**Contract No:**

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# Removal Action Design Plan (RADP) with Effectiveness Monitoring Plan (EMP) for the C-Area Groundwater (CAGW) Operable Unit (OU) (U)

**SEMS NUMBER: 82**

**SRNS–RP–2018-00807**

**Revision 0**

**August 2018**

SAVANNAH RIVER SITE • AIKEN, SOUTH CAROLINA

# DISCLAIMER



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**Prepared for**
**U.S. Department of Energy**
**and**
**Savannah River Nuclear Solutions, LLC**
**Aiken, South Carolina**

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## LIST OF ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| bgs | below ground surface |
| CAGW OU | C-Area Groundwater Operable Unit |
| CBRP | C-Area Burning/Rubble Pit |
| CERCLA | Comprehensive Environmental Response, Compensation, and Liability Act |
| DPT | direct-push technology |
| CFR | Code of Federal Regulations |
| CMS/FS | Corrective Measures Study/Feasibility Study |
| DO | dissolved oxygen |
| EMP | Environmental Monitoring Plan |
| EOS | edible oil substrate |
| ft | feet |
| ft/yr | feet per year |
| $ft^2$ | square foot |
| $ft^3$ | cubic foot |
| FFA | Federal Facility Agreement |
| gal | gallons |
| HASP | Health and Safety Plan |
| km | kilometers |
| L | liter |
| LUCs | Land Use Controls |
| LAZ | Lower Aquifer Zone |
| m | meter |
| m/yr | meters per year |
| $m^2$ | square meter |
| $m^3$ | cubic meter |
| MAZ | Middle Aquifer Zone |
| MCL | Maximum Contaminant Level |
| µg/L | microgram per liter |
| NTC | non-time critical |
| ORP | oxidation reduction potential |
| OSHA | Occupation, Safety and Health Agency |
| OU | Operable Unit |
| pCi/mL | picocuries per milliliter |
| PCE | tetrachloroethylene |
| QAPP | Quality Assurance Project Plan |
| RCRA | Resource Conservation and Recovery Act |
| RA | Removal Action |
| RADP | Removal Action Design Plan |
| RFI/RI | RCRA Facility Investigation/Remedial Investigation |
| ROD | Record of Decision |
| RSER/EE/CA | Removal Site Evaluation Report/Engineering Evaluation/Cost Analysis |

## LIST OF ACRONYMS AND ABBREVIATIONS (continued/end)

| | |
|---|---|
| SB/PP | Statement of Basis/Proposed Plan |
| SCDHEC | South Carolina Department of Health and Environmental Control |
| SEMS | Superfund Enterprise Management System |
| SRNS | Savannah River Nuclear Solutions |
| SRS | Savannah River Site |
| TCCZ | Tan Clay Confining Zone |
| TCE | trichloroethylene |
| TOC | total organic carbon |
| TSSP | Task Specific Safety Plan |
| UAZ | Upper Aquifer Zone |
| USDOE | United States Department of Energy |
| USEPA | United States Environmental Protection Agency |
| UTRA | Upper Three Runs Aquifer |
| VOC | volatile organic compound |
| WSRC | Washington Savannah River Company, LLC |

# 1.0 GENERAL DESCRIPTION

## 1.1 Purpose and Scope

The purpose of this Removal Action Design Plan (RADP) with Environmental Monitoring Plan (EMP) is to provide the final design information for the implementation of the non-time critical (NTC) removal action at the C-Area Groundwater (CAGW) Operable Unit (OU) and the post-construction plan for monitoring. Groundwater associated with the CAGW OU is contaminated with tritium and volatile organic compounds (VOCs), primarily trichloroethylene (TCE), due to releases associated with reactor operations. This removal action focusses on the TCE contamination in the distal portion of the groundwater plume. The United States Department of Energy (USDOE), US Environmental Protection Agency (USEPA), and South Carolina Department of Health and Environmental Control (SCDHEC), and USDOE agreed to conduct a NTC removal action at the CAGW OU to reduce potential risk to human health and the environment. This RADP presents the design details for the removal action including a description of the removal action construction strategy, removal action activities, and effectiveness monitoring plan. The removal action along with the Applicable or Relevant and Appropriate Requirements are presented in the Action Memorandum (AM), Revision 0 (USDOE 2018) for the CAGW OU and the *Removal Site Evaluation Report/Engineering Evaluation/Cost Analysis (RSER/EE/CA) for C-Area Groundwater Operable Unit* (SRNS 2018).

## 1.2 Description and History of the CAGW OU

C Area is situated near the center of the SRS (Figure 1). The primary SRS operation facility in C Area was the C-Reactor which operated between 1955 and 1985. Known sources associated with reactor operations such as the C-Reactor Seepage Basins (904-66G, -67G, -68G), C-Reactor Area TCE Vadose Zone Source, C-Reactor Purification Area Tritium Source, and other non-specified sources resulted in tritium and VOC contamination in groundwater.

The CAGW OU is located in the Fourmile Branch watershed and encompasses groundwater beneath C Area, which flows west to Fourmile Branch and south to Castor Creek. The

CAGW OU includes a groundwater subunit and a surface water subunit. The Groundwater Subunit consists of two plumes: 1) a southern TCE and tritium plume originating near the Reactor Building (105-C) extending west to Fourmile Branch and south to Castor Creek, and 2) a northern tritium plume in the vicinity of the Twin Lakes drainage, originating near the Retention Basin for 100-C Containment (904-89G) and extending to Fourmile Branch. VOC contamination in the Twin Lakes area is associated with releases from the C-Area Burning/Rubble Pit (CBRP) that is being remediated by monitored natural attenuation and is not part of the CAGW OU scope.

The nature and extent of contamination at the CAGW OU was comprehensively investigated beginning in 1998 using groundwater monitoring wells and direct-push technology (DPT) samples (WSRC 2004). The CAGW OU TCE groundwater plume extends south from the C-Area Reactor Building (105-C) to Castor Creek and an unnamed tributary to Castor Creek (Figure 2). Data from 2016 monitoring showed a small area above 100 µg/L near the C-Area Reactor Building (105-C) in the Upper Aquifer Zone (UAZ) of the Upper Three Runs Aquifer (UTRA), two wells exceeding 50 µg/L TCE at the distal portion of the plume in the Middle Aquifer Zone (MAZ) of the UTRA, and low levels of VOC contamination in the middle of the plume (Figure 2 and Figure 3). Results from the unnamed tributary to Castor Creek indicated the presence of TCE above the maximum contaminant level (MCL).

In December 2016, the USDOE, USEPA, and SCDHEC identified the distal portion of the CAGW OU TCE plume as a candidate for a NTC removal action. The *Removal Site Evaluation Report/Engineering Evaluation/Cost Analysis (RSER/EE/CA) for C-Area Groundwater Operable Unit* (SRNS 2018) evaluated the following three cleanup alternatives based on effectiveness, ease of implementation and cost analysis: 1) No Action, 2) Treatment Barrier Using Emulsified Edible Oil, 3) In Situ Chemical Oxidation Using Sodium Persulfate. The RSER/EE/CA was approved in 2018 and the AM selected a Treatment Barrier Using Emulsified Edible Oil as the technology to implement in the distal portion of the plume.

To support the removal action, detailed characterization of the discharge area of the plume in 2017-2018 demonstrates that the TCE contamination is limited to the MAZ which is about 5 m (16 ft) thick in the discharge area. The 2017 data are included on Figure 4 and Figure 5 indicate the margins of the TCE plume have shifted slightly towards the east. Two transects of direct push groundwater samples were collected; a northern transect of four locations (CAGW-01 thru CAGW-04), and a southern transect (CAGW-05 thru CAGW-10). The northern transect results were below the MCL, with location CAGW-03 and -04 showing the highest results. Subsequently well CRW024C was installed, which had a 2018 result of 31.9 µg/L. The southern transect results indicated CAGW-06, -07 and -10 exceeded 20 µg/L. Subsequently well CRW023C was installed, which had a 2018 result of 23.4 µg/L. In 2018, TCE was above the MCL (5.0 µg/L) in three surface water stations: CCT-03 (17.5 µg/L), CCT-02 (8.22 µg/L), and CCT-01 (12.1 µg/L). These three stations are located on the small unnamed tributary that discharges to Castor Creek. TCE is above the detection limit in Castor Creek, but TCE has not been detected above the MCL (5 µg/L) in Castor Creek.

The distal portion of the CAGW OU TCE groundwater plume for this NTC removal action extends from well CRW024C to the unnamed tributary, covering an area of approximately 9,390 square meters ($m^2$) (100,000 square feet [$ft^2$]) within the MAZ, which is approximately 3-m (10-ft) thick at the location of the transects. The MAZ has an estimated porosity of 0.25. Although the two well results are below 50 µg/L TCE, portions of the plume may exceed 50 µg/L.

Flow rates can be estimated using the distance and head difference between wells with the following equation:

$$Q = \frac{K}{n} \times \frac{dh}{dl}$$

Where:

- Q = Flow (feet [ft]/day);
- K = Hydraulic Conductivity (ft/day) = 13 ft/day;
- n = Effective Porosity = 0.25
- dh = Difference in Head (ft) (e.g. CRW024C – CRW023C = 3.7 ft); and
- dl = Distance between Wells (ft) (e.g. CRW024C to CRW023C = 240 ft).

In May 2018, the groundwater flow rate between CRW24C and CRW023C is estimated at 89.2 meters per year (m/yr) (292.6 feet per year [ft/yr]) and groundwater flow rate between CRW023C and CCT-02 on the unnamed creek is estimated at 231.5 m/yr (759.2 ft/yr). These flow estimates indicate that TCE concentration changes may be observed in the unnamed tributary within 4 months after injection.

## 2.0 REMOVAL ACTION DESIGN

The NTC removal action objective documented in the CAGW OU AM (USDOE 2018) is to protect human health and the environment by reducing the mass of TCE present in groundwater.

The selected removal action is to install a treatment barrier using emulsified oil in the distal portion of the CAGW OU TCE groundwater plume along two transects perpendicular to the groundwater flow towards the unnamed tributary to Castor Creek (Figure 4). Emulsified oil treatment has previously been successfully implemented at TNX (SRNL 2012, SRNS 2014, and SRNS 2015). Other studies have also documented the successful use of emulsified oil to remediate VOCs in groundwater (USDOD 2010 and USAF 2010).

### 2.1 Design Overview

In 2017, DPT groundwater samples collected along two transects (Figures 4 and 5), data from two monitoring wells, and field constructability considerations identified the optimal locations and depths for the oil injection points.

Based on the 2017 and 2018 data, injection locations will target the highest concentration portion of the plume prior to discharge to the unnamed tributary leading to Castor Creek. The planned DPT emulsified oil injection locations are shown in Figure 5. The emulsified oil will act as a treatment barrier both by sequestering TCE at the injection point and by bioaugmenting with a supplemental microbe culture enhancing the natural ability of the formation to biodegrade TCE between the point of injection and discharge to the unnamed tributary. As an organic contaminant, TCE preferentially partitions into the oil phase from the water phase. Previous data indicate that some natural biodegradation of TCE is occurring in groundwater based on the presence of cis-1,2 dichloroethylene (DCE), which is an anaerobic breakdown product of TCE. It is expected that the addition of emulsified oil will enhance this process, as the existing microorganisms and supplemental microbes will use the oil as a food source. However, the emulsified oil is not anticipated to migrate far from the injection points, and the treatment barrier is estimated to enhance TCE biodegradation for 3 to 5 years (USDOD 2010).

Groundwater and surface water samples will be collected prior to emulsified oil mixture injections at two upgradient wells, three downgradient wells, and four surface water stations to establish baseline conditions. These wells and surface water locations will be sampled after injection to monitor the effectiveness of the NTC removal action. Following implementation of the NTC removal action, regular monitoring of groundwater and surface water will occur for five years with the results documented in an annual effectiveness monitoring report.

## 2.2 Design Criteria

The emulsified oil injection DPTs will be spaced approximately 5-m (16-ft) apart at the locations surveyed by SRS (Figure 5). Five DPT injection points along the northern transect will have screen zone depths of approximately 16.8 – 19.8 m (55 – 65 ft) below ground surface (bgs). Ten DPT injection points along the southern transect will have screen zone depths of approximately 9.8 – 12.8 m (32 – 42 ft) bgs. The estimated target treatment volume of the aquifer is 1,070 cubic meters ($m^3$) (38,400 cubic feet [$ft^3$]).

The groundwater will first be augmented with EOS BAC-9, an enriched bioaugmentation culture of *Dehalococoides mccartyi* and enzymes in a water-based medium (Appendix A). Based on consultation with the vendor, it is estimated that about 2 liters (L) (0.528 gallons [gal]) of unconcentrated EOS BAC-9 will be used at each injection location. Nitrogen will be used as a carrier gas for the injection of the bioaugmentation culture to avoid adding oxygen into the groundwater. The emulsified oil mixture will consist of $EOS_{100}$™ emulsified oil (Appendix A), dilution water with a dechlorination agent, and a buffer. Dilution water obtained from B-Area and/or Central Shops contains chlorine which can kill the microbes, so the dilution water must be dechlorinated with a chemical agent (e.g. sodium thiosulfate, or sodium ascorbate [Appendix A]) prior to mixing with the emulsified oil (USDA 2005). A buffer solution (e.g., 1.6-1.8% sodium hydroxide with 6.9-7.1% sodium bicarbonate or CoBupH$_{Mg}$™ [Appendix A]) will be mixed into the dechlorinated dilution water to raise the groundwater pH to approximately 7. The oil mixture ratios for each injection location are as follows: 2 L (0.528 gal) of unconcentrated EOS BAC-9 injected first followed by 1041 L (275 gal) EOS$_{100}$™ emulsified oil; 5,205 L (1,375 gal) dilution water with 14 g (0.494 oz) of dechlorination agent and 5.3 L (1.4 gal) buffer solution. The buffer to dilution water ratio is nominally 1 to 1,000, but more or less buffer may be needed to adjust the final oil mixture pH to 9 +/- 0.5 prior to injection. To avoid adding oxygen to the groundwater, the emulsified oil mixture will be purged with nitrogen gas for five minutes and then injected into the groundwater. Figure 6 provides an example of a previous SRS oil injection project, and Figure 7 is a schematic of how the CAGW OU emulsified oil Treatment Barrier will function.

At each DPT injection location, the contaminated aquifer is approximately 3 m (10-ft) thick, based on two recent cores from the two injection areas. At each location, the subcontractor will need to inject approximately 6,246 L (1,650 gal) of oil mixture through a 3 m (10-ft) DPT screen zone (e.g., two Geoprobe™ 2.25 in diameter 5-ft Mill-Slotted DPT rods [Appendix A], or equivalent). This volume is based on the assumption that 40% of the available pore space is filled with the oil mixture out to a radius of 2.44 m (8 ft). SRS estimates it will require approximately 30 working days (20 hours) to inject the EOS BAC-9 and emulsified oil mixture into all 15 locations.

The final amount of EOS BAC-9 and emulsified oil mixture pumped into each DPT injection point will be recorded for all locations.

## 2.3 Drawings

The figures and tables contained in this document serve as the design drawings for this project. No additional drawings are planned for this project.

## 2.4 Surveys

In addition to the figures and tables contained in this document, a lay-out survey that identifies possible subsurface interferences will be prepared for each DPT and monitoring well location. An As-Built survey will be completed for each monitoring well and included in the Removal Action Report.

### 2.5 Site Preparation

The CAGW OU emulsified oil treatment barrier will be installed in a remote location, which is heavily vegetated and has no infrastructure (e.g phone lines or power lines) located within the project boundaries. The areas along each transect will need to be cleared of vegetation and gravel laid down for the emulsified oil tanks and associated equipment.

### 2.6 Confirmation Sampling

Confirmation sampling will not be conducted as part of this project. The EMP for monitoring of groundwater and surface water is described in Section 5.1.

## 3.0 PERMITTING REQUIREMENTS

The permitting requirements include the following:

- Storm water management plan for clearing the project areas;
- A Hydrogeologic Program Plan for the monitoring wells and; and
- An underground injection permit from SCDHEC for the EOS BAC-9 and emulsified oil mixture, which includes the DPT injection locations.

## 4.0 CONSTRUCTION

### 4.1 Construction Strategy

An emulsified oil mixture will be injected along two transects to create a treatment barrier in the MAZ perpendicular to the groundwater flow (Figure 5) which will sequester TCE at the injection point and biodegrade TCE between the point of injection and discharge to the unnamed tributary (Figure 7).

### 4.2 Construction Activities

The primary construction activity is clearing vegetation and preparing the project areas for the DPT rig, tanks, mixing equipment, and associated pipes and hoses for the injections. It is expected that gravel crush and run will be used to establish a stable working area. Approximately one-quarter acre will be cleared at the northern transect and one-half acre at the southern transect. Prior to injection, an In-Service Leak Test using potable water will be conducted on any hose, fittings, valves, and manifold leading from the mixing tank(s) to the DPT injection rods. Injection of EOS BAC-9, and the buffered oil/water mixture will occur at each location. All DPT equipment, mixing tanks, and associated piping for deployment is of a temporary nature (Figure 6), and will be removed from the project areas after completion of all the emulsified oil mixture injections.

## 4.3 Removal Action Design Change Control

An engineering team will remain engaged during the NTC removal action activities. The subcontractor will provide technical oversight to all removal activities and consult/report to Environmental Compliance & Area Completion Projects engineering, who will review and approve any field modifications through a supplier deviation disposition request. Although a specific volume of EOS BAC-9 and $EOS_{100}$ mixture are planned for each injection location, the volume at an individual well point may be modified to account for field conditions. However, SRS will attempt to inject the total volume of EOS BAC-9 and $EOS_{100}$ into the groundwater. Any and all changes will be documented as part of the project in the Removal Action Report. USDOE will notify USEPA and SCDHEC within a reasonable time frame should problems result in a significant change of scope with any aspect of the NTC removal action process. In particular, scheduling, budget and technical issues shall be brought to the attention of the regulators as soon as they are identified by the project team. Notifications will follow established protocols.

## 4.4 Waste Disposal and Transport

Waste management (handling, disposal, and transportation of wastes) will meet the requirements of applicable SRS manuals and procedures (i.e., SRS C1 Procedure Manual, *Environmental Compliance and Area Completion Projects Administrative Procedures*, [SRS 2014a], SRS 1S Procedure Manual, *SRS Radioactive Waste Requirements Manual* [SRS

2014b], SRS 3Q Procedure Manual, *Environmental Compliance Manual* [SRS 2015a], etc.) and the project-specific Waste Management Plan. It is expected that there will be no hazardous waste generated. Any job control waste (non-hazardous) will be disposed of as sanitary waste by the subcontractor.

### 4.5 Quality Assurance

Quality assurance for the CAGW OU NTC removal action is provided through the demonstrated adherence to performance requirements specified in the design documents (plans and specifications). Design documents are developed in accordance with the SRS Procedure Manual E7, *Conduct of Engineering and Technical Support Procedure Manual* (SRS 2015b). The subcontractor will be required to comply with an SRNS approved project-specific quality assurance project plan for execution of their tasks.

### 4.6 Non-Conformances

All non-conformances will be evaluated, resolved, or rectified as described in the pertinent sections of this document. Design changes from the resolution of non-conforming conditions will be processed per Section 4.3, Removal Action Design Change Control.

### 4.7 Health and Safety Plan (HASP)

An analysis of the hazards to workers from exposure to hazardous substances during removal activities at the CAGW OU treatment barrier will be conducted and documented in the Project Safety & Health Description. If the results of this analysis show that the activity described herein may expose workers to a level of hazardous chemicals or radiological contamination that would be harmful to their health, then a Site-Specific HASP meeting the criteria of 29 CFR 1910.120 will be developed to control health and safety aspects of this activity. At a minimum, an assisted hazards analysis will be completed and the subcontractor will prepare a worker protection plan for the identification and analyses of hazards expected when performing the scope of work and which identifies controls to prevent/mitigate the hazards. This plan also will include types of emergencies that may occur and the subcontractor's response to the emergency, including arrangements with onsite security, fire department, medical facility, and emergency response teams to coordinate emergency services.

# 5.0 POST CONSTRUCTION

## 5.1 Effectiveness Monitoring Plan

Two existing upgradient wells (CRW023C and CRW024C), four existing surface water stations (CCT-01, CCT-02, CCT-03 and CC-08) and three proposed downgradient wells (CRW025C thru CRW027C) for the CAGW OU treatment barrier will be installed and sampled prior to the start of the NTC removal action (Figure 5). These five wells and four existing surface water locations will be used to specifically monitor the CAGW OU treatment barrier effectiveness. Three of the surface water locations are on the tributary to Castor Creek (CCT-01, CCT-02, and CCT-03), and the fourth is on Castor Creek just downgradient of the tributary's confluence with Castor Creek (CC-08). The nine locations will be sampled monthly for three months, then quarterly for the remainder of the first year and semi-annually for the next four years. Eight existing monitoring stations located peripherally to the treatment zone shown on Figure 4 (CSB20D, CSB15D, CCSL-08, CCSL-11, CCSL-14, CCSL-23R, CC-05, and CC-07) will be sampled semi-annually for five years (Table 2). Analyses will include the following: VOCs (PCE, TCE, cis-1,2-dichloroethylene, chloroethene [vinyl chloride], and ethene), dissolved oxygen (DO), methane, nitrate, oxidation-reduction potential (ORP), sulfate, and total organic carbon (TOC) to identify the effects of the edible oil injections. Results for pH, DO, methane, nitrate, ORP, sulfate, and TOC have been used to assess the conditions favorable for biodegradation as a result of emulsified oil injections in an aquifer. The PCE, TCE, cis-1,2-dichloroethylene, vinyl chloride, and ethylene results have been used to observe reductive dechlorination. Semi-quantitative microbiological analysis will also be conducted at applicable well locations to supplement the assessment of reductive biological processes. Table 3 provides the analytical methods and detection limits for the VOCs, organic analyses, inorganic analyses and microbial analysis.

The USDOE, USEPA, and SCDHEC agreed to suspend submittal of the CAGW OU Monitoring Report during implementation of the NTC removal action, groundwater and surface water monitoring will continue. The effects of the CAGW OU Treatment Barrier will be reported annually in the *CAGW OU Annual Groundwater and Treatment Barrier Effectiveness Monitoring Report*. This report will also contain all the other CAGW OU data collected each year including tritium data.

## 5.2 Contingency Plan Implementation Strategy

If after five years, the CAGW OU treatment barrier is unsuccessful in lowering TCE concentrations in the unnamed tributary and/or Castor Creek, then TCE exceeding the MCL in surface water will be addressed in the final CAGW OU Record of Decision (ROD).

## 5.3 Operations, Maintenance, and Land Use Control

The oil injection is a single event using DPT rods. No infrastructure remains for operation or maintenance, with the exception of monitoring wells. The monitoring wells will be maintained so that sampling can be conducted to evaluate the effectiveness of the NTC removal action.

There is no current or projected future use of groundwater or surface water as a drinking water source at the CAGW OU, and site access is currently controlled by SRS facility security and administrative controls. Site specific land use controls are expected to be part of the final remedial action for the CAGW OU.

## 5.4 Requirements for Project Closeout

The fifth annual effectiveness monitoring report for the CAGW OU NTC removal action will evaluate the overall effectiveness of the NTC removal action in reducing the TCE mass in the MAZ, and its' sustainability. Any potential future actions would be addressed by the USDOE, USEPA, and SCDHEC as part of the final remedial decision process.

## 5.5 Schedule for Federal Facility Agreement Deliverables

The remaining FFA deliverables associated with this action will be a Removal Action Report and annual Effectiveness Monitoring Reports (five). The Removal Action Report will be submitted by December 2019. The first *CAGW OU Annual Groundwater and Treatment Barrier Effectiveness Monitoring Report* will be submitted 15 months after completion of the removal action, anticipated to be August 30, 2020. Additional FFA deliverables anticipated for the CAGW OU are the Statement of Basis / Proposed Plan (SB/PP) and the ROD for the final remedial action. The SB/PP and ROD will be submitted in accordance with the requirements for submittal of regulatory documents as identified in the FFA.

## 6.0 REFERENCES

FFA, 1993. *Federal Facility Agreement for the Savannah River Site,* Administrative Docket No. 89-05-FF (Effective Date: August 16, 1993)

SRNL, 2012. *Treatability Study for Edible Oil Deployment for Enhanced cVOC Attenuation for T-Area, Savannah River Site,* SRNL-RP-2012-00290, Rev 0, May 2012, Savannah River Nuclear Solutions, LLC, Savannah River Site, Aiken, SC

SRNS, 2011. *Statement of Basis / Proposed Plan for the C-Area Groundwater Operable Unit (U)*, SRNS-RP-2011-00207, Rev 0, April 2011, Savannah River Nuclear Solutions, LLC, Savannah River Site, Aiken SC

SRNS, 2014. *2013 Comprehensive TNX Area Annual Groundwater and Effectiveness Monitoring Strategy Report (U)*, SRNS-RP-2014-00469, Rev 0, June 2014, Savannah River Nuclear Solutions, LLC, Savannah River Site, Aiken SC

SRNS, 2015. *Second Corrective Measures Implementation/Remedial Action Implementation Plan (CMI/RAIP) for the TNX Operable Unit (U)*, SRNS-RP-2014-00469, Rev 0, June 2014, Savannah River Nuclear Solutions, LLC, Savannah River Site, Aiken SC

SRNS, 2018. *Removal Site Evaluation Report/Engineering Evaluation/Cost Analysis (RSER/EE/CA) for C-Area Groundwater Operable Unit (U)*, SRNS-RP-2014-00469, Rev 1, February 2018, Savannah River Nuclear Solutions, LLC, Savannah River Site, Aiken SC

SRS, 2014a. SRS Procedure Manual C1, *Environmental Compliance and Area Completion Projects Administrative Procedures,* Savannah River Site, Aiken, SC.

SRS, 2014b. SRS Procedure Manual 1S, *SRS Radioactive Waste Requirements Manual*, Savannah River Site, Aiken SC

SRS, 2015a. SRS Procedure Manual 3Q, *Environmental Compliance Manual*, Savannah River Site, Aiken, SC

SRS, 2015b. SRS Procedure Manual E7, *Conduct of Engineering and Technical Support Procedure Manual*, Savannah River Site, Aiken, SC.

Tikkanen, 2001. *Guidance Manual for the Disposal of Chlorinated Water*, M. Tikkanen, East Bay Municipal Utility District, Oakland, CA, AWWA Report 90863, 2001

USAF, 2010, *Protocol for In Situ Bioremediation of Chlorinated Solvents Using Edible Oil*, Final, October 2007, Airforce Center for Engineering and the Environmental Science Division, Technology Transfer Outreach Office, U.S. Air Force

USDA, 2005. *Using Vitamin C to neutralize Chlorine in Water Systems*, 2300 0523 1301-SDTDC, April 2005, United States Department of Agriculture, Forest Service, Technology & Development Program, 444 E. Bonita Ave., San Dimas, CA

USDOD, 2010. *Edible Oil Barriers for Treatment of chlorinated Solvent and Perchlorate-Contaminated Groundwater*, ER-0221, February 2010, Environmental Security Technology Certification Program, U. S. Department of Defense

USDOE, 2018. Action Memorandum and Responsiveness Summary for the Non-Time Critical Removal Action for the C-Area Groundwater Operable Unit (U), SEMS Number: 82, ARF-021638, May 18, 2018, Department of Energy Savannah River Operations Office, P.O. Box A, Aiken, South Carolina

WSRC, 2004. *RCRA Facility Investigation/Remedial Investigation Report for the C-Area Reactor Groundwater (CRGW) Operable Unit* (U), WSRC-RP-2003-4073, Revision 1, Westinghouse Savannah River Company, Savannah River Site, Aiken, South Carolina.

WSRC, 2005. *Corrective Measures Study/Feasibility Study Report for the C-Reactor Groundwater Operable Unit (U)*, WSRC-RP-2004-4113, Revision 1.1, Westinghouse Savannah River Company, Savannah River Site, Aiken, SC

## 7.0 APPENDICES

Appendix A Manufacturer Spreadsheets

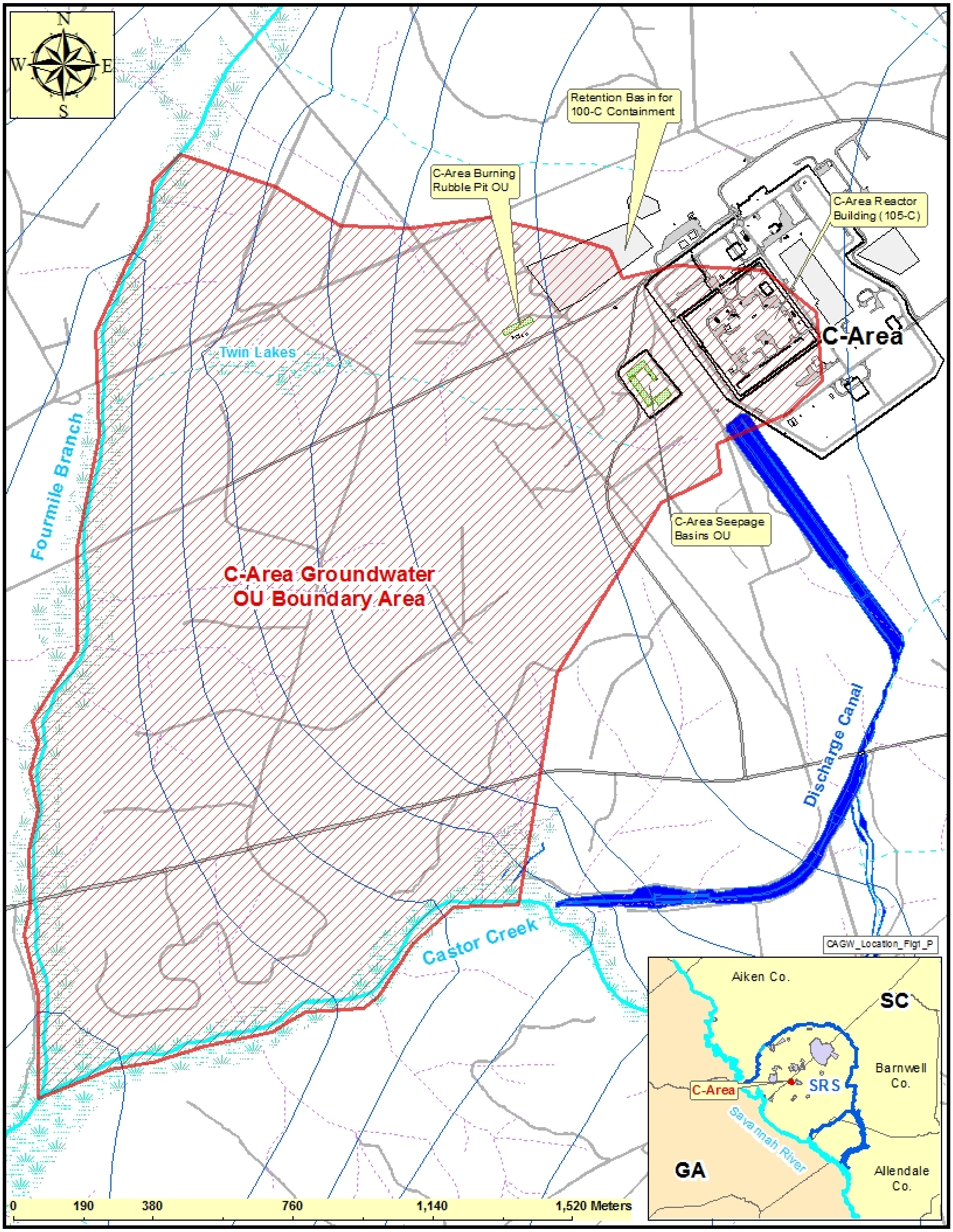


**Figure 1. CAGW OU Boundary Area**

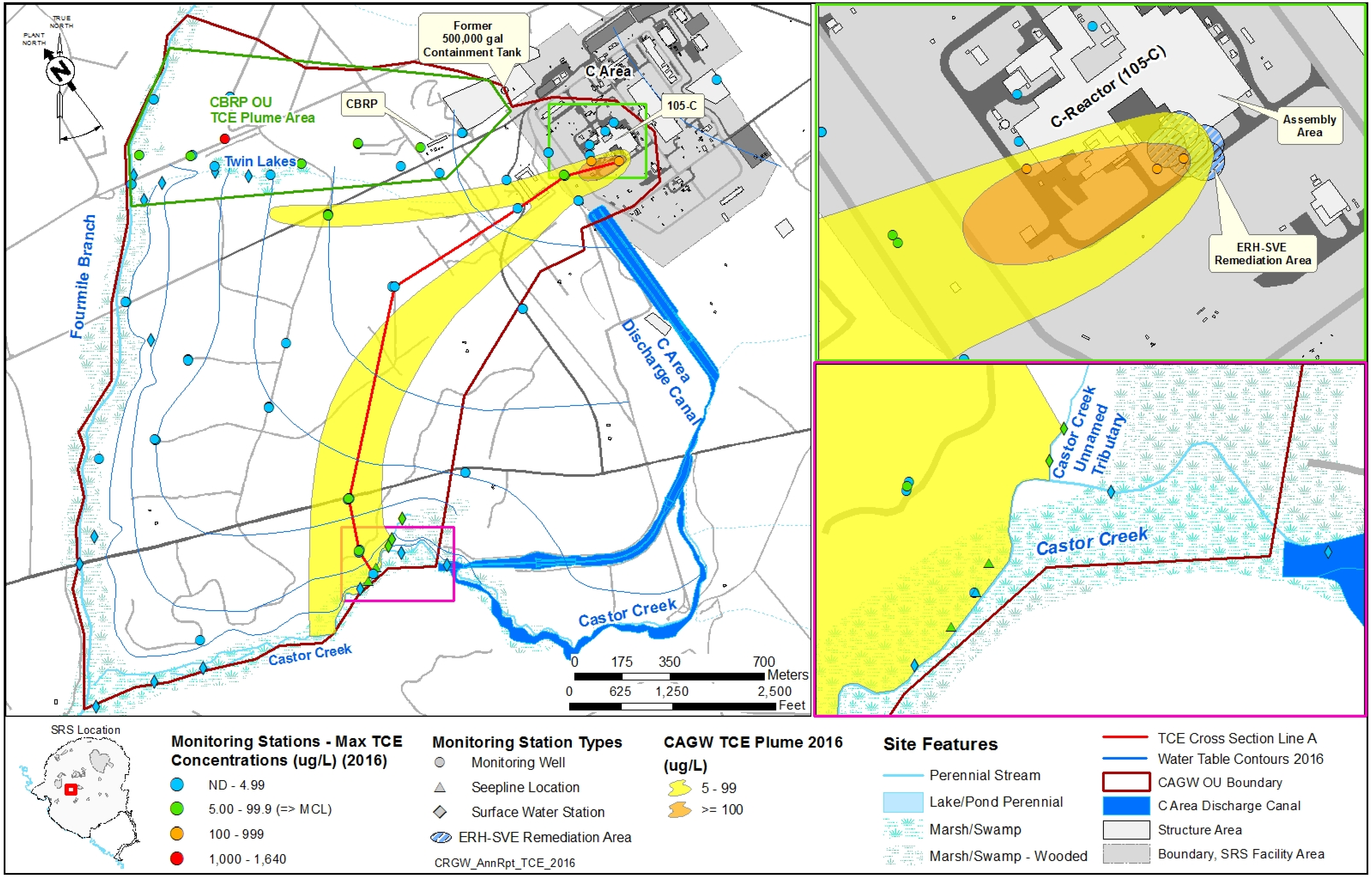


**Figure 2. CAGW OU TCE Plume, 2016**

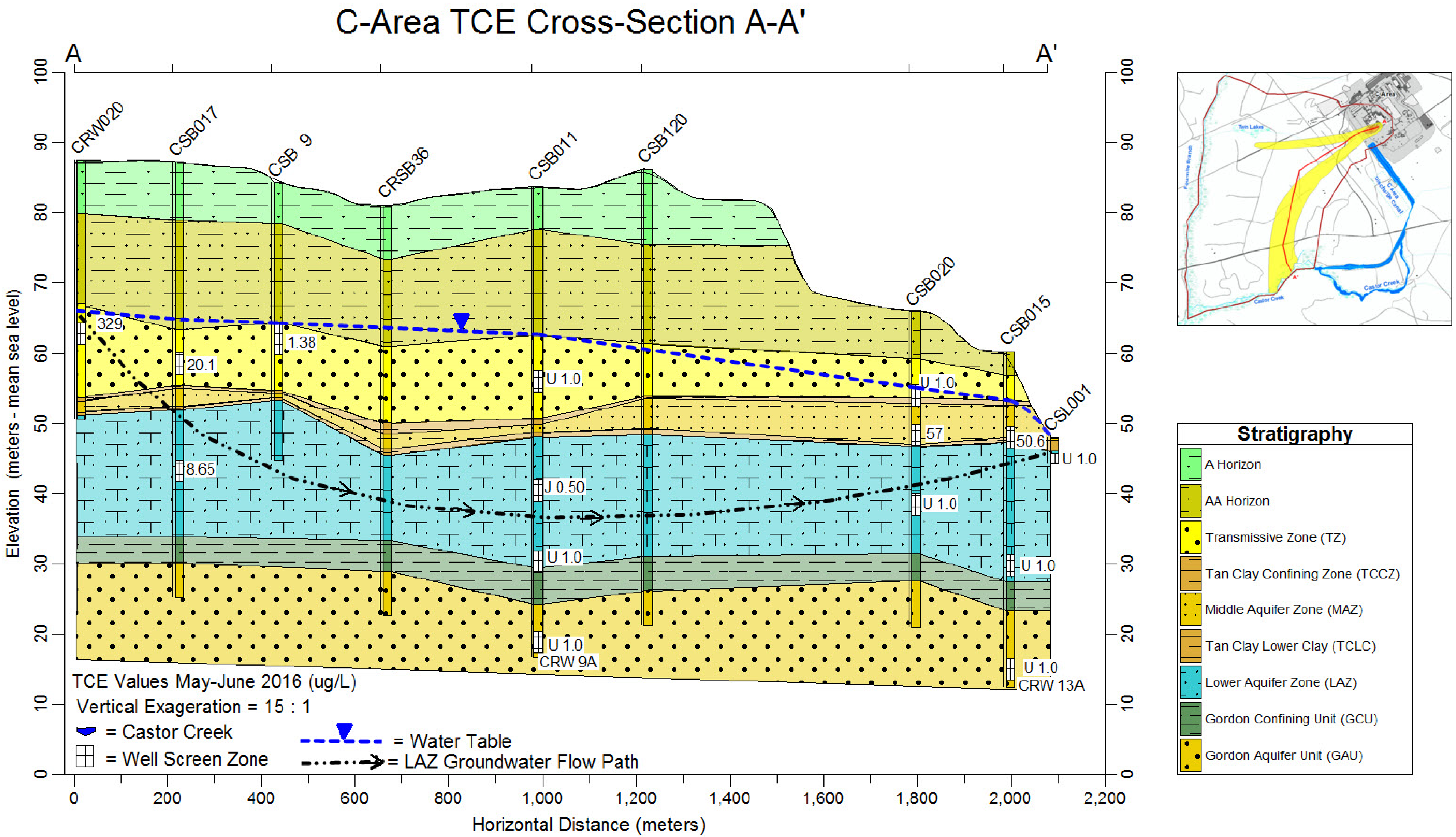


**Figure 3. CAGW OU Cross Section A – A' with 2016 TCE Values (µg/L)**

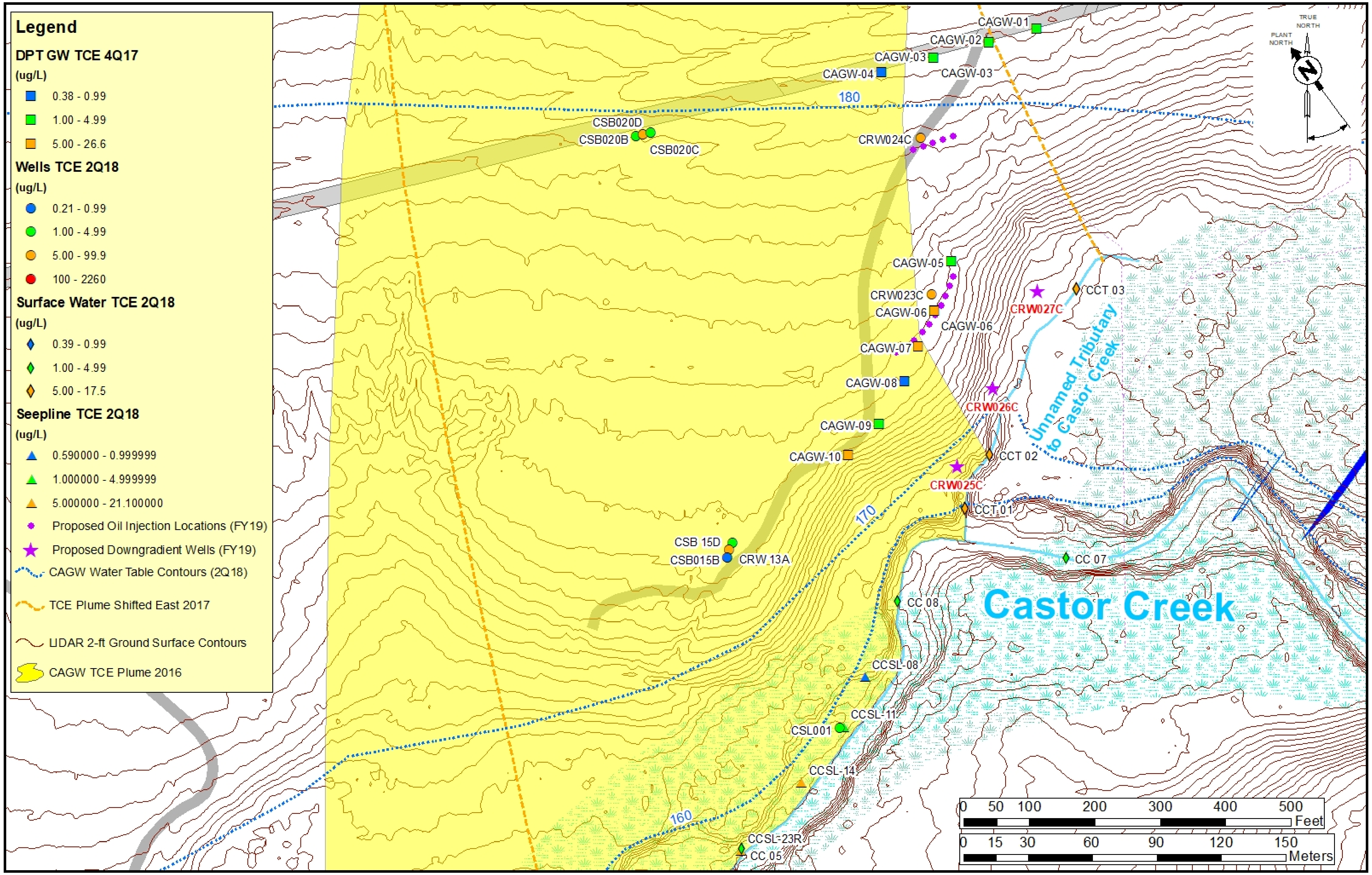


Figure 4. CAGW OU Distal TCE Groundwater Plume

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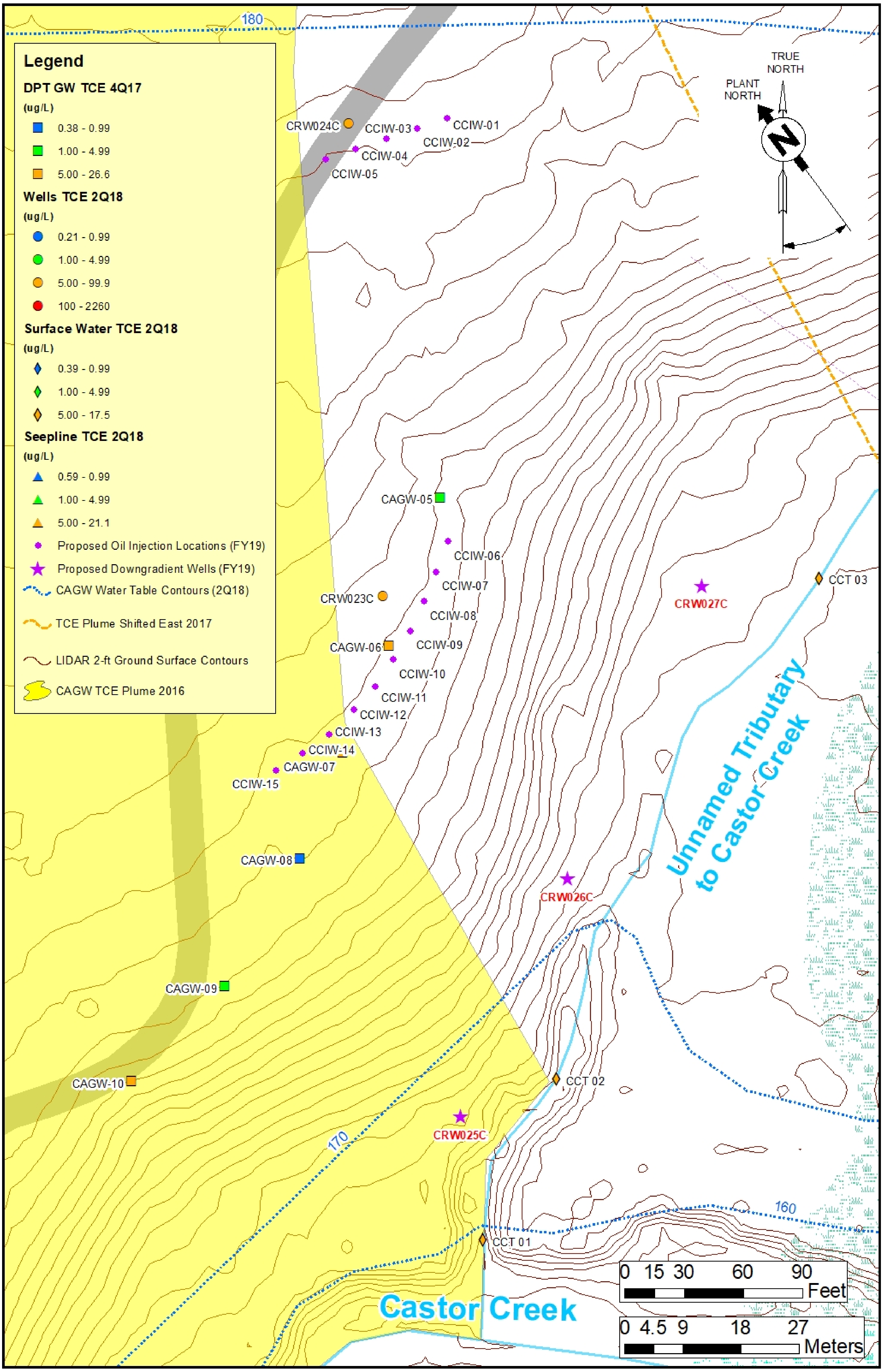


Figure 5. CAGW OU Treatment Barrier Oil Injection Wells and Effectiveness Monitoring Wells

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**Figure 6. Example of Oil Injection Project.**

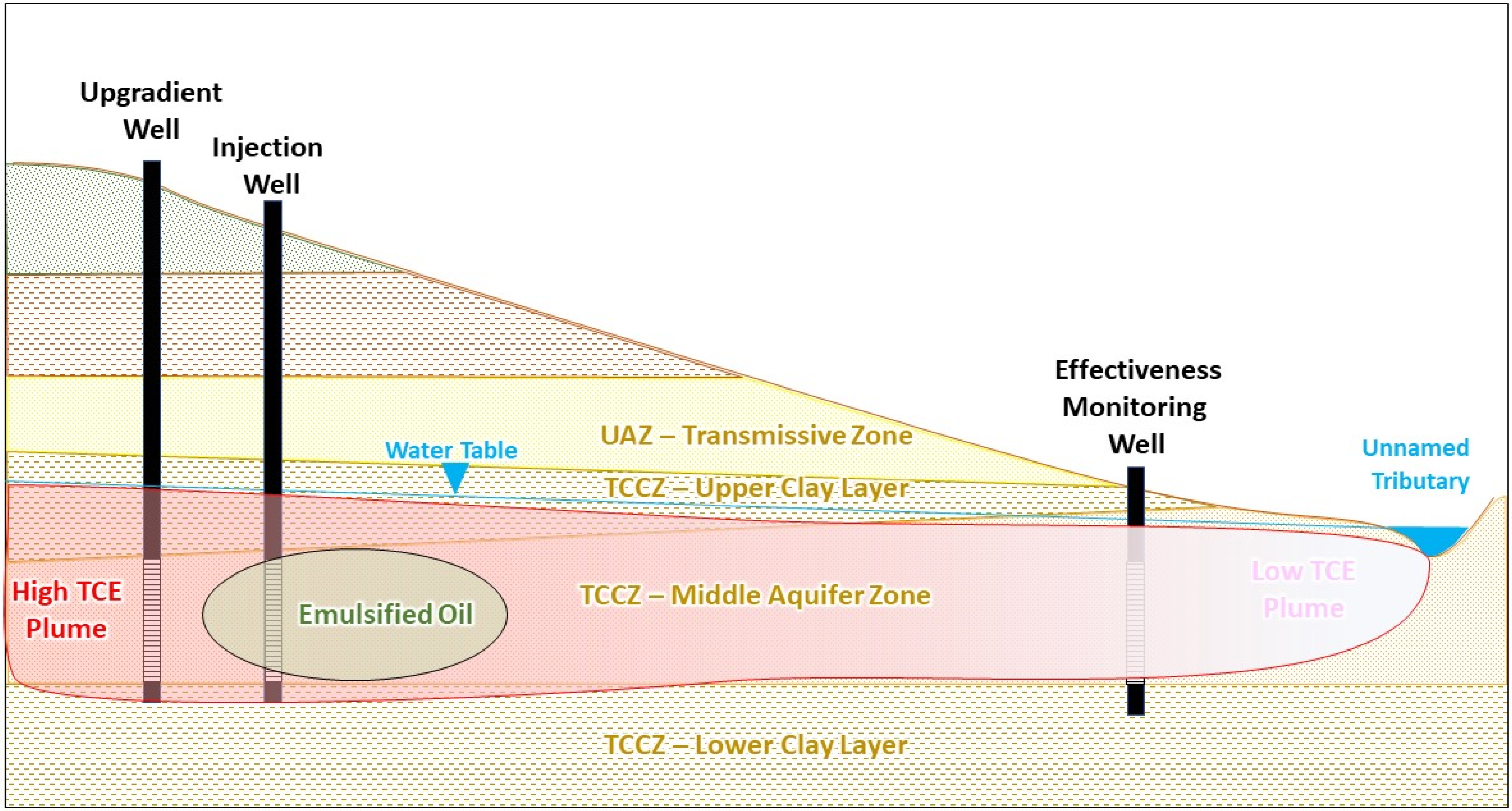


**Figure 7. Schematic of Emulsified Oil Treatment Barrier.**

| Milestone/Deliverable | Approximate Schedule |
|---|---|
| Award Emulsified Oil Treatment Barrier Contract | November 2018 |
| Complete installation of monitoring wells | December 2018 |
| Baseline Monitoring Well Sampling (RA Start) | January 2019 |
| Start Emulsified Oil Injections | March 2019 |
| Complete Emulsified Oil Injection | May 2019 |
| Subcontractor Final Report for Emulsified Oil Treatment Barrier Installation | June 2019 |
| Removal Action Report | December 2019 |

**Table 1. Estimated CAGW OU NTC Removal Action Implementation Schedule**

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## Table 2. Post Construction Monitoring

| Stations | Station Type | Sampling Frequency | Lab Analyses | Field Measurements |
|---|---|---|---|---|
| CC-05 | Surface Water | Semi-Annual - 5 yrs | VOCs, nitrate, sulfate | DO, ORP, pH, Flow Rate |
| CC-08 | Surface Water | Monthly – 3 mo.; Quarterly – 9 mo.; Semi-Annual - 4 yrs | VOCs, nitrate, sulfate | DO, ORP, pH, Flow Rate |
| CC-07 | Surface Water | Semi-Annual - 5 yrs | VOCs, nitrate, sulfate | DO, ORP, pH, Flow Rate |
| CCSL-08 | Seepline | Semi-Annual - 5 yrs | VOCs, methane, nitrate, sulfate, TOC. | DO, ORP, pH, Water Elevation |
| CCSL-11 | Seepline | Semi-Annual - 5 yrs | VOCs, methane, nitrate, sulfate, TOC. | DO, ORP, pH, Water Elevation |
| CCSL-14 | Seepline | Semi-Annual - 5 yrs | VOCs, methane, nitrate, sulfate, TOC. | DO, ORP, pH, Water Elevation |
| CCSL-23R | Seepline | Semi-Annual - 5 yrs | VOCs, methane, nitrate, sulfate, TOC. | DO, ORP, pH, Water Elevation |
| CCT-01 | Surface Water | Monthly – 3 mo.; Quarterly – 9 mo.; Semi-Annual - 4 yrs | VOCs, nitrate, sulfate | DO, ORP, pH, Flow Rate |
| CCT-02 | Surface Water | Monthly – 3 mo.; Quarterly – 9 mo.; Semi-Annual - 4 yrs | VOCs, nitrate, sulfate. | DO, ORP, pH, Flow Rate |
| CCT-03 | Surface Water | Monthly – 3 mo.; Quarterly – 9 mo.; Semi-Annual - 4 yrs | VOCs, nitrate, sulfate | DO, ORP, pH, Flow Rate |
| CRW023C | Monitoring Well | Monthly – 3 mo.; Quarterly – 9 mo.; Semi-Annual - 4 yrs | VOCs, methane, nitrate, sulfate, TOC, microbial analysis (annually). | DO, ORP, pH, Water Elevation |
| CRW024C | Monitoring Well | Monthly – 3 mo.; Quarterly – 9 mo.; Semi-Annual - 4 yrs | VOCs, methane, nitrate, sulfate, TOC, microbial analysis (annually). | DO, ORP, pH, Water Elevation |
| CRW025C | Monitoring Well | Monthly – 3 mo.; Quarterly – 9 mo.; Semi-Annual - 4 yrs | VOCs, methane, nitrate, sulfate, TOC, microbial analysis (semi-annually). | DO, ORP, pH, Water Elevation |
| CRW026C | Monitoring Well | Monthly – 3 mo.; Quarterly – 9 mo.; Semi-Annual - 4 yrs | VOCs, methane, nitrate, sulfate, TOC, microbial analysis (semi-annually). | DO, ORP, pH, Water Elevation |
| CRW27C | Monitoring Well | Monthly – 3 mo.; Quarterly – 9 mo.; Semi-Annual - 4 yrs | VOCs, methane, nitrate, sulfate, TOC, microbial analysis (semi-annually). | DO, ORP, pH, Water Elevation |
| CSB15D | Monitoring Well | Semi-Annual - 5 yrs | VOCs, methane, nitrate, sulfate, TOC. | DO, ORP, pH, Water Elevation |
| CSB020D | Monitoring Well | Semi-Annual - 5 yrs | VOCs, methane, nitrate, sulfate, TOC. | DO, ORP, pH, Water Elevation |
| CSL001 | Monitoring Well | Semi-Annual - 5 yrs | VOCs, methane, nitrate, sulfate, TOC. | DO, ORP, pH, Water Elevation |

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## Table 3. Analytical Specifications Table for VOCs Lab Analyses

| Analyte | Analyte ID | Preparation [B] Method | Analytical [B] Method | CRDL [A] (µg/L) |
|---|---|---|---|---|
| *Volatile Organic Compounds* | | | | |
| 1,1,1-Trichloroethane | 71-55-6 | 5021A,5030C,5031,5032 | EPA8260B | 1 |
| 1,1,2,2-Tetrachloroethane | 79-34-5 | 5021A,5030C,5031,5032 | EPA8260B | 1 |
| 1,1,2-Trichloro-1,2,2-trifluoroethane | 76-13-1 | 5021A,5030C,5031,5032 | EPA8260B | C |
| 1,1,2-Trichloroethane | 79-00-5 | 5021A,5030C,5031,5032 | EPA8260B | 1 |
| 1,1-Dichloroethane | 75-34-3 | 5021A,5030C,5031,5032 | EPA8260B | 1 |
| 1,1-Dichloroethylene | 75-35-4 | 5021A,5030C,5031,5032 | EPA8260B | 1 |
| 1,2,4-Trichlorobenzene | 120-82-1 | 5021A,5030C,5031,5032 | EPA8260B | 19.4 |
| 1,2-Dibromo-3-chloropropane | 96-12-8 | 5021A,5030C,5031,5032 | EPA8260B | 0.2 |
| 1,2-Dibromoethane | 106-93-4 | 5021A,5030C,5031,5032 | EPA8260B | 0.00075 |
| 1,2-Dichlorobenzene | 95-50-1 | 5021A,5030C,5031,5032 | EPA8260B | 10 |
| 1,2-Dichloroethane (EDC) | 107-06-2 | 5021A,5030C,5031,5032 | EPA8260B | 1 |
| 1,2-Dichloropropane | 78-87-5 | 5021A,5030C,5031,5032 | EPA8260B | 1 |
| 1,3-Dichlorobenzene | 541-73-1 | 5021A,5030C,5031,5032 | EPA8260B | 10 |
| 1,4-Dichlorobenzene | 106-46-7 | 5021A,5030C,5031,5032 | EPA8260B | 10 |
| 2-Hexanone | 591-78-6 | 5021A,5030C,5031,5032 | EPA8260B | 10 |
| Acetone | 67-64-1 | 5021A,5030C,5031,5032 | EPA8260B | 20 |
| Benzene | 71-43-2 | 5021A,5030C,5031,5032 | EPA8260B | 1 |
| Bromodichloromethane | 75-27-4 | 5021A,5030C,5031,5032 | EPA8260B | 1 |
| Bromoform (Tribromomethane) | 75-25-2 | 5021A,5030C,5031,5032 | EPA8260B | 1 |
| Bromomethane (Methyl bromide) | 74-83-9 | 5021A,5030C,5031,5032 | EPA8260B | 2 |
| Carbon disulfide | 75-15-0 | 5021A,5030C,5031,5032 | EPA8260B | 1 |
| Carbon tetrachloride | 56-23-5 | 5021A,5030C,5031,5032 | EPA8260B | 1 |
| Chlorobenzene | 108-90-7 | 5021A,5030C,5031,5032 | EPA8260B | 1 |
| Chloroethane | 75-00-3 | 5021A,5030C,5031,5032 | EPA8260B | 2 |
| Chloroethene (Vinyl chloride) | 75-01-4 | 5021A,5030C,5031,5032 | EPA8260B | 2 |
| Chloroform | 67-66-3 | 5021A,5030C,5031,5032 | EPA8260B | 1 |
| Chloromethane (Methyl chloride) | 74-87-3 | 5021A,5030C,5031,5032 | EPA8260B | 1.5 |
| cis-1,2-Dichloroethylene | 156-59-2 | 5021A,5030C,5031,5032 | EPA8260B | 1 |
| cis-1,3-Dichloropropene | 10061-01-5 | 5021A,5030C,5031,5032 | EPA8260B | 1 |
| Cumene (Isopropylbenzene) | 98-82-8 | 5021A,5030C,5031,5032 | EPA8260B | 0.875 |
| Cyclohexane | 110-82-7 | 5021A,5030C,5031,5032 | EPA8260B | 1 |
| Dibromochloromethane | 124-48-1 | 5021A,5030C,5031,5032 | EPA8260B | 1 |
| Dichlorodifluoromethane | 75-71-8 | 5021A,5030C,5031,5032 | EPA8260B | 1 |
| Dichloromethane (Methylene chloride) | 75-09-2 | 5021A,5030C,5031,5032 | EPA8260B | 1 |
| Ethylbenzene | 100-41-4 | 5021A,5030C,5031,5032 | EPA8260B | 1 |
| Methyl acetate | 79-20-9 | 5021A,5030C,5031,5032 | EPA8260B | 10 |
| Methyl ethyl ketone | 78-93-3 | 5021A,5030C,5031,5032 | EPA8260B | 20 |
| Methyl isobutyl ketone | 108-10-1 | 5021A,5030C,5031,5032 | EPA8260B | 10 |
| Methyl tertiary butyl ether (MTBE) | 1634-04-4 | 5021A,5030C,5031,5032 | EPA8260B | 10 |
| Methylcyclohexane | 108-87-2 | 5021A,5030C,5031,5032 | EPA8260B | 10 |
| Styrene | 100-42-5 | 5021A,5030C,5031,5032 | EPA8260B | 1 |
| Tetrachloroethylene (PCE) | 127-18-4 | 5021A,5030C,5031,5032 | EPA8260B | 1 |
| Toluene | 108-88-3 | 5021A,5030C,5031,5032 | EPA8260B | 1 |

## Table 3. Analytical Specifications Table for Lab Analyses *(continued)*

| Analyte | Analyte ID | Preparation [B] Method | Analytical [B] Method | CRDL [A] (µg/L) |
|---|---|---|---|---|
| ***Volatile Organic Compounds (continued)*** | | | | |
| trans-1,2-Dichloroethylene | 156-60-5 | 5021A,5030C,5031,5032 | EPA8260B | 1 |
| trans-1,3-Dichloropropene | 10061-02-6 | 5021A,5030C,5031,5032 | EPA8260B | 1 |
| Trichloroethylene (TCE) | 79-01-6 | 5021A,5030C,5031,5032 | EPA8260B | 1 |
| Trichlorofluoromethane | 75-69-4 | 5021A,5030C,5031,5032 | EPA8260B | 1 |
| o-Xylenes | 95-47-6 | 5021A,5030C,5031,5032 | EPA8260B | 1 |
| m,p-Xylene | MPXYL | 5021A,5030C,5031,5032 | EPA8260B | 1 |
| Bromochloromethane | 74-97-5 | 5021A,5030C,5031,5032 | EPA8260B | 1 |
| 1,4-Dioxane | 123-91-1 | 5021A,5030C,5031,5032 | EPA8260B | 100 |
| 1,2-Dichlorobenzene | 95-50-1 | 5021A,5030C,5031,5032 | EPA8260B | 1 |
| 1,2,3-Trichlorobenzene | 87-61-6 | 5021A,5030C,5031,5032 | EPA8260B | 1 |
| ***Organic Analyses*** | | | | |
| Methane | 74-82-8 | PM01G | AM20GAX | 1 |
| Microbial Analysis | N/A | DNA Extraction | CENSUS qPCR | 100 cells/L |
| Total Organic Carbon | 7440-44-0[F] | EPA9060A/SMS5310C | EPA9060A/ SMS5310C | 1,000 |
| ***Inorganic Analyses*** | | | | |
| Nitrate-Nitrite as Nitrogen[E] | See Note E | EPA353.1/EPA353.2 | EPA353.1/ EPA353.2 | 500 |
| Sulfate | 14808-79-8 | EPA9056A | EPA9056A | 1,000 |
| ***Radionuclides*** | | | | |
| Tritium | 10028-17-8 | EPA900.0MOD | EPA900.0 MOD | 15[D] |

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.
C) Laboratory instructed to obtain the lowest possible method detection limit.
D) Units for tritium are pCi/mL.
E) Nitrate CAS# = 14797-55-8; Nitrate CAS# = 14797-65-0; NO3 is the predominate form in SRS groundwater.
F) CAS# for carbon.

# APPENDIX A

## Manufacturer Spreadsheets

# EOS 100

## Technical Information

Emulsified Oils Family

### Description

USDA CERTIFIED BIOBASED PRODUCT

$EOS_{100}$ is a water-mixable vegetable oil based organic substrate which provides a long-lasting source of carbon for enhanced *in situ* anaerobic bioremediation. $EOS_{100}$ is shipped as a concentrate; simply mix with water to instantly create an injection-ready oil solution.

$EOS_{100}$ benefits:

- 100% fermentable
- Employs the proven EOS® technology
- Larger droplet size for greater oil retention
- Excellent for barrier and fractured rock applications

Domestic supply made in the USA with US farmed soybeans.

### Chemical & Physical Properties

| Oil Concentrate: $EOS_{100}$ | Typical |
|---|---|
| Organic Carbon (% by wt.) | 100 |
| Refined and Bleached US Soybean Oil (% by wt.) | 85 |
| Slow Release Organics (% by wt.) | 15 |
| Specific Gravity | 0.92 - 0.93 |
| Mass of Hydrogen Produced (lbs. $H_2$ per lb. $EOS_{100}$) | 0.40 |

### Packaging

Shipped in 55-gallon drums, 275-gallon IBC totes or bulk tankers (40,000 lbs.)

### Handling & Storage

$EOS_{100}$ is shipped as concentrated oil that is diluted with water in the field to prepare a solution for easy injection. $EOS_{100}$ has a low viscosity and can be distributed with commonly available pumps or by continuous metering with a diluter (e.g., Dosatron™). Dilution ratios for $EOS_{100}$ typically range from 4:1 to 20:1 (water: $EOS_{100}$) depending on site conditions. $EOS_{100}$ injections should be followed with additional chase water to maximize distribution of $EOS_{100}$ into the formation.

$EOS_{100}$ as shipped, has a shelf-life of ≥ 2 years depending on storage conditions.

## APPENDIX A

## Manufacturer Spreadsheets (continued)

# BAC-9

## Technical Information

Bioaugmentation Cultures & Media

### Description

BAC-9 is an enriched bioaugmentation culture capable of degrading chlorinated solvents to innocuous compounds efficiently via halorespiration.

Applications:

- Direct injection for *in situ* treatment of chlorinated ethenes
- Inoculation of on-site bioreactors
- Degrades: tetrachloroethylene (PCE), trichloroethene, (TCE), dichloroethene isomers (cis & trans-DCE), vinyl chloride (VC), Freon 113, mixed plumes containing trichloroethane (1,1,1-TCA & 1,1,2-TCA), dichloroethane isomers, carbon tetrachloride (CT), chloroform, and bromine compounds (carbon tetrabromide, bromoform, ethylene dibromide (EDB) and bromoethane)

### Chemical & Physical Properties

| Bioaugmentation Culture: BAC-9 | Typical |
|---|---|
| Microbial consortium including *Dehalococcoides mccartyi* and enzymes in a water-based medium | $10^{11}$ Cells/L |

### Packaging

Shipped in 19 liter pressurized soda keg. Orders greater than 19 liters are concentrated up to 10-fold to significantly reduce shipping and supply costs for your project. Actual volumes and concentration factor will be written on a hang tag attached with the keg.

See the EOS® website for an instructional video on BAC-9 handling and injection procedure.

### Handling & Storage

BAC-9 is shipped overnight direct to your site in a chilled cooler. Your BAC-9 delivery includes: instruction manual, delivery cylinder (request 1, 2 or 3.5 liter) with quick connects and ¼" ID tubing hose barbs. An inert gas (Nitrogen or Argon) cylinder, regulator, and additional tubing to reach the injection point are required but not included.

BAC-9 must be stored at 4°C (40°F) and can remain usable for up-to three weeks from delivery.

+1 919.873.2204
www.eosremediation.com

# APPENDIX A

## Manufacturer Spreadsheets (continued)

CoBupH$_{Mg}$


### Description

CoBupH$_{Mg}$ is a premium colloidal suspension of alkaline solids providing long-term, slow release adjustment of pH in acidic aquifers to optimum levels for biodegradation and immobilization of some dissolved metals. CoBupH$_{Mg}$'s patented formulation provides:

- Equilibrium pH of ~10 in a 10:1 dilution (DI water:CoBupH$_{Mg}$), minimizing the risk of overshooting the pH by buffer addition
- Micron scale, negatively charged particles promote distribution from the injection point
- Can be used in combination with our emulsified oil products.

### Chemical & Physical Properties

| Alkaline Colloidal Suspension Concentrate: CoBupH$_{Mg}$ | Typical |
|---|---|
| Alkaline Buffer (% by wt.) | 45 |
| Dispersant (% by wt.) | 1 |
| Stabilizer (% by wt.) | 0.5 |
| Specific Gravity | 1.37 |
| pH (Standard Units) - 10:1 dilution (DI water: CoBupH$_{Mg}$) | ~10 |
| Mean Particle Size (µm) | 0.6 |
| OH- equivalence (eq. OH- per lb. CoBupH$_{Mg}$) | 7±0.5 |

### Packaging

Shipped in 5-gallon pails (50 lbs.)

### Handling & Storage

CoBupH$_{Mg}$ is shipped as a ready-to-use concentrated suspension of alkaline solids that can be easily diluted with water in the field. CoBupH$_{Mg}$ has a low viscosity and is amenable to pumping with commonly available pumps. Before dilution, agitate to ensure product is adequately mixed. Dilution ratios typically range from 1:1 to 4:1 (water: CoBupH$_{Mg}$) depending on site conditions; CoBupH$_{Mg}$ injections should be followed with additional chase water to maximize distribution.

For best performance, use CoBupH$_{Mg}$ within 60 days of delivery and store at a temperature of 40°F (4°C) to 100°F (38°C).

# APPENDIX A

## Manufacturer Spreadsheets (continued)

VITA-D-CHLOR™

Home | Products | Equipment | Kits | Use Calculators | Technical | Contact Us | Promotions

Home — Products — Vita-D-Chlor Neutral

### Vita-D-Chlor Neutral

Vita-D-Chlor Neutral is always pH neutral, making it excellent for use with super-chlorinated water. It is safe to handle, even in accidental over-dechlorination situations. Solubility of 50% in the field makes it incredibly easy to mix and particularly advantageous for lengthier flows. Concentrations over 5% have good stability over multiple weeks.

#### Specifications

| | |
|---|---|
| **Active ingredient** | Sodium Ascorbate |
| **Activity** Quantity needed to neutralize 1ppm chlorine | 1 gram per 100 gallons<br>22 lbs. per 1 million gallons |
| **Form** | Easy dissolving fine granular |
| **Quality** | NSF Certified (Dechlorination and antioxidant chemical) Meets pharmaceutical industry standards for purity (USP) |
| **Packaging** | Plastic screw cap bottle and resealable plastic pail (airtight) |
| **Shelf life** | Up to 3 years |
| **Sizes** | 2.5 kg (5.5 lbs.), 12 kg (26.5 lbs.), 25 kg (55 lbs.) |


#### Applications

- Excellent for treatment of highly chlorinated water
- Has a higher solubility than Vita-D-Chlor, so it is easier to dissolve and feed solution batches can be more concentrated
- Use with metering pump set-up

### Contact Us

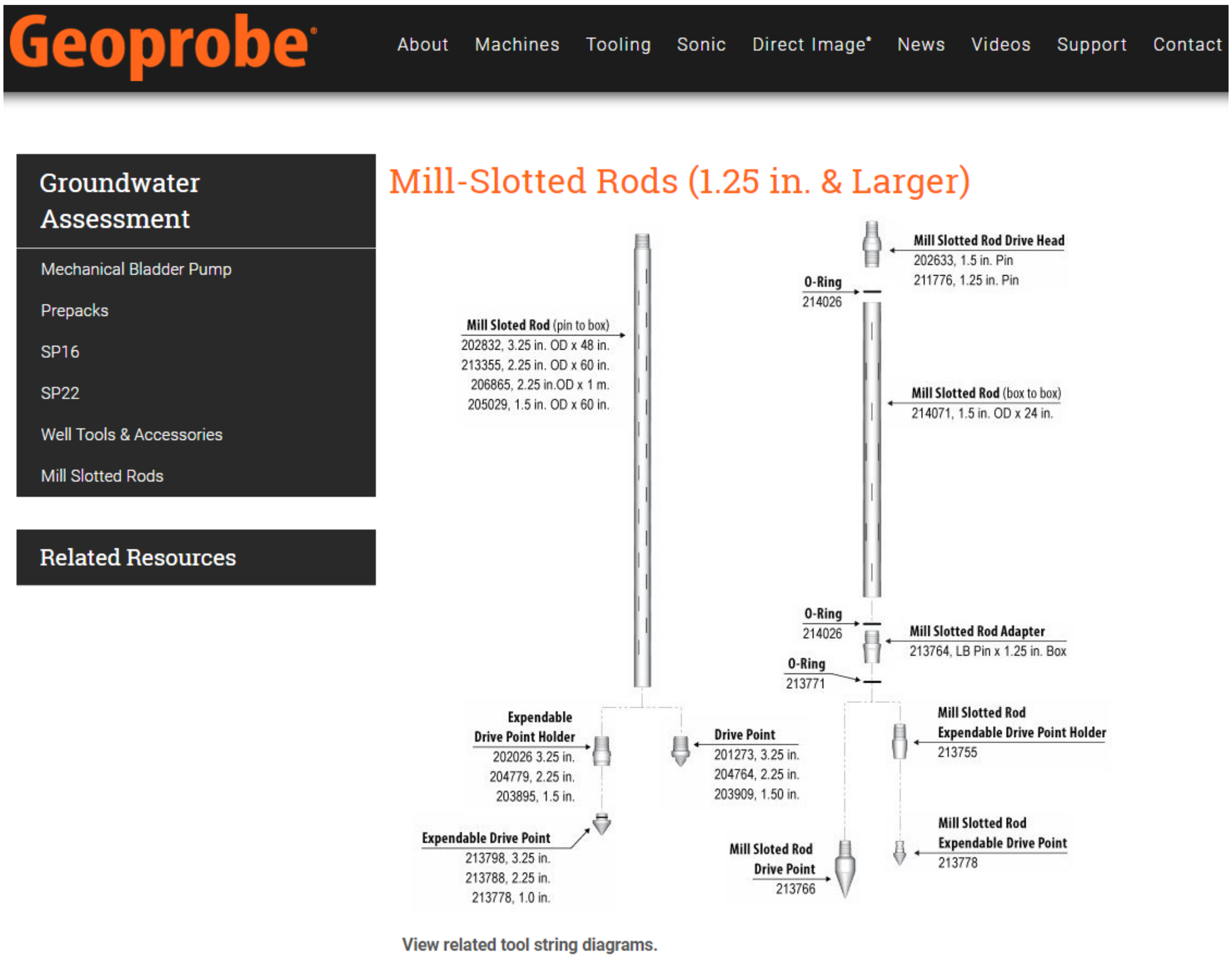
Integra Chemical Company is located in Kent, Washington which is immediately to the south of Seattle. Our business hours are 8:00 am to 5:00 pm, PST, Monday thru Friday. We can be reached during these hours via phone, fax, or e-mail. Outside of our business hours you may leave a message via phone, fax or e-mail and we will get back with you the next business day.

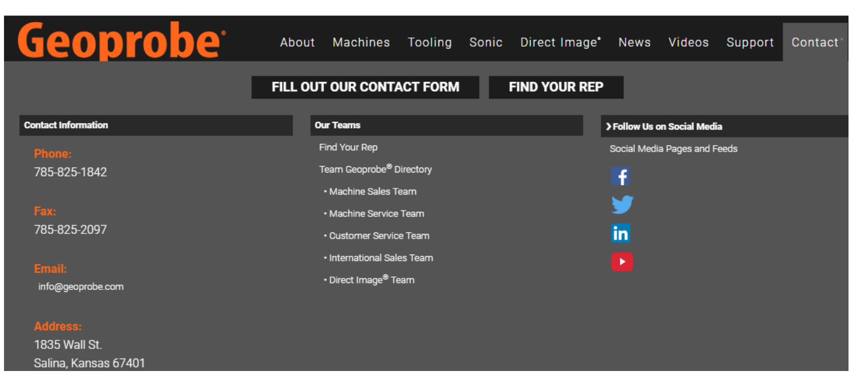


| | |
|---|---|
| **Mailing Address :** | Integra Chemical Company<br>1216 6th Ave North<br>Kent, WA 98032 |
| **Phone :** | 800.322.6646 or<br>253.479.7000 |
| **Fax :** | 253.479.7079 |
| **Email :** | info@Vita-D-Chlor.com |
| **Online Store :** | shop.vita-d-chlor.com |
| **Company Web Site :** | IntegraChem.com |

# APPENDIX A

## Manufacturer Spreadsheets (continued/end)



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