

Final Pilot Test Work Plan Installation Restoration Site 14

Alameda Point
Alameda, California

Contract No. N68711-02-D-8213
Task Order 0026
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Prepared for:



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Program Management Office West
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October 2007

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ALAMEDA POINT, ALAMEDA, CALIFORNIA

FINAL

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ACRONYMS AND ABBREVIATIONS

µg/L	micrograms per liter
AST	above-ground storage tank
bgs	below ground surface
CTO	Contract Task Order
CAA	corrective action area
DO	dissolved oxygen
DOC	dissolved organic carbon
DPT	direct-push technology
DTSC	(California) Department of Toxic Substances Control
EPA	United States Environmental Protection Agency
FFA	Federal Facility Agreement
FTA	Firefighter Training Area
FWBZ	first water bearing zone
GAP	generator accumulation point
gpm	gallons per minute
HSP	Health and Safety Plan
ICs	Institutional Controls
ID/IQ	Indefinite Delivery/Indefinite Quantity
IDW	investigation-derived waste
IR Site 14	Installation Restoration Site 14
ISCO	in situ chemical oxidation
ITRC	Interstate Technology and Regulatory Council
ITSI	Innovative Technical Solutions, Inc.
MSDS	Material Safety Data Sheets
NAS	Naval Air Station
Navy	United States Department of the Navy
NOD	natural oxidant demand

ACRONYMS AND ABBREVIATIONS, CONTINUED

ORP	oxidation-reduction potential
PID	photoionization detector
PPE	personal protective equipment
psi	pounds per square inch
PSOD	permanganate soil oxidant demand
PVC	polyvinyl chloride
RA	Remedial Action
RD	Remedial Design
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
ROI	radius of influence
ROICC	Resident Officer in Charge of Construction
RWQCB	Regional Water Quality Control Board, San Francisco Bay Region
SAP	Sampling and Analysis Plan
SOD	soil oxidant demand
SWMU	solid waste management unit
USA	Underground Service Alert
VC	vinyl chloride
VOC	volatile organic compound
WP	Work Plan

1.0 INTRODUCTION

Innovative Technical Solutions, Inc. (ITSI) prepared this Pilot Test Work Plan (WP) for remediation of a portion of the vinyl chloride (VC) groundwater plume located within the boundaries of Installation Restoration Site 14 (IR Site 14) at Alameda Point, in Alameda, California (Figure 1). This work is being conducted under the Indefinite Delivery/ Indefinite Quantity (ID/IQ) Contract Number N68711-02-D-8213, Contract Task Order (CTO) 0026, for the United States Department of the Navy (Navy) Naval Facilities Engineering Command, Southwest Division, San Diego, California.

The guiding document for the site cleanup is the *Final Record of Decision, Site 14, Alameda Point, Alameda, California* (ROD; Navy, 2007), dated January 31, 2007, and signed by the Navy, the U.S. Environmental Protection Agency (EPA), the California Department of Toxic Substances Control (DTSC), and the Regional Water Quality Control Board, San Francisco Bay Region (RWQCB). The pilot test will provide information that will support the development and optimization of a remedial design (RD) for the vinyl chloride contaminant plume. A Remedial Design/Remedial Action Work Plan (RD/RAWP) (ITSI, 2007b) will describe the activities that will be undertaken to implement the remedy selected in the ROD for IR Site 14, and to attain and maintain requirements identified in the ROD. A Site-Specific Accident Prevention Plan (APP) with Health and Safety Plan (HSP) has been prepared as a stand-alone document that will support the pilot test field work.

2.0 SITE HISTORY

This section briefly summarizes site background information for IR Site 14. The Final Remedial Investigation (RI) and Feasibility Study (FS) Reports (Tetra Tech Environmental Management, Inc. [TtEMI], 2003a and 2003b, respectively) contain more details regarding the site.

The U.S. Army acquired the original base property from the City of Alameda in 1930 and began construction activities in 1931. In 1936, the Navy acquired title to the land from the U.S. Army and began building Naval Air Station (NAS) Alameda in response to the military buildup in Europe before World War II. Construction of the base included several iterations of filling tidelands, marshlands, and sloughs with materials dredged from San Francisco Bay, the Oakland Inner Harbor, and Seaplane Lagoon. The base was operated as an active naval facility from 1940 to 1997. Historically, operations included aircraft, engine, gun, and avionics maintenance; fueling activities; and metal plating, stripping, and painting. The Navy operated two power plants, a transportation shop, and a pesticide shop. The base had a deepwater port capable of berthing aircraft carriers and a fuel-distribution pipeline network that transported aviation and diesel fuel to various areas on the base (TtEMI, 2003a).

IR Site 14 is approximately 14.4 acres in size and is located in the northwestern section of Alameda Point (Figure 2). The northern boundary of IR Site 14 is adjacent to the Oakland Inner Harbor and the southern boundary is located north of former Runway 7/25. The site was used for storage of airfield-related materials and equipment, with the northwestern portion of the site used for firefighter training activities. The site was originally designated as an Installation Restoration (IR) site based on concerns related to the fire-training activities; petroleum-related constituents in soil were the primary concern. Subsequent investigations revealed the presence of chlorinated solvents in groundwater, and these solvents are the current focus of the groundwater investigation and proposed remediation at the Site (Navy, 2007).

IR Site 14 is primarily open space and is partially paved, with a generally flat topography. The site currently includes five buildings (Buildings 26, 120, 121, 122, and 388); two closed above-ground storage tanks (ASTs) (96A and 96B) that contained nonpotable water; petroleum corrective action area (CAA)-2, which is the administrative unit designating the location of contamination from former underground storage tank (UST) FS-1; and several storm and

sanitary sewer lines. IR Site 14 also contains multiple solid waste management units (SWMUs): former generator accumulation points (GAPs) 9 and 11; washdown area (WD) 528; and petroleum-related SWMUs Area of Concern (AOC) 357, AST-179, and AST-528.

The Firefighter Training Area (FTA) was constructed between 1973 and 1979 and included a concrete pad surrounded on three sides by an earthen berm. ANSULITE® fire-fighting foam, carbon dioxide, potassium chloride, and Purple K (a dry-chemical extinguishing agent) were used to extinguish training fires. A sump was located in the northeastern corner of the concrete pad within the Firefighter Training Area. The sump apparently was used to collect runoff from fire training activities. The fire department stopped burning in the area circa 1986 (Shaw, 2004). The buildings at IR Site 14 are currently vacant, and access to the site is restricted (Navy, 2007).

In March and April 2007, ITSI conducted a Data Gap Investigation in the area of previously identified groundwater contamination in IR Site 14. The primary objective of the Data Gap Investigation was to collect additional groundwater characterization data to support development of remedial design. This investigation provided additional vertical and horizontal lithologic and groundwater chemical data, which showed slight expansion of the vinyl chloride contaminant plume since the RI was conducted (RI samples were collected in 1998-2001), and defined the depth of contamination to within the depth interval of approximately five to 20 feet below ground surface (bgs) across the contaminant plume. The current vinyl chloride plume is shown on Figure 3. The results of the Data Gap Investigation are presented in Appendix F of the Remedial Design/Remedial Action Work Plan (ITSI, 2007b).

3.0 IN SITU CHEMICAL OXIDATION TECHNICAL SUMMARY

In situ chemical oxidation (ISCO) involves the introduction of a chemical oxidant into the subsurface in order to transform groundwater or soil contaminants into less harmful chemicals. In general, the injected oxidant is reduced by accepting electrons released from the transformation (oxidation) of target and non-target reactive species. There are several chemicals that might be used in an ISCO procedure to remediate the vinyl chloride plume at IR Site 14. These include Fenton's reagent, ozone, sodium persulfate, and sodium or potassium permanganate. A good overview of these options can be found in *Technical and Regulatory Guidance for In Situ Chemical Oxidation of Contaminated Soil and Groundwater, Second Edition* (Interstate Technology and Regulatory Council [ITRC], 2005). The primary reagent chosen for this site is potassium permanganate. The advantages of potassium permanganate (KMnO₄) include:

It is known to be effective against the contaminant of concern, vinyl chloride.

The strong color of even dilute solutions of KMnO₄ is easily seen in groundwater and soil samples, allowing for relatively easy assessment of the distribution of the oxidant in the subsurface.

It has a relatively slow rate of reaction, which makes it persistent and allows for significant transport distances during injection delivery to medium- and high-permeability materials.

It is relatively safe to handle.

Contaminant oxidation by MnO₄⁻ occurs by electron transfer, which is slower than the H₂O₂ reaction and radical attack characteristic of Fenton oxidation. In addition to allowing for significant transport distances, this slower reaction time contributes to diffusive transport of MnO₄⁻ into low-permeability materials.

Potassium and sodium permanganate have a unique affinity for oxidizing organic compounds containing carbon-carbon double bonds, aldehyde groups, or hydroxyl groups. The reaction between KMnO₄ and dissolved vinyl chloride is as follows:



The by-products of the reaction are carbon dioxide, manganese dioxide, water, and potassium, chloride, and hydroxyl ions. These species are either considered to be innocuous or are readily rendered so by reactions with normal subsurface materials.

Many naturally occurring reactants other than the target contaminant(s) also react with permanganate, imposing a background oxidant demand. This natural oxidant demand (NOD) reduces oxidation efficiency as far as remediation of the contaminant plume, and is generally greater than the demand imposed by the target compound(s). Non-target reactants mainly include organic matter and reduced chemical species (e.g., ferrous, manganous, and sulfidic species; see *In-Situ Chemical Oxidation, Engineering Issue*, [EPA, 2006]). It is thus necessary to evaluate the site-specific natural oxidant demand, also called the soil oxidant demand (SOD), to determine the total amount of oxidant that needs to be delivered to provide a sufficient quantity still available to react with the target contaminant.

As part of the Data Gap Investigation, five IR Site 14 soil samples were submitted to Carus Corporation in April of 2007 for Permanganate Soil Oxidant Demand testing (PSOD). The measurement of PSOD is used to estimate the concentration of permanganate that will be consumed by the natural reducing agents as well as the contaminants of concern in the soil during a given time period. The Remediation Report from Carus Corporation is attached as Appendix B.

The soil samples were collected from the borings for M14-04, M14-06, and 14HP18, at depths ranging from five to 15 feet bgs. The samples were tested using low (3 g/kg), medium (15 g/kg), and high (30 g/kg) doses of permanganate solutions for 48 hours. The PSOD results for the samples ranged from 1.1 (low dose) to 26.3 g/kg (high dose), depending on the sample and dose. PSOD results below 15 g/kg are considered by Carus to be low, and results between 15 and 35 g/kg are considered to be moderate. Only one of the five IR 14 soil samples had a PSOD in the moderate range, with the other four samples in the low range. Generally, sites with a PSOD of less than 35 g/kg at 48 hours for the high permanganate dose are favorable for ISCO remediation with permanganate, and IR 14 clearly falls within this recommended range. One of the soil samples, 14HP18-15-16, was from just outside (below) the contaminant plume; the PSOD result from this sample fell toward the lower end of the range, at 3.8 g/kg.

Although potassium permanganate has been identified as likely to be an effective reagent for ISCO treatment at the site, physical conditions of portions of the site call for additional alternatives to be considered. Three storm drain corridors intersect parts of the northern portion of the plume, and could constitute preferential pathways that could potentially allow permanganate reagent to migrate to the Oakland Inner Harbor (see Figures 3 and 5). Potassium permanganate, being a highly visible purple color even at low concentrations, would appear in the harbor water even at relatively low levels; as a result, another oxidant will be considered for those portions of the plume nearest the harbor. This second ISCO reagent, sodium persulfate with an alkaline activator (sodium hydroxide or calcium peroxide), will be tested in a different part of the plume as part of this pilot study.

Sodium persulfate dissociates in water to form a persulfate anion ($S_2O_8^{2-}$) which is a strong oxidizer but is kinetically too slow to destroy a significant portion of the contaminant during the life of the oxidant in the subsurface. An alkaline activator, when mixed with the sodium persulfate, raises the subsurface pH to greater than 11, and causes the persulfate ion to form the sulfate radical ($\cdot SO_4^-$), which is a more powerful oxidant. The generation of sulfate radicals can be represented by the general equation



(Block et al., 2004), where the dot indicates an unpaired electron, which makes the radical highly reactive. The sulfate radical is one of the strongest aqueous oxidizing species, with a redox potential estimated at 2.6 V, similar to that of the hydroxyl radical, 2.7 V (EPA, 2006).

4.0 PILOT TEST OBJECTIVES

The objectives of the pilot test are to:

- Collect site-specific field data (including pumping rates and pressures, radius of influence [ROI], and injection methods) relating to the ability to distribute potassium permanganate throughout the target plume volume near the contaminant source area.
- Evaluate the effectiveness and suitability of permanganate for ISCO for full-scale remediation of the IR Site 14 VC plume.
- Collect hydraulic conductivity data from wells located across the site, to determine if data collected from the pilot test can reasonably applied to other areas of the site. These data will also allow verification of whether calculations of groundwater travel times toward the Oakland Inner Harbor based on information from the RI (TtEMI, 2003a), which indicated average groundwater velocity of 70 feet/year, are accurate.
- Collect hydraulic conductivity data from areas not currently monitored by wells, for preliminary evaluation of the potential risk that a full-scale ISCO application of permanganate could result in permanganate reaching the Oakland Inner Harbor.
- Evaluate the persistence of injected permanganate in site groundwater.
- Determine the volume and concentration of permanganate to be used in the full scale ISCO.
- Collect site-specific field data (including pumping rates and pressures, and radius of influence [ROI]) relating to the ability to distribute sodium persulfate with a sodium percarbonate activator throughout a target volume in a portion of the plume.
- Evaluate the effectiveness and suitability of sodium persulfate with a sodium percarbonate activator for full-scale ISCO remediation of at least a portion of the IR Site 14 VC plume.
- Evaluate the short-term persistence, in the site's groundwater, of both sodium persulfate and the high pH required for the formation of the sulfate radical.

Another objective is to gather information to determine oxidant loading for persulfate injection. Soil oxidant demand for permanganate was tested during the Data Gap Investigation, but persulfate was not under consideration at that time. Persulfate was

added later, since recognition of the presence of the storm drains, and soil oxidant demand for persulfate is needed. Testing is currently underway (late September), with the results expected before the scheduled injection of persulfate. The testing is being performed on two soil samples from the area to be injected with persulfate, including a sandy sample and a silty-clayey sample. This testing consists of analyzing (a) soil buffering capacity, and (b) persulfate soil oxidant demand. For effective generation of free radicals by alkaline activation, pH must attain a value of 11 or higher. We should note that percarbonate, specified in the Draft Work Plan as an activator for persulfate, was tested in this effort, and was ineffective in raising soil pH to the requisite value of 11. As alternative activating agents, sodium hydroxide and calcium peroxide are being tested; early results show that both compounds are capable of raising pH to the required minimum of 11. One of these two activators will be used in combination with persulfate; both activators have a successful record of use with persulfate in ISCO applications. The persulfate soil oxidant demand will yield the amount of persulfate that needs to be injected during the pilot test.

5.0 FIELD ACTIVITIES

This section discusses the field tasks to be completed as a part of the pilot test. Most sampling and data collecting tasks for the pilot test are governed by the Data Gap Investigation Sampling and Analysis Plan (SAP) (Appendix A of ITSI, 2007a). For the pilot test, several revisions to that SAP were needed, and these are gathered in an addendum referred to as SAP Addendum #1 to the Data Gap Investigation; this SAP Addendum is included as Appendix A of this Work Plan. Both these documents are cited below where appropriate.

5.1 UNDERGROUND UTILITIES CLEARANCE

Before drilling at any boring or well locations, all locations will be checked for utilities by reviewing utility drawings (provided by the Navy), notifying Underground Service Alert (USA), and conducting independent geophysical surveys. These activities will be closely coordinated with the Navy ROICC. The proposed well and soil boring locations may be relocated as necessary to avoid any surface or subsurface structures. All boring locations will be located at least 24 inches away from active underground utilities.

Proposed boring locations will be marked out on the ground with white paint or staked, to identify the location for underground utility clearance. Underground Service Alert (USA) will be notified a minimum of two working days prior to drilling so that utility companies can mark underground conduits and pipes near the marked locations. Each boring location also will be cleared by an independent utility locating or geophysical survey subcontractor using surface geophysical methods to identify possible subsurface obstructions within a 10-foot radius of each proposed location. Geophysical methods may include electromagnetic induction, geomagnetics, ground-penetrating radar, or a combination of methods. Suspected underground utilities will be marked on the ground with color-coded marking paint in accordance with American Public Works Association standards.

5.2 PRE-INJECTION SOIL AND GROUNDWATER SAMPLING

The permanganate pilot test area is located within the contaminant source area, located in the southern part of IR Site 14, centered approximately 20 feet north of well M101-A (see Figure 4). This area was selected for the pilot test because it contains the highest vinyl chloride groundwater concentration (390 µg/L at location 14HP01 [see Figure 4]) reported in the Data

Gap Investigation (Appendix F of ITSI, 2007b). Samples collected during the Data Gap Investigation showed that vinyl chloride contamination in this area was limited primarily to the five- to 10-foot bgs depth interval. However, more-detailed information on soil and groundwater concentrations of vinyl chloride in the pilot test area needs to be collected to verify treatment effectiveness throughout the subsurface volume targeted for the pilot test. Accordingly, soil samples will be collected from four direct-push soil borings before and after oxidant injection (borings 14SB01 through 14SB04). These locations are as follows: four borings, each within 18 inches of wells M101-A, M14-04, and M14-05, and a temporary well (TMW14-01) (temporary well to be installed about 12 feet north of the area of injection; see temporary well installation discussion below).

The location of the injection zone (an approximately three-foot circular area) for the permanganate part of the pilot study was chosen to make use of existing wells to monitor the radius of influence of the oxidant as effectively as possible. The existing wells are located at approximately five, 18, and 23 feet from the injection zone. The temporary well will be sited to provide data at a distance of about twelve feet from the injection zone, which fills the gap between five and 18 feet (see Figure 4).

The persulfate test area is located within the north-central part of the IR Site 14 contaminant plume, near the site of boring 14HP06. This area was chosen because of the significant VC result (180 ppb at eight to 10 ft. bgs.) in a hydropunch sample collected during the data gap investigation; its location away from the storm drain corridor some 80 feet to the west; and its location sufficiently far from the permanganate test area, such that it will be unaffected by those activities. The location of persulfate injection (an approximately three-foot circular area) will be six, 12 and 20 feet, respectively, from temporary monitoring wells TMW14-02, TMW14-03, and TMW14-04 (see Figure 5). Up to three soil samples (total) will be collected from these borings and submitted for laboratory analysis of the soil pH buffering capacity.

5.2.1 Temporary Well Installation

The temporary wells (TMW14-01 through TMW14-04) will be two-inch PVC wells installed by hollow-stem auger. The wells will be screened (0.010 slot) from six to 11 feet bgs with a Type 2-12 sand filter pack, with a bentonite chip seal to the surface. The auger flights will be used to tremie the filter pack and bentonite into place as the augers are withdrawn. The bentonite will be

hydrated with five gallons of water and allowed at least one hour of hydration time prior to well development. Development will be performed using the surge-and-pump or the surge-and-bail method, on the same day as well installation, since there is no concern with unset grout. The wells will be installed and developed at least two days prior to the pilot test injection event. Locations of all of the soil and groundwater sampling locations for this Work Plan are shown on Figures 4 and 5.

Following completion of all monitoring and sampling events for the pilot test, the four temporary wells will be removed and the boreholes will be backfilled with cement-bentonite grout, or converted to permanent wells.

5.2.2 Groundwater Sample Collection Methods

As specified in the SAP Addendum (Appendix A), groundwater from the three existing monitoring wells and four temporary wells within 25 feet of the injection zones will be sampled before oxidant injections (once) as well as after (four times). Water-level data and field parameters will also be collected from the wells (see Section 5.4).

Groundwater samples will be collected with a bladder pump (or equivalent) and dedicated sample tubing utilizing “low-flow” sampling techniques, as specified in Section 2.2.8 of the Data Gap Investigation SAP (Appendix A of ITSI, 2007a). Groundwater samples will be analyzed for VOCs and for dissolved chromium and nickel, as listed in Table A-3 of SAP Addendum 1 (Appendix A of this document). VOCs encompass the target compound (vinyl chloride) and will be sampled to gauge the progress of remediation at various times after injection. In the first and last events sampling only, metals will be sampled because of their potential for increased mobility under the altered pH (acidic for the permanganate injection, alkaline in the case of persulfate) and/or oxidizing conditions generated under ISCO remediation. Purge stabilization criteria for groundwater sampling are listed in Section 1.4.4 of SAP Addendum 1, and details of sampling procedures, labeling, and custody will follow the original SAP (Appendix A of ITSI, 2007a). Note that previous sampling has shown this area to have variable redox conditions; therefore, if DO and ORP do not stabilize during purging, then the “well-volume approach” described in Yeskis and Zavala (2002) will be used to determine when sampling can be performed.

5.2.3 Soil Sample Collection Methods

Soil samples will be collected before and approximately two weeks after the pilot test oxidant injection, to evaluate the ROI and the effectiveness of oxidant injection in remediating vinyl chloride. Soil samples will be collected using a direct-push rig that employs five-foot-long acetate tubes inserted within the first rod and driven into undisturbed soil in the borehole. Retrieval of the sampling tube after advancement of each five-foot rod allows collection of continuous soil samples.

Soil samples will be analyzed for VOCs by EPA Method SW8260B, and for manganese by EPA Method 6010B. VOCs encompass the target compound, and will be analyzed to gauge the progress of remediation; manganese will be analyzed because the formation of manganese oxides in the treatment area could signify a decrease in pore space in the aquifer. At depths of five, seven, and nine feet bgs, a representative portion of the soil sample will be collected from the soil tube using an EnCore® sampling device. Three EnCore® sample containers are required to provide sufficient matrix to analyze samples for VOCs. Because vinyl chloride, a highly volatile gaseous compound, is the compound of primary concern, exposure to the atmosphere will be minimized before and during VOC sample collection, particularly because vinyl chloride, a highly volatile gaseous compound, is the compound of greatest concern. Soil volumes for the other parameter, manganese, will then be collected using inert sampling tools and placed in one 8-ounce glass sample jar. Alternatively, soil samples for manganese may be left in the acetate tubes (cut to approximately 4-inch lengths), covered with Teflon sheets and capped with PVC end caps for sample shipment.

Soil sample containers and preservation requirements, are presented in Table A-6 of the SAP Addendum (Appendix A). Soil samples will be labeled in accordance with the sample numbering and labeling procedures described in Sections 2.3.2 and 2.3.3 of the Data Gap Investigation SAP (Appendix A of ITSI, 2007a). Following labeling, samples will be placed in re-sealable plastic bags and placed on ice in an insulated cooler for transportation to the laboratory. The chain of custody procedures described in Section 2.3 of the SAP will be utilized. A chain of custody form is presented with the field forms in Attachment 1 of the SAP. Decontamination procedures for equipment and materials used during soil sampling are presented in Section 2.2.12, of the SAP.

Soil samples for VOCs will be taken using En Core® Samplers, as follows:

1. Assemble the En Core® sampler by holding the coring body and pushing the plunger rod down until the small o-ring rests against the tabs. Depress the locking lever on the En Core® T-handle and place the plunger end of the coring body into the open end of the T-handle. Align the two slots on the coring body with the two locking pins in the T-handle. Twist the coring body clockwise to lock the pins in the slots. Finally, check to ensure that the coring body is locked in place.
2. Collect the En Core® sample by grasping the T-Handle with the open end of the coring body facing the soil sample. Using the T-Handle, push the sampler into soil until coring body is completely full. The coring body is full when the small o-ring is centered in the viewing hole in the T-Handle. Remove the Sampler from the soil and remove excess soil from the exterior of the coring body. Push and twist cap on the exposed end of the coring body until the ridges on the coring body snap into the grooves of the cap. Check to ensure that cap is properly secured.
3. Prepare the sample for shipment by removing the T-Handle from the En Core® Sampler by depressing the locking lever on T-Handle and then twist and pull the En Core® Sampler from T-Handle. Lock the plunger by rotating the extended plunger rod fully counter-clockwise until the wings rest firmly against the tabs. Attach the completed circular label to the cap of the coring body. Return the full En Core® Sampler to the zipper bag. Seal the bag and immediately place the bag in an ice chest filled with ice.

5.3 OXIDANT INJECTION

Potassium permanganate will be delivered to the site in 55-pound buckets. The drilling contractor will mix the oxidant in a tank with tap water delivered by truck to the site. A direct-push drill rig will be used to advance an injection point to 10 feet bgs. The rods will then be withdrawn to expose five feet of screen (the bottom-up method; the top-down method may be tested later; see Section 5.4). The driller will pump a 3% solution of potassium permanganate from the mix tank to the injection point. Injection flow rates, volumes, and pressures will be recorded. If it is not possible to inject permanganate at a reasonably sufficient rate (about 3 gpm) at a single injection point, two or three additional points may be driven into the injection zone (a

circular zone of about three feet in diameter) and employed as injection points. The anticipated volume to be injected is about 870 gallons containing 225 pounds of KMnO_4 , based on the site's average PSOD of 2.4 g/kg (the low-dose PSOD, because KMnO_4 is injected at low concentrations of approximately 3%), average VC concentration of about 75 $\mu\text{g/L}$ in groundwater, 30% soil porosity, and an estimated radius of influence of approximately 15 feet (see Appendix D, Carus Oxidant Calculator Worksheet). Several of these parameters are not well constrained, and could easily differ from those listed by factors of two or three.

Specifically, the effective PSOD (as opposed to the laboratory-determined value) and the radius of influence are prone to uncertainty until after the pilot test is completed; these parameters greatly affect how much oxidant will ultimately be required to remediate the overall plume.

After the injection event, the injection hole(s) will be grouted to the surface with cement-bentonite grout. The location(s) will be marked for later surveying by a state-licensed land surveyor.

Sodium persulfate and sodium percarbonate will both be delivered to the site in 50-pound bags. The drilling contractor will mix the oxidant and activator in a tank with tap water delivered by truck to the site at a mix ratio of approximately 1:1 (see following paragraph). A direct-push drill rig will be used to advance an injection point to six to 11 feet bgs. The results of the permanganate injection and the boring logs from the temporary well installation will be used to guide the selection of injection method (top-down or bottom-up) for the persulfate injection.

The anticipated injection mass of persulfate is approximately 640 pounds (310 gallons solution at 20% persulfate in water), based on the PSOD results from the soil samples sent to Carus Corporation's laboratory, soil volume and contaminant mass. (Typically, according to FMC technical representatives, the NOD for persulfate is lower than that of permanganate. However, for a conservative estimate of the amount of reagent needed, the value employed for persulfate NOD was the same as that for permanganate.) The mass of sodium percarbonate to be injected is anticipated to be about 640 pounds (310 gallons solution at 20% percarbonate in water) based on typical pH buffering capacity of soils in general. As noted in Section 5.2, up to three soil samples will be collected and analyzed for pH buffering at the start of field operations. These results will be used to adjust the quantity of sodium percarbonate used in the injection event.

5.4 EFFECTIVENESS MONITORING

Determination of the radius of influence (ROI) of the injected oxidant solutions is one of the primary objectives of this pilot test. The best ROI indicator in the permanganate test area is the presence or absence of permanganate, which is readily detected by visual inspection of soil or groundwater samples. A second indicator is groundwater mounding (i.e., a roughly circular area with groundwater elevations higher than surrounding areas), indicating a hydraulic connection between the injection zone and nearby monitoring wells. Water levels in the five wells near the injection zone (the four wells listed above plus M14-06, located approximately 45 feet from the injection location) will be recorded just before and after the injection of permanganate. These wells will be capped during the actual injection to prevent oxidant surfacing through the well casings. Similar monitoring of water levels will be performed in the temporary wells near the persulfate injection zone.

Within an hour or two of the permanganate injection event, a set of soil cores will be collected in a line extending northwest from the zone of injection. The first core will be collected three feet northwest of the northwest edge of the injection zone. The core will be visually inspected for evidence of permanganate infiltration at all depths from the surface to 12 feet bgs. If permanganate is found in any part of the core, the rig will be stepped out by 3 to 5 feet, depending on degree of permanganate saturation, and another soil core will be collected. This process will be continued until the ROI can be determined by finding a core with no visual evidence of permanganate. If no permanganate is observed in the first core, a step-in boring will be completed closer to the injection zone. A second set of visual-inspection cores stepping northeast from the zone of injection will then be collected. The step-out distance for the first core of this second set will be guided by the results from the first set of cores. Additional cores may be collected if, for example, the results from the first two sets of cores yield contrasting values for the ROI.

If the soil cores indicate that the permanganate has spread along a preferential stratum and left significant areas of the contaminated interval untreated, a top-down injection method will be used to attempt to deliver oxidant preferentially to the untreated zones. Top-down injection involves injection at a single point rather than through a screened interval, as is the case for the

bottom-up method. If top-down injection is performed, an additional set of visual soil cores will be collected, in the manner described above, to assess the effectiveness of the top-down method.

After the ISCO injection event, wells M101-A, M14-04, and M14-05 and TMW14-01 will be monitored periodically for water levels, DO, ORP, temperature, conductivity, pH, and dissolved permanganate by spectrophotometer. Temporary wells TMW14-02, TMW-03, and THW-04 will be monitored for water levels, DO, ORP, temperature, conductivity, pH. This monitoring will be done daily for about one week; then three times a week for two weeks; once in week four; and once in week eight. In addition, groundwater samples will be collected from the four wells at one, two, and four weeks after the ISCO injection event, and analyzed for VOCs. At the four week sampling event, samples will also be submitted for analysis of total and dissolved metals (chromium and nickel).

Two weeks after the ISCO injection event, a second set of analytical soil samples will be collected near the permanganate injection zone, by the direct-push method at points located within 18 inches of the four pre-injection soil sampling points (also approximately 18 inches from the three monitoring wells and one temporary well). The soil samples will be collected at the same depth intervals and analyzed for the same parameters as the pre-injection set of soil samples. Additionally, the soil will be visually inspected for evidence of permanganate. This soil sampling event will be timed to coincide with the two-week groundwater sampling event.

The proposed sampling/monitoring schedule for the ISCO pilot test is presented in Table 2. This schedule is subject to revision based on field conditions and reporting schedule requirements. Soil samples will be analyzed for VOCs by EPA Method 8260B and for metals (manganese only) by method 6010B/6020. Groundwater samples will be analyzed for VOCs by EPA Method 8260B and for total & dissolved metals (chromium and nickel only) by method 6010B/6020.

5.5 HYDRAULIC CONDUCTIVITY TESTING

A significant issue at IR Site 14 is the risk of an unidentified preferential pathway between the full-scale ISCO treatment zone and the harbor. One way of addressing this issue, in addition to historical research, is to collect and compare data on hydraulic parameters at various places on the site.

The eight wells located in or adjacent to the plume and screened in the first water-bearing zone (FWBZ) will be slug-tested to obtain hydraulic conductivity data. In addition to the four wells near the target zone, the wells to be slug-tested are M14-06, M14-07, M112-A, and M-113A. Additionally, monitoring well M14-04, which is expected to be well within the radius of influence for the pilot test, will be slug-tested both before and three weeks after the injection event. Comparison of the data from the two events may be useful in identifying any local changes to the conductivity of the FWBZ resulting from the formation of MnO₂ particles.

6.0 DATA EVALUATION AND REPORTING

The conclusions, field observations, and laboratory reports generated from the pilot test will be reported and incorporated into the Remedial Design (RD) for IR Site 14 at the 90% design point. If further monitoring data are generated after completion of the 90% RD document, these will be included in the 95% RD document, if possible.

7.0 HEALTH AND SAFETY

A Site-Specific Health and Safety Plan (HSP) has been prepared for this project as a separate internal Navy document. The HSP includes an Activity Hazard Analysis for all project tasks described in this Work Plan. It is anticipated that field work associated with direct-push drilling, auger drilling, temporary well installation and development, ISCO injection, and soil and groundwater sampling will be performed in modified Level D personal protective equipment (PPE) unless site conditions dictate otherwise, with the addition of an air-purifying respirator for activities that may involve risk from exposure to potassium permanganate dust.

Borehole air monitoring will be conducted using a calibrated PID to detect the presence of organic vapors. If vapor levels equal or exceed the allowable levels specified in the Site-Specific HSP, drilling will be halted immediately. Personnel will move upwind and the area will be allowed to vent. Work will not resume until air concentrations are below allowable limits. The Site Health and Safety Officer may choose to upgrade PPE levels if appropriate, based on breathing zone concentrations of organic vapors or other risks.

The MSDS for potassium permanganate, sodium persulfate, and sodium percarbonate are provided as Appendix C of this Work Plan. Copies of these MSDSs will be maintained on site during field activities and reviewed during tailgate safety meetings.

8.0 SCHEDULE

The implementation schedule for the pilot test is shown in Table 1. Field activities begin with the permitting process and notifications in early August 2007. Utility marking and clearance are scheduled to be completed by August 29. Drilling and ISCO injection activities are scheduled to take place between August 30 and September 7. Post-injection soil and groundwater monitoring are scheduled to be completed between September 10 and October 2.

9.0 OXIDANT CONTROL MEASURES

Potassium Permanganate is a relatively safe oxidant to use for ISCO, but a reasonable degree of preparation is required to assure safe handling and eliminate unexpected events . The following steps will be followed when conducting the pilot test:

- The area where the oxidant is stored or mixed, and the area under the oxidant solution pump during injection, will have a secondary containment system to contain any accidental leaks or spills.
- No oxidant, oxidant solution, or oxidant activator will be left unsecured overnight on the Site.
- The drilling contractor will have a sufficient quantity of one of the recommended neutralization chemicals available on site to neutralize any leaked, spilled, or surfacing permanganate solution (see Appendix E).
- The driller will have a suitable container available for holding any spilled dry oxidant or activator after it has been swept up.
- Areas where activator- and/or oxidant-contaminated equipment are decontaminated will have secondary containment to prevent the accidental release of contaminated rinsate.
- Any leaked or spilled oxidant or activator (dry or mixed) will be treated as IDW, as described in the Data Gap Investigation SAP.

10.0 REFERENCES

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- Yeskis, D. and B. Zavala, 2002. Ground-Water Sampling Guidelines for Superfund and RCRA Project Managers: Ground Water Forum Issue Paper. EPA 542-S-02-001. May.

TABLES

TABLE 1

**Implementation Schedule for Field Activities
Pilot Test, IR Site 14, Alameda Point**

Task	Start Date	End Date	Duration^a
Permitting Process and Notifications	September 14, 2007	September 24, 2007	7
Field Activities Kickoff Meeting w/Navy	September 24, 2007	September 28, 2007	5
Location Marking and Utility Clearance	September 25, 2007	September 27, 2007	3
Pre-Injection: Direct Push Drilling and Soil Sampling, Temporary Well Installation, Groundwater Sampling	October 1, 2007	October 4, 2007	2
Oxidant Injection, Visual Monitoring of Soil Cores	October 5, 2007	October 11, 2007	4
Collect Post-Injection Soil and Groundwater Samples	October 11, 2007	December 3, 2007	54

Notes:

a Duration in working days

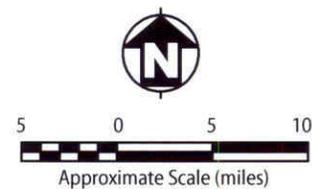
TABLE 2**Pilot Test Sampling/Monitoring Schedule
Pilot Test, IR Site 14, Alameda Point**

Event	Schedule	Objective
Soil and groundwater baseline sampling, 4 borings, 3 depths each, 7 wells (includes four temporary wells)	Completed concurrently with temporary well installation.	Obtain baseline data for pilot test (VOCs and Mn).
Slug testing at eight monitoring wells	Before ISCO injection.	Obtain hydraulic conductivity data to be used in determining if conductivity is uniform across the VC plume.
Collect at least two sets of soil cores in step-out pattern	Within 2 hours of permanganate injection.	Identify radius of influence and vertical distribution of injected KMnO_4 in soil.
Monitor groundwater in 7 wells for field parameters	Daily after ISCO injection for about 1 week, 3 times per week for 2 more weeks.	Obtain data on radius of influence and persistence of oxidants in groundwater.
Groundwater sampling of 4 wells in permanganate test area for VOCs, if no permanganate visible.	1, 2, 4, and 8 weeks after ISCO injection.	Evaluate VC concentrations and geochemical changes following ISCO.
Groundwater sampling of 3 wells in persulfate test area for VOCs.	1, 2, 4, and 8 weeks after ISCO injection.	Evaluate VC concentrations and geochemical changes following ISCO.
Repeat baseline soil event (VOCs and Mn)	Approximately 2 weeks after ISCO injection.	Determine VC decline and potential for VC desorption from soil to groundwater; determine increase in Mn, which could signify decrease in pore space.
Groundwater sampling of metals in 7 wells.	8 weeks after ISCO injections.	Evaluate for Cr and Ni mobilization
Slug testing at M14-04	Three weeks after ISCO injection.	Identify local changes to the conductivity resulting from the formation of MnO_2 particles.

FIGURES



- City
- Highway
- County Border



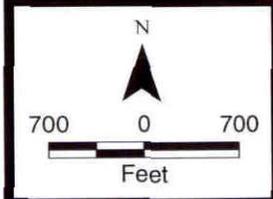
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Data Gap Sampling Investigation
 Installation Restoration Site 14
 Alameda Point
 Alameda, California

FIGURE 1
 Alameda Point Regional Map

IR Site 14



Pilot Test Work Plan
Installation Restoration Site 14
Alameda Point
Alameda, California

FIGURE 2
Site Location Map



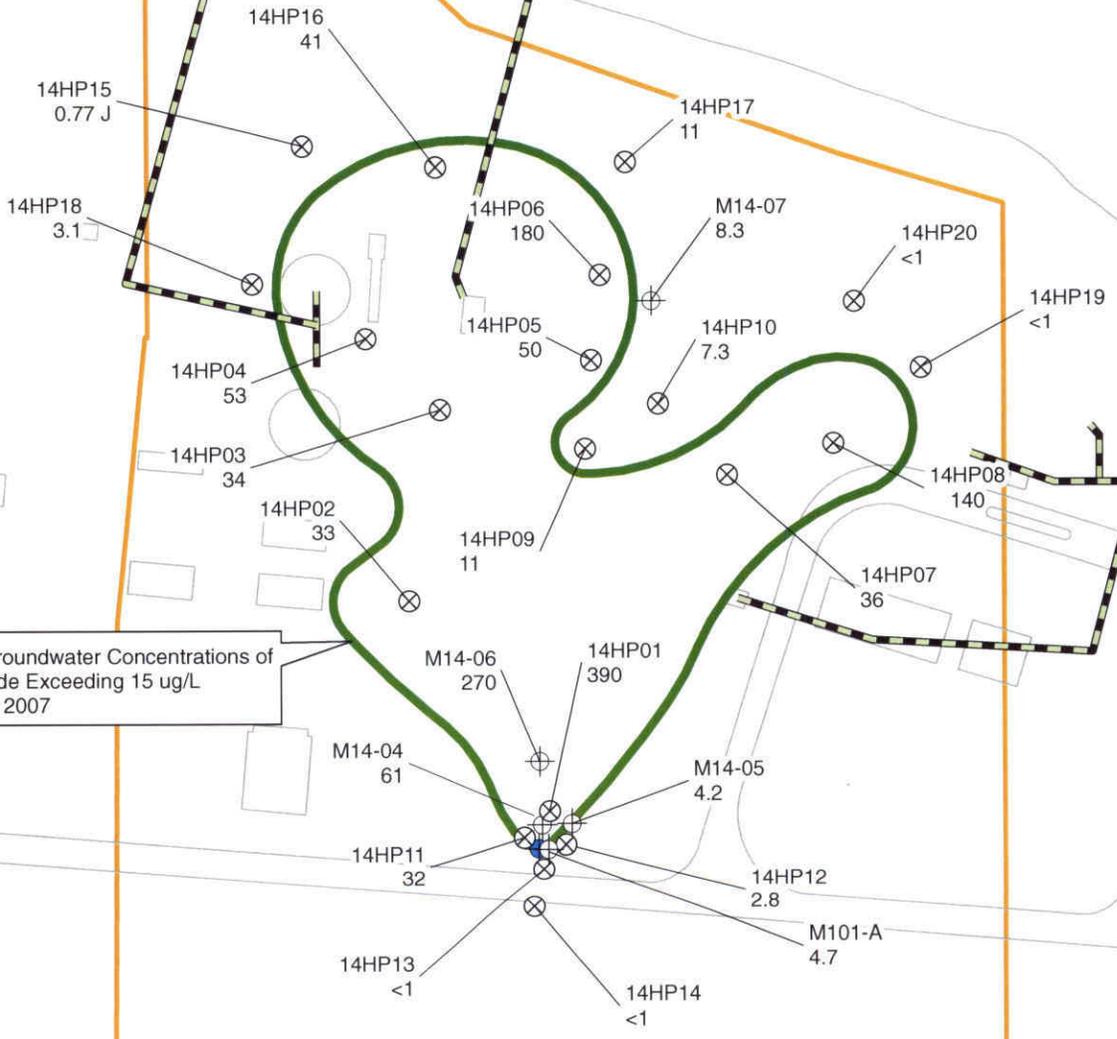
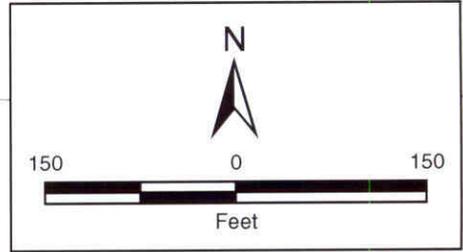
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Extent of Groundwater Concentrations of Vinyl Chloride Exceeding 15 ug/L March-April 2007

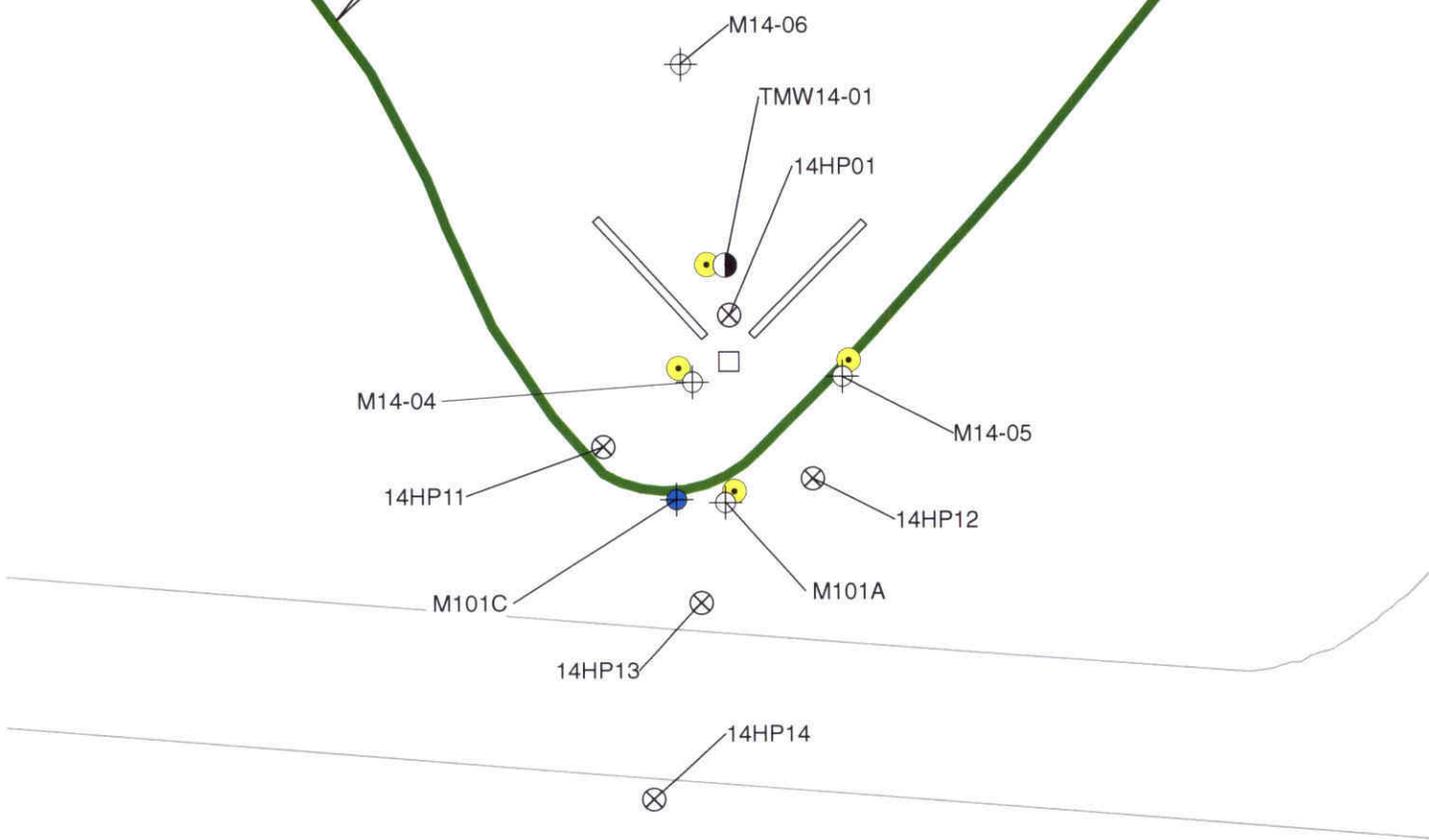
Legend

-  FWBZ Monitoring Well
-  Hydropunch
-  SWBZ Monitoring Well
-  Vinyl Chloride Contour
-  Storm Drain with Outfall to Oakland Inner Harbor
-  ITSI IR Site 14 Boundary
-  Facility Infrastructure

 Approximate Groundwater Flow Direction



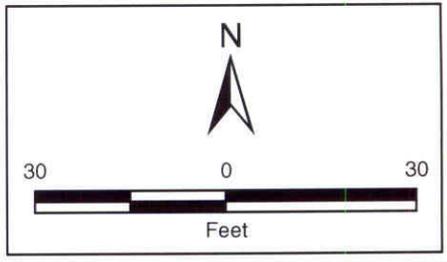
Extent of Groundwater Concentrations of Vinyl Chloride Exceeding 15 ug/L March-April 2007



Legend

- ⊕ Existing FWBZ Monitoring Well
- ⊗ Hydropunch, Samples collected in March, 2007
- Proposed Temporary Well
- ⊕ Existing SWBZ Monitoring Well
- Proposed Soil Boring/ Soil Sampling Locations
- ➔ Approximate Groundwater Flow Direction
- ~ Facility Infrastructure
- Area of Injection
- ▭ Zones of Soil Borings for Visual Identification of the Vertical and Horizontal Distribution of Potassium Permanganate

➔ Approximate Groundwater Flow Direction



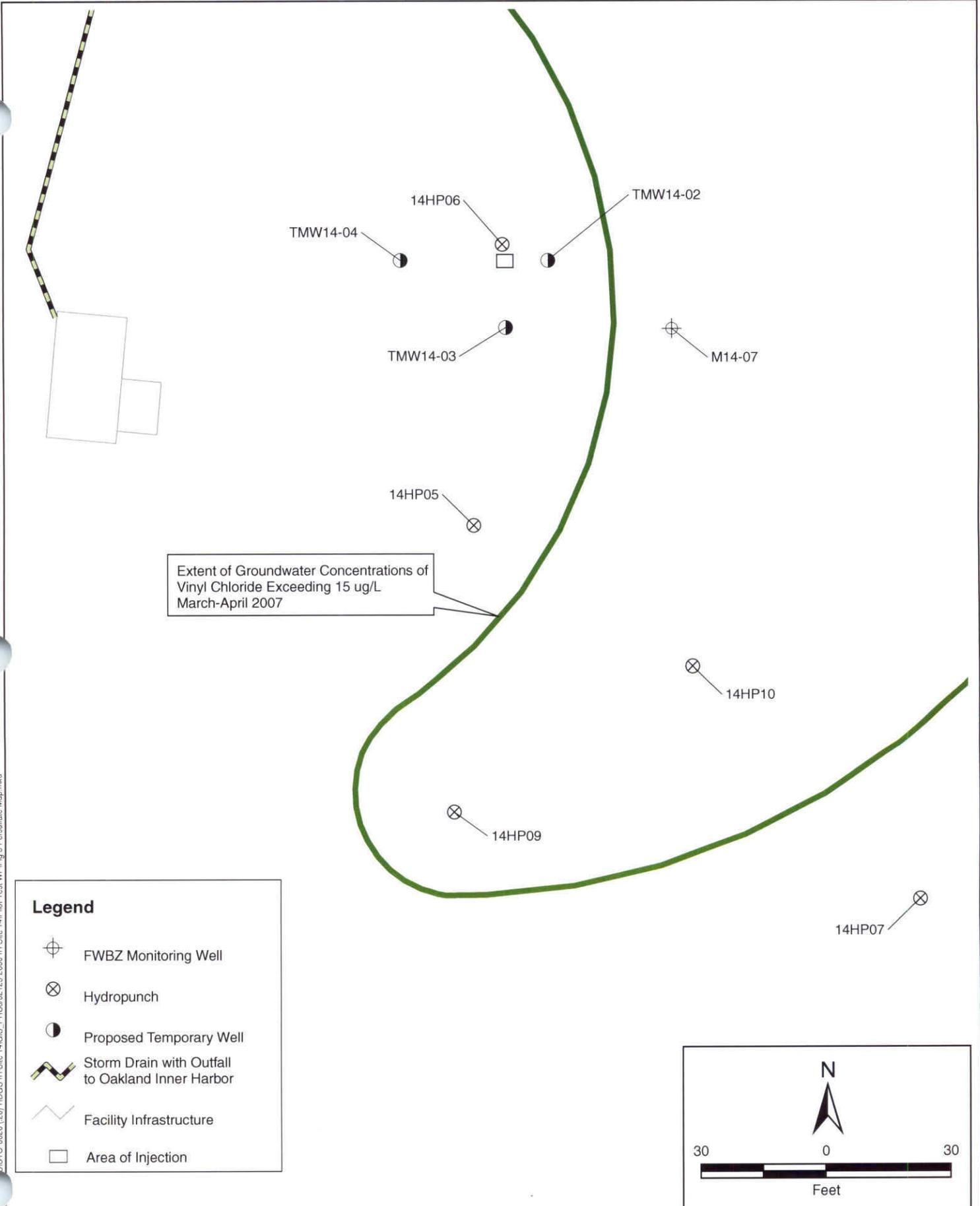
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Pilot Test Work Plan
 Installation Restoration Site 14
 Alameda Point
 Alameda, California

FIGURE 4
 Permanganate Injection
 Location Map

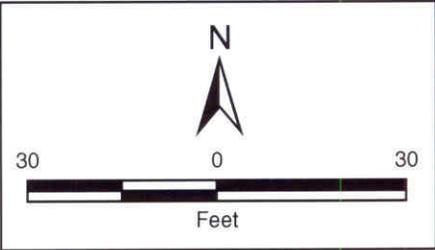
2002/02/25 Navy HPS/0212/... SICTO-0026 (26) RDGS IR Site 14/SIS_PRC/02125-2600 IR Site 14/Pilot Test WPFig 5 Persulfate Map.mxd



Extent of Groundwater Concentrations of Vinyl Chloride Exceeding 15 ug/L
March-April 2007

Legend

- FWBZ Monitoring Well
- Hydropunch
- Proposed Temporary Well
- Storm Drain with Outfall to Oakland Inner Harbor
- Facility Infrastructure
- Area of Injection



Pilot Test Work Plan
Installation Restoration Site 14
Alameda Point
Alameda, California

FIGURE 5
Persulfate Injection Location Map



Appendix A

Sampling and Analysis Plan Addendum

ADDENDUM 1 TO THE SAMPLING AND ANALYSIS PLAN

(FIELD SAMPLING PLAN/QUALITY ASSURANCE PROJECT PLAN)

**DATA GAP SAMPLING
INSTALLATION RESTORATION SITE 14
ALAMEDA POINT, ALAMEDA, CALIFORNIA**

FINAL

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Prepared Under:

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Contract Number N68711-02-D-8213
Task Order 0026**

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September 2007

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REVIEW AND APPROVAL

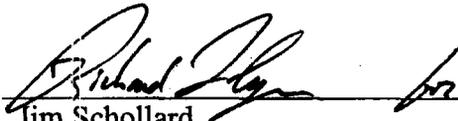
ADDENDUM 1 TO THE SAMPLING AND ANALYSIS PLAN (FIELD SAMPLING PLAN/QUALITY ASSURANCE PROJECT PLAN)

**DATA GAP SAMPLING
INSTALLATION RESTORATION SITE 14
ALAMEDA POINT, ALAMEDA, CALIFORNIA
CONTRACT NUMBER N68711-02-D-8213, CONTRACT TASK ORDER CTO 0026**

FINAL

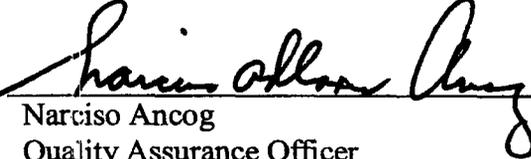
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ACRONYMS AND ABBREVIATIONS

AOC	Area of Concern
AST	aboveground storage tank
ASTM	American Society for Testing and Materials
BOD	biochemical oxygen demand
CAA	corrective action area
Cal-EPA	California Environmental Protection Agency
CCR	California Code of Regulations
CCV	continuing calibration verification
CDQMP	Chemical Data Quality Management Plan
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CL	control limit
COC	chemical of concern
CPR	Cardiopulmonary Resuscitation
CQC	Contractor Quality Control
CQMP	Construction Quality Management Plan
CTO	Contract Task Order
DoD	Department of Defense
DI	deionized
DQO	Data Quality Objectives
DQCR	Daily Quality Control Report
DTSC	Department of Toxic Substances Control
EBS	Environmental Baseline Survey
EDD	electronic data deliverable
ELAP	Environmental Laboratory Accreditation Program
EM	electromagnetic
EPA	U.S. Environmental Protection Agency
EWI	Environmental Work Instruction
FID	flame ionization detector
FS	Feasibility Study
FSP	field sampling plan
GAP	generator accumulation point
GC/MS	gas chromatography/mass spectrometry
GPR	ground penetrating radar

ACRONYMS AND ABBREVIATIONS (Continued)

HPLC	high-performance liquid chromatography
HSA	hollow-stem auger
HSP	Health and Safety Plan
IAS	initial assessment study
IC	Institutional Controls
ICP	inductively coupled plasma
ICV	initial calibration verification
ID	identification
ID/IQ	Indefinite Delivery/Indefinite Quantity
IDW	investigation-derived waste
IR14	Installation Restoration Site 14
ISCO	in-situ chemical oxidation
IT	International Technology Corporation
ITSI	Innovative Technical Solutions, Inc.
LCL	lower control limit
L/min	liters per minute
LCS/LCSD	laboratory control samples and laboratory control sample duplicates
LIMS	laboratory information management system
MDL	method detection limit
mg/L	milligram per liter
MIP	Membrane Interface Probe
mL	milliliters
msl	mean sea level
MS/MSD	matrix spikes and matrix spike duplicates
mV	millivolt
NA	natural attenuation
NAPL	non-aqueous phase liquid
NAS	Naval Air Station
NAVFAC SW	Naval Facilities Engineering Command, Southwest Division
Navy	United States Department of the Navy
NBS	National Bureau of Standards
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NEDD	Navy Electronic Data Deliverable
NFESC	Navy Facilities Engineering Service Center
NIST	National Institute of Standards and Testing
NPL	National Priority List
NTU	nephelometric turbidity units
OD	outside diameter
ORP	oxidation-reduction potential

ACRONYMS AND ABBREVIATIONS (Continued)

OSHA	Occupational Safety and Health Administration
OVA	organic vapor analyzer
OVM	organic vapor monitor
PARCC	precision, accuracy, representativeness, completeness, and comparability
PID	photoionization detector
PM	project manager
PP	proposed plan
PPE	personal protective equipment
PQCM	Project Quality Control Manager
PQL	practical quantitation limit
PTFE	polytetrafluoroethylene
PTM	Project Task Manager
PVC	polyvinyl chloride
QA	quality assurance
QAO	Quality Assurance Officer
QAPP	Quality Assurance Project Plan
QC	quality control
QCSR	Quality Control Summary Report
RAO	Remedial Action Objective
RCRA	Resource Conservation and Recovery Act
RD	Remedial Design
RFA	RCRA Facility Assessment
RFI	RCRA Facility Investigation
RI	Remedial Investigation
RL	reporting limit
ROD	Record of Decision
RPD	relative percent difference
RPM	Remedial Project Manager
RRF	relative response factor
RWQCB	Regional Water Quality Control Board
SAP	sampling and analysis plan
SARA	Superfund Amendments and Reauthorization Act
SC	soil conductivity
SDG	sample delivery group
SWMU	solid waste management unit
TPH	total petroleum hydrocarbons
TtEMI	Tetra Tech Environmental Management, Inc.
UCL	upper control limit
UFP	Uniform Federal Policy

ACRONYMS AND ABBREVIATIONS (Continued)

UN	United Nations
USA	Underground Safety Alert
USCS	Unified Soil Classification System
UST	underground storage tank
VOA	volatile organic analysis
VOC	volatile organic compound
WD	washdown area
µg/L	micrograms per liter
°C	degrees Celsius
%D	percent difference
%RSD	percent relative standard deviation

1.0 INTRODUCTION

This document is Addendum 1 to the Final Sampling and Analysis Plan (SAP) for the data gap sampling project at Installation Restoration Site 14 (IR14) at Alameda Point, Alameda, California.

The purpose of this SAP Addendum is to describe additional work to be performed in support of this project. The additional work will be to conduct a pilot-scale test of the in situ chemical oxidation (ISCO) process in the contaminant source area, to support development of the Remedial Design (RD).

This document only contains changes to the original SAP. All original procedures and specifications not referenced in this document remain applicable.

The following text is added to Section 1.0, Project Description, of the original SAP:

Potassium permanganate has been shown in numerous applications to be effective in remediating groundwater contaminated with chlorinated ethenes (ITRC, 2005). Also, permanganate-based ISCO is more fully developed than other oxidants. In-situ permanganate oxidation has been put to widespread use remediating a diversity of contaminants and geological environments under well-documented pilot- and field-scale conditions (in conjunction with long-term monitoring data and cost information); these applications have helped address decisions on design and deployment of permanganate ISCO systems (EPA, 2006).

The largest single factor in favor of permanganate over other oxidants is the persistence of permanganate in the subsurface, which is on the order of months; other oxidants persist for a matter of minutes to hours (hours to weeks in the case of persulfate). The relatively large size of the vinyl chloride plume (maximum dimensions approximately 550 by 600 feet) favors an oxidant with relatively long persistence in the environment, so that fewer injection points could be used.

Based on the foregoing factors, permanganate has been selected as the primary ISCO oxidant to be employed for the pilot test in the majority of target area. However, three storm drain corridors intersect parts of the northern portion of the plume, and these may constitute preferential pathways that could potentially allow permanganate reagent to migrate into the Oakland Inner Harbor.

Permanganate is a highly visible purple color at low concentrations in water, and may appear in the harbor water even at relatively low levels. To prevent this potential undesirable side-effect, another oxidant will be considered for those portions of the plume near the harbor. Sodium persulfate with a sodium hydroxide or calcium peroxide activator will be tested in a different part of the plume as part of this pilot study. Sodium persulfate is colorless and has innocuous byproducts, and its emanation to the harbor would not be cause for concern. Sodium persulfate also has a fairly extensive record of successful use as an ISCO oxidant, and is similarly effective as permanganate in remediating chlorinated ethenes such as vinyl chloride. Combined with its lifetime second only to permanganate among ISCO oxidants, these factors make persulfate the oxidant of choice for IR14 in areas near the storm drains or near the harbor.

The following text is added to Section 1.0, list of primary tasks, in the original SAP:

Sampling will also be performed in support of the following activity:

- Conduct a pilot-scale test of the in situ chemical oxidation (ISCO) process in the contaminant source area, to support development of the Remedial Design (RD). Operational issues such as oxidant injection flow rates, injection pressures, and radius of influence will be evaluated, as will effectiveness of the oxidant in removing vinyl chloride.

Additional project tasks covered by this Plan include:

- Conducting a pilot-scale test using potassium permanganate and sodium persulfate as oxidizing reagents to remove vinyl chloride in the contaminant source area; and
- Performing groundwater and soil monitoring for VOCs and selected other parameters, to assess the effectiveness of the oxidant as a function of distance from the injection points.

An implementation schedule for the pilot-scale test is provided in Table A-1.

1.1 ORIGINAL SAP SECTION 1.3: PROBLEM DEFINITION AND BACKGROUND

The following text is added to the first paragraph:

For the pilot-scale test, the RD needs to be supported by assessing operational parameters for the remedial action, such as oxidant injection flow rates, injection pressures, and radius of influence,

as well as the effectiveness of the oxidant in removing vinyl chloride. Figure A-4 presents the sampling locations for the pilot-scale test.

1.1.1 Original SAP Section 1.3.1: Problem to be Solved

The following text is added:

A pilot-scale test needs to be completed to address operational issues that directly affect the efficient operation of ISCO during full-scale remediation of the vinyl chloride contaminant plume at IR Site 14. ISCO depends on contact of the selected oxidant with the contaminant of concern. In order to maximize contact of reagent and contaminant, knowledge of optimal injection rates and pressures, as well as likely radius of influence, is needed. Pilot-scale testing will be performed by injecting oxidant in the contaminant source area just north of monitoring well M101-A, using various injection rates and pressures as appropriate, at approximately four locations. The extent and the effectiveness of the oxidant will be monitored through sampling of soil and groundwater before and after injection, using methods discussed in Section 1.5.

Natural organic matter affects ISCO application, because oxidizable matter exerts a demand for oxidant that competes with target contaminants. This issue has been addressed by collection of five saturated soil samples from within the plume for analysis of PSOD. The values range from 1.6 to 16.6 g/kg, within a range considered by Carus to represent low to medium oxidant demand (and the mean value of 6.5 g/kg, is well within the low range for PSOD of less than 15 g/kg). The sample results thus are considered to indicate that the site is amenable to ISCO. As discussed above, the amount of oxidant to be injected at this site (approximately 2600 gallons) should be sufficient to oxidize both the naturally-occurring oxidizable matter as well as the vinyl chloride.

1.1.2 Original SAP Section 1.3.2: Purpose of the Activities

The following text is added:

The purpose of the pilot-scale testing is to provide operational and effectiveness data obtained from a small-scale injection procedure at the IR Site 14 contaminant source area; the information so acquired will be used in the RD.

1.1.3 Original SAP Section 1.3.5: Previous Investigations

The following text is added: The history of investigations at IR14 includes the following:

- The Final ROD (Navy, 2007) was signed on January 31, 2007.
- Data acquired from the Data Gap Investigation of March-April 2007 reveals that the vinyl chloride contaminant plume is slightly larger than reported in the RI (TtEMI, 2003a), with the plume approximately 600 feet long and up to 550 feet wide at the 15 µg/L contour (see Figure A-5). Sampling near monitoring well M101-A shows that the contaminant source area is just north of this well. There is no evidence for the presence of dense non-aqueous phase liquids (DNAPL). The maximum depth of the vinyl chloride plume was defined, and ranges from approximately 12 to 22 feet across the site. Site geology appears to render the site readily amenable to ISCO treatment, as shallow units consist mainly of sands and silty sands.

1.2 ORIGINAL SAP SECTION 1.4: PROJECT DESCRIPTION

The following text is added:

The primary objective of the pilot testing is to acquire operational and effectiveness data to feed into the RD, with the ultimate aim of ensuring efficient operation of ISCO during full-scale remediation of the vinyl chloride contaminant plume. Specific data to be gathered includes operational information on injection rates, injection pressures, and radius of influence, and information on oxidant effectiveness in vinyl chloride destruction. This data will be obtained through collection of soil and groundwater samples before and after injection, using methods discussed in Section 1.5.

Field work for the pilot test is expected to be completed in August and September 2007. Most of the data from the Pilot Test will be available for use in preparation of the 90% RD document, scheduled for agency review in mid-October 2007. The Draft Pilot Test Report presenting the results of the pilot test is scheduled for agency review in late October or November 2007.

1.3 ORIGINAL SAP SECTION 1.5: DATA QUALITY OBJECTIVES

Text is added to the following sections as noted below.

Step 1: State the problem.

Describe the problem:

The following text is added to this section:

For the pilot test, the problem is that the optimal operational parameters for ISCO remediation at this site are not known. The pilot test will provide operational and effectiveness data that can be used in the RD. Successful application of ISCO requires that the oxidant make contact with the contaminant of concern (vinyl chloride) in the aqueous phase, where the relevant oxidation reactions occur. Thus the RD must provide for effective delivery of the oxidant throughout the subsurface volume occupied by vinyl chloride at concentrations above 15 µg/L. Effective delivery of the oxidant requires knowledge of (1) the soil's oxidant demand; (2) achievable injection rates and pressures; and (3) the radius of influence of the oxidant around the location of injection. Among these factors, the soil's oxidant demand is known with some degree of confidence from data collected during the Data Gap Investigation of March-April 2007 (report in preparation by ITSI); the remaining data can be obtained only from field-testing of ISCO such as in a pilot-scale test.

Describe the conceptual model of the potential hazard:

This text is added following the first paragraph:

The Data Gap Sampling Investigation revealed that subsurface units across IR Site 14 consist of sand and silty sand with local clayey intervals; based on expected hydraulic conductivities that are relatively high, such formations are generally conducive to the ISCO process, which depends on the ability of oxidant to migrate throughout the entire target volume in the subsurface.

Identify critical resources, constraints, and deadlines:

This text is added following the first paragraph:

Under this CTO, ITSI has been tasked to conduct a pilot test using the ISCO remedial method to support development of an RD and Remedial Action Workplan. ISCO operational and effectiveness data obtained during this effort will support the development and optimization of the RD. ITSI will also use observations of field parameters such as: injection flow rates, water levels, well pressures, observations of color (indicating the presence of the reagent), and standard field parameters including pH, dissolved oxygen, oxidation/reduction potential and conductivity. These field observations will provide inputs to the RD to enable development of specifications to ensure that oxidant injection can be operated at injection rates and pressures that can be attained by the full-scale remedial system, and to ensure the system employs the proper number of injection points based on radius of influence data obtained during the pilot test. In addition, effectiveness data will be collected to verify that the selected reagent can indeed destroy vinyl chloride in the subsurface environment. The project schedule requires that full-scale remediation be started by April 30, 2008. Meeting this schedule will require that the pilot test be completed by September 2007, so that the critical data can be incorporated into the 90% RD/RAWP document due in early October 2007. This schedule can be met through the use of an experienced subcontractor that can perform both oxidant injection as well as soil and groundwater sampling, as well as use of expedited turnaround of laboratory analytical samples.

Step 2: Identify the Goal of the Study

Specify the principal study questions:

The following is added to this section :

The goal of this pilot test is to answer the following questions:

- What injection rates and pressures can be sustained when injecting oxidant to the shallow subsurface in the area of the vinyl chloride plume?
- What is the radius of influence that can be expected when injecting oxidant to the shallow subsurface in the plume?
- Are the selected oxidants, potassium permanganate and sodium persulfate, effective in destroying vinyl chloride in the subsurface plume environment?
- Are metals mobilized when the selected oxidant is injected into the subsurface?
- Are the hydraulic properties of the shallow portion of the aquifer consistent across the site, such that the pilot test target area is reflective of the entire plume?

Specify the estimation statements that address the principal study questions:

The following is added to this section:

For the pilot test:

- (1) Pumping rates and pressures need to be recorded during the injection process, to determine the progress of injection.
- (2) Data on the distribution of vinyl chloride are needed before and after oxidant injection, to evaluate the magnitude of the radius of influence of the effective treatment area around the injection location.
- (3) Data on the magnitude of reduction in vinyl chloride concentrations from before to after the period of oxidant injection will assist in determining overall treatment effectiveness within the treatment volume.
- (4) Groundwater data for chromium and possibly nickel need to be collected to determine their potential for mobility in the subsurface environment of IR Site 14 (these metals are susceptible to becoming more soluble [and thus more mobile] under oxidizing conditions).
- (5) Acquire data that can assess the hydraulic conductivity across the breadth of the plume.

Step 3: Identify Information Inputs

Identify the types of information that are needed.

The following is added to this section:

The following types of information are needed:

- Pilot test operational data that can be recorded by site personnel, specifically on injection rates and pressures;
- Soil and groundwater data for vinyl chloride, collected before oxidant injection and then collected after injection from locations close to the previously-collected samples, thus providing rough comparability in results before and after injection; samples are needed from the entire interval of subsurface contamination (approximately five to 10 feet in the pilot test treatment area).
- Groundwater data for metals from wells close to the pilot test injection location as there is some potential of metal mobility due to pH changes after oxidant injection (pH is likely to fall near permanganate injection point and likely to rise near the persulfate injection location);
- Hydraulic conductivity data on wells at various locations in and adjacent to the contaminant plume.

Identify the sources of information.

The following text is added to this section:

Another source of information is the Data Gap Sampling Investigation (ITSI, currently in progress), which will provide data on the lateral and vertical extent of vinyl chloride at concentrations above the 15 µg/L goal. For this SAP Addendum, the additional information needs include field operational data and soil and groundwater analytical data that can be collected during the planned pilot test in the contaminant source area of IR Site 14.

Identify appropriate sampling and analysis methods.

The following text is added to this section:

The operational data for the pilot test and the hydraulic conductivity data are not chemical parameters, and thus discussion of sampling for these parameters is not relevant. The operational data will be collected by observation of field pressure gauges and other instruments and will be recorded in a field logbook. The hydraulic conductivity data will be collected through performance of slug tests to be conducted at seven wells located within or adjacent to the vinyl chloride contaminant plume. The methods to be used to collect hydraulic conductivity data are specified in Section 5.5 of the Pilot Test Work Plan.

For the planned analytical data, the project objectives can be addressed by collection of soil and groundwater samples before and after the pilot test oxidant injection. The samples will be collected to answer the questions about oxidant treatment effectiveness as well as quantifying the radius of influence (ROI). Samples will be analyzed for VOCs by EPA Method 8260B (soil and groundwater), metals by EPA Method 6020 (groundwater only), and manganese by method 6010B (soil only). While metals are not contaminants of concern at the site, manganese is being monitored since it is a component of the primary oxidant; of the other metals, they have a potential for mobilization under the changed pH (acidic or alkaline conditions generated by permanganate and persulfate injections, respectively) and/or oxidizing conditions that will be generated during the pilot test.

Step 4: Define the Boundaries of the Study

Specify the target population of interest:

The following text replaces the paragraph in this section:

The target population is all possible sets of groundwater and soil contamination profiles from subsurface borings advanced in or adjacent to the area influenced by oxidant injection during the pilot test in the contaminant source area of IR Site 14.

Specify the spatial and temporal boundaries and other practical constraints:

The following text replaces the first paragraph in this section:

For the pilot test, the spatial boundary for subsurface borings is defined laterally by the area approximately 25 feet from the oxidant injection location for the pilot test; this is the area considered moderately to strongly likely to display influence due to injection of oxidant.

The vinyl chloride plume is depicted on Figure A-5, based on sampling conducted during the Data Gap Investigation in March and April 2007.

The following text is added to the end of this section:

Due to the limitations of the project schedule, temporal study boundaries of the pilot test are limited to collection of pilot test data during August-September 2007.

Specify the scale of estimates to be made:

The following text is added to this section:

The accuracy of estimates of the ROI in the contaminant source area should be in the 2-to-5-foot range. This level of detail should provide sufficient information for designing the RD with reasonable accuracy (e.g., regarding quantities of reagent needed). The borings in the proposed field sampling effort allow collection of data at this level of detail. Because the vinyl chloride in the source area is depth-specific, samples from each boring will be collected across the entire contaminated interval. Soil samples should be collected every two feet to define contaminant presence to the degree of accuracy needed.

Step 5: Develop the Analytical Approach

Specify Appropriate Population Parameters for Making Decisions

Individual sample results will be compared to selected criteria to decide exceedances for each location.

Specify the Action Level

The action level of 15 µg/L of vinyl chloride will be used to define groundwater that is impacted at a level that may require further remediation.

Specify the Decision Rules:

If the concentration of vinyl chloride in a post injection groundwater sample is less than 15 µg/L, **then** the ISCO treatment will be considered to have been effective in the associated part of the injection area, **else** the ISCO treatment will be considered incomplete in the associated part of the injection area, and this information will be used to determine the radius of influence of the ISCO treatment.

For metals: If the concentration of a specific metal increases in groundwater samples increases by 20 percent or greater, **then** it will be concluded that there is mobilization of this metal during ISCO remediation, and the observation will be reported in the forthcoming 90% remedial design (RD) document, with statement of a cautionary note that metals mobilization during the full-scale remediation should be addressed through additional monitoring or other means; **else** the ISCO treatment will be considered to have a negligible effect on concentrations of metals in the groundwater.

If the concentration of manganese in soils increases by 30 percent or greater, **then** it will be concluded that manganese dioxide may be increasing (precipitating) in the soils as a result of the ISCO injection, and porosity and permeability may decline with time; this conclusion will be noted in the 90% RD document, with the note that design adjustments may be needed. **Else**, it will be concluded that manganese does not build up and that remediation does not decrease the porosity and permeability of the aquifer.

Determine the key study parameter and a specification of the estimator:

The following text is added to this section:

The key parameter to be estimated is the concentration of vinyl chloride in shallow groundwater in the contaminant source area just north of well M101-A. This parameter will diagnostically allow quantification of the ROI, because it is the compound that needs to be remediated to the goal of 15 µg/L in groundwater. Secondly, the vinyl chloride concentration in soil will assist in determining ISCO effectiveness: while oxidation reactions proceed generally in the liquid phase, contaminants adsorbed to the soil can desorb after ISCO is performed; the resultant dissolved contaminants can cause the commonly observed rebound in contamination reported for ISCO sites after initial injections. For this reason as well as to allow calculation of total contaminant mass, soil concentrations of vinyl chloride are needed.

Other key parameters to be estimated are non-chemical and include various operating parameters to be recorded during the pilot test, and hydraulic properties of the aquifer to be determined by slug testing. Quantification of these parameters will assist in developing a reliable design for full-scale remediation.

Step 6: Specify Performance or Acceptance Criteria

Specify how uncertainty will be accounted for in the estimate:

The following text is added to this section:

For the pilot test, spatial uncertainty will be minimized by selecting sampling locations known to be within the contaminant source area and at locations spaced as discussed in Steps 3 and 4.

Step 7: Develop the Detailed Plan for Obtaining Data

Select the sampling design:

The following text is added to this section:

The general sampling design for the pilot test will be based on the sampling and analysis methods listed in Step 3 above. The extent of vinyl chloride will be assessed by collecting groundwater and soil samples from soil borings co-located with monitoring wells. Injection will occur at an appropriate location relative to the monitoring wells such that the wells and co-located borings are inside and outside the expected radius of influence (approximately 10 to 20 feet). The four wells to be sampled include three existing wells and one temporary well to be installed at approximately 12 feet from the planned injection location.

Soil and groundwater samples will be collected before and two weeks after injection at these four sampling locations. To fully characterize this part of the contaminant source area, soil samples will be collected at two-foot depth intervals across the contaminated zone defined previously (at five, seven, and nine feet below ground surface). The depths of the screened intervals are approximately five to 12 feet, which encompass an interval slightly longer than the contaminated interval of five to 10 feet. In addition to being collected at two weeks after oxidant injection, groundwater samples will be collected at one week, four weeks, and eight weeks after injection. The later samples will help to define the extent of contaminant rebound after injection, commonly reported for some sites remediated by ISCO. Samples will be collected at different times to also assess whether and when additional oxidant injections may be needed for the full-scale system. Early samples will also be useful to provide initial data to feed into the 90% RD/RAWP document, due to the limited project schedule.

Soil samples will be analyzed for VOCs and manganese to quantify the pilot-test ROI, and to assess the accumulation of manganese oxides in the aquifer near the permanganate injection point. Manganese oxides form as byproducts of permanganate injection to the subsurface, and there is some concern about reduction in pore space and permeability of the aquifer matrix.

Groundwater samples will be analyzed for VOCs using EPA Method 8260B, and metals by EPA Method 6020. Metals will be analyzed because of a potential for mobilization in water under changed pH (low pH for permanganate, high pH for persulfate) and/or oxidizing chemical conditions as will be generated under ISCO.

1.4 SAMPLING PROCESS DESIGN

The following text is added to this section:

The primary objective of sample collection for the pilot test is to provide data that will quantify operational and effectiveness parameters for oxidant injection in the vinyl chloride contaminant source area at IR14, in order to support development of the RD. The oxidant injection location will be placed at a distance from the monitoring wells such that the wells are located inside and outside the likely radius of influence. Soil borings will be advanced adjacent to the monitoring wells for collection of soil samples; both groundwater and soil samples will encompass the vertical extent of vinyl chloride in the area to be pilot-tested. ITSI will also collect samples for waste profiling of IDW. Project DQOs are detailed in Section 1.5. The rationale for the sampling program is described in the following subsections. Sample collection methods are presented in Section 2.2.

1.4.1 Original SAP Section 2.1.2: Monitoring Well Groundwater Sampling

The following text is added to this section:

For the pilot test, groundwater samples will be collected from three existing wells and four temporary wells. The permanganate injection location will be placed such that it will be approximately 6, 12, 18, and 22 feet from the monitoring well locations. At the persulfate injection location, the temporary monitoring wells (TMW-02, TMW-03, and TMW-04) will be placed 6, 12, and 20 feet from the injection point. These locations will provide the necessary information to evaluate the radius of influence for the pilot test, which can then be used in developing the RD. Samples will be collected before and after oxidant injection, with samples after injection collected at one, two, four, and eight weeks after injection, as described in Step 7 of the DQO (Section 1.5).

1.4.2 Soil Sampling

The following text is added to this section:

Soil samples will be collected before and after pilot test oxidant injection, to evaluate the ROI and the effectiveness of oxidant injection in remediating vinyl chloride. Soil samples will be collected

from borings advanced adjacent to the four monitoring wells nearest the injection location, to provide data on vinyl chloride that may be present as constituents sorbed to the soil. Sorbed contaminants are less mobile than dissolved constituents, but can desorb from the soil to groundwater over time and become part of the groundwater contaminant plume. As for groundwater samples, soil samples will be collected to characterize the entire vertical interval of contamination in the pilot test area.

1.4.3 Original SAP Section 2.2.4: Monitoring Well Construction Procedures

The following text is added to this section:

Before the pilot test one temporary well will be installed at approximately 12 feet from the oxidant injection location. This well will be installed in a direct-push boring using two-inch rods. The well will be a one-inch inside-diameter PVC well with a slotted screen with pre-packed filter pack, and will be set with the screened interval at five to 12 feet to match the nearby monitoring wells. Once the temporary well boring has been advanced to the appropriate depth, the well will be lowered inside the direct-push rods; the rods will then be withdrawn and the formation allowed to collapse against the temporary well. Any annular space near the ground surface will be filled with cement-bentonite grout. This type of well is not developed, and the well will be sampled in the same way as the other wells.

1.4.4 Original SAP Section 2.2.8: Procedure for Groundwater Sampling from Monitoring Wells

The following text is added to this section:

For the pilot test, groundwater samples will be obtained from the four monitoring wells (refer to Worksheet 18, and to Figure A-4) nearest the injection location (including the one temporary well) and analyzed for VOCs and dissolved and total metals (chromium and nickel only) in accordance with the methods listed in Table A-2.

Purge water will be considered stable after a volume equal to the pump and tubing has been purged, and after three successive measurements of field parameters fall within the following ranges:

- pH: ± 0.1 pH units
- Electrical conductivity: ± 3 percent microSiemens per centimeter
- Temperature: ± 1.0 degree Celsius ($^{\circ}\text{C}$)
- Dissolved oxygen: ± 0.3 milligrams per liter (mg/L)
- ORP: ± 10 millivolts (mV)
- Turbidity: ± 10 percent or three successive measurements of less than 10 nephelometric turbidity units

1.4.5 The following Section is added:

2.2.14 Procedure for Soil Sampling

Soil samples will be collected before and after pilot test oxidant injection, to evaluate the ROI and the effectiveness of oxidant injection in remediating vinyl chloride (refer to Worksheet 18 and to Figure A-4). Soil samples will be collected using a direct-push rig that employs five-foot long acetate tubes inserted within the first rod and driven into undisturbed soil in the borehole.

Retrieval of the sampling tube after advancement of each five-foot rod allows collection of continuous soil samples.

At depths of five, seven, and nine feet a representative portion of the soil sample will be collected from the soil tube using an EnCore® sampling device. Three EnCore® sample containers are required to provide sufficient matrix to analyze samples for VOCs. Exposure to the atmosphere will be minimized before and during VOC sample collection, particularly because vinyl chloride, a highly volatile gaseous compound, is the compound of greatest concern. Soil volumes for the other parameter, manganese, will then be collected using inert sampling tools and placed in one 8-ounce glass sample jar. Alternatively, soil samples for manganese may be left in the acetate tubes (cut to approximately 4-inch lengths), covered with Teflon sheets and capped with PVC end caps for sample shipment.

Details of soil sample collection, including sample type, containers, and preservation requirements, are presented in Table A-6. Decontamination procedures for equipment and materials used during soil sampling are presented in Section 2.2.12.

Soil samples will be labeled in accordance with the sample numbering and labeling procedures described in Sections 2.3.2 and 2.3.3. Following labeling, samples will be placed in resealable plastic bags and placed on ice in an insulated cooler for transportation to the laboratory. The chain of custody procedures described in Section 2.3 will be utilized. A chain of custody form is presented with the field forms in Attachment 1. Soil samples will be analyzed for VOCs by EPA Method SW8260B, and manganese by EPA Method 6010B (Table A-2).

The following Subsection is added to Section 2.2.14:

2.2.14.1 Soil samples for VOCs will be taken using En Core® Samplers:

1. Assemble the En Core® sampler by holding the coring body and pushing the plunger rod down until the small o-ring rests against the tabs. Depress the locking lever on the En Core® T-handle and place the plunger end of the coring body into the open end of the T-handle. Align the two slots on the coring body with the two locking pins in the T-handle. Twist the coring body clockwise to lock the pins in the slots. Finally, check to ensure that the coring body is locked in place.
2. Collect the En Core® sample by grasping the T-Handle with open end of the coring body facing the soil sample. Using the T-Handle, push the sampler into soil until coring body is completely full. The coring body is full when the small o-ring is centered in the viewing hole in the T-Handle. Remove the Sampler from the soil and remove excess soil from the exterior of the coring body. Push and twist cap on the exposed end of the coring body until the ridges on the coring body snap into the grooves of the cap. Check to ensure that cap is properly secured.
3. Prepare the sample for shipment by removing the T-Handle from the En Core® Sampler by depressing the locking lever on T-Handle and then twist and pull the En Core® Sampler from T-Handle. Lock the plunger by rotating the extended plunger rod fully counter-clockwise until the wings rest firmly against the tabs. Attach the completed circular label to the cap of the coring body. Return the full En Core® Sampler to the zipper bag. Seal the bag and immediately place the bag in an ice chest filled with ice.

1.4.6 Original SAP Section 2.5.2.1: Field Duplicates

The following text is added to this section:

(Field duplicates will not be collected for soil samples owing to the heterogeneity of the soil medium.)

2.0 ADDITIONAL REFERENCES

EPA (U.S. Environmental Protection Agency), 2006, *In-Situ Chemical Oxidation*, Engineering Issue, EPA/600/R-06/072.

ITRC (Interstate Technology & Regulatory Council), 2005. Technical and Regulatory Guidance for In Situ Chemical Oxidation of Contaminated Soil and Groundwater, 2nd ed. ISCO-2. Washington D.C.: Interstate Technology & Regulatory Council, In Situ Chemical Oxidation Team. Available on the internet at <http://www.itrcweb.org>.

Innovative Technical Solutions, Inc. (ITSI), 2007. *Final Sampling and Analysis Plan, Data Gap Sampling, Installation Restoration Site 14 (IR14) at Alameda Point, Alameda, California.* April.

TABLES

**Each of the following tables supersedes and replaces the corresponding table in the original
SAP**

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TABLE A-1

**Implementation Schedule for Field Activities
Pilot Test, IR Site 14, Alameda Point**

Task	Start Date	End Date	Duration^a
Permitting Process and Notifications	September 14, 2007	September 24, 2007	7
Field Activities Kickoff Meeting w/Navy	September 24, 2007	September 28, 2007	5
Location Marking and Utility Clearance	September 25, 2007	September 27, 2007	3
Pre-Injection: Direct Push Drilling and Soil Sampling, Temporary Well Installation, Groundwater Sampling	October 1, 2007	October 4, 2007	2
Oxidant Injection Visual Monitoring of Soil Cores	October 5, 2007	October 11, 2007	4
Collect Post-Injection Soil and Groundwater Samples	October 11, 2007	December 3, 2007	54

Notes:

a Duration in working days

TABLE A-2

**Analytical Methods, Parameters for Analysis, and Reporting Limits
 IR14 Data Gap Sampling, Alameda Point**

Method and Parameters	Reporting Limit		
	Water (ug/L)	Soil (ug/kg)	RAO * (ug/L)
EPA Method 8260B: Volatile Organic Compounds			
Note: Analytes in BOLD have Site-Specific Cleanup Goals.			
Acetone	--	--	Not Established
Benzene	1.0	5.0	Not Established
Bromodichloromethane	1.0	5.0	Not Established
Bromoform	1.0	5.0	Not Established
Bromomethane	1.0	5.0	Not Established
2-Butanone	--	--	Not Established
Carbon disulfide	--	--	Not Established
Carbon tetrachloride	1.0	5.0	Not Established
Chlorobenzene	1.0	5.0	Not Established
Chloroethane	1.0	5.0	Not Established
Chloroform	1.0	5.0	Not Established
Chloromethane	1.0	5.0	Not Established
Dibromochloromethane	1.0	--	Not Established
1,1-Dichloroethane	1.0	5.0	Not Established
1,2-Dichloroethane	1.0	5.0	Not Established
1,1-Dichloroethene	1.0	5.0	Not Established
1,2-Dichloroethene (total)	1.0	5.0	Not Established
1,2-Dichloropropane	1.0	5.0	Not Established
cis-1,3-Dichloropropene	1.0	5.0	Not Established
trans-1,3-Dichloropropene	1.0	5.0	Not Established
Ethylbenzene	1.0	5.0	Not Established
2-Hexanone	--	--	Not Established
4-Methyl-2-pentanone	--	--	Not Established
Methylene chloride	1.0	10	Not Established
Styrene	1.0	5.0	Not Established
1,1,2,2-Tetrachloroethane	1.0	5.0	Not Established

TABLE A-2 (Continued)

**Analytical Methods, Parameters for Analysis, and Reporting Limits
 IR14 Data Gap Sampling, Alameda Point**

Method and Parameters	Reporting Limit		
	Water (ug/L)	Soil (ug/kg)	RAO * (ug/L)
Tetrachloroethene	1.0	5.0	Not Established
Toluene	1.0	5.0	Not Established
1,1,1-Trichloroethane	1.0	5.0-	Not Established
1,1,2-Trichloroethane	1.0	5.0	Not Established
1,1,2-Trichloro-1,2,2-trifluoroethane	--	--	Not Established
Trichloroethene	1.0	5.0	Not Established
Vinyl acetate	--	--	Not Established
Vinyl chloride	1.0¹	5.0	15
Xylenes (total)	1.0	5.0	Not Established
EPA Method 6020: Metals by ICP/MS ¹			
Aluminum	50	--	Not Established
Antimony	1	--	Not Established
Arsenic	1	--	Not Established
Barium	1	--	Not Established
Beryllium	1	--	Not Established
Cadmium	1	--	Not Established
Calcium	50	--	Not Established
Chromium	1	--	Not Established
Cobalt	1	--	Not Established
Copper	1	--	Not Established
Iron	50	--	Not Established
Lead	1	--	Not Established
Magnesium	50	--	Not Established
Manganese	1	250	Not Established
Molybdenum	5	--	Not Established
Nickel	1	--	Not Established
Potassium	50	--	Not Established
Selenium	1	--	Not Established
Silver	1	--	Not Established

TABLE A-2 (Continued)

**Analytical Methods, Parameters for Analysis, and Reporting Limits
IR14 Data Gap Sampling, Alameda Point**

Method and Parameters	Reporting Limit		
	Water (ug/L)	Soil (ug/kg)	RAO * (ug/L)
Sodium	50	--	Not Established
Thallium	1	--	Not Established
Vanadium	1	--	Not Established
Zinc	10	--	Not Established

Notes:

-- = Not applicable

(*) RAO – Remedial Action Objective

(1) EPA Method 6010B may be substituted for 6020 if the reporting limit and quality control acceptance criteria are met.

TABLE A-3

**Summary of External (Field) QC Samples
IR14 Data Gap Sampling, Alameda Point**

Method Number	Parameters	Trip Blanks	Equipment Blanks	Source Water Blanks	Field Duplicates
8260B	Volatile Organic Compounds	1 per container	1 per event	1 per lot of water	1 per 10 samples
6020	Metals by ICP/MS	NA	1 per event	1 per lot of water	1 per 10 samples

Notes:

1 per container indicates one trip blank per shipping container per laboratory.

1 per lot of water indicates one field water blank per discrete lot of water used for rinsing reusable sampling equipment.

Source water blanks are not required when dedicated or disposable sampling equipment is used.

ICP = Inductively-coupled plasma

NA = Not applicable

TABLE A-4

**Quality Assurance Goals: Precision, Relative Percent Difference
 IR14 Data Gap Sampling, Alameda Point**

Method and Parameters	Water Samples		Soil Samples	
	MS/MSD RPD(a)	Field Duplicate RPD(b)	MS/MSD RPD(a)	Field Duplicate RPD(b)
EPA Method 8260B Volatile Organic Compounds				
Note: Analytes in BOLD have Site-Specific Cleanup Goals				
Benzene	11	50	80 – 122	37
Chlorobenzene	13	50	80 – 121	38
1,2-Dichloroethane	15	50	76 – 120	36
1,1-Dichloroethene	14	50	75 – 120	42
1,2-Dichloroethene (total)	15	50	77 – 120	37
Tetrachloroethene	15	50	78 – 120	39
Toluene	13	50	80 – 121	39
Trichloroethene	14	50	80 – 120	40
Vinyl chloride	15	50	61 – 135	37
EPA Method 6020 Metals by ICP/MS				
Aluminum	20	50	NA	NA
Antimony	20	50	NA	NA
Arsenic	20	50	NA	NA
Barium	20	50	NA	NA
Beryllium	20	50	NA	NA
Cadmium	20	50	NA	NA
Calcium	20	50	NA	NA
Chromium	20	50	NA	NA
Cobalt	20	50	NA	NA
Copper	20	50	NA	NA
Iron	20	50	NA	NA
Lead	20	50	NA	NA
Magnesium	20	50	NA	NA
Manganese	20	50	80 - 120	NA
Molybdenum	20	50	NA	NA
Nickel	20	50	NA	NA
Potassium	20	50	NA	NA
Selenium	20	50	NA	NA
Silver	20	50	NA	NA

TABLE A-4 (cont'd.)

**Quality Assurance Goals: Precision, Relative Percent Difference
 IR14 Data Gap Sampling, Alameda Point**

Method and Parameters	Water Samples		Soil Samples	
	MS/MSD RPD(a)	Field Duplicate RPD(b)	MS/MSD RPD(a)	Field Duplicate RPD(b)
EPA Method 8260B Volatile Organic Compounds				
Note: Analytes in BOLD have Site-Specific Cleanup Goals				
Sodium	20	50	NA	NA
Thallium	20	50	NA	NA
Vanadium	20	50	NA	NA
Zinc	20	50	NA	NA

- (a) Matrix (laboratory) duplicate is performed in lieu of a matrix spike duplicate for inorganic analyses.
- (b) Field duplicate RPD applies to all target analytes with positive results above the RL in the test method.
- NA Not applicable.
- ¹ Control limits estimated. Laboratory specific QC limits for these methods will be updated when available.

TABLE A-5

**Quality Assurance Goals: Accuracy, Percent Recovery
 IR14 Data Gap Sampling, Alameda Point**

Method and Parameters	Water Samples			Soil Samples		
	LCS Recovery	MS/MSD Recovery	Surrogate Recovery	LCS Recovery	MS/MSD Recovery	Surrogate Recovery
EPA Method 8260B: Volatile Organic Compounds						
Note: Analytes in BOLD have Site-Specific Cleanup Goals.						
Benzene	76-127	76-127	NA	80-122	80-122	NA
Chlorobenzene	75-130	75-130	NA	80-121	80-121	NA
1,2-Dichloroethane	75-125	75-125	NA	76-120	76-120	NA
1,1-Dichloroethene	61-145	61-145	NA	75-120	75-120	NA
1,2-Dichloroethene (total)	75-125	75-125	NA	77-120	77-120	NA
Tetrachloroethene	75-125	75-125	NA	78-120	78-120	NA
Toluene	76-125	76-125	NA	80-121	80-121	NA
Trichloroethene	71-120	71-120	NA	80-120	80-120	NA
Vinyl chloride	75-125	75-125	NA	61-135	61-135	NA
4-Bromofluorobenzene	NA	NA	86-115	NA	NA	NA
1,2-Dichloroethane-d4	NA	NA	80-120	NA	NA	79-127
Toluene-d8	NA	NA	88-110	NA	NA	76-125
Dibromofluoromethane	NA	NA	86-118	NA	NA	80-124
EPA Method 6020: Dissolved Metals by ICP/MS						
Aluminum	80-120	75-125	NA	NA	NA	NA
Antimony	80-120	75-125	NA	NA	NA	NA
Arsenic	80-120	75-125	NA	NA	NA	NA
Barium	80-120	75-125	NA	NA	NA	NA
Beryllium	80-120	75-125	NA	NA	NA	NA
Cadmium	80-120	75-125	NA	NA	NA	NA
Calcium	80-120	75-125	NA	NA	NA	NA
Chromium	80-120	75-125	NA	NA	NA	NA
Cobalt	80-120	75-125	NA	NA	NA	NA
Copper	80-120	75-125	NA	NA	NA	NA
Iron	80-120	75-125	NA	NA	NA	NA
Lead	80-120	75-125	NA	NA	NA	NA
Magnesium	80-120	75-125	NA	NA	NA	NA
Manganese	80-120	75-125	NA	80-120	80-120	NA
Molybdenum	80-120	75-125	NA	NA	NA	NA

TABLE A-5 (continued)

**Quality Assurance Goals: Accuracy, Percent Recovery
 IR14 Data Gap Sampling, Alameda Point**

Method and Parameters	Water Samples			Soil Samples		
	LCS Recovery	MS/MSD Recovery	Surrogate Recovery	LCS Recovery	MS/MSD Recovery	Surrogate Recovery
EPA Method 6010B: Dissolved Metals by ICP						
Nickel	80-120	75-125	NA	NA	NA	NA
Potassium	80-120	75-125	NA	NA	NA	NA
Selenium	80-120	75-125	NA	NA	NA	NA
Silver	80-120	75-125	NA	NA	NA	NA
Sodium	80-120	75-125	NA	NA	NA	NA
Thallium	80-120	75-125	NA	NA	NA	NA
Vanadium	80-120	75-125	NA	NA	NA	NA
Zinc	80-120	75-125	NA	NA	NA	NA

Note: alternate surrogate compounds may be substituted, if appropriate. NA = Not applicable.

¹ Control limits estimated. Laboratory specific QC limits for these methods will be updated when available.

TABLE A-6

**Sample Preservation and Storage Requirements
 IR14 Data Gap Sampling, Alameda Point**

Method Number	Parameters	Matrix	Holding Time (from sample date)	Containers	Preservative	Minimum Sample Size
8260B	Volatile Organic Compounds	water	48 hrs, 7 days if frozen, 14 days if preserved	40 mL VOA vials with Teflon septa	Hydrochloric acid to pH < 2 Store at 4 +/- 2 deg C	3 x 40 mL
6010B/6020	Metals by ICP	water	analysis - 6 months	500 mL plastic	Nitric acid to pH < 2 Store at 4 +/- 2 deg C	500 mL
8260B	Volatile Organic Compounds	soil	analysis - 14 days	5 mL EnCore	Store at 4 +/- 2 deg C	3 x 5 mL
6010B/6020	Metals by ICP	soil	analysis - 6 months	Acetate tube	Store at 4 +/- 2 deg C	1 tube

Note:
 Any test requiring the same container and preservative may be obtained from a single container.

TABLE A-10

**Field Measurement Calibration Procedures and Precision Requirements
 IR14 Data Gap Sampling, Alameda Point**

Field Measurement	Instrument	Calibration Procedure	Precision
Water Level Survey	Electrical Sounder	Reference to Steel Tape	0.01 foot
Elevation of Sample Site	Level and Rod	Surveyor Calibration	0.01 foot
Location of Sample Site	Steel or Fiberglass Tape	Reference to New Tape	1 foot
Water pH	pH Meter	2-Point Buffer Solutions	0.1 pH
Electrical Conductivity	Conductivity Meter	KCl Reference Solution	10
Turbidity	Turbidity Meter	Reference to Factory Supplied Standard	Variable
Oxidation-Reduction Potential (ORP)	ORP Meter	Reference to Factory Supplied Standard	Variable
Dissolved Oxygen	D.O. Meter	Reference to Factory Supplied Standard	Variable
Water Temperature	Temperature Meter and Thermistor	Reference to NBS Mercury Thermometer	0.1°C
Water Flow Rate	1 Liter Graduated Cylinder and Water	Reference to Calibrated Containers and Clock	0.10 L
	Flow Meters	Factory Calibrated	1 gallon per minute
Organic Vapor Monitor	Photoionization Detector	Standard Calibration Gas	1%
Pressure	Pressure Gauge	Reference to Factory Supplied Standard	Variable

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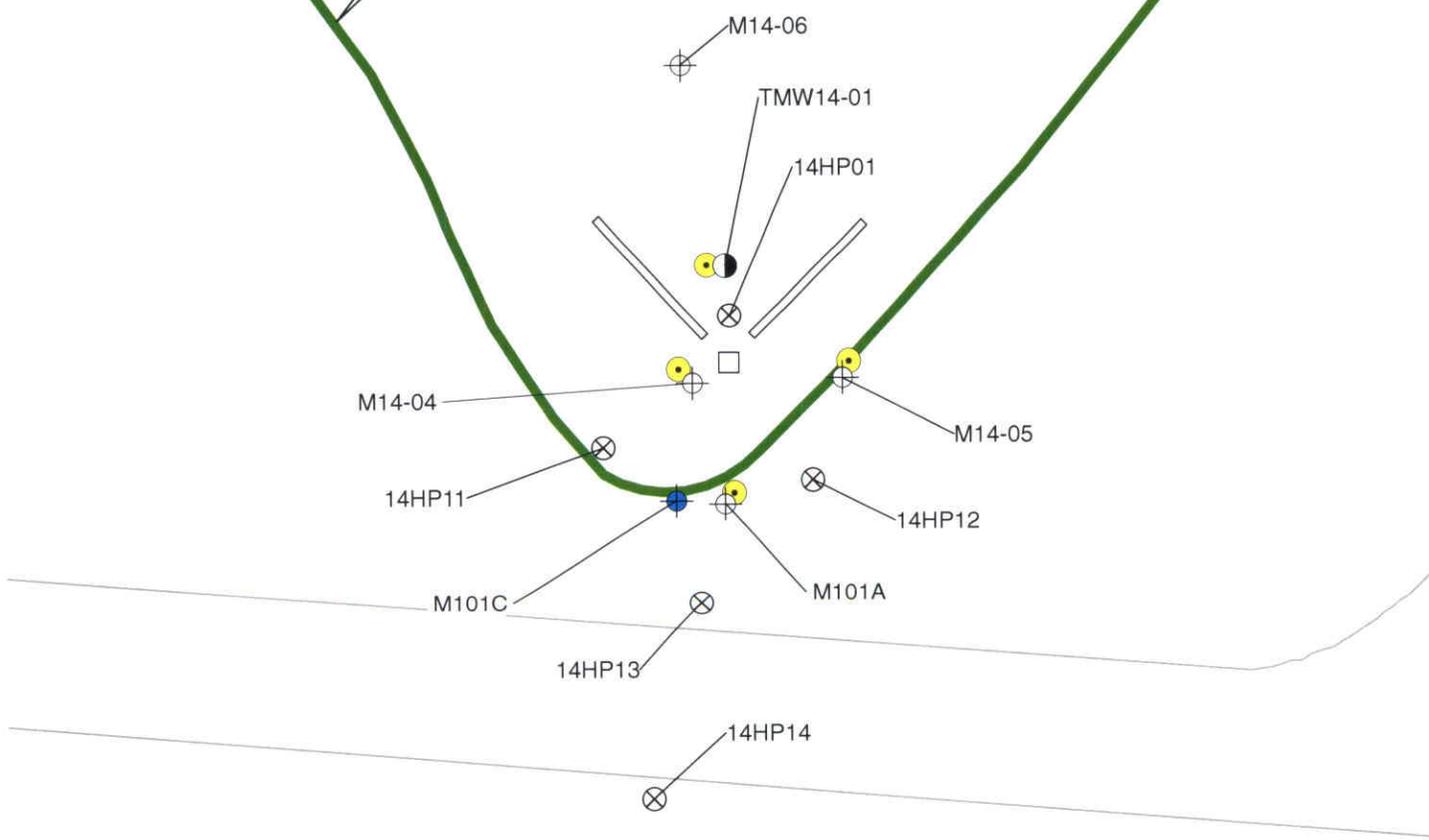
FIGURES

Figure A-4 supersedes and replaces the corresponding Figure in the original SAP

Figure A-5 is a new figure added to the original SAP

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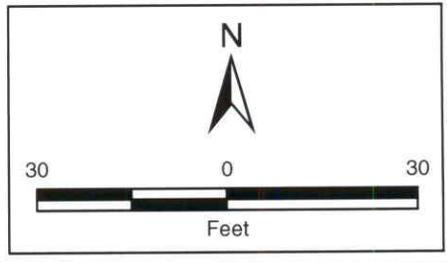
Extent of Groundwater Concentrations of Vinyl Chloride Exceeding 15 ug/L March-April 2007



Legend

- Existing FWBZ Monitoring Well
- Hydropunch, Samples collected in March, 2007
- Proposed Temporary Well
- Existing SWBZ Monitoring Well
- Proposed Soil Boring/ Soil Sampling Locations
- Approximate Groundwater Flow Direction
- Facility Infrastructure
- Area of Injection
- Zones of Soil Borings for Visual Identification of the Vertical and Horizontal Distribution of Potassium Permanganate

Approximate Groundwater Flow Direction



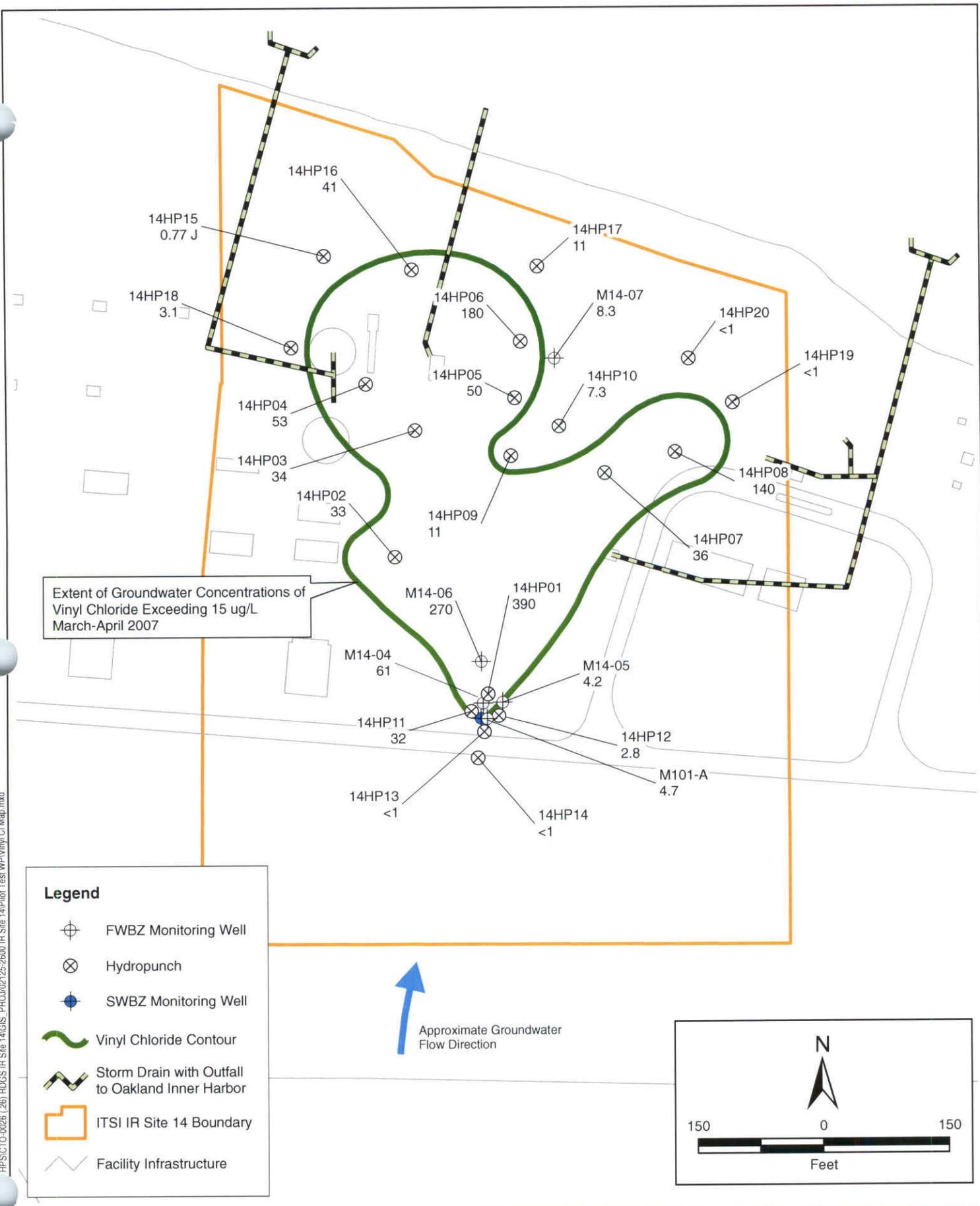
HPS\CTO-0026 (26) RDGS IR Site 14\GIS_PROJ\02125-2600 IR Site 14\Pilot Test WPI\Fig A-4 Pilot Test.mxd



Pilot Test Work Plan
 Installation Restoration Site 14
 Alameda Point
 Alameda, California

FIGURE A-4
 Permanganate Injection
 Location Map

HPS\CTO-0026 (26) RDGS IR Site 14\GIS_PROJ\02125-2600 IR Site 14\Pilot Test Work Plan\Vinyl CI Map.mxd
 200202125 Navy HPS



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ATTACHMENT 1

UFP-QAPP WORKSHEETS

Each of the following UFP QAPP Worksheets supersedes and replaces the corresponding UFP QAPP Worksheet in the original SAP

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UFP QAPP Worksheets

As per SAP Addendum 1, the following Worksheets have been amended:

Worksheet #11	Project Quality Objectives/Systematic Planning Process Statements
Worksheet #12	Measurement Performance Criteria
Worksheet #14	Summary of Project Tasks
Worksheet #15	Reference Limits and Evaluation
Worksheet #18	Sampling Locations and Methods/SOP Requirements
Worksheet #28	QC Samples
Worksheet #30	Analytical Services

NOTE: Each of the Worksheets above supersedes its counterpart in the original SAP.

SAP Worksheet #11 (UFP-QAPP Manual Section 2.6.1) -- Project Quality Objectives/Systematic Planning Process Statements

Who will use the data?

The data will be used primarily by the Navy and its subcontractors (including ITSI), and also by regulatory stakeholders including USEPA, California Regional Water Quality Control Board–San Francisco, and California Department of Toxic Substances Control.

What will the data be used for?

The data will be used to help address acquire operational and effectiveness data to feed into the Remedial Design at IR Site 14. See the project-specific SAP Addendum for the full discussion of Data Quality Objectives.

What types of data are needed (matrix, target analytes, analytical groups, field screening, on-site analytical or off-site laboratory techniques, sampling techniques)?

Collection of representative groundwater and soil samples for organic and inorganic analysis. The target analytes are VOCs by EPA 8260B, total and filtered metals by EPA 6010/6020 in water and manganese in soil by EPA 6010/6020. VOC samples will be collected using EnCore® samples. Groundwater sampling will be conducted using low-flow sampling protocol

Matrix: Soil and Groundwater

How “good” do the data need to be in order to support the environmental decision?

Data must be scientifically and legally defensible. Sample collection and analysis methods are to be selected to provide data of sufficient quality for the project objectives.

How much data are needed (number of samples for each analytical group, matrix, and concentration)?

Soil samples will be collected from 4 borings to approximately 11 feet bgs; definitive groundwater data to be collected from 1 temporary well and 3 monitoring wells screened in the shallow saturated zone. Concentrations of VOCs are expected to be low, in the range of 300 µg/L total VOCs.

SAP Worksheet #11 (UFP-QAPP Manual Section 2.6.1) -- Project Quality Objectives/Systematic Planning Process Statements (continued)

Where, when, and how should the data be collected/generated?

The samples and visual observations will be collected at the site within two months of approval of this plan. The sample and data analysis will be performed according to approved SOPs and final data from the project is presented in the remedial design.

Who will collect and generate the data?

Innovative Technological Solutions, Inc (ITSI) on behalf of Naval Facilities Engineering Command, Southwest Division (NAVFAC SW) will collect and report the data.

How will the data be reported?

Data is reported in electronic format as specified by ITSI and QAPP, and reports are retained in "pdf" format for archiving. The project team has access to the data and reports at their convenience. Data for review and final reports is clearly identified and will be reported in a Remedial Action Workplan to be distributed to the Navy and other stakeholders.

How will the data be archived?

Data will be archived electronically using CD-ROM. Computer readable electronic data files and reports are assured for at least 5 years from project initiation. Hardcopies of all final reports from the site is retained by the NAVFAC technical representative to ensure long-term access to the information.

SAP Worksheet #12 (UFP-QAPP Manual Section 2.6.2) -- Measurement Performance Criteria Table
Sample Matrix: Water

QC Sample	Analytical Group ¹	Frequency	Data Quality Indicators (DQIs)	Measurement Performance Criteria	QC Sample Assesses Error for Sampling (S), Analytical (A) or Both
Field Duplicates	VOC (8260B), Dissolved and Total Metals (6010B/6020)	10%	Precision- Overall	RPD < 50%	(S & A)
Laboratory Duplicates	Dissolved and Total Metals (6010B/6020)	5% or one per analytical batch	Precision- Analytical	RPD < 20%	(A)
Matrix Spike (MS) and Duplicate (MSD)	VOC (8260B), Dissolved and Total Metals (6010B/6020)	5% or one per analytical batch	Precision and Accuracy- Analytical	Recovery: 75% to 125% RPD < 20%	(A)
Laboratory Control Sample and Duplicate	VOC (8260B), Dissolved and Total Metals (6010B/6020)	5% or one per analytical batch	Precision and Accuracy- Analytical	Recovery: 75% to 125% RPD < 20%	(A)

SAP Worksheet #12 (UFP-QAPP Manual Section 2.6.2) -- Measurement Performance Criteria Table
Sample Matrix: Water
(continued)

QC Sample	Analytical Group ¹	Frequency	Data Quality Indicators (DQIs)	Measurement Performance Criteria	QC Sample Assesses Error for Sampling (S), Analytical (A) or Both
Method Blanks	VOC (8260B), Dissolved and Total Metals (6010B/6020)	one per analytical batch	Bias – Analytical	< RL	(A)
Equipment Rinsate Blanks	VOCs (8260B), Dissolved and Total Metals (6010B/6020)	one per day of sampling	Bias – Sampling	<RL	(S)
Source Water Blanks	VOC (8260B), Dissolved and Total Metals (6010B/6020)	one per batch of source water	Bias – Sampling	<RL	(S)
Trip Blanks	VOC (8260B)	One per sample cooler	Bias – Sampling	<RL	(S)

¹ If information varies within an analytical group, separate by individual analyte.

SAP Worksheet #14 (UFP-QAPP Manual Section 2.8.1) -- Summary of Project Tasks

Provide a brief overview of the listed project activities. The following table must be completed for each project area.

Sampling Tasks: Collect soil samples for VOCs and metals (manganese) at 4 borings prior to injection and the 4th week after injection. Perform groundwater sampling at 3 monitoring wells and 1 temporary well for VOCs for five rounds and dissolved and total metals for the prior to injection and the 8th week after injection rounds (prior to injection, 1st week after injection, 2nd week after injection, 4th week after injection, and 8th week after injection).

Analysis Tasks: Groundwater and soil samples will be analyzed at a subcontracted laboratory for VOCs by EPA method 8260B, and metals by EPA method 6010B/6020.

Quality Control Tasks: All analytical methods will perform the applicable QC described in the method, including initial calibrations, continuing calibrations, tuning, reagent blanks, surrogates, replicates, control spikes, and others as necessary. Media specific field quality control samples will be used to measure total process performance, including source water blanks, equipment rinsate samples, trip blanks, and field duplicates, as described in Section 2.6.2 of the SAP.

Secondary Data: Previously obtained data from wells historically present within the IR 14 area; data presented in the *Work Plan for Basewide Groundwater Monitoring Program, Alameda Point, Alameda, California* (Shaw, 2004a); the *Technical Memorandum, Basewide Monitoring Program Evaluation and Recommendations, Alameda Point, Alameda, California* (ITSI, 2005); and preliminary data from the data gap sampling investigation conducted in March/April 2007.

Other Data: None

Data Management Tasks: Analytical data generated by the fixed laboratory will be reviewed by the laboratory using three levels of document review and reporting. Review processes will be documented using appropriate checklists forms, or logbooks, that will be signed and dated by the reviewer. Analytical and field data will be uploaded to the Navy's NIRIS database via NEDD. Analytical data validation will be performed by an independent data validation firm.

SAP Worksheet #14 (UFP-QAPP Manual Section 2.8.1) -- Summary of Project Tasks (continued)

Documentation and Records: All relevant raw data and documentation, including (but not limited to) logbooks, data sheets, electronic files and final reports, will be maintained by the fixed laboratory for at least five years. ITSI will maintain electronic copies of all purge forms, chains-of-custody forms and all Navy Electronic Data Deliverables (NEDD). All data, field notes, raw analytical information, etc. will be stored in hardcopy and electronic format by ITSI in a central project file for the period specified in the contract. A hardcopy of the analytical data will be forwarded to the Navy's Administrative Records Division.

Assessment/Audit Tasks: During project activities, ongoing assessments will include peer review, quality control reviews, audits of field operations, checks to see that project personnel have read appropriate planning documents and are following documented procedures, and reviews to ensure that clearance activities and preliminary work have been satisfactorily completed. Laboratory audits are not scheduled to occur in conjunction with this project.

Data Review Tasks: All analytical data generated by subcontract laboratories in support of this project will be reviewed internally by the laboratory prior to reporting, to assure the validity of reported data. This internal laboratory process will consist of data reduction and three levels of document review. As the analytical data is received by ITSI, comparison of the generated data with project goals and objectives will be made by the project chemist to ensure project DQO's can be met by the data. Data review and validation will also be performed by a third-party data validation service. The data will be validated at 80% EPA Level III and 20% EPA Level IV.

SAP Worksheet #15 (UFP-QAPP Manual Section 2.8.1) -- Reference Limits and Evaluation Table
Matrix: SOIL

Analytical Group	Analyte	CAS Number	Project Action Limit (µg/kg)	Project Quantitation Limit (µg/kg)	Analytical Method MDLs (µg/kg)	Analytical Method QLs (µg/kg)
VOC	1,1,1-Trichloroethane	71-55-6	NA	5.0	0.80	5.0
VOC	1,1,2,2-Tetrachloroethane	79-34-5	NA	5.0	0.68	5.0
VOC	1,1,2-Trichloroethane	79-00-5	NA	5.0	2.9	5.0
VOC	1,1-Dichloroethane	75-34-3	NA	5.0	0.76	5.0
VOC	1,1-Dichloroethene	75-35-4	NA	5.0	1.2	5.0
VOC	1,2,4-Trichlorobenzene	120-82-1	NA	5.0	0.75	5.0
VOC	1,2-Dibromo-3-Chloropropane	96-12-8	NA	5.0	7.2	5.0
VOC	1,2-Dibromoethane	106-93-4	NA	10	0.79	10
VOC	1,2-Dichlorobenzene	95-50-1	NA	5.0	0.64	5.0
VOC	1,2-Dichloroethane	107-06-2	NA	5.0	0.73	5.0
VOC	1,2-Dichloropropane	78-87-5	NA	5.0	0.60	5.0
VOC	1,3-Dichlorobenzene	541-73-1	NA	5.0	0.75	5.0
VOC	1,4-Dichlorobenzene	106-46-7	NA	5.0	0.78	5.0
VOC	4-Methyl-2-Pentanone	108-10-1	NA	5.0		5.0
VOC	Acetone	67-64-1	NA	5.0		5.0
VOC	Benzene	71-43-2	NA	5.0	0.73	5.0
VOC	Bromodichloromethane	75-27-4	NA	5.0	0.53	5.0
VOC	Bromoform	75-25-2	NA	5.0	4.1	5.0
VOC	Bromomethane	74-83-9	NA	5.0	0.86	5.0
VOC	Carbon Disulfide	75-15-0	NA	5.0		5.0
VOC	Carbon Tetrachloride	56-23-5	NA	5.0	0.53	5.0
VOC	Chlorobenzene	108-90-7	NA	5.0	0.79	5.0
VOC	Chloroethane	75-00-3	NA	5.0	2.6	5.0
VOC	Chloroform	67-66-3	NA	5.0	0.75	5.0
VOC	Chloromethane	74-87-3	NA	5.0	1.5	5.0

SAP Worksheet #15 (UFP-QAPP Manual Section 2.8.1) -- Reference Limits and Evaluation Table (continued)

Analytical Group	Analyte	CAS Number	Project Action Limit (µg/kg)	Project Quantitation Limit (µg/kg)	Analytical Method MDLs (µg/kg)	Analytical Method QLs (µg/kg)
VOC	Cis-1,2-Dichloroethene	156-59-2	NA	5.0	0.89	5.0
VOC	Cis-1,3-Dichloropropene	10061-01-5	NA	5.0	0.64	5.0
VOC	Dibromochloromethane	124-48-1	NA	5.0	2.7	5.0
VOC	Dichlorodifluoromethane	75-71-8	NA	5.0	0.89	5.0
VOC	Ethylbenzene	100-41-4	NA	5.0	0.86	5.0
VOC	Isopropylbenzene	98-82-8	NA	5.0	0.52	5.0
VOC	Methylene Chloride	75-09-2	NA	5.0	0.84	5.0
VOC	Styrene	100-42-5	NA	5.0	0.76	5.0
VOC	Methyl Tert-Butyl Ether	1634-04-4	NA	5.0		5.0
VOC	Tetrachloroethene	127-18-4	NA	5.0	0.61	5.0
VOC	Toluene	108-88-3	NA	5.0	0.61	5.0
VOC	Trans-1,2-Dichloroethene	156-60-5	NA	5.0	0.91	5.0
VOC	Trans-1,3-Dichloropropene	10061-02-6	NA	5.0	0.75	5.0
VOC	Trichloroethene	79-01-6	NA	5.0	0.60	5.0
VOC	Trichlorofluoromethane	75-69-4	NA	5.0	0.80	5.0
VOC	Vinyl Chloride	75-01-4	15	5.0	1.6	5.0
VOC	Xylene (Total)	1330-20-7	NA	5.0	0.81	5.0
Metals	Manganese	7439-96-5	NA	50,000	7,500	50,000

SAP Worksheet #15 (UFP-QAPP Manual Section 2.8.1) -- Reference Limits and Evaluation Table

Matrix: WATER

Analytical Group	Analyte	CAS Number	Project Action Limit (µg/L)	Project Quantitation Limit (µg/L)	Analytical Method MDLs (µg/L)	Analytical Method QLs (µg/L)
VOC	1,1,1-Trichloroethane	71-55-6	NA	1.0	0.18	1.0
VOC	1,1,2,2-Tetrachloroethane	79-34-5	NA	1.0	0.37	1.0
VOC	1,1,2-Trichloro-1,2,2-Trifluoroethane	76-13-1	NA	---	--	--
VOC	1,1,2-Trichloroethane	79-00-5	NA	1.0	0.31	1.0
VOC	1,1-Dichloroethane	75-34-3	NA	1.0	0.1	1.0
VOC	1,1-Dichloroethene	75-35-4	NA	1.0	0.36	1.0
VOC	1,2,4-Trichlorobenzene	120-82-1	NA	1.0	0.23	1.0
VOC	1,2-Dibromo-3-Chloropropane	96-12-8	NA	2.0	0.95	2.0
VOC	1,2-Dibromoethane	106-93-4	NA	2.0	0.22	2.0
VOC	1,2-Dichlorobenzene	95-50-1	NA	1.0	0.14	1.0
VOC	1,2-Dichloroethane	107-06-2	NA	1.0	0.22	1.0
VOC	1,2-Dichloropropane	78-87-5	NA	1.0	0.15	1.0
VOC	1,3-Dichlorobenzene	541-73-1	NA	1.0	0.11	1.0
VOC	1,4-Dichlorobenzene	106-46-7	NA	1.0	0.13	1.0
VOC	2-Butanone	78-93-3	NA	--	--	--
VOC	2-Hexanone	591-78-6	NA	--	--	--
VOC	4-Methyl-2-Pentanone	108-10-1	NA	--	--	--
VOC	Acetone	67-64-1	NA	--	--	--
VOC	Benzene	71-43-2	NA	1.0	0.13	1.0
VOC	Bromodichloromethane	75-27-4	NA	1.0	0.14	4.0
VOC	Bromoform	75-25-2	NA	1.0	0.1	1.0
VOC	Bromomethane	74-83-9	NA	1.0	0.08	1.0
VOC	Carbon Disulfide	75-15-0	NA	--	--	--
VOC	Carbon Tetrachloride	56-23-5	NA	1.0	0.15	1.0
VOC	Chlorobenzene	108-90-7	NA	1.0	0.12	1.0
VOC	Chloroethane	75-00-3	NA	1.0	0.34	1.0
VOC	Chloroform	67-66-3	NA	1.0	0.12	1.0
VOC	Chloromethane	74-87-3	NA	1.0	0.25	1.0

SAP Worksheet #15 (UFP-QAPP Manual Section 2.8.1) -- Reference Limits and Evaluation Table (continued)

Analytical Group	Analyte	CAS Number	Project Action Limit (µg/L)	Project Quantitation Limit (µg/L)	Analytical Method MDLs (µg/L)	Analytical Method QLs (µg/L)
VOC	Cis-1,2-Dichloroethene	156-59-2	NA	1.0	0.1	1.0
VOC	Cis-1,3-Dichloropropene	10061-01-5	NA	1.0	0.22	1.0
VOC	Dibromochloromethane	124-48-1	NA	1.0	0.4	1.0
VOC	Dichlorodifluoromethane	75-71-8	NA	1.0	0.16	1.0
VOC	Ethylbenzene	100-41-4	NA	1.0	0.27	1.0
VOC	Isopropylbenzene	98-82-8	NA	1.0	0.12	1.0
VOC	Methylene Chloride	75-09-2	NA	1.0	0.35	1.0
VOC	Styrene	100-42-5	NA	1.0	0.15	1.0
VOC	Methyl Tert-Butyl Ether	1634-04-4	NA	--	--	--
VOC	Tetrachloroethene	127-18-4	NA	1.0	0.38	1.0
VOC	Toluene	108-88-3	NA	1.0	0.25	1.0
VOC	Trans-1,2-Dichloroethene	156-60-5	NA	1.0	0.11	1.0
VOC	Trans-1,3-Dichloropropene	10061-02-6	NA	1.0	0.3	1.0
VOC	Trichloroethene	79-01-6	NA	1.0	0.38	1.0
VOC	Trichlorofluoromethane	75-69-4	NA	1.0	0.23	1.0
VOC	Vinyl Chloride	75-01-4	15	1.0	0.12	1.0
VOC	Xylene (Total)	1330-20-7	NA	1.0	0.18	1.0
Metals	Aluminum	7429-90-5	NA	50	42	50
Metals	Antimony	7440-36-0	NA	5.0	4.3	5.0
Metals	Arsenic	7440-38-2	NA	5.0	2.8	5.0
Metals	Barium	7440-39-3	NA	20	1.6	20
Metals	Beryllium	7440-41-7	NA	3.0	0.68	3.0
Metals	Cadmium	7440-43-9	NA	2.5	0.55	2.5
Metals	Calcium	7440-70-2	NA	500	51	500
Metals	Chromium (total)	7440-47-3	NA	5.0	1.8	5.0
Metals	Cobalt	7440-48-4	NA	70	1.5	70
Metals	Copper	7440-50-8	NA	60	2.0	60
Metals	Iron	7439-89-6	NA	70	39	70
Metals	Lead	7439-92-1	NA	5.0	1.9	5.0
Metals	Magnesium	7439-95-4	NA	500	95	500
Metals	Manganese	7439-96-5	NA	20	1.8	20
Metals	Molybdenum	7439-98-7	NA	80	2.4	80
Metals	Nickel	7440-02-0	NA	40	2.0	40

Analytical Group	Analyte	CAS Number	Project Action Limit (µg/L)	Project Quantitation Limit (µg/L)	Analytical Method MDLs (µg/L)	Analytical Method QLs (µg/L)
Metals	Potassium	7440-09-7	NA	500	180	500
Metals	Selenium	7782-49-2	NA	5.0	4.2	5.0
Metals	Silver	7440-22-4	NA	70	1.4	70
Metals	Sodium	7440-23-5	NA	500	70	500
Metals	Thallium	7440-28-0	NA	2.0	3.5	2.0
Metals	Vanadium	7440-62-2	NA	4.0	1.5	4.0
Metals	Zinc	7440-66-6	NA	50	7.7	50

SAP Worksheet #18 (UFP-QAPP Manual Section 3.1.1) -- Sampling Locations and Methods/SOP Requirements Table

Sampling Location/ID Number	Matrix	Depth (feet)	Analytical Group	Sampling Reference ²
Prior to Injection				
M14-04A	Groundwater	5-12	VOCs (8260B), Dissolved and Total Metals (6010B/6020)	Section 2.2
M14-04A ¹	Groundwater	5-12	VOCs (8260B), Dissolved and Total Metals(6010B/6020)	Section 2.2
M14-05A	Groundwater	5-13	VOCs (8260B), Dissolved and Total Metals (6010B/6020)	Section 2.2
TMW14-01A	Groundwater	5-12	VOCs (8260B), Dissolved and Total Metals (6010B/6020)	Section 2.2
TMW14-02A	Groundwater	6-13	VOCs (8260B), Dissolved and Total Metals (6010B/6020)	Section 2.2
TMW14-03A	Groundwater	6-13	VOCs (8260B), Dissolved and Total Metals (6010B/6020)	Section 2.2
TMW14-04A	Groundwater	6-13	VOCs (8260B), Dissolved and Total Metals (6010B/6020)	Section 2.2
M101-AA	Groundwater	2.5-12.5	VOCs (8260B), Dissolved and Total Metals (6010B/6020)	Section 2.2
SB14-01A-1	Soil	5-7	VOCs (8260B), Manganese (6010B/6020)	Section 2.2
SB14-01A-2	Soil	7-9	VOCs (8260B), Manganese (6010B/6020)	Section 2.2
SB14-01A-3	Soil	9-11	VOCs (8260B), Manganese (6010B/6020)	Section 2.2
SB14-02A-1	Soil	5-7	VOCs (8260B), Manganese (6010B/6020)	Section 2.2
SB14-02A-2	Soil	7-9	VOCs (8260B), Manganese (6010B/6020)	Section 2.2
SB14-02A-3	Soil	9-11	VOCs (8260B), Manganese (6010B/6020)	Section 2.2
SB14-03A-1	Soil	5-7	VOCs (8260B), Manganese (6010B/6020)	Section 2.2
SB14-03A-2	Soil	7-9	VOCs (8260B), Manganese (6010B/6020)	Section 2.2

Sampling Location/ID Number	Matrix	Depth (feet)	Analytical Group	Sampling Reference ²
SB14-03A-3	Soil	9-11	VOCs (8260B), Manganese (6010B/6020)	Section 2.2
SB14-04A-1	Soil	5-7	VOCs (8260B), Manganese (6010B/6020)	Section 2.2
SB14-04A-2	Soil	7-9	VOCs (8260B), Manganese (6010B/6020)	Section 2.2
SB14-04A-3	Soil	9-11	VOCs (8260B), Manganese (6010B/6020)	Section 2.2
1 Week After Injection				
M14-04B	Groundwater	5-12	VOCs (8260B)	Section 2.2
M14-04B ¹	Groundwater	5-12	VOCs (8260B)	Section 2.2
M14-05B	Groundwater	5-13	VOCs (8260B)	Section 2.2
TMW14-01B	Groundwater	5-12	VOCs (8260B)	Section 2.2
TMW14-02B	Groundwater	6-13	VOCs (8260B)	Section 2.2
TMW14-03B	Groundwater	6-13	VOCs (8260B)	Section 2.2
TMW14-04B	Groundwater	6-13	VOCs (8260B)	Section 2.2
M101-AB	Groundwater	2.5-12.5	VOCs (8260B)	Section 2.2
2 Weeks After Injection				
M14-04C	Groundwater	5-12	VOCs (8260B)	Section 2.2
M14-04C ¹	Groundwater	5-12	VOCs (8260B)	Section 2.2
M14-05C	Groundwater	5-13	VOCs (8260B)	Section 2.2
TMW14-01C	Groundwater	5-12	VOCs (8260B)	Section 2.2
TMW14-02C	Groundwater	6-13	VOCs (8260B)	Section 2.2
TMW14-03C	Groundwater	6-13	VOCs (8260B)	Section 2.2
TMW14-04C	Groundwater	6-13	VOCs (8260B)	Section 2.2

Sampling Location/ID Number	Matrix	Depth (feet)	Analytical Group	Sampling Reference ²
M101-AC	Groundwater	2.5-12.5	VOCs (8260B)	Section 2.2
SB14-01B-1	Soil	5-7	VOCs (8260B), Manganese (6010B/6020)	Section 2.2
SB14-01B-2	Soil	7-9	VOCs (8260B), Manganese (6010B/6020)	Section 2.2
SB14-01B-3	Soil	9-11	VOCs (8260B), Manganese (6010B/6020)	Section 2.2
SB14-02B-1	Soil	5-7	VOCs (8260B), Manganese (6010B/6020)	Section 2.2
SB14-02B-2	Soil	7-9	VOCs (8260B), Manganese (6010B/6020)	Section 2.2
SB14-02B-3	Soil	9-11	VOCs (8260B), Manganese (6010B/6020)	Section 2.2
SB14-03B-1	Soil	5-7	VOCs (8260B), Manganese (6010B/6020)	Section 2.2
SB14-03B-2	Soil	7-9	VOCs (8260B), Manganese (6010B/6020)	Section 2.2
SB14-03B-3	Soil	9-11	VOCs (8260B), Manganese (6010B/6020)	Section 2.2
SB14-04B-1	Soil	5-7	VOCs (8260B), Manganese (6010B/6020)	Section 2.2
SB14-04B-2	Soil	7-9	VOCs (8260B), Manganese (6010B/6020)	Section 2.2
SB14-04B-3	Soil	9-11	VOCs (8260B), Manganese (6010B/6020)	Section 2.2
4 Weeks After Injection				
M14-04D	Groundwater	5-12	VOCs (8260B)	Section 2.2
M14-04D ¹	Groundwater	5-12	VOCs (8260B),	Section 2.2
M14-05D	Groundwater	5-13	VOCs (8260B)	Section 2.2
TMW14-01D	Groundwater	5-12	VOCs (8260B)	Section 2.2
TMW14-02D	Groundwater	6-13	VOCs (8260B)	Section 2.2
TMW14-03D	Groundwater	6-13	VOCs (8260B)	Section 2.2
TMW14-04D	Groundwater	6-13	VOCs (8260B)	Section 2.2

Sampling Location/ID Number	Matrix	Depth (feet)	Analytical Group	Sampling Reference ²
M101-AD	Groundwater	2.5-12.5	VOCs (8260B)	Section 2.2
8 Weeks After Injection				
M14-04E	Groundwater	5-12	VOCs (8260B), Dissolved and Total Metals (6010B/6020)	Section 2.2
M14-04E ¹	Groundwater	5-12	VOCs (8260B), Dissolved and Total Metals(6010B/6020)	Section 2.2
M14-05E	Groundwater	5-13	VOCs (8260B), Dissolved and Total Metals (6010B/6020)	Section 2.2
TMW14-01E	Groundwater	5-12	VOCs (8260B), Dissolved and Total Metals (6010B/6020)	Section 2.2
TMW14-02E	Groundwater	6-13	VOCs (8260B), Dissolved and Total Metals (6010B/6020)	Section 2.2
TMW14-03E	Groundwater	6-13	VOCs (8260B), Dissolved and Total Metals (6010B/6020)	Section 2.2
TMW14-04E	Groundwater	6-13	VOCs (8260B), Dissolved and Total Metals (6010B/6020)	Section 2.2
M101-AE	Groundwater	2.5-12.5	VOCs (8260B), Dissolved and Total Metals (6010B/6020)	Section 2.2

¹ Field duplicate sample

² SAP Section that describes the sample collection procedures.

SAP Worksheet #28 (UFP-QAPP Manual Section 3.4) -- QC Samples Table (continued)

Matrix	Groundwater and Soil					
Analytical Group	Dissolved and total metals (manganese for soil)					
Concentration Level	Unknown					
Sampling SOP	SAP Section 2.2					
Analytical Method / SOP Reference	6010B / 6020					
Sampler's Name	TBD					
Field Sampling Organization	Innovative Technical Solutions, Inc.					
Analytical Organization	STL-Sacramento					
Number of Sample Locations	2 monitoring wells 4 temporary well, and 4 soil borings					
QC Sample	Frequency / Number	Method / SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Equipment rinsate blank	NA	See Worksheet #12	Evaluate method blank. Evaluate field sampling and decontamination procedures. Evaluate field water source. Modify sampling and decontamination procedures, as appropriate.	ITSI	Bias (contamination)	< Project Action Limit
MS (Lab QC)	1/10 of samples collected	See Worksheet #12	Evaluate system. Reanalyze MS/MSD. If acceptable, report acceptable data only. If unacceptable, re-extract and reanalyze MS/MSD and report both sets of data.	Laboratory (TBD)	Bias (matrix interference)	Percent Recovery 70 – 130%

Matrix	Groundwater and Soil					
Analytical Group	Dissolved Metals					
QC Sample	Frequency / Number	Method / SOP QC Acceptance Limits	Corrective Action	Person(s) Responsible for Corrective Action	Data Quality Indicator (DQI)	Measurement Performance Criteria
Field Duplicate (groundwater only)	1/10 of samples collected	See Worksheet #12	Evaluate method blank. Evaluate field sampling and decontamination procedures. Evaluate field water source. Modify sampling and decontamination procedures, as appropriate.	Laboratory (TBD)	Precision (analysis)	RPD < 30%
Field Blank (Source water)	1 per day of sampling	See Worksheet #12	Evaluate field sampling and decon procedures	ITSI	Bias (contamination)	< Project Action Limit

SAP Worksheet #30 (UFP-QAPP Manual Section 3.5.2.3) -- Analytical Services Table

Matrix	Analytical Group	Concentration Level	Sample Locations/ D Number	Analytical SOP	Data Package Turnaround Time	Laboratory / Organization <small>(name and address, contact person and telephone number)</small>	Backup Laboratory / Organization <small>(name and address, contact person and telephone number)</small>
Water	VOCs	Low (*)	all	8260	21 Days	STL-Sacramento 880 Riverside Parkway West Sacramento, CA 95605 Ph: 916-374-4443 Contact: Robert Weidenfeld	Curtis & Tompkins, Ltd. 2323 Fifth St. Berkeley, CA 94710 Ph: 1-800-522-1878 Contact: John Goyette
Water	Total and dissolved metals	Low	all	6010B/6020	21 Days	STL-Sacramento 880 Riverside Parkway West Sacramento, CA 95605 Ph: 916-374-4443 Contact: Robert Weidenfeld	Curtis & Tompkins, Ltd. 2323 Fifth St. Berkeley, CA 94710 Ph: 1-800-522-1878 Contact: John Goyette
Soil	VOCs	Low (*)	all	8260	21 Days	STL-Sacramento 880 Riverside Parkway West Sacramento, CA 95605 Ph: 916-374-4443 Contact: Robert Weidenfeld	Curtis & Tompkins, Ltd. 2323 Fifth St. Berkeley, CA 94710 Ph: 1-800-522-1878 Contact: John Goyette
Soil	Metals (manganese)	Low	all	6010B/6020	21 Days	STL-Sacramento 880 Riverside Parkway West Sacramento, CA 95605 Ph: 916-374-4443 Contact: Robert Weidenfeld	Curtis & Tompkins, Ltd. 2323 Fifth St. Berkeley, CA 94710 Ph: 1-800-522-1878 Contact: John Goyette

(*) Concentrations of VOCs are expected to be in the range of 300 µg/L total VOCs.

Appendix B

Carus Corporation Remediation Reports



CARUS CORPORATION
Technology and Quality
Remediation Report

13 April 2007

Customer: Innovative Technical Solutions, Inc.
2730 Shadelands Drive, Suite 100
Walnut Creek, CA 94598

Cc: M. Dingsen
K. Frasco
B. Veronda
P. Vella

Attention: Mark Sorenson

From: E. Vlastnik

Keywords: Permanganate
Remediation
Soil

TECH # 10469

Subject: RemOx[®] S ISCO Reagent Soil Oxidant Demand

Summary

The average permanganate soil oxidant demand (PSOD) for the low permanganate dose at 48 hours was determined to be 1.7 g/kg. The average PSOD for the medium permanganate dose at 48 hours was determined to be 2.6 g/kg. The average PSOD for the high permanganate dose at 48 hours was determined to be 3.1 g/kg. These values are calculated on a weight as potassium permanganate (KMnO₄) per dry weight of soil. Based on the soil demands, in-situ chemical oxidation with permanganate is recommended for this site.

Background

Two soil samples were received from Innovative Technical Solutions, Inc. from the IR Site 14 Project (Project Number 02125.2600) located at Pt. Alameda, California on April 5, 2007. The soil sample descriptions were 14HP18-10-11 and 14HP18-15-16. The samples were analyzed for permanganate soil oxidant demands. The measurement of the permanganate soil oxidant demand is used to estimate the concentration of permanganate that will be consumed by the natural reducing agents as well as the contaminants of concern in the soil during a given time period.

Experimental

To determine the PSOD of the soil, a reaction vessel for each sample was filled with 50 grams of the soil. Large rocks (>5 grams) were excluded from the analysis. A total volume of 100 mLs of deionized water and concentrated permanganate dosing solution were added for a 1:2 soil to added water ratio. The initial permanganate concentrations were 3.0 g/kg (low dose), 15.2 g/kg (medium dose), and 30.4 g/kg (high dose) as KMnO₄ on a dry soil basis. The reaction vessels were inverted twice per day during the 48-hour reaction time. Residual permanganate (MnO₄⁻) was determined at 48 hours. The moisture content for each soil sample was determined using ASTM Method D 2216-98 and the demands were calculated on a dry weight basis.

Results

The permanganate demand is the amount of permanganate consumed in a given amount of time. It should be noted that in a soil or groundwater sample, the oxidation of any compound by permanganate is dependent on the initial dose of permanganate and the reaction time available. As the permanganate dose is increased, the reaction rate and oxidant consumption may also

increase. Some compounds that are not typically oxidized by permanganate under low doses can become reactive with permanganate at higher concentrations. Therefore, increasing the permanganate dose to extreme excess could be disadvantageous to a remediation project (e.g., inefficient chemical usage, higher costs, etc.).

The 48-hour PSOD results of the soil for the low, medium, and high oxidant doses can be seen in Table 1 (on a dry soil basis).

Table 1: 48-Hour PSOD* for the Low, Medium, and High Permanganate Doses

Sample ID Soil	Low Dose (g/kg)	Medium Dose (g/kg)	High Dose (g/kg)	Soil Moisture (%)
14HP18-10-11	1.1	1.5	1.8	12.84
14HP18-15-16	2.3	3.8	4.4	13.60
Average	1.7	2.6	3.1	13.22

*Demands were calculated on a weight KMnO_4 /dry soil weight basis. To convert from a dry basis to an as received basis, multiply the dry value by 1 minus the moisture. For example, the average demand from the high dose is $3.1 \text{ g/kg (dry)} \times (1 - 0.1322) = 2.7 \text{ g/kg (as received)}$.

Conclusions

For this application the amount of permanganate needed will be dependent on the reaction time allowed. The samples had low soil demands with an average 48-hour permanganate demand value of 3.1 g/kg for the high permanganate dose. Generally, remediation sites with a soil demand of less than 35.0 g/kg at 48 hours for the high permanganate dose are favorable for in-situ chemical oxidation with permanganate (see Table 2 for additional information).

Table 2: Correlation of Soil Oxidant Demand Results*

PSOD (g/kg)	Rank	Comment
<15	Low	ISCO with MnO_4^- is recommended. PSOD contribution to MnO_4^- demand is low.
15-35	Moderate	ISCO with MnO_4^- is recommended.
35-50	Moderately High	ISCO with MnO_4^- is recommended but PSOD will contribute significantly to MnO_4^- demand. Pilot testing may help define these demands.
>50	High	Pilot testing is highly recommended to determine effective PSOD at the site.

*Dry Weight Basis

RemOx[®] ISCO Reagent is a registered trademark of Carus Corporation



CARUS CORPORATION
Technology and Quality
Remediation Report

26 April 2007

Customer: Innovative Technical Solutions, Inc.
2730 Shadelands Drive, Suite 100
Walnut Creek, CA 94598

Cc: M. Dingens
K. Frasco
B. Veronda
P. Vella

Attention: Mark Sorenson

From: E. Vlastnik

Keywords: Permanganate
Remediation
Soil

TECH # 10479

Subject: RemOx[®] S ISCO Reagent Soil Oxidant Demand

Summary

For the soil sample M14 04 8-9' the permanganate soil oxidant demand (PSOD) for the low permanganate dose a 48 hours was determined to be 2.2 g/kg. The PSOD for the medium permanganate dose was determined to be 3.7 g/kg. The PSOD for the high permanganate dose at 48 hours was determined to be 4.2 g/kg.

For the soil sample M14 06 5-6' the permanganate soil oxidant demand (PSOD) for the low permanganate dose a 48 hours was determined to be 2.7 g/kg. The PSOD for the medium permanganate dose was determined to be 6.9 g/kg. The PSOD for the high permanganate dose at 48 hours was determined to be 11.9 g/kg.

For the soil sample M14 06 9-10' the permanganate soil oxidant demand (PSOD) for the low permanganate dose a 48 hours was determined to be greater than 3.6 g/kg. The PSOD for the medium permanganate dose was determined to be 16.6 g/kg. The PSOD for the high permanganate dose at 48 hours was determined to be 26.3 g/kg.

These values are calculated on a weight as potassium permanganate (KMnO₄) per dry weight of soil basis. Because of the variation observed in these soil demands a discussion with a Carus Chemical Company Hazardous Remediation Marketing representative about parameters of this application is recommended.

Background

Three soil samples were received from Innovative Technical Solutions, Inc. from the IR Site 14 Project (Project Number 02125.2600) located at Pt. Alameda, California on April 17, 2007. The soil sample descriptions were M14 04 8-9, M14 06 5-6, and M14 06 9-10. The samples were analyzed for permanganate soil oxidant demands. The measurement of the permanganate soil oxidant demand is used to estimate the concentration of permanganate that will be consumed by the natural reducing agents as well as the contaminants of concern in the soil during a given time period. These soil samples were submitted for additional site characterization following previous permanganate soil oxidant demand testing (See TECH 10464)

Experimental

To determine the PSOD of the soil, a reaction vessel for each sample was filled with 50 grams of the soil. Large rocks (>5 grams) were excluded from the analysis. A total volume of 100 mLs of deionized water and concentrated permanganate dosing solution were added for a 1:2 soil to added water ratio. The initial permanganate concentrations for M14 04 8-9 were 3.1 g/kg (low dose), 15.4 g/kg (medium dose), and 30.9 g/kg (high dose) as KMnO_4 on a dry soil basis. The initial permanganate concentrations for M14 06 5-6 were 3.1 g/kg (low dose), 15.5 g/kg (medium dose), and 31.0 g/kg (high dose) on a dry soil basis. The initial permanganate concentrations for M14 06 9-10 were 3.6 g/kg (low dose), 18.0 g/kg (medium dose), and 35.9 g/kg (high dose) on a dry soil basis. The initial permanganate concentrations varied by soil because the soil moistures were different for each of the soils. The reaction vessels were inverted twice per day during the 48-hour reaction time. Residual permanganate (MnO_4^-) was determined at 48 hours. The moisture content for each soil sample was determined using ASTM Method D 2216-98 and the demands were calculated on a dry weight basis.

Results

The permanganate demand is the amount of permanganate consumed in a given amount of time. It should be noted that in a soil or groundwater sample, the oxidation of any compound by permanganate is dependent on the initial dose of permanganate and the reaction time available. As the permanganate dose is increased, the reaction rate and oxidant consumption may also increase. Some compounds that are not typically oxidized by permanganate under low doses can become reactive with permanganate at higher concentrations. Therefore, increasing the permanganate dose to extreme excess could be disadvantageous to a remediation project (e.g., inefficient chemical usage, higher costs, etc.).

The 48-hour PSOD results of the soil for the low, medium, and high oxidant doses can be seen in Table 1 (on a dry soil basis).

Table 1: 48-Hour PSOD* for the Low, Medium, and High Permanganate Doses

Sample ID Soil	Low Dose (g/kg)	Medium Dose (g/kg)	High Dose (g/kg)	Soil Moisture (%)
M14 04 8-9'	2.2	3.7	4.2	14.79
M14 06 5-6'	2.7	6.9	11.9	14.50
M14 06 9-10'	>3.6	16.6	26.3	25.71

*Demands were calculated on a weight KMnO_4 /dry soil weight basis. To convert from a dry basis to an as received basis, multiply the dry value by 1 minus the moisture. For example, the demand from the high dose for M14 04 8-9 is 4.2 g/kg (dry) \times (1-0.1479) = 3.6 g/kg (as received).

Conclusions

For this application the amount of permanganate needed will be dependent on the reaction time allowed. The sample labeled M14 06 9-10 had a moderate soil demand with a 48-hour permanganate demand value of 26.3 g/kg for the high permanganate dose. The remaining samples (M14 04 8-9 and M14 06 5-6) had low soil demands with 48-hour permanganate demand values ranging from 4.2 to 11.9 g/kg for the high permanganate dose. Generally, remediation sites with a soil demand of less than 35.0 g/kg at 48 hours for the high permanganate dose are favorable for in-situ chemical oxidation with permanganate (see Table 2 for additional information). Based on the variation observed in these demands, good site characterization and discussion with a Carus Chemical Company Hazardous Remediation Sales or Marketing representative about parameters of this application are recommended.

Table 2: Correlation of Soil Oxidant Demand Results*

PSOD (g/kg)	Rank	Comment
<15	Low	ISCO with MnO_4^- is recommended. PSOD contribution to MnO_4^- demand is low.
15-35	Moderate	ISCO with MnO_4^- is recommended.
35-50	Moderately High	ISCO with MnO_4^- is recommended but PSOD will contribute significantly to MnO_4^- demand. Pilot testing may help define these demands.
>50	High	Pilot testing is highly recommended to determine effective PSOD at the site.

*Dry Weight Basis

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Appendix C

MSDS for Oxidants



RemOx® S ISCO Reagent

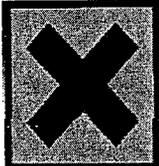
EC- SAFETY DATA SHEET according to EC directive 2001/58/EC MATERIAL SAFETY DATA SHEET

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Section 1 Chemical Product and Company Identification

PRODUCT NAME: RemOx® S ISCO Reagent TRADE NAME: RemOx® S ISCO Reagent		Revised Date: January 2006
USES OF SUBSTANCE: RemOx® S ISCO Reagent is an oxidant recommended for applications that require a strong oxidant.		
COMPANY NAME (Europe): CARUS NALON S.L.	COMPANY ADDRESS: Carus Nalon S.L. Barrio Nalon, s/n 33100 Trubia-Oviedo Espana, Spain INFORMATION: (34) 985-785-513 (34) 985-785-513 www.caruseurope.com (Web) carus@carusnalon.com (Email)	EMERGENCY TELEPHONE: (34) 985-785-513
COMPANY NAME (US): CARUS CHEMICAL COMPANY	COMPANY ADDRESS: 315 Fifth Street Peru, IL 61354, USA INFORMATION: (815)-223-1500 www.caruschem.com (Web) salesmkt@caruschem.com (Email)	EMERGENCY TELEPHONE: (800) 435-6856 (USA) (800) 424-9300 (CHEMTREC, USA) (815-223-1500 (Other countries)

Section 2 Hazardous Ingredients

<u>MATERIAL OR COMPONENT</u>	<u>CAS NO.</u>	<u>EINECS</u>	<u>HAZARD DATA</u>
Potassium Permanganate	7722-64-7	231-760-3	PEL/C 5 mg Mn per cubic meter of air TLV-TWA 0.2 mg Mn per cubic meter of air
<u>HAZARD SYMBOLS:</u>			
 O	 Xn	 N	
<u>RISK PHRASES:</u>			
8 Contact with combustibles may cause fire.			
22 Harmful if swallowed.			
50/53 Very toxic to aquatic organisms, may cause long-term effects in the aquatic environment.			
<u>SAFETY PHRASES:</u>			
60 This material and its container must be disposed of as hazardous waste.			
61 Avoid releases to the environment. Refer to special instructions / Safety data sheet.			



Section 3 Hazards Identification

1. EYE CONTACT

RemOx® S ISCO Reagent is damaging to eye tissue on contact. It may cause severe burns that result in damage to the eye.

2. SKIN CONTACT

Contact of solutions at room temperature may be irritating to the skin, leaving brown stains. Concentrated solutions at elevated temperature and crystals are damaging to the skin.

3. INHALATION

Acute inhalation toxicity data are not available. However, airborne concentrations of RemOx® S ISCO Reagent the form of dust or mist may cause damage to the respiratory tract.

4. INGESTION

RemOx® S ISCO Reagent, if swallowed, may cause severe burns to mucous membranes of the mouth, throat, esophagus, and stomach.

Section 4 First Aid Measures

1. EYES

Immediately flush eyes with large amounts of water for at least 15 minutes holding lids apart to ensure flushing of the entire surface. Do not attempt to neutralize chemically. Seek medical attention immediately. **Note to physician:** Soluble decomposition products are alkaline. Insoluble decomposition product is brown manganese dioxide.

2. SKIN

Immediately wash contaminated areas with water. Remove contaminated clothing and footwear. Wash clothing and decontaminate footwear before reuse. Seek medical attention immediately if irritation is severe or persistent.

3. INHALATION

Remove person from contaminated area to fresh air. If breathing has stopped, resuscitate and administer oxygen if readily available. Seek medical attention immediately.

4. INGESTION

Never give anything by mouth to an unconscious or convulsing person. If person is conscious, give large quantities of water. Seek medical attention immediately.



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Section 5 Fire Fighting Measures

NFPA* HAZARD SIGNS

Health Hazard	1	=	Materials which under fire conditions would give off irritating combustion products. (less than 1 hour exposure)
			Materials that on the skin could cause irritation.
Flammability Hazard	0	=	Materials that will not burn.
Reactivity Hazard	0	=	Materials which in themselves are normally stable, even under fire exposure conditions, and which are not reactive with water.
Special Hazard	OX	=	Oxidizer

***National Fire Protection Association 704 (USA)**

FIRST RESPONDERS:

Wear protective gloves, boots, goggles, and respirator. In case of fire, wear positive pressure breathing apparatus. Approach incident with caution.

FLASHPOINT

None

FLAMMABLE OR EXPLOSIVE LIMITS

Lower: Nonflammable Upper: Nonflammable

EXTINGUISHING MEDIA

Use large quantities of water. Water will turn pink to purple if in contact with RemOx® S ISCO Reagent. Dike to contain. Do not use dry chemicals, CO₂ Halon® or foams.

SPECIAL FIREFIGHTING PROCEDURES

If material is involved in fire, flood with water. Cool all affected containers with large quantities of water. Apply water from as

far

a distance as possible. Wear self-contained breathing apparatus and full protective clothing.

UNUSUAL FIRE AND EXPLOSION

Powerful oxidizing material. May decompose spontaneously

if

exposed to heat (150°C / 302°F). May be explosive in contact

with

certain other chemicals (Section 10). May react violently with finely divided and readily oxidizable substances. Increases burning rate of combustible material.

Section 6 Accidental Release Measures

PERSONAL PRECAUTIONS:

Ensure adequate ventilation. Avoid dust formation. Avoid inhalation and contact with eyes and skin. Personnel should wear protective clothing suitable for the task. Remove all ignition sources and incompatible materials before attempting clean up.

ENVIRONMENTAL PRECAUTIONS:

Do not flush into sanitary sewer system or surface water. If accidental release into the environment occurs, inform the responsible authorities. Keep the product away from drains, sewers, surface and ground water and soil.

STEPS TO BE TAKEN IF MATERIAL IS RELEASED OR SPILLED:

Clean up spills immediately by sweeping or shoveling up the material. Do not return spilled material to the original container – transfer to a clean metal drum. To clean contaminated surfaces or floors, flush with abundant quantities of water into sewer, if permitted by federal, state, and local regulations - if not, collect water and treat chemically (Section 13).



RemOx®S ISCO Reagent

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Section 7 Handling and Storage

WORK/HYGIENIC PRACTICES

Wash hands thoroughly with soap and water after handling RemOx® S ISCO Reagent. Do not eat, drink or smoke when working with RemOx® S ISCO Reagent. Wear proper protective equipment. Remove clothing, if it becomes contaminated.

VENTILATION REQUIREMENTS

Provide sufficient mechanical and/or local exhaust to maintain exposure below the TLV/TWA.

CONDITIONS FOR SAFE STORAGE

Store in accordance with NFPA 430 requirements for Class II oxidizers. Protect containers from physical damage. Store in a cool, dry area in closed containers. Segregate from acids, peroxides, formaldehyde, and all combustible, organic, or easily oxidizable materials including antifreeze and hydraulic fluid.

Section 8 Exposure Controls and Personal Protection

RESPIRATORY PROTECTION

In cases where overexposure to dust may occur, the use of an approved NIOSH-MSHA dust respirator or an air supplied respirator is advised. Engineering or administrative controls should be implemented to control dust.

EYE

Faceshield, goggles, or safety glasses with side shields should be worn. Provide eyewash in working area.

GLOVES

Rubber or plastic gloves should be worn.

OTHER PROTECTIVE EQUIPMENT

Normal work clothing covering arms and legs, and rubber, or plastic apron should be worn.

Section 9 Physical and Chemical Properties

APPEARANCE AND ODOR

Dark purple solid with metallic luster, odorless

BOILING POINT, 760 mm Hg

Not applicable

VAPOR PRESSURE (mm Hg)

Not applicable

SOLUBILITY IN WATER % BY SOLUTION

6% at 20°C (68°F) and 20% at 65°C (149°F)

PERCENT VOLATILE BY VOLUME

Not volatile

EVAPORATION RATE

Not applicable

MELTING POINT

Starts to decompose with evolution of oxygen (O₂) at temperatures above 150°C (302°F). Once initiated, the decomposition is exothermic and self-sustaining.

SPECIFIC GRAVITY

2.7 at 20°C (68°F)

BULK DENSITY

Approximately 1.45 - 1.6 kg / l

VAPOR DENSITY (AIR=1)

Not applicable

OXIDIZING PROPERTIES

Strong oxidizer



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Section 10 Stability and Reactivity

STABILITY	Under normal conditions, the material is stable.
CONDITIONS TO AVOID	Contact with incompatible materials or heat (150°C / 302°F) could result in violent exothermic chemical reaction.
INCOMPATIBLE MATERIALS	Acids, peroxides, formaldehyde, anti-freeze, hydraulic fluids and all combustible organic or readily oxidizable inorganic materials including metal powders. With hydrochloric acid, chlorine gas is liberated.
HAZARDOUS DECOMPOSITION PRODUCTS	When involved in a fire, RemOx® S ISCO Reagent may liberate corrosive fumes.
CONDITIONS CONTRIBUTING TO HAZARDOUS POLYMERIZATION	Material is not known to polymerize.

Section 11 Toxicological Information

POTASSIUM PERMANGANATE:

1. ACUTE TOXICITY

INGESTION:

LD 50 oral rat: 780 mg/kg male (14 days); 525 mg/kg female (14 days).

Harmful if swallowed. ALD: 10g. Ingestion may cause nausea, vomiting, sore throat, stomach-ache and eventually lead to a perforation of the intestine. Liver and kidney injuries may occur.

SKIN CONTACT:

LD 50 dermal: no data available.

The product may be absorbed into the body through the skin. Major effects of exposure: severe irritation, brown staining of skin.

INHALATION:

LC 50 inhalation: No data available.

The product may be absorbed into the body by inhalation. Major effects of exposure: respiratory disorder, cough.

2. CHRONIC TOXICITY

No known cases of chronic poisoning due to permanganates have been reported. Prolonged exposure, usually over many years, to heavy concentrations of manganese oxides in the form of dust and fumes may lead to chronic manganese poisoning, chiefly involving the central nervous system.

3. CARCINOGENICITY

Potassium permanganate has not been classified as a carcinogen by ACGIH, NIOSH, OSHA, NTP, or IARC.

4. MEDICAL CONDITIONS GENERALLY AGGRAVATED BY EXPOSURE

Potassium permanganate solution will cause further irritation of tissue, open wounds, burns or mucous membranes.



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Section 12 Ecological Information

ENTRY TO THE ENVIRONMENT

Potassium permanganate has a low estimated lifetime in the environment, being readily converted by oxidizable materials to insoluble MnO₂.

BIOCONCENTRATION POTENTIAL

In non-reducing and non-acidic environments, MnO₂ is insoluble and has a very low bioaccumulative potential.

AQUATIC TOXICITY

The toxicity data for Potassium permanganate is given below:

Rainbow trout, 96 hour LC ₅₀ :	1.8 mg/L
Bluegill sunfish, 96 hour LC ₅₀ :	2.3 mg/L
Milk fish (Chanos Chanos)/ 96 hour LC ₅₀ :	>1.4mg/l

Section 13 Disposal Considerations

Offer surplus and non-recyclable product or solutions to a licensed disposal company.

Reduce RemOx® S ISCO Reagent in aqueous solutions with sodium thiosulfate, a bisulfite or ferrous salt solution. The bisulfite or ferrous salt may require some dilute sulfuric acid (10% w/w) to promote reduction. Neutralize with sodium carbonate to neutral pH, if acid was used. Decant or filter and deposit sludge in approved landfill. Where permitted, the sludge may be drained into sewer with large quantities of water. Contact Carus Chemical Company for additional recommendations.

Packaging materials must be triple rinsed to remove all RemOx® S ISCO Reagent prior to re-cycling or disposal.

Section 14 Transport Information

USA (land, D.O.T.)	Proper Shipping Name: 49 CFR172.101....Potassium Permanganate Hazard Class: 49 CFR172.101....Oxidizer ID Number: 49 CFR172.101....UN 1490 Packing Group: 49 CFR172.101....II Division: 49 CFR172.101....5.1
European Labeling in accordance Road/Rail Transport (ADR/RID)	ID Number: UN 1490 ADR/RID Class 5.1 Description of Goods: Potassium Permanganate Hazard Identification No. 50
European Labeling in accordance with EC directive (Water, I.M.O.)	Proper Shipping Name: Potassium Permanganate Hazard Class: Oxidizer ID Number: UN 1490 Packing Group: II Division: 5.1 Marine Pollutant: No



EC- SAFETY DATA SHEET according to EC directive 2001/58/EC
MATERIAL SAFETY DATA SHEET

Section 14 Transport Information (contd.)

European Labeling in accordance with EC directive (Air, I.C.A.O.)	Proper Shipping Name:	Potassium Permanganate
	Hazard Class:	Oxidizer
	ID Number:	UN 1490
	Packing Group:	II
	Division:	5.1

Section 15 Regulatory Information

EUROPEAN AND INTERNATIONAL REGULATIONS:

MARKINGS ACCORDING TO EU GUIDELINES:

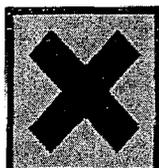
The product has been classified and marked in accordance with EU directives/ordinances on hazardous materials.

<u>CHEMICAL NAME</u>	<u>CAS NO.</u>	<u>EINECS</u>	<u>UN NUMBER</u>
Potassium Permanganate	7722-64-7	231-760-3	UN 1490

CODE LETTER AND HAZARD DESIGNATION OF THE PRODUCT:



O
Oxidizer



Xn
Harmful



N
Dangerous to the Environment

RISK PHRASES:

- 8 Contact with combustibles may cause fire.
- 22 Harmful if swallowed.
- 50/53 Very toxic to aquatic organisms, may cause long-term effects in the aquatic environment.

SAFETY PHRASES:

- 60 This material and its container must be disposed of as hazardous waste.
- 61 Avoid releases to the environment. Refer to special instructions / Safety data sheet.



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Section 15 Regulatory Information (contd.)

US FEDERAL REGULATIONS:

CHEMICAL INVENTORY STATUS – PART 1

<u>Ingredient</u>	<u>CAS. NO.</u>	<u>TSCA</u>	<u>EC</u>	<u>Japan</u>	<u>Australia</u>
Potassium Permanganate	7722-64-7	Yes	Yes		

CHEMICAL INVENTORY STATUS – PART 2 -- CANADA--

<u>Ingredient</u>	<u>CAS. NO.</u>	<u>Korea</u>	<u>DSL</u>	<u>NDSL</u>	<u>PHIL</u>
Potassium Permanganate	7722-64-7	No	Yes		

This product has been classified in accordance with the hazard criteria of the Controlled Products Regulation (CPR, Canada) and the MSDS contains all of the information required by the CPR.

FEDERAL, STATE & INTERNATIONAL REGULATIONS – PART 1

<u>Ingredient</u>	<u>CAS. NO.</u>	<u>SARA 302</u>		<u>SARA 313</u>	
		<u>RQ</u>	<u>TPQ</u>	<u>List</u>	<u>Chemical Catg.</u>
Potassium Permanganate	7722-64-7	N/A	N/A	Yes	Yes

(Manganese compounds)

FEDERAL, STATE & INTERNATIONAL REGULATIONS – PART 2

<u>Ingredient</u>	<u>CAS. NO.</u>	<u>CERCLA</u>	<u>RCRA</u>	<u>TSCA 8(d)</u>
Potassium Permanganate	7722-64-7	Yes (RQ =100 lbs)	D001	No

<u>Ingredient</u>	<u>CAS. NO.</u>	<u>CWC</u>	<u>TSCA 12(b)</u>	<u>CDTA</u>	<u>SARA</u>
Potassium Permanganate	7722-64-7	No	No	311/312	4545 Kg

<u>Ingredient</u>	<u>CAS. NO.</u>	<u>Acute</u>	<u>Chronic</u>	<u>Fire</u>	<u>Pressure</u>	<u>Reactivity</u>	<u>Pure/Liquid</u>
Potassium Permanganate	7722-64-7	Yes	Yes	Yes	No	No	Pure

<u>Ingredient</u>	<u>CAS. NO.</u>	<u>Australian Hazchem Code</u>	<u>Poison Schedule</u>	<u>WHMIS</u>
Potassium Permanganate				C, D2B



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Section 16 Other Information

NIOSH	National Institute for Occupational Safety and Health
MSHA	Mine Safety and Health Administration
OSHA	Occupational Safety and Health Administration
NTP	National Toxicology Program
IARC	International Agency for Research on Cancer
PEL	Permissible Exposure Limit
C	Ceiling Exposure Limit
TLV-TWA	Threshold Limit Value-Time Weighted Average
CAS	Chemical Abstract Service
EINECS	Inventory of Existing Chemical Substances (European)

Chithambarathanu Pillai (S.O.F.)
January 2006

The information contained herein is accurate to the best of our knowledge. However, data, safety standards and government regulations are subject to change and, therefore, holders and users should satisfy themselves that they are aware of all current data and regulations relevant to their particular use of product. CARUS CHEMICAL COMPANY DISCLAIMS ALL LIABILITY FOR RELIANCE ON THE COMPLETENESS OR ACCURACY OR THE INFORMATION INCLUDED HEREIN. CARUS CHEMICAL COMPANY MAKES NO WARRANTY, EITHER EXPRESS OR IMPLIED, INCLUDING, BUT NOT LIMITED TO, ANY WARRANTIES OF MERCHANTABILITY OR FITNESS FOR PARTICULAR USE OR PURPOSE OF THE PRODUCT DESCRIBED HEREIN. All conditions relating to storage, handling, and use of the product are beyond the control of Carus Chemical Company, and shall be the sole responsibility of the holder or user of the product.

CARUS CHEMICAL COMPANY IS A DIVISION OF CARUS CORPORATION, 315 5TH STREET, PERU, ILLINOIS 61354
CARUS NALON S.L. IS A DIVISION OF CARUS CORPORATION, 315 5TH STREET, PERU, ILLINOIS 61354



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MSDS Number: S4730 * * * * * Effective Date: 11/10/05 * * * * * Supercedes: 02/18/03



From: Mallinckrodt Baker, Inc.
222 Red School Lane
Phillipsburg, NJ 08865



24 Hour Emergency Telephone: 908-859-2151
CHEMTREC: 1-800-424-9300

National Response In Canada
CANUTEC: 613-998-6666

Outside U.S. And Canada
Chemtrec: 703-527-3887

NOTE: CHEMTREC, CANUTEC and National Response Center emergency numbers to be used only in the event of chemical emergencies involving a spill, leak, fire, exposure or accident involving chemicals.

All non-emergency questions should be directed to Customer Service (1-800-582-2537) for assistance.

Sodium Persulfate

1. Product Identification

Synonyms: Sodium Peroxydisulfate; Peroxydisulfuric Acid, Disodium Salt
CAS No.: 7775-27-1
Molecular Weight: 238.03
Chemical Formula: Na₂O₈S₂
Product Codes: V035

2. Composition/Information on Ingredients

Ingredient	CAS No	Percent	Hazardous
Peroxydisulfuric Acid Disodium Salt	7775-27-1	90 - 100%	Yes

3. Hazards Identification

Emergency Overview

DANGER! STRONG OXIDIZER. CONTACT WITH OTHER MATERIAL MAY CAUSE FIRE. HARMFUL IF SWALLOWED OR INHALED. MAY CAUSE BURNS TO SKIN AND

EYES. CAUSES RESPIRATORY TRACT IRRITATION. MAY CAUSE ALLERGIC SKIN OR RESPIRATORY REACTION.

J.T. Baker SAF-T-DATA^(tm) Ratings (Provided here for your convenience)

Health Rating: 2 - Moderate

Flammability Rating: 0 - None

Reactivity Rating: 3 - Severe (Oxidizer)

Contact Rating: 3 - Severe (Corrosive)

Lab Protective Equip: GOGGLES; LAB COAT; PROPER GLOVES

Storage Color Code: Yellow (Reactive)

Potential Health Effects

There is limited information available on the hazards of this chemical. The health effects listed for this substance are based on information found for compounds of similar structure.

Inhalation:

Causes irritation to the respiratory tract. Symptoms may include sore throat, shortness of breath, inflammation of nasal passages, coughing, and wheezing. May cause lung edema, a medical emergency. Any exposure may cause an allergic reaction. Asthma-like symptoms and life-threatening shock may result.

Ingestion:

Causes severe irritation and possible burns to the mouth and throat. Gastrointestinal disturbances may be expected with nausea, abdominal pain, and vomiting.

Skin Contact:

Causes severe irritation or burns. Symptoms include redness, itching and pain. May cause allergic skin reactions.

Eye Contact:

Can cause severe irritation or burns with eye damage.

Chronic Exposure:

No information found.

Aggravation of Pre-existing Conditions:

Persons with impaired respiratory function may be more susceptible to the effects of the substance.

4. First Aid Measures

Inhalation:

Remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention immediately.

Ingestion:

If swallowed, DO NOT INDUCE VOMITING. Give large quantities of water. Never give anything by mouth to an unconscious person. Get medical attention immediately.

Skin Contact:

Immediately flush skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Get medical attention immediately. Wash clothing before reuse. Thoroughly

clean shoes before reuse.

Eye Contact:

Immediately flush eyes with plenty of water for at least 15 minutes, lifting lower and upper eyelids occasionally. Get medical attention immediately.

5. Fire Fighting Measures

Fire:

Not combustible, but substance is a strong oxidizer and its heat of reaction with reducing agents or combustibles may cause ignition. Heating or contact with water releases oxygen which may intensify combustion in an existing fire.

Explosion:

An explosion hazard when mixed with finely powdered organic matter, metal powder, or reducing agents. Strong oxidants may explode when shocked, or if exposed to heat, flame, or friction. Also may act as initiation source for dust or vapor explosions.

Fire Extinguishing Media:

Use any means suitable for extinguishing surrounding fire. Do not use water.

Special Information:

In the event of a fire, wear full protective clothing and NIOSH-approved self-contained breathing apparatus with full facepiece operated in the pressure demand or other positive pressure mode. Sealed containers may rupture when heated.

6. Accidental Release Measures

Remove all sources of ignition. Ventilate area of leak or spill. Keep unnecessary and unprotected people away from area of spill. Wear appropriate personal protective equipment as specified in Section 8. Spills: Pick up and place in a suitable container for reclamation or disposal, using a method that does not generate dust. Do not contact with water.

7. Handling and Storage

Keep in a tightly closed container, stored in a cool, dry, ventilated area. Protect against physical damage and moisture. Isolate from any source of heat or ignition. Avoid storage on wood floors. Separate from incompatibles, combustibles, organic or other readily oxidizable materials. Containers of this material may be hazardous when empty since they retain product residues (dust, solids); observe all warnings and precautions listed for the product.

8. Exposure Controls/Personal Protection

Airborne Exposure Limits:

- ACGIH Threshold Limit Value (TLV):

0.1 mg/m³ (TWA), Persulfates, Sodium

Ventilation System:

A system of local and/or general exhaust is recommended to keep employee exposures below the Airborne Exposure Limits. Local exhaust ventilation is generally preferred because it can control the emissions of the contaminant at its source, preventing dispersion of it into the general work area. Please refer to the ACGIH document, *Industrial Ventilation, A Manual of Recommended Practices*, most recent edition, for details.

Personal Respirators (NIOSH Approved):

If the exposure limit is exceeded and engineering controls are not feasible, a full facepiece particulate respirator (NIOSH type N100 filters) may be worn for up to 50 times the exposure limit or the maximum use concentration specified by the appropriate regulatory agency or respirator supplier, whichever is lowest. If oil particles (e.g. lubricants, cutting fluids, glycerine, etc.) are present, use a NIOSH type R or P filter. For emergencies or instances where the exposure levels are not known, use a full-facepiece positive-pressure, air-supplied respirator. **WARNING:** Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.

Skin Protection:

Wear impervious protective clothing, including boots, gloves, lab coat, apron or coveralls, as appropriate, to prevent skin contact.

Eye Protection:

Use chemical safety goggles and/or a full face shield where splashing is possible. Maintain eye wash fountain and quick-drench facilities in work area.

9. Physical and Chemical Properties

Appearance:

White powder.

Odor:

Odorless.

Solubility:

Appreciable (> 10%)

Specific Gravity:

2.40

pH:

6.0 (1% solution)

% Volatiles by volume @ 21C (70F):

0

Boiling Point:

No information found.

Melting Point:

180C (356F) Decomposes.

Vapor Density (Air=1):

No information found.

Vapor Pressure (mm Hg):

No information found.

Evaporation Rate (BuAc=1):

No information found.

10. Stability and Reactivity

Stability:

Unstable. Gradually decomposes losing oxygen. Decomposes more rapidly at higher temperatures. Stability decreases in the presence of moisture. Metals other than stainless steel are apt to cause decomposition of persulfate solutions.

Hazardous Decomposition Products:

Oxides of sulfur and the contained metal. Oxygen is released.

Hazardous Polymerization:

Will not occur.

Incompatibilities:

Reducing agents, organic material, sodium peroxide, water and powdered metals especially aluminum.

Conditions to Avoid:

Moisture, heat, flame, ignition sources, shock, friction, incompatibles.

11. Toxicological Information

No LD50/LC50 information found relating to normal routes of occupational exposure.

Ingredient	---NTP Carcinogen---		IARC Category
	Known	Anticipated	
Peroxydisulfuric Acid Disodium Salt (7775-27-1)	No	No	None

12. Ecological Information

Environmental Fate:

No information found.

Environmental Toxicity:

No information found.

13. Disposal Considerations

Whatever cannot be saved for recovery or recycling should be handled as hazardous waste and sent to a RCRA approved waste facility. Processing, use or contamination of this product may change the waste management options. State and local disposal regulations may differ from federal disposal regulations. Dispose of container and unused contents in accordance with federal, state and

local requirements.

14. Transport Information

Domestic (Land, D.O.T.)

Proper Shipping Name: SODIUM PERSULFATE

Hazard Class: 5.1

UN/NA: UN1505

Packing Group: III

Information reported for product/size: 12KG

International (Water, I.M.O.)

Proper Shipping Name: SODIUM PERSULFATE

Hazard Class: 5.1

UN/NA: UN1505

Packing Group: III

Information reported for product/size: 12KG

15. Regulatory Information

-----\Chemical Inventory Status - Part 1\-----
Ingredient TSCA EC Japan Australia

Peroxydisulfuric Acid Disodium Salt (7775-27-1) Yes Yes Yes Yes

-----\Chemical Inventory Status - Part 2\-----
Ingredient Korea DSL NDSL Phil.

Peroxydisulfuric Acid Disodium Salt (7775-27-1) Yes Yes No Yes

-----\Federal, State & International Regulations - Part 1\-----
-SARA 302- -SARA 313-----
Ingredient RQ TPQ List Chemical Catg.

Peroxydisulfuric Acid Disodium Salt (7775-27-1) No No No No

-----\Federal, State & International Regulations - Part 2\-----
Ingredient CERCLA RCRA TSCA

Peroxydisulfuric Acid Disodium Salt (7775-27-1) No 261.33 8(d)

Chemical Weapons Convention: No TSCA 12(b): No CDTA: No
SARA 311/312: Acute: Yes Chronic: No Fire: Yes Pressure: No

Reactivity: No (Pure / Solid)

Australian Hazchem Code: 2P
Poison Schedule: None allocated.

WHMIS:

This MSDS has been prepared according to the hazard criteria of the Controlled Products Regulations (CPR) and the MSDS contains all of the information required by the CPR.

16. Other Information

NFPA Ratings: Health: 3 Flammability: 0 Reactivity: 1 Other: **Oxidizer**

Label Hazard Warning:

DANGER! STRONG OXIDIZER. CONTACT WITH OTHER MATERIAL MAY CAUSE FIRE. HARMFUL IF SWALLOWED OR INHALED. MAY CAUSE BURNS TO SKIN AND EYES. CAUSES RESPIRATORY TRACT IRRITATION. MAY CAUSE ALLERGIC SKIN OR RESPIRATORY REACTION.

Label Precautions:

- Keep from contact with clothing and other combustible materials.
- Do not get in eyes, on skin, or on clothing.
- Remove and wash contaminated clothing promptly.
- Do not breathe dust.
- Store in a tightly closed container.
- Use only with adequate ventilation.
- Wash thoroughly after handling.

Label First Aid:

If swallowed, DO NOT INDUCE VOMITING. Give large quantities of water. Never give anything by mouth to an unconscious person. In case of contact, immediately flush eyes or skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Wash clothing before reuse. If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. In all cases get medical attention immediately.

Product Use:

Laboratory Reagent.

Revision Information:

No Changes.

Disclaimer:

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SODIUM PERSULFATE

1136
March 2002

CAS No: 7775-27-1
RTECS No: SE0525000
UN No: 1505

Peroxydisulfuric acid, disodium salt
 $\text{Na}_2\text{S}_2\text{O}_8$
Molecular mass: 238.1

TYPES OF HAZARD/ EXPOSURE	ACUTE HAZARDS/SYMPTOMS	PREVENTION	FIRST AID/FIRE FIGHTING
FIRE	Not combustible but enhances combustion of other substances. Gives off irritating or toxic fumes (or gases) in a fire.	NO contact with combustibles.	In case of fire in the surroundings: use appropriate extinguishing media.
EXPLOSION	Risk of fire and explosion on contact with combustible substances and reducing agents.		In case of fire: keep drums, etc., cool by spraying with water.

EXPOSURE		PREVENT DISPERSION OF DUST! STRICT HYGIENE!	
Inhalation	Cough. Laboured breathing. Sore throat. Wheezing.	Local exhaust or breathing protection.	Fresh air, rest. Artificial respiration may be needed. Refer for medical attention.
Skin	Redness. Pain.	Protective gloves. Protective clothing.	First rinse with plenty of water, then remove contaminated clothes and rinse again.
Eyes	Redness. Pain.	Safety goggles or eye protection in combination with breathing protection if powder.	First rinse with plenty of water for several minutes (remove contact lenses if easily possible), then take to a doctor.
Ingestion	Diarrhoea. Nausea. Sore throat. Vomiting.	Do not eat, drink, or smoke during work.	Give plenty of water to drink. Refer for medical attention.

SPILLAGE DISPOSAL	PACKAGING & LABELLING
Sweep spilled substance into containers. Carefully collect remainder. Then wash away with plenty of water. Do NOT absorb in saw-dust or other combustible absorbents. Personal protection: P2 filter respirator for harmful particles.	UN Hazard Class: 5.1 UN Pack Group: III

EMERGENCY RESPONSE	SAFE STORAGE
Transport Emergency Card: TEC (R)-51G02-I+II+III	Well closed. Separated from combustible and reducing substances, strong bases, powdered metals.



JONES CHEMICALS, INC. -- SODIUM HYDROXIDE SOLUTION, 25% -- 6810-00N008914

===== Product Identification =====

Product ID:SODIUM HYDROXIDE SOLUTION, 25%
 MSDS Date:11/26/1985
 FSC:6810
 NIIN:00N008914
 MSDS Number: BCRHV
 === Responsible Party ===
 Company Name:JONES CHEMICALS, INC.
 Address:985 MONTAG EXPRESSWAY
 City:MILPITAS
 State:CA
 Info Phone Num:ADDITIONAL INFO:716-538-2311
 Emergency Phone Num:408-262-8300;CHEMITREC;800-924-4300
 CAGE:HO409

===== Contractor Identification =====

Company Name:JONES CHEMICALS INC
 Address:985 MONTAGUE EXPRESSWAY
 Box:City:MILPITAS
 State:CA
 ZIP:95035
 Country:US
 Phone:408-262-8300
 CAGE:3E576
 Company Name:JONES CHEMICALS, INC.
 Address:985 MONTAG EXPRESSWAY
 Box:City:MILPITAS
 State:CA
 Phone:ADDITIONAL INFO:716-538-2311
 CAGE:HO409

===== Composition/Information on Ingredients =====

Ingred Name:SODIUM HYDROXIDE (SARA III)
 CAS:1310-73-2
 RTECS #:WB4900000
 Fraction by Wt: 25%
 Other REC Limits:N/K
 OSHA PEL:2 MG/M3
 ACGIH TLV:C 2 MG/M3; 9293
 EPA Rpt Qty:1000 LBS
 DOT Rpt Qty:1000 LBS

===== Hazards Identification =====

LD50 LC50 Mixture:N/K
 Routes of Entry: Inhalation:YES Skin:YES Ingestion:YES
 Reports of Carcinogenicity:NTP:NO IARC:NO OSHA:NO
 Health Hazards Acute and Chronic:ACUTE OVEREXPOSURE IS CORROSIVE TO ALL
 BODY TISSUES.CHRONIC LOCAL EFFECT MAY CONSIST OF MULTIPLE AREAS OF
 SUPERFICIAL DESTRUCTION OF THE SKIN OR PRIMARY IRRITANT
 DERMATITIS.INHAL OF SPRAY OR MIST MAY R ESULT IN VARYING GEGREES OF
 IRRIT OR DAMAGE TO THE RESP TRACT TISSUE & INCREASED SUSCEPTIBILITY
 TO RESP ILLINESS.
 Explanation of Carcinogenicity:NONE
 Effects of Overexposure:INHAL:SPRAY/MIST MAY CAUSE DMG TO LUNGS & UPPER
 RESP TRACT WICH COULD PRODUCE CHEM PNEUM.SKIN:CORROSIVE.WILL
 PRODUCE SEV BURNS EYES:DESTRUCT TO EYE TISSUE ON CONTACT .WILL
 CAUSE SEV BURNS THAT RESULT IN DMG TO EYES & EVEN
 BLINDNESS.INGEST:WILL CAUSE SEV BURNS & COMPLETE TISSUE
 PERFORATION OF MUCCOUS MEMBRANES(SUP DATA)
 Medical Cond Aggravated by Exposure:N/K

===== First Aid Measures =====

First Aid:EYES: WITHIN 1 MIN,FLULSH EYES W/ LARGE AMTS OF H*2O FO AT
 LEAST 15 MIN,HOLDING LIDS APART.GET MED ATTN IMMED.SKIN W/ PLENTY
 OF H*2O/.WASH CLTLHG BEFORE REUSE.DISCARD FOOTWEAR WHICH CANNOT BE
 DECONTAM .GET MED ATTN IMMED.INGEST:DO NOT INDUCE VOMITING.IF
 CONSCIOUS,GIVE LARGE QTYS OF H*2O (MILK IF AVAIL).IF VOMITING
 OCCURS SPONTANEOUSLY,KEEP AIRWAY (SEE SUPP DATA)

===== Fire Fighting Measures =====

Extinguishing Media:MATERIAL DOES NOT BURN OR SUPPORT COMBUSTION.
 Fire Fighting Procedures:USE NIOSH/MSHA APPROVED SCBA & FULL PROTECTIVE
 EQUIPMENT .MATERIAL IS CORROSIVE TO ALL HUMAN TISSUES;AVOID BODY
 CONTACT.
 Unusual Fire/Explosion Hazard:RXN W/ AL,MG,ZN,SZ WILL GENERATE H*2
 EXPLO IN AIR.RXN W/ STRONG ACIDS WILL CAUSE INCR IN TEMP.PRESS.RXN
 W/ ORGANICS SUCH AS CHLORIN HYDROCARB CAN CAUSE EXPLO.

===== Accidental Release Measures =====

Spill Release Procedures:REMOVE SPILLS USING VACCUUM TRUCK.NEUTRAL
 REMAINING MATL W/ H*2O.COVER W/ SODIUM BICARBONATE.PUT CLEAN-UP
 MATL IN APPRVD,LABLD CNTRNS TO AWAIT DISPOS.IF SPILLED ON
 DIRT/SAND,REMOVE CONTAM SOIL.PUT IN A APPRVD CNTNR.
 Neutralizing Agent:ACETIC OR OTHER DILUTE ACID

===== Handling and Storage =====

Handling and Storage Precautions:STORE IN LEAKPROOF CNTNR AT TEMP
 >OF.DO NOT STORE NEAR ACID,METALS,EXPLOSIVES & ORGANICS.KEEP CNTNR
 CLOSED WHEN NOT IN USE.
 Other Precautions:TO AVOID VIOLENT SPLATTERING WHEN MAKING SLNS,ADD
 NAOH SLOWLY TO SURFACE OF H*2O & STIR CONSTANTLY.STORE & HANDLE
 NAOH NEAR VALVED H*2O SOURCE WHICH CAN BE USED FOR EMER.AVOID
 CONTACT W/ EYES,SKIN & C LTHG.DO NOT BRTH VAP OR TAKE INTERNALLY.

===== Exposure Controls/Personal Protection =====

Respiratory Protection:NIOSH/MSHA APPROVEFD RESPIRATOR APPROPRIATE
 EXPOSURE OF CONCERN .RESPIRATORY PROTECTION NOT REQUIRED FOR NORMAL
 USE UNLESS CHEMICAL MIST IS PRESENT.
 Ventilation:LOCAL AND GENERAL VENTILATION NECESSARY TO KEEP AIR
 CONCENTRATION BELOW TLV
 Protective Gloves:RUBBER.WASH GLOVES W/MILD SOAP & WATER.
 Eye Protection:CHEM WORK GOGG,FACESHLD.
 Other Protective Equipment:PROTECTIVE RUBBER CLOTHING & BOOT TO PREVENT
 SKIN CONTACT.SAFETY SHOWES AND EYEWASH STATIONS SHOULD BE READILY
 AVAIL.
 Work Hygienic Practices:WASH THOROUGHLY AFTER HANDLING.PROTECTIVE
 CLOTHING SHOULD BE WASHED W/ SOAP AND WATER AND DRIED THOROUGHLY
 BEFORE REUSE
 Supplemental Safety and Health
 SIGN & SYMPTOMS OF OVEREXPOSURE:OF THE MOUTH,THROAT,ESOPHAGUS AND
 STOMACH.EMERGENCY FIRST AID PROCEDURES:CLEAR.GET MEDICAL ATTENTION
 IMMEDIATELY.INHALATION:REMOVE TO FRESH AIR.IF BREATHING HAS STOPPED
 ,RESUSCITATE AND ADMINISTER OXYGEN IF READILY AVAILABLE.GET MEDICAL
 ATTENTION IMMEDIATELY.VP:30 MMHG AT 100F,38C.

===== Physical/Chemical Properties =====

Boiling Pt:B.P. Text:232F,111C
 Decomp Temp:Decomp Text:N/K
 Vapor Pres:SUPP DATA
 Spec Gravity:1.278 (WATER=1)
 pH:14.0
 Evaporation Rate & Reference:N/K
 Solubility in Water:COMPLETE
 Appearance and Odor:CLEAR COLORLESS LIQUID,NO ODOR.

===== Stability and Reactivity Data =====

Stability Indicator/Materials to Avoid: YES
METALS (ESPECIALLY ZN, MG, AL, SN, AND ALLOYS OF THESE). ORGANICS. STRONG
ACIDS, NITROMETHANE, LEATHER, WOOL, AND EXPLOSIVES.
Stability Condition to Avoid: N/K
Hazardous Decomposition Products: NONE
Conditions to Avoid Polymerization: VIOLENT POLYMERIZATION WILL OCCUR
UPON REACTION WITH SOME ORGANICS SUCH AS ACROLEIN AND
ACRYLONITRILE.

===== Disposal Considerations =====

Waste Disposal Methods: DISPOSAL MUST BE IN ACCORDANCE WITH
FEDERAL, STATE & LOCAL REGULATIONS. ALL RESIDUAL SODIUM HYDROXIDE
SOLUTION SHOULD BE REMOVED FROM ITS CONTAINER BEFORE REUSE OR
DISPOSAL OF THE CONTAINER.

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particular situation.

VAN WATERS & ROGERS INC -- CALCIUM PEROXIDE, 233410 -- 6810-00N082977

=====
Product Identification
=====

Product ID:CALCIUM PEROXIDE, 233410
MSDS Date:07/06/1993
FSC:6810
NIIN:00N082977
MSDS Number: CGPJB
=== Responsible Party ===
Company Name:VAN WATERS & ROGERS INC
Address:6100 CARILLON POINT
City:KIRKLAND
State:WA
ZIP:98033
Country:US
Info Phone Num:206-889-3400
Emergency Phone Num:800-424-9300(CHEMTREC)
CAGE:DO735

==== Contractor Identification ===
Company Name:VAN WATERS & ROGERS SUBSIDIARY OF UNIVAR
Address:6100 CARILLON POINT
City:KIRKLAND
State:WA
ZIP:98033
Country:US
Phone:425-889-3400
CAGE:DO735

Company Name:VOPAK USA INC
Address:6100 CARILLON POINT
Box:City:KIRKLAND
State:WA
ZIP:98033-7357
Country:US
Phone:425-889-3400/425-889-3617
CAGE:0STM5

=====
Composition/Information on Ingredients
=====

Ingred Name:CALCIUM PEROXIDE CONTAINING INGREDIENTS 2-4
CAS:1305-79-9
RTECS #:EW3865000
Fraction by Wt: 60%
OSHA PEL:N/K
ACGIH TLV:N/K

Ingred Name:ARSENIC (SARA 313) (CERCLA) % WT: EQUAL TO/LESS THAN 3 PPM
CAS:7440-38-2
RTECS #:CG0525000
Fraction by Wt: <0.1%
OSHA PEL:N/K
ACGIH TLV:0.01 MG/M3
EPA Rpt Qty:1 LB
P Rpt Qty:1 LB

Ingred Name:CHROMIUM (SARA 313) (CERCLA) % WT: EQUAL 10/LESS THAN 0.5

PPM

CAS:7440-47-3
RTECS #:GB4200000
Fraction by Wt: <0.1%
OSHA PEL:1 MG/M3
ACGIH TLV:0.5 MG/M3
EPA Rpt Qty:1 LB
DOT Rpt Qty:1 LB

Ingred Name:LEAD (SARA 313) (CERCLA) % WT: EQUAL 10/LESS THAN 2 PPM
CAS:7439-92-1
RTECS #:OF7525000
Fraction by Wt: <0.1%
OSHA PEL:N/K
ACGIH TLV:0.15 MG/M3 DUST
EPA Rpt Qty:1 LB
DOT Rpt Qty:1 LB

Ingred Name:CALCIUM HYDROXIDE
CAS:1305-62-0
RTECS #:EW2800000
OSHA PEL:15 MG/M3 TDUST
ACGIH TLV:5 MG/M3

Ingred Name:SUPDAT: ARE TO BE EXPECTED; DILUTION W/WATER INDICATED AS
MAY BE GASTRIC EVACUATION BY EMESIS OR LAVAGE IF LARGE (ING 7)
RTECS #:9999999ZZ

Ingred Name:ING 6: DOSES OR SEVERE IRRIT IS EVIDENT. DEMULCENTS SHOULD
BE HELPFUL. NO SYSTEMIC EFTS ARE EXPECTED THOUGH (ING 8)
RTECS #:9999999ZZ

Ingred Name:ING 7: HUMAN TOXICITY DATA IS SPARSE.
RTECS #:9999999ZZ

Ingred Name:WASTE DISP METH: & BECAUSE REGULATORY REQS MAY CHANGE, THE
APPROP REGULATORY AGENCIES SHOULD BE CONTACTED PRIOR TO DISP.
RTECS #:9999999ZZ

Ingred Name:HNDLG/STOR PRECS: PIPE, RADIANT HEATERS, HOT AIR VENT OR
NEAR WELDING SPARKS. AVOID CNTCT W/REDUCING AGENTS. (ING 11)
RTECS #:9999999ZZ

Ingred Name:ING 10: REACTS W/MOISTURE. IF COMPOUNDED W/ORGANIC OR
COMBUST MATL, BE SURE TO EXCLUDE MOISTURE. FOR STORAGE (ING 12)
RTECS #:9999999ZZ

Ingred Name:ING 11: REQS, REFER TO NFPA BULLETIN 43A ON THE STORAGE OF
LIQUID & SOLID OXIDIZING MATLS. KEEP CNTNRS TIGHTLY (ING 13)
RTECS #:9999999ZZ

Ingred Name:ING 12: CLOSED WHEN NOT IN USE.
RTECS #:9999999ZZ

==== Hazards Identification =====

LD50 LC50 Mixture:LD50: (ORAL, RAT) >5 G/KG

Routes of Entry: Inhalation:YES Skin:YES Ingestion:YES
 Reports of Carcinogenicity:NTP:NO IARC:NO OSHA:NO
 Health Hazards Acute and Chronic:ACUTE: DUST IRRITATING TO EYES, NOSE,
 THROAT AND LUNGS. CHRONIC: LEAD APPEARS ON THE NAVY LISTING OF
 OCCUPATIONAL CHEMICAL REPRODUCTIVE HAZARDS. SEEK CONSULTATION FROM
 APPROPRIATE HEALTH PROFESSIONALS CONCERNING LATEST HAZARD LIST
 INFORMATION AND SAFE HANDLING AND EXPOSURE INFORMATION .

Explanation of Carcinogenicity:NOT RELEVANT
 Effects of Overexposure:SEE HEALTH HAZARDS.
 Medical Cond Aggravated by Exposure:ANY MEDICAL CONDITIONS GENERALLY
 RECOGNIZED AS BEING AGGRAVATED BY EXPOSURE WERE EXAMINED AND NO
 INFORMATION WAS FOUND OR IS AVAILABLE.

=====
 First Aid Measures
 =====

First Aid:EYES: IMMEDIATELY FLUSH EYES WITH CLEAN WATER FOR AT LEAST 15 MIN. SEE
 OPHTHALMOLOGIST. SKIN: FLUSH AFFECTED AREAS WITH WATER. IF IRRIT
 OCCURS & PERSISTS, OBTAIN MEDICAL ATTENTION. INHALATION: REMOVE TO FRESH AIR. IF
 DISCOMFORT OCCURS & PERSISTS, OBTAIN MEDICAL ATTENTION. INGESTION: DRINK
 WATER. OBTAIN MEDICAL ATTENTION. DECONTAMINATION PROCEDURE: WASH WITH SOAP & WATER.
 NOTES TO MD: MODEST IRRITATION IS THE ONLY EXPECTED EFFECTS & SHOULD
 HAVE NO (SUPERDAT)

=====
 Fire Fighting Measures
 =====

Extinguishing Media:DELUGE WITH WATER.
 Fire Fighting Procedures:USE NIOSH APPROVED SCBA AND FULL PROTECTIVE
 EQUIPMENT . CONSIDER CALCIUM PEROXIDE A STRONG OXIDIZER. COOL
 EXPOSED CONTAINERS WITH WATER.
 Casual Fire/Explosion Hazard:NONCOMBUSTIBLE - DECOMPOSES WITH
 LIBERATION OF OXYGEN.

=====
 Accidental Release Measures
 =====

Spill Release Procedures:MATERIAL SHOULD BE PUT INTO AN APPROVED DOT
 CONTAINER THEN DILUTED WITH LARGE QUANTITY OF WATER AND DISPOSED OF
 ACCORDING TO METHODS OUTLINED FOR WASTE DISPOSAL.
 Neutralizing Agent:NONE SPECIFIED BY MANUFACTURER.

=====
 Handling and Storage
 =====

Handling and Storage Precautions:AVOID CONTAMINATION & WEAR SUITABLE PROTECTIVE
 CLOTHING. KEEP MATERIAL DRY. STORE IN A CLEAN, DRY PLACE. DO NOT STORE OR
 EXPOSE TO HEAT SOURCES SUCH AS STEAM (ING 10)
 Other Precautions:AT ROOM TEMPERATURE, CALCIUM PEROXIDE IS AN EXTREMELY
 STABLE COMPOUND. THE STABILITY OF THE CALCIUM PEROXIDE IS
 ADVERSELY AFFECTED IF IT IS KEPT AT ELEVATED TEMPERATURES IN A
 HUMID ATMOSPHERE OR WHEN WET.

=====
 Exposure Controls/Personal Protection
 =====

Respiratory Protection:WHEN EXPOSURE ABOVE THE ESTABLISHED STANDARD IS
 LIKELY, A RESPIRATORY PROGRAM WHICH COMPLIES WITH OSHA GENERAL
 INDUSTRY STANDARD 1910.134(E) AND NIOSH APPROVED RESPIRATORY
 EQUIPMENT SUCH AS A DUST MASK SHOULD BE IMPLEMENTED.
 Ventilation:USE ONLY IN WELL VENTILATED AREA. CONTROL DUST IN WORK
 PLACE AT OR BELOW RECOMMENDED TLV (5 MG/M3).

Protective Gloves:RUBBER OR NEOPRENE GLOVES.
 Eye Protection:ANSI APPRVD CHEM WORKERS GOGGLES .
 Other Protective Equipment:ANSI APPROVED EYE WASH & DELUGE SHOWER . GEN
 PURPOSE RUBBER OR NEOPRENE FOOTWEAR.
 Work Hygienic Practices:AVOID PROLONGED OR REPEATED SKIN CONTACT AND
 USE GOOD PERSONAL HYGIENE.
 Supplemental Safety and Health
 MP: ALWAYS DECOMPOSES ON HEATING. PH (AS IS): N/A; (1% SOLN): SLURRY
 12-13. FIRST AID PROC: SERIOUS CONSEQUENCES EXCEPT PERHAPS IN CASE
 OF DIRECT EYE CONTACT. CONTAMD EXTERNAL SURFS SHOULD BE FLOODED
 W/WATER & DIRECT EYE CONTACT DESERVES OPHTHALMOLOGIC EVALUATION. IF
 INGESTED, GI IRRIT BUT NOT CAUSTIC BURNS (ING 6)

===== Physical/Chemical Properties =====

Melt/Freeze Pt:M.P/F.P Text:SUPDAT
 Vapor Pres:NONE
 Spec Gravity:2.92 (H*20=1)
 pH:SUPDAT
 Solubility in Water:INSOLUBLE
 Appearance and Odor:YELLOW TO WHITE POWDER; ODORLESS.

===== Stability and Reactivity Data =====

Stability Indicator/Materials to Avoid:NO
 REDUCING AGENTS. INCOMPATIBLE WITH HEAVY METALS.
 Stability Condition to Avoid:HEAT, MOISTURE AND GRINDING MIXTURES WITH
 ORGANICS. REDUCING AGENTS.
 Hazardous Decomposition Products:OXYGEN WHICH SUPPORTS COMBUSTION.

===== Disposal Considerations =====

Waste Disposal Methods:AN ACCEPTABLE METHOD OF DISPOSAL IS TO DISSOLVE
 IN WATER & DISPOSE VIA A TREATMENT SYSTEM I/A/W ALL LOCAL, STATE &
 FEDERAL ENVIRONMENTAL LAWS, RULES, REGS, STANDARDS & OTHER REQS
 BECAUSE ACCEPTABLE ME THODS OF DISPOSAL MAY VARY BY LOCATION (ING
 9)

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 assume responsibility for the suitability of this information to their
 particular situation.

First Aid:EYES: WITHIN 1 MIN,FLULSH EYES W/ LARGE AMTS OF H*2O FO AT LEAST 15 MIN,HOLDING LIDS APART.GET MED ATTN IMMED.SKIN W/ PLENTY OF H*2O/.WASH CLTLHG BEFORE REUSE.DISCARD FOOTWEAR WHICH CANNOT BE DECONTAM .GET MED ATTN IMMED.INGEST:DO NOT INDUCE VOMITING.IF CONSCIOUS,GIVE LARGE QTYS OF H*2O (MILK IF AVAIL).IF VOMITING OCCURS SPONTANEOUSLY,KEEP AIRWAY (SEE SUPP DATA)

===== Fire Fighting Measures =====

Extinguishing Media:MATERIAL DOES NOT BURN OR SUPPORT COMBUSTION.
Fire Fighting Procedures:USE NIOSH/MSHA APPROVED SCBA & FULL PROTECTIVE EQUIPMENT .MATERIAL IS CORROSIVE TO ALL HUMAN TISSUES;AVOID BODY CONTACT.
Unusual Fire/Explosion Hazard:RXN W/ AL,MG,ZN,SZ WILL GENERATE H*2 EXPLO IN AIR.RXN W/ STRONG ACIDS WILL CAUSE INCR IN TEMP.PRESS.RXN W/ ORGANICS SUCH AS CHLORIN HYDROCARB CAN CAUSE EXPLO.

===== Accidental Release Measures =====

Spill Release Procedures:REMOVE SPILLS USING VACCUUM TRUCK.NEUTRAL REMAINING MATL W/ H*2O.COVER W/ SODIUM BICARBONATE.PUT CLEAN-UP MATL IN APPRVD,LABLD CNTNRNS TO AWAIT DISPOS.IF SPILLED ON DIRT/SAND,REMOVE CONTAM SOIL.PUT IN A APPRVD CNTNR.
Neutralizing Agent:ACETIC OR OTHER DILUTE ACID

===== Handling and Storage =====

Handling and Storage Precautions:STORE IN LEAKPROOF CNTNR AT TEMP >OF.DO NOT STORE NEAR ACID,METALS,EXPLOSIVES & ORGANICS.KEEP CNTNR CLOSED WHEN NOT IN USE.
Other Precautions:TO AVOID VIOLENT SPLATTERING WHEN MAKING SLNS,ADD NAOH SLOWLY TO SURFACE OF H*2O & STIR CONSTANTLY.STORE & HANDLE NAOH NEAR VALVED H*2O SOURCE WHICH CAN BE USED FOR EMER.AVOID CONTACT W/ EYES,SKIN & C LTHG.DO NOT BRTH VAP OR TAKE INTERNALLY.

===== Exposure Controls/Personal Protection =====

Respiratory Protection:NIOSH/MSHA APPROVEFD RESPIRATOR APPROPRIATE EXPOSURE OF CONCERN .RESPIRATORY PROTECTION NOT REQUIRED FOR NORMAL USE UNLESS CHEMICAL MIST IS PRESENT.
Ventilation:LOCAL AND GENERAL VENTILATION NECESSARY TO KEEP AIR CONCENTRATION BELOW TLV
Protective Gloves:RUBBER.WASH GLOVES W/MILD SOAP & WATER.
Eye Protection:CHEM WORK GOGG,FACESHLD.
Other Protective Equipment:PROTECTIVE RUBBER CLOTHING & BOOT TO PREVENT SKIN CONTACT.SAFETY SHOWES AND EYEWASH STATIONS SHOULD BE READILY AVAIL.
Work Hygienic Practices:WASH THOROUGHLY AFTER HANDLING.PROTECTIVE CLOTHING SHOULD BE WASHED W/ SOAP AND WATER AND DRIED THOROUGHLY BEFORE REUSE
Supplemental Safety and Health
SIGN & SYMPTOMS OF OVEREXPOSURE:OF THE MOUTH,THROAT,ESOPHAGUS AND STOMACH.EMERGENCY FIRST AID PROCEDURES:CLEAR.GET MEDICAL ATTENTION IMMEDIATELY.INHALATION:REMOVE TO FRESH AIR.IF BREATHING HAS STOPPED ,RESUSCITATE AND ADMINISTER OXYGEN IF READILY AVAILABLE.GET MEDICAL ATTENTION IMMEDIATELY.VP:30 MMHG AT 100F,38C.

===== Physical/Chemical Properties =====

Boiling Pt:B.P. Text:232F,111C
Decomp Temp:Decomp Text:N/K
Vapor Pres:SUPP DATA
Spec Gravity:1.278 (WATER=1)
pH:14.0
Evaporation Rate & Reference:N/K
Solubility in Water:COMPLETE
Appearance and Odor:CLEAR COLORLESS LIQUID,NO ODOR.

===== Stability and Reactivity Data =====

Stability Indicator/Materials to Avoid: YES
METALS (ESPECIALLY ZN, MG, AL, SN, AND ALLOYS OF THESE). ORGANICS. STRONG
ACIDS, NITROMETHANE, LEATHER, WOOL AND EXPLOSIVES.
Stability Condition to Avoid: N/K
Hazardous Decomposition Products: NONE
Conditions to Avoid Polymerization: VIOLENT POLYMERIZATION WILL OCCUR
UPON REACTION WITH SOME ORGANICS SUCH AS ACROLEIN AND
ACRYLONITRILE.

===== Disposal Considerations =====

Waste Disposal Methods: DISPOSAL MUST BE IN ACCORDANCE WITH
FEDERAL, STATE & LOCAL REGULATIONS . ALL RESIDUAL SODIUM HYDROXIDE
SOLUTION SHOULD BE REMOVED FROM ITS CONTAINER BEFORE REUSE OR
DISPOSAL OF THE CONTAINER.

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assume responsibility for the suitability of this information to their
particular situation.

Appendix D

Carus Oxidant Calculator Worksheet

Appendix D - Carus Oxidant Calculator Worksheet

Version 3.0 0104

Parameters	Units	Estimates
*** Site Description ***		
Length	Ft.	
Width	Ft.	
Area	Sq. Ft.	706
Thickness	Ft.	6
Total Volume	Cu. Yd.	157
Porosity	%	30
Plume Total Pore Volume	Gal.	9507
Avg. Contaminant Conc.	ppm	0.075
Mass of Contaminant	lb.	0.00595075
PSOD	g/Kg	2.4
Effective PSOD%	10	0.24
PSOD	lb/yd ³	0.17128
PSOD Oxidant Demand	lb	111.83
Avg. Stoichiometric Demand	lb/lb	2.4
Contaminant Oxidant Demand	lb	0.014261815
Theoretical Oxidant Demand	lb	111.84
Confidence Factor	???	2
Calculated Oxidant Demand		223.69
*** Injection Design ***		
		KMnO4 NaMnO4
Radius of Influence	Ft.	15.00 16
Number of Injection Points		100 100
Injection Concentration	% w/wt	3.00% 10.00%
Flow Rate Per Injection Point	GPM	2.00 2
Number of Wells per Phase		1 4
Total Injection Flow Rate	GPM	2.00 2
Estimated Injection Pressure	PSIG	40.00 40
Injection Volume/Hole	Gal.	868.27
*** Injection Schedule ***		
Hours per Day	Hrs	8.00 8
Days Per Week	Days	5.00 5
Number of Inj. Days	Days	40.90 40
Number of Inj. Weeks	Weeks	0.18

40% NaMnO4 Injection Options						
Pounds of 40% NaMnO4 Solu	Gallons of 40% Solut	Number of Pails	Number of Drums	Number of Totes	Price per Lb of Solutit	Total Cost of Chemicals
498	43.66	6.73	0.91	0.20		
Total Gallons of Dilution W Required			Dilution Water Flow Rate - GPM	OR	Dilution Water Gals per Drum	Dilution Water Gals per Drum
179.03			1.61	OR	20.50	1196.83

Dry KMnO4 Injection Options						
Pounds of KMnO4 (Dry Cry)	Number of Pails	Number of Drums	Number of Totes	Price per Lb (Dry)	Total Cost of Chemicals	
224	4.07	0.88	0.07		\$0.00	
Total Gallons of Dilution W Required		Dilution Water Flow Rate - GPM	OR	Dilution Water Gals per Drum	Dilution Water Gals per Drum	
887.22		2.00	OR	213.23	1279.36	

2.96
 Instructions: Fill in all white colored blanks. Leave all shaded cells - these calculate themselves.
 Please call Carus at 800/435-8856 for current chemical pricing.

0.23	lb KMnO4	kg soil	454 g soil	assumed density	Result
0.10	lb KMnO4	1000 g soil	lb soil	110 lb soil	27 ft ³ soil
0.23	kg soil	454 g KMnO4	1000 g soil	lb soil	yd ³ soil



Appendix E

Oxidant Neutralizing Solutions

PERMANGANATE NEUTRALIZING SOLUTIONS

RemOx[®] S ISCO Reagent (potassium permanganate) and RemOx[®] L ISCO Reagent (sodium permanganate) are commonly used for the in situ chemical oxidation of chlorinated solvents such as PCE, TCE, and their daughter products. Both permanganates are strong oxidizers and require careful handling. During the course of the application of permanganate, there is the chance that the neutralization and/or disposal of excess permanganate may be required. Regardless of whether the need is for the clean up and removal of a small spill, the neutralization of excess permanganate solution from equipment, the rinse water produced when cleaning buckets and drums, or any other activity where excess permanganate may cause a concern, following a few simple rules will ensure that the process will be safe and easy.

If neutralization is required because of a spill, and the spill is dry RemOx S, it can be swept or shoveled up and transferred to a clean, metal container. Dilute the product with water, and mix the solution until all the crystals are dissolved prior to neutralization. If the spill is a liquid RemOx S solution, contain the liquid by diking or collecting and neutralize.

If the spill is RemOx L, the first step is to contain or collect the spill. Prior to any neutralization, sodium permanganate **MUST BE DILUTED** with water to a concentration of 6% or less. Once the product has been diluted, it can be safely neutralized.

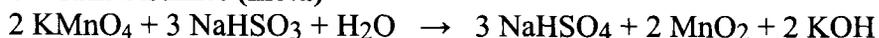
There are a number of different chemicals that will neutralize permanganate solutions. Below are some of the commonly used chemicals, their reactions with permanganate and the stoichiometric requirements.

Sodium thiosulfate



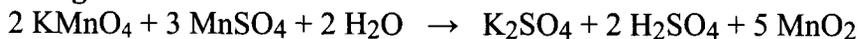
Weight Ratio: 0.375 parts Na₂S₂O₃ : 1 part KMnO₄

Sodium bisulfite (meta)



Weight Ratio: 1 part NaHSO₃: 1 part KMnO₄

Manganous sulfate



Weight Ratio: 1.43 parts MnSO₄ : 1 part KMnO₄

Hydrogen peroxide



Weight Ratio: 0.43 part H₂O₂: 1 part KMnO₄

Note: at pH <9

In addition to the above, permanganate solutions can be neutralized using products readily available for purchase locally. These include the following:

Cleaning/Neutralizing Solution

This solution consists of products that can be purchased from a local food or drug store. This solution is especially effective for removal of brown stains on skin; however, it has also been used, in some cases, as a neutralization solution for small spills. It would not be economical for anything but the smallest volumes of dilute permanganate.

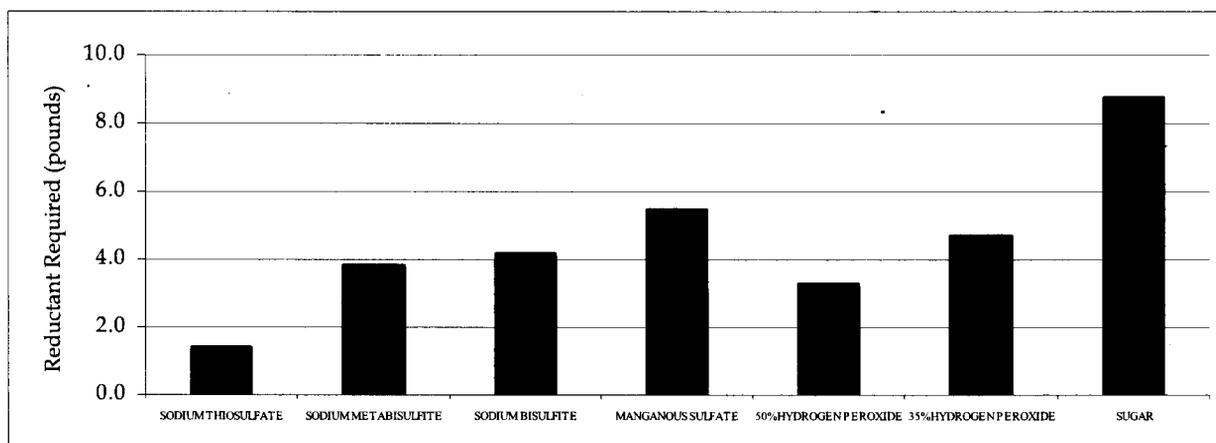
30 parts water
40 parts white vinegar
30 parts 3% hydrogen peroxide

Sugar

White sugar is also readily available and can be used to neutralize permanganate solution. The reaction of permanganate and sugar is relatively slow, taking about 30 minutes for a complete reaction. The by-product of the reaction is typically a gelatinous residue.

Sugar ($C_{12}H_{22}O_{11}$) Weight Ratio: 8.8 parts sugar : 1 part $KMnO_4$

The following chart summarizes the amount of neutralizing agent required, in pounds, to neutralize one pound of permanganate.



- Never use any of these solutions on sensitive tissues such as eyes, mucous membranes, open wounds, etc.
- Do not add directly to concentrated permanganate solutions.
- Dilute the permanganate solution to less than 6% before using any of these solutions.