EMAIL REGARDING DRAFT WORK PLAN FOR IN-SITU CHEMICAL OXIDATION TREATABILITY STUDY AT SITE 45 DRY CLEANING FACILITY SPILL AREA WITH ATTACHMENTS MCRD PARRIS ISLAND SC

3/6/2009

U S EPA REGION IV

From:	Llamas.Lila@epamail.epa.gov
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Subject:	Re: URGENT !!! Site 45 ISCO Treatability Study
Date:	Monday, March 09, 2009 4:03:53 PM
Attachments:	Parris Island Remediation_Figures.doc Parris Island Remediation Workplan_version 1.doc
Importance:	High

Hi Folks,

If you are having trouble viewing Figures 3 - A, B, C, and D, or any others for that matter, when you open the Figures File, go to "View" on the toolbar, and select "Print Layout". You should now be able to see them. If not, let me know.

Charles gets Kudos for being the first to give approval. Thanks Charles! Don't let this deter the rest of you. The same prize goes out to second place, third place, etc. : -)

Thanks,
Lila

Lila Llamas/R4/USEPA/US
03/06/2009 10:16 AM

To
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cc

Subject
URGENT !!! Site 45 ISCO Treatability Study

Hi Folks,!

For background, please see my previous email of February 13, alerting the team as to this forthcoming workplan and the associated request for expedited review. As I hope you recall, Scott has completed

implementation of his Phase I work plan for gathering additional site characterization data, and is now submitting the draft workplan for the next phase - implementation of the oxidant treatment being studied (which may also include a wee bit more characterization, in order to expand the transects a little closer to the building).

Now, see the email below, which submits for our review, the draft work plan for the field implementation portion of the ISCO treatability study. You will see in Scott's note that he wishes to be in the field on March 22, 2009. Don't panic. Also recall that we do not need to do a full technical review of this work plan, being this is a treatability study for a process under development. However recall we will want to look for at least the following: all that is necessary to obtain state approval for permits (if new wells are requested), proper disposition of IDW, commitments to providing reports, a schedule, precautions with respect to confining layers, safety issues, coordination with other groups, and an understanding that when we are ready to move forward with Site work, we will have to move forward, etc.

Please let me know if there is anything Scott can do to help expedite this review and obtain approval. He will be happy to participate on a quick conference call at any point you feel it would benefit your review.

Thanks,
Lila

Lila, attached are two files containing the text and figures associated with the draft ISCO Work Plan for the Parris Island MCRD, Site 45. We are planning to be at the site on 3/22 - 3/26. Our work will follow the field work being done at the emulsified oil/ZVI project with Dr. Su (3/13 - 3/22). The attached work plan provides some of the site characterization data and information from the initial field investigation (March, 2008). Based on the data and information we have gathered, in conjunction with Dr. Vroblesky's (USGS) data and information (and consultation), I feel we have developed an accurate conceptual model of contaminant distribution at the site. The site visit the last two weeks of this month will involve the collection of a few more cores in the source area that will help to improve the resolution of contaminant distribution in the source area.This information will serve to focus ISCO activities and to improve performance evaluation of ISCO remediation. Proposed field activities (cores, micro-wells) for 3/22 - 3/26 are summarized in section 3.4.3 and 3.4.2 of the work plan.

Based on the results of the treatability study conducted by Dr. Watts (Washington State University), the site 45 ISCO design, and specific site characteristics, it seems ISCO has a good chance of achieving significant reduction in contaminant mass. Post-oxidation site characterization efforts will be rigorous and comprehensive, and will provide the scientific basis to make a final assessment of treatment performance. This data and information will be summarized and provided to the Parris Island Partnering Team.

Thank you in advance for your help on this matter and for coordinating this work plan with the Parris Island Partnering Team. Scott

(See attached file: Parris Island Remediation_Figures.doc)(See attached file: Parris Island Remediation Workplan_version 1.doc)

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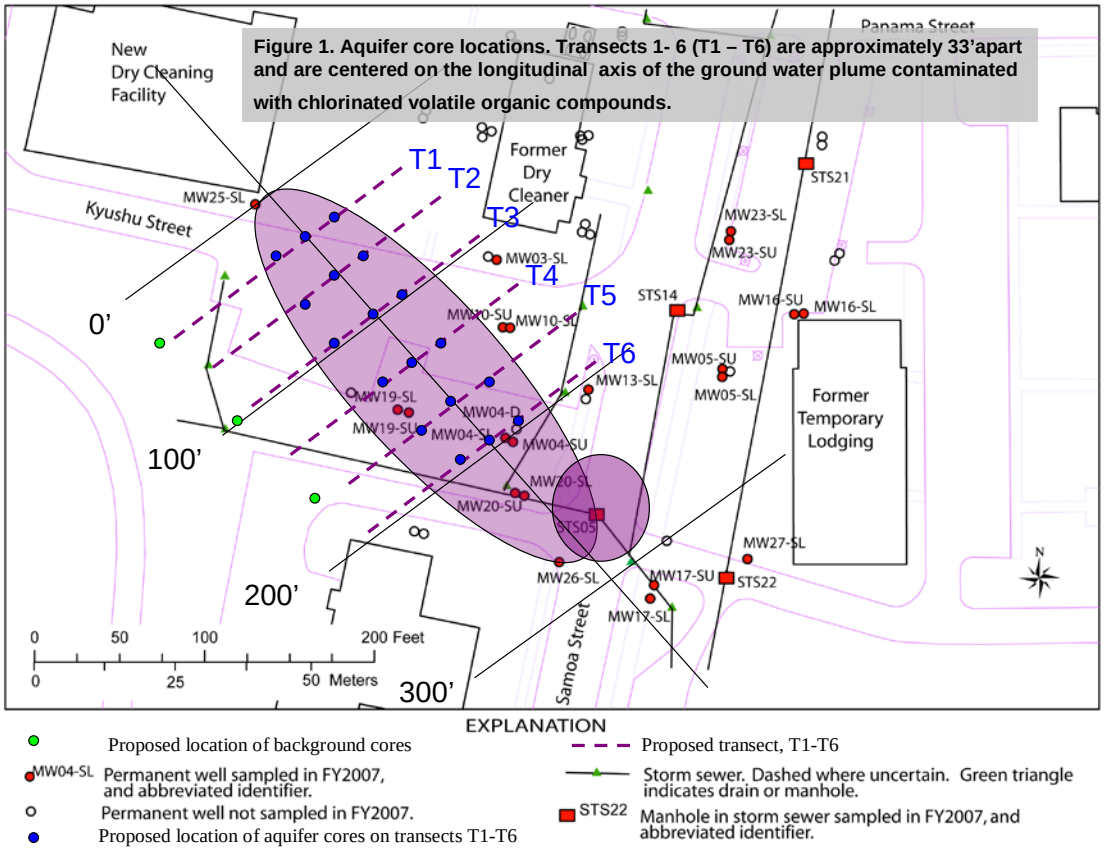


Figure 1. Aquifer core locations. Transects 1- 6 (T1 – T6) are approximately 33'apart and are centered on the longitudinal axis of the ground water plume contaminated with chlorinated volatile organic compounds.

Figure 2. Photo of sediments collected in aquifer core. The core was collected along transect 2, location C (T2-C). Below ground surface depth intervals are T2-C-XA and XB (3.1'), T2-C1 (8.5'), T2-C2 (10'), T2-C3 (12.4'), T2-C4a (14'), T2-C4b (16'), T2-C4b duplicate (16').

Figure 3A. Total VOCs (mg/kg) at Parris Island MCRD OU45.

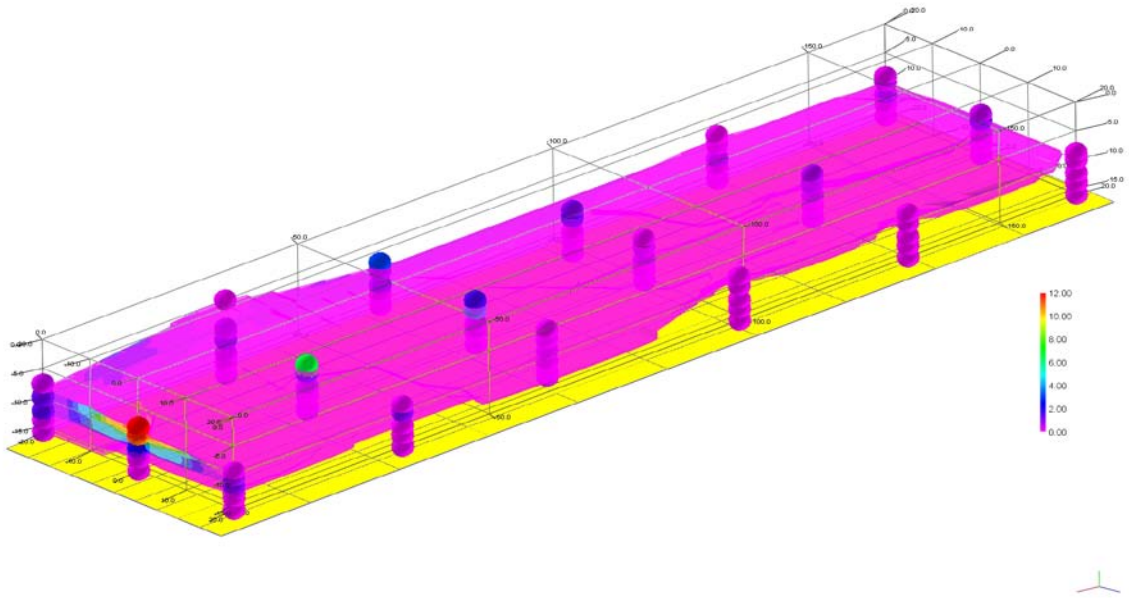


Figure 3B. PCE (mg/kg) at Parris Island MCRD OU45.

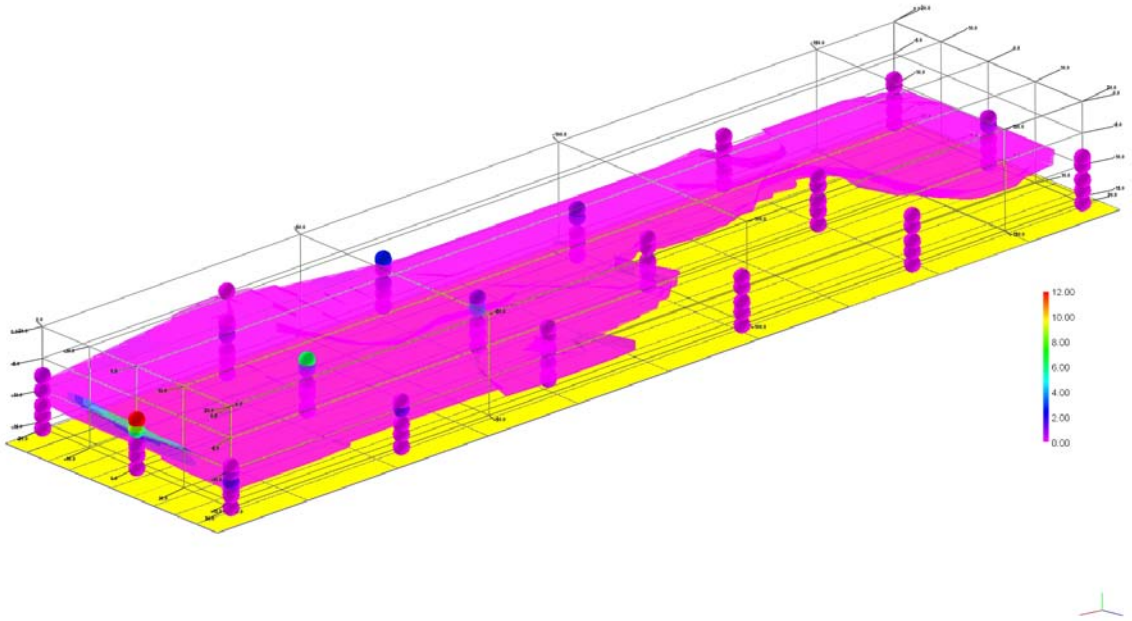


Figure 3C. TCE (mg/kg) at Parris Island MCRD OU45.

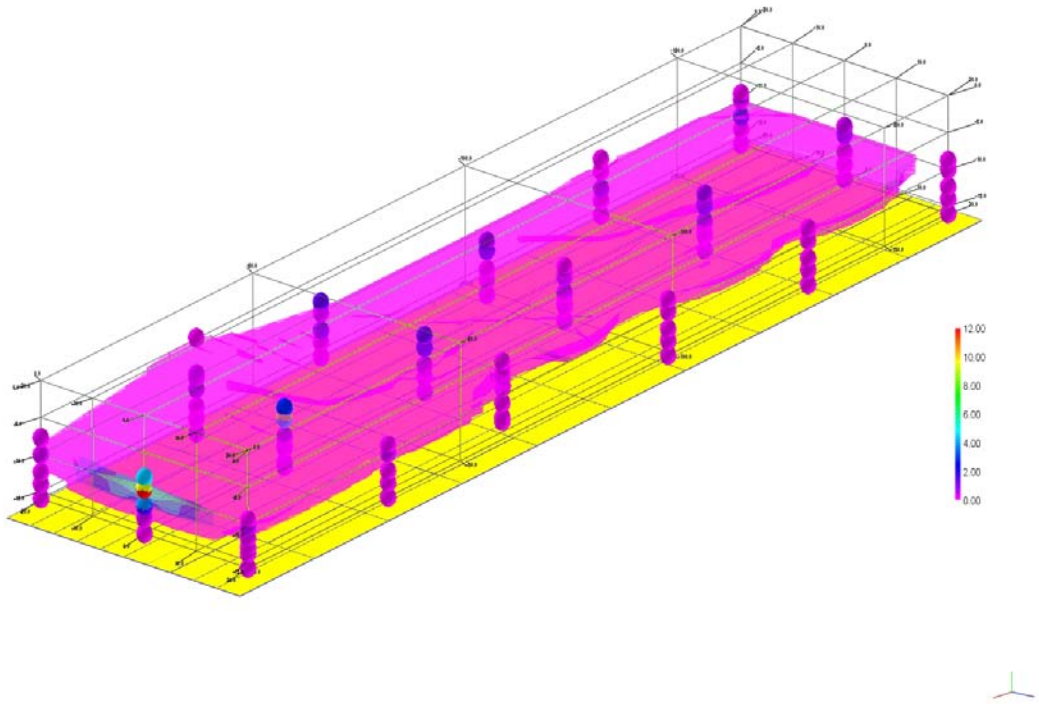


Figure 3D. C-1,2 DCE (mg/kg) at Parris Island MCRD OU45.

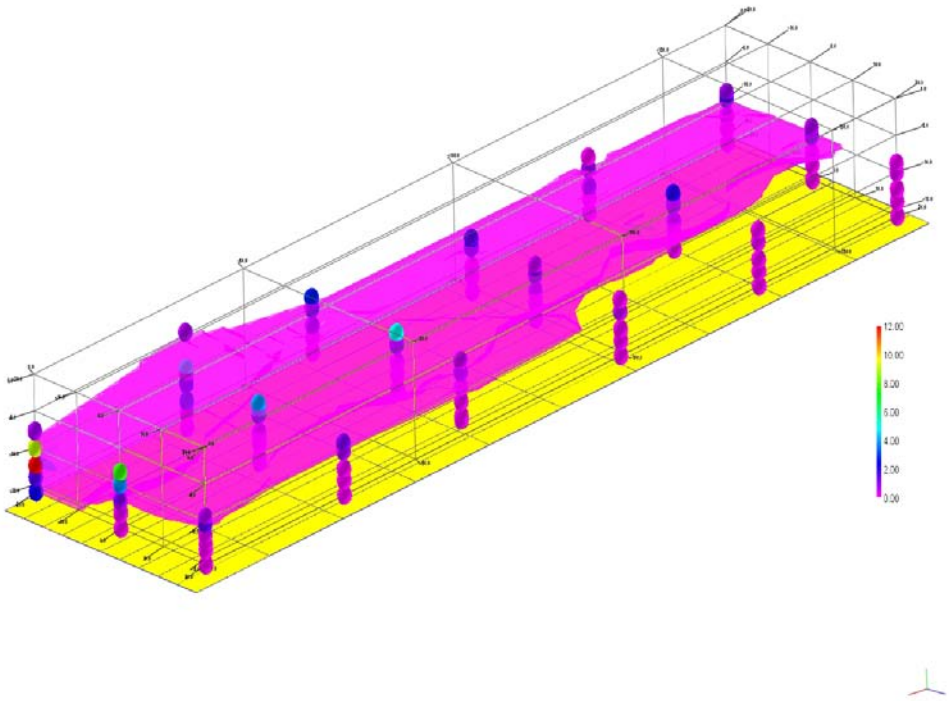
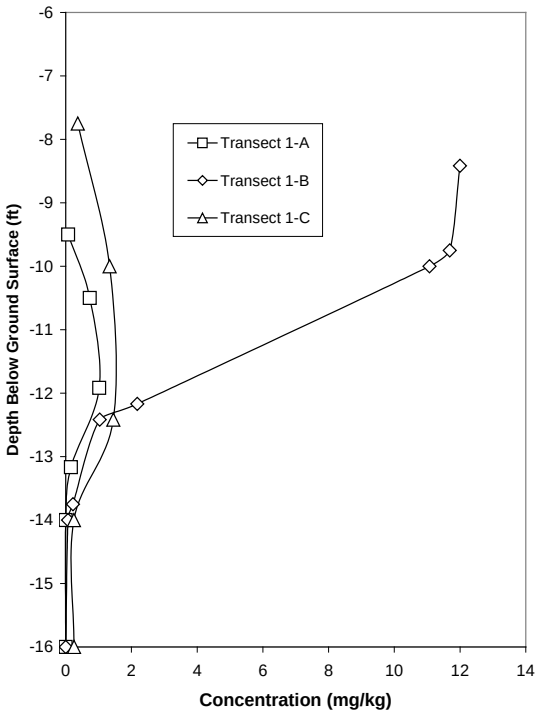


Figure 4. Vertical distribution of total VOCs (Parris Island, site 45) at Transect 1 and Transect 2.



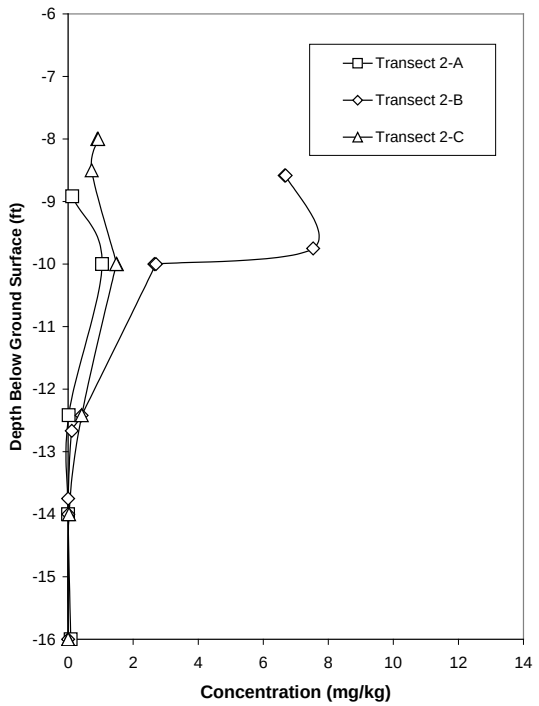


Figure 5. TOC distribution with depth. Samples collected from transect locations T1-B, T3-B, and T5-B.

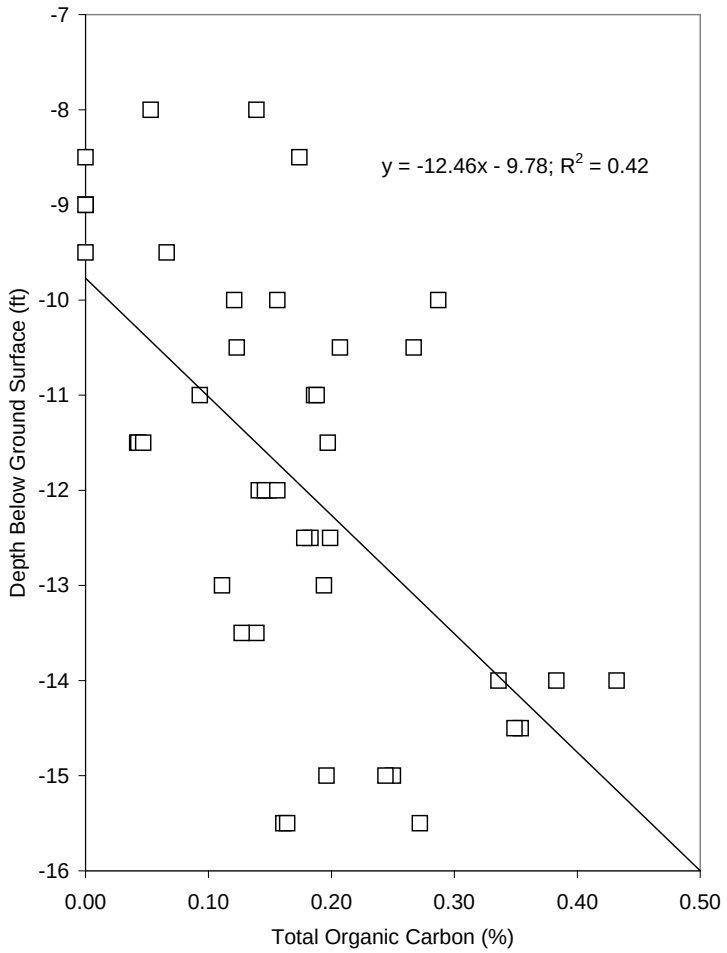


Figure 6. Injection wells are located 5’ upgradient from the first transect (T1) where aquifer cores were collected. Wells are spaced 10’ apart, the radius of influence of injection wells is approximately 5.5’. Assuming 30% porosity, 440 and 530 gallons of oxidant would be injected into 2’ and 2.5’ screened wells, respectively. Wells would be clustered, not nested.

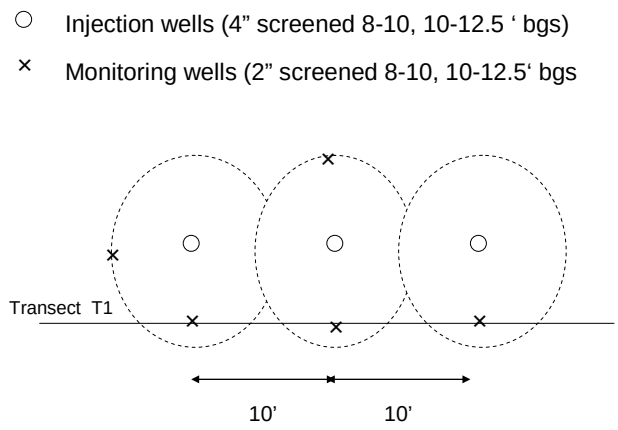
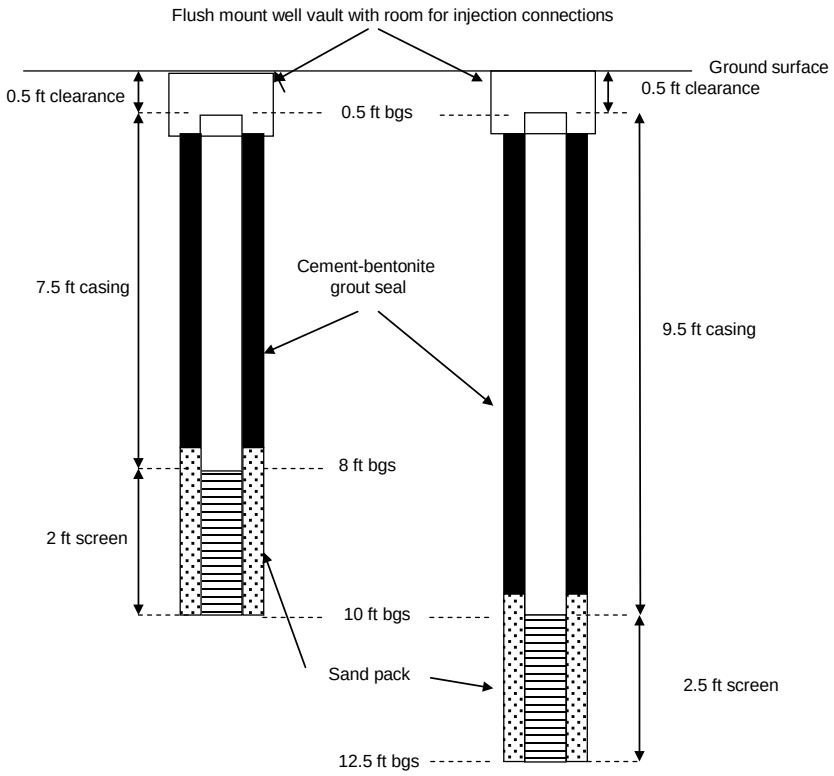


Figure 7. Well Construction Schematic (not to scale) SHP injection wells: 4-inch 304SS in 8-inch boreholes SP injection well: 4-inch PVC in 8-inch boreholes
Monitoring wells: 1-inch 304SS (for SHP) or PVC (for SP) in 4-inch boreholes



Parris Island Site Characterization Workplan – Phase I
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In-Situ Chemical Oxidation Workplan (DRAFT)

Field Demonstration, Optimization, and Rigorous Validation of Peroxygen-Based ISCO for the Remediation of Contaminated Groundwater (ER-0632)

Parris Island Marine Corp Recruit Depot
Site OU45 (Former Dry Cleaner Site – South Plume)

February 19, 2009

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1.0 Introduction and Objectives.

In-situ chemical oxidation (ISCO) at the Parris Island Marine Corp Recruit Depot (Parris Island, S. Carolina) solid waste management unit 45 site is being carried out in conjunction with the Department of Defense (DoD), Environmental Security Technology Certification Program (ESTCP) project (ER-0632, Field Demonstration, Optimization, and Rigorous Validation of Peroxygen-Based ISCO for the Remediation of Contaminated Groundwater). The general goal of this program is to promote innovative, cost-effective environmental technologies through demonstration and validation at DoD sites. This project is a collaboration between the DOD-ESTCP and the Peroxygen Team comprised of Washington State University (WSU), Environmental Research Management (ERM), FMC Corp., and the Environmental Protection Agency-Robert S. Kerr Environmental Research Center (EPA-RSKERC).

This remediation workplan is a detailed presentation of proposed in-situ chemical oxidation activities at the Parris Island Marine Corp Recruit Depot (PI-MCRD), solid waste management unit (SWMU) 45 (Former MWR Dry Cleaning Facility). This site was selected by the Peroxygen Team based on an analysis of site selection criteria in conjunction with site specific details of SWMU 45 (Appendix A).

The general objectives of this research are, (1) to apply rational process chemistry to improve the design and implementation of peroxygen ISCO at the demonstration level, including maximizing hydrogen peroxide (H_2O_2) and persulfate ($S_2O_8^{2-}$) distribution, evaluating H_2O_2 and $S_2O_8^{2-}$ stabilization procedures, and comparing increased H_2O_2 stability to the stability of $S_2O_8^{2-}$, (2) to validate the effectiveness of peroxygen ISCO in the field by detailed assessment of contaminant loss, fate, and product formation, including the potential for concurrent and subsequent biological degradation of contaminants, and (3) to implement and document an ISCO optimization approach that involves multiple phases ranging from bench-scale treatability studies to full-scale application. The results of this study will provide a conceptual approach and guidelines that can be used by DoD remedial project managers when condsidering ISCO for site remediation.

2.0 Previous Investigations.

Data and information from previous investigations were available for review and included contaminant distribution, hydrogeology, and other chemical and physical parameters (TetraTech NUS, 2004; 2005; Vroblesky, 2007; 2008). This data and information was important to understand contaminant fate and transport, guide the Phase I site characterization activities, and to develop an accurate site conceptual model. This information has been integrated into this report and used to establish proposed ISCO activities and design.

2.1 Site Characterization and Development of Site Conceptual Model

2.1.1 USGS site characterization

The ground water contamination plume depicted in Figure 1 was based on a

previous investigation by the USGS (Vroblesky, 2007). A membrane interface probe (MIP) survey was performed which provided vertical contaminant distribution data. Plan view isocontour maps were prepared illustrating isopleth of PCE, TCE, c-DCE and vinyl chloride. Based on this information, the areal and vertical extent of the ground water plume was documented and an accurate conceptual model was established upon which to base the preliminary site characterization activities associated with ER-0632.

2.1.2 TetraTech NUS (2004; 2005)

The surficial aquifer underlying Site 45 consists of the sandy Pliocene to Holocene sediments to an average depth of approximately 18 feet (TtNUS, 2004). In general, the water table encountered within these heterogeneous sediments is shallow and is typically encountered at a depth of 3 to 4 feet bgs at the site. Groundwater is expected to preferentially migrate through the higher permeability sandy sediments within the surficial aquifer. Because of their limited areal extents, the localized silty/clayey lenses found within the surficial aquifer are not expected to function as significant confining units. Localized hydraulic effects were observed because of silt and clay (TtNUS, 2004). Recharge to the surficial aquifer is likely to occur primarily through infiltration of precipitation.

2.1.2.1 Aquifer Characteristics

Slug tests and aquifer tests were conducted in the area associated with the former dry cleaner building (TtNUS, 2004). Some of these tests were conducted within approximately 125’ from the proposed ISCO test areas and therefore are useful to help assess oxidant and reagent transport in the study area.

Table 3-6 of the RI (TetraTech, 2004) presents a summary of the slug tests performed in wells in the upper surficial aquifer (3-7’ bgs) and lower surficial aquifer (9-14’ bgs). The hydraulic conductivity arithmetic and geometric means of the upper surficial was 11.9 and 8 ft/d (n=8) and the lower surficial was 2.4 and 2.0 ft/day (n=6), respectively. Table 3.7 of the RI also reports results of the aquifer tests at RW-3 where 8 observation wells screened in the upper and lower were used during the test. Although the methods used are generally for confined aquifers, boring log data indicate that the surficial aquifer is unconfined, but the drawdown patterns more closely represent a confined or leaky-confined aquifer. This may be the result of the presence of the relatively finer-grained sediments (silty-sand) within the upper portion of the shallow aquifer in comparison to the deeper sediments (fine sand). The average transmissivity was 230 ft^2/day and assuming an average thickness of 15’, the overall hydraulic conductivity of the shallow aquifer sediments is 15.3 ft/day. The well (RW-3) that was pumped was screened in the upper and lower surficial aquifer (4-16’ bgs). Given that the water table is approximately 3.5’ bgs, and the bottom of the surficial aquifer was 16’, a more accurate estimate of the aquifer thickness and average hydraulic conductivity is 12.5 ft and 18.4 ft/day (6.6×10^{-3} cm/s), respectively. The results of the slug tests indicate that the majority of water captured by RW-3 was from the upper surficial aquifer.

Summary of Aquifer Characteristics (TtNUS, 2005).

The upper surficial aquifer contains white sand material that grades into the dark material with depth. Given the following parameter values, porosity 0.3, K = 8 ft/d (geometric mean), dh/dl = 0.005, the seepage velocity is 48.7 ft/yr (clean to silty sand).

The lower surficial aquifer is comprised of darker material. Assuming the following parameter values, porosity 0.3, K = 2 ft/d, dh/dl = 0.006, the seepage velocity is 14.6 ft/yr (silty sand).

Deep wells (17-27' bgs) penetrate much deeper than targeted intervals in the ISCO demonstration. Assuming porosity 0.3, K = 1 ft/d, dh/dl = 0.004, the seepage velocity is 4.9 ft/yr.

The surficial aquifer extends to a depth of approximately 17 ft bgs (TtNUS, 2004). The peat and clayey material found underlying the surficial aquifer sediments throughout the site at depths ranging from 17 to 27 feet (bgs) is expected to function locally as a confining unit to groundwater flow (TtNUS, 2004). Based on the results of previous laboratory hydraulic conductivity testing of six samples from this unit, the geometric mean vertical hydraulic conductivity for this confining unit is 0.00166 feet per day (5.8 $\times 10^{-7}$ cm/sec) (TtNUS, 2004). This, in combination with an average thickness of 5 to 6 feet, indicates that the unit significantly restricts vertical groundwater flow.

The low permeable materials in the 17-27 ft bgs interval likely serves as a vertical impediment to downward transport of contaminated water. The aquifer cores collected in the Phase I site characterization investigation only extended to 16 ft bgs and did not penetrate the confining unit that separates the surficial and lower aquifers. Site characterization efforts and other subsurface investigations at site 45 will not extend beyond 16 ft bgs.

3. Updated Site Characterization and Remedial Design

3.1 Phase I site characterization activities (ER-0632 ISCO Team)

EPA-RSKERC conducted preliminary site characterization activities in 2008 (April 21-25) involving the collection of aquifer cores. The objectives were to (1) obtain aquifer materials for the laboratory studies to be conducted by Washington State University (WSU)), (2) obtain aquifer materials for microbial characterization to be conducted by EPA RSKERC, (3) characterize contaminant distribution at the site by sampling and analyzing aquifer material, (4) establish lithology (sand, silt, clay) and stratigraphy (layering, lenses), (5) assess the presence of NAPL, and/or heavily contaminated sludge and soil near the suspected source area (cracked/leaking sanitary sewer drain pipe), and (6) make a general assessment of accessibility issues.

3.1.1 Aquifer Cores

Aquifer cores were collected along 6 transects (T1-T6) spaced 33' apart along the longitudinal axis of the projected ground water plume (Figure 1). Cores were collected at 3 locations (A, B, and C) along each transect. Core location "B" was collected at the longitudinal axis of the ground water plume. Core locations A and C were located 20' laterally from core location "B". Two-4' cores were collected at each location and extended from approximately 8-16' below ground surface (bgs), (i.e., 8-12' bgs, 12-16' bgs). Aquifer cores were collected in transparent acetate sleeves allowing a visual inspection of the core. These cores were placed on dry ice and transported back to the EPA-RSKERC where they are stored at 4 ^{O}C. The cores were analyzed for VOCs and metals.

A second set of aquifer cores were collected (8-16' bgs) at transect location "B" for transects T1-T6 and provided to WSU. These cores were off-set by 0.5-1' from other cores collected at this location used for VOC and metals analyses.

A third set of cores were collected for microbial characterization along the longitudinal axis of the ground water plume (transect location "B") at transects T1, T3, and T5 (i.e., T1-B, T3-B, T5-B). Again, these cores were off-set by approximately 1' from the cores collected for VOC and metals analyses.

A cement/bentonite mixture (4% bentonite by weight) was pressure injected into each abandoned core locations to seal the exploratory boring as a potential preferential pathway.

3.1.1.1 Visual Inspection of Core Material

Visual inspection of the cores and of the sub-samples collected from the cores revealed two distinct layers. Some of the aquifer material obtained from the 3-8.5' bgs is comprised of light colored sandy material. This material is sometimes overlain by an orange-colored sandy layer. The orange-colored sandy material indicates the presence of oxidized iron (Figure 2). The light-colored sandy material grades into a darker sand material with depth containing greater levels of silt, clay, and organic matter (refer to total organic carbon data below). It is noted that the slug tests reported above did not include the interval of 7-9' bgs. Rather the slug tests were reported for 3-7' and 9-14' bgs. Aquifer cores were collected and analyzed over the entire interval of 8-16' bgs.

3.1.2 CVOC

Aquifer material was collected in a minimum of five sub-cores for each core at the following depths, 8', 10', 12', 14', and 16' bgs. Sub-core aquifer samples (~ 25-40 g dry weight) were extracted with methanol and analyzed for organics via gas chromatography/mass spectroscopy (GC/MS). Total extract samples represent organics found in both the aqueous and solid (adsorbed) phases. Based on a contaminant mass distribution analysis, it was determined that NAPLs were not present in these subsamples. Based on isocontour plan view maps of the VOCs (Figures 3A-3D), the source of total VOCs, PCE, TCE, and c-1,2-DCE in ground water is near the corner of the new dry

cleaner building. The ground water plume originates at the source area and transport of contaminants is to the southeast. These results are consistent with previous investigations which indicate that the source of PCE was from the old dry cleaner facility; the PCE entered the sanitary sewer system and then leaked from cracks in the sanitary sewer located at the corner of the new dry cleaner facility (Vroblesky, 2007; 2008).

The distribution of total VOCs are mostly limited to the 8-12' bgs interval (Figure 4). Based on the general lithology performed for well PAI-45-MW-28D, a loose sand exists at approximately 6-11' bgs (Vroblesky, personal communication, 2009). Further, the loose sand is underlain by a silty sand that extends down to 16' bgs. The loose sand and silty sand are expected to have high and low hydraulic conductivity, respectively. Conceptually, the general interface area between these two zones could represent a lower boundary that limits downward contaminant migration and distribution. Given the source of contamination was introduced above this location, the vertical migration would have been impeded by the silty sand layer. This conceptual model appears to be consistent with ground water samples collected and analyzed in temporary wells collected above and below this zone (Vroblesky, personal communication, 2009).

3.1.3 Total Organic Carbon

Total organic carbon (TOC) was analyzed in the aquifer cores (8-16' bgs) in 0.5-1.0' intervals. These cores were collected for microbial characterization and included transects T1, T3, and T5. The average TOC values were lower in the 8-12' bgs interval than the 12-16' bgs interval (see summary below). A distinct correlation between TOC and depth was not established (Figure 5). These data suggest that there is not a distinct, high organic, lithologic layer in the subsurface. Rather, there is a general increasing trend with depth. The TOC data indicate that the darker color of aquifer material in the deeper cores is attributed to the organic matter which is characteristically dark.

Transect-Location	Interval	TOC (%)	Number of samples analyzed
T1-B	8-12'	0.120	9
	12-16'	0.227	8
T3-B	8-12'	0.112	7
	12-16'	0.259	6
T5-B	8-12'	0.107	10
	12-16'	0.281	6

3.1.4 Metals

The sub cores that were extracted an analyzed for CVOC were also sub-sampled in replicate and analyzed for metals. Sub-samples were extracted with a 10% nitric acid solution and analyzed via inductively coupled argon plasma, optical emission spectroscopy. Due to the large number of samples, the results from these analyses have

not yet been completed. The final results will be incorporated into a later version of this workplan, and in the final report(s).

3.2 Pre-Field Activities

3.2.1 Treatability Study Results Washington State University

Treatment optimization studies were conducted involving Fenton oxidation (catalyzed hydrogen peroxide) and persulfate oxidation (Watts *et al.*, 2008). Experiments were conducted to screen oxidant consumption in the aquifer materials. In these studies, the aquifer material (30 g with groundwater) was amended with phytate, citrate, or malonate (10 mM), and amended with H_2O_2 (4%). In the persulfate oxidation studies, 5-15% persulfate was amended to aquifer material (30 g) under unactivated and activated (iron chelate) conditions. Contaminant and oxidant concentrations were monitored in the test reactors to assess the feasibility and optimal treatment conditions. Peroxygen concentrations were monitored for over three half-lives, and > 99% contaminant loss was the treatment objective. Given this criteria for contaminant loss, the longest oxidant half-life was the metric used for the most effective process condition.

Oxidant (H_2O_2, persulfate) reaction was more rapid in the lower surficial aquifer material relative to the upper surficial aquifer material. The most significant reduction in oxidant reaction was achieved through the addition of the phytate stabilizer. The final process conditions recommended for the field demonstration/validation study are as follows:

Catalyzed H_2O_2. 4% H_2O_2, 50 mM sodium phytate

Persulfate oxidation. 5% Sodium persulfate, 50 mM sodium phytate

3.2.2 Subsurface Utilities

Utility clearance will be completed prior to drilling, following state regulations and utility practices. The Palmetto Utility Protection Service, Inc. (P.U.P.S.) will be notified at 1-888-721-7877 during business hours, at least working three days prior to drilling. They will be requested to have the utilities marked across the entire width of Kyushu Street, including the parking area along the south side of Kyushu Street, from the intersection of Samoa Street and Kyushu Street heading west to midway past Building 192, the Dry Cleaning Facility. The requested area to be marked will also extend 20 ft north from Kyushu Street into the grass and 75 ft south from Kyushu Street into the grass.

The utility clearance ticket(s) will be reviewed by the project team once received from P.U.P.S. The appropriate Marine Corps personnel (in 4/08, this was Capt. Daniel Kuelker, USMC) will also be notified of the utility clearance ticket(s). Once on site, the site will be visually inspected for the utility markings. All project team members and any subcontractors will be fully informed of the utility clearance and markings as part of the health and safety meetings. Site personnel will be asked (again, as follow-up to earlier

useful information provided by them) for any new or additional information on underground utilities or structures. Per state law, no drilling will occur within 2.5 ft on either side of a marked utility line.

3.2.3 Health and Safety Plan

The Health and Safety Plan is Appendix B.

3.2.4 Contact Information for Parris Island Partnering Team (PIPT) and ISCO Team.

Contact information is provided in Appendix C.

3.3 Oxidant and Reagent Injection

3.3.1 Injection Locations, Intervals, and Sequence

Two sub-sites will be used in the peroxygen ISCO demonstration study where stabilized H_2O_2 (SHP) and stabilized persulfate (SP) will be evaluated. There are two test site locations. Site 1 and site 2 are located 5' upgradient from transect locations T1 and T2, respectively (Figure 6). SP will be injected first at site 2. Since SP will persist for longer time frames in the aquifer than SHP, it may potentially migrate downgradient into another study site. For this reason, it will be injected in the downgradient location (site 2). H_2O_2 will react more quickly than SP and is less likely to persist for long periods of time, migrate significant distances, and impact the downgradient SP sub-site. Therefore, SHP will be injected at site 1, upgradient from the SP site.

Oxidants and reagents will be injected across the contaminated interval of 8-12.5' bgs. Screened intervals include 8-10' and 10-12.5' bgs. Narrow screened intervals are used to minimize the potential for preferential pathways to distribute disproportionate volumes of oxidant and reagents into zones of varying permeability.

3.3.2 Injection Wells

3.3.2.1 Injection Well Design and Construction

A line of 3 wells will be located 5' upgradient from transects T1 and T2 (Figure 6). In the SHP test site, injection wells will be constructed with 4" stainless steel (SS) and SS slotted or wire wrapped screens. In the SP test site, injection wells will be constructed with 4" schedule 40 PVC and slotted or wrapped screens. Blank risers will be used for casing.

Injection well pairs will be clustered (not nested) and will be screened 8-10' and 10-12.5' bgs. These well pairs will be constructed side-by-side approximately 1' apart in separate holes. A sandpack will be placed in the annular space resulting from an 8" auger. Sand will be placed in the annular space from the bottom of the screen to 0.5' above the screened interval. A cement/bentonite seal will extend from the top of the sand pack to

the surface. The cement/bentonite grout mixture will be comprised of 4% bentonite (by mass of cement). Injection wells will be completed to the surface with a male quick-connect that is compatible with oxidant injection equipment/nozzles. Wells will be covered by a traffic-rated vault box set in concrete. Wells should be set for 48 hours before they are developed. Well development procedures will use appropriate pump/surge techniques until accumulated sediments have been removed, a minimum of 10 well volumes of water have been removed, and the returned water is clear and free of sediment.

Figure 7 provides a schematic of the well design. Well completion reports and well-development forms will be submitted to the South Carolina Department of Health and Environmental Control, as needed.

3.3.2.2 Oxidant and Reagent Injection Volumes

It is assumed that full contact between the oxidant and the targeted interval will require the injection of 1 pore volume. Each of the 3 well pairs will have an ideal radius of influence (ROI) of 5.5' (Figure 6). The volume of oxidant solution required to achieve 5.5' ROI in 2' and 2.5' screened intervals are 430 and 530 gallons, respectively (Table 1).

Table 1. Volume of oxidant required to achieve specified radius of influence.

Well	Vertical interval(1) (ft bgs)	ROI (ft)	Injected volume/well (gallons)	Total volume(2) (gallons)
Upper	8-10	5.5	430	1290
Lower	10-12.5	5.5	530	1590 Total 2,880

(1) 8-12.5' bgs is partially comprised of the light colored (more permeable aquifer material), and dark colored aquifer material (less permeable aquifer material); hydraulic conductivity decreases with depth.
(2) Three well pairs include two wells per location (upper, lower).

3.3.2.3 Tracer Study

A tracer study will be conducted in one of the proposed injection study areas. A tracer will be injected into one of the clustered injection well pairs. The tracer has not yet been selected but may include (1) phytate, a soluble, mobile H_2O_2 stabilizer, (2) fluorescent dye, or an inorganic such as bromide. The concentration of the tracer will be low, but distinguishable for background. The results of this test will provide information on (1) the rate of fluid injection that can be achieved in the injection well, (2) the radius of influence, and (3) the uniformity of tracer transport. Injection and monitoring wells adjacent to the injection well will be monitored for the tracer.

3.3.3 Peroxygens

3.3.3.1 Catalyzed hydrogen peroxide (stabilized)

The treatability study report indicated that sufficient iron (Fe) exists in the aquifer material to catalyze H_2O_2 reactions. Fe amendment to the subsurface system is not needed. Fenton-driven oxidation is often carried out under acidic pH conditions. However, the laboratory treatability study indicated that pH adjustments were not required in the phytate stabilized H_2O_2 system to achieve significant PCE oxidation and removal. H_2O_2 is stable in a solution containing phytate. Therefore, in the phytate stabilized H_2O_2 injections, a solution of 50 mM phytate and 4% H_2O_2 can be prepared and mixed above-ground, and subsequently injected.

3.3.3.2 Stabilized persulfate

A solution consisting of 5% sodium persulfate and 50 mM sodium phytate will be prepared above-ground and injected.

3.4 Monitoring and Site Characterization

3.4.1 Ground Water Monitoring Wells

A cluster of 2 ground water monitoring wells will be placed at 5 locations per ISCO study site (i.e., 10 wells per ISCO site) (Figure 6).

In the SHP test site, monitoring wells will be constructed with 1” stainless steel (SS) and SS slotted or wire wrapped screens. In the SP test site, monitoring wells will be constructed with 1” schedule 40 PVC and slotted or wrapped screens. Blank risers will be used for casing.

Monitoring well pairs will be clustered (not nested) and will be screened 8-10’ and 10-12.5’ bgs. These well pairs will be constructed side-by-side approximately 1’ apart in separate holes. A sandpack will be placed in the annular space resulting from an 4” auger. Sand will be placed in the annular space from the bottom of the screen to 0.5’ above the screened interval. A cement/bentonite seal will extend from the top of the sand pack to the surface. The cement/bentonite grout mixture will be comprised of 4% bentonite (by mass of cement). Monitoring wells will be completed to the surface and constructed with a cap that can withstand elevated temperature and pressures during SHP ISCO. This could involve threaded male ends with a female threaded cap. Wells will be covered by a traffic-rated vault box set in concrete. Wells should be set for 48 hours before they are developed. Well development procedures will use appropriate pump/surge techniques until accumulated sediments have been removed, a minimum of 10 well volumes of water have been removed, and the returned water is clear and free of sediment.

3.4.2 Monitoring Points

Monitoring points will be installed 20’ laterally (side gradient) from both sides of

the exterior injection wells. These will serve as sentry wells to be used to assess whether the ground water plume shifts laterally as a function of ISCO activities. At each location, monitoring points will be installed using direct push technology.

Monitoring points will be constructed with PTFE tubing, stainless steel GeoProbe screens, and clustered at 8-10' and 10-12.5' bgs. A 1" GeoProbe rod will be driven to depth, an assembly consisting of ¼" stainless steel screen (21" in length), attached to ¼" (OD) PTFE tubing will be inserted into the rod to the bottom. The rod will be removed and the surficial aquifer material will collapse around the screen and PTFE tubing. The upper 3-4' of the hole will be sealed with a cement/bentonite mixture to the ground surface. Wells will be covered by a traffic-rated vault box set in concrete. Wells should be set for 48 hours before they are developed. Well development procedures will use appropriate pump/surge techniques until accumulated sediments have been removed, a minimum of 10 well volumes of water have been removed, and the returned water is clear and free of sediment.

3.4.3 Aquifer Cores

Additional aquifer cores will be collected approximately 15-20' upgradient from transect T1 and will be referred to as T0. Aquifer cores will be collected at approximately the center-line of the ground water plume depicted in Figure 1, and to the adjacent sides approximately 10-15' (i.e., T0-A, T0-B, and T0-C). These cores will be sub-sampled and analyzed using similar handling and analytical methods as previously used.

Post-oxidation aquifer cores will be collected at three locations along the T1 and T2 transects (i.e., locations A, B, and C). Sub-samples of these cores will be collected and analyzed to help assess oxidation performance. Similar steps and procedures will be used to handle, sub-sample, and analyze the sub-cores that was described previously in the Phase I Site Characterization work plan and in Section 3.1, above.

3.4.4 Ground Water Monitoring Plan

The following parameters will be monitored in the injection wells, monitoring wells, and monitoring points (sentry wells) for operational purposes and to assess performance evaluation. The Hydrolab suite include temperature, redox, conductivity, etc. The frequency of monitoring will be determined based on site conditions and system response.

Parameter	Pre-Oxidation	During Oxidation	Post-oxidation
Cations/anions	+	-	+
VOCs	+	-	+
Metals	+	-	+
H_2O_2	-	+	-
Persulfate	-	+	+
Hydrolab suite	+	+	+

3.4.5 Hydraulic Properties

3.4.5.1 Pneumatic Slug tests

Pneumatic slug tests will be performed in all injection and monitoring wells before and after oxidation. Other wells are currently under consideration as candidates for slug testing.

3.4.5.2 Electromagnetic (EM) borehole flowmeter tests

Given the shallow ground water aquifer and limited depth, wells at this site have been constructed with short screened intervals. Short screened intervals are problematic for EM flowmeter testing. Currently, wells have not yet been identified in the south plume area that appear to serve useful for the EM flowmeter. This test procedure is on hold until site wells can be identified, and the overall utility of this test can be re-evaluated.

3.4.6 Vacuum Extraction versus Off-gas monitoring

The shallow water table (3' bgs) provides limited opportunity to construct and operate a vacuum extraction system at this site. Injection of oxidant and reagents will also result in localized mounding in the test areas and will potentially raise the water table into the screened intervals of wells or lateral lines used for vacuum extraction. Further, due to the presence of finer-grained lithologic zones in the upper portion of the surficial aquifer (refer to section 2.2.1, above) it is possible that oxygen gas (O_2(g)) will not rise to the surface in the near injection well vicinity. This suggests that a vacuum extraction system would not effectively capture O_2(g) emissions if the O_2(g) would rise and then be diverted laterally away from the source area.

3.4.7 Investigation-Derived Waste

All soil cores removed from the subsurface will be transported to research laboratories in Ada, OK (EPA-RSKERC) or Pullman, WA (Washington State University). No investigation-derived soil wastes are expected from the soil coring.

The GeoProbe rods will be decontaminated between core locations. This will be performed using two side-by-side containers. Rods will be scrubbed with water in the first container, and rinsed clean with high pressure jet washing in the second container. Rods will have a final rinse with clean water in the second container and laid on racks to dry. CVOC concentrations are expected to be very low in the residual decontamination water. Approximately 20-30 and 70-80 gallons of decon water will be produced during the preliminary and final aquifer coring activities and will be stored in barrels at Site 45. Triplicate samples will be collected from each drum and analyzed at the EPA R.S. Kerr Environmental Research Center. Results will be communicated to Jim Clark who will evaluate whether concentrations are below RCRA action levels. Assuming concentrations are below the action levels, the water will be transported and disposed in

the on-site waste water treatment system at the Parris Island MCRD. If the concentrations are not below the action levels, the waste will be disposed appropriately. Under this condition, input will be requested from the Parris Island Partnering Team regarding guidance on disposal options. An unknown volume of decontamination water will be produced during injection and monitoring well construction. However, the same practice will be followed as described above.

Analytical results from Phase I site investigation indicated that the decontamination water contained very low levels of unregulated contaminants and was not hazardous. Assuming the Parris Island Partnering Team agreed that the decontamination water would likely be uncontaminated during this visit, temporary storage of the decontamination water would not be required and the water could be disposed immediately.

Soil cuttings from the borings will be containerized and stored onsite in 55-gallon drums pending characterization and disposal, if necessary, at an appropriate facility. Wastewater generated during well installation, development, and/or ground-water sampling will include ground water and rinseate from equipment decontamination . This water will be addressed as described above for the GeoProbe coring.

3.5 Injection Events

3.5.1 Persulfate Injection

The 5% sodium persulfate + 50 mM sodium phytate solution will be injected into the upper surficial aquifer (430 gallons; 8-10’ bgs), and in the lower surficial aquifer (530 gallons;10-12.5’ bgs) at each injection location. The oxidant solution will first be injected into all of the upper surficial injection wells, followed by the lower surficial wells. The sequence of injection will be the outside wells first, and the middle injection well last. The total volume injected into the upper and lower surficial aquifer is 1290 and 1590 gallons, respectively. A total of 2,880 gallons stabilized persulfate will be injected into all three wells at two intervals.

The shallow ground water table (3-4’ bgs) results in low hydrostatic pressure to counter balance injection pressures. Therefore, oxidant injection will occur under low pressure and injection will be carefully monitored. Optimistically, the presence of finer-grained lithologic zones in the upper portion of the surficial aquifer may help minimize vertical transport of oxidant. The injection rate will be monitored and adjusted based on conditions observed in the field.

3.5.2 H_2O_2 Injection

The stabilized hydrogen peroxide solution (4% H_2O_2, 50 mM sodium phytate) will follow a similar injection schedule as described for the stabilized persulfate injection schedule and sequence. H_2O_2 injection will occur after the persulfate injection.

3.6 Contingency Plan

3.6.1 Daylighting

If oxidant solution is observed seeping at the ground surface, injection activities will cease and an assessment of site conditions will commence. At a minimum, the exact location of the seeping point will be located. The GeoProbe rig will be moved to the daylighting location, a GeoProbe rod will be advanced through the abandoned borehole to the bottom of the surficial aquifer, and a cement/bentonite mixture will be injected from the bottom-up over the entire surficial aquifer location (0-16' bgs). Sufficient time will be allowed for the cement/bentonite to cure and to form a seal. Adjustments may be made to the injection flow rate and pressure.

3.6.2 Storm water drainage system

The injection of H_2O_2 in proximity to the subsurface storm drains and sanitary sewer has resulted in questions regarding entry of the oxidant into the drains and potential impacts. In general, impacts of H_2O_2 oxidant could include generation of heat and gases, or migration of contaminant vapors or solution to receptors. However, potential impacts of the SHP (H_2O_2) relative to the sewers will be minimized for the following reasons: (1) low concentrations (4%) will be used, minimizing rise in temperature and rapid gas generation, (2) the relatively small oxidant solution volumes used and the distances between the injection wells and the drains will decrease the possibility of oxidant entering the sewers prior to consumption of the oxidant; (3) no combustible materials (such as fuel LNAPLs) have been identified at the site; (4) no mass of CVOC DNAPL has been identified that could be mobilized toward the sewers.

One monitoring well is to be located upgradient of the injection wells between the injection wells and the sewers. This well will be monitored for H_2O_2. If significant H_2O_2 concentrations are detected in that monitoring well, H_2O_2 will be monitored in the water in the storm and/or sanitary sewers. If significant H_2O_2 is detected in the sewers, non-toxic oxidizable material contained in permeable material ("sock") can be placed in the water within the sewer to consume the oxidant before it can move downstream.

4. Schedule

March, 2009. A site visit is planned for the last two weeks in March. During this visit, the aquifer cores (section 3.4.3, above) will be collected near the source area, and four pairs of clustered sentry wells (8 monitoring points total) (section 3.4.2, above) will be installed with the GeoProbe. EPA field support staff and technical staff will be on-site for both the emulsified oil/ZVI study in the original PCE spill area (north plume), and in the secondary source location (south plume).

April-June, 2009. Injection/monitoring well installation, hydrogeologic characterization (pneumatic slug tests), tracer test, baseline ground-water sampling, oxidant injection, process monitoring, post-injection pneumatic slug testing.

Fall, 2009. Post-oxidation ground water monitoring. Pre-oxidation baseline ground water monitoring and pneumatic slug testing, second oxidant injection, pneumatic slug testing, process monitoring.

Spring, 2010. Post-oxidation comprehensive performance monitoring – ground water sampling and aquifer cores.

Summer/Fall, 2010. Final report.

5. Reporting

A final work plan and interim and final reports will be provided to the Parris Island Partnering Team and the ISCO Team for review and comments.

Assuming the PIPT plans to move forward with ISCO at this site, EPA will provide technical support on ISCO design and associated work plans for the successful deployment of ISCO at site 45. Other ISCO team members may also continue their involvement but will be volunteer.

6. References

TetraTech NUS, 2004. Remedial Investigation RCRA Facilities Investigation for Site /WMU 45 Former MWR Dry Cleaning Facility (Contract No. N62467-94-D-0888).

TetraTech NUS, 2005. Remedial Investigation Addendum for Site/SWMU 45 - Former MWR Dry Cleaning Facility Marine Corps Recruit Depot Parris Island, South Carolina Contract Task Order 0335 October 2005.

US EPA, 2008a. Health and Safety Plan for the Field Demonstration and Validation of Peroxygen-Based ISCO for the Remediation of Contaminated Groundwater Using Rational and Mechanism-Based Design at Solid Waste Management Unit 45, Marine Corps Recruit Depot, Parris Island, South Carolina.

US EPA, 2008b. GWERD Quality Assurance Project Plan for Field Demonstration and Validation of Peroxygen-Based ISCO for the Remediation of Contaminated Groundwater Using Rational and Mechanism-Based Design at Solid Waste Management Unit 45, Marine Corps Recruit Depot, Parris Island, South Carolina.

US EPA RSKOP Method 259.1. Determination of Volatile Organic Compounds (Fuel Oxygenates, Aromatic and Chlorinated Hydrocarbons) in Water Using Automated Headspace Gas Chromatography/Mass Spectrometry (TEKMAR 7000 HS-Varian 2100T GC/MS System-ION Trap Detector).

US EPA RSKOP Method 299.0. Determination of Volatile Organic Compounds (Fuel

Oxygenates, Aromatic and Chlorinated Hydrocarbons) in Water Using Automated Headspace Gas Chromatography/Mass Spectrometry (Agilent 6890/5973 Quadrupole GS/MS System)

US EPA RSKOP Method 120.3 Determination of Total Carbon and Total Organic Carbon in Solids using the LECO CR-412 Carbon Analyzer.

Vroblesky, D. 2007. "Preliminary Results: USGS Investigation of Site 45 MCRD, Parris Island, April-July, 2007. Power Point presentation given to the Parris Island Environmental Team on July 30, 2007.

Vroblesky, D. 2008. Progress Report for US Geological Survey FY 2007 Activities and Workplan for FY 2008 Field Activities at Site 45, Marine Corps Recruit Depot, Parris Island, South Carolina. U.S. Geological Survey, 720 Gracern Road, Suite 29, Columbia, SC, 29210-7651.

Watts, R.J., Teel, A.L., Trynka, J.J., Vaughn, R.E., Brown, R.A., Block, P.A., Huling, S.G., Keely, A.A. Field Demonstration, Optimization, and Rigorous Validation of Peroxygen-Based ISCO for the Remediation of Contaminated Groundwater (ER-0632).

Appendix A. Parris Island Site 45 - Site Selection Evaluation
Parris Island Site Selection Evaluation (10/22/2007)

Site/SWMU 45 (Former MWR Dry Cleaning Facility) at the Parris Island Marine Corp Recruit Depot is a candidate site for the in-situ peroxygen study. The following site selection criteria were previously established by the Peroxygen Team and are discussed in context to the SWMU 45 site.

1. **Aquifer characteristics:** Moderate to high permeability is preferred. Sandy material would be ideal. Clay, silty clay, and fractured systems would represent worse case conditions. This will allow sufficient delivery of oxidant and reagents into the subsurface. A low degree of heterogeneity is preferred since this will allow a more uniform distribution of oxidant and reagents. Low organic content is preferred since this may result in significant depletion of the oxidants.

Evaluation: There is a shallow surficial aquifer that extends 17-18' bgs. The shallow unconfined aquifer consists of fine to medium sands. Localized silty, clayey lenses in the surficial aquifer are of limited areal extent and not expected to be functional confining unit. There is a peat layer found at depths of 17-27' bgs that functions as a local confining unit 5.8×10^{-7} cm/s (dh/dl = 0.002-0.003). The average hydraulic conductivity (K) (n=19) is 1.4×10^{-3} (4 ft/day). The average upper and lower K are 8 ft/d and 2 ft/d, respectively. The K in the deep aquifer is 2.1 cm/s $\times10^{-4}$. Hydraulic parameters used in a modeling exercise were Kx, Ky, Kz = 15.3, 15.3, and 3 ft/d; effective porosity = 0.12, total porosity = 0.24, dh/dl = 0.0026, average thickness = 15 ft. This information and data was extracted from the RI report for SWMU 45.

2. **Depth to ground water:** The ground water table should be ∃ 10' below ground surface (bgs) and no greater than 30' bgs. The contaminated zone should be no deeper than 65' bgs. The saturated interval that is being treated will be limited to 30'. This will limit the depth of drilling and well construction materials/costs. A geoprobe will most likely be used to deliver the oxidant and reagents into the subsurface. At depths greater than 70', specialized geoprobe equipment may be required.

Evaluation: The ground water is 3-4' bgs. The water table fluctuates with the tide (0.2-0.6 ft). Refer to the contaminant isopleths maps in the Power Point file prepared by Dr. Don Vroblesky (USGS summary through July07.ppt).

3. **Contaminants:** The contaminants should include chlorinated VOCs. Ideally, the site should contain ethenes such as PCE and/or TCE. These compounds are vulnerable to both oxidative and reductive transformations. Other compounds that are poorly oxidized but show vulnerability to reductive transformations include but are not limited to carbon tetrachloride, chloroform, methylene chloride, 1,1,1-TCA (and associated daughter products) and/or 1,1,2-TCA. A mixture of contaminants from both of these groups would be ideal. This will allow testing the oxidative and reductive treatment capabilities of the peroxygens. The concentration of total VOCs should

approximately be between 0.1 - 10 mg/L. Other contaminants may also be present such as petroleum compounds that are often co-mingled in VOC plumes at DoD sites.

Evaluation: The site is a former dry cleaning operation that involved PCE. Dr. Don Vroblesky at the USGS is involved in some site characterization activity/research at the site and has reported a new ground water plume that appears to be the result of preferential pathways leading from the original source area. It is suggested that we concentrate on the "new" plume area. PCE is present > 10,000 µg/L and TCE, c-DCE, and VC are present at > 1000 µg/L. Refer to the contaminant isopleths maps in the Power Point file prepared by Dr. Don Vroblesky (USGS summary through July07.ppt).

4. **DNAPLs:** The site should not contain large quantities of DNAPL, especially mobile DNAPL. This may not be easy to ascertain. DNAPL removal is an important pretreatment step to in-situ chemical oxidation (ISCO) and would detract from the resources and time on this study. Additionally, excessive DNAPL would make it difficult to accomplish significant mass reduction. Some DNAPL will likely exist at most sites containing CVOC's. Historical information regarding DNAPL handling and releases, site characterization data, and ongoing remedial efforts would be useful to help assess the relative quantity of DNAPL that could be in the subsurface. The technology will likely be implemented in a source area that does not contain large amounts of DNAPL.

Evaluation: On-site soil core samples (n= 31) were tested for DNAPL using a fluorescent light screening method. No information was found in the RI report (Former MWR Dry Cleaning Facility Remedial Investigation/RCRA Facilities Investigation report) suggesting that there was DNAPL present in these cores or in conjunction with other investigations.

5. **pH, alkalinity:** The pH nor alkalinity should be excessively high. Ground water pH < 7 is ideal. Low alkalinity/buffer capacity is ideal and ground water alkalinity data is requested.

Evaluation: Refer to selected data reproduced from Table 5.3 (RI Report) below. The pH ranges from 4.6-5.9 in upgradient, source area, and downgradient wells. Alkalinity ranges from 20-220 mg/L.

6. **Transition metals:** An overabundance of transition metals (excluding Fe) such as Mn is undesirable. This could result in excessive H_2O_2 decomposition and poor distribution in the subsurface. The total Fe oxides should be < than 2% and manganese oxides should be < 0.25.

Evaluation: Refer to selected data reproduced from Table 5.3 (RI Report) below. Mn is < 0.31 mg/L, and ferrous Fe is 0.4 – 19.5 mg/L.

7. **Historical activity:** The site should not be impacted significantly from past remedial or site characterization efforts that may negatively impact the ability to carry

our ISCO. For example, in-situ permanganate oxidation, solvents, surfactants, enhanced bioremediation using reductive dechlorination (i.e., carbon amendments, vegetable oil, HRC, etc.), ZVI, etc. Sites where pump and treat has been implemented is an acceptable remediation technology that could be followed by ISCO.

Evaluation: The "new" plume area has not been impacted by past remedial activities. Previously, in-situ Fenton oxidation was attempted in the source area plume. Apparently there were problems with the monitoring activities associated with performance monitoring and consequently no final report was prepared. Currently, an emulsified ZVI study is underway in the original source area. ISCO activities are not anticipated to disrupt this study whether it is conducted in either the "old" or "new" plume areas. A pump and treat system was previously used at the site but is no longer in operation.

8. **Site characteristics:** The site cannot have significant access limitations regarding the placement of wells, pumps, injection equipment/vehicles, chemical storage vessels, etc. Additionally, the site should not contain significant above- or below-ground utilities that will interfere with the deployment of the technology.

Evaluation: See site photos. There are some storm sewer lines that will need to be located and evaluated. Some of this (if not all) has been done by Dr. Don Vroblesky (USGS) in his effort to assess preferential pathways. There are probably some as-built construction maps that can be obtained and reviewed to help identify the presence of subsurface utilities. There are some above-ground HVAC lines that may present some access limitations. The new plume has migrated under an existing parking lot. Access to this parking lot may have to be restricted during the study if the site is selected.

9. **Location:** Southern half of the US. This criteria is mainly due to the accessibility of the site throughout the year. The oxidation technologies to be investigated in this study could be implemented at sites in the north. However, for the purpose of this study, this could limit site access during freezing weather or snow.

Evaluation: The climate is hot and humid during the summer months and the winters is mild. Beaufort's average elevation is 21 feet above sea level; the highest point in the county is 34 feet above sea level at the base of the Control Tower at the Marine Corps Air Station. The average growing season is 293 days, in a temperature similar to a semi-tropical climate. The winters are moderate, and the summers are hot.

Snowfall is very rare, and electrical storms are common in the summer. The average rainfall is 49.9", while the average annual humidity is 75%. The mean high temperature is 76.5 degrees Fahrenheit, and the mean low is 57.2 degrees Fahrenheit.

General Observations: The site is on the US Marine Corp Recruit Depot. Access to the base will require that you pass through a security gate and identify the purpose of the visit. You will be given a pass to put on the vehicle. The site is bounded by streets on the north and east sides, by a new dry cleaner operation on the west, and by a parking

lot on the south. There is a lot of activity at the site in the form of cars, trucks, buses, pedestrians (Marine Corp., pre-schoolers, tourists). The US Marine Corp. museum is across the street

Electricity (115V) exists on the site and is accessible in the “pumping” building and possibly at each of 3 well houses. Fresh water is available across the street (perhaps closer) and is available for on-site use via a hose.

Selected Data from Table 5-3 in the RI report are reproduced below.

Analysis	**Units**	**MW01SU**	**MW04SU**	**MWO5SL**	**MWO6SU**	**MW08SU**
Well Location		Upgradient	Far Downgradient	Far Downgradient	Near Downgradient	Source Area
pH	SU	5.18	4.56	5.1	5.9	5
Spec. Cond.	mS/cm	0.36	0.452	1.19	7.22	0.43
Temperature	oC	22.3	23	24.2	23.3	21.4
Turbidity	NTU	3.5	4.5	4.09	1.64	2.06
DO, meter	mg/L	4.18	5.98	5.82	4.88	5.26
DO, test kit	mg/L	2-3	2-3	2-3	4-5	3-4
Oxid./Red. Pot.	mV	-10	138	-35	-53	27
Carbon Dioxide	mg/L	25	48	45	30	150
Sulfide	mg/L	0	0	0.02	0	0
Alkalinity	mg/L	160	<20	30	220	110
TOC	mg/L	22	8.4	10	23	51
Chloride	mg/L	9	100	300	2000	30
Manganese	mg/L	0.023	0.014	0.308	0.081	0.014
Ferrous Iron	mg/L	2.49	0.43	19.5	11.4	14.5
BOD	mg/L	<24	<6	<6	<6	<24
COD	mg/L	30	<15	20	50	50
Methane	mg/L	0.097	0.12	3	0.43	0.9
Ethane	mg/L	ND	ND	ND	ND	0.019
Ethene	mg/L	ND	ND	ND	ND	ND
Tetrachloroethene	ug/L	ND	6	9	200	10000
Trichloroethene	ug/L	ND	1	1 9	120	10000
cis-1,2-DCE	ug/L	ND	2	1	1400	3400
Vinyl Chloride	ug/L	ND	1	ND	630	710

Appendix B. Health and Safety Plan (HASP)

The Health and Safety Plan (US EPA, 2008a) prepared for this project will be implemented during field activities at this site scheduled for March, 2009. The draft HASP which addresses a larger set of field activities including well installation and oxidant injection activities is in preparation. This revised HASP will be provided to the EPA RSKERC Health and Safety Manager for approval before field activities commence. The HASP will be provided to the Parris Island Partnering Team and all field personnel when it has been approved by the EPA RSKERC Health and Safety Manager.

Appendix C. Contact Information for Parris Island Partnering Team (PIPT) and ISCO Team.

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