interest since these constituents provide necessary information in regards to the potential presence of other radionuclides (natural and/or man-made).

Review of historical groundwater data associated with the COCs from those wells interior to the HTF (i.e., HTF well series) are summarized in the following paragraphs.

Nitrates/nitrites have been detected in the UAZ within the HTF. Nitrates/nitrites have been detected in the UAZ within the HTF. Concentrations have ranged from below detection to 36 mg/L (HTF 8, 1992), which is above the MCL of 10 mg/L. Groundwater data collected in 2011 and reported in the F and H Tank Farm annual groundwater report, have a range of below detection to 2.3 mg/L. Cadmium, chromium, manganese, and sodium have also been detected in the UAZ within the HTF.

Cadmium concentrations have ranged from below detection to 143 ug/L (HTF 7, 1993), which is above the MCL of 5 ug/L. More recent groundwater data indicate that cadmium is typically below detection, cadmium data was not collected in 2011. Cadmium will be monitored under this plan. Chromium concentrations have ranged from below detection to 487 ug/L (HAA 7D, 2011) exceeding the MCL of 100 ug/L. The elevated result in HAA 7D is unusual because this well typically has chromium levels below the quantification limit. Current thinking is that the result is an laboratory error and will be confirmed with additional future sampling. Without the HAA 7D result all the wells monitored in 2011 are well below the MCL for chromium.

Manganese concentrations have ranged from below detection to 3.3 mg/L (HTF 7, 1994) exceeding the MCL of 0.05 mg/L. There are no recent manganese data, however, manganese will be monitored under this plan. Manganese dioxide mineralization is common in the coastal plain sediments of SRS. Sodium concentrations have ranged from 0.65 to 28.3 mg/L (HTF 12D, 2003). 2011 monitoring data range from 1.8 mg/L to 23.2 mg/L, there is no sodium MCL, and the values do not appear elevated.

Tritium has been identified as the prevalent radionuclide and groundwater contaminant at the HTF as a result of historical monitoring. Tritium activities have historically ranged from 1.08 to 355 pCi/mL (HTF 12, 1986), which exceeds the MCL of 20 pCi/mL. However, 2011 tritium data indicate a maximum tritium activity of 12 pCi/ml (HTF 10), which is well below the MCL (20 pCi/mL). Tritium has been below the MCL for several years. Currently, there is no defined tritium plume at the HTF, which indicates that there is little contamination in the groundwater from the tank farm. Technetium-99 activities have been detected but only in two occurrences with those activities ranging from 301 to 1,130 pCi/L (HTF 5, 1992), which is above the MCL of 900 pCi/L. However, these results were observed in two different wells in two different sampling events. Other results for technetium-99 for these same two wells and from other surrounding wells have been below the detection limit. A false positive in older technetium-99 data is common when low concentrations of tritium are also present.

Radionuclide indicators gross alpha and nonvolatile beta have been detected in the UAZ at the HTF. Activities of gross alpha have ranged from below detection to 500 pCi/L (HTF 6, 1989), which is above the MCL of 15 pCi/L. 2011 data indicate a range of below detection to 17.1 pCi/L (HTF 22), the lack of elevated tritium or nonvolatile beta at HTF 22 suggest that the alpha in the water is naturally occurring or in error. Activities of nonvolatile beta have ranged from below detection to 51,600 pCi/L (HTF 8, 1994) and have been observed exceeding the trigger level of 50 pCi/L. Groundwater data from 2011 indicate a range from below detection to 8.5 pCi/L. The lack of elevated nonvolatile beta and tritium in the groundwater suggests an overall lack of contamination from the H Tank Farm.

3.0 PROJECT DATA QUALITY OBJECTIVES (DQOs)

The Data Quality Objective (DQO) process is a series of logical steps that guides managers or staff to a plan for the resource-effective acquisition of environmental data. It is both flexible and iterative, and applies to both decision-making (i.e., compliance/non-compliance with a standard) and estimation (i.e., ascertaining the mean concentration level of a contaminant). The DQO process is used to establish performance and acceptance criteria, which serve as the basis for designing a plan for collecting data of sufficient quality and quantity to support the goals of the study. Use of the DQO process leads to efficient and effective expenditure of resources; consensus on the type, and quantity of data needed to meet the project goal; and the full documentation of actions taken during the development of the project. The DQO process is a series of seven planning steps based on the scientific method (Sections 3.1.1 to 3.1.7 below) and is detailed in USEPA Guidance (USEPA 2006).

3.1 Groundwater at the H-Area Tank Farm

The intent of this document is to provide supporting information with regards to groundwater monitoring during the interim period from the time the H-Area waste tanks and ancillary equipment are removed from service and final closure of the HTF OU. It is not the intent of this document to address all known or potential sources of contamination to the groundwater, or to address potential soil contamination areas from previous known spills or releases. This will be addressed as part of the HTF OU and GSA Eastern Groundwater OU investigations.

3.1.1 State the Problem

Pursuant to HTF GCP Section 8.0 - *Maintenance and Monitoring*, USDOE and SCDHEC, in consultation with USEPA must agree to a monitoring plan. Specifically the GCP states:

- *Groundwater monitoring will be continued as requested by SCDHEC in support of Construction Permit #17,424-IW during the interim period from the time the* *individual waste tanks and ancillary structures are removed from service up to the final closure of the HTF OU in accordance with an HTF groundwater monitoring plan.*

- *This plan includes such elements as a groundwater monitoring network, sampling frequency, constituents and associated detection limits, reporting frequency, data evaluation, and triggers for evaluation of corrective action.*

- *The analysis of groundwater samples will be performed by a laboratory certified for applicable parameters in accordance with SCDHEC R.61-81, State Environmental Laboratory Certification Program.*

3.1.2 Identify Goals of the Study

The objective of this GWMP is to establish a monitoring program that consists of a sufficient number of wells and appropriate analytes to support evaluation of groundwater conditions at the HTF during the interim period from the time the individual waste tanks and ancillary equipment are removed from service to the time of final closure of the HTF Area OU in accordance with an HTF groundwater monitoring plan.

3.1.3 Identify Information Inputs

Historical groundwater data have been reviewed and summarized previously in this GWMP (see Section 2.4). The data are of sufficient quality to make decisions concerning groundwater quality; however, there are gaps in the existing data set. The following actions are recommended to fill these data gaps:

- Five (5) two (2)-well groundwater clusters (total of 10) are recommended for installation. Each well cluster will have a well installed in the UAZ and LAZ of the UTRA. The well clusters are located in downgradient areas at the HTF where groundwater modeling and current head data indicate possible flow paths for contaminants in the event contaminants are released. The groundwater divide, in which the HTF resides, also plays a part in the diverging groundwater flow paths.

- Well cluster HAA 1, specifically, wells HAA 1D, HAA 1C, and HAA 1A are recommended as background wells.

- Twice-a-year collection of routine groundwater samples and analyses from 46 wells around the HTF (Figure 11), including the proposed ten (10) wells and three (3) background wells, so that data trends and analysis can be performed to determine long-term impacts on groundwater quality.

- Preparation and submittal of an annual groundwater report that documents the current state of groundwater quality at the HTF.

3.1.4 Define the Boundaries of the Study

The study area is approximately 45 acres on which the HTF resides within the GSA (Figure 2). The area to be monitored is heavily industrialized with many operational areas and FFA OUs.

The UAZ and LAZ of the UTRA are the primary hydrostratigraphic units that are to be monitored as part of this GWMP; except for monitoring of the background well cluster which monitors the UAZ and LAZ of the UTRA and GAU. GAU monitoring is being performed in support of groundwater monitoring for the GSA Eastern Groundwater OU.

3.1.5 Develop the Analytical Approach

Consistent with the F-Area Tank Farm GWMP (SRNS 2012c), implementation of the HTF GWMP will be guided by the following accepted SRS protocols/procedures:

- Samples will be analyzed using laboratories certified for applicable parameters in accordance with SCDHEC R.61-81, *State Environmental Laboratory Certification Program.*

- Wells will be installed in accordance with SCDHEC *Well Standards and Regulations* and with SRS site wide procedures found in Manual 3Q1 *Hydrogeologic Data Collection Procedures and Specifications*.
- Samples will be collected, packed and shipped in accordance with the site wide procedures found in Manual 3Q1 *Hydrogeologic Data Collection Procedures and Specifications*.
- Data management for the HTF groundwater monitoring program will be performed in accordance with the *Environmental Restoration Data Management System (ERDMS) Data Management Plan* (Q-DMP-B-00001, Revision 3, June 2006 or most current version). ERDMS will be used for database management including mobilization, field measurements and analytical data.
- The Quality Assurance Program is described in *Area Completion Projects Programmatic Quality Assurance Project Plan for Environmental Data Collection and Management*, ERD-AG-2005-00001, Rev. 5.

The decision rules associated with the data evaluation are defined below.

- If screening for gross alpha or nonvolatile beta results exceeds trigger levels, then the appropriate alpha, beta, and/or gamma spectroscopy analyses will be performed. The trigger levels for groundwater are 15 pCi/L gross alpha and 50 pCi/L nonvolatile beta.

  If analysis yields results at or above 15 pCi/L for gross alpha, new samples will be collected and analyzed for specific radionuclides to determine the cause of the elevated alpha results, and to distinguish USDOE program-added radioactivity from natural background (such as radon-thoron). If the primary HTF process alpha emitters, which include americium-241, plutonium-238, plutonium-239/240, and uranium-238 are not detected, then additional constituents will be evaluated, including any of those constituents listed as Contaminant Migration Constituents of Concern (CMCOC) in the HTF PA.

If analysis yields at or above 50 pCi/L for nonvolatile beta, new samples will be collected and analyzed for specific radionuclides in order to determine the cause of the elevated nonvolatile beta results. Mobile beta emitters (such as cesium-137, cobalt-60, iodine-129, and strontium-90), present in the tank inventories, will be evaluated first. If none of these radionuclides are detected, samples will be analyzed for other constituents until the radionuclide responsible for the elevated nonvolatile beta results is identified. It will then be added to the monitoring list for that well.

- As described in Sections 4.1.4 and 4.1.5 of this Plan, data will also be evaluated for comparison with risk-based thresholds and/or MCLs and statistically evaluated to monitor for trends in contaminant concentrations. If the data evaluation identifies a concern, subsequent meetings may be arranged to review the data and determine whether a response action is necessary.

- If the monitoring well network is insufficient for monitoring groundwater contamination in the UAZ and LAZ, additional permanent monitoring wells may be installed. As described in Sections 4.1.4 and 4.1.5, data evaluations will be performed to evaluate for comparison with risk-based thresholds and/or MCLs, trending of contaminant concentrations, and to evaluate upgradient sources. If data evaluation identifies a concern, subsequent meetings may be arranged to review the data and determine a pathforward, and as needed, additional wells may be identified to further enhance monitoring at the HTF.

3.1.6 Specify Performance or Acceptance Criteria

According to USEPA guidance (USEPA 2006), "The USEPA has developed the DQO Process as the Agency's recommended planning process when environmental data are used to select between two or more alternatives or to derive an estimate of contamination." The DQO process is a seven step method designed to ensure that the appropriate type, quantity, and quality of environmental data are collected for the intended application. SW-846 methods are analytical procedures for sample analyses and are presented in the Analytical Plan, Section 5. Section 4 presents DQO worksheets developed for each subunit and/or media and specifies the quantity, type, and quality, of data as well as ensuring representative data is collected for each sampling population.

Total study error is the additive impact of two main sources of error: 1) sampling error and 2) measurement error, with sampling error being responsible for the vast majority of the total error. "As much as 90% or more of the uncertainty in environmental data sets is due to sampling variability as a direct consequence of the heterogeneity of the environmental matrices" (Crumbling 2001). The method best suited to reduce sampling error is to gather representative samples (Crumbling 2001).

It is incorrect to assume that randomly collected, non-representative samples, plus perfect analytical chemistry will always lead risk managers to correct risk management decisions. In order to avoid incorrect risk management decisions, it is more important to develop Decision Quality Data (DQD). DQD is defined as data of known quality that can logically be demonstrated to be effective for making the specified decision because both the sampling and analytical uncertainties are managed to the degree necessary to meet clearly defined and stated data needs (Crumbling 2001). Therefore, it is more important for the risk managers to use decision quality data, emphasizing representative sampling with a specified percentage of definitive data, in order to make a correct decision and should not be confused by emphasizing analytical data quality which does not necessarily equate to a correct risk management decision.

The DQOs for the HTF represent the type and level of analytical quality needed for groundwater monitoring in this area and can be found in Sections 4 and 5 of this GWMP.

3.1.7 Develop the Plan for Obtaining the Data (Project Quality Objectives)

The monitoring approach uses a layered scheme that considers the results of the previous groundwater sampling data. Activities under this GWMP will include additional monitoring well installations in the UAZ and LAZ of the UTRA and continued groundwater monitoring of existing, newly installed monitoring wells, and background wells. Existing and proposed monitoring wells under this GWMP will be sampled twice-a-year, unless modified by the Core Team. Monitoring results will continue to be reported in the *Annual Groundwater Monitoring Report for the F- and H-Area Radioactive Liquid Waste Tank Farms* to be submitted by March 31 of each year beginning in calendar year 2013. Split samples collected in support of continued groundwater monitoring will be performed by SRS field or subcontractor personnel.

Project quality objectives (PQOs) are qualitative and quantitative statements derived from the DQO process and are used as the basis for establishing the quality and the quantity of data needed to support decisions. The PQOs for the HTF include the following:

- Relative percent difference (RPD) < 100% between regular groundwater samples and field duplicates when the groundwater sample result >= MDL but < sample-specific estimated quantitation limit (ssEQL) for the precision data quality indicator (DQI).
- RPD <100% when groundwater sample result >=method detection limit but <ssEQL for the precision DQI.
- Percent Recovery from Matrix Spike and Matrix Spike Duplicates are generally >= 135% or < 30% for accuracy/bias data quality indicator. Matrix Spike recovery windows may be tighter than those listed. Tables 12 and 28 of the Quality Assurance Project Plan (QAPP) list the general and analyte/media specific Matrix Spike and Matrix Spike Duplicate recovery limits for various analytical classifications (i.e., VOCs, SVOCs, etc.) as well as the frequency of sampling which is by reference to Area Completion Projects Standard Operating Procedure Analytical Data Qualification (ER-SOP-033).
- No target compound >=ssEQL for equipment blanks, field blanks, method blanks, or instrument blanks for the accuracy DQI.
- ssEQL <MCL, RSL, or PRG for the sensitivity DQI.
- Split sample result will have an RPD = 100% for groundwater samples.

- 5% of the samples will be split samples for the comparability DQI.
- 95% of the samples sent to the laboratory will have useable (non-rejected) results for the completeness DQI.
- 90% of the planned samples will be collected and their data will be useable for the completeness DQI.

The objective for the representativeness DQI is qualitative and will be met by properly documenting field and analytical protocols. In the event these procedures and methods are not able to be implemented, the appropriate corrective action documentation should encompass the impact on the representativeness of the information. When review of the data and documentation determines the data to be non-representative with regards to the DQIs, the data will be qualified and investigated to determine the appropriate use of the data.

4.0 SAMPLING DESIGN AND RATIONALE

Implementation of the GWMP to obtain decision quality data for each subunit/media is documented in the remaining sections of this plan. The following section describes how the plan is implemented to collect the physical data to meet the criteria developed during the DQO process. A DQO worksheet was developed for the groundwater at the HTF which specifies the quantity, type, and quality of data and ensures representative data are collected for each sampling population (Table 1).

4.1 Rationale for HTF Groundwater Monitoring Plan

The groundwater monitoring plan at the HTF consists of a three-part strategy that includes the installation of groundwater monitoring wells, redevelopment of background wells, and groundwater sampling and reporting of existing and newly installed wells.

4.1.1 Groundwater Well Installations

Ten (10) groundwater wells will be installed at five (5) two (2)-well clusters around the HTF. Each well cluster will have a well installed in the UAZ and LAZ (Figure 11). Three of the well clusters are to be installed to the northeast of the HTF while the remaining two well clusters will be installed to the southwest of the HTF. The installation of these well clusters is based on the diverging flow paths in the UAZ and LAZ due to the location of the HTF on the groundwater divide and insufficient groundwater monitoring in these areas (Figure 4). Additionally, groundwater modeling in support of the PA for the HTF has indicated groundwater flow in these directions in the event contaminants were released from the HTF. The installation of these new wells along with the existing monitoring wells around the HTF will provide sufficient coverage to detect any releases that may occur from the HTF.

4.1.2 Redevelopment of Background Wells

Due to the lack of sampling activity for over a decade at the background well cluster (i.e., HAA 1), it is recommended that an aggressive redevelopment of the background wells be conducted so as to provide more accurate data on the background groundwater quality for the HTF.

Redevelopment may be accomplished by air lifting with reverse air, pumping, bailing, jetting, swabbing, or any combination of the above methods. Any sediment that has accumulated in the sump should be removed during redevelopment. Redevelopment should continue until clear, sediment-free water is consistently produced. If possible the well should be redeveloped until the turbidity is <15 Nephelometer Turbidity Units.

Measurements to be taken during redevelopment will include specific conductance, pH, temperature, turbidity, flow rate, depth to water, and yield.

4.1.3 Groundwater Sampling of Newly Installed and Existing Monitoring Wells

A total of forty-six monitoring wells (17 UAZ, 28 LAZ, and one GAU), existing (36) and proposed wells (10), will be sampled for nitrate/nitrite, cadmium, chromium, manganese, sodium, gross alpha, nonvolatile beta, technetium-99, and tritium (Figure 11 and Tables 2 and 3). The analytes identified were chosen based on the most prominent chemical and radiological species present in the HTF during operations, waste removal, and tank closure activities.

The list of analytes, along with their contract-required detection limits (CRDLs), MCLs, and RSLs, is shown in Tables 2, 4, and 5.

4.1.4 Data Evaluation

Because this is a groundwater detection monitoring program, and there are potential sources of contamination in the area upgradient of the tank farm (i.e., inactive process sewers lines and the separations facility, construction area, etc.), a data evaluation process was developed to help formalize data evaluations as shown in Figure 12. The process evaluates data above and below the MCL, changes in data that are trending outside of limits, and how the data compare statistically within a given population and when comparing a population to background conditions (hypothesis tests). Initial data evaluations also include statistical descriptions of the analyte population, the use of minimum data set tests (background and site), and data set management techniques in low frequency of detection situations. These methods are necessary to determine when sufficient data is available to perform hypothesis testing. The use of concentration results that trend outside of the control limits (when sufficient background and downgradient data is available) will be used as an indicator when more robust detection monitoring statistical tests are required. This indicator is commonly used in control chart evaluations of population behavior over time, where actions are taken if the data exceed the Upper Control Limit (UCL) for a set number of consecutive events. If the data exceed the UCL only one or two consecutive events (under 3 and 2 sigma limits) it typically is an indication of a different population mean or an outlier is present.

The ultimate goal of the evaluation, as illustrated by Figure 12, is to determine if the constituent data are: statistically conclusive; are statistically consistent with upgradient (background) conditions; or statistically indicate that a constituent may be sourced from tank farm releases. All of these conditions would be determined through hypothesis tests when sufficient data is available and reported annually. If data analysis indicates that a release is occurring from upgradient or the tank farm, SRS would report this situation promptly to the USEPA and SCDHEC.

The EPA guidance "*Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities*" (USEPA 2009), provides a good discussion of the types of statistical tests that may be used to evaluate groundwater data from a detection monitoring network perspective, and also recognizes the limitations in statistical analysis, (having a large enough data set to mimic natural population variability, autocorrelation, temporal correlation, and spatial correlation). The new EPA ProUCL Version 4.1.00 software includes hypothesis testing and data set management in situations with and without non-detect observations. The methods offered in the software are a good beginning point for statistical analysis, and it is likely that the software will become more robust with time. EPA ProUCL will be used for the initial statistical evaluation. However, changes to the statistical evaluation methodology may be appropriate as data is collected to ensure accurate decision-making. SRS will employ the appropriate statistical analysis methods to manage variability and correlation effects, to compare trends within populations and between populations, and to test the statistical difference between data populations. Any changes to the methodology will be agreed to by the Core Team prior to implementation. SRS will propose meetings between the three parties as data becomes available to discuss detections, trends, and statistical data evaluations.

4.1.5 Reporting

Monitoring results will continue to be reported in the *Annual Groundwater Monitoring Report for the F- and H-Area Radioactive Liquid Waste Tank Farms* to be submitted by March 31 of each year beginning in calendar year 2013. The report will contain the year's sampling data, maps showing the locations of all wells sampled, time vs. concentration plots, and a discussion of results. Statistical evaluations using hypothesis test comparisons between background and down-gradient monitoring well data will be performed when sufficient data is available, with findings included in the report. If data analysis indicates that a release is occurring from upgradient or the tank farm, USDOE would report this situation promptly to the USEPA and SCDHEC. Data scoping meetings may be called to review data findings with USEPA and SCDHEC annually, or as needed. These Core Team scoping meetings will include a discussion of the groundwater monitoring data and a decision on the necessity of any steps to be taken should the monitoring data warrant such action. Subsequent meetings for the specific purpose of discussing action to be taken will be scheduled as deemed necessary by the Core Team.

5.0 ANALYTICAL PLAN

This section describes the data quality levels for each type of data being collected. All data collected under this GWMP will follow the *Area Completion Projects Quality Assurance Project Plan for Environmental Data Collection* and *Management* (QAPP) (SRNS 2012a). The data quality level is determined by the intended use of the data. Groundwater data will be collected under this GWMP.

Groundwater data are needed to continue groundwater monitoring at the HTF during the interim period from the time the individual waste tanks and ancillary equipment are removed from service and final closure of the HTF OU. Groundwater data collected under this GWMP will be compared to various risk-based screening criteria (i.e., MCLs, radiological PRGs, and RSLs).

5.1 Data Quality Levels

All (100%) of the off-site laboratory analyses for groundwater samples collected at the HTF wells will be verified and validated (VV). In addition, 10% of the VV samples will have supplemental validation to meet more stringent definitive data criteria. Definitive data are analytical data that are suitable for final decision making, including data used for human health risk assessments (Table 6). Table 7 lists the specific methods and detection limits for analytical analysis in groundwater. Table 8 lists the method and quantitation limits for radiological analysis. Table 9 lists hold times, preservatives, and sample containers for the analytes listed for monitoring at the HTF.

Regardless of data usage, laboratory quality assurance/quality control (QA/QC) samples will be performed as specified in ACP Standard Operating Procedure *Analytical Data Qualification* (ER-SOP-033) and *ACP Programmatic Quality Assurance Project Plan for Environmental Data Collection and Management* (ERD-AG-2005-00001). Sufficient quantity of sample will be collected to ensure laboratory QA/QC samples are performed and reported.

5.2 Field Analytical Sampling Quality Assurance/Quality Control

All field analytical sampling quality assurance/quality control (QA/QC) will be maintained through the use of QA/QC samples consisting of field duplicates, rinsate/equipment blanks, field blanks, trip blanks, and split samples. Field personnel will ensure that QA/QC samples are collected at the correct frequency and methodology as described below.

Field quality assurance/quality control will be maintained through the use of quality control/quality (QA/QC) samples and methods as described below:

1. <u>Field Duplicate (co-located) Samples</u>: Two or more independent samples collected from side-by-side locations at the same point in time and space so as to be considered identical. These separate samples are intended to represent the same population and are carried through all steps of the sampling and analytical procedures in an identical manner. These samples are used to assess precision of the total method, including sampling, analysis, and site heterogeneity. Field duplicate samples are planned at a combined minimum rate of 5% according to *Obtaining and Managing Data for Area Completion Projects (ACP)* (ER-SOP-043), or typically 1 per 20 samples and analyzed for the same parameters as the associated samples.

2. Equipment Blank: A sample of water free of measurable contaminants poured over or through decontaminated field sampling equipment that is considered ready to collect or process an additional sample. The purpose of this blank is to assess the adequacy of the decontamination process. Also called rinse blank or rinsate blank. Equipment blanks are typically planned at a rate of 1 blank per 40 samples.

3. Field Blank: A blank used to provide information about contaminants that may be introduced during sample collection, storage, and transport; also a clean sample exposed to sampling conditions, transported to the laboratory, and treated as an environmental sample. Field blanks are optional and may be collected when contamination from external environmental sources is anticipated by the project team. Typically field blanks, when used, are planned at a rate of 1 blank per 40 samples.

4. Trip Blank: A clean sample of water free of measurable contaminants that is taken to the sampling site and transported to the laboratory for analysis without having been exposed to sampling procedures. Trip blanks are analyzed to assess whether contamination was introduced during sample shipment (typically analyzed for volatile organic compounds only). A blank consists of distilled-deionized water provided by the laboratory to be placed in every cooler with volatile organic compound samples typically at the rate of 1 trip blank per cooler.

5. Split Samples: Two or more representative portions from a sample in the field, analyzed by at least two different laboratories and/or methods. Prior to splitting, a sample is mixed (except volatiles, oil and grease, or when otherwise determined) to minimize sample heterogeneity. These are quality control samples used to assess precision, variability, and data comparability between laboratories. Split samples are planned at a combined minimum rate of 5% or typically 1 per 20 samples and analyzed for the same parameters as the associated samples.

5.3 Sample Matrix Table

Table 3 provides a sampling matrix table that includes the following information:

- sample count,
- station identifier,
- sample type,
- sample media
- sample collection method,
- analytical suites, and
- coordinates*.

*Proposed coordinates may change as necessary due to field conditions.

5.4 Sample Location Map

A maps showing the proposed groundwater monitoring well sample locations are shown on Figure 11.

6.0 FIELD IMPLEMENTATION

The following sections outline the field implementation procedures and processes for the HTF GWMP. Additional implementing documents, such as the environmental checklist, automated hazard analysis, safe work permits, radiological work instructions, site-specific health and safety plan, and investigation-derived waste (IDW) management plans, are internal to SRS and detail day-to-day sampling operations and safety requirements.

6.1 List of Sampling/Collection Equipment

The types of sampling/collection equipment needed to execute the field implementation plan are as follows:

- Portable/hand-held pH meter,
- Portable/hand-held Conductivity meter,
- Portable/hand-held Turbidity meter,
- Portable/hand-held Water Level Indicator,
- KIJ-5 Radio, cell phone, and/or pager,

- Field vehicle,
- Personal protective equipment,
- Chain-of-custodies,
- Sampling supplies,
- Sample bottles with preservatives,
- Coolers and frozen blue ice or equivalent for packing samples in the field.

Equipment needs will vary from day to day based on sampling requirements and field conditions.

6.2 Investigation Derived Waste

Investigation derived waste (IDW) will be managed according to the site-specific IDW management plan developed for the project.

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FIGURES

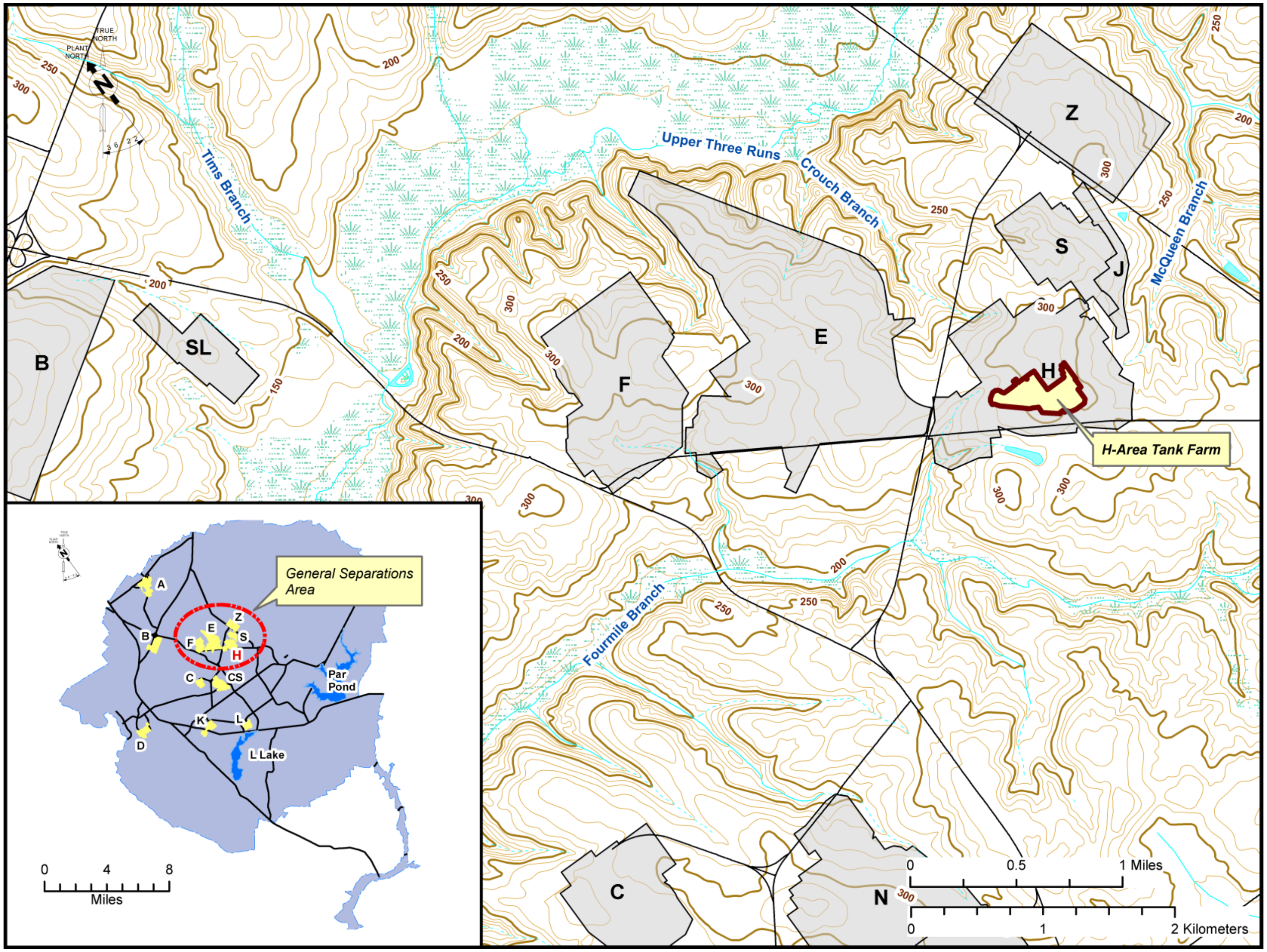


Figure 1: Location of H Area in the General Separations Area at the Savannah River Site

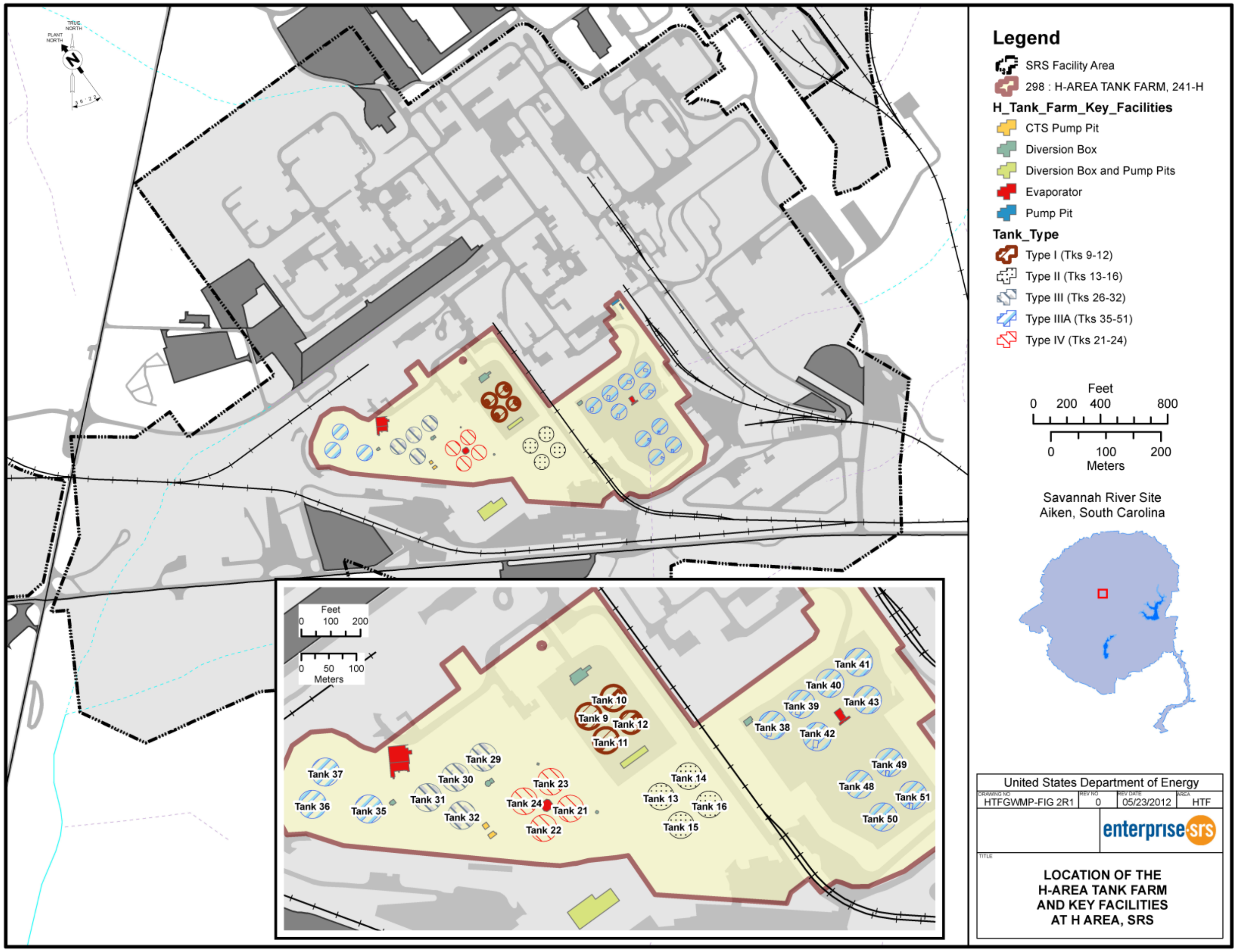


Figure 2: Location of the H-Area Tank Farm and Key Facilities at H Area, SRS

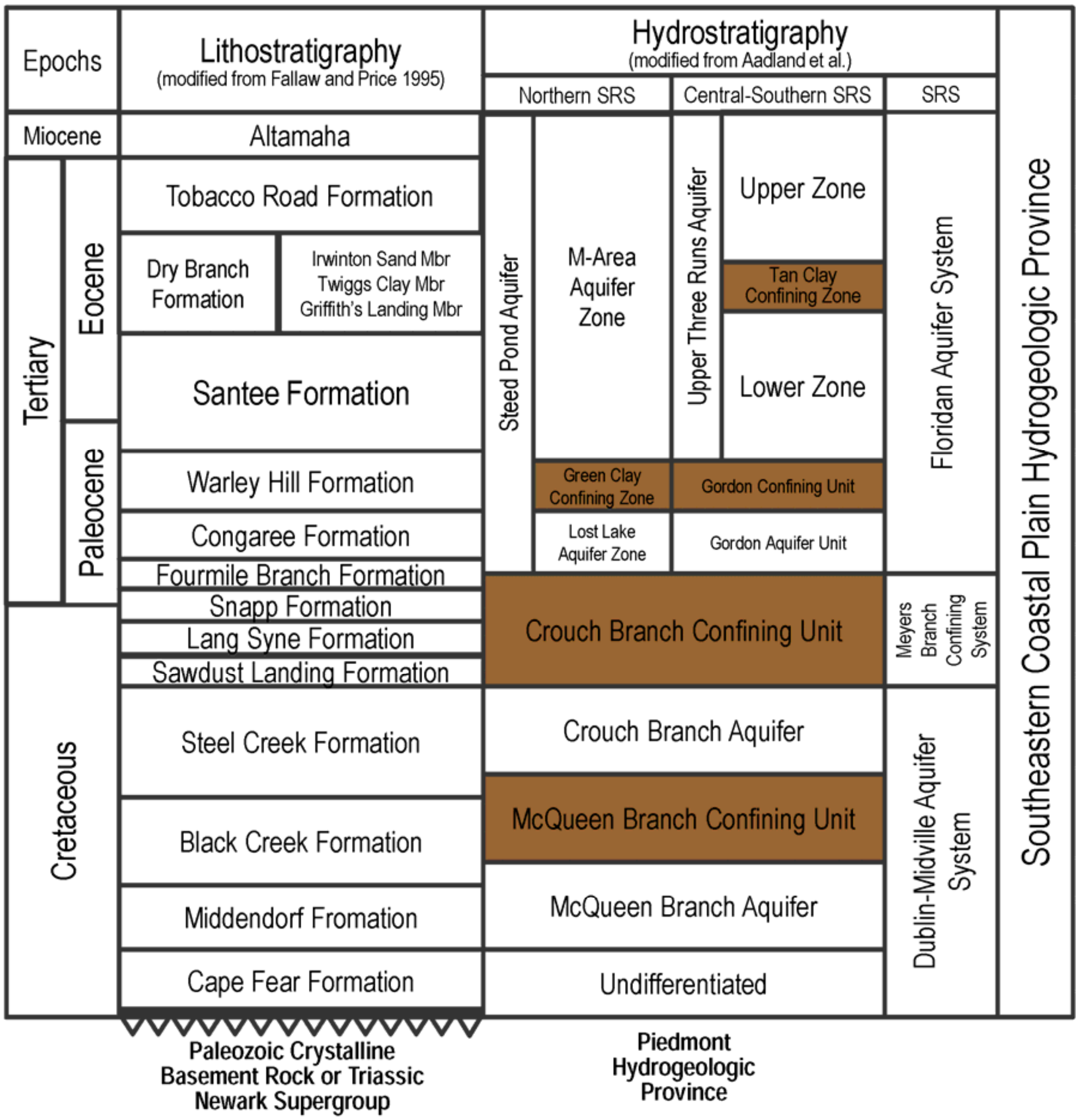


Figure 3: Hydrostratigraphic Units at H Area (modified from Aadland et al, 1995)

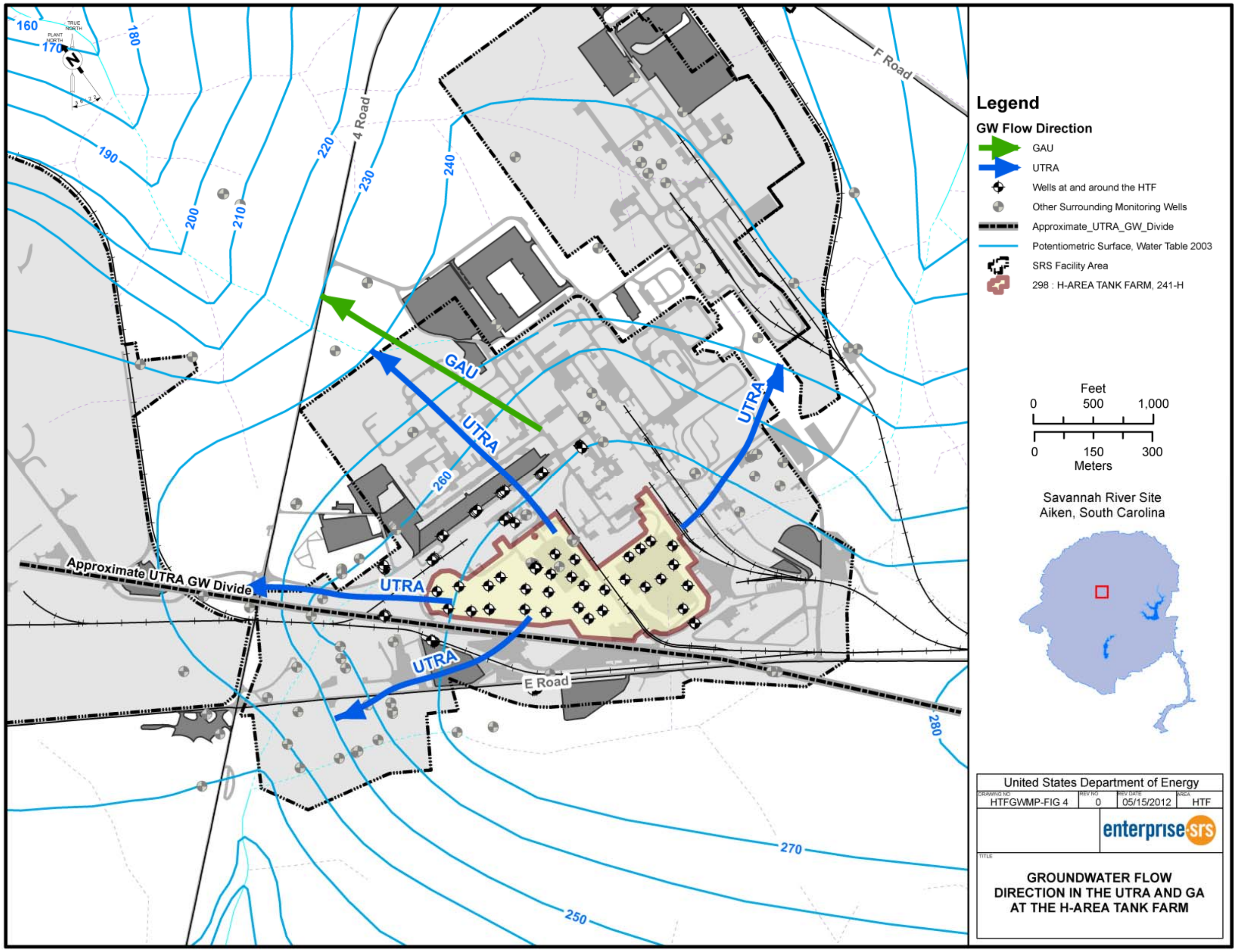


Figure 4: Potentiometric Surface and Groundwater Flow Directions at the H-Area Tank Farm

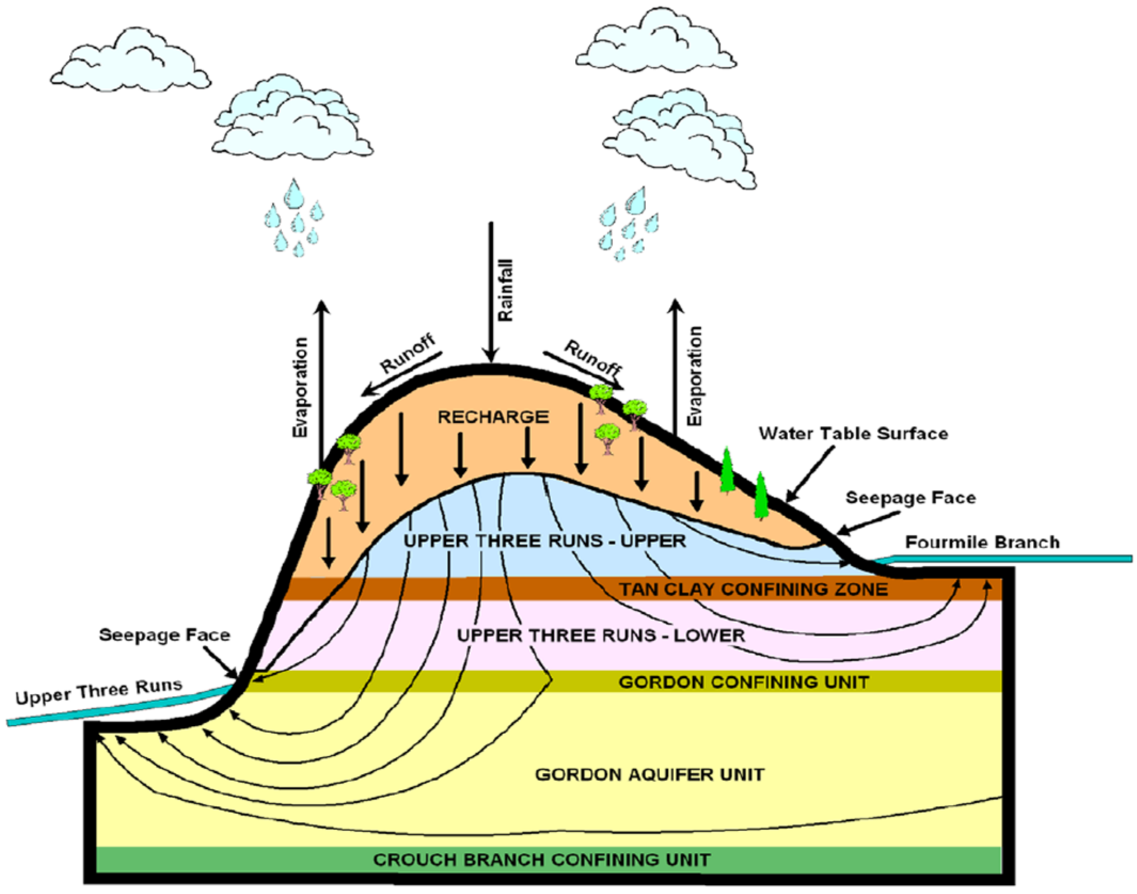


Figure 5: Surface and Groundwater Flow at the General Separations Area (modified from SRR, 2011)

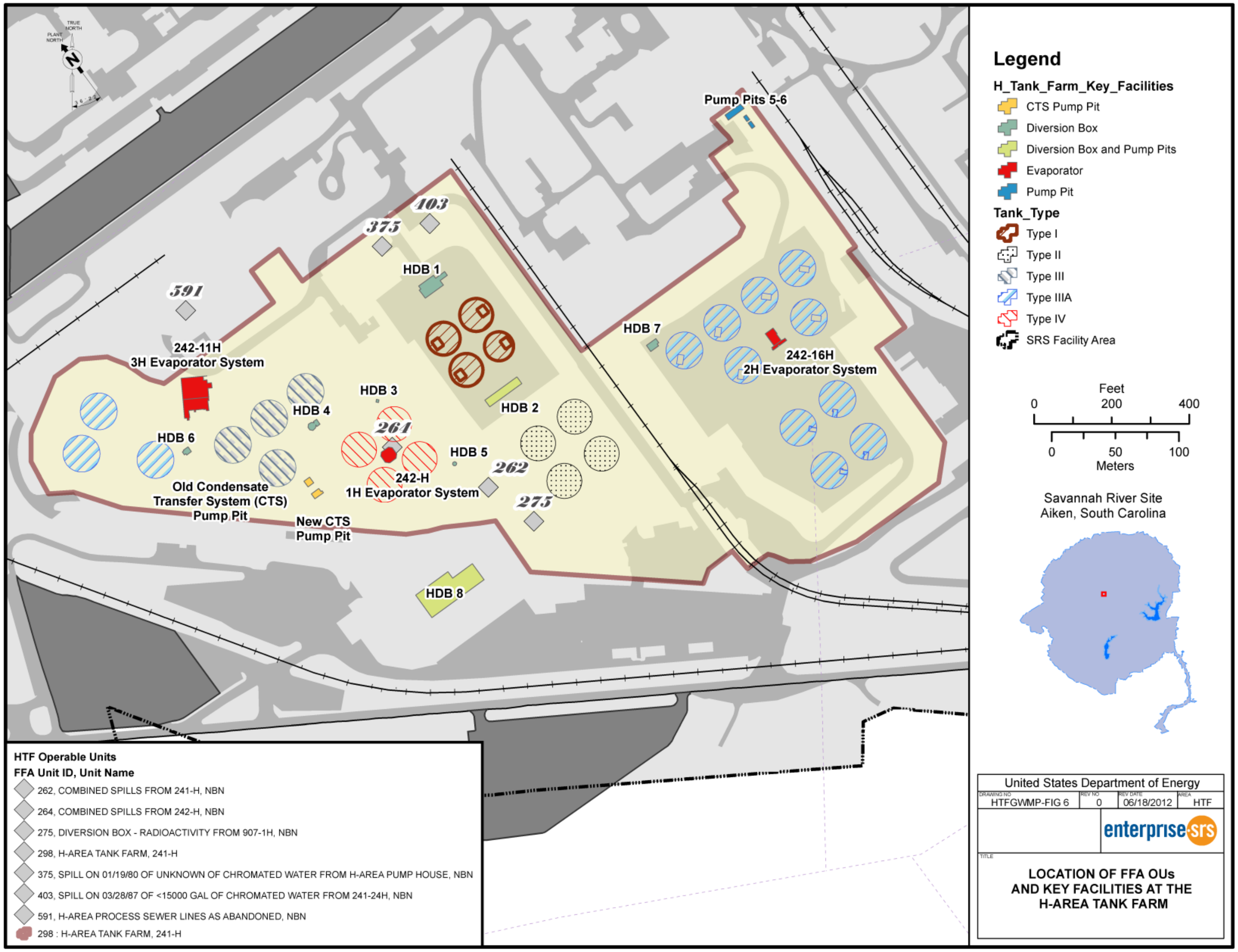


Figure 6: Location of FFA OUs and Key Facilities at the H-Area Tank Farm

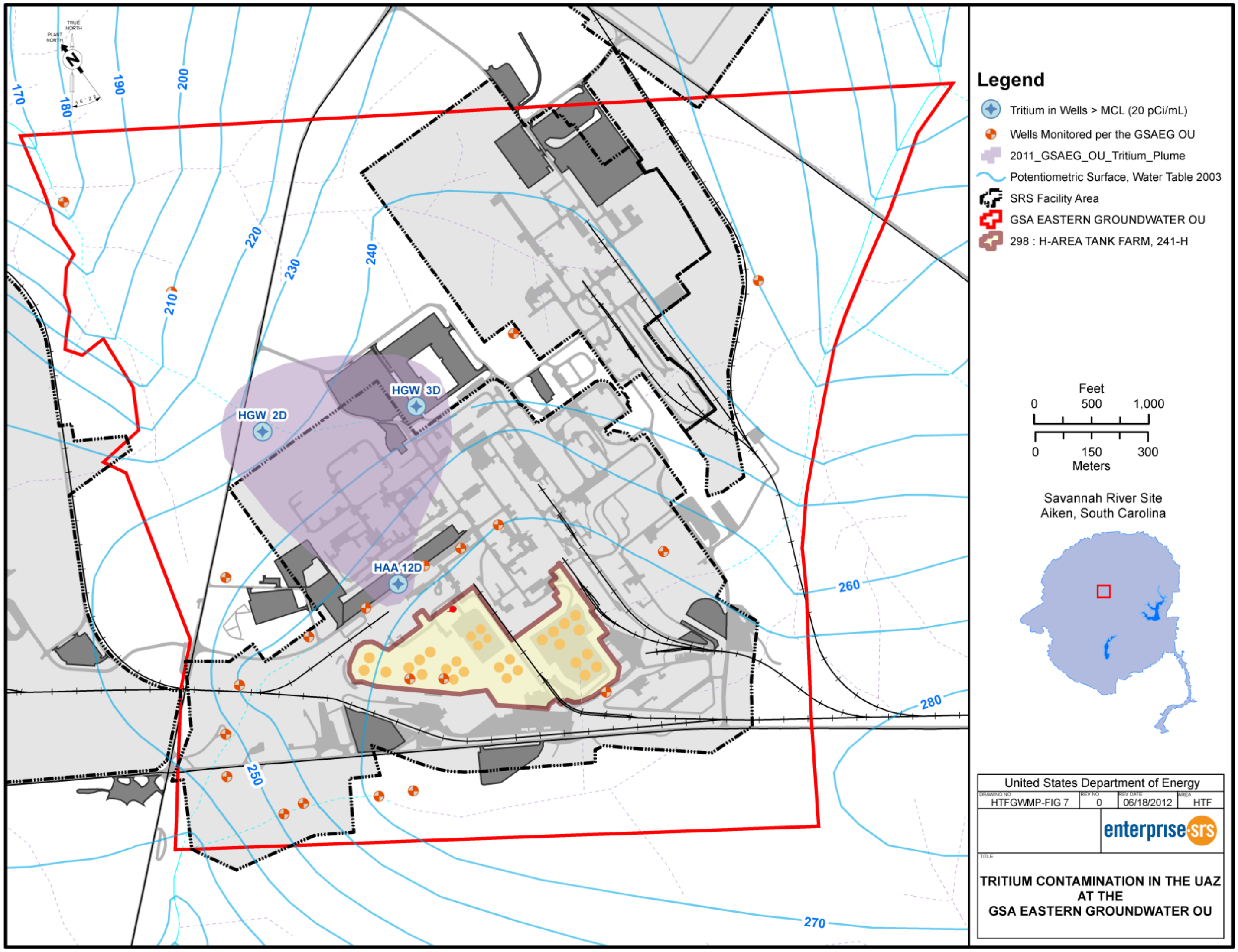


Figure 7: Tritium Contamination in the UAZ at the GSA Eastern Groundwater Operable Unit

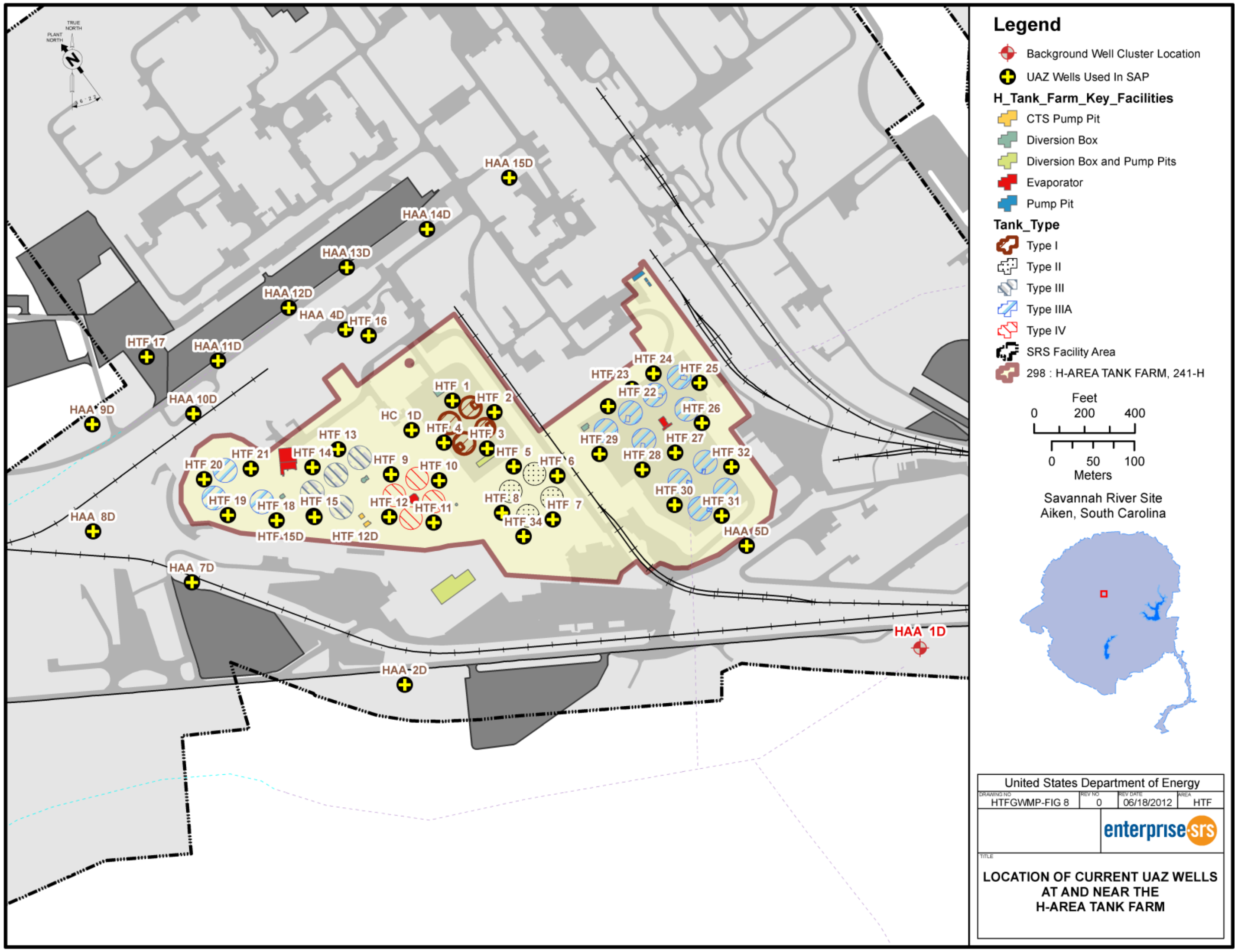


Figure 8: Location of Current UAZ Wells At and Near the H-Area Tank Farm (Tank Farm Interior Wells and Perimeter Monitoring Network)

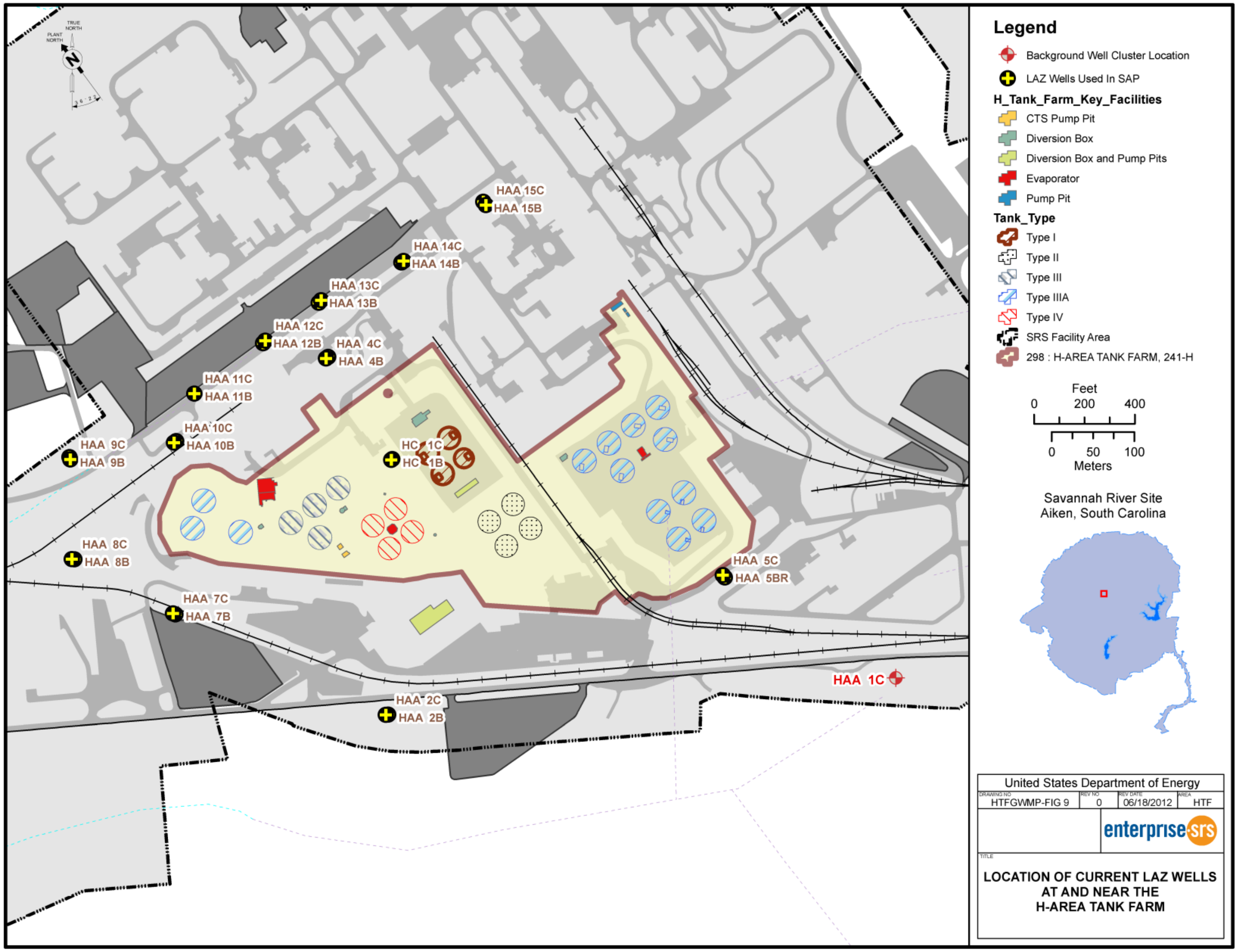


Figure 9: Location of Current LAZ Wells At and Near the H-Area Tank Farm (Tank Farm Interior Wells and Perimeter Monitoring Network)

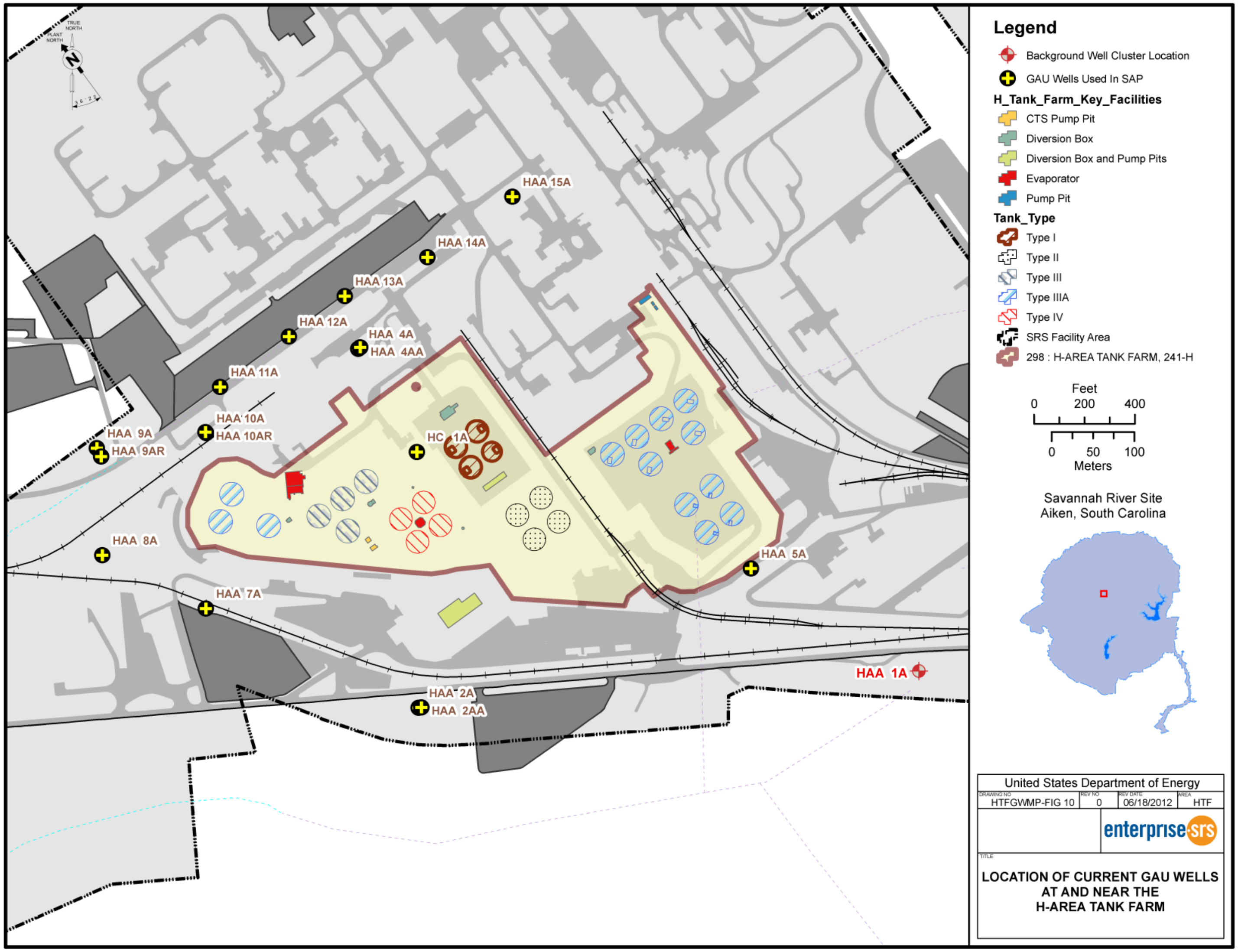


Figure 10: Location of Current GAU Wells At and Near the H-Area Tank Farm

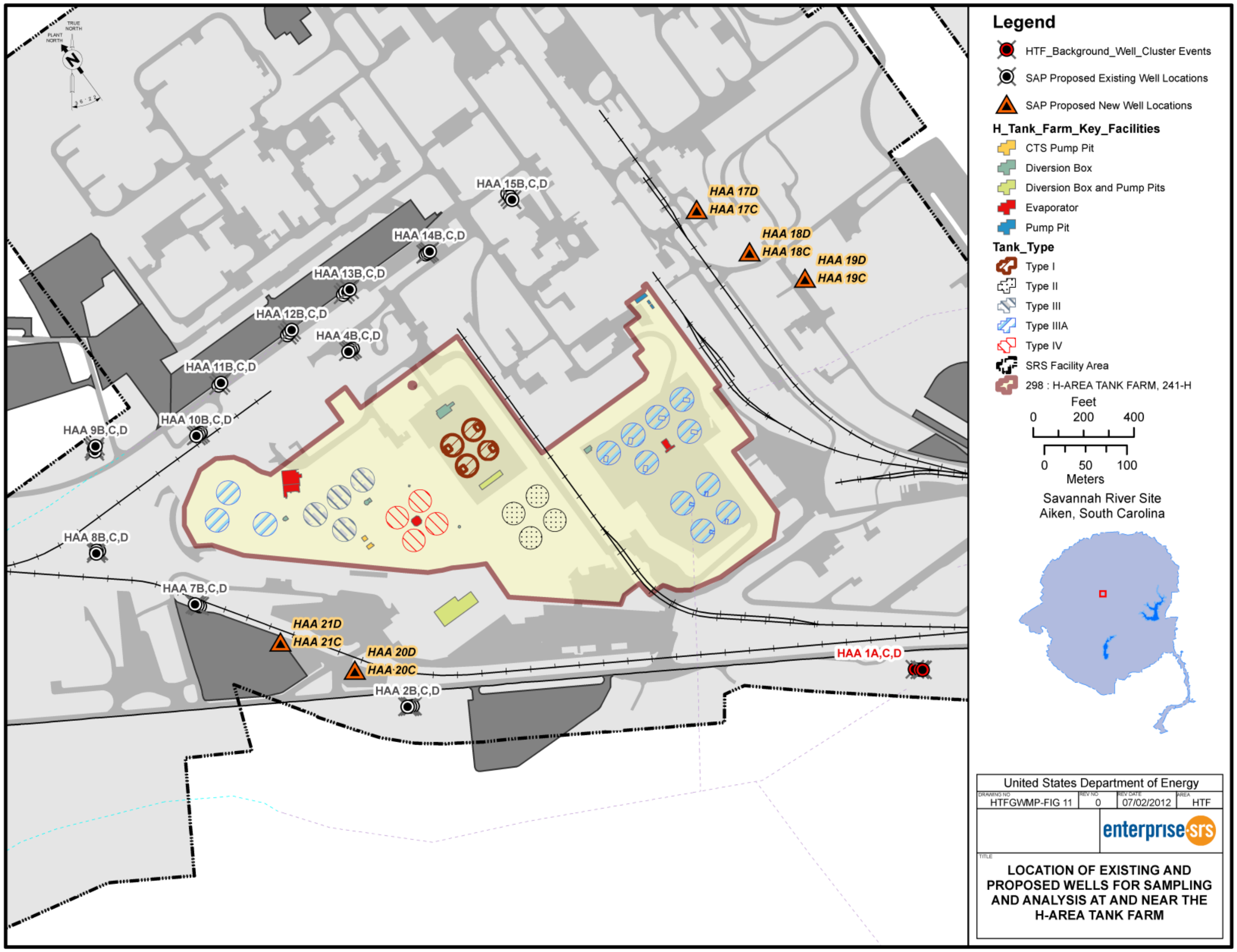
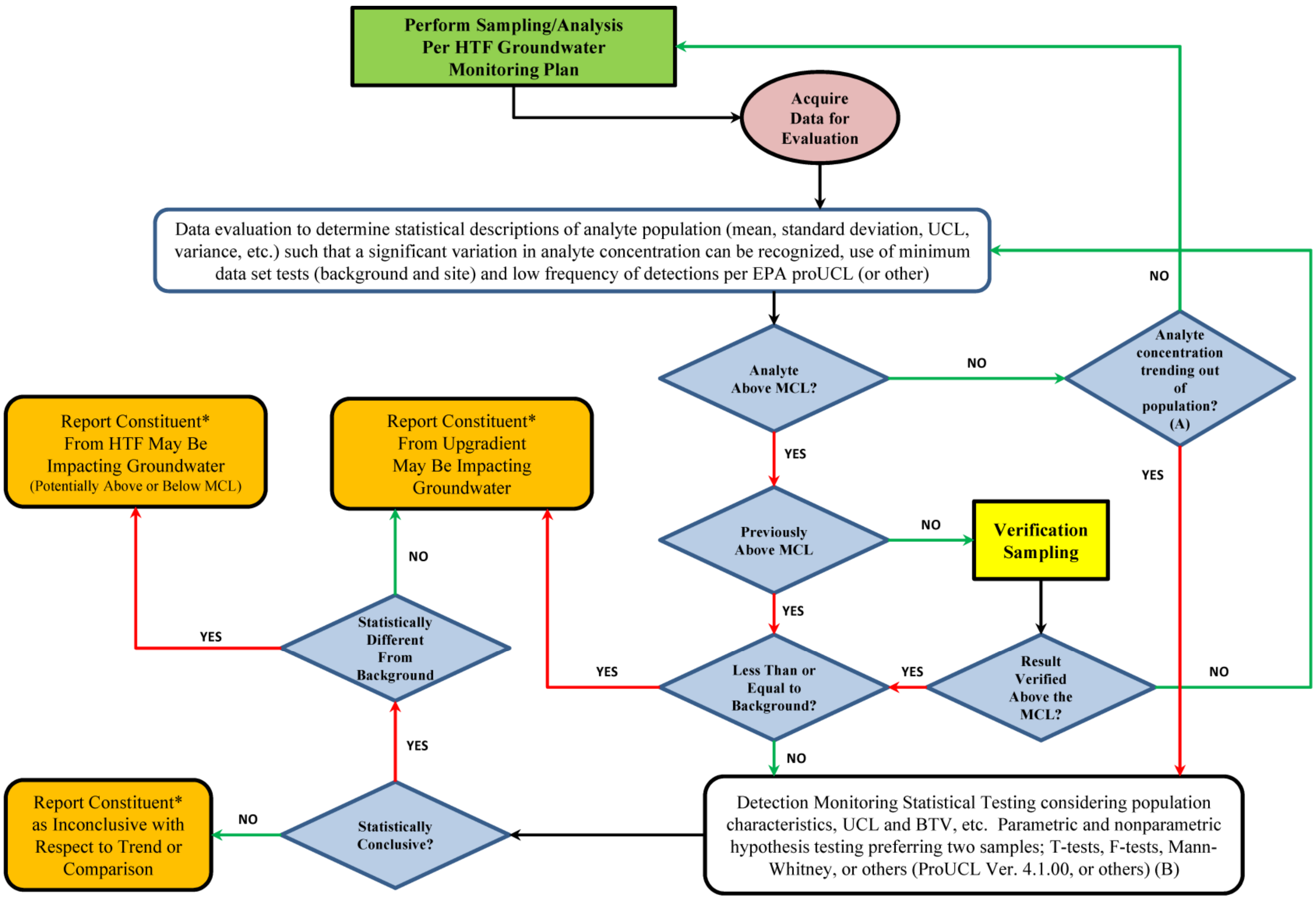


Figure 11: Location of Proposed Wells for Sampling and Analysis at and near the H-Area Tank Farm



Report Constituent * includes annual reporting, and on an as needed basis to the EPA and SCDHEC for unusual events, (A) comparison to population variance may use simple control chart analysis, (B) when sufficient data are available comparison testing to background may be performed without being above MCL or trending out of the population variance (above UCL)

Figure 12: Data Evaluation Process

TABLES

Table 1: Data Quality Objectives Worksheet for Groundwater at the H-Area Tank Farm

Pathway (Media)	Probable Conditions	Exposure Pathway and/or Release Mechanisms	Data Needs and DQOs Including Engineering/Physical Processes	Field Activities Including Removal and Characterization	Parameters	Potential Remedial Action Alternatives
Groundwater	Contamination of groundwater from leaching of secondary sources and spills from primary sources (i.e., waste tanks). Contaminated groundwater elevated above risk-based screening criteria exists. Known VOC and tritium plumes are present. Varying shallow subsurface groundwater flow directions and rates result in multiple flow paths.	Ingestion or dermal contact with groundwater or inhalation of groundwater vapor.	Establish permanent monitoring locations in the UAZ and LAZ to monitor and evaluate groundwater contaminant concentration trends. Obtain groundwater data needed to adequately monitor possible contaminant release and movement in the groundwater. Establish and monitor background groundwater locations for data comparisons to upgradient groundwater quality at the HTF.	Install and sample proposed monitoring wells in the UAZ and LAZ to monitor groundwater in the northeast and southwest vicinity of the HTF. Sample existing groundwater wells installed in the UAZ, LAZ, and GAU (background well only) at the HTF. Redevelop background wells.	Nitrate/nitrite, cadmium, chromium, manganese, sodium, gross alpha, nonvolatile beta, technetium-99, and tritium. Alpha, beta, and/or gamma speciation, if trigger levels exceeded for gross alpha (15 pCi/L) and/or nonvolatile beta (50 pCi/L), as required.	No remedial actions are warranted. , Semi -annual sampling of groundwater monitoring wells and annual reporting will continue.

Table 2: Monitoring Parameters for the H-Area Tank Farm Groundwater Monitoring Plan

Proposed Analytes for Existing and New Wells (2 times/year)‡	Current Monitoring Program	Analytical Method	MCL/PRG (pCi/L, pCi/mL, mg/L)	Action Level	CRDL/Typical MDA
Inorganics					
Nitrate/Nitrite	X	EPA353.2	10 mg/L	NA	0.01 mg/L (3)
Metals					
Cadmium		EPA6010C	0.005 mg/L	NA	0.002 mg/L (3)
Chromium	X	EPA6010C	0.1 mg/L	NA	0.002 mg/L (3)
Manganese		EPA6010C	NA	NA	0.002 mg/L (3)
Sodium	X	EPA6010C	NA	NA	0.002 mg/L (3)
Radionuclide Indicators					
Gross Alpha	X	EPA900.0MOD	NA	15 pCi/L	Sample Specific (2)
Nonvolatile Beta	X	EPA900.0MOD	NA	4 mrem	Sample Specific (2)
Radionuclides					
Technetium-99		Beta Spectroscopy (1)	900 pCi/L	NA	17.3 pCi/L (3)
Tritium	X	EPA906.0MOD	20 pCi/mL	NA	0.50 pCi/mL (3)
Alpha Speciation (if gross alpha ≥ 15 pCi/L)	X	Alpha Spectroscopy (1)	NA	NA	See Table 5 for selected isotopes
Beta Speciation (if nonvolatile beta ≥ 50 pCi/L)	X	Beta Spectroscopy (1)	NA	NA	See Table 5 for selected isotopes
Gamma Speciation (if nonvolatile beta ≥ 50 pCi/L)	X	Gamma Spectroscopy (1)	NA	NA	See Table 5 for selected isotopes

Proposed Field Parameters	
Depth to Water	X
pH	X
specific conductance	X
temperature	X
turbidity	X

(1) No nationally recognized standardized methods, except Ra-226 and Ra-288 (EPA903.0MOD).
(2) All minimum detected activities (MDAs) are on a sample specific basis, typical MDA for selected isotopes are provided in Tables 7 and 8, limits are not always attainable.
(3) Contract Required Detection Limits (CRDL) are not always attainable.

‡The Analyte List includes radionuclides for information only.

Table 3: Sampling Matrix Table

Sample Count	Station ID	Sample Type	Sample Media	Collection Method	Analyte Suite	Sample Coordinates	
						East	North
1	HAA 1A‡	REG	Groundwater	pump	1, 2, 3, 4, 5	440708.05	3682656.65
2	HAA 1C‡	REG	Groundwater	pump	1, 2, 3, 4, 5	440714.09	3682656.18
3	HAA 1D‡	REG	Groundwater	pump	1, 2, 3, 4, 5	440717.33	3682655.86
4	HAA 2B	REG	Groundwater	pump	1, 2, 3, 4, 5	440099.73	3682611.93
5	HAA 2C	REG	Groundwater	pump	1, 2, 3, 4, 5	440096.72	3682611.62
6	HAA 2D	REG	Groundwater	pump	1, 2, 3, 4, 5	440093.78	3682611.37
7	HAA 4B	REG	Groundwater	pump	1, 2, 3, 4, 5	440027.10	3683044.31
8	HAA 4C	REG	Groundwater	pump	1, 2, 3, 4, 5	440024.60	3683042.57
9	HAA 4D	REG	Groundwater	pump	1, 2, 3, 4, 5	440022.13	3683040.84
10	HAA 7B	REG	Groundwater	pump	1, 2, 3, 4, 5	439842.22	3682733.14
11	HAA 7C	REG	Groundwater	pump	1, 2, 3, 4, 5	439839.33	3682734.17
12	HAA 7D	REG	Groundwater	pump	1, 2, 3, 4, 5	439836.44	3682735.21
13	HAA 8B	REG	Groundwater	pump	1, 2, 3, 4, 5	439720.01	3682799.78
14	HAA 8B	SPL	Groundwater	pump	1, 2, 3, 4, 5	439720.01	3682799.78
15	HAA 8C	REG	Groundwater	pump	1, 2, 3, 4, 5	439717.00	3682799.93
16	HAA 8D	REG	Groundwater	pump	1, 2, 3, 4, 5	439716.81	3682796.86
17	HAA 9B	REG	Groundwater	pump	1, 2, 3, 4, 5	439714.23	3682923.10
18	HAA 9C	REG	Groundwater	pump	1, 2, 3, 4, 5	439715.08	3682920.18
19	HAA 9D	REG	Groundwater	pump	1, 2, 3, 4, 5	439715.95	3682926.26
20	HAA 10B	REG	Groundwater	pump	1, 2, 3, 4, 5	439843.12	3682942.46
21	HAA 10B	FD	Groundwater	pump	1, 2, 3, 4, 5	439843.12	3682942.46
22	HAA 10C	REG	Groundwater	pump	1, 2, 3, 4, 5	439840.65	3682940.67
23	HAA 10D	REG	Groundwater	pump	1, 2, 3, 4, 5	439838.19	3682938.87
24	HAA 11B	REG	Groundwater	pump	1, 2, 3, 4, 5	439865.16	3682999.87
25	HAA 11C	REG	Groundwater	pump	1, 2, 3, 4, 5	439865.16	3682999.87
26	HAA 11D	REG	Groundwater	pump	1, 2, 3, 4, 5	439867.77	3683002.94
27	HAA 12B	REG	Groundwater	pump	1, 2, 3, 4, 5	439948.32	3683060.95
28	HAA 12C	REG	Groundwater	pump	1, 2, 3, 4, 5	439950.92	3683064.02
29	HAA 12D	REG	Groundwater	pump	1, 2, 3, 4, 5	439953.53	3683067.08
30	HAA 13B	REG	Groundwater	pump	1, 2, 3, 4, 5	440015.87	3683109.81
31	HAA 13C	REG	Groundwater	pump	1, 2, 3, 4, 5	440018.48	3683112.88
32	HAA 13D	REG	Groundwater	pump	1, 2, 3, 4, 5	440023.67	3683115.92
33	HAA 14B	REG	Groundwater	pump	1, 2, 3, 4, 5	440115.79	3683158.62

Table 3: Sampling Matrix Table (Continued)

Sample Count	Station ID	Sample Type	Sample Media	Collection Method	Analyte Suite	Sample Coordinates	
						East	North
34	HAA 14C	REG	Groundwater	pump	1, 2, 3, 4, 5	440118.26	3683160.40
35	HAA 14C	SPL	Groundwater	pump	1, 2, 3, 4, 5	440118.26	3683160.40
36	HAA 14D	REG	Groundwater	pump	1, 2, 3, 4, 5	440120.65	3683162.09
37	HAA 15B	REG	Groundwater	pump	1, 2, 3, 4, 5	440214.79	3683231.79
38	HAA 15C	REG	Groundwater	pump	1, 2, 3, 4, 5	440217.89	3683227.68
39	HAA 15D	REG	Groundwater	pump	1, 2, 3, 4, 5	440220.20	3683224.31
40	HAA 17C[a]	REG	Groundwater	pump	1, 2, 3, 4, 5	440444	3683213
41	HAA 17D[a]	REG	Groundwater	pump	1, 2, 3, 4, 5	440444	3683213
42	HAA 18C[a]	REG	Groundwater	pump	1, 2, 3, 4, 5	440508	3683162
43	HAA 18C[a]	FD	Groundwater	pump	1, 2, 3, 4, 5	440508	3683162
44	HAA 18D[a]	REG	Groundwater	pump	1, 2, 3, 4, 5	440508	3683162
45	HAA 19C[a]	REG	Groundwater	pump	1, 2, 3, 4, 5	440575	3683130
46	HAA 19D[a]	REG	Groundwater	pump	1, 2, 3, 4, 5	440575	3683130
47	HAA 20C[a]	REG	Groundwater	pump	1, 2, 3, 4, 5	440030	3682656
48	HAA 20D[a]	REG	Groundwater	pump	1, 2, 3, 4, 5	440030	3682656
49	HAA 21C[a]	REG	Groundwater	pump	1, 2, 3, 4, 5	439940	3682690
50	HAA 21D[a]	REG	Groundwater	pump	1, 2, 3, 4, 5	439940	3682690

[a]Proposed new well to be installed.
REG = Regular sample.
FD = Field duplicate.
SPL = Split sample.

‡Background Well

Table 3: Sampling Matrix Table (Continued)

	Regular and QA Sample Summary for Monitoring Wells	Comments
Regular Samples	46	
Field Duplicates	2	Collect at 1 per 20
Split Samples	2	Collect at 1 per 20
Rinsate Samples	0	None to be collected as sampling will be conducted using existing, dedicated downhole well pumps
Field Blank	0	Optional. None to be collected.
Trip Blanks	0	None to be collected or shipped with samples since volatile organic compounds are not included in the analyte suite
Total Samples	50	

QA = Quality assurance.

Analytical Suites

1. Inorganics: Nitrate/Nitrite
2. Metals: Cadmium, Chromium, Managanese, Sodium
3. Radionuclide Indicators: Gross Alpha and Nonvolatile Beta[b]
4. Radionuclides: Technetium-99 and Tritium
5. Field Parameters: Depth to Water, pH, specific conductance, temperature, and turbidity

[b] If the gross alpha result exceeds 15 pCi/L, then an alpha spectroscopy will be performed to include americium-241, plutonium-238, plutonium-239/240, and uranium-238. If the nonvolatile beta result exceeds 50 pCi/L, then a beta/gamma spectroscopy will be performed to include iodine-129, strontium-90, cesium-137, and cobalt-60.

Table 4: Laboratory Contract Required Detection Limits Compared to Regional Screening Levels for Surface or Groundwater Media

Analyte	CAS	Tap Water RSL (µg/L)	MCL (µg/L)	CRDL (µg/L)	CRDL> MCL/RSL
Cadmium	7440-43-9	6.9E-03		2.0E+00	>RSL
Chromium	7440-47-3		1.0E+02	2.0E+00	No
Manganese	7439-96-5	8.8E+02		2.0E+00	No
Nitrate-Nitrite as Nitrogen	NO3NO2			1.0E+01	No
Sodium	7440-23-5			2.0E+00	No

>RSL means CRDL is greater than the RSL

Table 5: Minimum Detected Activity Compared to Water Radiological MCL/PRGs

Analyte	Typical MDA	MCL/PRG	MDA>MCL/PRG	Proposed Analytes for Existing and New Wells (2 times/year)
Alpha Spectroscopy (pCi/L)				
Americium-241	0.4	15	No	X
Americium-243	0.462	15	No	
Curium-242	0.9	15	No	
Neptunium-237	0.771	15	No	
Plutonium-238	0.35	15	No	X
Plutonium-239/240	0.353	15	No	X
Plutonium-242	0.372	15	No	
Thorium-228	0.445	15	No	
Thorium-230	0.523	15	No	
Thorium-232	0.45	15	No	
Uranium-233/234	0.663	10	No[a]	
Uranium-235	0.684	0.47	No[a]	
Uranium-238	0.744	10	No[a]	X
Gamma Spectroscopy (pCi/L)				
Actinium-228	25	26.6	No	
Cesium-137	5	200	No	X
Cobalt-60	10	100	No	X
Lead-214	20	154	No	
Potassium-40	75	2.14	Yes	
Specific Analyses (pCi/L)				
Carbon-14	10	2,000	No	
Iodine-129	1	1	No	X
Nickel-59	20	300	No	
Nickel-63	10	50	No	
Promethium-147	10	600	No	
Radium-226	0.3	5	No	
Radium-228	0.5	5	No	
Strontium-90	0.852	8	No	X
Technetium-99	17.3	900	No	X
Tritium (pCi/mL)	0.5	20	No	X

[a]From Rucker 2001.

Note: All minimum detected activities (MDAs) are sample specific. The MDAs represented above are typical MDA as reported by the subcontract laboratories but are not always achievable.

Table 6: Minimum Field Quality Control/Quality Assurance Sampling Requirements

Data Quality Level	Field Quality Control/Quality Assurance Samples	Frequency of Field Quality Control/ Quality Assurance Sample
VV	Co-located Field Duplicate	Minimum 5% (1)
	Trip Blank	Minimum 1 per cooler
	Equipment Blank	1 per 40 samples(2)
	Field Blank	Optional; 1 per 40 samples(3)
	Split Sample	Minimum 5%
D	Co-located Field Duplicate	Minimum 5%(1)
	Trip Blank	1 per cooler
	Equipment Blank	1 per 40 samples(2)
	Field Blank	Optional; 1 per 40 samples(3)
	Split Sample	Minimum 5%

Data Quality Levels

VV Data Verified and Validated Data (validated to automated criteria; equivalent to USEPA Screening Level Data)
D Data USEPA Definitive Level Data

Footnotes:
(1) Minimum frequency established per ER-SOP-043
(2) Typical frequency
(3) Recommended based on project needs; typical frequency

Table 7: Laboratory Analytical Specifications Table for TAL/TCL Analytes for Groundwater Media

Analyte	Analyte ID	Preparation [B] Method	Analytical [B] Method	CRDL [A] (μg/L)
Metals				
Cadmium	7440-43-9	3005A,3015A	EPA6010C	2.0
Chromium	7440-47-3	3005A,3015A	EPA6010C	2.0
Manganese	7439-96-5	3005A,3015A	EPA6010C	2.0
Sodium	7440-23-5	3005A,3015A	EPA6010C	2.0
Inorganics				
Nitrate-Nitrite as Nitrogen	NO3NO2		EPA353.2	10.0

A) CRDL is the Contract Required Detection Limit and is not always attainable.
B) Extraction and preparation methods differ depending upon media, concentration, instrument, laboratory, and analytical method. Preparation methods will also influence detection limits.

Table 8: Laboratory Analytical Specifications Table for Radiological Analytes in Soil, Sediment, Surface, and Groundwater Media

Radionuclides	Typical Water MDAs[a]	Analytical Method
***Alpha Spectroscopy* (pCi/L)**		
Americium-241	0.40	NNS
Americium-243	0.462	NNS
Curium-243/244	0.503	NNS
Curium-245/246	0.458	NNS
Neptunium-237	0.771	NNS
Plutonium-238	0.35	NNS
Plutonium-239/240	0.353	NNS
Plutonium-242	0.372	NNS
Thorium-228	0.445	NNS
Thorium-230	0.523	NNS
Thorium-232	0.45	NNS
Uranium-233/234	0.663	NNS
Uranium-235	0.684	NNS
Uranium 238	0.744	NNS
***Gamma Pulse Height Analyses* (pCi/L)**		
Actinium-228	25.00	NNS
Cesium-137	5.0	NNS
Cobalt-60	10.00	NNS
Lead-214	20.00	NNS
Potassium-40	75.00	NNS
***Radiological Indicators* (pCi/L)**		
Gross Alpha	3	EPA900.0MOD
Non-volatile Beta	4	EPA900.0MOD
***Individual Analyses* (pCi/L)**		
Carbon-14	10.00	NNS
Iodine-129	1.00	NNS
Nickel-59	20.00	NNS
Nickel-63	10.00	NNS
Promethium-147	10.00	NNS
Radium-226	0.30	EPA903.0MOD
Radium-228	0.50	EPA903.0MOD
Strontium-90	0.852	NNS
Technetium-99	17.3	NNS
Tritium (pCi/mL)	0.00050	EPA906.0MOD

[a] All MDAs are sample-specific. The MDAs represented above are typical MDAs as reported by the subcontract laboratories but are not always achievable.

MDA = Minimum detected activity.

NNS = No national standard.

USEPA = United States Environmental Protection Agency.

Table 9: Preservatives, Holding Times, and Sample Containers for Groundwater Collected at the HTF

Parameter	Preservative	Holding Time	Container
Metals (except chromium [VI] and mercury)	HNO_3 to pH <2	6 months	1-L HDPE
Miscellaneous			
Nitrate-Nitrite	Cool to 4° C. H_2SO_4 to pH < 2.	28 days	250 mL HDPE
Radionuclides			
Radiological Test Gross Alpha	HNO_3 to pH <2	6 months	2-L HDPE
Radiological Test Non-volatile Beta	HNO_3 to pH <2	6 months	2-L HDPE
Radium Total	HNO_3 to pH <2	6 months	2-L HDPE
Tritium	None, Cool 0 to 6°C	180 days	250-mL amber glass

°C = Degrees Celsius.
H_2SO_4 = Sulfuric acid.
HDPE = High-density polyethylene.
HNO_3 = Nitric acid.