WSRC-RP-96-441

Test Plan for Geo-Cleanse Demonstration (In Situ Destruction of Dense Non-Aqueous Phase Liquid (DNAPL)

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September 1996

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for

Geo-Cleanse® Demonstration

(In Situ Destruction of Dense Non-Aqueous Phase Liquid (DNAPL))

U. S. Department of Energy Office of Technology Development
U.S. Department of Energy Savannah River Operations

Prepared by:

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and
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U. S. Department of Energy
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Savannah River Technology Center

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1.0 EXECUTIVE SUMMARY

Soils and groundwater beneath an abandoned process sewer line in the A/M Area of the Savannah River Site (SRS) contain elevated levels of volatile organic compounds, specifically trichloroethylene (TCE) and tetrachloroethylene (PCE), two common chlorinated solvents. These compounds have low aqueous solubilities, thus when released to the subsurface in sufficient quantity, tend to exist as immiscible fluids or nonaqueous phase liquids (NAPLs). Because chlorinated solvents are also denser than water, they are referred to by the acronym DNAPLs, or dense non-aqueous phase liquids. Technologies targeted at the efficient characterization or removal of DNAPL are not currently proven. For example, most DNAPL studies rely on traditional soil and water sampling and the fortuitous observation of immiscible solvent. Once DNAPL is identified, soil excavation (which is only applicable to small contained spill sites) is the only "proven" cleanup method. New cleanup approaches based on destruction of DNAPL either in situ or ex situ have been proposed and tested at the pilot scale. The proposed demonstration, as described within this document, will evaluate the applicability to DNAPL plumes of a technology proven for in situ destruction of light non-aqueous phase liquids (LNAPLs) such as oils.

As characterization of the DNAPL plume in the vicinity of the M-Area Settling Basin progresses to defining the zones of pure phase NAPL, remediation technologies to treat the DNAPL are being identified and tested. One area being pursued in Phase II of the DNAPL program is onsite destruction technologies. Savannah River Site has completed work on remediation technologies to include horizontal wells combined with soil vapor extraction, traditional pump and treat, off-gas treatment technologies, and heating technologies. These technologies have been directed at either the vadose zone contamination or the aqueous, dissolved phase contamination. Geo-Cleanse® is an onsite, in situ destruction technology which can treat both the aqueous, dissolved phase contamination and the pure phase NAPL. Remediation of DNAPL plumes will require a suite of techniques which can treat DNAPL in the gaseous, aqueous, and pure phase. Treatment of the pure phase DNAPL will be a key step in a timely cleanup of the plume.

One promising method of remediating pure phase DNAPLs from aquifers is the Geo-Cleanse® process which is an in situ destruction technology resulting in generation of water, carbon dioxide and chloride ions with no secondary waste. This technology is based on Fenton's chemistry. Geo-Cleanse® was originally developed by Hudson Environmental Services for remediation of soil and groundwater contaminated with organic compounds including fuel oils, gasoline, solvents, chlorinated compounds, and PCBs. The system has been successfully utilized on several sites in New Jersey with the full approval of the New Jersey Department of Environmental Protection. In September 1996, the Geo-Cleanse® process was granted a UIC permit by the South Carolina Department of Health and Environmental Control (SCDHEC) for treatment at Shaw Air Force Base, SC. We plan to test the Geo-Cleanse® process for in situ destruction of DNAPLs as opposed to LNAPLs where the process is proven successful.

The Geo-Cleanse® demonstration will evaluate the ability of this process to destroy DNAPL in the subsurface. The demonstration involves installation of four (4) injectors, four (4) monitoring wells and four (4) piezometers to remediate an area no greater than 1,225 square feet adjacent to the closed M-Area Basin. In addition, three additional borings will be drilled, sampled continuously from the water table to the top of the green clay, and abandoned after the demonstration test to provide confirmatory data on the success of the technology to destroy the DNAPL in the test zone. The test zone is within the DNAPL plume at an approximate depth of 165 feet below ground surface, located just above the "green clay". By use of a drilling technology such as resonant sonic or rotosonic for the installation of the injectors and monitoring wells combined with the in situ remediation, little to no Investigation Derived Waste (IDW) and no secondary waste will be generated during this demonstration. The test period (injection and remediation) is projected for a two week period with monitoring before, during and after the test.

2.0 INTRODUCTION

In continuing our support to the A/M-Area groundwater corrective action, we plan to demonstrate an innovative technology for the in situ destruction of DNAPL in the subsurface near the M-Area Settling Basin and other sources. A small scale demonstration is proposed as a part of the development and demonstration of remediation activities.

3.0 BACKGROUND

The M-Area of Savannah River Site was a fuel and target fabrication facility. The mission of this area was processing uranium, lithium and other materials into fuel elements and targets for use in the nuclear production reactors. The processes were primarily metallurgical and mechanical, such as casting, extrusion, plating, hot-die-sizing, welding and magneforming. Solvent cleaning and acid/caustic etching were used to prepare the materials.

The M-Area Settling Basin and associated areas (the overflow ditch, Lost Lake, the seepage area, and the inlet process sewer line) have been designated as the M-Area Hazardous Waste Management Facility. This facility received process effluent from 1958 until 1985. VOC contamination of soils and groundwater occurred in M-Area as a result of breaks in the old process-sewer line and disposal to the basin. Other sources in A/M Area include the A-014 Outfall, the solvent storage tank, and surface discharges from the Savannah River Technical Center.

The M-Area Settling Basin Hazardous Waste Management Facility has been capped and closed under RCRA and is a certified closure as a landfill. The work being proposed is intended to support the A/M Area groundwater corrective action.

There have been a wide range of research and development activities that have been performed in support of the A/M -Area groundwater corrective action. These various activities have been designated the Integrated Demonstration and include use of horizontal wells for remediation, an in situ air stripping test, in situ bioremediation test, off gas treatment technology tests, a radio frequency heating test, and an ohmic heating test.

Characterization of DNAPL above and below the water table is an important component of developing a comprehensive remediation system. Characterization of DNAPL below the water table is often difficult, due to DNAPL's dispersed occurrence and complex behavior. Above the water table, residual DNAPL will reside in intergranular pores, held by capillary forces. The overall characterization of subsurface DNAPL distribution requires application of specifically focused characterization technologies based on contaminant attributes and hydrogeological setting. To minimize the potential for DNAPL spreading, noninvasive or minimally invasive technologies should be employed.

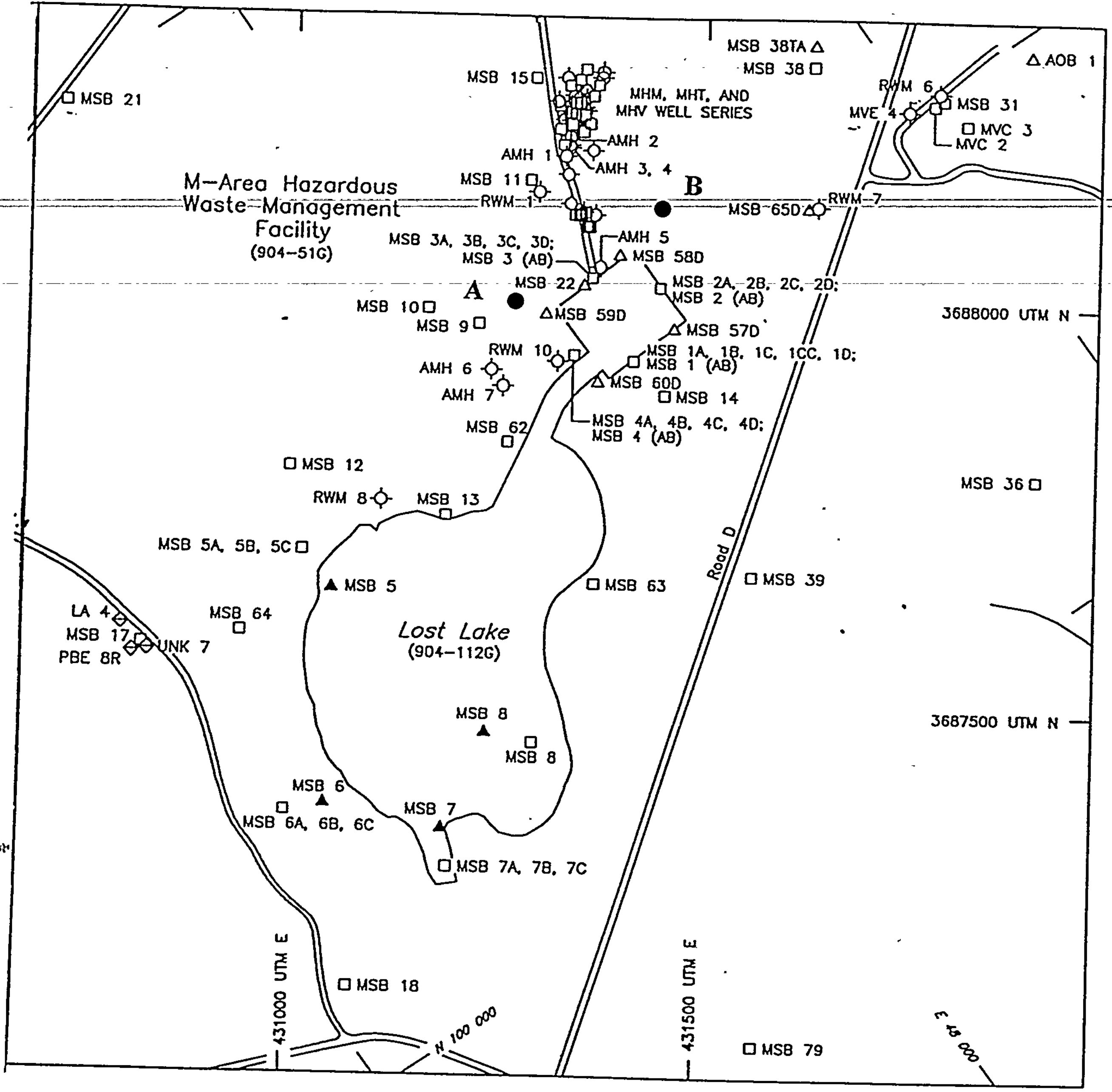
Several technologies were used during the earlier Phase I DNAPL characterization. These included: (1) physical and chemical measurements in existing monitoring wells (e.g., interface probe and bailer samples, and visual examination), (2) cone penetrometer to provide detailed data on the geology (clay layers and lithologic controls), and (3) geophysical logging of existing monitoring wells to examine the well casing and formation outside the well casing for indications of DNAPL. Historical data were used to focus the study on the most promising wells and techniques.

A separate phase was identified in monitoring wells MSB-3D and MSB-22 sumps. Both identifications were made based on direct observation of a bottom filling bailer. The dense phases collected from these two wells were sampled and analyzed at different times to allow testing of various hypotheses for DNAPL occurrence. The observed changes in the volume and composition of the dense phase collected from the two sumps at separate times were specifically related to possible DNAPL behavior scenarios. The data suggest that DNAPL has reached the water table only at the largest volume release areas, the M-Area Settling Basin (Settling Basin) and the A-014 Outfall. The relatively thick vadose zone beneath A/M-Area tends to limit the downward flux of DNAPL and capture some DNAPL in layered clays. As expected, DNAPL below the water table has been observed where solvent release exceeded the capacity of the vadose zone to moderate the flux of the pure phase to the groundwater. The clearest evidence of DNAPL below the water table was found at the Settling Basin, where a separate phase was identified in the sumps of two wells. The data collected at separate times suggest that the DNAPL below the water table occurs as relatively diffuse ganglia and/or a thin layer on the top of aquitards, and that DNAPL collects in well sumps as a result of dynamic processes. One such process is the accumulation of dense ganglias in the well sump as the well is actively purged and sampled (similar to the accumulation of sediments in the sump).

The cone penetrometer allowed refinement of the delineation of an important clay zone (the "green clay") beneath the water table. Undulations and other structural variations on top of this layer would serve to control the movement of a dense phase below the water table. Based on the cone penetrometer results, structure controlled pathways for density-dominated transport below the water table were discerned. Two potential pathways were identified. The primary potential pathway of contaminant migration begins near the Settling Basin, where DNAPL was found in monitoring wells MSB-3D and MSB-22, Figure 3.1. The contour grades toward the west and then north toward MSB-76, where high dissolved constituent concentrations (> 1000ug/L) are reported. Areas along the low points of the path described in this interpretation will be locations of future DNAPL investigation. The geophysical logging data indicate the physical integrity of the PVC monitoring well casings in A/M-Area have not been substantially impacted by exposure to chlorinated solvents. The wells, even immediately adjacent to the highest volume release areas, do not show signs of mechanical instability, leakage, or other types of large scale failure. Data from a few monitoring wells, however, provide subtle indications of potential exposure to DNAPL. The most consistent DNAPL indications are provided in monitoring wells MSB-9A and MSB-22, with less probable indications from monitoring wells MSB-10A and MSB-11A.

Phase I of the DNAPL characterization provided significant insight into the nature and location of DNAPL in the SRS subsurface. In particular, the data indicate a substantial amount of DNAPL has been trapped in clays and silts in the vadose zone above the water table. The DNAPL present is composed of approximately 95% TCE and 5% PCE. Remediation of this material by soil vapor extraction (SVE) before it reaches the water table represents the first major DNAPL-targeted remediation technology. SVE demonstrations have been performed in the A/M-Area using both horizontal and vertical wells. A full scale SVE design, installed as a component of the A/M-Area groundwater corrective action program is underway, and additional remediation technology demonstrations are planned. Phase I characterization data also suggest that DNAPL below the water table in A/M-Area is present as disconnected ganglia, rather than as a large, solvent-saturated layer. The objectives of Phase 2 of the DNAPL remediation will focus on: (1) pure phase DNAPL, (2) recycle of DNAPL, and (3) on site destruction of DNAPL.

The Geo-Cleanse® demonstration is an important element of the Phase 2 remediation activities. This demonstration involves the in situ oxidative reduction of the DNAPL plume using Fenton's chemistry. It will be conducted within one quarter mile of the M-Area Settling Basin Hazardous Waste Management Facility. Figure 3.1 shows two potential locations for the proposed Geo-Cleanse® demonstration, the area of review, all monitoring wells, surface bodies of water, roads, and other cultural features. Because "treatment" of pure phase NAPL is the key to a successful and timely cleanup, Geo-Cleanse® technology is a most promising system for destruction of both aqueous and pure phase NAPL in the subsurface.



● Proposed Demonstration Locations

Figure 3.1 Area Map of the Test Site, Located Adjacent to the M-Area Hazardous Waste Management Facility

4.0 SUMMARY DESCRIPTION OF PROPOSED TEST

Two potential areas for the demonstration have been identified based on available geologic and seismic data. They are on the east and west sides of the closed M-Area Basin. The area to the west of the basin, labeled A in Figure 3.1, is an area where DNAPL may be migrating through what appears to be a subsurface channel. A new area, labeled B in Figure 3.1, has recently been identified to the east of the M-Area Basin where DNAPL may be pooling. A boring will be drilled at each location to determine which of these locations is the preferred site for the demonstration. Each of these two borings will be completed as monitoring wells. Upon selection of the test site, several soil borings will be continuously cored and sampled followed by installation of the injection wells. These injectors, whose design is the property of Geo-Cleanse®, are used to transport the hydrogen peroxide solution and ferrous sulfate (catalyst) to the treatment zone. The treatment period is scheduled for completion within two weeks. This is to be followed by continuously coring several additional soil borings within the test area to verify the success of the Geo-Cleanse® technology.

Initial verification of the suitability of the test area for the demonstration and the installation of the injectors will be conducted using a drilling method which minimizes and eliminates, if possible, the generation of Investigation Derived Waste (IDW). Successful use of such a drilling method will make cleanup with this technology one that generates a minimal, if any, secondary waste. Continuous coring and sampling will be conducted during these drilling activities. This will serve two purposes. First, it will verify the selection of this location as the demonstration site; and second, it will provide additional data for characterization of DNAPL in a zone of possible migration where little data is present to date.

The target zone of influence is approximately 35 feet by 35 feet at an elevation just above the "Green Clay", approximately 165 feet below ground surface. This zone will be accessed by the four injectors which are configured as shown in Figure 4.1. A description of the injection process is described in Section 5.2. The treatment period for the test location is scheduled to be completed within a two week period. Field monitoring of the treatment process will occur throughout the treatment period.

Immediately after completing treatment additional soil borings will be drilled and samples collected to verify the success of the demonstration. The monitoring wells will also be sampled at this time. Upon receipt of all data, a report will be prepared evaluating the success of the demonstration.

A summary of the construction parameters for the injectors and monitoring wells are provided in Table 4.1 with a summary of operating parameters for the demonstration provided in Table 4.2.

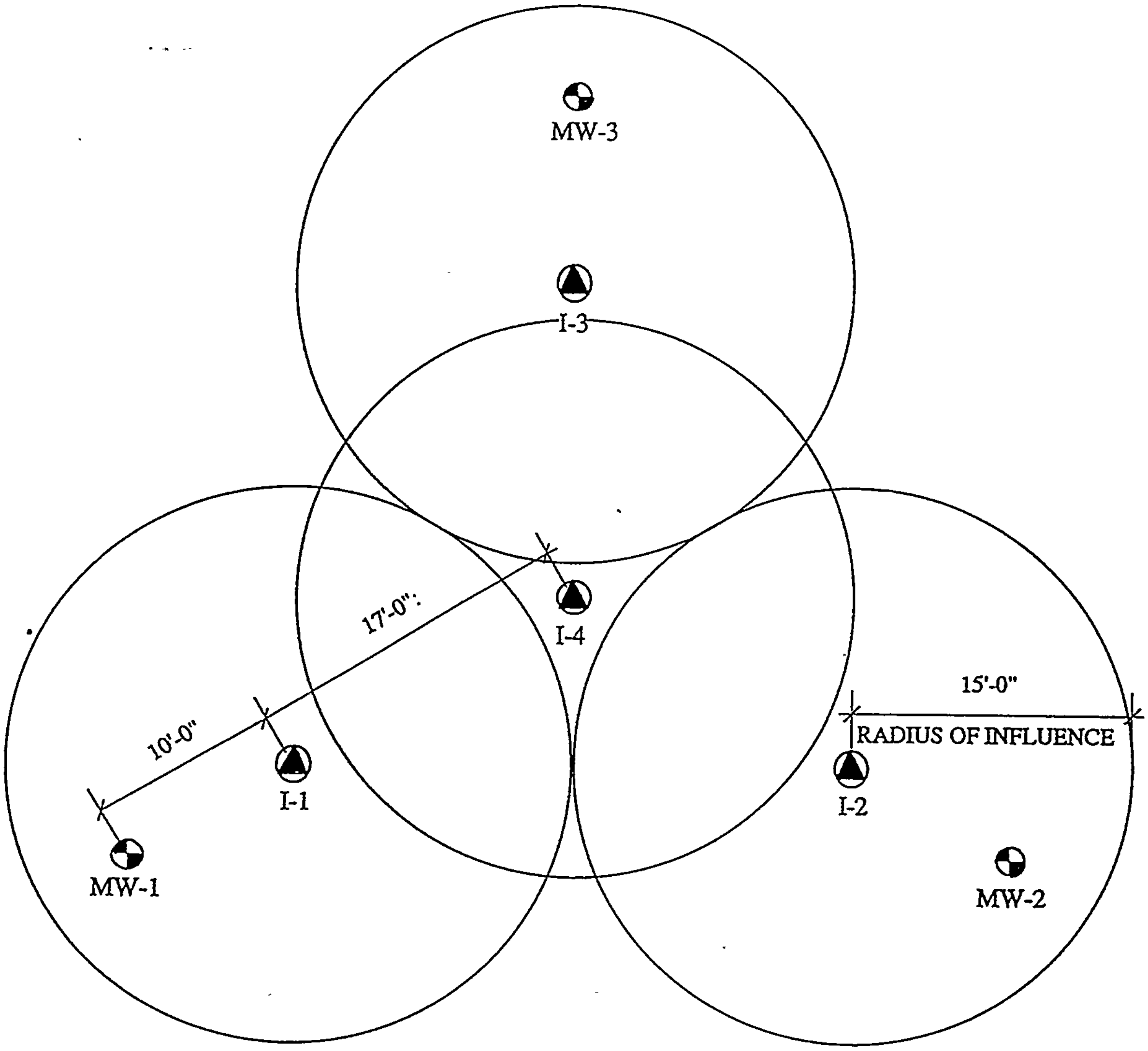
5.0 TECHNICAL BASIS

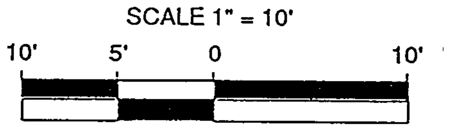
5.1 Fenton's Chemistry

The Geo-Cleanse® process is an in situ oxidative reduction process based on Fenton's chemistry.

H. J. H. Fenton developed a chemistry which oxidized malic acid through the use of hydrogen peroxide and iron salts in the 1890s. This chemistry has been, and is still widely used by the waste water industry for treatment of organic wastes. Hydrogen peroxide is the active ingredient in the oxidation of organics compounds by this methodology. The hydroxyl radical is the reactive species in this process.

The chemistry of Fenton's reagent (1) is well documented as a method for producing hydroxyl radicals by the reaction of hydrogen peroxide and ferrous iron (Fe+2). Hydroxyl radicals are very powerful, effective and nonspecific oxidizing agents that are approximately 10^6 to 10^9 times more powerful than oxygen or ozone alone.





I - Injector Well
MW - Monitoring Well

Figure 4.1 Injector and Monitoring Well Layout Pattern for Geo-Cleanse® Demonstration

Table 4.1 Summary Table of Construction Parameters of Injectors and Monitoring Wells for Geo-Cleanse® Demonstration

Parameters	Injectors	Monitoring Wells
Total Depth	165 ft (above top of "green" clay)	165 ft (above top of "green" clay)
Total Number	4	3
Screen Length	5 feet	5 feet
Screen Diameter	2 inch	2 inch
Screen Slot Size	0.010 inch, slotted	0.020 inch
Screen Material	Stainless Steel	Stainless Steel
Riser Length	175 feet	100 feet
Riser Diameter	1-1/4 inch	2 inch *
Riser Material	Black Steel	PVC - SCH 40 *
Materials - Gravel	5 ft^3	*
Material - Grout	136 ft^3	*
Materials - Bentonite	2 ft^3	*
Materials - Concrete	4 ft^3	*

* Standard SRS construction per the 3Q5 Manual.

Table 4.2 Summary Table of Operating Parameters for the Geo-Cleanse® Demonstration

Maximum Solution Volumes Hydrogen Peroxide Catalyst	 7,930 gallons, 50% solution (150 drums) 10,000 gallons ferrous sulfate, 100 ppm solution
Maximum Injection Rate	4 gpm
Injection Depth	approximately 165 feet, on top of "Green Clay"

$$H_2O_2 + Fe^{2+} \Rightarrow Fe^{3+} + OH^- + OH^\bullet \qquad (1)$$

With the Geo-Cleanse® process, iron salts in the form of ferrous sulfate (Fe+2) and hydrogen peroxide are injected with a patented process, Patent #5,525,008 to generate hydroxyl radicals. Proprietary mixtures of non-hazardous metallic salts are used to control the reaction. During the optimum reaction sequence and when the catalyst is iron, ferrous iron (Fe+2) is converted to ferric iron (Fe+3). Ferrous iron is soluble in water at the target pH and is necessary for the generation of the hydroxyl radical, but ferric iron will not generate the hydroxyl radical and is less soluble at the target pH range (pH 5 to 6). However, under properly controlled and buffered conditions, the ferric iron can be regenerated back to ferrous iron by a subsequent reaction with another molecule of hydrogen peroxide (2).

$$H_2O_2 + Fe^{3+} \Longleftrightarrow Fe^{2+} + H^+ + HO_2^{\bullet} \qquad (2)$$

In this case, the iron will remain available in the ferrous form as long as the pH is properly buffered and there is sufficient hydrogen peroxide. Eventually as the hydrogen peroxide is consumed, some of the iron will precipitate out as ferric iron (if the pH is moderate). The Geo-Cleanse® process has been widely used for LNAPLs and adverse impacts due to precipitation of iron have not been observed.

There are many reactions that occur during the oxidation of a contaminant (3), but as shown by equation (3) a contaminant (RHX), hydrogen peroxide, and ferric iron, as a catalyst, are consumed to produce water and carbon dioxide. RHX represents an organic compound and X represent a halide (such as chloride). If the compound is non-halogenated (no X), then the hydrogen ion and halide anion are not formed in the *overall* reaction. Thus compounds such as BTEX are converted to carbon dioxide and water, whereas trichloroethylene is converted to carbon dioxide, water, hydrogen and chloride ions, which of course are all non-toxic at the levels they will be produced.

$$\overset{\text{Fe+2}}{\text{RHX}} + H_2O_2 \Longleftrightarrow H_2O + CO_2 + H^+ + X^- \quad (3)$$

5.2 Description of Geo-Cleanse® Technology

Geo-Cleanse® technology, an in situ destruction technique, utilizes Fenton's reagent (ferrous iron and hydrogen peroxide) to convert organic contaminants to water and carbon dioxide. The hydrogen peroxide and catalyst (ferrous sulfate and/or sulfuric acid) are injected into the groundwater zone where the DNAPL contamination to be treated is located. A patented injection process is used to inject the hydrogen peroxide and catalyst.

After the initial characterization of the site and installation of the injectors in the zone of contamination, the treatment process is initiated. The number of injectors installed and the volume of injectate is based on the source area size, as calculated in Section 5.5. Injection of the catalyst solution with 1 to 2 cfm of air to sparge the catalyst away from the injector into the formation is the initial step in the treatment. This adjusts the pH of the groundwater to between pH of 4 and 6, where metals, specifically iron, will be at the optimal electron state, +3. This is followed by injection of hydrogen peroxide. The air sparging is discontinued once oxidation begins. The mixing of the catalyst and the hydrogen peroxide in the subsurface will generate heat as the reaction with the organic contaminants progresses. Monitoring is conducted during the treatment phase for water vapor; carbon dioxide gas; and hydrogen peroxide, pH, conductivity, dissolved oxygen, and the contaminants to be destroyed in the aqueous phase. Catalyst solution may be added throughout the injection process to maintain the pH of the groundwater within the range of pH 4 to 6.

A key part of this technology is the injection process. The injection process is proprietary and Patent #5,525,008 has been issued. The injector contains a mixing head which is utilized for mixing the reagents and has components to stimulate the circulation of groundwater to promote rapid reagent diffusion and dispersion. Thus, all reagents are injected into the subsurface through one injector per well. Each reagent is injected at a distinct time within the treatment process, as described in the preceding paragraph, followed by fresh water to clear the wellbore. The injector is designed with a check valve system which prevents the mixing of the chemicals before they have reached the zone of contamination/treatment. Thus, the chance of reaction within the wellbore is eliminated.

5.3 Green Clay Integrity in the Vicinity of the M-Area Basin

Typical of the Atlantic Coastal Plain, the sediments beneath the A/M Area are interbedded sands, silts and clays deposited during periods of high sea level and modified by erosion during intervening times. Clay rich confining, or restrictive, intervals are interspersed with more transmissive, sandier, intervals. In A/M Area, there are several clay rich intervals above the water table (with elevations of about 325 feet msl, 305 feet msl, and 270 feet msl). The ground surface in central A/M Area is about 365 feet msl and the water table is approximately 135 feet deep (elevation 235 feet msl). DNAPL below the water table (the target contamination for the in situ oxidation test) accumulates in sandy layers on top of clayey layers. The uppermost significant clay beneath the water table is termed the "Green Clay." This layer is at an elevation of approximately 200 feet msl (or about 35 feet below the water table). The surface of this layer was carefully delineated in WSRC (1992). The delineation indicated that the Green Clay is generally present in the vicinity of the M Area Settling Basin and that the top surface of the Green Clay is not flat, but has structural features, undulating or irregular features forming local depressional or trough-like areas that control the migration of DNAPL near the basin. The data from A/M Area indicate that discontinuities are present in the Green Clay. Note, however, that the scale and pattern of DNAPL migration (in a narrow structural feature located between the M Area Settling Basin and well cluster MSB 76), indicate that DNAPL accumulated above the Green Clay is a target of opportunity for in situ destruction technologies. A second possible DNAPL accumulation area, just east of the closed M Area Settling Basin, is also being evaluated as an alternative test location. Figure 5.1 is a representation of the Green Clay in the vicinity of the M Area Settling Basin. It is based on cone penetrometer data and hydrostratigraphic information collected in the general vicinity of the M Area Settling Basin and Integrated Demonstration Site. Figure 5.1 will be updated as more information becomes available.

5.4 Selection of Demonstration Location

The area selected for this demonstration will contain measurable DNAPL. Two such locations have been identified adjacent to the closed M-Area Basin, see Figure 5.1. One location is located approximately 50 yards off the western corner of the closed M-Area basin, location A in Figure 5.1. This potential site is in a bowl shaped surface depression approximately 50 feet square. This site is located within a suspected subsurface trough in the green clay through which DNAPL is migrating. The second location is off the eastern corner of the closed M-Area basin, location B in Figure 5.1. This potential site is a depressional area where DNAPL is believed to be pooling. The "green clay" is the unit on which the DNAPL is pooling.

The initial field work in this demonstration will be to continuously core and collect samples in both locations to determine the preferred site. One boring will be drilled at each location. The location with the greatest concentration of TCE and PCE will be the selected site for the demonstration.

5.5 Calculation of Zone of Influence and Injection Volumes for the Demonstration

In determining the zone of influence and injection volumes, the volume of TCE for the suggested treatment area was calculated. The calculations are conservative in nature to insure sufficient reagents for the complete destruction of the DNAPL in the test area. Based on Figure 3.4.6a of *WSRC-RP-92-1302, Assessing DNAPL Contamination, A/M Area, Savannah River Site: Phase I Results*, the thickness of the DNAPL pool was estimated. For purposes of these calculations it is assumed the DNAPL pool is 70% DNAPL and 30% water.

Estimate of Volume of DNAPL to be Treated During Geo-Cleanse® Demonstration for a 35 foot by 35 foot test area.

Determination of DNAPL Pool Thickness:

Assume DNAPL "pool" thickness is determined by difference in elevation at the source (M-Area Basin) from the elevation at the demonstration area. Elevation for source and demo site is the elevation of the "green clay".

Elevation at basin	200.5 ft msl
Expected elevation at demo site	198.5 ft msl
DNAPL "pool" thickness	2.0 ft

Total porosity is 0.4

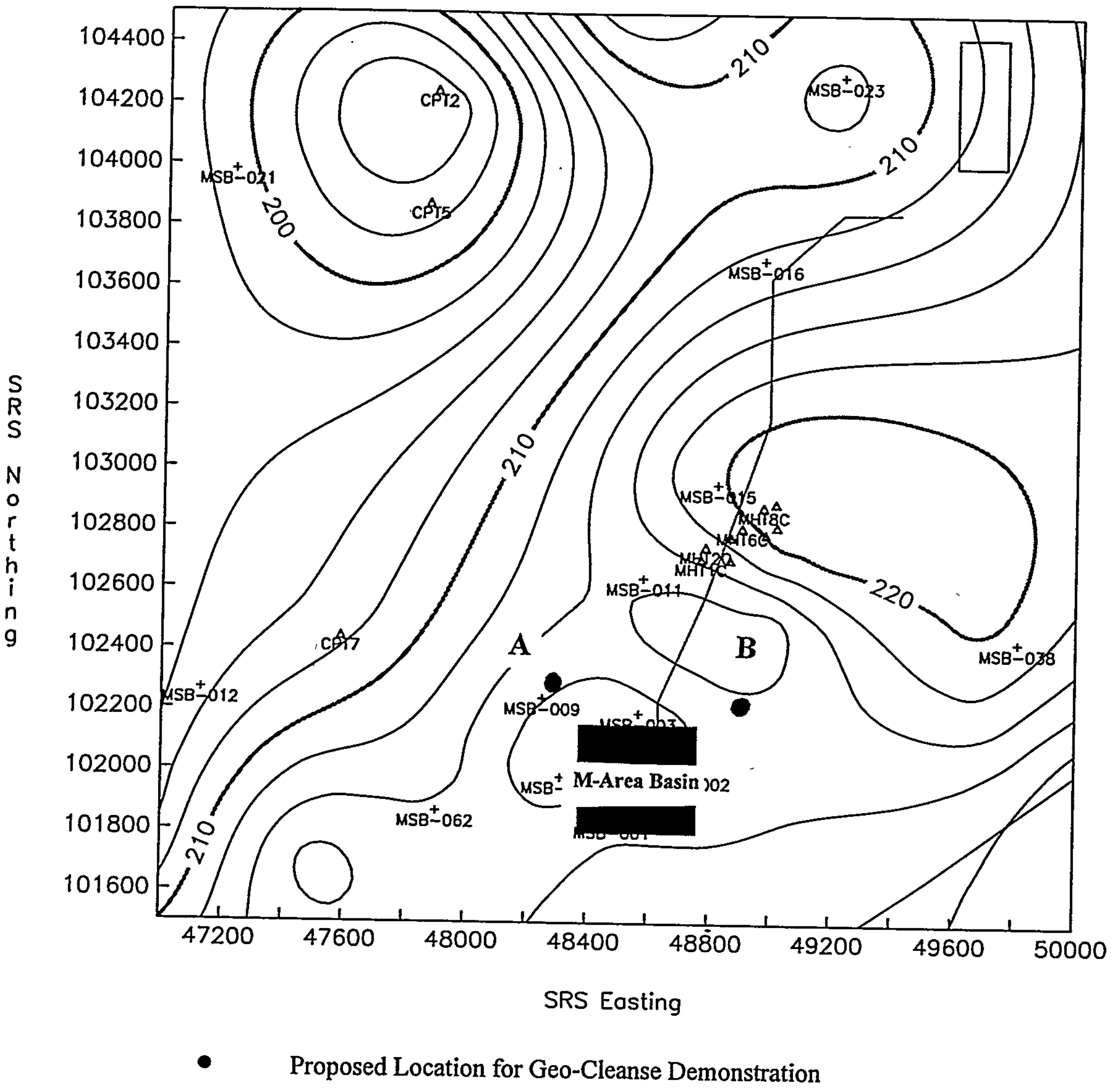


Figure 5.1 Map of the Green Clay in the Vicinity of the Proposed Locations for the Geo-Cleanse® Demonstration

Fraction of pores occupied by water (f_w) is 0.3
Fraction of pores occupied by DNAPL (f_{DNAPL}) is 0.7

Assume the demonstration site will be an area of 35 feet by 35 feet.

Volume of DNAPL to be treated

$V_{DNAPL} = A_{demo}$ * "pool" thickness * porosity * f_{DNAPL}

$V_{DNAPL} = (35ft * 35\ ft) * 2\ ft * 0.4 * 0.7$

$V_{DNAPL} = 686\ ft^3$ of DNAPL

Mass of DNAPL = V_{DNAPL} * 7.48 gallons/ft^3 * 10 lbs/gallon

Mass of DNAPL = 686 ft^3 * 7.48 gallons/ft^3 * 10 lbs/gallon

Mass of DNAPL = 51,300 lbs DNAPL

Volume of hydrogen peroxide required for reaction

$$V_{\text{hydrogen peroxide}} = 51{,}300 \text{ lb TCE} * \frac{\text{1 lb-mole TCE}}{\text{132 lbs TCE}} * \frac{\text{3 moles } H_2O_2}{\text{mole TCE}} * \frac{\text{34 lbs } H_2O_2}{\text{lb-mole } H_2O_2}$$
(100% solution)

$V_{\text{hydrogen peroxide}}$ (100% soln) = 39,700 lbs

The solution to be used for demonstration will be a 50% solution.

$$V_{\text{hydrogen peroxide}} \text{ (50\% soln)} = V_{\text{hydrogen peroxide}} \text{ (100\% soln)} * \frac{\text{1 gal } H_2O_2}{\text{10 lb}} * \frac{1}{\text{percentage soln}}.$$

$V_{\text{hydrogen peroxide}}$ (50% soln) = 39,700 lbs H_2O_2 *0.1 gal H_2O_2/lb *1/0.5

$V_{\text{hydrogen peroxide}}$ (50% soln) =7930 gallons of 50% H_2O_2

6.0 ANALYTICAL METHODS

Primary, backup and QA lab methods are summarized in Table 6.1. QA samples will be a 5% split of the complete sample set and will be representative of all samples and all media.

7.0 WASTE MANAGEMENT

A central objective of the SRS DNAPL program is minimization of investigation derived waste (IDW) and secondary waste. Therefore, whenever possible, solid materials will be reused rather than discarded and techniques which minimize IDW will be utilized. Items such as sample bailers, plastic sheeting, and similar items will be placed in a sealed storage container on site. One goal of this demonstration is to generate as little waste as possible. A drilling method has been selected which will minimize to the extent possible, if

Table 6.1 Summary of Analytical Methods for Samples Collected during Geo-Cleanse® Demonstration

Category	Sample Type	Method Description	Reference
Field Measurements			
	Aqueous Samples		
	Specific Conductivity	field meter	
	Chloride Concentration	field kit and/or ion chromatography	
	Hydrogen Peroxide	Hach kit	
	pH	field meter	
	Gas Samples		
	Carbon dioxide	meter (B&K)	
	Oxygen	meter (RK1 Eagle)	
	Trichloroethylene and Tetrachloroethylene	meter (B&K)	
Laboratory Analysis			
	Aqueous Samples		
	VOCs	modified headspace gas chromatography with dual electron capture and flame ionization detector	WSRC/ESS Procedure: ESSOP-2-70
	Soil Samples		
	VOCs	modified headspace gas chromatography with dual electron capture and flame ionization detector	WSRC/ESS Procedure: ESSOP-2-70
	X-ray fluorescence	mineralogy	

not eliminate, the generation of IDW. Any IDW that is generated from demonstration preparation activities, will be handled in accordance with the IDW Management Plan. Geo-Cleanse® technology is an in situ oxidative destruction technology which produces no waste products.

7.1 Contingency Plans

Containment of equipment and IDW waste (if required to be containerized) will control/minimize the chance of spills or unplanned releases. However, a supply of appropriate sorbent pigs and pillows will be maintained at the site to be used for rapid containment in the event of such a release. Further, SRS has a trained spill response team that will be immediately called in the event of any release of DNAPL material to the environment. Site emergency numbers are a required element of the training necessary to work at SRS. These numbers will also be posted near phones at the support facility located at the field test area adjacent to the former M Area Settling Basin. Any unplanned releases will be addressed through the SRS spill reponse process. All work associated with DNAPL contaminated soils, hydrogen peroxide and ferrous sulfate will be conducted with the Health and Safety Plan for the Geo-Cleanse demonstration.

A contingency plan required by RCRA will be prepared prior to establishment of a staging area for wastes. The main purpose of the staging area will be for containerization of equipment such personal protective equipment and sampling materials.

8.0 ENVIRONMENTAL IMPACT

No adverse environmental impact is anticipated. The research is focused on developing improved (faster and less expensive) clean up of the primary contaminants (TCE and PCE) in A/M Area. A National Environmental Protection Act (NEPA), 10 CFR 1021, checklist has been completed for this activity. We anticipate a Finding of No Significant Impact since the activity is covered under the following categories of exclusions: B3.1 (site characterization and monitoring), B3.8 (outdoor ecological/environmental research in a small area), and B6.2 (siting/construction/operation of pilot scale waste collection/treatment/stabilization/containment facilities).

9.0 ADDRESSES

Any additional information needed related to this program may be obtained by contacting the following individuals:

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10.0 REFERENCES

Schwille, F. *Dense Chlorinated Solvents in Porous and Fractured Media,* Lewis Publishers, Chelsea, Michigan, 146 pp. (1988).

Westinghouse Savannah River Company. *Assessing DNAPL contamination, A/M-Area, Savannah River Site: Phase I Results (U).* Prepared for the US DOE Contract #DE-AC09-89SR18035 (1992).