



Sampling and Analysis Plan Addendum for the P-Area Groundwater Operable Unit (U)

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at two (2) locations where TCE has been detected. SC-03 has historically exhibited elevated concentrations in exceedance of the MCL while at SC-02, TCE detections were variable with no detections in the last 12 years.

Table 1 provides a summary of the data collected at these four (4) locations since 2014. As with historical data, tritium and TCE are the primary contaminants detected in surface water above the MCLs.

2.1.2 Depth-Discrete Groundwater Samples

Depth-discrete groundwater sampling was utilized to investigate the extent of VOC groundwater contamination to the east of P Area along SRS Road F and to delineate the extent of tritium contamination in the GAU near the PRSBs (Figure 6).

Eastern VOC Groundwater Investigation

Five (5) cone penetrometer technology (CPT) locations along SRS Road F were utilized to collect up to ten (10) groundwater samples from each location to determine if VOC and tritium contaminants were present in the Upper and Lower Aquifer Zones. Previous characterization work conducted in 2010 defined low concentrations of VOC and tritium groundwater contamination east of P Area. The Core Team agreed to conduct additional sampling to ensure the extent of the VOC and tritium groundwater plumes was delineated.

Overall, 39 groundwater samples out of 46 attempts were collected from various depths from the five (5) CPT locations and analyzed for Target Compound List (TCL) VOCs and tritium. Table 2 provides a summary of PCE, TCE, and tritium results from each CPT location. Tritium was detected in 64% of the samples collected but none of the results exceeded the MCL. Tritium concentrations are within expected background concentrations associated with impact from rainfall and are not associated with impact from reactor operations. TCE was detected in 46% of the samples collected with only one (1) exceedance (7.68 ug/L) of the MCL in the Lower Aquifer Zone (LAZ) at sampling location PRGW090. Tetrachloroethylene (PCE) was detected in 51% of the samples collected with four (4) exceedances of the MCL. Of the four (4) MCL exceedances, three (3) of the samples were from the same location (PRGW087) in the Upper Aquifer Zone (UAZ). ~~Previous groundwater investigation (2010) of PCE contamination in P Area determined~~

~~the plumes to be localized within the P Area facility with primary flow of the contamination to the west. Groundwater flow from this sampling location is to the east towards an unnamed tributary to PAR Pond. The presence of PCE groundwater contamination found at PRGW087 is not associated with the source area located in P Area and is supported by previous groundwater investigation conducted in 2010. The result of the investigation did not determine PCE groundwater contamination beyond P Area to the east. However, the investigation did determine PCE groundwater contamination to the west and was co-mingled with the TCE groundwater contamination~~ (Figure 19). Therefore, the elevated concentrations of PCE determined at ~~this~~ location PRGW087 are ~~not~~ associated with no known source area and ~~are~~ not associated with existing PCE groundwater plumes in P Area.

Other VOCs detected include 1,2-dichloroethane, 1,2,4-trichlorobenzene, acetone, chloroform, c12DCE, toluene, and trichlorofluoromethane. Table 3 presents a data summary of detected results for the CPT data collected. Chloroform was the only other VOC that exceeded the regional screening level (RSL) in 44% of the samples collected. The presence of chloroform is a typical lab contaminant and is not associated with reactor operations. The detection of other VOCs such as 1,2,4-trichlorobenze, acetone, toluene, and trichlorofluoromethane are localized, of minimal concentrations which do not indicate a larger groundwater impact, and are not observed at other areas at the PAGW OU.

As a follow-on to the completion of the 2013 SAP CPTs, two (2) additional CPTs (PRGW110 and 111) were completed to delineate the extent of the PCE groundwater contamination determined at sampling location PRGW087 (Figure 6). The results from these two (2) locations determined the extent of the PCE groundwater contamination to be slightly above the MCL downgradient of sampling location PRGW087 (Table 2). PCE concentrations were detected in exceedance of the MCL in one (1) sample collected in the UAZ at sampling location PRGW110. In total, eleven (11) of 18 attempted groundwater samples were collected. Other VOCs detected include 1,2-dibromomethane, 1,2-dichloropropane, 1,2,4-trichlorobenzene, 2-hexanone, acetone, chloroform, c12DCE, ethylbenzene, methyl ethyl ketone, methylcyclohexane, toluene, and trichloroethylene (Table 3). Chloroform, as exhibited at sampling locations PRGW087 through 091, also exceeded the RSL in 55% of the samples collected. The presence of chloroform is a typical lab contaminant and is not associated with P-reactor operations. Tritium was detected in 73% of the samples with

Sixteen (16) wells (Figure 11) were sampled for wide range of constituents that included VOCs, total organic carbon, dissolved organic carbon, total inorganic carbon, manganese, nitrate, nitrite, sulfate, sulfide, chloride, tritium, total iron, phosphate, chemical oxygen demand, ferrous and ferric iron, permanent gases, and light hydrocarbons. A subset of the wells was also sampled for compound specific isotope and microbial analyses.

Overall, four (4) inorganics, four (4) metals, one (1) radionuclide, and 14 VOCs, of which seven (7) are light hydrocarbons, were detected. Table 5 summarizes the detected values from the study site and compares the results to the appropriate screening level. Of the detected constituents, eight (8)~~seven (7)~~ exceeded MCLs or RSLs. Total phosphate (as P) exceeded the RSL in seven (7) of 16 samples. Iron and manganese also exceeded the RSL in 11 and one (1) of 16 samples collected, respectively. The presence of these constituents is associated with the injected media (e.g., AquaBupH, emulsified oil substrate [EOS[®]], and microbe suspension media). Tritium was found to be in exceedance of the MCL in 17 of 20 samples. Overall, four (4) VOCs were determined to be in exceedance of the MCLs. Both TCE and PCE exceeded the MCL in 18 and three (3) of 23 samples collected, respectively. Degradation byproduct c12DCE was determined to exceed the MCL in ten (10) of 23 samples collected. The presence of this VOC is associated with reductive degradation of PCE and TCE. Dichloromethane (methylene chloride) exceeded the MCL in two (2) of 20 samples collected and is typically a laboratory contaminant.

Compound specific isotope analysis (CSIA) was conducted to further evaluate biodegradation activity. Many processes affecting contaminants in groundwater, such as dilution, sorption, and volatilization, have little or no effect on isotopic ratios. Processes such as biodegradation however, are associated with significant isotopic fractionation. This change in isotopes is measured by comparing the difference in the heavier carbon-13 (¹³C) versus the lighter carbon-12 (¹²C) bonds on a VOC molecule. During biodegradation, the lighter ¹²C bond is broken leaving a higher isotopic fraction of ¹³C present with the VOCs. The extent of biodegradation can be determined from the change in the ratio of the stable isotopes as indicated by the reported specific VOC-carbon data (e.g., TCE-Carbon).

CSIA samples were collected from three (3) wells (background [PMW001DL], injection [PMW005DL], and downgradient [P002U]) associated with the study area (Figure 11). An earlier

goals (PRGs), or RSLs. UAZ data included in this summary were collected from 2014 and 2016. A total of nine (9) metals, seven (~~75~~) radionuclides, and six (6) VOCs were determined to have exceeded MCL or RSL screening levels. In addition, radiological indicators (gross alpha and nonvolatile beta) were detected above radiological trigger limits.

Metals detected in the UAZ above their screening criteria include aluminum, arsenic, chromium, cobalt, iron, lead, manganese, selenium, and uranium. Except for iron, the remaining metals were detected above their risk-based screening criteria in less than 5% of the samples. One well in particular (PAO001DU) consistently exhibited metals above the risk-based screening criteria. This is due to the location of the well within the ISCO treatment zone resulting in the release of naturally occurring metals from subsurface sediments into the groundwater. Iron was detected in 45 of 59 samples with 42 of those detections exceeding the RSL.

Radionuclides detected above their screening criteria include bismuth-214, iodine-129, strontium-90, tritium, and uranium-238. In addition, gross alpha and nonvolatile beta were detected above trigger levels (15 and 50 pCi/L). Tritium was the most widespread radionuclide present in groundwater and was detected in 100 of 104 samples with 40 of those exceeding the MCL. The maximum tritium concentration was 7,790 pCi/mL. Iodine-129 exceeded the MCL in approximately 3% (2 of 60) of the samples at two (2) wells during 2014. Subsequent sampling determined iodine-129 concentrations to be nondetects. Historical review of data prior to 2014, did not detect iodine-129 at these wells. The occurrence of this radionuclide is not indicative of groundwater contamination and is further supported by consistently low nonvolatile beta concentrations exhibited at these wells. Bismuth-214 and uranium-238 were found in exceedance of the MCLs primarily at one well, PAO001DU. As described earlier in the metals discussion, this well has been impacted by ISCO and the detection of radionuclides in groundwater are associated with naturally occurring radioactive material found in subsurface sediments that were released because of the chemical injections. Strontium-90 was detected in 12 of 62 samples with three (3) exceeding the MCL. The MCL exceedances were solely exhibited at well PSB 1A. This well has historically exhibited strontium-90 exceedances. The presence of this contaminant is associated with a process sewer line break near the PRSBs that originated from the P-RBC disassembly basin. The process sewer line and soil was remediated as part of the PRSBs remedial efforts (WSRC 2006a).

water samples collected from Steel Creek. PCE groundwater plume in the LAZ covers approximately 11 ac with a maximum concentration of 6.66 ug/L (4Q2016) at well PGW029C.

- C12DCE groundwater plume (>MCL) covers approximately six (6) ac in the UAZ with the maximum concentration of 4,740 ug/L (4Q2016) at well PMP002DL, which is located at the MicroCED study area. The c12DCE groundwater plume in the LAZ covers approximately 10 ac with a maximum concentration of 200 ug/L (4Q2016) at well PGW026C, which is located near Steel Creek.
- Tritium groundwater plume (>MCL) covers approximately 96 ac in the UAZ and discharges to Steel Creek with the maximum concentration of 6,860 pCi/mL (4Q2016) at well PSB011DL. The tritium groundwater plume in the LAZ covers approximately 78 ac with a maximum concentration of 13,400 pCi/mL (4Q2016) at well PSB002B, which is located at the PRSBs. The tritium groundwater plume in the GAU covers approximately <0.5 ac with a maximum concentration of 5,480 pCi/mL (4Q2016) at well PSB002AA, which is located at the PRSBs.

PAGW OU has TCE and tritium in surface water above the MCLs in Steel Creek:

- TCE concentration in surface water was 12.2 ug/L (4Q2016) at SC-03. No other surface water location exhibited TCE contamination. The historical maximum detected at SC-03 was 28.3 ug/L (2Q2013).
- Tritium concentration in surface water was 607 pCi/mL (4Q2016) at SC-03. Tritium concentrations were found in exceedance of the MCL at all surface water locations downstream of this location to L Lake.

3.1.2 *Identify the Goals of the Study*

The objective of this sampling activity is to collect groundwater, surface water, and soils data of sufficient quality that will be used to support the evaluation of remedial/removal alternatives for managing VOC groundwater plumes to Steel Creek. Because Steel Creek is impacted by contaminated groundwater, surface water in Steel Creek will be monitored in conjunction with

Groundwater (Figure 26)

- Twenty-six (26) boring locations with four (4) contingent locations are proposed to delineate the extent of VOC groundwater contamination. Samples will be collected via the Savannah River National Laboratory (SRNL) headspace soil sampling method and analyzed by SRNL. Completion of the borings will be performed through the use of Rotasonic drilling. The four (4) contingent locations are proposed and will only be sampled if ~~the extent of the data from the nearby boring does not indicate the presence of~~ VOC ~~groundwater plumes are not~~ defined contamination above the MCLs.
 - Continuous core will be collected from each location and described in the field.
 - Gamma logs will be collected from seven (7) of 26 locations.
 - Up to 42 undisturbed samples (e.g., Shelby Tubes) are proposed to be collected from six (6) boring locations. The samples will be submitted to an offsite geotechnical laboratory.
- Eleven (11) CPT locations are proposed for the collection of electric logs using a piezocone. No environmental samples are proposed for collection.
- One (1) well cluster consisting of two (2) wells is proposed for installation. The well cluster will consist of a well installed in the UAZ and LAZ and constructed of standard well material. Samples will be collected via an installed dedicated bladder pump.

As part of monitoring at the PAGW OU, the following is proposed:

Surface Water (Figure 27)

- Collection of surface water data from the four (4) established sampling locations along Steel Creek. These data are needed to develop data trends and monitor impact to Steel Creek. In addition, new location SC-08 and any new surface water location(s) retained based on the results of the proposed SAP Addendum activities identified earlier will also be included.

- 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, Revision 5 (SRNS 2012c).

To support long-term monitoring of plume migration, impact to surface water in Steel Creek, and development of concentration trends, existing surface water and groundwater monitoring wells will be sampled annually. Annual sampling is proposed since all groundwater source units have been addressed and are no longer contributing to groundwater contamination, overall groundwater flow is relatively slow, any change to plume orientation will be slow to develop, and changes to groundwater VOC and tritium concentrations are slow to develop. Any new wells and appropriate surface water locations completed as an outcome of the SAP Addendum will be added to the list.

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

1. Laboratory data will meet the analytical and CRDLs listed in Tables 18 through 21.
2. Samples will follow preservative guidelines as listed in Table 22.
3. All (i.e., 100%) of the offsite laboratory analytical data that meets QA requirements will be verified and have supplemental validation to meet more stringent verified and validated (VV) data criteria (Table 23). All reasonable efforts will be made to ensure sample preparation and collection are adequate so that sampling errors are kept to a minimum. If sampling preparation errors are identified, then replacement samples will need to be collected and resubmitted for laboratory analysis if DQOs are not met.
4. At least one split sample will be collected from surface water and groundwater monitoring wells for data quality comparability.
5. Split sample result will have a relative percent difference (RPD) = 100% for surface water samples.
6. At least one surface water and groundwater monitoring well sample will be field duplicate sample for the comparability data quality indicator.
7. 95% of samples sent to laboratory have useable (non-rejected) results for completeness data quality indicator.

with one (1) well cluster having a single well (Figure 25). Each well cluster will consist of a well installed to 1.5 m (5 ft) and 3 m (10 ft) bls. The single well cluster will have a 3 m (10 ft) shallow well installed. However, due to the abundance of riprap present in the area, it may not be possible to install this well. The purpose of these wells is to provide long-term trend data on groundwater contaminant discharges to Steel Creek. Each well will be sampled annually for a reduced list of TCL VOCs and tritium as identified on Table 13.

4.2 Groundwater Investigation

The extent of VOC contaminated groundwater in the UAZ and LAZ in the distal area of the VOC groundwater plumes is needed to aid in the decision-making for potential response action(s) in the future. The primary focus will be located in the elbow portion of the distal area of the VOC groundwater plumes. However, some work will be performed to define the furthestmost western extent of the VOC groundwater plumes. Portions of the groundwater plumes are currently impacting surface water in Steel Creek.

The extent of VOC groundwater plumes in the distal area is defined by limited groundwater monitoring well and previous CPT data. The overall extent is not fully understood. Because the VOC groundwater plumes are impacting surface water and based on existing data, the elbow portion is being considered for possible removal action (SRNS 2017a). However, data uncertainties exist and must be addressed before an informed decision can be made in this portion of the plume.

Characterization of the distal area of the VOC groundwater plumes, with primary focus in the elbow portion, will consist of performing headspace sampling on core collected from 21 m (70 ft) to 61 m (200 ft) bls or until the Gordon Confining Unit (Green Clay) is encountered at 26 borehole locations (Figure 26). Soil sampling for headspace analysis is proposed because previous work at SRS has demonstrated that VOCs, even in the dilute state in groundwater, tend to sorb to soil particles and are in equilibrium with groundwater concentrations through diffusion. AThis method allows for collection of a greater density of samples can be collected over traditional depth-discrete groundwater sampling; even in lower permeable sediments that normally don't yield groundwater for sampling; over traditional depth discrete groundwater sampling. ThisThe soil headspace sampling approach allows for a detailed characterization in determining the extent of groundwater

contamination. Up to 50 samples will be collected and submitted to SRNL for VOC analysis as identified on Table 12. Four (4) contingent locations are planned in the event the extent of the VOC groundwater plumes is not defined.

To provide detailed lithologic data in the elbow portion, each core will be described. Seven (7) of the 26 boring locations will be geophysically logged. Six (6) locations will have up to 42 undisturbed samples (e.g., Shelby Tubes) collected and submitted to an offsite laboratory for various geotechnical analysis. To provide greater geotechnical information on subsurface sediments, eleven (11) CPTs will collect piezocone data (Figure 26).

Based on the results of the headspace data, two (2) wells, one in the UAZ and LAZ, will be installed for long-term monitoring (Figure 26) in the elbow portion. The proposed well locations as shown on Figure 26 are based on existing groundwater data and estimated location of the groundwater plumes, and may be refined based on the borehole headspace results. The decision on where each well screen will be installed vertically will be based on the observed VOC concentrations within the UAZ and LAZ and the stratigraphic horizon (targeting higher VOC levels and permeable zones that will produce sufficient water to support sampling activities). These wells will be sampled annually for specific VOCs and tritium as identified on Table 13.

4.3 Surface Water and Groundwater Sampling

Long-term monitoring of surface water and groundwater at the PAGW OU is needed to establish current conditions, develop data trends, monitor movement of identified plumes, and to define vertical and horizontal extent of contamination.

4.3.1 Surface Water

Surface water in Steel Creek is currently impacted by discharges of VOC and tritium contaminated groundwater. Historical data and previous data evaluations indicate that tritium and VOCs (primarily TCE) are the principal constituents routinely detected in surface water and in exceedance of the MCLs. Unlike tritium, which is detected along the entire stretch of Steel Creek, TCE is only exhibited in a small area near the headwaters at sampling location SC-03.

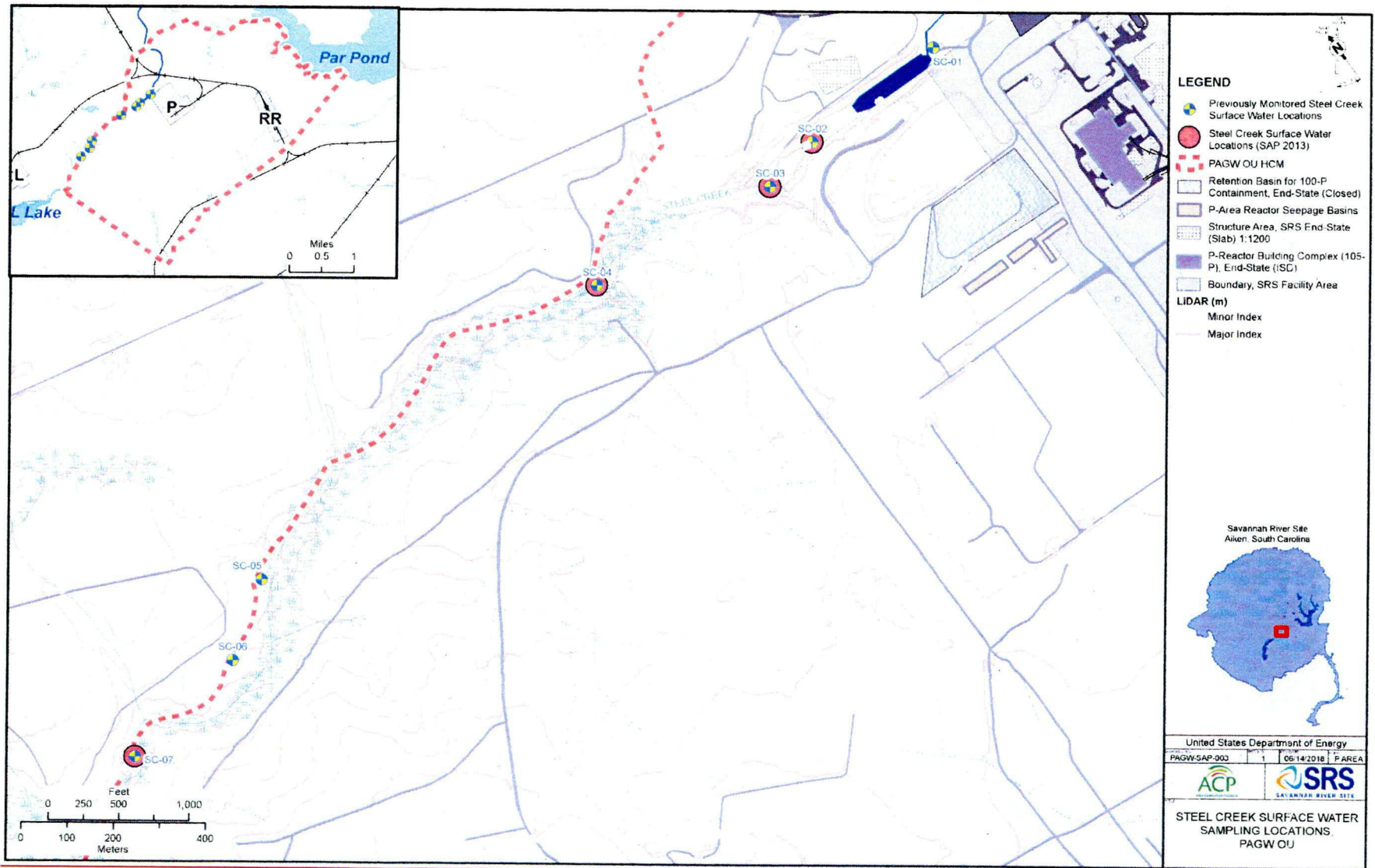


Figure 3. Steel Creek Surface Water Monitoring Locations, PAGW OU

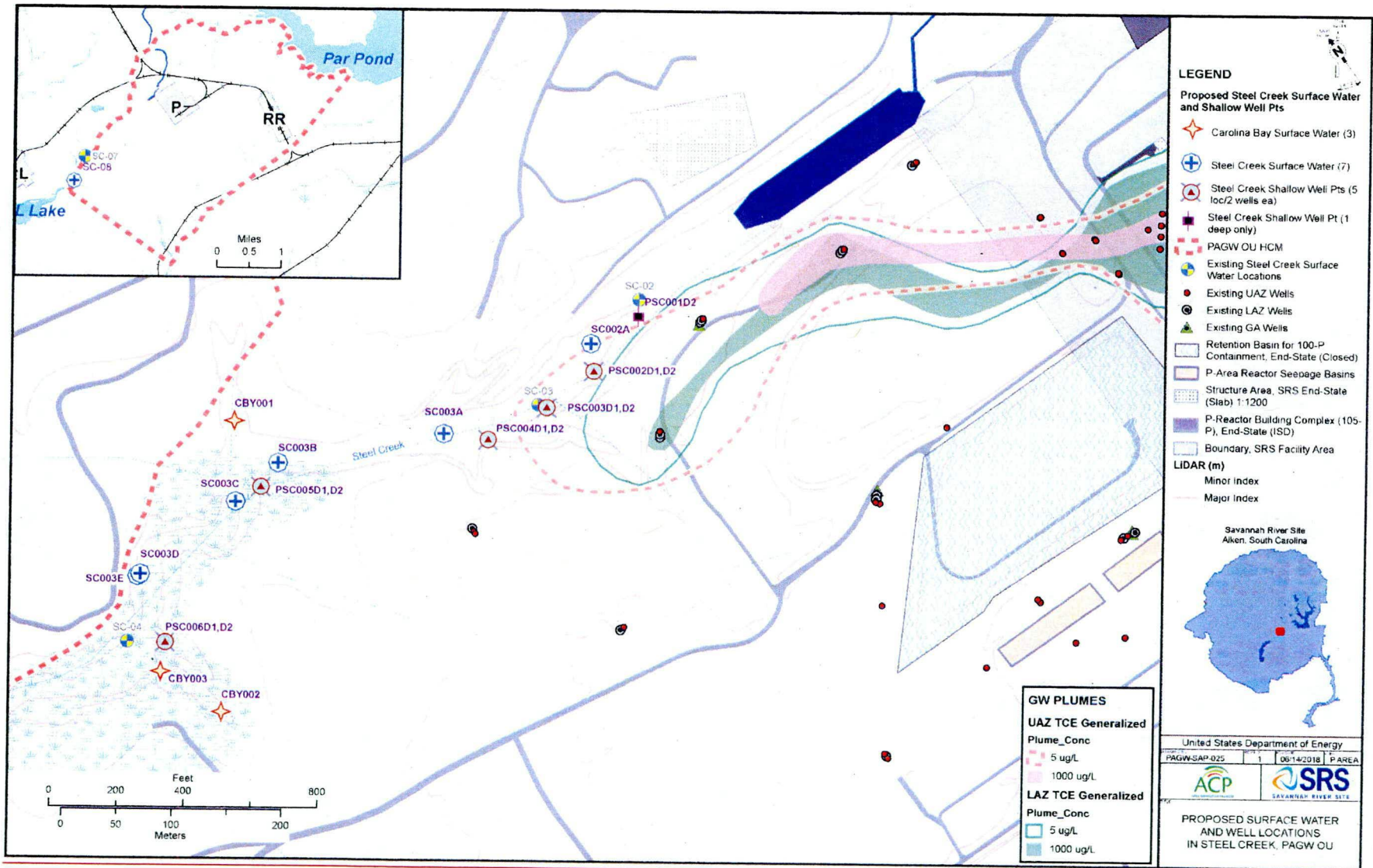


Figure 25. Proposed Surface Water and Well Locations in Steel Creek, PAGW OU

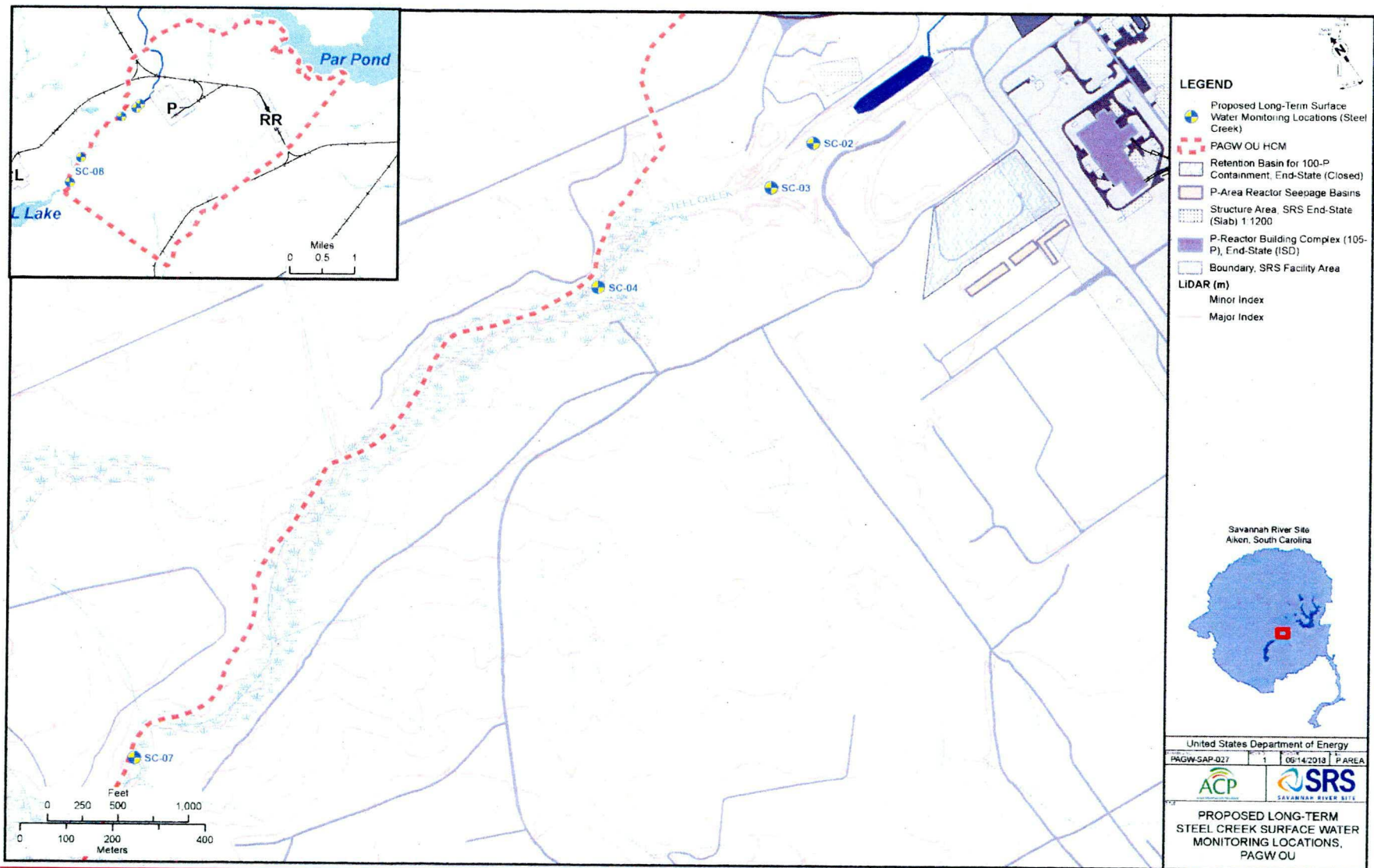


Figure 27. Proposed Steel Creek Surface Water Monitoring Locations, PAGW OU