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Final Bench Scale Treatability Study Technical Memorandum

White Chemical Corporation
Superfund Site, OU3-Groundwater

Remedial Investigation/Feasibility Study

Newark, Essex County, New Jersey

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CDM Smith

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Acronyms and Abbreviations

°C	degrees Celsius
µg/L	microgram per liter
BAFeIII	bioavailable ferric iron
BES	bromoethane sulfonic acid
bgs	below ground surface
cis-1,2-DCE	cis-1,2-dichloroethene
CDM Smith	CDM Federal Programs Corporation
CERCLA	Comprehensive Environment Response, Compensation and Liability Act
CLP	Contract Laboratory Program
COD	chemical oxygen demand
COI	contaminant of interest
1,2-DCA	1,2-dichloroethane
DESA	Division of Environmental Science and Assessment
DHC	dehalococcoides
DNAPL	dense non-aqueous phase liquid
DO	dissolved oxygen
DQO	data quality objective
EPA	United States Environmental Protection Agency
ETL	Environmental Treatability Laboratory
FCR	field change request
Fe(II)	ferrous iron
g	gram
GC/FID	gas chromatography – flame ionization detector
GC/MS	gas chromatography – mass spectroscopy
HASP	health and safety plan
IC	ion chromatography
ICP-MS	inductively coupled plasma with mass spectroscopy
IDW	investigation-derived waste
ISCR	in situ chemical reduction
ISE	ion selective electrode
ITRC	Interstate Technology Regulatory Council
kg	kilograms
L	liters
mg/L	milligrams per liter
mL	milliliter
MEEA	methane, ethene, ethane, acetylene
mV	millivolts
NAVFAC	Naval Facility Engineering Command
NPL	National Priorities List
ORP	oxidation-reduction potential
OU	operable unit
PCE	tetrachloroethene
ppmv	parts per million in volume
QA	quality assurance
QAPP	quality assurance project plan
QC	quality control
RI/FS	remedial investigation/feasibility study

ROD	Record of Decision
SM	Standard Methods
SOP	standard operation procedure
TAL	target analyte list
TCL	target compound list
1,1,2-TCA	1,1,2-trichloroethane
TCE	trichloroethene
TOC	total organic carbon
USACE	United States Army Corps of Engineers
µg/L	microgram per liter
VC	vinyl chloride
VOC	volatile organic compound
WCC	White Chemical Corporation
ZVI	zero valence iron

Section 1
Introduction

CDM Federal Programs Corporation (CDM Smith) received Task Order 006 under the United States Army Corps of Engineers (USACE) Contract No. W912DQ-08-D-0018 to perform a Remedial Investigation/ Feasibility Study (RI/FS) for the White Chemical Corporation (WCC) Superfund Site, Operable Unit (OU) 3 Groundwater (the Site) in Newark, Essex County, New Jersey.

To support the FS, CDM Smith performed a bench scale treatability study in general accordance with the EPA guidance "Guide for Conducting Treatability Study under CERCLA – Biodegradation Remedy Selection Interim Guidance" (EPA 1993).

1.1 Scope of Work

A bench scale treatability study was conducted at CDM Smith's Environmental Treatability Laboratory (ETL), located in Bellevue, Washington. Potential applicable remedial technologies identified for the WCC Superfund Site groundwater include in situ bioremediation and in situ chemical reduction (ISCR). The purpose of this bench scale treatability study was to investigate the effectiveness of these technologies to treat site contaminants.

This technical memorandum describes the technical basis for the design of the bench scale study; the materials and methods used to conduct the bench scale study and to collect and analyze samples; and the test results. It also provides conclusions and recommendations for a pilot study and the FS.

1.2 Site Background

The Site is defined as the WCC property and associated contaminated areas. The WCC property is a 4.4-acre empty parcel, located at 660 Frelinghuysen Avenue, Newark, Essex County, New Jersey (Block 3872, Lot 109 on the Tax Map of Essex County). Frelinghuysen Avenue is a major thoroughfare with significant residential, commercial, and industrial developments. Within 0.5 mile of the WCC property are Newark Liberty International Airport, Conrail and Amtrak rail lines (rail line corridor), and U.S. highway Routes 1 and 9. Figure 1-1 presents the Site location map.

White Chemical Corporation produced three primary groups of chemical products: acid chlorides, brominated organics (both aliphatic and aromatic) and mineral acids, most notably hydriodic acid and fire retardant compounds. The finished products, mostly solids and powders, were generally formulated in small batches following individual customer's specifications.

The past operation has contaminated Site soil and groundwater. In 1990 and 1991, EPA removed several thousand drums and performed several assessments. The Site was listed on the National Priorities List (NPL) on September 25, 1991. The OU1 Record of Decision (ROD) (September 26, 1991) required on-Site treatment or neutralization of contaminated material, off-Site treatment, recycling or disposal of contaminated material, decontamination and off-Site disposal or recycling of empty drums and containers, decontamination of on-Site storage tanks and piping, and environmental

monitoring. Starting in 1998, EPA conducted a remedial investigation of contaminated building material, soil and overburden groundwater for OU2. The OU2 ROD (September 29, 2005) called for demolition of on-Site buildings and excavation and off-Site disposal of contaminated soil. Building demolition and off-Site disposal of demolition debris for OU2 were completed in December 2006. Excavation of contaminated soil from the ground surface to the water table was completed by EPA under OU2 in 2009. OU3 addresses contaminated groundwater.

The Site is located in the Newark Basin, which is primarily composed of a sequence of sedimentary rocks known as the Newark Group - a Triassic fluvial deposit. The geologic units underlying the Site include the following:

- Overburden Materials: reddish-brown sand, silt, and clay; thickness ranging from 20 feet in the northwest portion of the Site to 50 feet thick in the southeast portion of the Site.
- Weathered Bedrock: reddish-brown, highly weathered rock fragments and mud; thickness ranges from 2 feet in the northwest to 15 feet in the southeast.
- Fractured Bedrock: reddish-brown, fractured Brunswick Shale, with bedding planes striking north/northwest and dipping approximately 10 degrees west; bedrock is encountered from 30-60 feet below the ground surface (bgs).

The primary groundwater contaminants are chlorinated and brominated aliphatic compounds, mainly 1,2-dichloroethane (1,2-DCA), 1,1,2-trichloroethane (1,1,2-TCA), trichloroethene (TCE), and 1,2-dibromoethane with concentrations at milligram per liter (mg/L) levels or higher. Vinyl chloride (VC) and tetrachloroethene (PCE) also exceed the New Jersey Department of Environmental Protection (NJDEP) groundwater standards but are at microgram per liter (µg/L) levels. Three rounds of groundwater sampling were performed in 2010 and 2011 (CDM Smith 2012). These sampling events included monitoring wells located in the shallow overburden, deep overburden, and bedrock units. The highest levels of groundwater contaminations were found in wells completed in the deep overburden and bedrock aquifers. The highest results of representative compounds from the wells at different vertical zones during Round 2 sampling event are summarized below.

- Shallow Overburden: 1,2-DCA at 2,300 µg/L; TCE at 160 µg/L; 1,1,2-TCA at 96 µg/L.
- Deep Overburden: 1,2-DCA at 160,000 µg/L; TCE at 10,000J µg/L; 1,1,2-TCA at 10,000J µg/L.
- Bedrock: 1,2-DCA at 180,000 µg/L; TCE at 2,800 µg/L, 1,1,2-TCA at 2,500J µg/L.

The contaminants are generally co-located. These high levels of contaminant concentrations indicate the potential presence of dense non-aqueous phase liquid (DNAPL) or that the contaminants were originally released in a DNAPL form. No DNAPL was encountered during drilling, installation, sampling of the monitoring wells, or DNAPL testing.

Based on the groundwater geochemistry data collected during the Round 2 sampling event, the groundwater at the core of contamination is under anaerobic conditions and biological degradation of Site contaminants has occurred. For this bench study, deep overburden geochemistry data will be discussed. The pH values of groundwater ranged from 6 to 8.1, suitable for biodegradation. The dissolved oxygen (DO) measurements ranged from 0.1 to 2.4 mg/L. The 2.4 mg/L DO reading was from the most contaminated well (MW-3D) with the oxidation reduction potential (ORP) readings at -110 millivolts; therefore, it is likely the DO measurement was erroneous and that this well is under anaerobic conditions. Nitrate/nitrite concentrations ranged from non-detect to 0.78 mg/L. Ferrous iron (Fe II) concentrations ranged from non-detect to 1.1 mg/L. Sulfate concentrations ranged from 18 to 110 mg/L. Ethane and ethene, the final degradation products of chlorinated

or brominated aliphatic compounds, were detected in several wells, including MW-1D, MW-2D, MW-3D, MW-6D, MW-7D, and at trace levels in MW-16D. Overall, the groundwater geochemistry data indicate that the aquifer is conducive to anaerobic bioremediation.

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Section 2
Bench Study Objectives and Approach

This section presents the objectives of the bench scale study, an overview of the biotic and abiotic degradation mechanisms that will be evaluated, and the general approach for the bench scale study.

2.1 Objectives

The objectives of this bench scale study as established in the Final Bench Scale Treatability Study Work Plan (CDM Smith 2011b) were the following:

1) Evaluate the effectiveness of specific electron donors and bioaugmentation cultures to promote biotic degradation of key site contaminants: 1,2-DCA, 1,1,2-TCA, and TCE to non-toxic compounds

2) Evaluate the effectiveness of Adventus EHC® to promote combined abiotic and biotic degradation of key Site contaminants to non-toxic compounds

3) Recommend the best biotic or biotic/abiotic amendment(s) for potential use at the Site

In addition, the sampling and analyses met the data quality objectives (DQOs) set in the Final Bench Scale Treatability Study Work Plan and QAPP Addendum 3 (CDM Smith 2011b).

2.2 Overview of Biotic/Abiotic Degradation of Site Contaminants

Biotic and abiotic degradation pathways are discussed for the three primary contaminants, 1,2-DCA, 1,1,2-TCA, and TCE.

2.2.1 Biotic Degradation of Site Contaminants

Enhanced in situ bioremediation is a remedial technology designed to facilitate the in situ biological destruction of contaminants over a wide range of concentrations in groundwater. Depending on the biodegradation mechanism to be enhanced, it might involve introducing electron donors, electron acceptors, bioaugmentation cultures, and/or nutrients into the subsurface to simulate the natural reactions of microorganisms to detoxify contaminants, such as chlorinated solvent compounds. The degradation pathways of the three key contaminants are discussed below.

Biodegradation of 1,2-DCA is known to occur under both aerobic and anaerobic conditions. Under aerobic conditions, 1,2-DCA can be used as the sole source of carbon and energy for certain microorganisms and has been shown to be mineralized to carbon dioxide, water and inorganic chloride (Klečka et al. 1998). The intermediates are 2-chloroethanol, chloroacetaldehyde, chloroacetic acid, glycolic acid. Under anaerobic conditions, 1,2-DCA has been reported to biodegrade to ethene and/or ethane under sulfate reducing or methanogenic conditions. Two different reaction mechanisms have been documented:

1) dihaloelimination reaction yielding ethene and 2) consecutive hydrogenolysis reactions yielding chloroethane and ethane (Klečka 1998).

Microorganisms capable of biodegrading 1,2-DCA may or may not be naturally present at the Site. Klečka et al (1998) studied the ability of naturally occurring microorganisms to biodegrade 1,2-DCA in a microcosm study, and found that even for a site that does not have evidence of natural biological attenuation of 1,2-DCA, degradation of 1,2-DCA with aquifer material was possible, but a microbial adaption period appeared to be required. In addition, 1,2-DCA was transformed to ethene in a single step via reductive dihaloelimination; no other metabolites were detected in their microcosm study. While aerobic biodegradation of 1,2-DCA is possible and can be rapid, aerobic biodegradation of other key Site contaminants (i.e., 1,1,2-TCA and TCE) is possible only via cometabolism and is relatively slow. Therefore, this treatability study focused on anaerobic rather than aerobic biodegradation.

Biodegradation of 1,1,2-TCA occurs predominantly under anaerobic conditions. Natural biological degradation of 1,1,2-TCA has been observed under sulfate reducing or methanogenic conditions (Field and Sierra-Alvarez 2004). The predominant intermediates are VC and 1,2-DCA. The major biological reactions responsible for 1,1,2-TCA degradation under anaerobic conditions are dichloroelimination and reductive dehydrogenolysis (or reductive dechlorination) as shown in Figure 2-1. In the presence of oxygen, 1,1,2-TCA can also be cometabolically degraded by methane-oxidizing and ammonia-oxidizing bacteria; however, this mechanism is not well established. The aerobic degradation pathway is also illustrated in Figure 2-1.

Biodegradation of TCE occurs under both anaerobic and aerobic conditions, while the degradation rate is significantly faster under anaerobic conditions compared to aerobic conditions. The mechanism for anaerobic degradation of TCE is reductive dechlorination. TCE is degraded to cis-1,2-dichloroethene (cis-1,2-DCE) which is then degraded to VC and ethene under sulfate reducing and methanogenic conditions. Furthermore, a special group of bacteria called *Dehalococcoides* (DHC) is responsible for complete dechlorination to ethene. Without DHC, the degradation may stall at cis-1,2-DCE or VC.

2.2.2 Abiotic Degradation of Site Contaminants

In situ chemical reduction (ISCR) is a remedial technology utilizing chemical reduction reactions to detoxify contaminants into innocuous compounds. This chemical reduction is typically accomplished by the addition of chemical reducing reagents, such as zero valence iron (ZVI). The addition of ZVI to water creates a highly reducing environment in which chlorinated volatile organic compounds (VOCs), such as TCE, are thermodynamically unstable. Because they are unstable, they degrade into more thermodynamically stable compounds that are benign.

Two reactions are involved when TCE is dechlorinated by ZVI, as shown in Figure 2-2. Most of the TCE is converted to ethene and chloride by a beta-elimination reaction, during which short-lived intermediates, such as acetylene, are generated. A small portion of TCE decomposes by hydrogenolysis, a sequential reduction pathway in which TCE is reduced to cis-1,2-DCE, VC, and finally ethene (Roberts 2005).

ZVI can reduce 1,1,2-TCA (Interstate Technology Regulatory Council [ITRC 2005]), but is generally considered not effective in treating 1,2-DCA (Lai 2006). Therefore, use of a strictly abiotic mechanism for remediation is not applicable to this Site. However, a combination of abiotic and biotic mechanisms may be applicable. EHC® is a proprietary product by Adventus Environmental Solutions Team of FMC. A 99 percent reduction of 1,2-DCA was achieved in the laboratory studies with this product (Lakhwala 2009).

EHC is a controlled-release, integrated solid-phase biodegradable carbonaceous electron donor derived from wheat and ZVI that is claimed by the vendor to yield oxidation-reduction (redox) potential (ORP) in the -500 to -

650 millivolt (mV) range. This ORP is significantly lower than that achieved when using either organic electron donors (lactate, molasses, and sugars) or ZVI alone. ORP in this range can promote destruction of chlorinated organic compounds (e.g., TCE) without the formation of potentially problematic intermediates, such as cis-1,2-DCE and VC.

The micro-scale ZVI used in EHC has particle sizes less than 250 micrometers (µm), and 45 percent (by weight) of the particles have particle sizes less than 75 µm. The reactivity of EHC is slower than ZVI initially, but once the low redox conditions are established, the overall reactivity may be greater than ZVI alone because of the dual degradation pathways. The carbonaceous electron donor in the EHC will generally not remain active as long as the ZVI, although the EHC is claimed to remain active for up to five years. EHC is commonly used with hydraulic fracturing. Additionally, EHC is potentially capable of mitigating pH excursions because pH increases often associated with ZVI oxidation are mitigated by organic acid production during fermentation of the carbonaceous electron donor. Therefore, EHC could be a potentially cost effective option for Site remediation and was tested in the bench scale study.

2.3 Design of Bench Study

Three amendments were selected for technology testing:

Two for in situ bioremediation technology testing,

- Emulsified vegetable oil product (i.e., EOS® 598): EOS® represents a long lasting electron donor which promotes anaerobic biodegradation of chlorinated solvent contaminants.
- A combination of sodium lactate and whey: This combination is designed to promote dissolution of DNAPL, if present, to expedite the bioremediation process. In addition, the fermentation of whey generates organic acids which can lower the groundwater pH and hinder the biodegradation process. Adding lactate provides buffer capacity to balance the acid and prevent excess pH decreases.

One for in situ combined abiotic and biotic remedial technology testing,

- EHC: EHC contains ZVI and slow release organics that would promote both abiotic and biotic degradation.

Bacteria capable of degrading TCE, 1,2-DCA, and 1,1,2-TCA may or may not exist in Site soil and groundwater. Groundwater samples from the five most contaminated wells (MW-2D, MW-3D, MW-3B1, MW-7D, and MW-16B2) were collected and analyzed for DHC species during the Round 2 sampling event. DHC results were at the reporting limit, which indicate that even if DHC are present, they are not at sufficient quantity to promote biodegradation. To expedite the bench scale study, bioaugmentation cultures known to be capable of degrading TCE, 1,2-DCA, and 1,1,2-TCA were added to selected test conditions. There are several commercially available cultures that can degrade TCE, 1,2-DCA, and 1,1,2-TCA. A combination of two cultures, SDC-9 and TCA-20, produced by the Shaw Group, were used. SDC-9 is particularly suited for reductive dechlorination of chlorinated alkenes, and TCA-20 for chlorinated alkanes.

Soil and groundwater samples from the most contaminated area in the deep overburden, MW-3D, were used in the bench study. Using the high contaminant mass in the bench tests enabled the evaluation of: potential inhibitory behavior of the contaminants to microorganisms and percent mass removal that can be achieved in the presence of contaminated soil on a bench scale. Results from the bench tests with the highest contaminant levels would be applicable to other areas of the Site where the contaminant mass is less.

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Section 3
Bench Study Materials and Methods

The bench-scale study was conducted according to the Final Work Plan/Quality Assurance Project Plan Addendum No. 3, Bench Scale Treatability Study, for the White Chemical Corporation Superfund Site OU3, Groundwater. A field change request (FCR 1) was prepared before the setup of the bench study to include the standard operation procedure (SOP) for using the Four-Gas meter (Appendix A) during the bench study setup in the anaerobic chamber. Additional details of the work performed and deviations from the work plan are presented below.

3.1 Sample Collection

Approximately 4 kilograms (kg) of soil were collected using split spoons and a hollow stem auger rig from the well screen depth adjacent to monitoring well MW-3D. The soil was collected on March 28, 2011 and shipped on ice overnight to the ETL, where it was stored at 4 degrees Celsius (°C) until use. Approximately 20 liters (L) of groundwater were collected from monitoring well MW-3D on July 11, 2011 and shipped overnight to the ETL, where it was stored at 4°C until used.

3.2 Bench Study Set Up

Microcosms for the bench-scale treatability study were set up on July 12, 2011. The bench scale study included six test conditions (1 through 6) and two controls (7 and 8), as shown in Table 3-1. The amendments were provided by the suppliers as follows:

- Sodium Lactate: JRW Bioremediation; Lenexa, Kansas
- EOS 598: EOS Remediation; Raleigh, North Carolina
- EHC: Adventus Americas; Freeport, Illinois
- SDC-9 & TCA-20: The Shaw Group; Lawrenceville, New Jersey

Each test condition was set up in triplicate using 240-milliliter (mL) serum (air tight) bottles. These bottles were smaller than specified in the work plan, and were chosen due to a shortage of the 500-mL bottles from the supplier. Triplicates rather than duplicates were used to ensure sufficient sample volume for offsite laboratory analyses. The triplicates were labelled A, B, and C. Bottles A and B were sampled regularly as specified in the work plan. Bottle C was only sampled at the beginning (2 days after the setup) and at the end (after 152 days of incubation) of the test period. FCR 2 documenting this deviation (using three 240-mL serum bottles instead of using two 500-mL serum bottles) is included in Appendix A.

The test bottles were set up in a nitrogen-purged anaerobic chamber to minimize exposure to oxygen during soil and groundwater transfer. The chamber was purged with nitrogen until the oxygen concentration was less than one percent prior to opening the soil and groundwater samples.

The oxygen concentration was also monitored throughout the setup period to ensure that it was less than one percent. Soil was homogenized and rocks were removed before the soil was weighed into the serum bottles. Groundwater and amendments were added to the bottles, which were then capped with thick butyl rubber stoppers held in place with aluminum crimps.

The contents of each bottle were allowed to equilibrate for approximately two days before the addition of the bioaugmentation culture. This also allowed the dissolved oxygen, if any, to be consumed prior to inoculation. On July 15, the culture (a mixture of SDC-9 and TCA-20) was introduced into bottles for Tests 2, 4, 6, and 7 through the stoppers using nitrogen-flushed needles and syringes.

On July 14, a small crack was observed in the serum bottle for Test 3, replicate B. The bottle was returned to the anaerobic chamber and its contents transferred to a new bottle. A fourth replicate was established for this test on July 15, as a backup, due to the concern that possible oxygen exposure in the cracked bottle might negatively impact the test results.

For the duration of the study, the bottles were stored upside-down, in the dark, at room temperature, and were hand-shaken twice a day to ensure contact between the water and soil. Prior to each sampling event, the bottles were shaken, and then stored right-side up to allow the soil to settle.

After two months of incubation, test conditions 2 and 6, lactate/whey with culture; and EHC with culture, showed more than 80 percent removal of 1,2-DCA but less removal of TCE as described in Section 4. To investigate if TCE degradation by DHC was inhibited early in the study by high concentrations of chlorinated ethanes, Tests 2 and 6 were bioaugmented a second time using SDC-9 culture on October 4, 2011. This deviation from the work plan is documented in FCR 3 included in Appendix A.

3.3 Sampling and Analysis

On July 12, at the beginning of the bench study, one groundwater sample and three homogenized soil samples were collected at the ETL and shipped to Chem Tech Consulting Group, a Contract Laboratory Program (CLP) laboratory located at 284 Sheffield Street, Mountainside, New Jersey for baseline analysis of the VOCs on the Target Compound List. The three soil samples were collected by homogenizing all soils sent to the ETL. Groundwater samples taken at this time were also analyzed for VOCs at the ETL.

During the course of the bench study, a total of seven sampling events were conducted at the ETL to monitor the treatment progress. The sampling dates and analyses performed are shown in Table 3-2. Some events included repeat sampling when re-analysis was necessary; these sampling dates are indicated in the table. Samples were collected every two weeks at the beginning of the study; however, after 42 days of incubation, the sampling interval were increased to one month or six weeks because of the slower-than-expected fermentation and contaminant degradation rates in test conditions with EOS, and the second bioaugmentation conducted on October 4.

For each test, bottles A and B were sampled during each sampling event. Sampling and analysis were conducted in accordance with the methods specified in the work plan and the QAPP Addendum 3 (CDM Smith 2011), with the following variations: 1) The gas chromatography/flame ionization detector (GC/FID) method for analysis of methane, ethane, ethene, and acetylene (MEEA) used standards prepared at a lower concentration and different column flow rates and pressures than specified in the SOP and 2) Samples for Fe(II) and pH analysis were syringe-filtered and analyzed immediately. The filtered samples were subsequently used for sulfate and chloride analysis by ion chromatography (IC) and determination of chemical oxygen demand (COD). These deviations did not impact the DQOs set for this study. The analytical methods used for sample analysis are listed in Table 3-3.

At the end of the test period, the third replicate, bottle C, from each test was sacrificed. Soil and water samples were collected and sent to the Division of Environmental Science and Assessment (DESA) laboratory, a division of EPA Region 2, for VOC analysis. The soil samples sent at the end of the study were saturated. Therefore the contaminant concentrations in the aqueous phase would likely impact the soil sample results.

Results from all analyses are presented in Section 4.

3.4 Detection and Identification of 1-bromo-2-chloroethane

Gas chromatography with mass-selective detection (GC/MS) analysis of VOCs in the groundwater and microcosm samples revealed a compound that was not identified in the Bench Scale Treatability Study Work Plan and QAPP Addendum 3. This compound is also not on the Target Compound List using the CLP SMO1.2 method, and, therefore, was not identified as a Site contaminant in the OU3 RI or previous investigations at the Site. This compound was tentatively identified as 1-bromo-2-chloroethane based on a close match of its mass spectrum to the library spectrum (cross-correlation value was approximately 0.9; identical match would equal 1.0). This compound is not in the compound list for EPA Method 8260B. The intensity of the GC-MSD response suggested that the compound was present at high concentrations in the groundwater. It was necessary to identify and quantify this compound positively in order to account for its degradation products for mass balance evaluations. The standard for 1-bromo-2-chloroethane was purchased from Sigma-Aldrich, St. Louis, Missouri, at 98 percent concentration and analyzed on the GC-MSD in parallel with samples from this study. The close match of the elution times and mass spectra of the known 1-bromo-2-chloroethane and the unknown compound (shown in Figure 3-1) confirmed the detection of 1-bromo-2-chloroethane. Analysis on October 31, 2011 of stored groundwater (collected on July 11, 2011 and kept at 4 ℃ in the ETL) suggests that this compound is present at concentrations comparable to 1,2-DCA, and higher than 1,1,2-TCA, 1,2-dibromoethane, and TCE.

3.5 Analysis of Bromide

Due to the high concentration detected for 1-bromo-2-chloroethane and the presence of 1,2-dibromoethane, bromide was analyzed and quantified in the sixth and seventh sampling events, on October 31, 2011 and December 12, 2011.

3.6 Control of Investigation-Derived Waste

Three types of waste were generated during the bench scale treatability study: waste soil, excess groundwater, and analytical waste generated during sample analysis. Aqueous waste was disposed of by the ETL in accordance with applicable laws and regulations, and the laboratory Chemical Hygiene Plan. Waste soil was shipped back to New Jersey and properly disposed of by Seacoast, the investigation-derived waste (IDW) subcontractor for this project.

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Section 4
Bench Study Results

Results analyzed by the ETL are presented in Table 4-1. Results analyzed by the CLP laboratory (Chem Tech Consulting Group) and DESA are provided in Appendix B. Evaluation of changes in amendment concentrations, groundwater geochemistry, contaminant reduction, generation of degradation products, and mass balance are discussed below.

4.1 Organic Amendments

COD is measured as an indicator of concentrations of electron donors, another word for the organic amendment promoting anaerobic reductive dechlorination. The COD concentration varied significantly among different amendments as shown in Table 4-1 and Figure 4-1. COD concentrations for Tests 1 and 2, lactate/whey and lactate/whey plus culture were significantly higher than tests with EOS (Tests 3 and 4) or EHC (Tests 5 and 6) throughout the course of bench study. Even though the target electron donor concentration for Tests 3 and 4 with EOS was 5,000 mg/L, EOS is an oil-based amendment and adsorbs to the soil, thus its measured aqueous concentration was less than the target. Similarly, the organic electron donors in EHC dissolve slowly, so COD results in water samples represent only a fraction of the total electron donor mass present. The COD concentrations in the un-amended controls (Tests 7 and 8) were relatively lower as expected.

Over time, COD concentrations in Tests 1 and 2 fluctuated, but generally remained near the starting concentrations at approximately 4,000 mg/L for both Test 2 (with culture) and Test 1(without culture). COD concentrations started to increase slowly for tests with EOS after 28 days of incubation in Test 3-A, and after 68 days in Test 3-B. The increasing trend continued to the end of the study. The initial COD concentrations in tests with EOS were approximately 800 mg/L; at the end of the study, COD concentrations ranged from approximately 1,500 mg/L to 2,000 mg/L. The increasing trend for EOS is consistent with hydrolysis of the oil and slow release of soluble organics to the aqueous phase over time. COD concentrations of tests with EHC (Tests 5 and 6) started to increase after 14 days of incubation to between 1,200 mg/L and 1,600 mg/L. This level was sustained in Test 5 (EHC alone), but not in Test 6 (bioaugmented EHC). COD dropped to approximately 750 mg/L after the second bioaugmentation conducted on October 4, 2011 after 83 days of incubation. At the end of the bench study, COD concentrations in Test 6 were approximately 500 mg/L. COD results of the controls (Tests 7 and 8) were generally less than 250 mg/L and were stable throughout the study.

Overall, amendment limitation was not observed in the bench scale study.

4.2 Groundwater Geochemical Parameters

For anaerobic biodegradation and/or chemical reduction of chlorinated or brominated contaminants to occur, the biodegradation of the electron donor will first change groundwater geochemistry to reducing conditions. Once the ORP is conducive to reductive dechlorination processes, degradation of contaminants can start. The geochemical parameters monitored as indicators of the oxidation-reduction conditions included: pH, ORP, nitrate/nitrite, ferrous iron, sulfate, and methane. Results

for these parameters are presented in Table 4-1.

pH

All of the tests with amendment developed substantially lower pH than the controls, as shown in Figure 4-2. The pH values were lower than the controls even after two days of incubation. It is unknown whether the low pH after two days was due to biodegradation or low pH of the amendments themselves. However, fermentation of whey and generation of volatile fatty acids is a relatively rapid process and likely led to the pH decreases. Similarly, hydrolysis and fermentation of vegetable oil in EOS would also decrease the pH, but occurred at a later time and most likely at a slower rate as expected. While the COD data for EHC indicated that organic matter began to dissolve within 14 days; the pH data indicated that biodegradation of that material began in earliest between 14 and 28 days. It should be noted that organic acids were not measured in this study.

For tests with lactate/whey or EHC, the decreasing pH trends continued for more than six weeks. The pH fell as low as 6.1. Then, the pH values started to rebound after 68 days of incubation, gradually increasing to 6.4 and above. For tests with EOS, the pH values started to decrease after 14 days of incubation; this decreasing trend continued to the end of the study. If the pH is too low for an extended period, it can result in inhibition of the reductive dechlorination process; however, the pH at which that occurs varies among microbial consortia. In such a case, addition of a buffer may be necessary to enhance dechlorination.

Ferrous Iron

The initial ferrous iron concentrations were at trace levels, less than 0.2 mg/L. Increases of ferrous iron concentrations were first observed in tests with lactate and EHC after 14 days of incubation; and in tests with EOS after 28 days of incubation. For all three amendments with or without culture, an increasing trend of ferrous iron was observed throughout the study and final concentrations were about 100 to 200 mg/L (Table 4-1 and Figure 4-3). These concentrations are very high and indicate the presence of significant concentrations of bioavailable ferric iron (BAFeIII). Very high BAFeIII can be one cause of cis-1,2-DCE stall (Evans and Koenigsberg 2001). The ferrous iron concentration did not increase in the two controls.

Sulfate

The initial sulfate concentration was approximately 80 mg/L (Test 8 as shown in Table 4-1). Sulfate depletion occurred within six weeks under all test conditions, but not in the controls. These data indicate that development of highly reducing conditions was possible even though significant iron reduction was occurring. No sulfate reduction was observed in the controls. Sulfate reduction results are presented in Table 4-1 and concentration trends are presented in Figure 4-3.

ORP

The ORPs of all test conditions were generally stable throughout the course of the study, ranging from -50 millivolts (mV) to -150 mV, although a gradual increase in ORP was observed in Tests 3 and 4 with EOS. At the end of the study, final ORP values were about -100 mV for Tests 1 and 2, -50 mV for Tests 3 and 4, and -110 to -120 mV for Tests 5 and 6. The ORP readings for Tests 5 and 6 with EHC were the lowest possibly because of the presence of ZVI in its formulation. However, the very low ORP values of -500 mV claimed by the manufacturer were not observed. While elevated ORP values in the Test 8 control at 14 and 28 days are not considered representative, data are reported for completeness. ORP results are presented in Table 4-1 and concentration trends are presented in Figure 4-3.

Methane

Figure 4-4 presents the methane results. ORP results are presented here in addition to Figure 4-3 to allow comparison with other parameters. A lack of methane generation indicating methanogenic conditions was not reached in Test Conditions 1 to 4, lactate/whey or EOS with or without culture. However, high concentrations of methane were detected in Tests 5 and 6 with EHC. Methanogenic conditions were observed in Test 5 (EHC without culture) after 110 days of incubation; methanogenic conditions were observed in Test 6 (EHC with culture) after 68 days of incubation. The ZVI contained in EHC likely initiated some abiotic reaction and indirectly facilitated the establishment of methanogenic conditions. The lack of methane production, especially in Test 1 and Test 2 after the second bioaugmentation, may indicate that the high VOC concentrations, such as 1,1,2-TCA, at the Site inhibited methanogenic activity.

Another possibility for the observed inhibition of methanogenesis was the presence of brominated organics. For tests 5 and 6, even with the presence of ZVI, the methanogenic conditions were established after 1,2-dibromoethane and 1-bromo-2-chloroethane were degraded. Bromoethane sulfonic acid (BES) is a well documented inhibitor of methanogenesis (Chiu 2001; Loffler et al. 1997). BES is a structural analog of coenzyme M – an important biochemical responsible for donating a methyl group during methane formation – and results in complete inhibition of methanogenesis. Additionally, BES has been demonstrated to inhibit biological TCE reduction (Loffler et al. 1997). However, this inhibition has not been observed in other cases (Chiu 2001). Nevertheless, it is possible that unidentified brominated organic compounds are present in Site groundwater and these compounds may inhibit methanogenesis and biological reductive dechlorination. Since 1-bromo-2-chloroethane was identified in Site groundwater during this study but had not previously been identified, it is reasonable to believe that other unidentified brominated compounds might exist. If BES is in Site groundwater, it would not be detected by GC/MS because it is not a volatile compound.

The second bioaugmentation did not appear to facilitate the development of methanogenic conditions directly, since Test 5 developed methanogenic conditions without the second bioaugmentation. Test 2 did not become methanogenic even with the second bioaugmentation.

Methane results are presented in Table 4-1 and concentration trends are presented in Figure 4-3.

Summary

Overall, reducing conditions developed in all test conditions, as evidenced by low ORP, high ferrous iron (Fe(II)) concentrations, and depleted sulfate. On the other hand, methane production was not observed except in the presence of EHC. The reduced conditions in tests without bioaugmentation (Tests 1, 3, and 5) are evidence of stimulation of the indigenous microbial community in the Site soil and groundwater. This community was able to reduce electron acceptors such as sulfate and ferric iron when electron donors were provided. For tests with both EOS and lactate/whey, with bioaugmentation, release of ferrous iron and sulfate removal began sooner than those tests without bioaugmentation. This suggests that bioaugmentation did increase the microbial activity, at least at the beginning of the experiment. However, these data alone do not provide sufficient justification for bioaugmentation.

Both the negative control and the culture-only control did not become as reduced as tests with amendment(s), even though the ORP measurements were approximately -150 mV. Ferrous iron concentrations were low, less than 1 mg/L; sulfate concentrations decreased in the culture-only control, but were not depleted, and sulfate concentrations did not decrease in the negative control, indicating that the amendments were necessary to achieve iron reducing conditions or sulfate reducing conditions.

4.3 Contaminant Degradation

Table 4-1 presents the analytical results by the ETL. Appendix B provides the analytical results by the CLP laboratory, Chem Tech Consulting Group, or by DESA for both soil and groundwater samples collected at the beginning of the bench study and at the conclusion of the bench study.

The baseline soil sample results (see Table B-3 in Appendix B) indicate low levels of VOC contamination in soil. 1,2-DCA was detected at the highest concentrations, ranging from 500 micrograms per kilogram (µg/kg) to 1,000 µg/kg; followed by 1,1,2,2-tetrachloroethane, detected at approximately 40 µg/kg. It should be noted that 1,1,2,2-tetrachloroethane is a contaminant of concern for the Site, but was not detected at high concentrations in monitoring well MW-3D. 1,2-Dibromoethane was detected at 11 µg/kg to 17 J µg/kg. TCE and PCE were detected at less than 10 µg/kg concentrations. In comparison, contaminants were detected at much higher concentrations in the final soil samples (Table B-4 in Appendix B). This does not mean that more contaminants were attached to the soil after the bench test. The higher than baseline contaminant concentrations were most likely from the higher percentage of contaminated groundwater water in the samples (soil samples were saturated like soil slurry).

The contaminants of interest (COI) for this bench study include: 1,2-DCA, 1,1,2-TCA, 1,2-dibromoethane, TCE, and PCE. Additionally, 1-bromo-2-chloroethane was found at high concentrations, comparable to 1,2-DCA during the bench scale study. This compound is not on the Target Compound List for CLP VOC analysis. Therefore, it had not been identified in the past as a Site contaminant. Removal of these six COIs with different amendments is discussed in Section 4.3.1; the degradation intermediates, such as cis-1,2-DCE, VC, and chloroethane (CA), and the degradation products, including ethane, ethene, chloride, and bromide are discussed in Section 4.3.2.

4.3.1 Contaminant Removal

Table 4-2 shows the percent removal during the final sampling event using data collected by ETL. This percent removal is calculated using the final results from Test 8 as the reference instead of the initial contaminant concentrations. Calculating contaminant removal in this manner focuses on the degradation mechanism resulting from the addition of amendment(s); and disregards the contaminant loss due to other processes.

Table 4-3 shows the percent removal using the results from the off-site laboratories. The removal trends are generally in agreement with ETL data shown in Table 4-2. It should be noted that analyzing percent removal in this way does not differentiate among reduction due to biodegradation, absorption (the case with EOS), or volatilization loss.

As shown in Table 4-2 and Figures 4-5a to 4-5c, EHC with culture (Test 6) was the most effective amendment, achieving the highest contaminant removal for all six COIs. The removal of PCE, 1,1,2-TCA, 1,2-DCA, 1,2-dibromoethane, and 1-bromo-2-chloroethane ranged from 98 percent to nearly 100 percent. TCE removal reached 78 percent. No accumulation of degradation intermediates, such as CA, VC, and cis-1,2-DCE was observed, and their average percent removals were 69 percent, more than 99 percent, and 57 percent, respectively. Even though the TCE result in bottle 6-C was 464 µg/L analyzed by ETL; the TCE concentration was non-detect for the groundwater sample collected approximately 2 days later from bottle 6-C and analyzed by DESA (see Table 4-2). Therefore, the actual TCE removal for this test condition may be higher.

As shown in Table 4-2 and Figures 4-6a to 4-6c, EHC without culture (Test 5) achieved similar contaminant reduction for PCE, 1,1,2-TCA, 1,2-DCA, 1,2-dibromoethane, 1-bromo-2-chloroethane and TCE, as EHC with culture in one bottle (5-B), but was slightly less effective in the other bottle (5-A) for TCE and PCE removal. In

addition, accumulation of cis-1,2-DCE, VC, and CA was observed, indicating that the microbial community for complete reduction of these compounds was likely inadequate.

As shown in Table 4-2 and Figures 4-7a to 4-7c, lactate/whey with culture (Test 2) was effective in degrading all of the contaminants except 1,1,2-TCA, which showed minimal degradation (if any). Removal of 1,2-DCA, 1,2-dibromothane, and 1-bromo-2-chloroethane was more than 99 percent; and removal of PCE and TCE was more than 70 percent. However, it was not effective in removing 1,1,2-TCA. Thus lactate/whey with bioaugmentation was not as effective as EHC with bioaugmentation. Similar to Test Condition 6, EHC with culture, no accumulations of VC, cis-1,2-DCE, or CA were observed, and average percent removals were 96 percent, 83 percent, and >99 percent, respectively. TCE was non-detect in the sample from bottle 2-C analyzed by DESA (Table 4-2).

As shown in Table 4-2 and Figures 4-8a to 4-8c, lactate/whey without culture (Test 1) was effective in degrading some but not all of the contaminants. Removals of 1,2-dibromoethane and 1-bromo-2-chloroethane were more than 99 percent. Removal of 1,2-DCA was more than 99 percent in one replicate and 95 percent in the other replicate. Degradation of 1,1,2-TCA averaged 61 percent which was unexpected because no removal was observed with lactate/whey in the presence of the culture. The reason for this difference is not known. This test condition was not effective in degrading PCE and TCE. Furthermore, accumulation of cis-1,2-DCE and VC were observed under this condition, indicating that the microbial community for complete reduction of these compounds was likely inadequate, consistent with Test 5. Chloroethane was partially degraded with an average 55 percent removal.

As shown in Tables 4-1, 4-2 and Figures 4-9a to 9c, and Figures 4-10a to 10c, EOS with or without culture (Tests 3 and 4) did not appear to be effective in degrading the COIs. Contaminant concentrations analyzed after two days of incubation were significantly less than those in other tests (Table 4-1). Over time, however, the concentrations of site contaminants gradually increased. This increase occurred in parallel with the increase in COD noted for these conditions (Section 4.1, Figure 4-1), suggesting that these compounds partitioned into the oil, which was adsorbed to the soil at the beginning. The contaminants were slowly released as the oils were hydrolyzed into small molecular weight water-soluble organic compounds. It is uncertain if the contaminant removals (especially for PCE and 1,2-dibromoethane) shown in Table 4-2 for tests with EOS are valid, due to the partition of contaminants in oil and soil. It should be noted that as a slow-release product, EOS might become more effective if tested over a longer time, such as a year.

Few changes occurred in the VOC concentrations in the control (Test 8) and culture-only control (Test 7) bottles as shown in Figures 4-11 and 4-12. However, accumulations of cis-1,2-DCE and VC were observed in the culture-only control. This was not unexpected since the culture contained residual electron donor.

Substantial increases in 1-bromo-2-chloroethane concentrations were observed after 14 days of incubation in all test conditions, except EHC with culture (Test 6). These increases could be the result of desorption or potential decomposition of another unidentified organic compound. Nevertheless, 1-bromo-2-chloroethane was subsequently degraded in tests with EHC (Tests 5 and 6) and tests with lactate/whey (Tests 1 and 2).

After two months of incubation, TCE concentrations remained high even in the best performing tests (i.e., Tests 2 and 6). Bioaugmentation was repeated after 83 days of incubation to test the hypothesis that initial conditions had inhibited or killed some part of the microbial community. However, this second bioaugmentation did not show a clear improvement on VOC removal in either treatment. As discussed in Section 4.1, electron donor limitation in Test 6 (i.e., EHC with bioaugmentation) may have prevented further TCE destruction. Addition of supplemental electron donor to test this hypothesis was not conducted.

A comparison of degradation rates by different amendment with and without culture was made by comparing the degradation trends of 1,2-DCA over time as shown in Figure 4-13. Different amendments are shown in different colors: tests with lactate and whey are shown in blue; tests with EOS are shown in red; and tests with EHC are shown in green; controls are shown in purple. Figure 4-13 illustrates that Test 6 (EHC with culture) achieved faster degradation of 1,2-DCA than Test 2 (lactate/whey with culture) and Test 5 (EHC), followed by Test 1 (lactate/whey). For tests with EOS, 1,2-DCA concentrations were increasing up to 110 days. From 110 days to 152 days, the aqueous 1,2-DCA concentration appeared to stabilize.

Overall, EHC (Tests 5 and 6) achieved the greatest removal of the six COIs among the six test conditions. However, Test 5 (no culture) showed accumulation of the degradation products cis-1,2-DCE; VC; and CA. Lactate and whey (Tests 1 and 2) also achieved 99 percent removal of 1,2-DCA, 1-bromo-2-chloroethane, and 1,2-dibromoethane, but were not consistently effective in degrading 1,1,2-TCA under the batch test conditions. Test 2 (with culture) completely removed the degradation products of cis-1,2-DCE; VC; and CA. Test 1 (without culture), like Test 5, did not. 1,2-DCA; 1-bromo-2-chloroethane; and 1,2-dibromoethane are the most abundant VOCs in the groundwater. Removal of these three compounds represented a substantial reduction in the total VOCs.

4.3.2 Degradation Products – Ethene, Ethane, Chloride, Bromide

Observed final degradation products of the halogenated VOCs included ethane, ethene, chloride, and bromide. Acetylene is often produced during the abiotic degradation of TCE and cis-1,2-DCE via beta-elimination. However, acetylene production was not observed during this study, suggesting that beta-elimination was not a significant pathway. The concentrations of ethane, ethene, and chloride are shown in Figure 4-14.

Ethane was detected as high as 260 parts per million in volume (ppmv) in Test Condition 5 with EHC and as high as 120 ppmv in Test Condition 6 with EHC and culture. It should be noted that ethane and ethene concentrations in Table 4-1 were measured in the headspace of each test bottles. Ethane was not detected in any other test conditions with meaningful concentrations. This suggests that EHC promoted different degradation pathways than other amendments.

Substantial production of ethene and chloride occurred in four tests: lactate and whey (Test 1), lactate and whey with culture (Test 2), EHC (Test 5), and EHC with culture (Test 6). Ethene concentrations were measured at greater than 10,000 ppmv for all four test conditions in the last two rounds of sampling; chloride concentrations increased by approximately 400 mg/L or 500 mg/L at the end of the study in these four tests. Much less ethene production occurred in tests with EOS (Tests 3 and 4). Ethene was measured at several hundred ppmv in Test 4, EOS with culture; and less than 200 ppmv in Test 3. No apparent chloride concentration increase was observed in tests with EOS. Ethene was also detected in the culture-only control (Test 7) at several hundred ppmv.

The timing with which chloride and ethene production occurred in Tests 1, 2, 5, and 6 was consistent with the observed VOC degradation. Ethene concentrations rose soonest in conditions 2 and 6, supporting the evidence from the VOCs that addition of culture to these tests promoted rapid degradation of VOCs. Ethene production with EHC alone (Test 5) occurred slightly later than those with culture (Test 6). Ethene production in Test 1 occurred last among these four conditions. Ethene concentrations were greater than 10,000 ppmv by day 14 in Tests 2 and 6, and by day 28 in Test 5, and by day 110 for Test 1. Chloride production followed similar patterns.

Degradation of 1,2-dibromoethane and 1-bromo-2-chloroethane would release bromide. Bromide was not quantified until the last two rounds of sampling; therefore, bromide results from the negative control (Test 8) are used as the benchmark for discussion. Bromide concentrations increased more than 60 mg/L in tests with EHC compared to Test 8; bromide concentrations increased approximately 50 mg/L in tests with lactate/whey compared to Test 8. No bromide concentration increase was observed for tests with EOS (see Table 4-1)

The lack of generation of ethene, chloride, and bromide in tests with EOS was consistent with the minimal changes that occurred in VOC concentrations in these conditions.

4.4 Mass Balance

The reductive dehalogenation of brominated and chlorinated VOCs releases bromide and chloride, respectively. The theoretical amount of bromide and chloride released from the degradation can be calculated from the stoichiometry of the reactions. For example, when one mole of 1,2-DCA is degraded to ethene, it is expected to release 2 moles of chlorine. The calculated molar release of bromide or chloride based on contaminant degradation (mass of VOC decreased) can be compared to the measured molar changes of bromide or chloride. The results of this balance can be used to evaluate the extent to which contaminant losses were attributable to complete dehalogenation versus other loss mechanisms such as partial dehalogenation, sorption, volatilization, or analytical inaccuracy.

The unexpected presence of 1-bromo-2-chloroethane complicated the mole balance calculation in several respects.

1. Its aqueous concentrations increased over time in the controls and some of the tests, indicating either release from soil or decomposition of another unidentified organic contaminant.

2. The quantified concentrations in the last two rounds of sampling were high, comparable to concentrations of 1,2-DCA; therefore it has a substantial impact on the overall VOC balance.

3. Its degradation released bromide as well as chloride, and neither 1-bromo-2-chloroethane nor bromide was quantified until the later sampling events.

Table 4-4 presents the mass balance calculation. To overcome the challenges mentioned above, the mass balance for chloride and bromide were calculated as indicated below.

1. The final concentrations of 1,2-DCA, bromide and 1-bromo-2-chloroethane in Test Condition 8 (negative control) were used as the bench mark for calculating mass reduction of these compounds in each test bottle.

2. Only 1,2-DCA and 1-bromo-2-chloroethane were used for predicting molar releases of chloride and bromide, because the mass of 1,2-DCA and 1-bromo-2-chloroethane were more than an order of magnitude greater than the next-most abundant contaminants, and would therefore have the dominant effect on the mole balance calculation. It should be noted that the measured VOC moles included both the amount measured in the liquid and the amount predicted to be in the headspace at equilibrium with the liquid concentration.

3. Since 1,2-DCA contains two chlorine atoms, and 1-bromo-2-chloroethane contains one chlorine and one bromine, the predicted chloride production was calculated as the 1-bromo-2-chloroethane mole removal plus twice the 1,2-DCA mole removal. The predicted bromide production was calculated as equal to the 1-bromo-2-chloroethane mole removal.

4. The actual chloride produced in each test bottle was calculated by subtracting the initial chloride moles from the final chloride moles after 152 days of testing. In this manner, the initial differences in chloride content induced by the amendments would not impact the mass balance calculations.

5. The percent recovery for each anion was calculated as the actual production divided by the predicted production.

As shown in Table 4-4, the mole balances of chloride in test conditions where significant contaminant removal was observed (i.e., Tests 1, 2, 5, and 6) ranged from 130 to 200 percent. The measured chloride production for tests with EHC, lactate/whey, and EOS were consistently higher than the predicted chloride production. Potential causes of this disagreement between predicted chloride mass and measureable chloride mass are indicated below.

1. Concentrations of 1,2-DCA analyzed by ETL were biased low relative to CLP laboratory results (Table 4-5 and 4-6). This may have resulted in an underestimate of the predicted chloride production and thus an overestimate of chloride recovery. Use of CLP laboratory data would have resulted in a percent recovery closer to 100 percent.

2. The initial concentrations of 1-bromo-2-chloroethane in groundwater were quantified using calibration factors obtained several months after the start of the study because the compound had not yet been identified. Thus the accuracy of initial concentrations is not known. An increase of 1-bromo-2-chloroethane in the aqueous phase was observed after 14 days of incubation, which could be desorption of 1-bromo-2-chloroethane from the soil. Even though using final results of 1-bromo-2-chloroethane in Test Condition 8 would account for some release of 1-bromo-2-chloroethane from soil, degradation of 1-bromo-2-chloroethane with amendments (either EHC or lactate/whey) may have increased desorption from the soil, which could have resulted in even higher release of chloride than predicted by the current calculation.

Considering these factors, the percent chloride recovery is reasonable.

The mole balances of bromide in tests where significant 1-bromo-2-chloroethane degradation was observed (i.e., Tests 1, 2, 5, and 6) ranged from 38 to 67 percent with the higher values being associated with the EHC tests. The CLP laboratory did not quantify this compound so definitive conclusions are not possible. Nevertheless, more than 50 percent of bromide was recovered in the EHC tests. Considering the uncertainty regarding the concentrations of brominated compounds in the groundwater matrix, this level of recovery is reasonable.

It should be noted that negative values appeared in the calculated contaminant mass removal and predicted chloride or bromide mass increase on Table 4-4. These negative values do not mean generation of contaminants or loss of chloride or bromide. The mass balance is calculated using the negative controls as the reference to predict how much contaminants were removed and how much chloride and/or bromide were generated. Due to the accuracy of analysis, some results in the tests appeared to have less loss of contaminants than the negative controls, so the value on Table 4-4 became negative.

4.5 Data Quality

Analytical results collected by ETL were screening level data. Therefore, comparison between data by ETL and by a CLP laboratory or DESA is for informational purpose only. The aqueous sample results analyzed by ETL and by the CLP laboratory or DESA at the beginning of the bench scale study and at the end of bench scale study are compared in Table 4-5 and Table 4-6, respectively. For the baseline groundwater results (Table 4-5), the average PCE and VC results from the ETL were 88 percent and 114 percent higher than those analyzed by the CLP laboratory, while 1,2-DCA concentrations were only 52 percent of those analyzed by the CLP laboratory. For the final sampling event, similar to the baseline event, PCE, TCE, 1,1,2-TCA, cis-1,2-DCE, and VC analyzed by ETL were higher than those analyzed by DESA, while results of 1,2-DCA were significantly less than those analyzed by DESA as shown in Table 4-6. This variation in concentrations would not significantly impact the trend of contaminant removals presented in Table 4-2.

It should be noted that TCE results from bottle C of Test 2 (lactate/whey with culture) were approximately 610 µg/L by the ETL but non-detect by DESA; from bottle C of Test 6 (EHC with culture) were approximately 460 µg/L by the ETL but non-detect by DESA. The disparity between these results was investigated. Both laboratories were contacted and asked to review the bench notes from their analysis to confirm that there were no anomalies noted by the analyst. The analytical methodologies employed by the individual laboratories were also reviewed. Both laboratories reported that there were no particular anomalies noted during the analysis. It was concluded that the differing calibration procedures used by the laboratories was most likely the primary reason for the disparity in the results. The laboratory performing the bench scale study used a single point calibration as opposed to a multi-point calibration used by the DESA laboratory. The use of a single point calibration is not problematic since the bench test laboratory's goal is to identify trends in contaminant concentrations over the course of the study rather than verify the concentration of a given compound in the sample. The goal of the DESA laboratory is to quantify, as accurately as possible, the concentration of a given compound in the sample. These two differing analytical goals at the core of the variability and need to be taken into account when comparing the analytical data from each.

A data usability summary for the ETL data is provided in Appendix C.

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Section 5
Conclusions and Recommendations

5.1 Conclusions

Based on the bench study results, the conclusions are summarized below.

- Adventus Americas EHC, a product comprising ZVI coated with a cellulosic electron donor, in combination with a mixture of Shaw bioaugmentation cultures SDC-9 (80 percent) and TCA-20 (20 percent) was the most effective amendment tested for treating site contaminants. Based on data collected by the ETL, detected Site contaminants that were treated included:
    - 1,2-DCA which was reduced from approximately 90,000 µg/L to less than 100 µg/L (99.9 percent removal)
    - 1-bromo-2-chloroethane which was reduced from approximately 90,000 µg/L to approximately 70 µg/L (99.9 percent removal)
    - 1,2-dibromoethane which was reduced from approximately 5,000 µg/L to non-detect (100 percent removal)
    - 1,1,2-trichloroethane which was reduced from approximately 5,000 µg/L to non-detect (100 percent removal)
    - PCE which was reduced from approximately 300 µg/L to 4 µg/L or non-detect (>98 percent removal)
    - TCE was reduced from approximately 2,000 µg/L to about 500 µg/L (75 percent removal). However, split sample analyzed by DESA indicated that TCE at the end of the study was non-detect. Therefore, TCE removal may have been better than 75 percent.
    - VC did not accumulate and was reduced from approximately 1,000 µg/L to non-detect in the aqueous phase (100 percent removal)
    - cis-1,2-DCE did not accumulate and was reduced from about 300 µg/L to about 20 µg/L (93 percent removal)
    - CA was not detected at the beginning of the study. CA accumulated with concentrations increasing from less than 5 µg/L up to 70 µg/L

- EHC without bioaugmentation also resulted in significant removals, with the following exceptions:
    - cis-1,2-DCE and VC were not removed and accumulated to varying concentrations ranging from about 300 to 3000 µg/L.
    - CA accumulated up to 180 µg/L
- Degradation of halogenated ethanes with EHC was complete in about 40 days with bioaugmentation and in about 150 days without bioaugmentation. Degradation of PCE and TCE (based on DESA's results) with EHC was complete in about 150 days with bioaugmentation and was still ongoing at 150 days without bioaugmentation.
- Lactate/whey in the presence of the Shaw bioaugmentation culture performed similar to EHC with the culture except that 1,1,2-trichloroethane was not removed.
- No significant removal was observed in the presence of emulsified oils (EOS) with or without bioaugmentation culture. The potential causes might be that EOS is not an effective electron donor for this mixture of contaminants; or the testing period was not long enough for EOS to become effective.
- Within the limited test period (approximately six months), accumulation of cis-1,2-DCE and VC was observed in the absence of bioaugmentation in Tests 1 and 5. This does not preclude the possibility that in the field test, with more time, microbial community capable of degrading VC could be stimulated. However, bioaugmentation with DHC would enhance overall degradation of contaminants and minimize daughter product accumulation.
- Evidence of complete mineralization was provided by accumulation of ethene, chloride, and bromide. Chloride and bromide mole balances were based on degradation of the two dominant organic compounds – 1,2-DCA and 1-bromo-2-chloroethane. In tests where significant degradation was observed, chloride recoveries ranged from 130 to 200 percent. Recoveries may have been elevated because of inaccuracy of screening-level analytical data. Chloride recoveries would be more than 80 percent if the 80 mg/L to 100 mg/L of 1,2-DCA concentration difference between the CLP laboratory and the ETL data was taken into account. Bromide recoveries ranged from 38 to 67 percent for tests with lactate/whey and ranged from 54 to 67 percent for tests with EHC. Recoveries might be affected by quantification of the previously unidentified organic compound 1-bromo-2-chloroethane.
- The organic compound 1-bromo-2-chloroethane was detected in Site groundwater at a concentration of approximately 90,000 µg/L. This compound is not on the CLP SMO1.2 or EPA 8260B analyte list and had not previously been detected or quantified at the Site. Current and historical uses of this compound include solvent, organic synthesis reactant, and fumigant.
- While iron reduction, sulfate reduction, and biodegradation of Site contaminants were observed, methanogenesis was inhibited except in the presence of EHC. Methanogenesis is known to be inhibited by the brominated compound bromoethane sulfonic acid (BES) (Chiu and Lee 2001; Loffler et al. 1997). Other brominated compounds have also been observed to be toxic to microorganisms. EHC was able to overcome this inhibition resulting in methanogenesis. EHC – with its reactive ZVI – may have promoted the abiotic degradation of an unidentified inhibitory compound.
- Even though both 1-bromo-2-chloroethane and 1,2-dibromoethane can be toxic to certain microorganisms, they were degraded by more than 99 percent in the bench study using both lactate/whey and EHC as amendments. Therefore, these specific brominated compounds may not be

inhibitory to the overall in situ bioremediation. However, inhibition of methanogenesis (except in the case with EHC) indicates that inhibitory compound or compounds may be present in groundwater.

- Even though pH decreased for a period initially during the study, the systems were sufficiently self-buffering in most cases to allow pH to recover somewhat, and at the end of the study were sufficient for the biodegradation to proceed. Adjustment of pH would not be necessary.

5.2 Recommendations

Recommendations based on the bench scale study are summarized below.

- A field pilot study is recommended to validate the bench-scale study. Based on the bench study results, EHC is the recommended amendment, while lactate/whey should also be tested. Lactate/whey is easier to distribute in the subsurface and has a potential advantage of solubilising DNAPL, which might be present, and increases remediation effectiveness. While these potential advantages exist, it is important to recognize that consistent and complete biodegradation of 1,1,2-TCA may not occur with lactate/whey based on the bench scale study results. In the case that multiple rounds of amendment injection are necessary, lactate/whey may be used following EHC treatment.
- Bioaugmentation is recommended because of the observed accumulation of VC and cis-1,2-DCE.
- The pilot study may be conducted in both the most contaminated area and the contaminant plume to determine the required dosage for full scale implementation. An EHC dosing rate of 3.8 grams per liter (g/L) of groundwater (15 grams per kilogram [g/kg] of soil) was used in the bench study and was determined to be effective. This dose provides a reasonable starting point for pilot study design.
- The pilot study should be designed to investigate the effectiveness of amendment delivery methods, such as radius of influence from injection point(s) or using variable low pressure injection for EHC delivery.
- The potential inhibition by brominated organic compounds or competition among different Site contaminants should be considered during pilot testing based on the observation that the brominated compounds were degraded faster than PCE and TCE, and degradation of 1,1,2-TCA stalled with lactate/whey as amendment.

Due to the high concentrations of 1-bromo-2-chloroethane (as high as 1,2-dichloroethane) found in the bench study, the extent of 1-bromo-2-chloroethane contamination should be defined prior to the remedial action. In addition, identifying and quantifying other brominated compounds potentially present at the Site should be considered during future sampling events.

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Section 6
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Tables

Table 3-1
Test Conditions and Experiment Setup
Bench Scale Treatability Study
White Chemical Corporation Superfund Site, OU3
Newark, New Jersey

Test Condition [1]	Amendments	Soil (g)	Groundwater (mL)	Electron Donor Stock Solution Concentration (g/L)	Electron Donor Target Concentration[2] (mg/L or as specified)	EHC (g)	Lactate Solution (mL)	Whey Solution (mL)	EOS Solution (mL)	Culture[3] (mL)
1	Lactate + Whey + No Culture	40	160	200	2500	-	2	2	-	-
2	Lactate + Whey + SDC-9 + TCA-20	40	160	200	2500	-	2	2	-	2
3	EOS598 + No Culture	40	160	300	5000	-	-	-	2.7	-
4	EOS598 + No Culture + SDC-9 + TCA-20	40	160	300	5000	-	-	-	2.7	2
5	EHC®	40	160	-	1.5% wt/wt soil	0.6	-	-	-	-
6	EHC® + SDC-9 + TCA-20	40	160	-	1.5% wt/wt soil	0.6	-	-	-	2
7	SDC-9 + TCA-20	40	160	-	-	-	-	-	-	2
8	Negative Control	40	160	-	-	-	-	-	-	-

Notes:
1) All conditions were set up in triplicate on July 12. On July 15, a fourth replicate was set up for condition three , after a crack was discovered in one replicate's bottle.
2) For lactate and whey, the concentration shown is for each amendment.
3) Bioaugmentation culture was added after the bottles incubated for two days. The culture was a mixture of 80% SDC-9 and 20% TCA-20.
Stock solution concentrations:
Sodium Lactate solution: 200 g/L
EOS solution: 300 g oil/L
Whey solution: 200 g/L

g: gram
mL: milliliter
mg/L: milligram per liter

g/L: gram per liter
wt: weight
%: percent

Table 3-2
Sample Collection and Analysis
Bench Scale Treatability Study
White Chemical Corporation Superfund Site, OU3
Newark, New Jersey

Sampling Event	Date	Elapsed time[1] (d)	Samples[2]	Analyses	Laboratory
Setup for CLP	7/12/2011	0	Groundwater	VOCs	ETL
	7/12/2011	0	Groundwater and Soil	VOCs	CLP
#1	7/15/2011	2	All Conditions	VOC, MEEA, pH, COD, ORP, Fe^{2+}, Chloride, Sulfate	ETL
	7/16/2011	3	1A, 4B	VOC	ETL
	7/16/2011	3	All Conditions	MEEA	ETL
	7/20/2011	7	3D	VOC, MEEA, pH, COD, Chloride, Sulfate	ETL
	7/21/2011	8	3D	ORP, Fe^{2+}	ETL
#2	7/27/2011	14	All Conditions	VOC, MEEA, pH, COD, ORP, Fe^{2+}, Chloride, Sulfate	ETL
repeat for #2	8/2/2011	20	1A, 1B	Chloride, Sulfate	ETL
#3	8/10/2011	28	All Conditions	VOC, MEEA, pH, COD, ORP, Fe^{2+}, Chloride, Sulfate	ETL
	8/11/2011	29	1A, 2A, 2B, 7B, 8A, 8B	VOC	ETL
	8/11/2011	29	2A, 2B, 3B, 6A, 6B	Chloride, Sulfate	
#4	8/24/2011	42	All Conditions	VOC, MEEA, pH, COD, ORP, Fe^{2+}, Chloride, Sulfate	ETL
#5	9/19/2011	68	All Conditions	VOC, MEEA	ETL
	9/20/2011	69	All Conditions	pH, COD, ORP, Fe^{2+}, Chloride, Sulfate	ETL
second bioaugmenation	10/4/2011	84	None		
#6	10/31/2011	110	All Conditions	VOC, MEEA, pH, COD, ORP, Fe^{2+}, Chloride, Sulfate	ETL
#7 Final for ETL	12/12/2011	152	All Conditions	VOC, MEEA, pH, COD, ORP, Fe^{2+}, Chloride, Sulfate	ETL
Final for CLP	12/14/2011	154	Replicate C from all conditions	VOC	CLP

Notes:
1) All A, B, and C replicate bottles were set up on 7/12/2011, Day 0. Bottle 3D was set up on 7/15/2011, but elapsed time was counted relative to Day 0.
2) "All Conditions" includes the A and B replicates of all conditions, and bottle 3D. Re-analyses of specific bottles occurred as noted, either to check results or because a different dilution was necessary for appropriate analysis.

ETL: CDM Smith's Environmental Treatability Laboratory; Bellevue, WA
COD: chemical oxidant demand
CLP: contract laboratory program
Fe^{2+}: ferrous iron
MEEA: methane, ethane, ethene, acetylene
VOC: volatile organic compound
ORP: oxidation reduction potential

Table 3-3
Analytical Methods
Bench Scale Treatability Study
White Chemical Corporation Superfund Site, OU3
Newark, New Jersey

Analyte	Matrix	Laboratory	ETL Method or SOP	Basis of ETL Method Development
VOCs	Aqueous	CLP/DESA	SOM01.2	
VOCs	Soil/ slurry	CLP/DESA	SOM01.2	
VOCs	Aqueous	ETL	ETL-005	EPA 8260M
MEEA	Aqueous	ETL	ETL-010	RSKSOP-175
pH	Aqueous	ETL	ETL-002	EPA 150.1
COD	Aqueous	ETL	ETL-001	HACH 8000
ORP	Aqueous	ETL	ETL-003	SM 2580B
Fe^{2+}	Aqueous	ETL	ETL-006	HACH 8146
Chloride, sulfate, and bromide	Aqueous	ETL	ETL-009	EPA 300.0

Notes:
RSKSOP — U.S. EPA Robert S. Kerr Laboratory Standard Operating Procedure
SOM01.2 — multi-medial, multi-concentration organics analysis

CLP: contract laboratory program
COD: chemical oxidant demand
DESA: Division of Environmental Science and Assessment
EPA: United States Environmental Protection Agency
ETL: CDM Smith's Environmental Treatability Laboratory; Bellevue, WA
Fe^{2+}: ferrous iron
MEEA: methane, ethane, ethene, acetylene
ORP: oxidation reduction potential
VOCs: volatile organic compounds

Table 4-1
Analytical Results by CDM Smith Environmental Treatability Study Laboratory
Bench Scale Treatability Study
White Chemical Corporation Superfund Site, OU3
Newark, New Jersey

Days of Incubation (days)	pH (SU)	COD (mg/L)	ORP (mv)	Fe(II) (mg/L)	Sulfate (mg/L)	Chloride (mg/L)	Methane (ppmV)	Ethane (ppmV)	Ethene (ppmV)	Acetylene (ppmV)	PCE (µg/L)	TCE (µg/L)	cis-1,2-DCE (µg/L)	VC (µg/L)	1,1,2-TCA (µg/L)	1,2-DCA (µg/L)	CA (µg/L)	1,2-dibromoethane (µg/L)	1,2-dibromo-3-chloropropane (µg/L)	1-bromo-2-chloroethane (millions of GC-MS response)	1-bromo-2-chloroethane (µg/L)	Gas Production (mL)
1-A																						
Lactate and whey																						
2	6.8	4,100	190	0.1	86	510	100	ND	190	ND	390	2,300	21 J	800	4,200	81,000	ND	5,700	32 J	87	NQ	0
14	6.5	3,600	14	6.4	93	520	39	ND	250	ND	400	2,200	26 J	1,100	4,500	86,000	ND	5,500	ND	78	NQ	68
28	6.4	3,700	-150	19.0	ND	470	38	ND	250	ND	300	2,200	38 J	430	4,400	88,000	ND	5,000	21 J	260	NQ	21
42	6.3	3,700	-140	25.0	10	560	38	ND	1,200	ND	310	2,200	51 J	430	4,500	88,000	12 J	4,700	30 J	370	NQ	5.2
68	6.3	3,600	-83	31.0	0.8	1,000	51	ND	1,300	ND	280	2,800	290	520	4,100	54,000	15 J	130	ND	24	NQ	0
110	6.4	3,800	-120	23.0	ND	1,100	44	ND	63,000	ND	200	1,800	53 J	800	2,300	4,300	28 J	12 J	ND	0.68	180	0
152	6.6	4,000	-110	88.0	ND	1,100	16	ND	26,000	ND	220	2,100	98 J	2,000	790	340	27 J	10 J	ND	0.31	83 J	0
1-B																						
Lactate and whey																						
2	6.8	4,300	150	0.2	83	480	77	ND	160	ND	430	2,500	22 J	640	4,600	86,000	91 J	6,800	19 J	79	NQ	0
14	6.4	3,800	-65	12.0	86	440	63	ND	200	ND	360	2,100	24 J	1,100	4,300	75,000	ND	5,400	ND	75	NQ	75
28	6.3	4,000	-130	23.0	ND	410	52	ND	480	ND	350	2,200	43 J	520	4,400	96,000	33 J	4,100	ND	250	NQ	4.0
42	6.3	3,900	-120	40.0	11	490	59	ND	550	ND	250	2,000	63 J	480	3,900	75,000	38 J	3,200	ND	370	NQ	0
68	6.4	3,900	-110	49.0	0.8	420	54	ND	1,200	ND	270	2,800	150	430	4,300	95,000	32 J	3,100	ND	270	NQ	0
110	6.4	3,700	-110	92.0	ND	1,000	50	ND	55,000	ND	230	1,900	65 J	690	3,800	6,100	59 J	12 J	ND	1.2	320	6.0
152	6.5	4,000	-92	98.0	ND	990	28	ND	28,000	ND	210	1,900	98 J	780	3,000	4,300	58 J	20 J	ND	2.1	550	1.0
2-A																						
Lactate and whey with culture																						
2	7.0	3,900	-89	0.2	82	530	150	ND	5,700	ND	380	2,300	190	820	4,400	76,000	ND	5,900	ND	74	NQ	0
14	6.3	3,600	-120	27.0	ND	820	110	6 J	27,000	ND	300	1,300	4 J	2,500	4,600	71,000	ND	49 J	ND	1.2	NQ	60
28	6.1	3,600	-110	48.0	ND	1,100	67	10 J	63,000	ND	170	1,400	ND	230	3,100	730	ND	42 J	ND	2.4	NQ	17
42	6.1	3,600	-110	82.0	ND	1,200	77	13	64,000	ND	200	1,100	ND	210	3,200	1,500	11 J	56 J	ND	4.9	NQ	1.6
68	6.1	3,400	-85	83.0	2.8	1,100	56	9 J	53,000	ND	200	730	ND	69 J	3,600	5,500	23 J	110 J	ND	8.3	NQ	0
110	6.4	3,600	-110	77.0	0.4	1,200	200	10 J	50,000	ND	58 J	1,100	ND	21 J	3,000	160	ND	58 J	ND	0.07	18 J	0
152	6.7	3,800	-90	130.0	ND	1,200	140	5 J	29,000	ND	47 J	600	9 J	23 J	3,700	26 J	ND	ND	ND	0.25	67 J	0
2-B																						
Lactate and whey with culture																						
2	6.8	3,700	-89	0.2	83	540	140	ND	5,600	ND	390	2,300	160	750	4,300	75,000	ND	5,700	ND	73	NQ	0
14	6.3	3,700	-120	73.0	ND	760	110	10 J	21,000	ND	260	1,300	10 J	4,700	4,200	70,000	ND	15 J	ND	0.83	NQ	68
28	6.2	3,600	-110	43.0	ND	950	57	10 J	49,000	ND	210	1,400	ND	190	4,400	39,000	ND	ND	ND	0.18	NQ 0	18
42	6.1	3,600	-110	75.0	ND	1,100	55	9 J	61,000	ND	200	1,100	ND	63 J	4,100	22,000	ND	6 J	ND	0.54	NQ 0	2.2
68	6.2	3,400	-92	110.0	3.3	1,000	72	8 J	60,000	ND	190	740	ND	36 J	4,500	13,000	ND	ND	ND	0.23	NQ 0	0
110	6.5	3,500	-110	110.0	0.1	1,100	88	12 J	59,000	ND	82 J	1,100	ND	14 J	3,900	560	ND	ND	ND	ND	ND	0
152	6.5	3,800	-97	140.0	ND	1,100	48	5 J	32,000	ND	74 J	550	6 J	14 J	5,000	62 J	ND	ND	ND	0.23	61 J	0
3-A																						
EOS																						
2	7.0	860	190	ND	80	270	95	ND	14	ND	57 J	990	15 J	570	2,700	74,000	ND	4,000	180	61	NQ	0
14	7.2	820	-130	1.7	93	340	97	ND	25	ND	51 J	740	9 J	730	2,600	73,000	ND	3,700	ND	58	NQ	0
28	6.7	900	-120	7.8	68	260	77	ND	44	ND	44 J	700	6 J	390	2,500	78,000	ND	3,500	ND	190	NQ	0
42	6.2	1,200	-76	26.0	4.2	280	84	ND	60	ND	57 J	1,000	23 J	410	2,900	74,000	ND	4,100	ND	360	NQ	4.4
68	6.0	1,500	-39	36.0	6.2	260	84	8 J	96	ND	92 J	2,200	40 J	350	3,600	92,000	ND	4,900	ND	260	NQ	5.5
110	6.2	1,800	-71	82.0	6.0	250	78	7 J	120	ND	180	2,100	27 J	340	4,800	98,000	ND	6,000	ND	310	83,000	6.0
152	6.1	2,000	-49	110.0	5.5	270	55	ND	83	ND	310	2,900	41 J	530	7,000	95,000	ND	8,700	ND	370	98,000	1.0
3-B																						
EOS																						
2	7.2	820	190	ND	80	270	ND	ND	ND	ND	32 J	540	ND	170	2,100	70,000	ND	3,100	ND	47	NQ	0
14	7.4	890	-120	1.2	82	510	14	ND	12 J	ND	44 J	540	ND	270	2,100	59,000	ND	3,000	ND	46	NQ	0
28	6.9	800	-130	4.7	ND	270 J	9 J	ND	26	ND	36 J	510	ND	160	2,000	61,000	ND	2,900	ND	160	NQ	0
42	6.8	870	-120	6.1	ND	280	ND	ND	62	ND	44 J	690	15 J	180	2,300	69,000	12 J	3,300	ND	350	NQ	1.7
68	6.8	820	-100	11.0	1.3	260 J	12 J	ND	110	ND	48 J	1,600	16 J	170	2,500	84,000	13 J	3,400	ND	220	NQ	0
110	6.4	1,800	-84	58.0	ND	250 J	10 J	ND	200	ND	69 J	900	25 J	150	3,300	89,000	170	3,500	ND	280	73,000	9.9
152	6.1	2,700	-48	100.0	5.4	270 J	8 J	ND	130	ND	130	1,700	44 J	190	4,000	84,000	9 J	4,600	ND	310	81,000	12

Table 4-1
Analytical Results by CDM Smith Environmental Treatability Study Laboratory
Bench Scale Treatability Study
White Chemical Corporation Superfund Site, OU3
Newark, New Jersey

Days of Incubation (days)	pH (SU)	COD (mg/L)	ORP (mv)	Fe(II) (mg/L)	Sulfate (mg/L)	Chloride (mg/L)	Methane (ppmV)	Ethane (ppmV)	Ethene (ppmV)	Acetylene (ppmV)	PCE (µg/L)	TCE (µg/L)	cis-1,2-DCE (µg/L)	VC (µg/L)	1,1,2-TCA (µg/L)	1,2-DCA (µg/L)	CA (µg/L)	1,2-dibromoethane (µg/L)	1,2-dibromo-3-chloropropane (µg/L)	1-bromo-2-chloroethane (millions of GC-MS response)	1-bromo-2-chloroethane (µg/L)	Gas Production (mL)
3-D																						
EOS																						
2	7.3	720	-54	ND	93	220	140	ND	16	ND	41 J	680	11 J	600	2,100	68,000	ND	3,000	13 J	52	NQ	0
14	7.3	830	140	0.5	81	250	95	ND	20	ND	30 J	580	7 J	740	1,800	59,000	ND	2,700	ND	44	NQ	0
28	6.8	780	-120	7.2	58	220	100	ND	37	ND	38 J	630	5 J	420	2,000	62,000	ND	2,900	ND	160	NQ	0
42	6.7	820	-140	9.1	1.1	300	86	ND	52	ND	39 J	780	19 J	430	2,100	68,000	72 J	3,100	ND	340	NQ	1.1
68	6.6	880	-85	20.0	1.3	230	95	6 J	81	ND	43 J	1,700	19 J	400	2,300	84,000	90 J	3,300	ND	210	NQ	0.5
110	6.6	1,100	-98	42.0	ND	220	86	5 J	130	ND	48 J	860	18 J	430	2,400	85,000	130	3,000	ND	240	62,000	4.0
152	6.3	1,500	-72	67.0	ND	240	47	4 J	100	ND	54 J	1,700	24 J	490	2,500	80,000	26 J	3,600	ND	280	73,000	0
4-A																						
EOS with culture																						
2	7.0	920	-120	ND	80	330	190	ND	570	ND	38 J	720	28 J	540	2,500	72,000	ND	3,500	ND	56	NQ	0
14	7.0	840	-120	6.3	ND	350	180	ND	880	ND	38 J	640	63 J	840	2,300	72,000	ND	3,000	ND	52	NQ	8.0
28	6.7	880	-100	12.0	ND	320	170	ND	900	ND	45 J	690	77 J	440	2,400	77,000	ND	2,800	ND	170	NQ	0
42	6.5	880	-120	17.0	ND	360	160	ND	940	ND	47 J	800	120 J	420	2,300	73,000	47 J	2,900	ND	350	NQ	1.5
68	6.4	1,100	-60	28.0	1.3	330	160	6 J	890	ND	65 J	1,900	110 J	410	2,900	88,000	120 J	3,500	460	230	NQ	1.0
110	6.5	1,200	-89	42.0	ND	320	140	5 J	850	ND	63 J	960	110 J	410	2,700	89,000	100 J	2,900	ND	250	67,000	2.0
152	6.3	1,600	-62	71.0	ND	350	91	ND	540	ND	75 J	1,400	110 J	490	3,300	86,000	9 J	3,800	ND	280	73,000	2.0
4-B																						
EOS with culture																						
2	7.0	980	-170	ND	80	320	220	ND	490	ND	35 J	680	24 J	530	2,400	72,000	ND	3,200	ND	54	NQ	0
14	7.0	910	-120	5.8	ND	380	180	ND	590	ND	37 J	640	57 J	840	2,400	72,000	ND	3,200	ND	53	NQ	5.0
28	6.6	880	-100	11.0	ND	310	190	ND	630	ND	42 J	670	70 J	390	2,300	77,000	ND	2,800	ND	170	NQ	0
42	6.5	910	-120	16.0	ND	340	160	ND	600	ND	48 J	830	110 J	390	2,500	73,000	40 J	3,200	ND	350	NQ	1.3
68	6.4	1,000	-65	25.0	1.4	310	160	ND	600	ND	52 J	1,900	96 J	370	2,600	87,000	140	3,100	ND	220	NQ	1.0
110	6.6	1,300	-84	47.0	ND	320	130	6 J	740	ND	60 J	870	97 J	330	2,900	91,000	310	3,400	ND	270	70,000	3.4
152	6.3	1,600	-54	86.0	ND	340	78	3 J	530	ND	83 J	1,400	100 J	370	3,700	86,000	78 J	4,500	ND	270	72,000	3.0
5-A																						
EHC																						
2	6.8	590	160	1.0	100	280	63	24	940	ND	290	2,000	27 J	690	3,900	73,000	ND	4,800	ND	70	NQ	0
14	6.6	1,400	-120	28.0	ND	360	100	250	4,200	ND	300	2,000	62 J	1,400	4,100	76,000	98 J	1,700	ND	58	NQ	8.0
28	6.5	1,600	-110	55.0	ND	350	110	260	14,000	ND	300	1,900	85 J	790	3,600	92,000	140	780	ND	140	NQ	0
42	6.3	1,500	-130	59.0	ND	700	84	220	43,000	ND	270	2,000	130	1,400	2,300	49,000	110 J	63 J	ND	70	NQ	4.9
68	6.4	1,500	-68	78.0	2.4	900	75	230	67,000	ND	84 J	2,800	220	2,100	81 J	2,700	120 J	110 J	ND	5.4	NQ	2.0
110	6.4	1,500	-130	110.0	ND	900	1,000	230	62,000	ND	64 J	1,400	220	2,200	130	4,500	220	150	ND	8.7	2,300	0
152	6.4	1,400	-120	200.0	ND	950	6,200	140	32,000	ND	51 J	1,300	250	2,700	270	66 J	180	ND	ND	0.26	68 J	0
5-B																						
EHC																						
2	6.8	520	170	0.4	100	280	84	28	1,000	ND	300	2,200	28 J	1,200	4,100	74,000	ND	5,100	ND	72	NQ	0
14	6.7	1,200	-120	21.0	ND	300	100	230	3,600	ND	310	2,100	59 J	1,300	4,200	76,000	72 J	2,200	ND	63	NQ	5.0
28	6.4	1,300	-110	46.0	ND	430	120	220	24,000	ND	300	1,900	76 J	2,800	51 J	90,000	81 J	40 J	140	9.9	NQ	0
42	6.2	1,300	-120	59.0	ND	970	83	220	79,000	ND	5 J	960	2100	2,500	21 J	1,000	83 J	ND	ND	0.84	NQ	5.7
68	6.4	1,100	-100	59.0	2.5	910	82	190	69,000	ND	ND	1,300	2100	2,300	ND	110 J	65 J	ND	ND	0.22	NQ J	0
110	6.6	1,100	-130	130.0	ND	900	2,700	180	63,000	ND	ND	880	1700	2,300	ND	88 J	130	8 J	ND	0.26	70 J	0
152	6.5	1,400	-110	140.0	ND	920	19,000	160	31,000	ND	6 J	490	1800	2,900	ND	76 J	140	ND	ND	0.28	75 J	0
6-A																						
EHC with culture																						
2	6.7	760	-150	0.8	96	330	150	27	5,800	ND	250	1,700	210	1,400	4,100	74,000	ND	4,200	ND	69	NQ	0
14	6.6	1,200	-120	23.0	ND	450	160	48	22,000	ND	200	230	64 J	3,000	4,200	73,000	ND	90 J	ND	9.9	NQ	0
28	6.3	1,400	-100	50.0	ND	690	160	61	53,000	ND	180	1,100	ND	84 J	3,200	54,000	ND	ND	ND	0.36	NQ J	3.0
42	6.2	1,400	-120	62.0	ND	1,000	110	75	81,000	ND	59 J	910	ND	81 J	24 J	140	13 J	ND	ND	0.15	NQ J	6.5
68	6.4	1,400	-96	93.0	2.9	950	5,000	110	76,000	ND	ND	1,300	350	ND	ND	36 J	ND	ND	ND	0.10	NQ J	0
110	6.8	600	-140	93.0	ND	1,100	300,000	ND	44,000	ND	7 J	180	ND	ND	ND	67 J	21 J	ND	ND	0.05	14 J	48
152	6.9	440	-130	120.0	ND	1,100	220,000	ND	19,000	ND	4 J	460	18 J	ND	ND	71 J	23 J	ND	ND	0.28	73 J	28

Table 4-1
Analytical Results by CDM Smith Environmental Treatability Study Laboratory
Bench Scale Treatability Study
White Chemical Corporation Superfund Site, OU3
Newark, New Jersey

Days of Incubation (days)	pH (SU)	COD (mg/L)	ORP (mv)	Fe(II) (mg/L)	Sulfate (mg/L)	Chloride (mg/L)	Methane (ppmV)	Ethane (ppmV)	Ethene (ppmV)	Acetylene (ppmV)	PCE (µg/L)	TCE (µg/L)	cis-1,2-DCE (µg/L)	VC (µg/L)	1,1,2-TCA (µg/L)	1,2-DCA (µg/L)	CA (µg/L)	1,2-dibromoethane (µg/L)	1,2-dibromo-3-chloropropane (µg/L)	1-bromo-2-chloroethane (millions of GC-MS response)	1-bromo-2-chloroethane (µg/L)	Gas Production (mL)
6-B																						
EHC with culture																						
2	6.8	610	-160	0.5	99	350	170	14	4,900	ND	350	2,400	270	1,300	4,800	86,000	ND	5,100	ND	79	NQ	0
14	6.6	1,300	-110	25.0	ND	520	170	43	26,000	ND	250	130	35 J	2,300	4,200	73,000	ND	32 J	ND	4.7	NQ	2.0
28	6.2	1,400	-87	60.0	ND	910	130	46	71,000	ND	220	1,200	ND	150	2,800	43,000	ND	ND	ND	0.06	NQ J	7.0
42	6.1	1,500	-120	70.0	ND	1,100	120	76	88,000	ND	100 J	210	ND	49 J	3 J	24 J	10 J	5 J	ND	0.04	NQ J	5.2
68	6.2	1,500	-85	100.0	3.4	1,000	8,800	120	79,000	ND	75 J	380	150	7 J	ND	50 J	ND	ND	ND	0.03	NQ J	0.5
110	6.7	770	-130	140.0	ND	1,200	300,000	ND	50,000	ND	6 J	210	ND	ND	ND	75 J	29 J	ND	ND	0.03	8 J	47
152	6.8	640	-120	150.0	ND	1,200	250,000	ND	22,000	ND	ND	460	17 J	ND	ND	72 J	36 J	ND	ND	0.27	70 J	32
7-A																						
Culture-only control																						
2	7.5	270	-160	ND	82	340	160	ND	120	ND	400	2,400	20 J	510	4,200	74,000	ND	6,100	ND	74	NQ	0
14	7.6	210	-160	0.1	68	360	140	ND	190	ND	360	2,000	28 J	1,900	4,600	75,000	ND	6,500	ND	77	NQ	0
28	7.3	180	-170	0.3	53	330	160	ND	300	ND	310	1,800	34 J	1,000	4,200	81,000	ND	5,900	ND	240	NQ	0
42	7.3	190	-180	0.4	59	360	130	ND	310	ND	270	2,200	62 J	1,300	3,700	74,000	ND	5,200	20 J	380	NQ	0
68	7.6	190	-160	0.5	56	340	120	ND	340	ND	260	2,400	110 J	790	3,800	90,000	ND	5,100	ND	260	NQ	0
110	7.6	180	-170	0.5	55	350	130	ND	390	ND	220	1,900	71 J	950	3,700	90,000	ND	4,500	ND	280	75,000	0
152	7.7	210	-150	0.7	55	370	87	ND	360	ND	230	2,500	91 J	840	4,100	86,000	ND	4,500	ND	320	85,000	0
7-B																						
Culture-only control																						
2	7.6	380	-140	ND	83	340	190	ND	120	ND	450	2,800	36 J	590	4,600	85,000	ND	6,500	ND	81	NQ	0
14	7.6	220	-170	0.1	66	380	160	ND	230	ND	460	2,600	32 J	2,100	5,300	86,000	ND	7,700	ND	88	NQ	0
28	7.4	250	-160	0.4	58	370	180	ND	370	ND	340	2,400	41 J	450	4,500	98,000	ND	6,100	ND	260	NQ	0
42	7.3	190	-170	0.5	63	370	130	ND	440	ND	360	2,800	81 J	1,500	4,600	90,000	55 J	6,400	ND	370	NQ	0
68	7.6	180	-150	0.9	60	350	140	ND	530	ND	350	3,000	120 J	790	5,200	100,000	91 J	6,800	ND	310	NQ	0
110	7.3	160	-160	0.7	60	380	150	ND	1,600	ND	300	2,500	100 J	720	4,900	100,000	340	5,400	ND	330	87,000	0
152	7.8	220	-150	1.3	58	400	86	ND	1,200	ND	290	2,300	110 J	670	5,700	98,000	26 J	6,400	ND	370	97,000	0
8-A																						
Control																						
2	7.6	300	-140	ND	84	270	98	ND	23	ND	450	2,700	21 J	600	4,300	75,000	ND	6,300	ND	76	NQ	0
14	7.6	140	150	ND	80	320	95	ND	20	ND	420	2,500	26 J	2,200	4,800	85,000	ND	7,000	ND	83	NQ	0
28	7.5	210	150	ND	87	270	75	ND	24	ND	290	2,200	14 J	320	4,000	87,000	ND	5,900	ND	250	NQ	0
42	7.5	170	-140	ND	92	300	72	ND	35	ND	340	2,700	40 J	1,400	4,300	88,000	12 J	6,400	ND	370	NQ	0
68	7.6	130	-130	0.1	89	300	78	ND	40	ND	300	2,900	130	1,000	4,600	99,000	140	6,600	ND	290	NQ	0
110	7.7	150	-130	ND	90	290	79	ND	43	ND	270	2,300	22 J	320	4,200	95,000	260	5,800	ND	320	83,000	0
152	7.8	200	-140	0.1	92	320	54	ND	38	ND	270	2,200	44 J	510	4,700	91,000	80 J	6,500	ND	340	90,000	0
8-B																						
Control																						
2	7.6	220	-130	ND	86	290	85	ND	14	ND	370	2,400	21 J	410	4,400	84,000	ND	6,500	ND	77	NQ	0
14	7.6	180	150	ND	82	310	91	ND	19	ND	440	2,700	23 J	1,100	5,400	88,000	ND	8,000	ND	92	NQ	0
28	7.3	230	130	ND	100	360	76	ND	25	ND	370	2,800	17 J	420	4,900	100,000	ND	7,200	ND	280	NQ	0
42	7.5	200	-120	ND	94	310	84	ND	37	ND	310	2,600	41 J	660	4,600	100,000	14 J	6,900	ND	370	NQ	0
68	7.6	200	-110	ND	91	300	84	7 J	45	ND	330	3,100	64 J	480	5,300	100,000	110 J	7,800	ND	320	NQ	0
110	7.8	170	-130	ND	92	310	85	7 J	60	ND	280	2,500	26 J	350	4,400	96,000	220	6,100	ND	320	85,000	0
152	7.9	210	-120	ND	93	340	65	6 J	48	ND	220	1,900	37 J	470	5,000	91,000	110 J	7,100	ND	360	94,000	0

Notes:

COD: chemical oxidant demand
1,2-DCA: 1,2-dichloroethane
ppmv: parts per million in volume

Fe(II): ferrous iron
cis-1,2-DCE: cis-1,2-dichloroethene
mg/L: milligram per liter

MEEA: methai MEEA: methane, ethane, ethene, acetylene
CA: chloroeth CA: chloroethane
mv: millivolt mv: millivolt

ORP: oxidation reduction potential
1,1,2-TCA: 1,1,2-trichloroethane
J: estimated value

VOC: volatile organic compound
TCE: trichloroethene
ND: non-detect

µg/L: microgram per liter
PCE: tetrachloroethene
NQ: not quantified

mL: milliliter
VC: vinyl chloride
0: no gas generation

Table 4-2
VOC Removal and Generation
Bench Scale Treatability Study
White Chemical Corporation Superfund Site, OU3
Newark, New Jersey

Test Condition	Replicate	Percent Removal								
		PCE	TCE	cis-1,2-DCE	VC	1,1,2-TCA	1,2-DCA	CA	1,2-dibromoethane	1-bromo-2-chloroethane
Lactate + Whey	1A	13%	-2%	-150%	-310%	84%	>99%	71%	>99%	>99%
	1B	17%	7%	-150%	-58%	38%	95%	39%	>99%	99%
Lactate + Whey + Culture	2A	81%	71%	79%	95%	24%	>99%	>99%	>99%	>99%
	2B	70%	73%	86%	97%	-3%	>99%	>99%	>99%	>99%
EOS	3A	-25%	-40%	-2%	-7%	-45%	-5%	>99%	-28%	-6%
	3B	47%	20%	-10%	62%	18%	8%	90%	32%	12%
	3D	78%	18%	40%	1%	49%	12%	73%	47%	21%
EOS + Culture	4A	70%	33%	-160%	1%	31%	5%	91%	44%	21%
	4B	67%	30%	-160%	25%	24%	6%	17%	34%	22%
EHC	5A	80%	35%	-530%	-440%	94%	>99%	-91%	>99%	>99%
	5B	98%	76%	-4400%	-480%	>99%	>99%	-47%	>99%	>99%
EHC + Culture	6A	98%	78%	56%	>99%	>99%	>99%	76%	>99%	>99%
	6B	>99%	78%	58%	>99%	>99%	>99%	62%	>99%	>99%
Culture-only Control	7A	8%	-20%	-130%	-71%	15%	5%	>99%	33%	8%
	7B	-18%	-10%	-170%	-35%	-18%	-8%	72%	6%	-5%

Notes:
Contaminant removal higher than 50 percent is shown in red.
Negative values (shown in blue) may indicate a net production of the compound.
1,2-DCA: 1,2-dichloroethane
1,1,2-TCA: 1,1,2-trichloroethane
VC: vinyl chloride
cis-1,2-DCE: cis-1,2-dichloroethene
TCE: trichloroethene
CA: chloroethane
PCE: tetrachloroethene

Table 4-3
VOC Removal Using Off-Site Data
Bench Scale Treatability Study
White Chemical Corporation Superfund Site, OU3
Newark, New Jersey

Laboratory	Baseline		Final - Lactate/whey (1-C)			Final Lactate/whey + culture (2-C)			Final EOS (3-C)			Final EOS + culture (4-C)		
			DESA		Removal	DESA		Removal	DESA		Removal	DESA		Removal
PCE (µg/L)	320		140		56%	28		91%	500	U	NA	500	U	NA
TCE (µg/L)	2,200		1,300		41%	5	U	100%	990		55%	550		75%
1,1,2-TCA (µg/L)	3,200		2,400		25%	2,500		22%	3,000		6%	2,100		34%
1,2-DCA (µg/L)	160,000	J	330		100%	19		100%	200,000		-25%	150,000		6%
1,2-dibromoethane (µg/L)	5,000		5	U	100%	5	U	100%	4,100		18%	2,400		52%

Notes:
DESA: Division of Environmental Science and Assessment
1,2-DCA: 1,2-dichloroethane
1,1,2-TCA: 1,1,2-trichloroethane
TCE: trichloroethene
PCE: tetrachloroethene
Contaminant removal higher than 50 percent is shown in red.
Negative values (shown in blue) may indicate a net production of the compound.

J: estimated value
U: non-detect
UJ: estimated but non-detected value
NA: not applicable
µg/L: microgram per liter
%: percent

Table 4-3
VOC Removal Using Off-Site Data
Bench Scale Treatability Study
White Chemical Corporation Superfund Site, OU3
Newark, New Jersey

Laboratory	Final EHC (5-C)			Final EHC + culture (6-C)			Final Culture-only control (7-C)			Final Negative control (8-C)		
	DESA		Removal	DESA		Removal	DESA		Removal	DESA		Removal
PCE (µg/L)	8		98%	5	U	98%	500	U	NA	500	UJ	NA
TCE (µg/L)	160		93%	5	U	100%	790		64%	500	UJ	NA
1,1,2-TCA (µg/L)	5	U	100%	5	U	100%	2,000		38%	2,100	J	34%
1,2-DCA (µg/L)	180		100%	33		100%	130,000		19%	120,000	J	25%
1,2-dibromoethane (µg/L)	7		100%	5	U	100%	2,400		52%	3,200	J	36%

Notes:
DESA: Division of Environmental Science and Assessment
1,2-DCA: 1,2-dichloroethane
1,1,2-TCA: 1,1,2-trichloroethane
TCE: trichloroethene
PCE: tetrachloroethene
Contaminant removal higher than 50 percent is shown in red.
Negative values (shown in blue) may indicate a net production of the compound.

J: estimated value
U: non-detect
UJ: estimated but non-detected value
NA: not applicable
µg/L: microgram per liter
%: percent

Table 4-4
Mass Balance of chloride and Bromide
Bench Scale Treatability Study
White Chemical Corporation Superfund Site, OU3
Newark, New Jersey

Test ID	Description	1-bromo-2-chloroethane concentration (µg/L)	1-bromo-2-chloroethane content (µmol)	1-bromo-2-chloroethane removal (µmol)	Predicted chloride and bromide from 1-bromo-2-chloroethane degradation (µmol)	1,2-DCA content (µmol)	1,2-DCA removal (µmol)
1-A	Lactate + Whey, No Culture	8.3E+01	9.3E-02	1.0E+02	1.0E+02	5.8E-01	1.5E+02
1-B	Lactate + Whey, No Culture	5.5E+02	6.2E-01	1.0E+02	1.0E+02	7.2E+00	1.5E+02
2-A	Lactate + Whey + Culture	6.7E+01	7.5E-02	1.0E+02	1.0E+02	4.3E-02	1.5E+02
2-B	Lactate + Whey + Culture	6.1E+01	6.9E-02	1.0E+02	1.0E+02	1.0E-01	1.5E+02
3-A	EOS598, No Culture	9.8E+04	1.1E+02	-6.7E+00	-6.7E+00	1.6E+02	-7.2E+00
3-B	EOS598, No Culture	8.1E+04	9.2E+01	1.2E+01	1.2E+01	1.4E+02	1.2E+01
3-D	EOS59, No Culture	7.3E+04	8.2E+01	2.2E+01	2.2E+01	1.4E+02	1.9E+01
4-A	EOS598 + Culture	7.3E+04	8.2E+01	2.1E+01	2.1E+01	1.5E+02	8.4E+00
4-B	EOS598 + Culture	7.2E+04	8.1E+01	2.3E+01	2.3E+01	1.5E+02	9.0E+00
5-A	EHC®, no Culture	6.8E+01	7.7E-02	1.0E+02	1.0E+02	1.1E-01	1.5E+02
5-B	EHC®, no Culture	7.5E+01	8.4E-02	1.0E+02	1.0E+02	1.3E-01	1.5E+02
6-A	EHC® + Culture	7.3E+01	8.2E-02	1.0E+02	1.0E+02	1.2E-01	1.5E+02
6-B	EHC® + Culture	7.0E+01	7.9E-02	1.0E+02	1.0E+02	1.2E-01	1.5E+02
7-A	Culture-only Control	8.5E+04	9.6E+01	8.1E+00	8.1E+00	1.5E+02	8.3E+00
7-B	Culture-only Control	9.7E+04	1.1E+02	-5.3E+00	-5.3E+00	1.7E+02	-1.2E+01
8-A	Negative Control	9.0E+04	1.0E+02			1.5E+02	
8-B	Negative Control	9.4E+04	1.1E+02			1.5E+02	

Notes:
1,2-DCA - 1,2-dichloroethane
µmol: micro-mole
NQ: not quantified

Table 4-4
Mass Balance of chloride and Bromide
Bench Scale Treatability Study
White Chemical Corporation Superfund Site, OU3
Newark, New Jersey

Test ID	Description	Predicted chloride from 1,2-DCA degradation (µmol)	Total predicted chloride from VOCs removal (µmol)	Final chloride content (µmoL)	Observed chloride production (µmol)	Final bromide content (µmol)	Observed bromide production (µmol)	Chloride percent recovery	Bromide percent recovery
1-A	Lactate + Whey, No Culture	3.1E+02	4.1E+02	1.1E+03	5.7E+02	1.0E+02	4.5E+01	140%	43%
1-B	Lactate + Whey, No Culture	2.9E+02	4.0E+02	9.9E+02	5.0E+02	9.8E+01	3.9E+01	130%	38%
2-A	Lactate + Whey + Culture	3.1E+02	4.1E+02	1.2E+03	7.0E+02	1.1E+02	5.1E+01	170%	49%
2-B	Lactate + Whey + Culture	3.1E+02	4.1E+02	1.1E+03	5.9E+02	1.1E+02	5.1E+01	140%	49%
3-A	EOS598, No Culture	-1.4E+01	-2.1E+01	2.7E+02	3.7E+00	5.6E+01	-2.8E+00	-17%	41%
3-B	EOS598, No Culture	2.3E+01	3.6E+01	2.7E+02	8.8E+00	5.4E+01	-4.7E+00	25%	-38%
3-D	EOS59, No Culture	3.8E+01	6.0E+01	2.4E+02	1.9E+01	4.4E+01	-1.4E+01	32%	-64%
4-A	EOS598 + Culture	1.7E+01	3.8E+01	3.5E+02	1.9E+01	6.1E+01	3.0E+00	50%	14%
4-B	EOS598 + Culture	1.8E+01	4.1E+01	3.4E+02	1.5E+01	6.0E+01	2.0E+00	35%	9%
5-A	EHC®, no Culture	3.1E+02	4.1E+02	9.5E+02	6.7E+02	1.3E+02	6.9E+01	160%	67%
5-B	EHC®, no Culture	3.1E+02	4.1E+02	9.2E+02	6.4E+02	1.2E+02	6.5E+01	160%	62%
6-A	EHC® + Culture	3.1E+02	4.1E+02	1.1E+03	7.9E+02	1.1E+02	5.6E+01	190%	54%
6-B	EHC® + Culture	3.1E+02	4.1E+02	1.2E+03	8.3E+02	1.3E+02	7.0E+01	200%	67%
7-A	Culture-only Control	1.7E+01	2.5E+01	3.7E+02	3.7E+01	5.9E+01	9.9E-01	150%	12%
7-B	Culture-only Control	-2.4E+01	-3.0E+01	4.0E+02	5.8E+01	6.6E+01	7.9E+00	-200%	-150%
8-A	Negative Control			3.2E+02		5.7E+01			
8-B	Negative Control			3.4E+02		6.0E+01			

Notes:
1,2-DCA - 1,2-dichloroethane
µmol: micro-mole
NQ: not quantified

Table 4-5
Baseline Groundwater VOC Concentrations
Bench Scale Treatability Study
White Chemical Corporation Superfund Site, OU3
Newark, New Jersey

Compound	ETL Average (µg/L)	ETL Range * (µg/L)	CLP (µg/L)
Tetrachloroethene	600	500 - 770	320
Trichloroethene	3,400	3,000 - 4,100	2,200
cis-1,2-Dichloroethene	17	14 - 22	22 J
Vinyl Chloride	940	910 - 1,000	440
1,1,2-Trichloroethane	4,100	3,600 - 5,200	3,200
1,2-Dichloroethane	82,000	78,000 - 94,000	160,000 J
Chloroethane	5	ND - 23	5 U
1,2-dibromoethane	6,100	5,400 - 7,700	5,000
1,2-dibromo-3-chloropropane	ND	ND - ND	11
1-bromo-2-chloroethane **	76,000	70,000 - 84,000	NA

Notes:
* Except for 1-bromo-2-chloroethane, these data are from analysis of five separate bottles of groundwater, sampled and analyzed at the Environmental Treatability Laboratory (ETL) on July 12, 2011
** The 1-bromo-2-chloroethane data are from triplicate samples analyzed on 31 October 2011. The triplicate samples were collected from three groundwater bottles stored at 4 degree Celsius since July 2011.

J: estimated value U: non-detect µg/L: microgram per liter
ND: non-detect by ETL

Table 4-6
Final Groundwater VOC Data by Both ETL and DESA Laboratories
Bench Scale Treatability Study
White Chemical Corporation Superfund Site, OU3
Newark, New Jersey

Laboratory	ETL			DESA	ETL			DESA
Sample Run	1-A	1-B	1-C	1-C	2-A	2-B	2-C	2-C
Chemical Name								
PCE (µg/L)	220	210	280	140	47	74	64	28
TCE (µg/L)	2,100	1,900	2,200	1,300	600	550	610	5 U
cis-1,2-DCE (µg/L)	98	98	67	5 U	9	6	6	5 U
VC (µg/L)	2,000	780	1,500	520	23	14	30	12
1,1,2-TCA (µg/L)	790	3,000	3,300	2,400	3,700	5,000	4,600	2,500
1,2-DCA (µg/L)	340	4,300	440	330	26	62	27	19
CA (µg/L)	27	58	41	10	ND	ND	ND	5 U
1,2-dibromoethane (µg/L)	10	20	ND	5 U	ND	ND	ND	5 U
1,2-dibromo-3-chloropropane (µg/L)	ND	ND	ND	ND	ND	ND	ND	ND
1-bromo-2-chloroethane (µg/L)	83	550	89	NA	67	61	72	NA

Note:
ETL: Environmental Treatability Laboratory
DESA: Division of Environmental Science and Assessment
J: estimated value
U: non-detect
UJ: estimated but non-detected value
ND: non-detect
NA: not analyze
µg/L: microgram per liter

PCE: tetrachloroethene
TCE: trichloroethene
cis-1,2-DCE: cis-1,2-dichloroethene
VC: vinyl chloride
1,1,2-TCA: 1,1,2-trichloroethane
1,2-DCA: 1,2-dichloroethane
CA: chloroethane

Table 4-6
Final Groundwater VOC Data by Both ETL and DESA Laboratories
Bench Scale Treatability Study
White Chemical Corporation Superfund Site, OU3
Newark, New Jersey

Laboratory	ETL				DESA	ETL			DESA
Sample Run	3-A	3-B	3-D	3-C	3-C	4-A	4-B	4-C	4-C
Chemical Name									
PCE (µg/L)	310	130	54	150	500 U	75	83	48	500 U
TCE (µg/L)	2,900	1,700	1,700	1,900	990	1,400	1,400	1,100	550
cis-1,2-DCE (µg/L)	41	44	24	31	500 U	110	100	85	500 U
VC (µg/L)	530	190	490	560	500 U	490	370	290	500 U
1,1,2-TCA (µg/L)	7,000	4,000	2,500	4,100	3,000	3,300	3,700	2,000	2,100
1,2-DCA (µg/L)	95,000	84,000	80,000	89,000	200,000	86,000	86,000	77,000	150,000
CA (µg/L)	ND	9	26	21	500 U	9	78	16	500 U
1,2-dibromoethane (µg/L)	8,700	4,600	3,600	5,100	4,100	3,800	4,500	2,200	2,400
1,2-dibromo-3-chloropropane (µg/L)	ND	ND	ND	ND	500 U	ND	ND	ND	500 U
1-bromo-2-chloroethane (µg/L)	98,000	81,000	73,000	85,000	NA	73,000	72,000	54,000	NA

Note:
ETL: Environmental Treatability Laboratory
DESA: Division of Environmental Science and Assessment
J: estimated value
U: non-detect
UJ: estimated but non-detected value
ND: non-detect
NA: not analyze
µg/L: microgram per liter

PCE: tetrachloroethene
TCE: trichloroethene
cis-1,2-DCE: cis-1,2-dichloroethene
VC: vinyl chloride
1,1,2-TCA: 1,1,2-trichloroethane
1,2-DCA: 1,2-dichloroethane
CA: chloroethane

Table 4-6
Final Groundwater VOC Data by Both ETL and DESA Laboratories
Bench Scale Treatability Study
White Chemical Corporation Superfund Site, OU3
Newark, New Jersey

Laboratory	ETL			DESA	ETL			DESA
Sample Run	5-A	5-B	5-C	5-C	6-A	6-B	6-C	6-C
Chemical Name								
PCE (µg/L)	51	6	16	8	4	ND	ND	5 U
TCE (µg/L)	1,300	490	640	160	460	460	460	5 U
cis-1,2-DCE (µg/L)	250	1,800	620	430	18	17	16	5 U
VC (µg/L)	2,700	2,900	2,200	650	ND	ND	ND	5 U
1,1,2-TCA (µg/L)	270	ND	ND	5 U	ND	ND	ND	5 U
1,2-DCA (µg/L)	66	76	65	180	71	72	67	33
CA (µg/L)	180	140	100	26	23	36	29	6
1,2-dibromoethane (µg/L)	ND	ND	ND	7	ND	ND	ND	5 U
1,2-dibromo-3-chloropropane (µg/L)	ND	ND	ND	5 U	ND	ND	ND	5 U
1-bromo-2-chloroethane (µg/L)	68	75	67	NA	73	70	71	NA

Note:
ETL: Environmental Treatability Laboratory
DESA: Division of Environmental Science and Assessment
J: estimated value
U: non-detect
UJ: estimated but non-detected value
ND: non-detect
NA: not analyze
µg/L: microgram per liter

PCE: tetrachloroethene
TCE: trichloroethene
cis-1,2-DCE: cis-1,2-dichloroethene
VC: vinyl chloride
1,1,2-TCA: 1,1,2-trichloroethane
1,2-DCA: 1,2-dichloroethane
CA: chloroethane

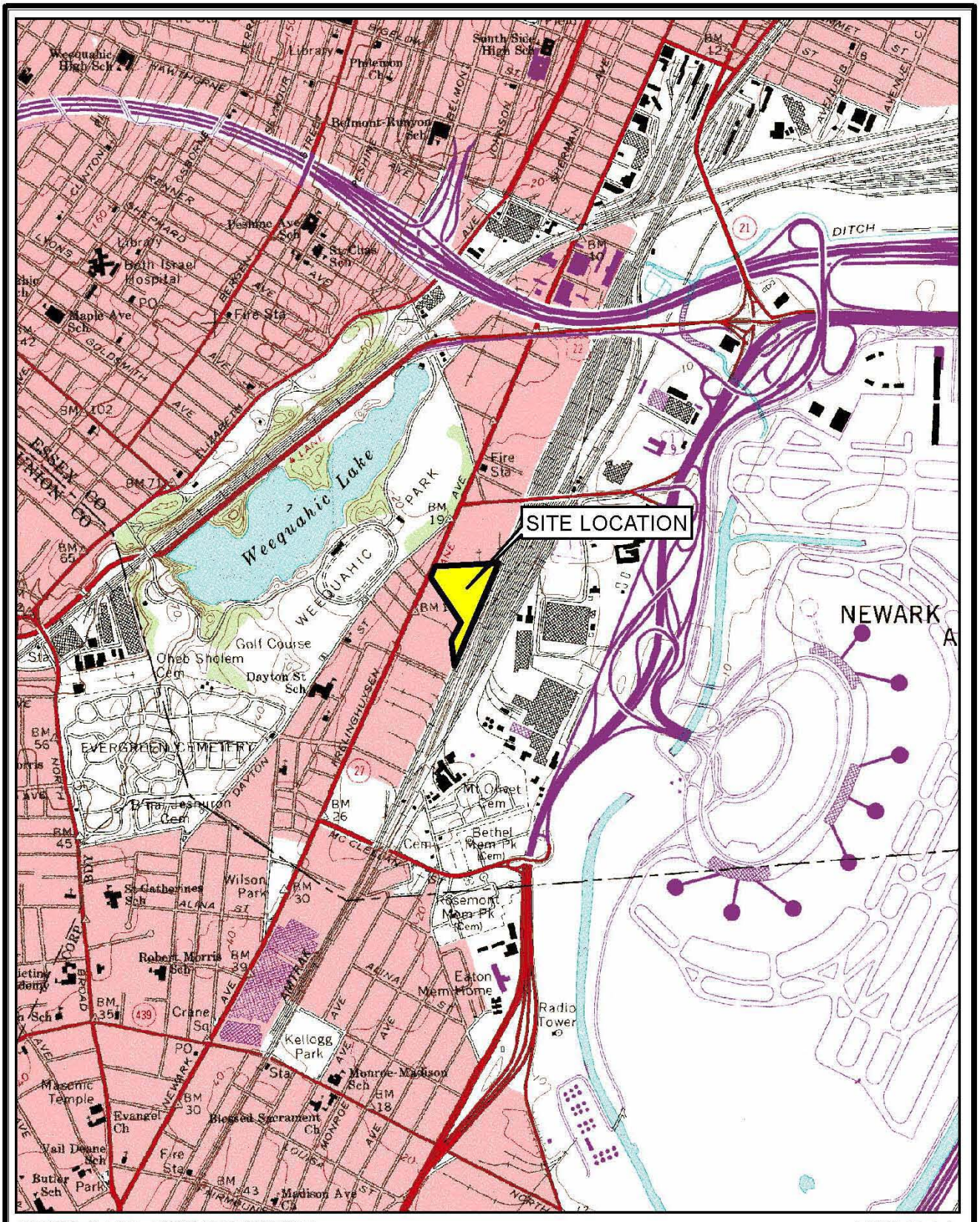
Table 4-6
Final Groundwater VOC Data by Both ETL and DESA Laboratories
Bench Scale Treatability Study
White Chemical Corporation Superfund Site, OU3
Newark, New Jersey

Laboratory	ETL			DESA		ETL			DESA	
Sample Run	**7-A**	**7-B**	**7-C**	**7-C**		**8-A**	**8-B**	**8-C**	**8-C**	
Chemical Name										
PCE (µg/L)	230	290	180	500	U	270	220	200	500	UJ
TCE (µg/L)	2,500	2,300	1,700	790		2,200	1,900	1,900	500	UJ
cis-1,2-DCE (µg/L)	91	110	120	500	U	44	37	45	500	UJ
VC (µg/L)	840	670	890	500	U	510	470	610	500	UJ
1,1,2-TCA (µg/L)	4,100	5,700	3,600	2,000		4,700	5,000	3,800	2,100	J
1,2-DCA (µg/L)	86,000	98,000	82,000	130,000		91,000	91,000	84,000	120,000	J
CA (µg/L)	ND	26	15	500	U	80	110	48	500	UJ
1,2-dibromoethane (µg/L)	4,500	6,400	4,000	2,400		6,500	7,100	5,600	3,200	J
1,2-dibromo-3-chloropropane (µg/L)	ND	ND	ND	500	U	ND	ND	ND	24	J
1-bromo-2-chloroethane (µg/L)	85,000	97,000	77,000	NA		90,000	94,000	85,000	NA	

Note:
ETL: Environmental Treatability Laboratory
DESA: Division of Environmental Science and Assessment
J: estimated value
U: non-detect
UJ: estimated but non-detected value
ND: non-detect
NA: not analyze
µg/L: microgram per liter

PCE: tetrachloroethene
TCE: trichloroethene
cis-1,2-DCE: cis-1,2-dichloroethene
VC: vinyl chloride
1,1,2-TCA: 1,1,2-trichloroethane
1,2-DCA: 1,2-dichloroethane
CA: chloroethane

Figures



ELIZABETH, NJ - USGS QUADRANGLE

FIGURE 1-1
SITE LOCATION MAP

WHITE CHEMICAL CORPORATION
SUPERFUND SITE
NEWARK, NEW JERSEY

CDM Smith

R2-0018127

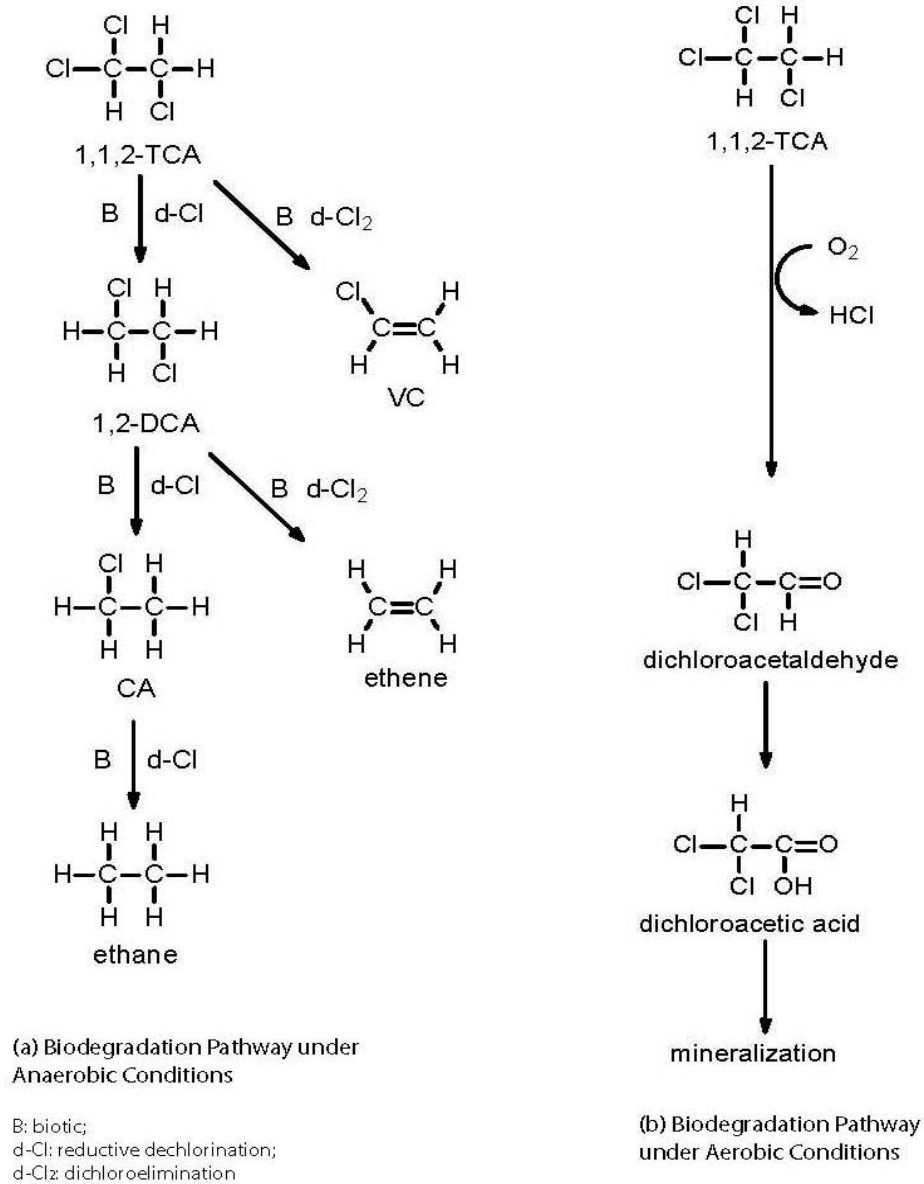


Figure 2-1 Biodegradation Pathway for 1,1,2-Trichloroethane under Anaerobic and Aerobic Conditions (Field and Sierra-Alvarez 2004)

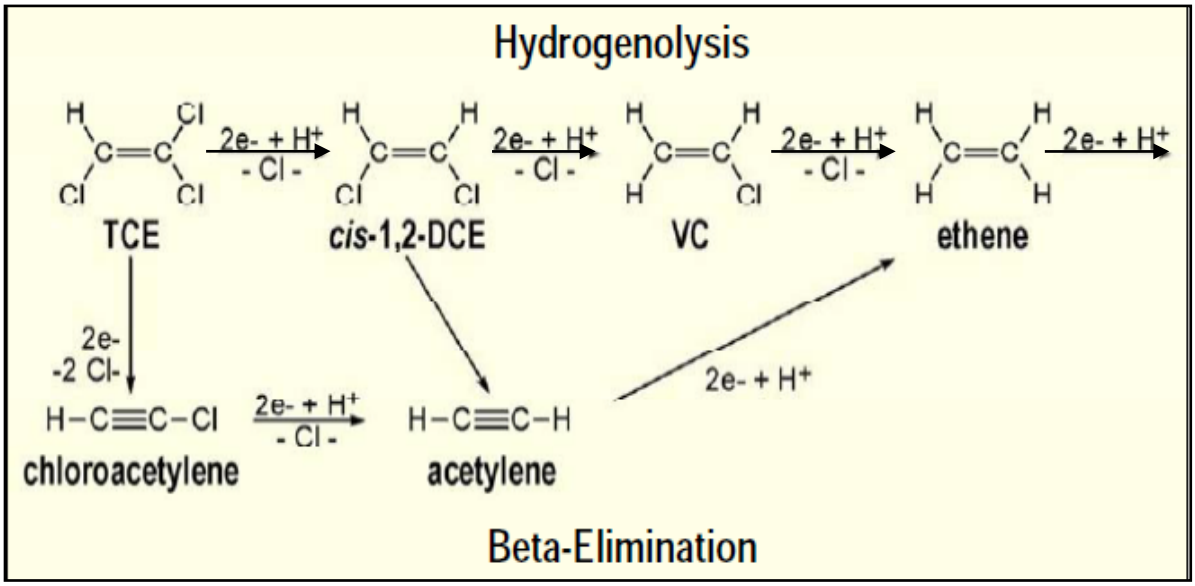
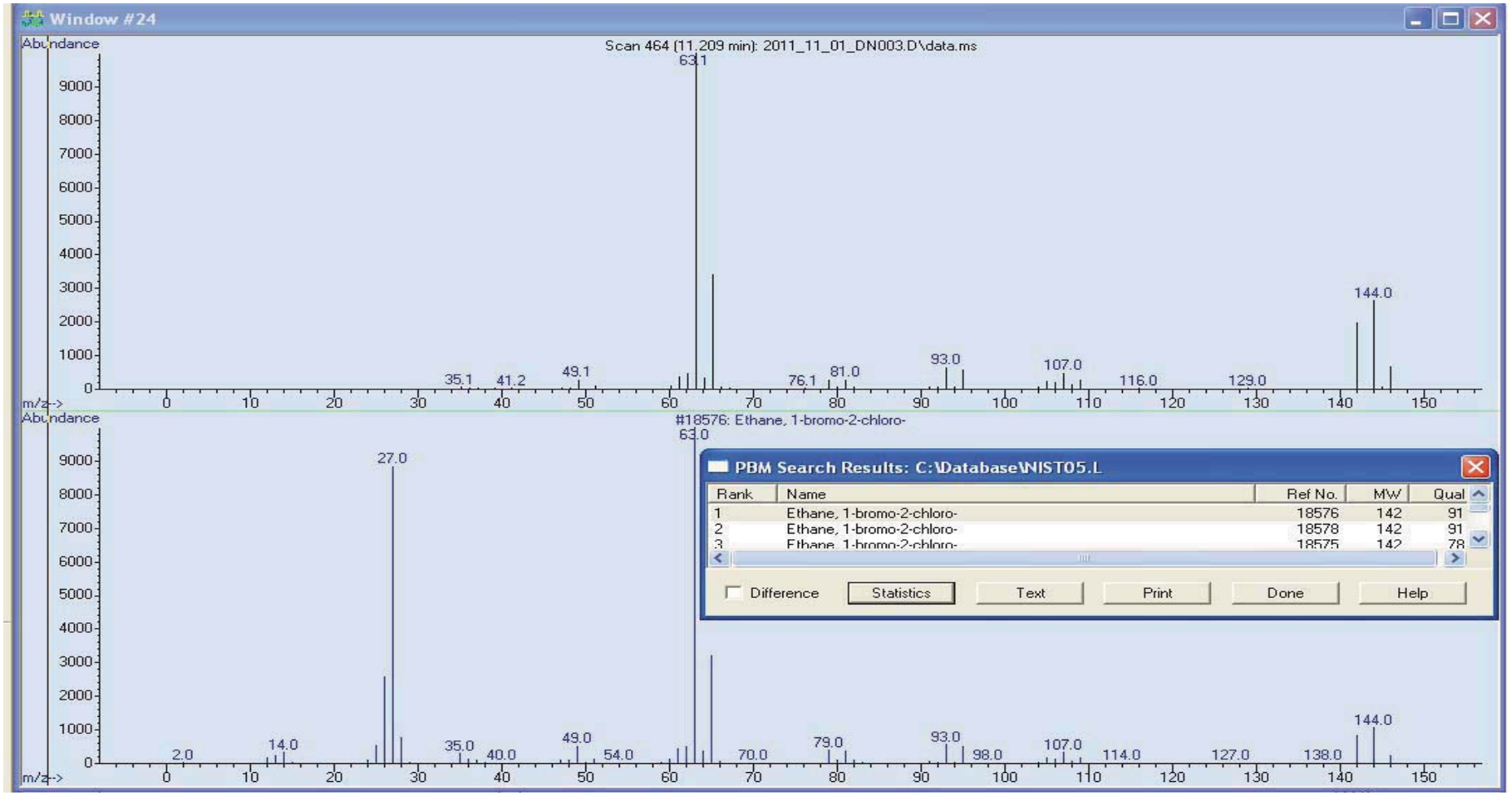


Figure 2-2 Abiotic Reduction of TCE by ZVI (NAVFAC 2005)



Notes: -Top: Ion chromatograph from sample analysis
-Bottom: Reference chromatograph

Figure 3-1 GC/MS Chromatograph of 1-bromo-2-chloroethane

CDM Smith

Figure 4-1
Chemical Oxygen Demand Changes for All Tests

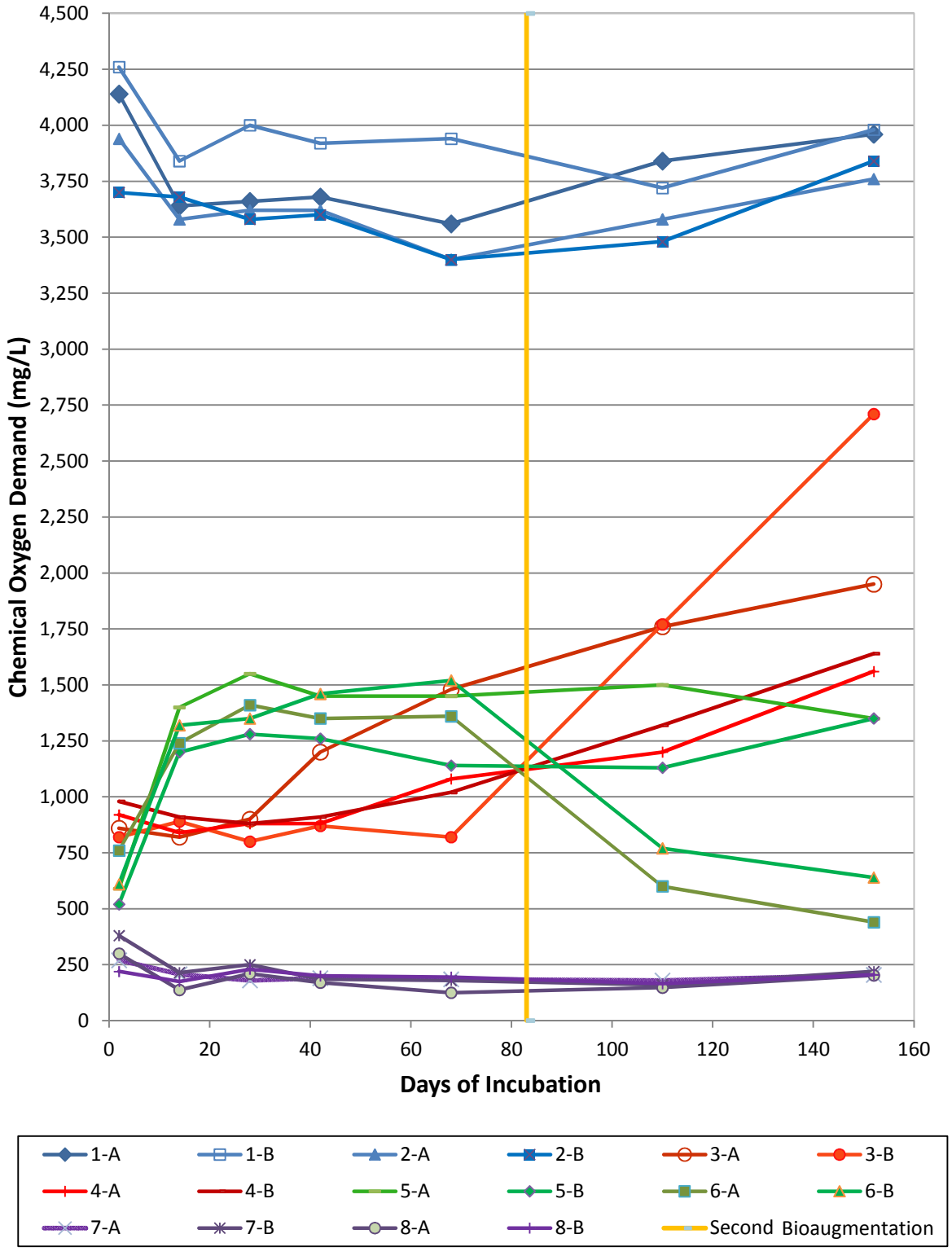


Figure 4-2
pH Changes for All Tests

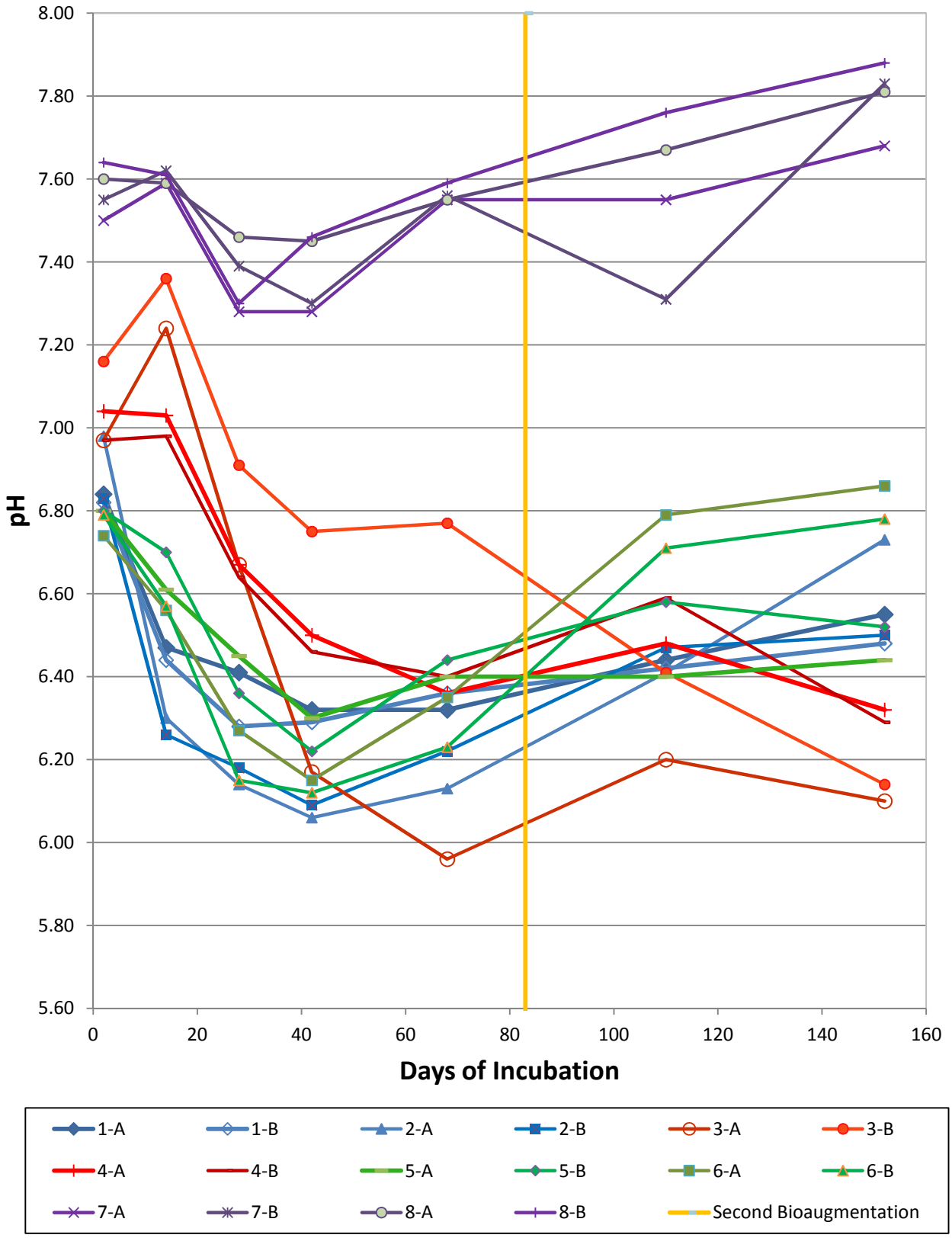


Figure 4-3a
ORP, Fe(II), and Sulfate
Test 1: Lactate and Whey

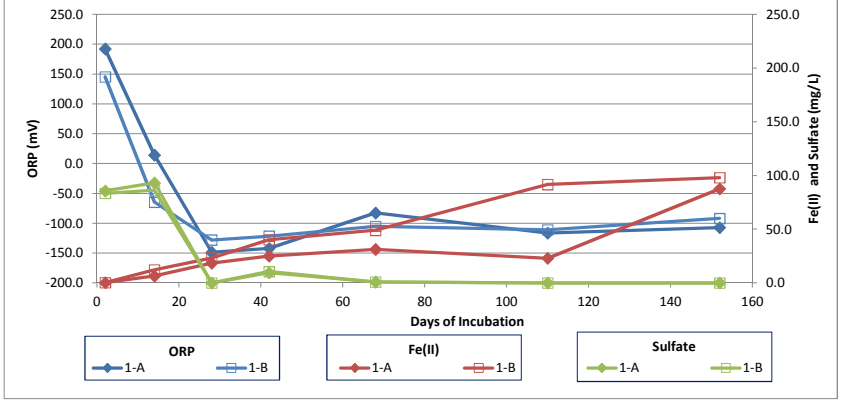


Figure 4-3c
ORP, Fe(II), and Sulfate
Test 3: EOS

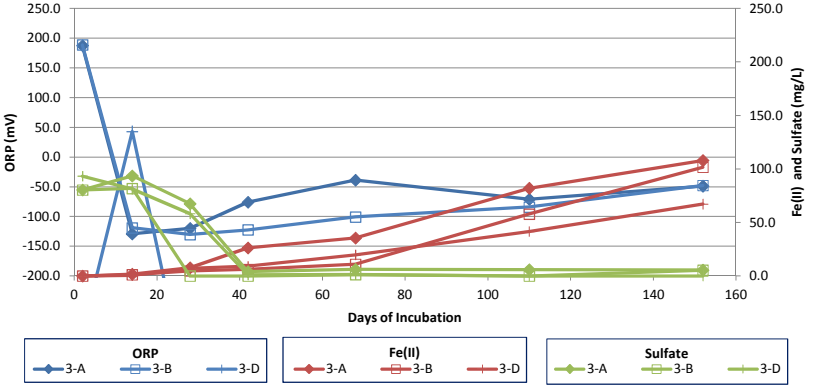


Figure 4-3b
ORP, Fe(II), and Sulfate
Test 2: Lactate and Whey with Culture

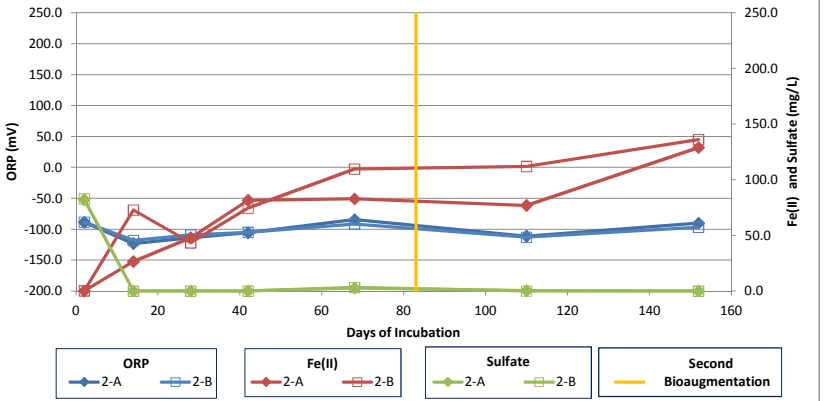
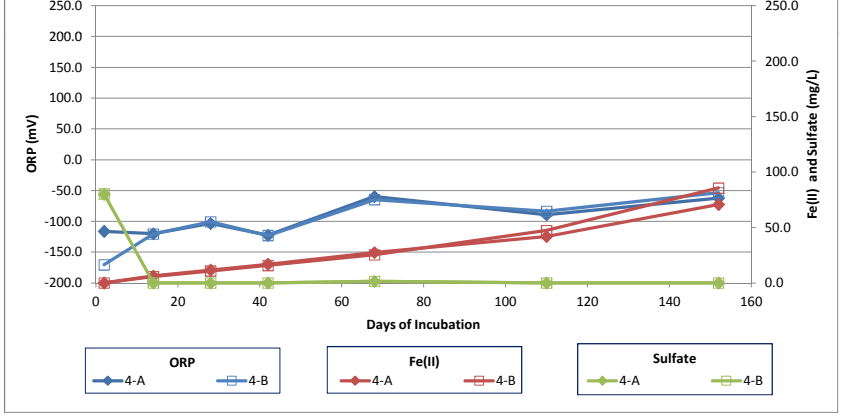


Figure 4-3d
ORP, Fe(II), and Sulfate
Test 4: EOS with Culture



Fe(II) : ferrous iron ORP: oxidation reduction potential mv: millivolts mg/L: milligram per liter

Figure 4-3e
ORP, Fe(II), and Sulfate
Test 5: EHC

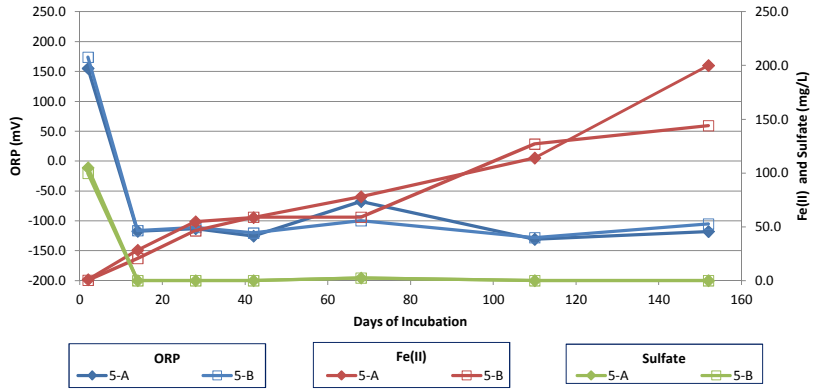


Figure 4-3g
ORP, Fe(II), and Sulfate
Test 7: Culture-only Control

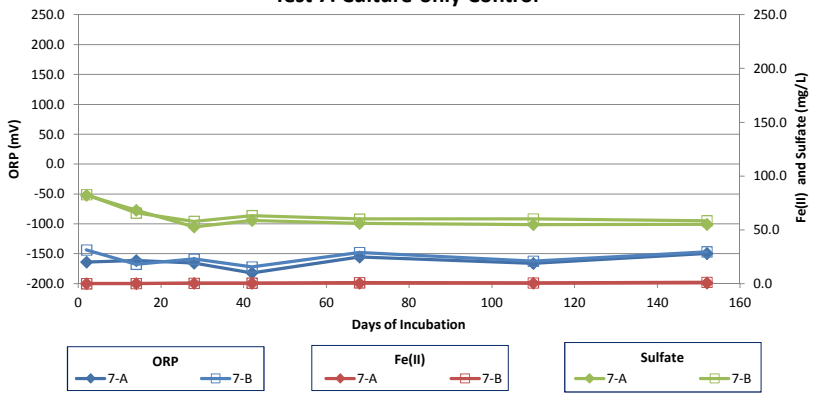


Figure 4-3f
ORP, Fe(II), and Sulfate
Test 6: EHC with Culture

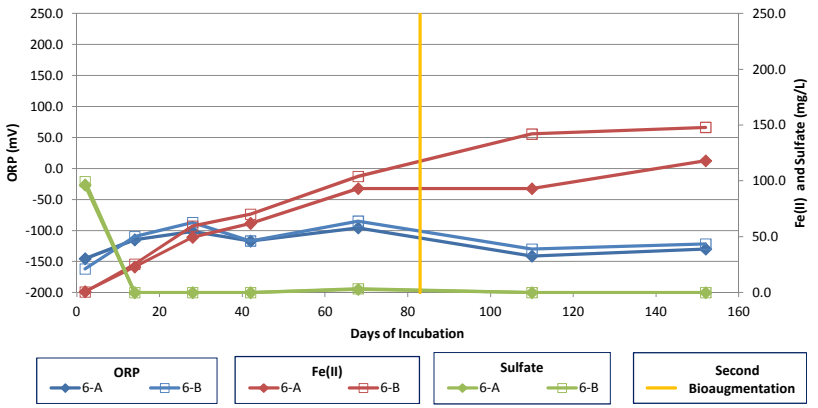
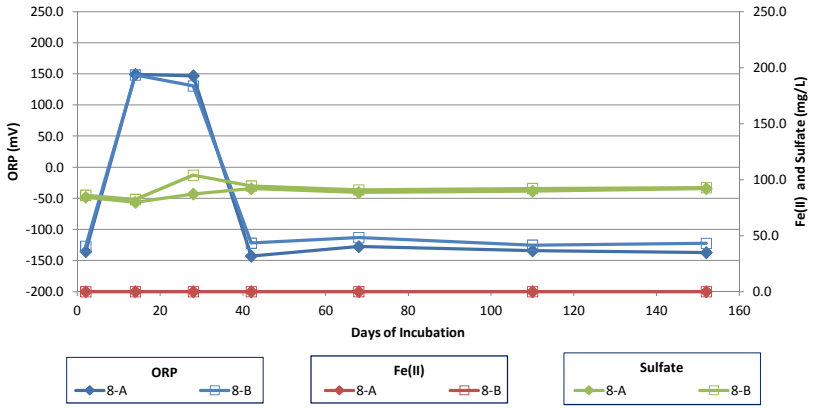
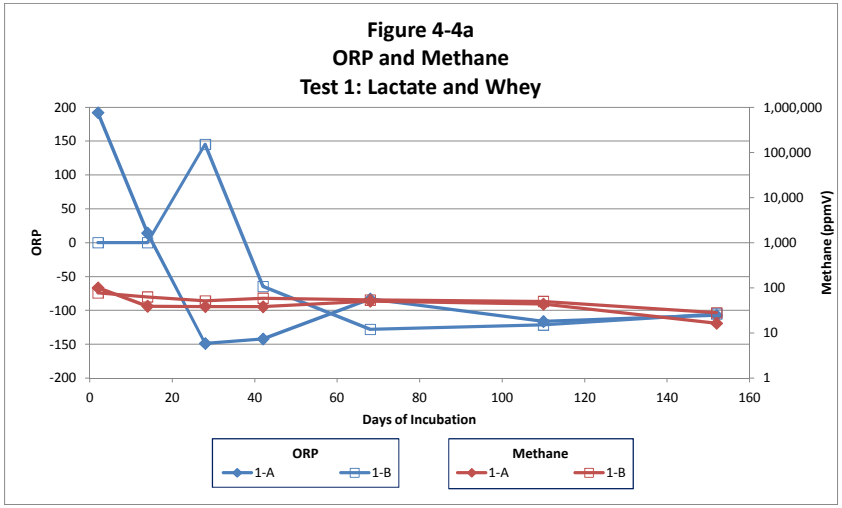
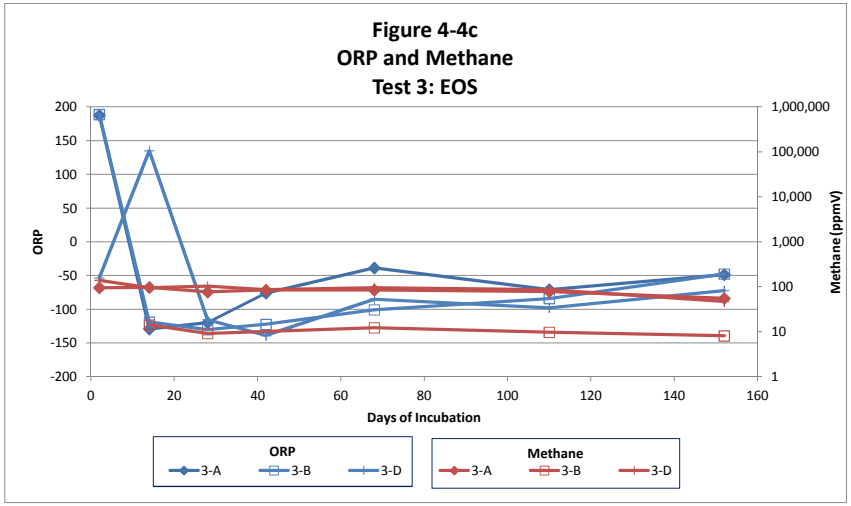


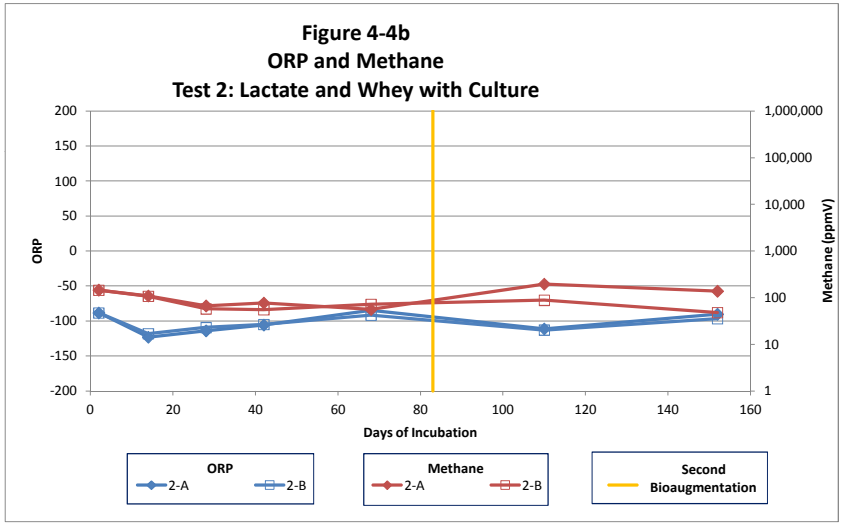
Figure 4-3h
ORP, Fe(II), and Sulfate
Test 8: Negative Control

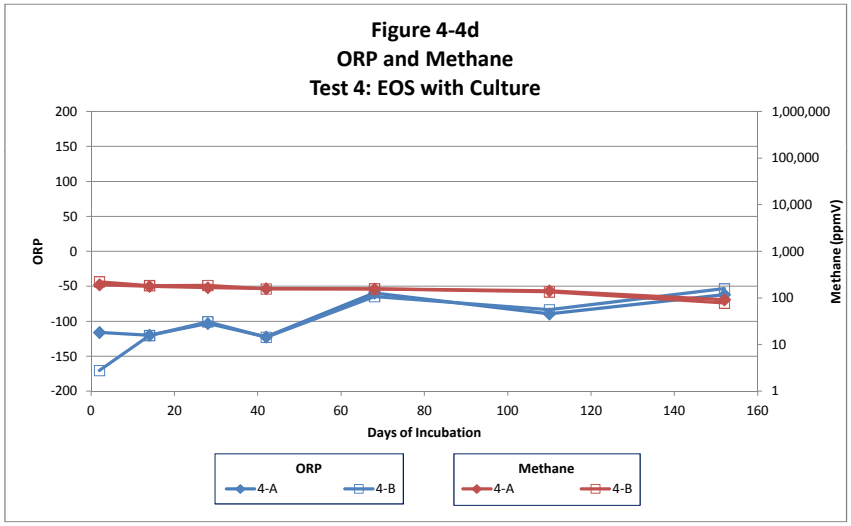


Fe(II) : ferrous iron ORP: oxidation reduction potential mV: millivolts mg/L: milligram per liter









ORP: oxidation reduction potential

ppmv: part per million in volume

Figure 4-4e
ORP and Methane
Test 5: EHC

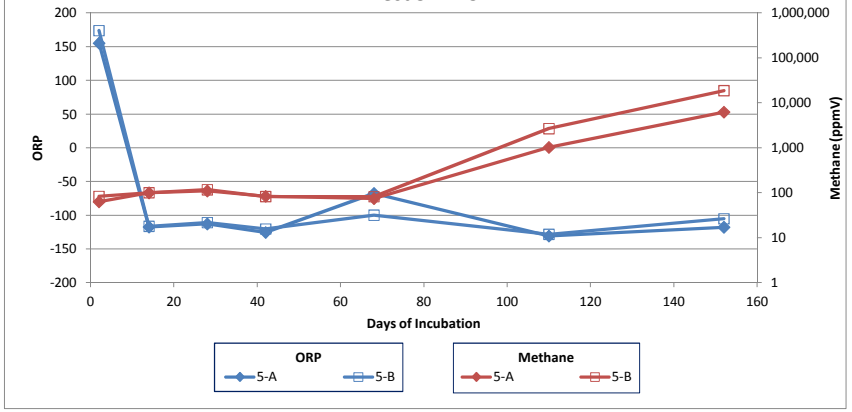


Figure 4-4g
ORP and Methane
Test 7: Culture-only Control

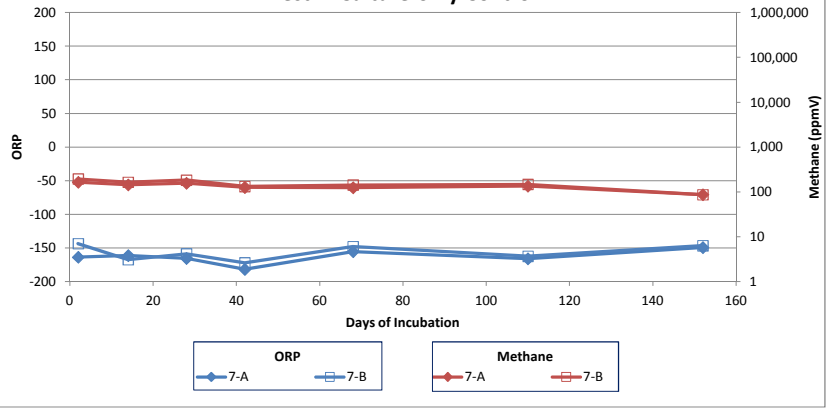


Figure 4-4f
ORP and Methane
Test 6: EHC with Culture

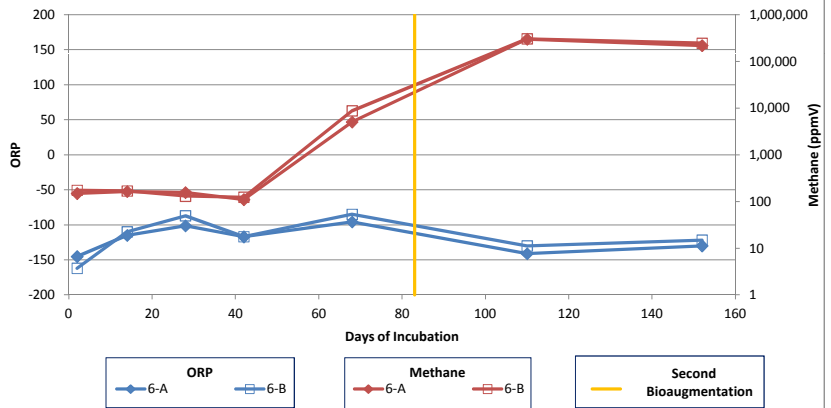
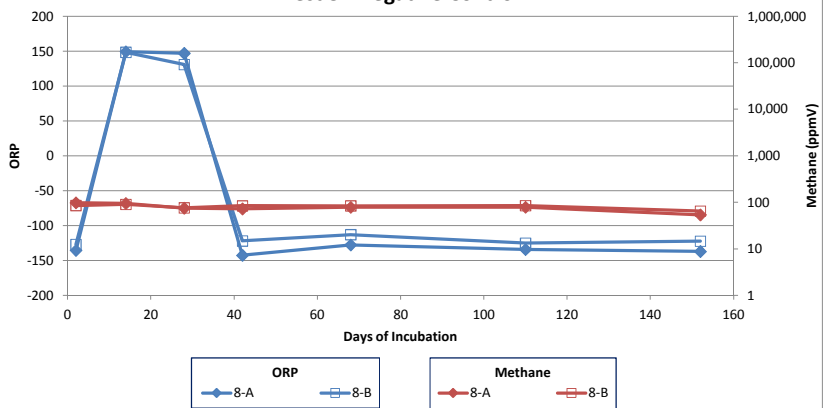


Figure 4-4h
ORP and Methane
Test 8: Negative Control



ORP: oxidation reduction potential

ppmv: part per million in volume

Figure 4-5a
Halogenated Ethanes
Test 6: EHC with Culture

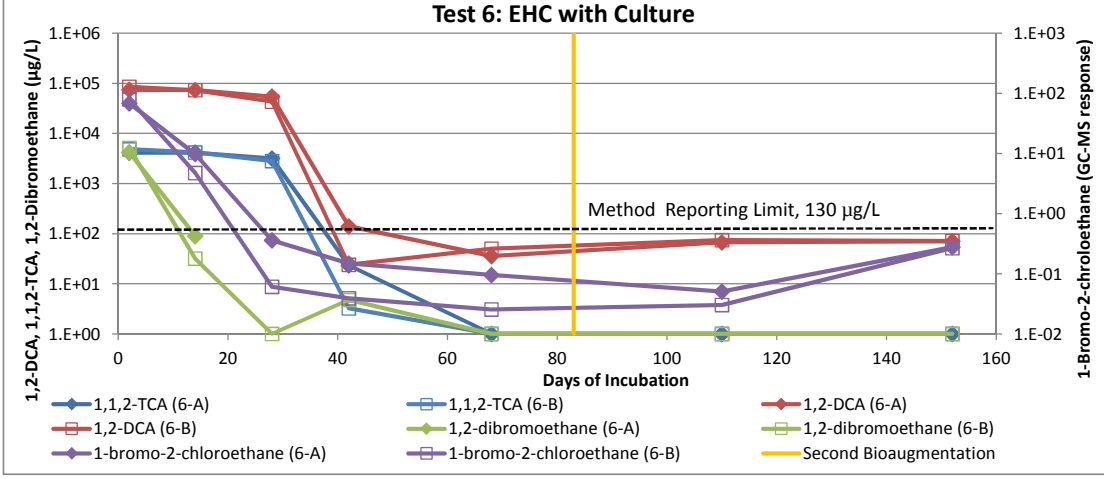


Figure 4-5b
PCE and TCE
Test 6: EHC with Culture

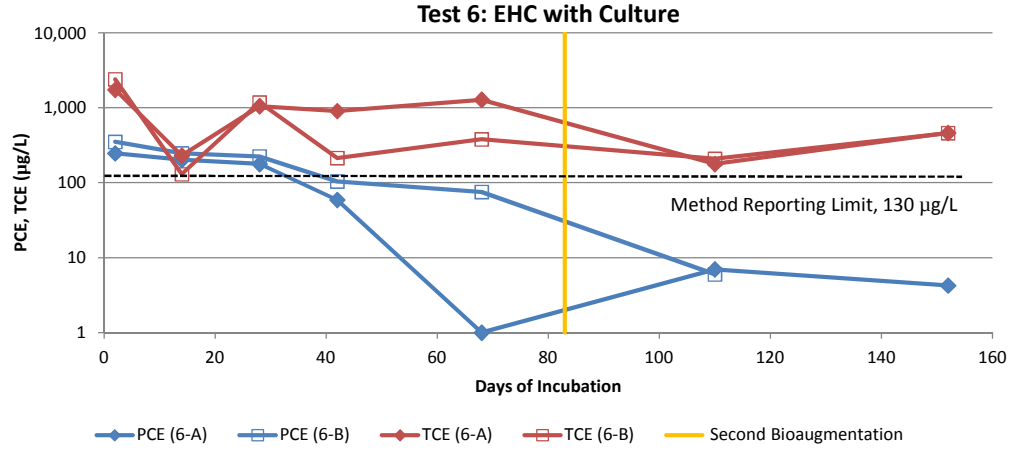
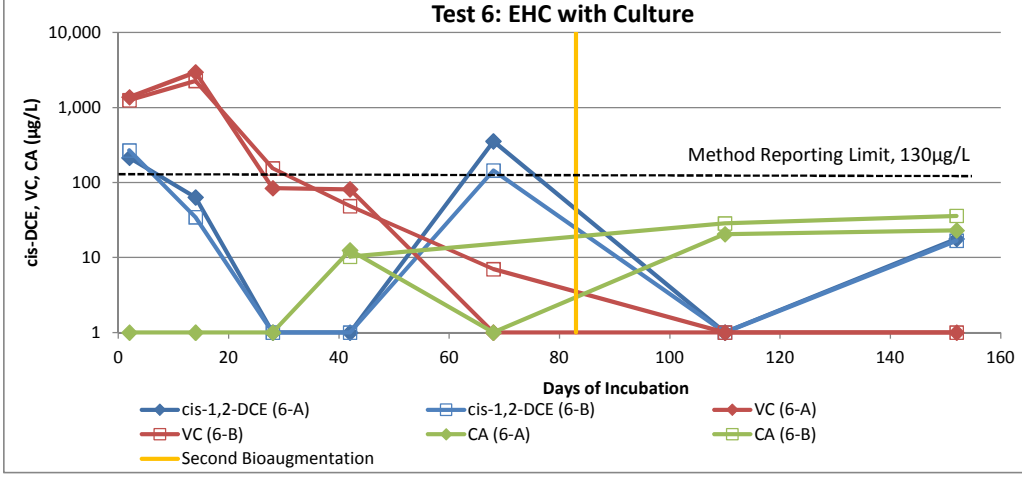


Figure 4-5c
Halogenated Daughter Products
Test 6: EHC with Culture



1,2-DCA: 1,2-dichloroethane
CA: chloroethane
VC: vinyl chloride
cis-1,2-DCE: cis-1,2-dichloroethene
PCE: tetrachloroethene
µg/L: microgram per liter
1,1,2-TCA: 1,1,2-trichloroethane
TCE: trichloroethene

Figure 4-6a
Halogenated Ethanes
Test 5: EHC

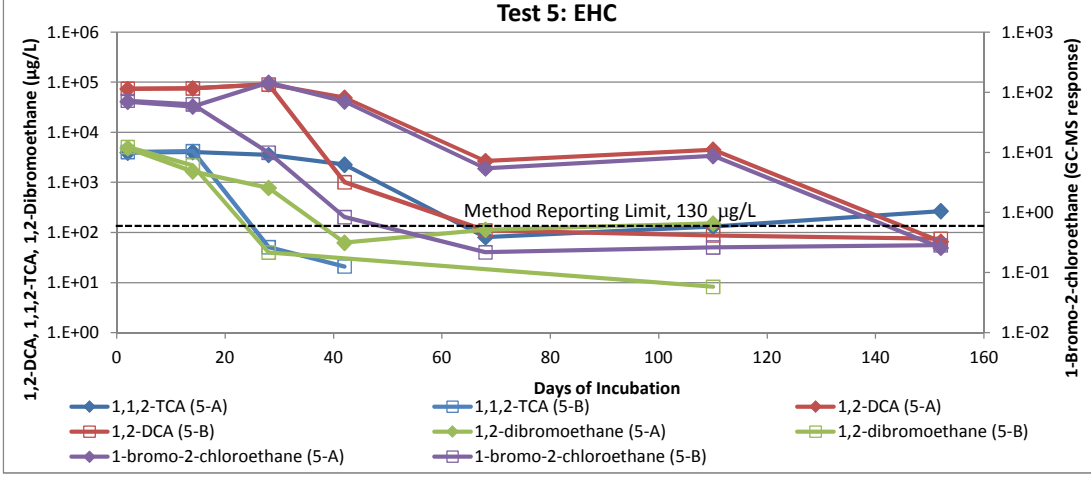


Figure 4-6b
PCE and TCE
Test 5: EHC

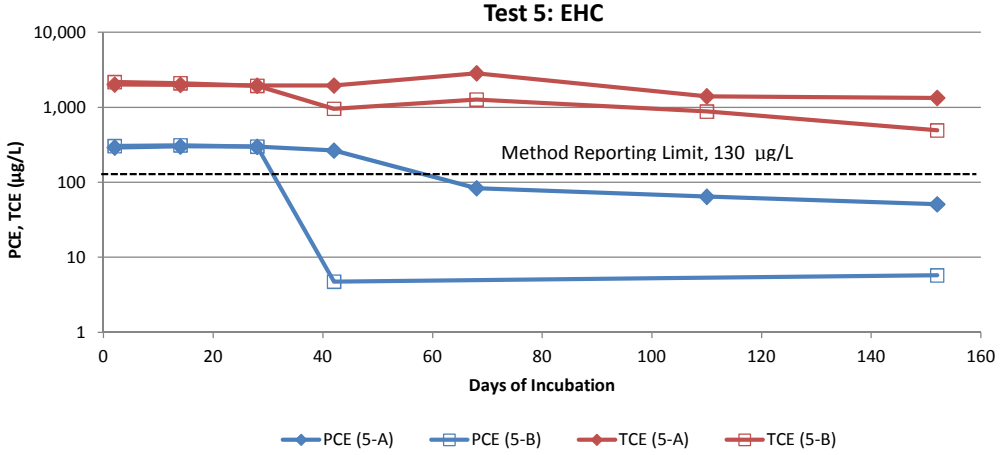
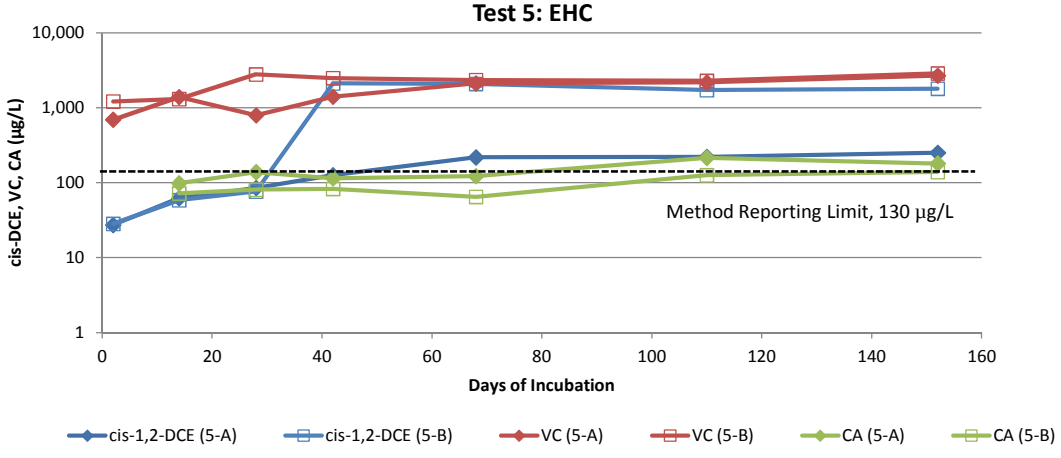


Figure 4-6c
Halogenated Daughter Products
Test 5: EHC



1,2-DCA: 1,2-dichloroethane
CA: chloroethane
VC: vinyl chloride
cis-1,2-DCE: cis-1,2-dichloroethene
PCE: tetrachloroethene
µg/L: microgram per liter
1,1,2-TCA: 1,1,2-trichloroethane
TCE: trichloroethene

Figure 4-7a
Halogenated Ethanes
Test 2: Lactate and Whey with Culture

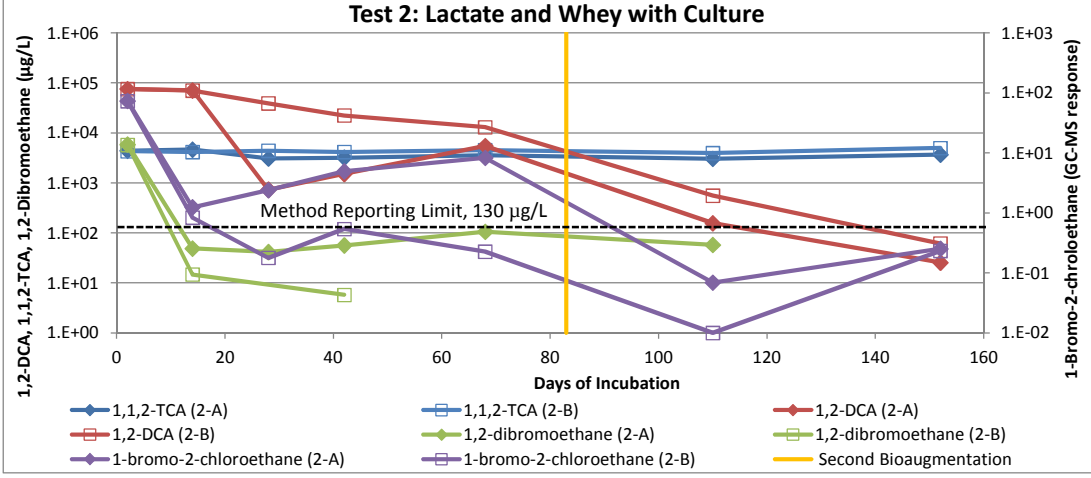


Figure 4-7b
PCE and TCE
Test 2: Lactate and Whey with Culture

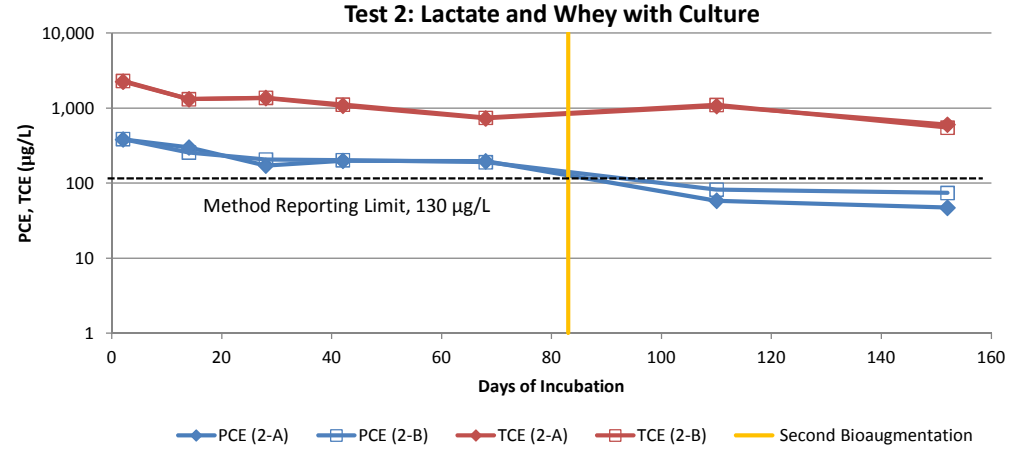
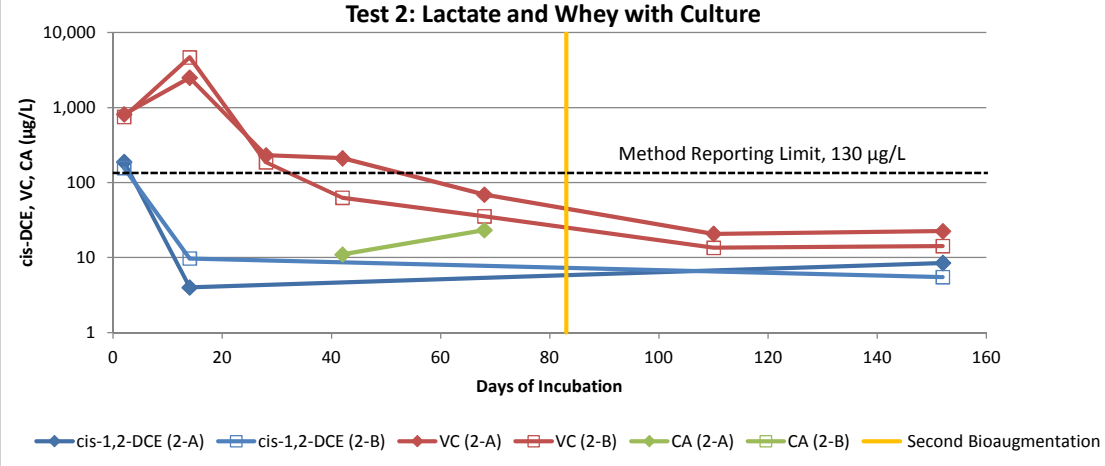


Figure 4-7c
Halogenated Daughter Products
Test 2: Lactate and Whey with Culture



1,2-DCA: 1,2-dichloroethane
CA: chloroethane
VC: vinyl chloride
cis-1,2-DCE: cis-1,2-dichloroethene
PCE: tetrachloroethene
µg/L: microgram per liter
1,1,2-TCA: 1,1,2-trichloroethane
TCE: trichloroethene

Figure 4-8a
Halogenated Ethanes
Test 1: Lactate and Whey

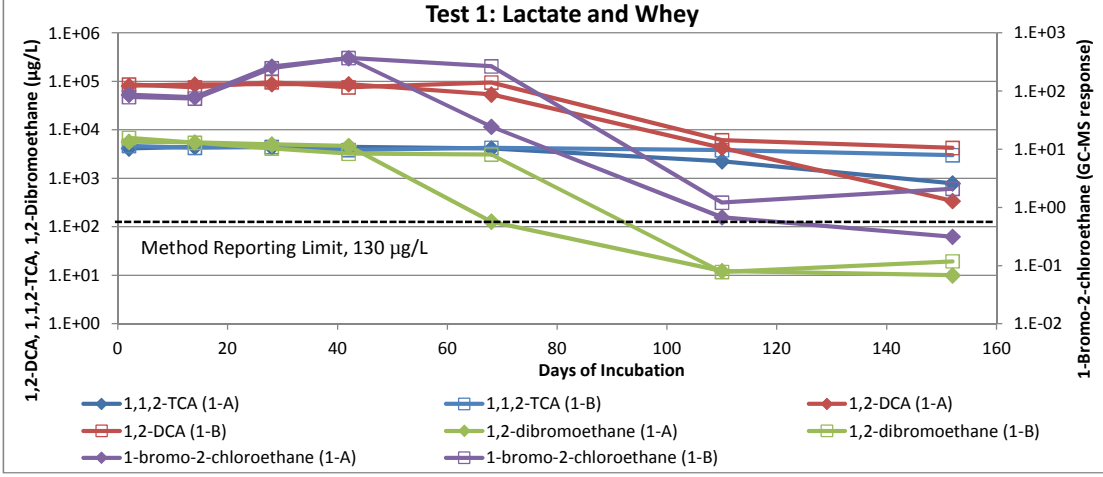


Figure 4-8b
PCE and TCE
Test 1: Lactate and Whey

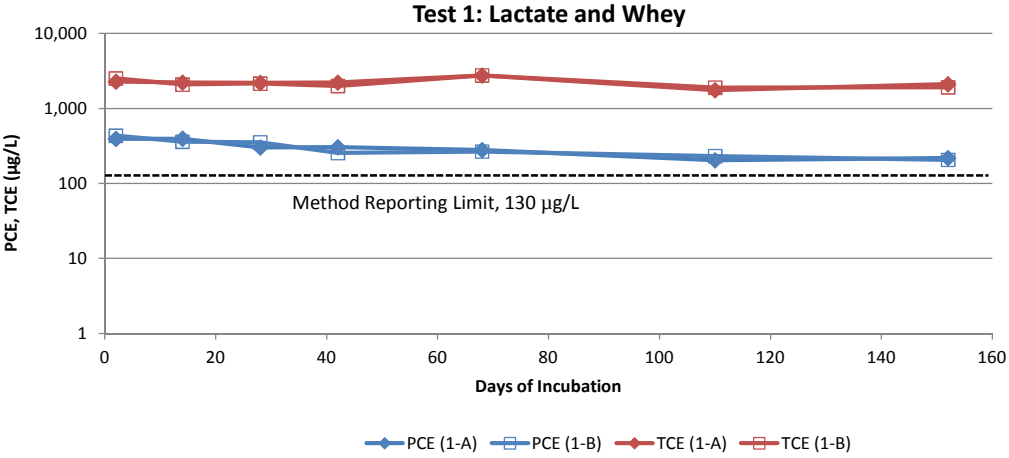
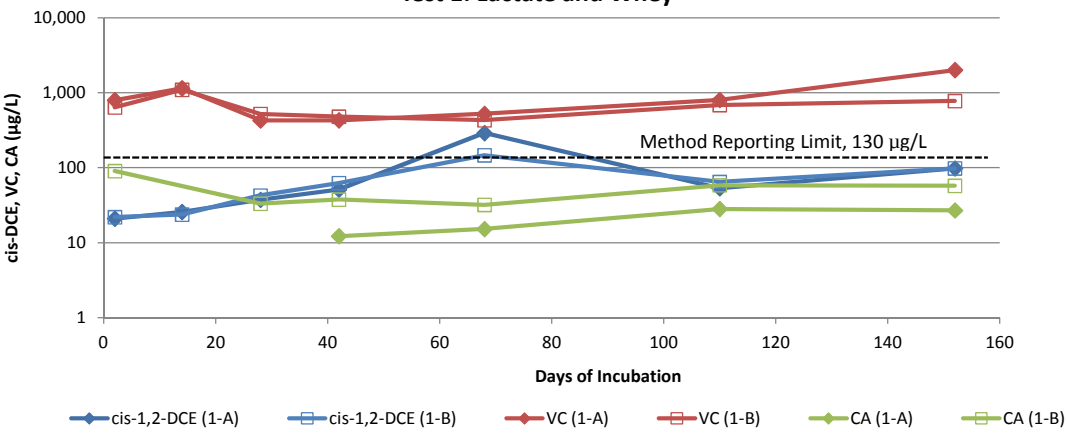


Figure 4-8c
Halogenated Daughter Products
Test 1: Lactate and Whey



1,2-DCA: 1,2-dichloroethane
CA: chloroethane
VC: vinyl chloride
cis-1,2-DCE: cis-1,2-dichloroethene
PCE: tetrachloroethene
µg/L: microgram per liter
1,1,2-TCA: 1,1,2-trichloroethane
TCE: trichloroethene

Figure 4-9a
Halogenated Ethanes
Test 3: EOS

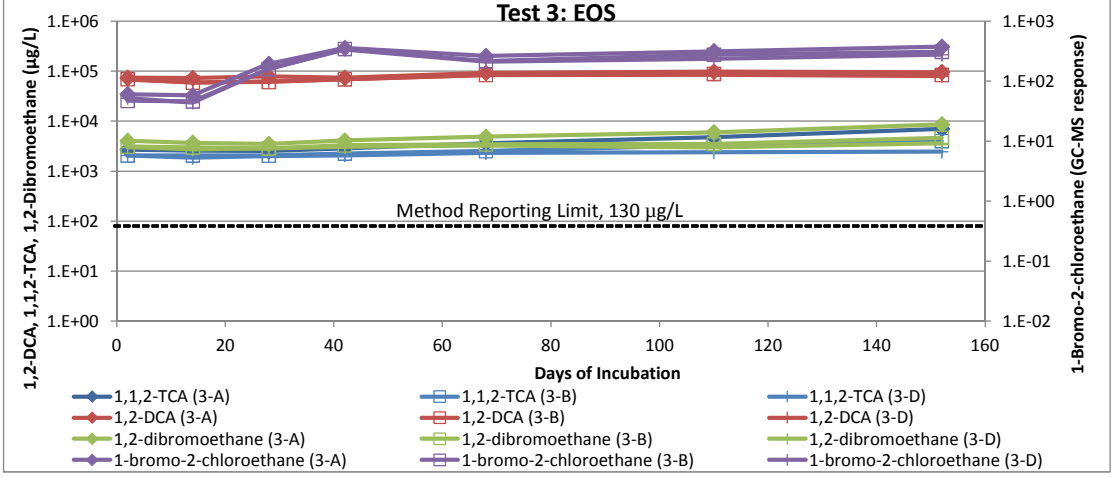


Figure 4-9b
PCE and TCE
Test 3: EOS

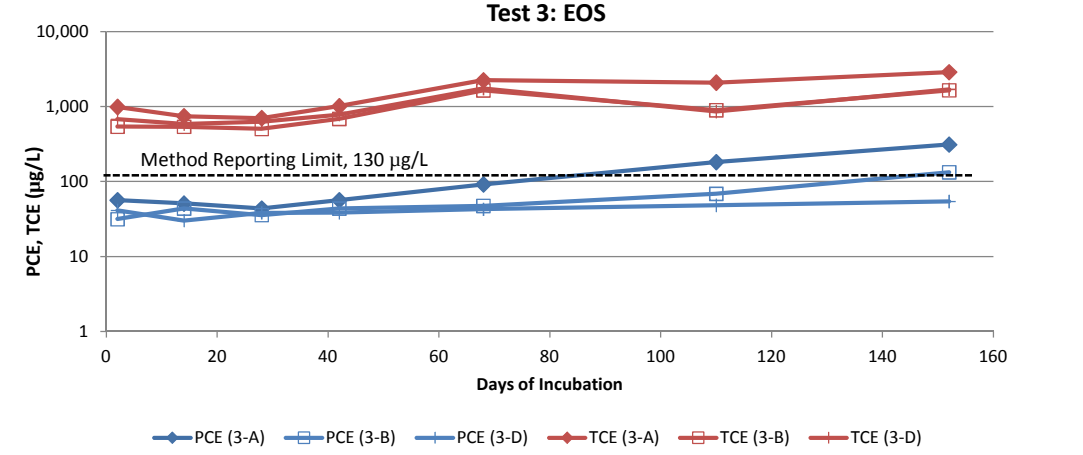
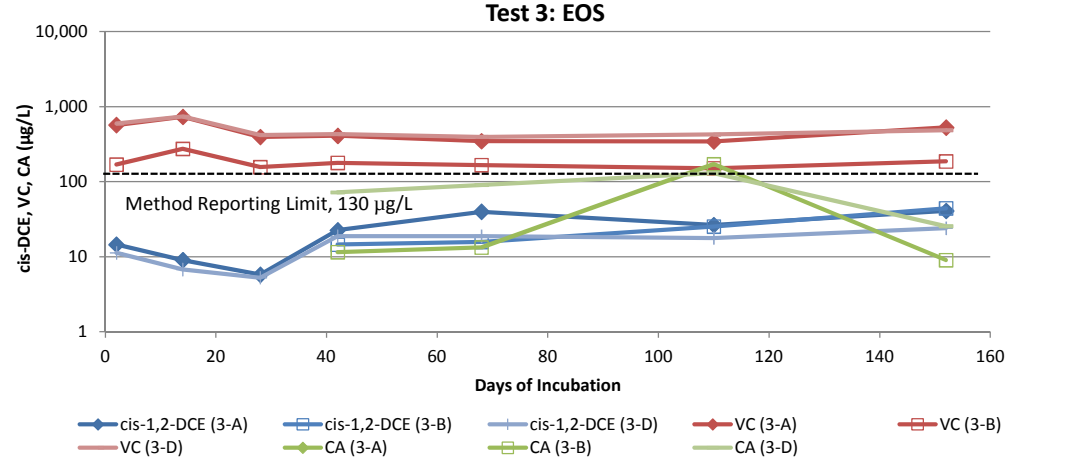


Figure 4-9c
Halogenated Daughter Products
Test 3: EOS



1,2-DCA: 1,2-dichloroethane
CA: chloroethane
VC: vinyl chloride
cis-1,2-DCE: cis-1,2-dichloroethene
PCE: tetrachloroethene
µg/L: microgram per liter
1,1,2-TCA: 1,1,2-trichloroethane
TCE: trichloroethene

Figure 4-10a
Halogenated Ethanes
Test 4: EOS with Culture

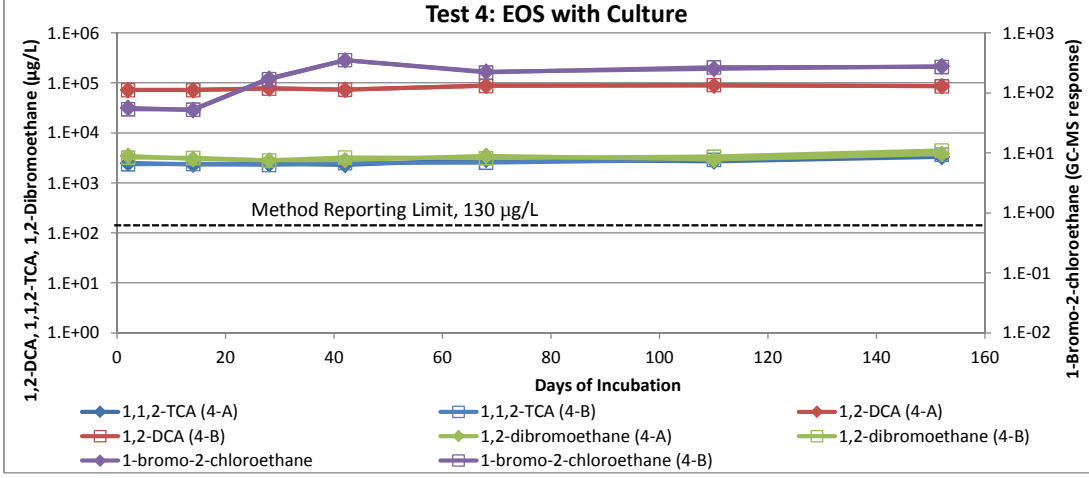


Figure 4-10b
PCE and TCE
Test 4: EOS with Culture

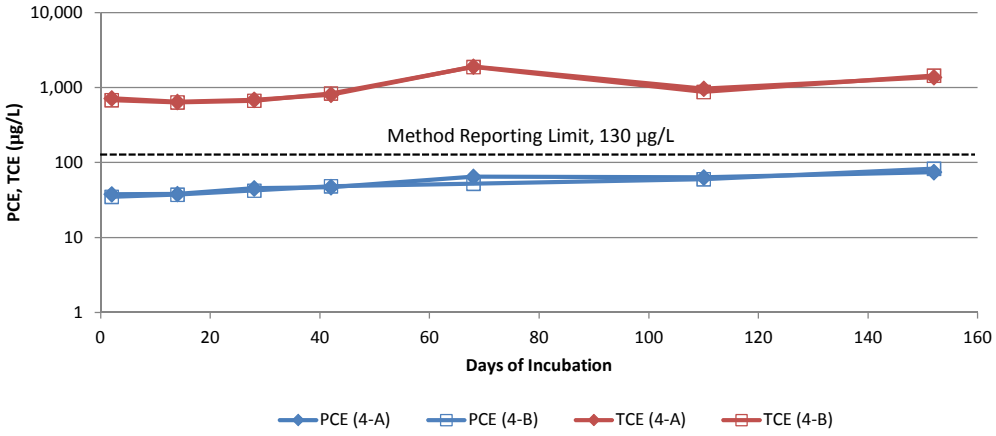
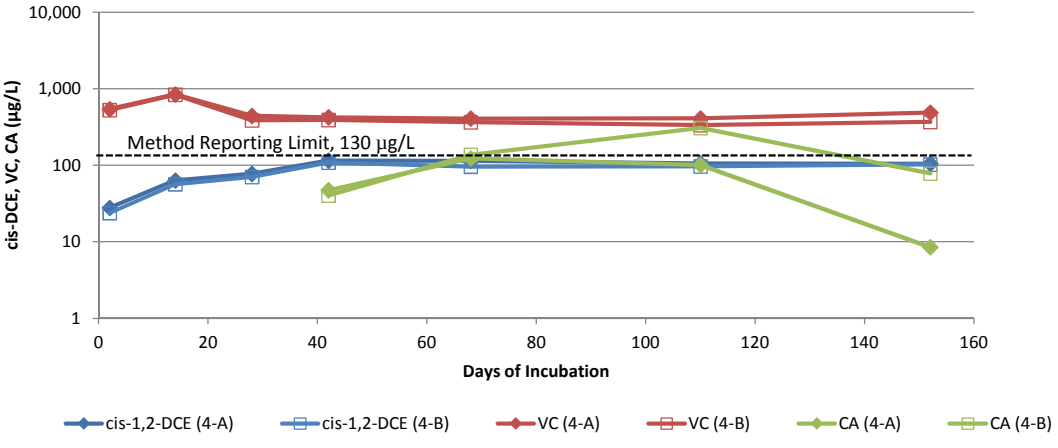


Figure 4-10c
Halogenated Daughter Products
Test 4: EOS with Culture



1,2-DCA: 1,2-dichloroethane
CA: chloroethane
VC: vinyl chloride
cis-1,2-DCE: cis-1,2-dichloroethene
PCE: tetrachloroethene
µg/L: microgram per liter
1,1,2-TCA: 1,1,2-trichloroethane
TCE: trichloroethene

Figure 4-11a
Halogenated Ethanes
Test 7: Culture-only Control

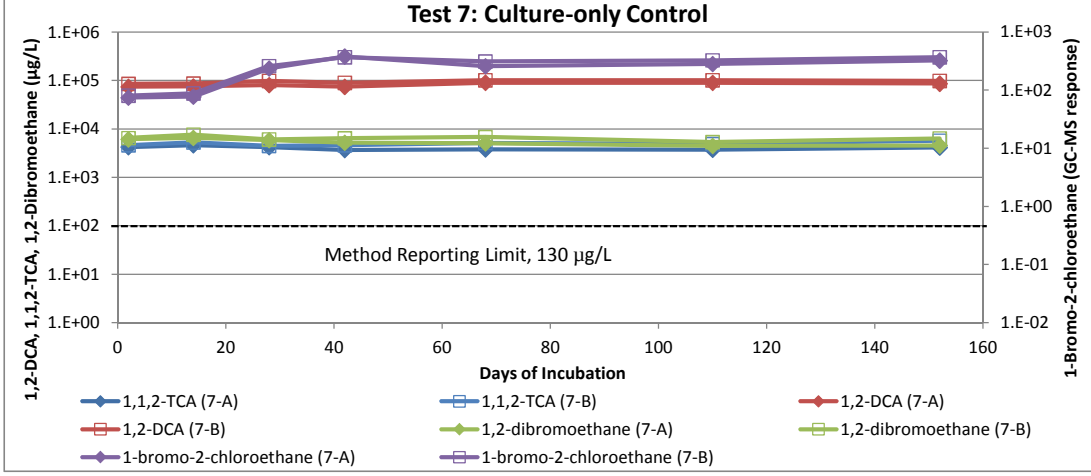


Figure 4-11b
PCE and TCE
Test 7: Culture-only Control

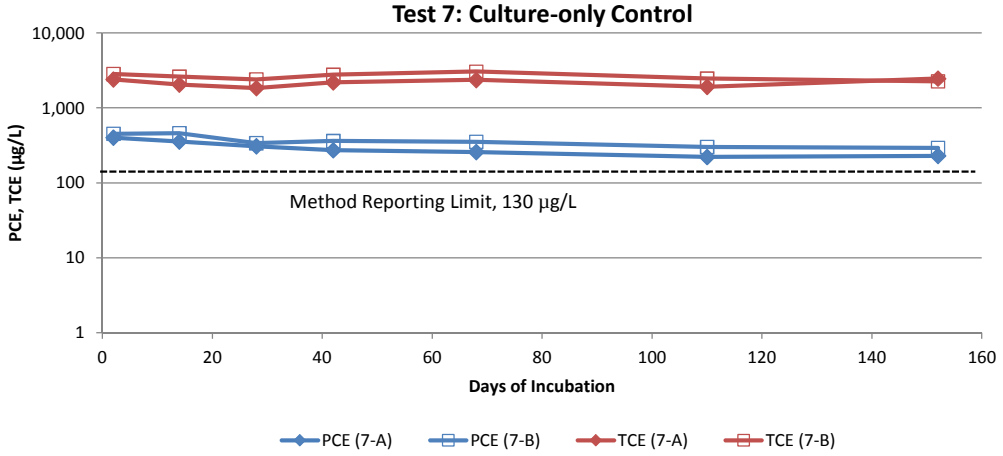
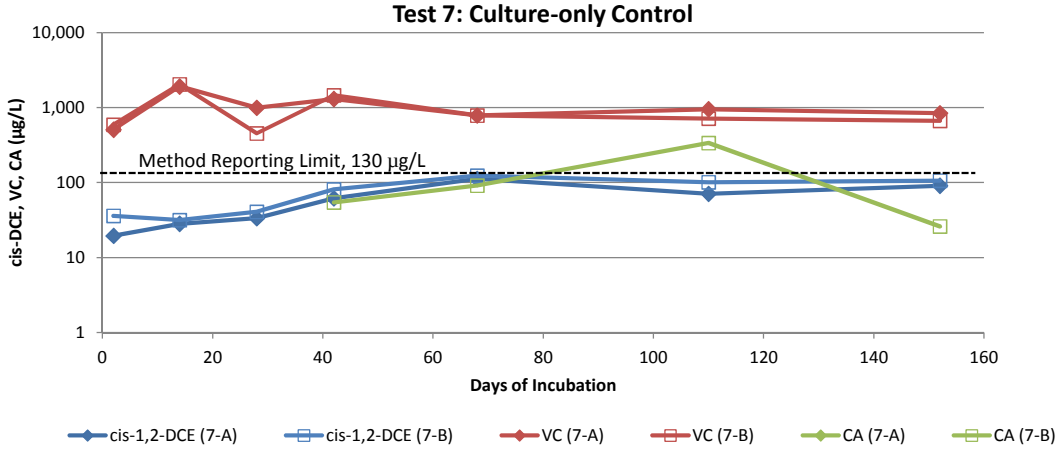


Figure 4-11c
Halogenated Daughter Products
Test 7: Culture-only Control



1,2-DCA: 1,2-dichloroethane
CA: chloroethane
VC: vinyl chloride
cis-1,2-DCE: cis-1,2-dichloroethene
PCE: tetrachloroethene
µg/L: microgram per liter
1,1,2-TCA: 1,1,2-trichloroethane
TCE: trichloroethene

Figure 4-12a
Halogenated Ethanes
Test 8: Negative Control

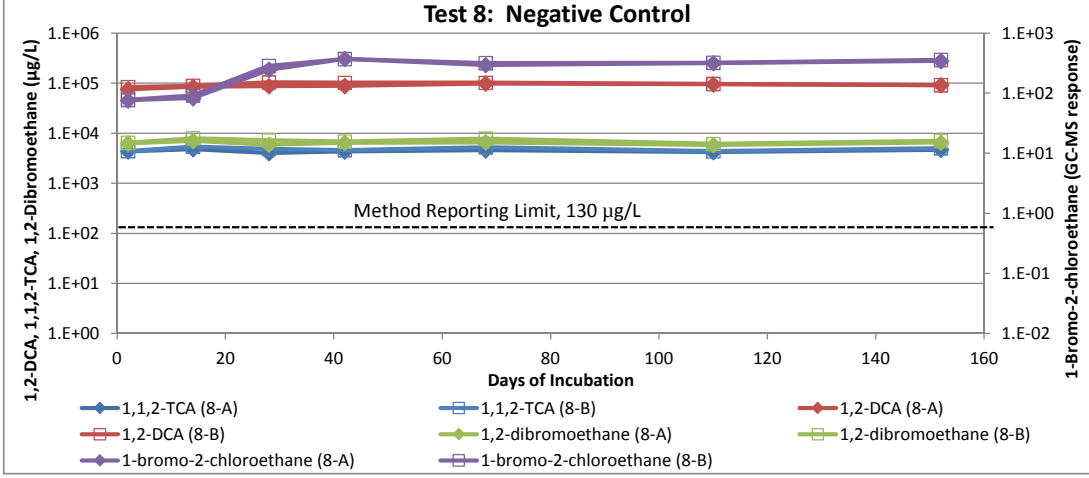


Figure 4-12b
PCE and TCE
Test 8: Negative Control

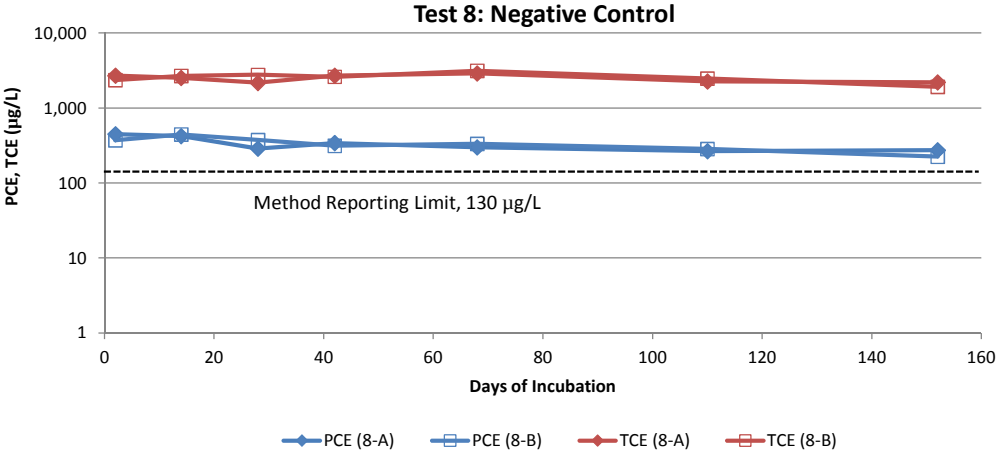
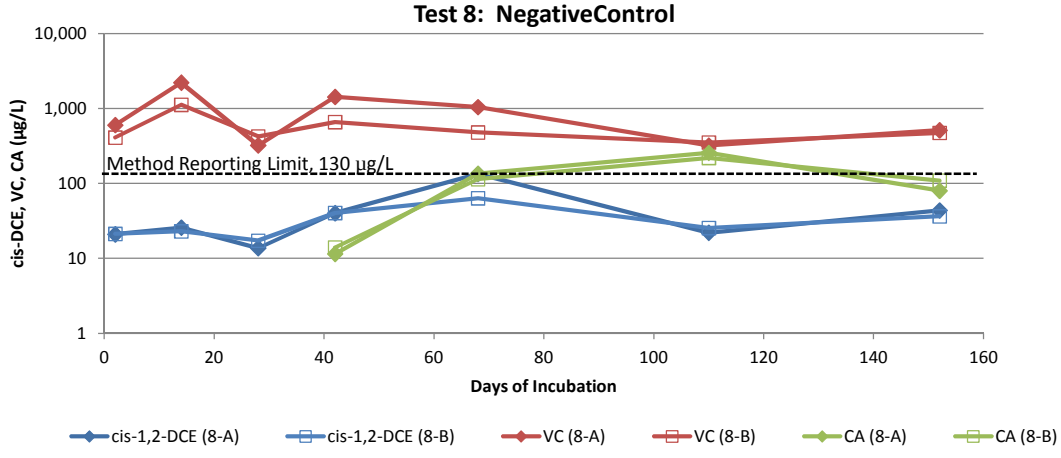
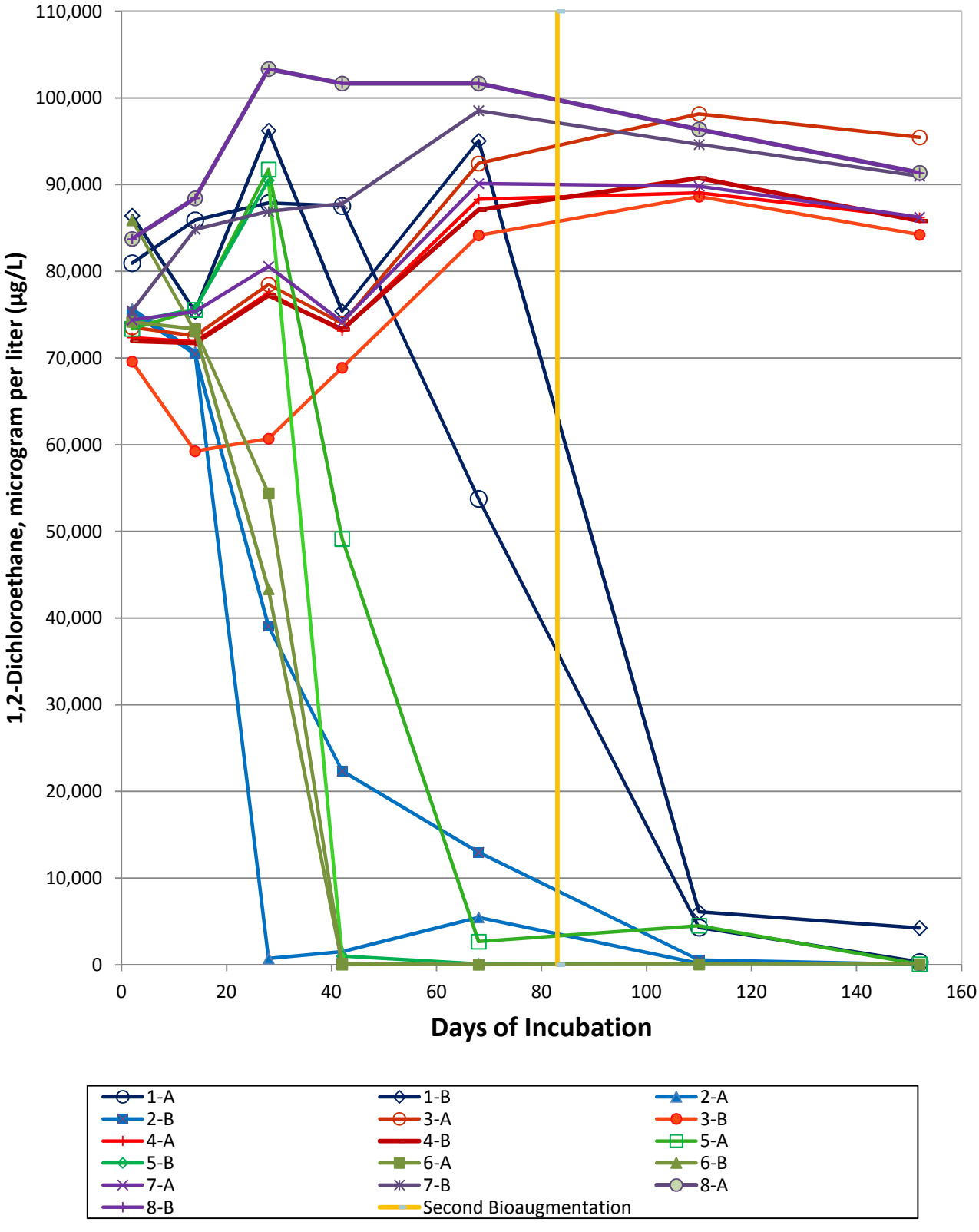


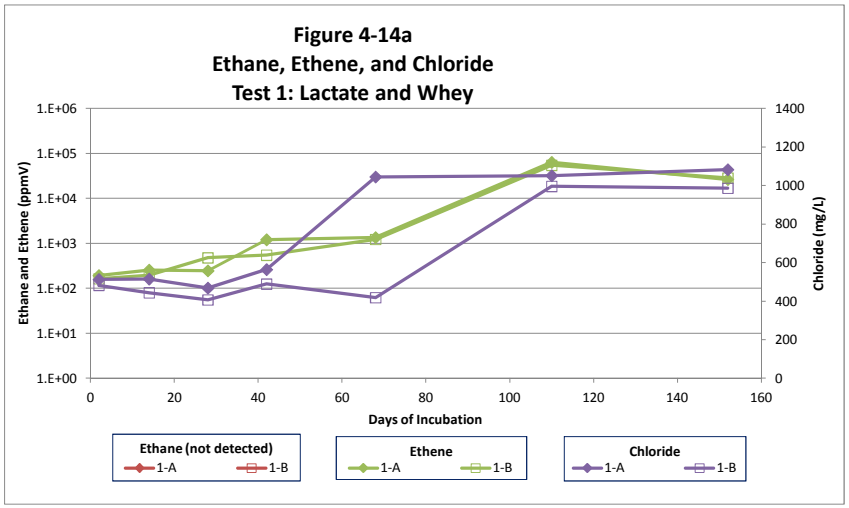
Figure 4-12c
Halogenated Daughter Products
Test 8: NegativeControl

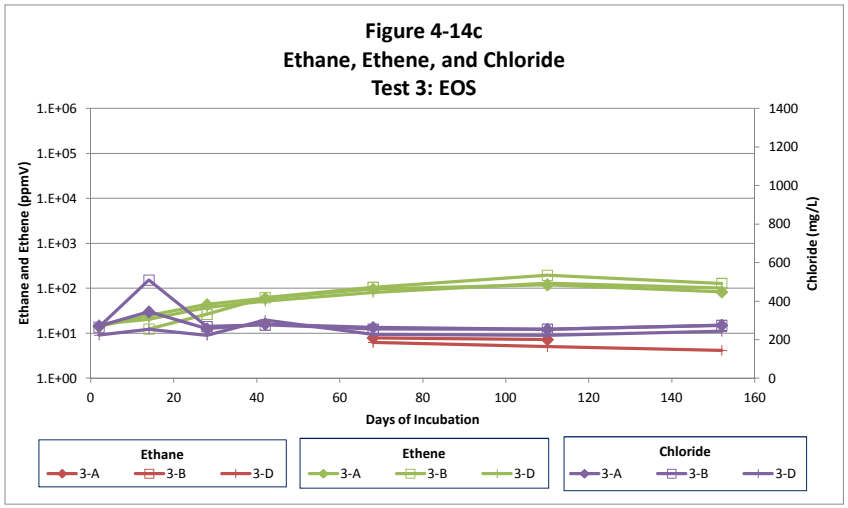


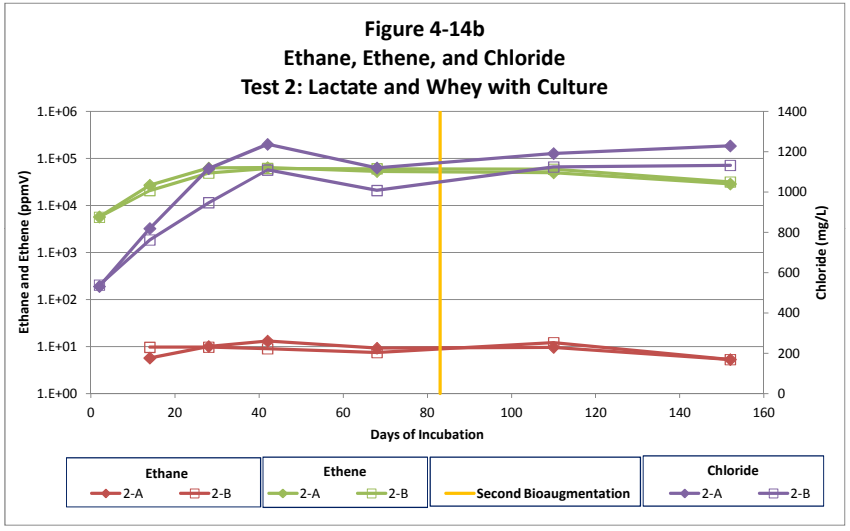
1,2-DCA: 1,2-dichloroethane
CA: chloroethane
VC: vinyl chloride
cis-1,2-DCE: cis-1,2-dichloroethene
PCE: tetrachloroethene
µg/L: microgram per liter
1,1,2-TCA: 1,1,2-trichloroethane
TCE: trichloroethene

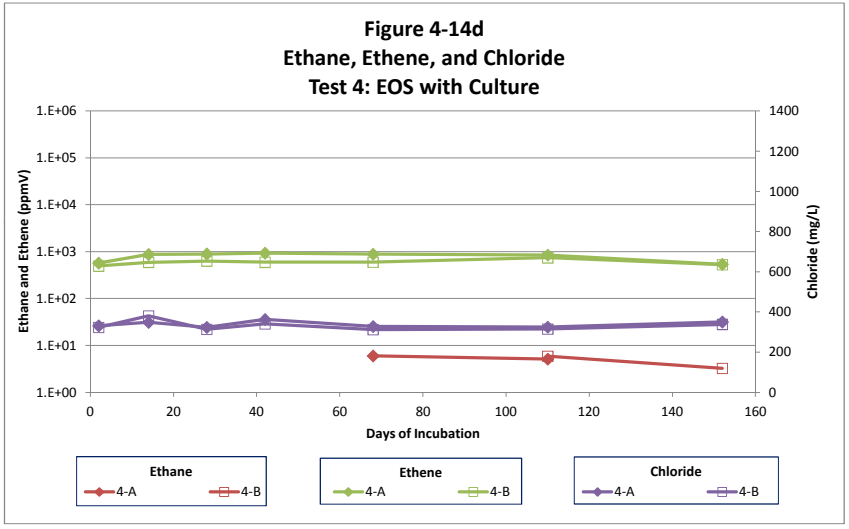
Figure 4-13
1,2-Dichloroethane Degradation in All Tests



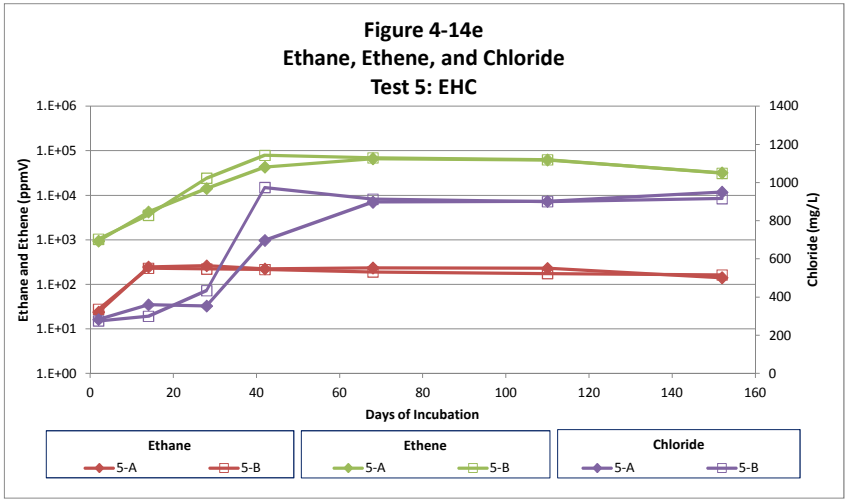


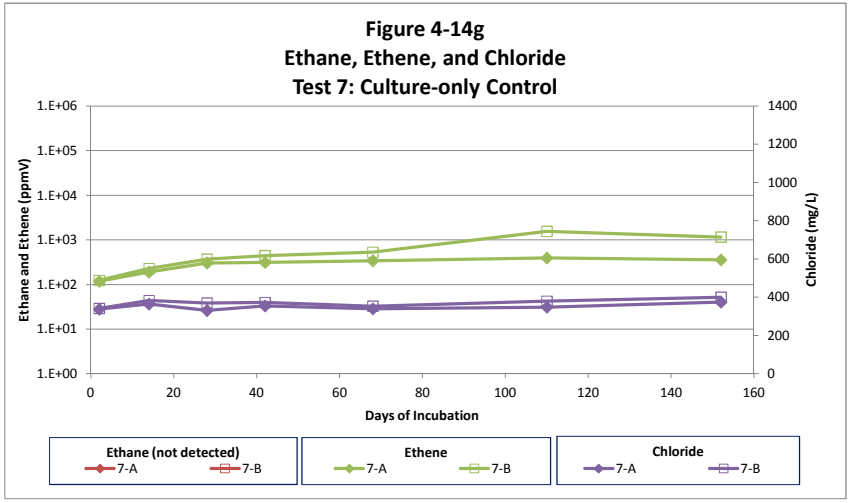


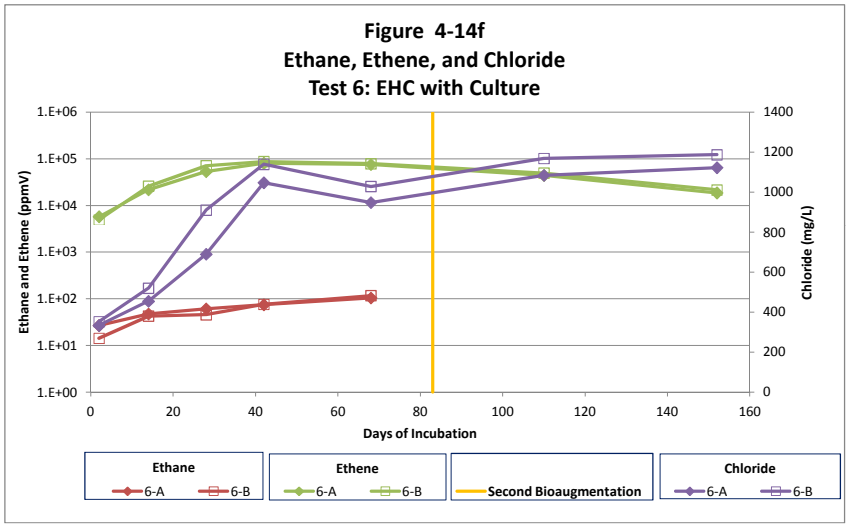


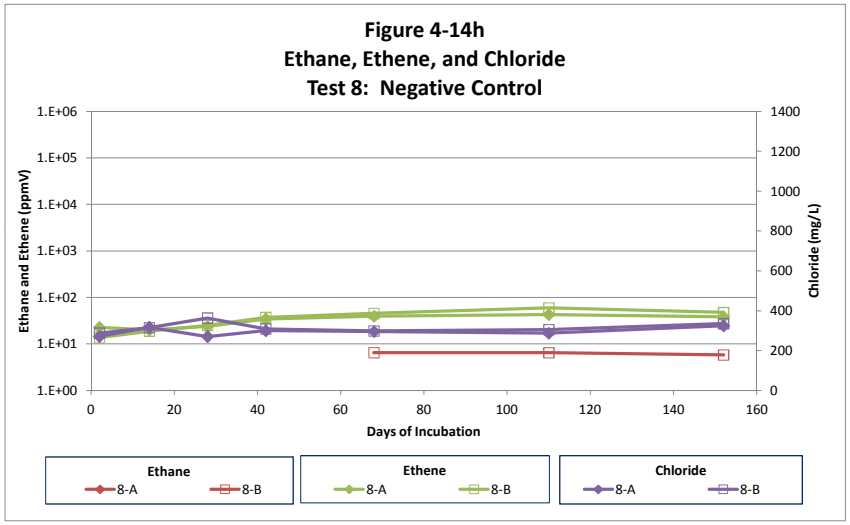


Notes:
ppmv: part per million in volume µg/L: microgram per liter mg/L: milligram per liter
Reporting limit for ethane and ethene is 13 µg/L.









Notes
ppmv: part per million in volume µg/L: microgram per liter mg/L: milligram per liter
Reporting limit for ethane and ethene is 13 µg/L.

Appendix A

Field Change Request Forms

White Chemical Corporation Superfund Site
OU3-Groundwater RI/FS
Newark, NJ

Field Change Request

Date: June 30, 2011

Request No.: BSTS-1

FCR Title: Addition of SOP ETL-011

Description: Appendix C of the Bench Scale Treatability Study (BSTS) QAPP specifies the standard operating procedures (SOPs) to be used by CDM's Bellevue Treatability Study Laboratory. SOP-ETL-011, *Analysis of Volatile Organic Compounds, Oxygen, Carbon Monoxide, Hydrogen Sulfide, and Lower Explosive Limits by the BW Technologies Four-Gas Meter*, is included with this FCR to amend Appendix C of the Final BSTS QAPP.

Reason for Deviation: The SOP ETL-011 was received after the submission of the Final BSTS QAPP, and needs to be included in Appendix C.

Recommended/Modification: Include SOP ETL-011 in Appendix C of the Final BSTS QAPP, dated June 10, 2011.

Impact on Data Quality Objectives: The inclusion of SOP ETL-011 will enable the data quality objectives to be met.

USACE Contract No.: W912DQ-08-D-0018

Task Order No.: 006

Signatures:

for Mike Ehnot, CDM Field Team Leader

Kathy Baker, USACE Project Manager

Sharon Budney, CDM Task Order Manager

cc:
Ray Klimcsak, EPA Remedial Project Manager
Bill Sy, EPA QA Officer
Amy Darpinian, USACE Project Chemist
Lisa Campbell, CDM RI Task Manager
Jeniffer Oxford, CDM Quality Assurance Coordinator
White Chemical Field Team

Standard Operating Procedure ETL-011

Analyses of Volatile Organic Compounds, Oxygen, Carbon Monoxide, Hydrogen sulfide and Lower Explosive Limits by the BW Technologies Four Gas Meter

Revision 1.0

Approved on: 06/20/2011

CDM

Environmental Treatability Laboratory
Bellevue, WA

Author		Diane Nelsen
Technical Reviewer		Pat Evans
Quality Reviewer		Janelle Amador

This document is intended for distribution to CDM employees only. All hardcopy documents are considered uncontrolled; therefore, the controlled version of this document can be accessed on the Bellevue Projects Server.

A. Scope and Application

The BW Technologies GasAlertMicro5+PID meter is capable of measuring up to five atmospheric hazards concurrently and warns of hazardous gases at levels above user-selectable alarm set-points. Such gases include Volatile Organic Compounds (VOCs), CO, H_2S, O_2, SO_2, PH_3, NH_3, NO_2, HCN, Cl_2, ClO_2 and O_3. Based on the equipped sensors with the purchased meter, this standard operating procedure (SOP) is devoted to analyses of VOCs, CO, H_2S, O_2, and percent of Lower Explosive Limits (%LEL). Please refer to the User Manual for any information not contained within this SOP.

B. Summary of Method

The BW Technologies GasAlertMicro5 PID meter continuously monitors the concentration of different gases either by passive diffusion or by an active pump. O2 is measured with a capillary controlled concentration sensor, combustibles with a plug-in catalytic bead, VOCs with a photo-ionization detector (PID), and other gases with electrochemical cells. The PID uses a 10.6 eV lamp to ionize organic compounds.

C. Safety/Hazards

Care should be taken when handling the calibration gas cylinders, especially while the regulator is attached. Consult the Chemical Hygiene Plan for more information on how to handle highly-pressurized cylinders.

The calibration gas mix used to calibrate the H_2S, CO, %LEL, and O_2 sensors contains a harmful concentration of H_2S (25ppm) and CO (100ppm). The calibration mix to calibrate the VOC sensor contains isobutylene (2-methylpropene), which is flammable. Calibration must be done under the hood.

The analyst should wear protective clothing and safety glasses

If a hazardous gas concentration is detected in room air, evacuate the laboratory. Notify the chemical hygiene officer (CHO), the Bellevue Health and Safety Coordinator, or the ETL Director. Consult the chemical hygiene plan (CHP) for the appropriate response to the hazardous gas.

When using the meter, any rapid up-scaling reading followed by a declining or erratic reading may indicate a gas concentration beyond the upper scale limit, which may indicate a hazardous condition.

D. Equipment and Instruments

Four Gas Meter, BW Technologies Model Gas Alert Micro 5 PID

E. INTERFERENCES

The meter will work properly until the battery is completely depleted and the meter powers off. A number of interferences should be taken into account when using this meter.

- Moisture is a potential interference for both the %LEL and PID sensors. Therefore, prior to sampling, check and make sure there is an in-line filter present at the pump inlet.
- Hydrogen and alcohols may cause the CO sensor to give a false-positive reading.
- Methanol may cause the H_2S sensor to give a false-positive reading.
- Higher hydrocarbons, alcohols, ketones, esters, hydrogen sulfide, and other sulfur containing compounds may interfere with the %LEL sensor, i.e. such interferences may cause the %LEL sensor of the GasAlertMicro5+PID meter to give a false positive of explosive gases.

The PID's lamp energy is 10.6ev, which means it is capable of ionizing almost all organic materials. However, there are some organic materials such as a few of the freons, methane, ethane, and propane that are not ionized and thus not detected. Therefore, before conducting an actual experiment or field work, please consult the CRC's Handbook of Chemistry and Physics or the Chemical Table on CDM's Health and Safety webpage the for a complete list of ionization potentials.

F. RESTRICTIONS/LIMITATIONS

Calibration should be performed only by the CHO or their designee. If any sensor is past due for calibration, notify the CHO and do not use the meter until it has been calibrated.

G. REAGENTS AND CHEMICALS

Name	Description
Calibration Gas Mix	A 25ppm H_2S, 100ppm CO, 50% LEL (2.5% CH_4), 18% O_2 and balanced N_2 calibration gas mixture should be used to calibrate the H_2S, CO, %LEL, and O_2 sensors.
PID Calibration Gas	A 100ppm C_4H_8 (isobutylene) and balanced N_2 calibration gas mixture should be used to calibrate the PID sensor.

H. Quality Control

Commercially-prepared cylinders of calibration gas are used to calibrate the GasAlertMicro5+PID monthly. Should the instrument's reading be off the desired readings more than 10% after calibration, recalibrate until within this range.

If any problems are encountered, please consult the troubleshooting section of the user's manual. If problems persist, immediately stop all work in which safety relies on the meter, mark the meter as out of service by placing tape across the front which states "Meter Not Working: Do Not Use" along with the date and your initials. Immediately contact the Chemical Hygiene Officer (CHO), the Bellevue Health and Safety Coordinator, or the ETL Director.

I. Quality Records

The calibration date and calibration gases used should be recorded in the Monthly Lab Safety Audit checklist. Any problems encountered or maintenance performed should be recorded in the equipment management spreadsheet.

A calibration check will be performed prior to each day's use, and the results recorded in the appropriate project notebook. If the calibration-check readings are more than 10% different from the calibration gas concentrations, the meter will be recalibrated before use.

J. Procedures

Instrument Start-Up

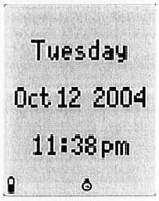
To turn the unit on, press the power button ⏻ with the unit in a clean atmosphere. When the detector is activated, it performs a self-test and a pump test.

a. Self-test

1. All of the LCD elements display simultaneously as the detector beeps, flashes, vibrates, and briefly activates the backlight.

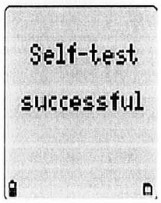
2. The version and serial number of the detector displays.

3. The date and time displays.



4. The detector then runs a self-test to verify the sensors and power supply.

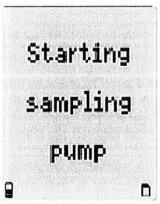
5. **Self-test Successful:** If successful, the following screen displays.

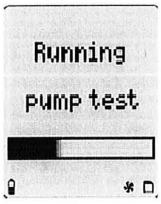


b. The TWA, STEL, low, and high alarm setpoints then display.

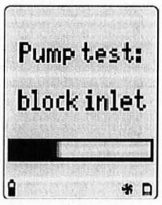
c. **<u>Pump test</u>**

1. If the pump module is attached to the detector, the following screens display.

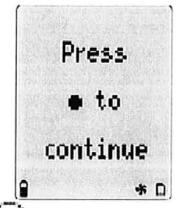


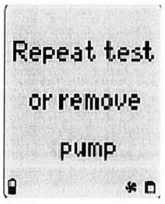


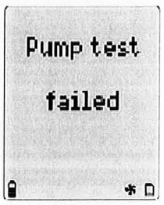
2. When the following screen displays, block the pump inlet with finger.



3. If the pump inlet is not blocked within 10 seconds or the pump test fails, the following screens display.

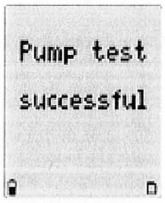






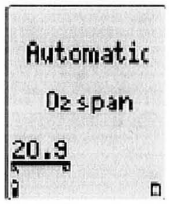
4. If ○ is not pressed or the pump is not removed within 25 seconds, the detector performs the pump test again.

5. If the pump test is successful, the following screen displays and the self-test continues.

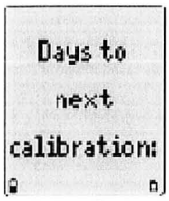


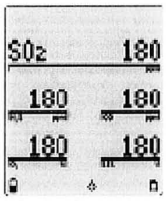
6. The oxygen (O_2) sensor is calibrated automatically.

If the span is successful, the detector beeps twice.

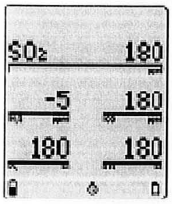


7. The number of days remaining before calibration is due is displayed for all sensors.





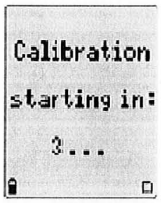
8. If any sensor is past due for calibration, the name of the sensor and the number of days past due display. Notify the CHO and do not use the meter until it has been calibrated.



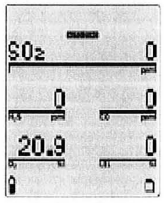
Calibration

Calibration will be performed monthly by the CHO or their designee.

1. In a clean atmosphere outside of the fume hood, press and hold ◯ and ▼ simultaneously (as the detector beeps and flashes to the corresponding countdown) to enter calibration. The detector then reads starting calibration.



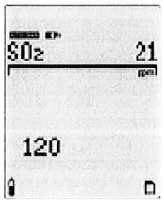
2. AUTO-ZERO flashes in the top center of the display while the detector zeroes all of the sensors and calibrates the oxygen sensor. If a sensor failed to auto zero, it will bypass the span.



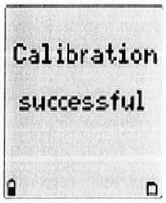
3. Next, the following three screens appear:
-Apply span gas now to calibrate
-or press ◯ to select sensor(s)
-or press ⓜ to skip calibration

4. Attach the calibration tube and apply gas at a flow rate of 500 mL/min. ■ flashes at the top left corner of the display as the unit senses which gas is being applied. If you wait too long, the unit will exit Calibration Mode.

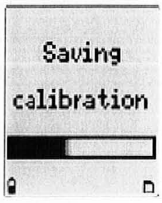
After 30 seconds, AUTO-SPAN flashes and a countdown appears while the unit completes the span. This step takes ~ 2 minutes.



5. One the span is complete, the following three screens appear:
-Calibration successful
-Press ▼ to apply a new cal gas
-Press ▲ to end span
Repeat steps #3-6 to calibrate the remaining sensors.



6. Saving calibration displays to indicate that calibration is complete.



7. Remove the calibration line and close the calibration gas regulator.

8. Record calibration results in the Monthly Lab Safety Audit checklist.

Calibration Checks

- Calibration checks should be performed prior to each use.
- Calibration checks are performed by connecting the unit to both types of calibration gas (see Reagents and Chemicals section) and recording the stabilized readings.
- If the readings are more than 10% different from the calibration gas concentrations, recalibration is required. Notify the CHO that recalibration is necessary, and do not use the meter until it has been calibrated.
- Record results of calibration checks in the appropriate project notebook.

Sample analysis

- Once calibrated, the GasAlertMicro5+PID is ready for sample analysis by directing the meter's detection probe to a potential source of hazardous gas until a stable reading is obtained.
- The unit will alarm if concentrations of hazardous gas above the alarm set-points are detected. If lab room air is at hazardous levels, evacuate the lab and notify the CHO, the Bellevue Health

and Safety Coordinator, or the ETL Director. Consult the CHP for the appropriate response to the hazardous gas.

K. Interpretation and Results

The meter will display detected concentrations. If concentrations go over the set-points, the unit will alarm and vibrates at the same time.

L. Training

In order to be considered proficient at the procedures explained in this document, laboratory staff must have:

- Read and understood the content of this SOP
- Performed the operations under supervision
- Been verified as trained by ETL Management

M. References

1. GasAlertMicro 5 and GasAlertMicro 5 PID User Manual

Document History

Revision	Approval Date	Changes	Retirement Date
1	06/20/2011	New document	

White Chemical Corporation Superfund Site
OU3-Groundwater RI/FS
Newark, NJ
Field Change Request

Date: July 7, 2011

Request No.: BSTS-2

FCR Title: Change to Bioreactor Bottle Size

Description: The treatability study is originally designed to include two (2) 500 milliliter (ml) test bottles for each of the eight test conditions. This field change request describes the change to the bottle setup for each test condition from two (2) 500-ml bottles to three (3) 250-ml bottles. Revised Tables 1 and 2 from the work plan are attached.

Reason for Deviation: The 500-ml bottles ordered on May 20th are on back-order, and the manufacturer cannot guarantee a delivery date. They will not be available in time to start the bench test; therefore, 250-ml bottles, which are available, will be used for the set up in place of the 500-ml bottles.

Recommended/Modification: The project team recommends using three (3) 250-ml bottles for each test condition instead of the two (2) 500-ml bottles. For each 3-bottle set:

- *The first two* bottles will be analyzed as previously described in the Bench Scale Treatability Study QAPP Addendum, with the exception that no aqueous CLP samples will be collected at the end of the test..
- *The third bottle* will be sampled as follows: 1) initially at the same time as the other two bottles (two days after the start of the test and after the addition of culture) and analyzed by CDM's laboratory for VOCs; and 2) two samples at the end of the tests for VOC analysis: one to be analyzed by CDM's laboratory; and one to be analyzed by a CLP laboratory.

Impact on Data Quality Objectives: The purpose of using two (2) 500-ml bottles was to provide sufficient volume for the collection of a CLP sample from each test bottle at the completion of the treatability study; the use of three (3) 250-ml bottles will still provide enough volume to collect the planned samples. The results from the CLP laboratory will be compared to the analytical results from CDM's laboratory for quality assurance purposes. The recommended approach will not impact the data quality objective because it allows the comparison of analytical results from the CLP laboratory and the CDM laboratory.

USACE Contract No.: W912DQ-08-D-0018

Task Order No.: 006

Signatures:

Grace Chen, CDM Treatability Study Task Manager

Kathy Baker, USACE Project Manager

Sharon Budney, CDM Project Manager

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White Chemical Field Team

Revised Table 1 – Bench Study Set-up

Test ID	Amendment(s)	Bottle Size (mL)	Weight of Contaminated Soil (g)	Groundwater (mL)	Target Concentration (mg/L)	Duration
1	Lactate + whey + No Culture	250	75	150	2,500 mg/L lactate + 2,500 mg/L whey	Approximately 5 months
2	Lactate + whey + Culture SDC-9 and TCA-20	250	75	150	2,500 mg/L lactate + 2,500 mg/L whey + 5mL (SDC-9 + TCA-20)	Approximately 3 months
3	EOS 598 + No Culture	250	75	150	5,000 mg oil/L EOS	Approximately 5 months
4	EOS 598 + Culture SDC-9 and TCA-20	250	75	150	5,000 mg oil/L EOS + 5mL (SDC-9 + TCA-20)	Approximately 3 months
5	EHC®	250	75	150	0.75 g	Approximately 3 months
6	EHC® + Culture SDC-9 and TCA-20	250	75	150	0.75 g + 2.5mL (SDC-9+TCA-20)	Approximately 3 months
7	Culture SDC-9 and TCA-20 Control	250	75	150	2.5mL (SDC-9 + TCA-20)	Approximately 5 months
8	No Culture Control	250	75	150	None	Approximately 5 months

Notes: mL: milliliter; g: gram; mg/L: milligram per liter.

Revised Table 2 – Sampling and Analysis Schedule

Analyte(s)	Method	Frequency	Purposes of Analyte
TCL VOCs (GW) to be analyzed in a CLP laboratory	SOM01.2	One groundwater sample as received prior to start up of the tests	Initial groundwater contaminant concentrations prior to the bench tests
Medium VOCs (Soil) to be analyzed in a CLP laboratory	SOM01.2	Three soil samples prior to start up the tests	The averaged value will represent the initial soil contaminant concentrations prior to the bench tests
Halogenated VOCs*	EPA 8260 (Gas chromatography with mass selective detection)	1) Groundwater sample as received 2) 3) primary and secondary test bottles at two days and every two weeks for three to five months 4) tertiary test bottles at two days and endpoint	Monitoring the progress of contaminant degradation
Methane, ethene, ethane, and acetylene (MEEA)	RSKSOP-175 (Gas chromatography with flame ionization detection)	Primary and secondary test bottles at two days and then every two weeks for three to five months	Monitoringthe degradation products (ethene, ethane, and acetylene) and the oxidation-reduction status of the reaction (methane)
Ferrous iron	HACH 8146 (Colorimetric phenanthroline method)	Primary and secondary test bottles at two days and then every two weeks for three to five months	Monitor the oxidation-reduction status of the reaction
Sulfate and Chloride	EPA 300.0 (ion chromatography)	Primary and secondary test bottles at two days and then every two weeks for three to five months	Monitoring the oxidation-reduction status of the reaction; chloride for the evaluation of dechlorination

Revised Table 2 – Sampling and Analysis Schedule

Analyte(s)	Method	Frequency	Purposes of Analyte
Chemical oxygen demand (COD)	HACH 8000 (Colorimetric heated persulfate oxidation)	Primary and secondary test bottles at two days, and then every two weeks for three to five months	Monitoring to ensure that sufficient electron donor is present
pH	EPA 150.1 (pH probe)	Primary and secondary test bottles at two days, and then every two weeks for three to five months	Monitoring the pH range to ensure it is suitable for biodegradation reactions
ORP	SM 2580B (ORP probe using a microelectrode	Primary and secondary test bottles at two days, and then every two weeks for three to five months	For evaluation if suitable oxidation-reduction potential has been achieved for complete biodegradation of contaminants.
TCL VOC or trace VOCs (GW) to be analyzed in a CLP laboratory	SOM01.2	At the conclusion of the tests only from the tertiary set of bottles	For confirmation and comparison of contaminant concentrations at the end of the tests.
Low VOCs (soil)	SOM01.2	At the conclusion of the tests from the primary and secondary bottles	To determine the soil contaminant concentrations at the end of the tests.

Notes:

* Halogenated VOCs include TCE, 1,2-DCA, 1,1,2-TCA, cis-1,2-DCE, VC, and 1,2-dibromoethane etc.
SM – Standard Methods
RSKSOP – U.S. EPA Robert S. Kerr Laboratory Standard Operating Procedure
1. MEEA sample will be collected directly from the headspace of batch reactors
Sample matrix is water unless otherwise noted.

2. All analyses done at CDM Bellevue laboratory unless otherwise noted.

3. Three sets of test bottles for each test condition. The primary and secondary bottles will be sampled regularly throughout the test and the tertiary set of bottles will be treated in the same manner but only sampled at the beginning and the end for VOCs.

White Chemical Corporation Superfund Site
OU3-Groundwater RI/FS
Newark, NJ
Field Change Request

Date: October 25, 2011

Request No.: BSTS-3

FCR Title: Second Bioaugmentation

Description: The reductive dechlorination culture SDC-9 from The Shaw Group Inc, will be added into test bottles for conditions #2 and #6. The next round of samples will be collected four weeks after this bioaugmentation.

Reason for Deviation: After 10 weeks of incubation, test conditions #2 (lactate+whey+culture) and #6 (EHC+culture) have shown the best contaminant degradation. More than 82 percent decrease of 1,2-DCA was achieved under condition#2; and more than 99 percent decrease of 1,2-DCA was achieved under condition #6. However, TCE degradation lagged behind. The average decreases of TCE under test conditions #2 and #6 were 67 percent and 60 percent, respectively. The degradation of TCE appears to be inhibited for unknown reasons.

Recommended/Modification: CDM plans to conduct bioaugmenation in test bottles for conditions #2 and #6 using the TCE degrading culture SDC-9 to understand if the bacteria are somehow compromised by the initial geochemistry.

Impact on Data Quality Objectives: This will ensure that the data quality objectives are met by promoting the biological degradation of TCE and providing data for the analysis of the cause of the slowed TCE degradation.

USACE Contract No.: W912DQ-08-D-0018

Task Order No.: 006

Signatures:

Grace Chen, CDM Treatability Study Task Manager

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Jeniffer Oxford, CDM QA Coordinator
Bill Sy, EPA QA Officer
Lisa Campbell, CDM RI Task Manager
White Chemical Field Team

Appendix B

CLP/DESA Laboratory Results

Table B-1
Baseline Groundwater Sample Results by a CLP Laboratory
White Chemical Corporation Superfund Site
Newark, New Jersey

			Sample Identification	BLGW-CLP	BLGW-1B1
			Sample Name	Baseline GW	Trip Blank
			Sample Date	7/12/2011	7/12/2011
cas_rn	chemical_name	analytic_method	result_unit		
71-55-6	1,1,1-TRICHLOROETHANE	E624	µg/L	1.7 J	5 U
79-34-5	1,1,2,2-TETRACHLOROETHANE	E624	µg/L	5 U	5 U
76-13-1	1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE	E624	µg/L	5 UJ	5 U
79-00-5	1,1,2-TRICHLOROETHANE	E624	µg/L	3200	5 U
75-34-3	1,1-DICHLOROETHANE	E624	µg/L	5.1	5 U
75-35-4	1,1-DICHLOROETHENE	E624	µg/L	1100	5 U
87-61-6	1,2,3-TRICHLOROBENZENE	E624	µg/L	5 U	5 U
120-82-1	1,2,4-TRICHLOROBENZENE	E624	µg/L	5 U	5 U
96-12-8	1,2-DIBROMO-3-CHLOROPROPANE	E624	µg/L	11	5 U
106-93-4	1,2-Dibromoethane (EDB)	E624	µg/L	5000	5 U
95-50-1	1,2-DICHLOROBENZENE	E624	µg/L	5 U	5 U
107-06-2	1,2-DICHLOROETHANE	E624	µg/L	160000 J	5 U
78-87-5	1,2-DICHLOROPROPANE	E624	µg/L	5 U	5 U
541-73-1	1,3-DICHLOROBENZENE	E624	µg/L	5 U	5 U
106-46-7	1,4-DICHLOROBENZENE	E624	µg/L	5 U	5 U
123-91-1	1,4-DIOXANE	E624	µg/L	100 U	100 U
78-93-3	2-BUTANONE (MEK)	E624	µg/L	10 U	10 U
591-78-6	2-HEXANONE	E624	µg/L	10 U	10 U
108-10-1	4-METHYL-2-PENTANONE (MIBK)	E624	µg/L	10 U	10 U
67-64-1	ACETONE	E624	µg/L	10 U	1.9 J
71-43-2	BENZENE	E624	µg/L	5 UJ	5 U
74-97-5	BROMOCHLOROMETHANE	E624	µg/L	5 U	5 U
75-27-4	BROMODICHLOROMETHANE	E624	µg/L	2.4 J	5 U
75-25-2	BROMOFORM	E624	µg/L	5 U	5 U
74-83-9	BROMOMETHANE	E624	µg/L	5 U	5 U
75-15-0	Carbon Disulfide	E624	µg/L	5 U	5 U
56-23-5	CARBON TETRACHLORIDE	E624	µg/L	2.3 J	5 U
108-90-7	Chlorobenzene	E624	µg/L	5 U	5 U
75-00-3	Chloroethane	E624	µg/L	5 U	5 U
67-66-3	CHLOROFORM	E624	µg/L	21	5 U
74-87-3	CHLOROMETHANE	E624	µg/L	2.5 J	5 U

Table B-1
Baseline Groundwater Sample Results by a CLP Laboratory
White Chemical Corporation Superfund Site
Newark, New Jersey

			Sample Identification	BLGW-CLP	BLGW-1B1
			Sample Name	Baseline GW	Trip Blank
			Sample Date	7/12/2011	7/12/2011
cas_rn	chemical_name	analytic_method	result_unit		
156-59-2	CIS-1,2-DICHLOROETHENE	E624	µg/L	22 J	5 U
10061-01-5	CIS-1,3-DICHLOROPROPENE	E624	µg/L	5 U	5 U
110-82-7	Cyclohexane	E624	µg/L	5 U	5 U
124-48-1	DIBROMOCHLOROMETHANE	E624	µg/L	5 U	5 U
75-71-8	DICHLORODIFLUOROMETHANE	E624	µg/L	5 U	5 U
100-41-4	ETHYLBENZENE	E624	µg/L	5 U	5 U
98-82-8	ISOPROPYLBENZENE	E624	µg/L	5 U	5 U
179601-23-1	m,p-Xylene	E624	µg/L	5 U	5 U
79-20-9	Methyl Acetate	E624	µg/L	5 UJ	5 U
1634-04-4	METHYL TERT-BUTYL ETHER (MTBE)	E624	µg/L	5 UJ	5 U
108-87-2	Methylcyclohexane	E624	µg/L	5 U	5 U
75-09-2	METHYLENE CHLORIDE	E624	µg/L	5 UJ	5 U
95-47-6	O-XYLENE	E624	µg/L	5 U	5 U
100-42-5	STYRENE	E624	µg/L	5 U	5 U
127-18-4	TETRACHLOROETHENE	E624	µg/L	320	5 U
108-88-3	TOLUENE	E624	µg/L	5 U	5 U
156-60-5	TRANS-1,2-DICHLOROETHENE	E624	µg/L	9.5 J	5 U
10061-02-6	TRANS-1,3-DICHLOROPROPENE	E624	µg/L	5 U	5 U
79-01-6	TRICHLOROETHENE	E624	µg/L	2200	5 U
75-69-4	TRICHLOROFLUOROMETHANE	E624	µg/L	5 UJ	5 U
75-01-4	VINYL CHLORIDE	E624	µg/L	440	5 U

Notes
CLP: contract laboratory program
J: estimated result
U: non detect
UJ: estimated but non-detected result

Table B-2
Final Aqueous Sampling Results from C bottle of Eeach Test Condition
White Chemical Corporation Superfund Site
Newark, New Jersey

		Sample Identification	WCC-1-C-F	WCC-2-C-F	WCC-3-C-F	WCC-4-C-F	WCC-5-C-F	WCC-6-C-F	WCC-7-C-F	WCC-8-C-F
		Test Condition	WCC-1	WCC-2	WCC-3	WCC-4	WCC-5	WCC-6	WCC-7	WCC-8
		Sample Date	12/14/2011	12/14/2011	12/14/2011	12/14/2011	12/14/2011	12/14/2011	12/14/2011	12/14/2011
cas_rn	chemical_name	result_unit								
71-55-6	1,1,1-TRICHLOROETHANE	µg/L	5 U	5 U	500 U	500 U	5 U	5 U	500 U	500 UJ
79-34-5	1,1,2,2-TETRACHLOROETHANE	µg/L	5 U	5 U	500 U	500 U	5 U	5 U	500 U	500 UJ
76-13-1	1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE	µg/L	5 U	5 U	500 U	500 U	5 U	5 U	500 U	500 UJ
79-00-5	1,1,2-TRICHLOROETHANE	µg/L	2400	2500	3000	2100	5 U	5 U	2000	2100 J
75-34-3	1,1-DICHLOROETHANE	µg/L	5 U	5 U	500 U	500 U	5 U	5 U	500 U	500 UJ
75-35-4	1,1-DICHLOROETHENE	µg/L	450	5 U	500 U	500 U	260 J	5 U	500 U	500 UJ
87-61-6	1,2,3-TRICHLOROBENZENE	µg/L	5 U	5 U	500 U	500 U	5 U	5 U	500 U	500 UJ
96-18-4	1,2,3-TRICHLOROPROPANE	µg/L	100 NJ	100 NJ						
120-82-1	1,2,4-TRICHLOROBENZENE	µg/L	5 U	5 U	500 U	500 U	5 U	5 U	500 U	500 UJ
96-12-8	1,2-DIBROMO-3-CHLOROPROPANE	µg/L	5 U	5 U	500 U	500 U	5 U	5 U	500 U	500 UJ
106-93-4	1,2-Dibromoethane (EDB)	µg/L	5 U	5 U	4100	2400	7.4	5 U	2400	3200 J
95-50-1	1,2-DICHLOROBENZENE	µg/L	5 U	5 U	500 U	500 U	5 U	5 U	500 U	500 UJ
107-06-2	1,2-DICHLOROETHANE	µg/L	330	19	200000	150000	180	33	130000	120000 J
78-87-5	1,2-DICHLOROPROPANE	µg/L	5 U	5 U	500 U	500 U	5 U	5 U	500 U	500 UJ
541-73-1	1,3-DICHLOROBENZENE	µg/L	5 U	5 U	500 U	500 U	5 U	5 U	500 U	500 UJ
142-28-9	1,3-DICHLOROPROPANE	µg/L					10 NJ			
106-46-7	1,4-DICHLOROBENZENE	µg/L	5 U	5 U	500 U	500 U	5 U	5 U	500 U	500 UJ
107-04-0	1-Bromo-2-chloroethane	µg/L			16 NJ	20000 NJ	13000 NJ		14000 NJ	24 J
78-93-3	2-BUTANONE (MEK)	µg/L	92	3700	1000 U	1000 U	14	37	1000 U	1000 UJ
591-78-6	2-HEXANONE	µg/L	10 U	10 U	1000 U	1000 U	10 U	10 U	1000 U	1000 UJ
78-83-1	2-Methyl-1-Propanol	µg/L	38 NJ							
108-10-1	4-METHYL-2-PENTANONE (MIBK)	µg/L	10 U	10 U	1000 U	1000 U	10 U	10 U	1000 U	1000 UJ
67-64-1	ACETONE	µg/L	19 K	14 K	1000 U	1000 U	20 K	18 K	1000 U	1000 UJ
71-43-2	BENZENE	µg/L	5 U	5 U	500 U	500 U	5 U	5 U	500 U	500 UJ
74-97-5	BROMOCHLOROMETHANE	µg/L	5 U	5 U	500 U	500 U	5 U	5 U	500 U	500 UJ
75-27-4	BROMODICHLOROMETHANE	µg/L	5 U	5 U	500 U	500 U	5 U	5 U	500 U	500 UJ
75-25-2	BROMOFORM	µg/L	5 U	5 U	500 U	500 U	5 U	5 U	500 U	500 UJ
74-83-9	BROMOMETHANE	µg/L	5 U	5 U	500 U	500 U	5 U	5 U	500 U	500 UJ
75-15-0	Carbon Disulfide	µg/L	5 U	5 U	500 U	500 U	5 U	5 U	500 U	500 UJ
56-23-5	CARBON TETRACHLORIDE	µg/L	5 U	5 U	500 U	500 U	5 U	5 U	500 U	500 UJ
108-90-7	Chlorobenzene	µg/L	5 U	5 U	500 U	500 U	5 U	5 U	500 U	500 UJ
75-00-3	Chloroethane	µg/L	9.9	5 U	500 U	500 U	26	5.5	500 U	500 UJ
67-66-3	CHLOROFORM	µg/L	5 U	5.7	500 U	500 U	5 U	5 U	500 U	500 UJ
74-87-3	CHLOROMETHANE	µg/L	5 U	5 U	500 U	500 U	5 U	5 U	500 U	500 UJ
156-59-2	CIS-1,2-DICHLOROETHENE	µg/L	5 U	5 U	500 U	500 U	430	5 U	500 U	500 UJ
10061-01-5	CIS-1,3-DICHLOROPROPENE	µg/L	5 U	5 U	500 U	500 U	5 U	5 U	500 U	500 UJ
110-82-7	Cyclohexane	µg/L	5 U	5 U	500 U	500 U	5 U	5 U	500 U	500 UJ
124-48-1	DIBROMOCHLOROMETHANE	µg/L	5 U	5 U	500 U	500 U	5 U	5 U	500 U	500 UJ
75-71-8	DICHLORODIFLUOROMETHANE	µg/L	5 U	5 U	500 U	500 U	5 U	5 U	500 U	500 UJ
3658-80-8	Dimethyl trisulfide	µg/L					16 NJ			
101-84-8	Diphenyl Ether (Phenylether)	µg/L	76 NJ	83 NJ			64 NJ	55 NJ		
100-41-4	ETHYLBENZENE	µg/L	5 U	5 U	500 U	500 U	5 U	5 U	500 U	500 UJ

Table B-2
Final Aqueous Sampling Results from C bottle of Eeach Test Condition
White Chemical Corporation Superfund Site
Newark, New Jersey

		Sample Identification	WCC-1-C-F	WCC-2-C-F	WCC-3-C-F	WCC-4-C-F	WCC-5-C-F	WCC-6-C-F	WCC-7-C-F	WCC-8-C-F
		Test Condition	WCC-1	WCC-2	WCC-3	WCC-4	WCC-5	WCC-6	WCC-7	WCC-8
		Sample Date	12/14/2011	12/14/2011	12/14/2011	12/14/2011	12/14/2011	12/14/2011	12/14/2011	12/14/2011
cas_rn	chemical_name	result_unit								
98-82-8	ISOPROPYLBENZENE	µg/L	5 U	5 U	500 U	500 U	5 U	5 U	500 U	500 UJ
79-20-9	Methyl Acetate	µg/L	5 U	5 U	500 U	500 U	5 U	5 U	500 U	500 UJ
624-92-0	Methyl Disulfide	µg/L	110 NJ	52 NJ			99 NJ	6.2 NJ		
110-43-0	Methyl n-Amyl Ketone	µg/L						6.9 NJ		
1634-04-4	METHYL TERT-BUTYL ETHER (MTBE)	µg/L	5 U	5 U	500 U	500 U	5 U	5 U	500 U	500 UJ
108-87-2	Methylcyclohexane	µg/L	5 U	5 U	500 U	500 U	5 U	5 U	500 U	500 UJ
75-09-2	METHYLENE CHLORIDE	µg/L	7.1	6.4	500 U	500 U	5 U	5 U	500 U	500 UJ
56-04-2	Methylthiouracil	µg/L		46 NJ			10 NJ	25 NJ		
95-47-6	O-XYLENE	µg/L	5 U	5.1	500 U	500 U	5 U	5 U	500 U	500 UJ
115-07-1	Propylene (Propene)	µg/L					16 NJ	15 NJ		
100-42-5	STYRENE	µg/L	5 U	5 U	500 U	500 U	5 U	5 U	500 U	500 UJ
7446-09-5	Sulfur Dioxide	µg/L		22 NJ						
127-18-4	TETRACHLOROETHENE	µg/L	140	28	500 U	500 U	7.6	5 U	500 U	500 UJ
108-88-3	TOLUENE	µg/L	5 U	5 U	500 U	500 U	5 U	5 U	500 U	500 UJ
1330-20-7	Total Xylenes	µg/L	11	12	500 U	500 U	10	9.6	500 U	500 UJ
156-60-5	TRANS-1,2-DICHLOROETHENE	µg/L	10	11	500 U	500 U	49	5 U	500 U	500 UJ
10061-02-6	TRANS-1,3-DICHLOROPROPENE	µg/L	5 U	5 U	500 U	500 U	5 U	5 U	500 U	500 UJ
79-01-6	TRICHLOROETHENE	µg/L	1300	5 U	990	550	160	5 U	790	500 UJ
75-69-4	TRICHLOROFLUOROMETHANE	µg/L	5 U	5 U	500 U	500 U	5 U	5 U	500 U	500 UJ
75-01-4	VINYL CHLORIDE	µg/L	520	12	500 U	500 U	650	5 U	500 U	500 UJ

Notes:
J: estimated result
U: non-detect
UJ: estimated but non-detected
NJ: tentatively identified, estimated
K: biased high

Table B-3
Baseline Soil Results by a CLP Laboratory
White Chemical Corporation Superfund Site
Newark, New Jersey

		Sample Identification	BLGW-CLP-1	BLGW-CLP-2	BLGW-CLP-3
		Sample Name	Baseline Soil-1	Baseline Soil-2	Baseline Soil-3
		Sample Date	7/12/2011	7/12/2011	7/12/2011
cas_rn	chemical_name	result_unit			
71-55-6	1,1,1-TRICHLOROETHANE	µg/kg	5.1 U	5.9 U	5 U
79-34-5	1,1,2,2-TETRACHLOROETHANE	µg/kg	39	48	41
76-13-1	1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE	µg/kg	5.1 U	5.9 U	5 U
79-00-5	1,1,2-TRICHLOROETHANE	µg/kg	9.5	16	13
75-34-3	1,1-DICHLOROETHANE	µg/kg	5.1 U	5.9 U	5 U
75-35-4	1,1-DICHLOROETHENE	µg/kg	5.1 U	5.9 U	5 U
87-61-6	1,2,3-TRICHLOROBENZENE	µg/kg	5.1 U	5.9 U	5 U
120-82-1	1,2,4-TRICHLOROBENZENE	µg/kg	5.1 U	5.9 U	5 U
96-12-8	1,2-DIBROMO-3-CHLOROPROPANE	µg/kg	5.1 U	5.9 U	5 U
106-93-4	1,2-Dibromoethane (EDB)	µg/kg	11	17 J	14 J
95-50-1	1,2-DICHLOROBENZENE	µg/kg	5.1 U	5.9 U	5 U
107-06-2	1,2-DICHLOROETHANE	µg/kg	1000	500	690
78-87-5	1,2-DICHLOROPROPANE	µg/kg	5.1 U	5.9 U	5 U
541-73-1	1,3-DICHLOROBENZENE	µg/kg	5.1 U	5.9 U	5 U
106-46-7	1,4-DICHLOROBENZENE	µg/kg	5.1 U	5.9 U	5 U
123-91-1	1,4-DIOXANE	µg/kg	100 R	120 R	99 R
78-93-3	2-BUTANONE (MEK)	µg/kg	10 UJ	12 UJ	9.9 UJ
591-78-6	2-HEXANONE	µg/kg	10 UJ	12 UJ	9.9 UJ
108-10-1	4-METHYL-2-PENTANONE (MIBK)	µg/kg	10 UJ	12 UJ	9.9 UJ
67-64-1	ACETONE	µg/kg	10 U	12 U	9.9 U
71-43-2	BENZENE	µg/kg	5.1 U	5.9 U	5 U
74-97-5	BROMOCHLOROMETHANE	µg/kg	5.1 U	5.9 U	5 U
75-27-4	BROMODICHLOROMETHANE	µg/kg	5.1 U	5.9 U	5 U
75-25-2	BROMOFORM	µg/kg	5.1 U	5.9 U	5 U
74-83-9	BROMOMETHANE	µg/kg	5.1 U	5.9 U	5 U
75-15-0	Carbon Disulfide	µg/kg	5.1 U	5.9 U	5 U
56-23-5	CARBON TETRACHLORIDE	µg/kg	5.1 U	5.9 U	5 U
108-90-7	Chlorobenzene	µg/kg	5.1 U	5.9 U	5 U
75-00-3	Chloroethane	µg/kg	5.1 U	5.9 U	5 U
67-66-3	CHLOROFORM	µg/kg	5.1 U	5.9 U	5 U
74-87-3	CHLOROMETHANE	µg/kg	5.1 U	5.9 U	5 U
156-59-2	CIS-1,2-DICHLOROETHENE	µg/kg	5.1 U	1.1 J	5 U
10061-01-5	CIS-1,3-DICHLOROPROPENE	µg/kg	5.1 U	5.9 U	5 U
110-82-7	Cyclohexane	µg/kg	5.1 U	5.9 U	5 U
124-48-1	DIBROMOCHLOROMETHANE	µg/kg	5.1 U	5.9 U	5 U
75-71-8	DICHLORODIFLUOROMETHANE	µg/kg	5.1 U	5.9 U	5 U
100-41-4	ETHYLBENZENE	µg/kg	5.1 U	5.9 U	5 U
98-82-8	ISOPROPYLBENZENE	µg/kg	5.1 U	5.9 U	5 U
179601-23-1	m,p-Xylene	µg/kg	5.1 U	5.9 U	5 U
79-20-9	Methyl Acetate	µg/kg	5.1 UJ	5.9 UJ	5 UJ
1634-04-4	METHYL TERT-BUTYL ETHER (MTBE)	µg/kg	5.1 U	5.9 U	5 U
108-87-2	Methylcyclohexane	µg/kg	5.1 U	5.9 U	5 U
75-09-2	METHYLENE CHLORIDE	µg/kg	5.1 U	5.9 U	5 U
95-47-6	O-XYLENE	µg/kg	5.1 U	5.9 U	5 U
100-42-5	STYRENE	µg/kg	5.1 U	5.9 U	5 U
127-18-4	TETRACHLOROETHENE	µg/kg	1.4 J	3 J	2.4 J
108-88-3	TOLUENE	µg/kg	5.1 U	5.9 U	5 U
156-60-5	TRANS-1,2-DICHLOROETHENE	µg/kg	5.1 U	5.9 U	5 U
10061-02-6	TRANS-1,3-DICHLOROPROPENE	µg/kg	5.1 U	5.9 U	5 U
79-01-6	TRICHLOROETHENE	µg/kg	2.6 J	6.7	5.6
75-69-4	TRICHLOROFLUOROMETHANE	µg/kg	5.1 U	5.9 U	5 U
75-01-4	VINYL CHLORIDE	µg/kg	5.1 U	5.9 U	5 U

Notes:

J: estimated results

U: non-detect

UJ: estimated but non-detected

R: rejected

Table B-4
Final Soil Results from DESA
White Chemical Corporation Superfund Site
Newark, New Jersey

		Sample Identification	WCC-1-C-FS	WCC-2-C-FS	WCC-3-C-FS	WCC-4-C-FS	WCC-5-C-FS	WCC-6-C-FS	WCC-7-C-FS	WCC-8-C-FS
		Sample Name	WCC-1	WCC-2	WCC-3	WCC-4	WCC-5	WCC-6	WCC-7	WCC-8
		Sample Date	12/14/2011	12/14/2011	12/14/2011	12/14/2011	12/14/2011	12/14/2011	12/14/2011	12/14/2011
cas_rn	chemical_name	result_unit								
71-55-6	1,1,1-TRICHLOROETHANE	µg/kg	4.6 U	5.3 U	6.4 U	5.2 U	6.1 U	6 U	5.4 U	5.7 U
79-34-5	1,1,2,2-TETRACHLOROETHANE	µg/kg	4.6 UJ	5.3 UJ	6.4 UJ	5.2 UJ	6.1 UJ	6 UJ	5.4 UJ	5.7 UJ
76-13-1	1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE	µg/kg	4.6 U	5.3 U	6.4 UL	5.2 UL	6.1 U	6 U	5.4 UL	5.7 UL
79-00-5	1,1,2-TRICHLOROETHANE	µg/kg	720 J	370 J	650 L	690 L	6.1 UL	6 UL	470 J	350 J
75-34-3	1,1-DICHLOROETHANE	µg/kg	4.6 U	5.3 U	6.4 UL	5.2 UL	6.1 U	6 U	5.4 UL	5.7 UL
75-35-4	1,1-DICHLOROETHENE	µg/kg	140	5.3 U	180 L	110 L	30	6 U	64 L	48 L
87-61-6	1,2,3-TRICHLOROBENZENE	µg/kg	4.6 UJ	5.3 UJ	6.4 UJ	5.2 UJ	6.1 UL	6 UL	5.4 UJ	5.7 UJ
96-18-4	1,2,3-TRICHLOROPROPANE	µg/kg	48 NJ	28 NJ	76 NJ	67 NJ			27 NJ	17 NJ
120-82-1	1,2,4-TRICHLOROBENZENE	µg/kg	4.6 UJ	5.3 UJ	6.4 UJ	5.2 UJ	6.1 UL	6 UL	5.4 UJ	5.7 UJ
96-12-8	1,2-DIBROMO-3-CHLOROPROPANE	µg/kg	4.6 UJ	5.3 UJ	6.4 UJ	5.2 UJ	6.1 U	6 U	5.4 UJ	5.7 UJ
106-93-4	1,2-Dibromoethane (EDB)	µg/kg	4.6 UJ	5.3 UJ	1100 L	880 L	6.1 U	6 U	670 J	660 J
95-50-1	1,2-DICHLOROBENZENE	µg/kg	4.6 UJ	5.3 UJ	6.4 UJ	5.2 UJ	6.1 U	6 U	5.4 UJ	5.7 UJ
107-06-2	1,2-DICHLOROETHANE	µg/kg	110	7	14000 L	17000	7.8	6 U	2400 L	6200 L
78-87-5	1,2-DICHLOROPROPANE	µg/kg	4.6 U	5.3 U	6.4 U	5.2 U	6.1 U	6 U	5.4 U	5.7 U
541-73-1	1,3-DICHLOROBENZENE	µg/kg	4.6 UJ	5.3 UJ	6.4 UJ	5.2 UJ	6.1 UJ	6 UJ	5.4 UJ	5.7 UJ
106-46-7	1,4-DICHLOROBENZENE	µg/kg	4.6 UJ	5.3 UJ	6.4 UJ	5.2 UJ	6.1 UJ	6 UJ	5.4 UJ	5.7 UJ
78-93-3	2-BUTANONE (MEK)	µg/kg	180	1100 J	62 L	40 L	69	12 U	11 UL	11 UL
591-78-6	2-HEXANONE	µg/kg	9.2 UJ	11 UJ	13 UJ	10 UJ	12 U	12 U	11 UJ	11 UJ
108-10-1	4-METHYL-2-PENTANONE (MIBK)	µg/kg	9.2 U	11 U	13 U	10 U	12 U	12 U	11 U	11 U
64-19-7	acetic acid	µg/kg		22 NJ	21 NJ					
67-64-1	ACETONE	µg/kg	150 J	280 J	58 J	95 J	180 J	42 J	18 J	11 UJ
71-43-2	BENZENE	µg/kg	4.6 U	5.3 U	6.4 U	5.2 U	6.1 U	6 U	5.4 U	5.7 U
74-97-5	BROMOCHLOROMETHANE	µg/kg	4.6 U	5.3 U	6.4 UL	5.2 UL	6.1 U	6 U	5.4 UL	5.7 UL
75-27-4	BROMODICHLOROMETHANE	µg/kg	4.6 U	5.3 U	6.4 U	5.2 U	6.1 U	6 U	5.4 U	5.7 U
75-25-2	BROMOFORM	µg/kg	4.6 UJ	5.3 UJ	6.4 UJ	5.2 UJ	6.1 UL	6 UL	5.4 UJ	5.7 UJ
74-83-9	BROMOMETHANE	µg/kg	4.6 UJ	5.3 UJ	6.4 UJ	5.2 UJ	6.1 UJ	6 UJ	5.4 UJ	5.7 UJ
75-15-0	Carbon Disulfide	µg/kg	6.4	6.2	6.4 UL	5.2 UL	21	23	11 L	5.7 UL
56-23-5	CARBON TETRACHLORIDE	µg/kg	4.6 U	5.3 U	6.4 U	5.2 U	6.1 U	6 U	5.4 U	5.7 U
108-90-7	Chlorobenzene	µg/kg	4.6 U	5.3 U	6.4 U	5.2 U	6.1 U	6 U	5.4 U	5.7 U
75-00-3	Chloroethane	µg/kg	4.6 U	5.3 U	6.4 UL	5.2 UL	6.1 U	6 U	5.4 UL	5.7 UL
67-66-3	CHLOROFORM	µg/kg	4.6 U	5.3 U	6.4 UL	5.2 UL	6.1 U	6 U	5.4 UL	5.7 UL
74-87-3	CHLOROMETHANE	µg/kg	4.6 U	5.3 U	6.4 UL	11 L	6.1 U	6 U	13 L	12 L
156-59-2	CIS-1,2-DICHLOROETHENE	µg/kg	16	5.3 U	6.4 UL	20 L	53	6 U	9.9 L	5.7 UL
10061-01-5	CIS-1,3-DICHLOROPROPENE	µg/kg	4.6 U	5.3 U	6.4 U	5.2 U	6.1 U	6 U	5.4 U	5.7 U
110-82-7	Cyclohexane	µg/kg	4.6 U	5.3 U	6.4 U	5.2 U	6.1 U	6 U	5.4 U	5.7 U
124-48-1	DIBROMOCHLOROMETHANE	µg/kg	4.6 UJ	5.3 UJ	6.4 UJ	5.2 UJ	6.1 U	6 U	5.4 UJ	5.7 UJ
75-71-8	DICHLORODIFLUOROMETHANE	µg/kg	4.6 U	5.3 U	6.4 UL	5.2 UL	6.1 U	6 U	5.4 UL	5.7 UL
101-84-8	Diphenyl Ether (Phenylether)	µg/kg	15 NJ	20 NJ						
100-41-4	ETHYLBENZENE	µg/kg	4.6 U	5.3 U	7.2	6.4	6.1 U	6 U	5.4 U	5.7 U

Table B-4
Final Soil Results from DESA
White Chemical Corporation Superfund Site
Newark, New Jersey

		Sample Identification	WCC-1-C-FS	WCC-2-C-FS	WCC-3-C-FS	WCC-4-C-FS	WCC-5-C-FS	WCC-6-C-FS	WCC-7-C-FS	WCC-8-C-FS
		Sample Name	WCC-1	WCC-2	WCC-3	WCC-4	WCC-5	WCC-6	WCC-7	WCC-8
		Sample Date	12/14/2011	12/14/2011	12/14/2011	12/14/2011	12/14/2011	12/14/2011	12/14/2011	12/14/2011
cas_rn	chemical_name	result_unit								
98-82-8	ISOPROPYLBENZENE	µg/kg	4.6 U	5.3 U	6.4 U	5.2 U	6.1 U	6 U	5.4 U	5.7 U
79-20-9	Methyl Acetate	µg/kg	4.6 UJ	5.3 UJ	9.3 J	5.2 UJ	6.1 U	6 U	5.4 UL	5.7 UJ
624-92-0	Methyl Disulfide	µg/kg		13 NJ				59 NJ		
107-87-9	Methyl Propyl Ketone	µg/kg	17 NJ							
1634-04-4	METHYL TERT-BUTYL ETHER (MTBE)	µg/kg	4.6 UJ	5.3 UJ	6.4 UJ	5.2 UJ	6.1 U	6 U	5.4 UJ	5.7 UJ
108-87-2	Methylcyclohexane	µg/kg	4.6 U	5.3 U	6.4 U	5.2 U	6.1 U	6 U	5.4 U	5.7 U
75-09-2	METHYLENE CHLORIDE	µg/kg	4.6 U	5.3 U	6.4 UL	5.2 UL	6.1 U	6 U	5.4 UL	5.7 UL
95-47-6	O-XYLENE	µg/kg	4.6 U	5.3 U	7.9	7.8	6.1 U	6 U	5.4 U	5.7 U
115-07-1	Propylene (Propene)	µg/kg					14 NJ	14 NJ		
100-42-5	STYRENE	µg/kg	4.6 U	5.3 U	6.4 U	5.2 U	6.1 U	6 U	5.4 U	5.7 U
127-18-4	TETRACHLOROETHENE	µg/kg	59	6	250	170	6.1 U	6 U	28	15
108-88-3	TOLUENE	µg/kg	4.6 U	5.3 U	6.4 U	5.2 U	6.1 U	6 U	5.4 U	5.7 U
1330-20-7	Total Xylenes	µg/kg	5.6	5.3 U	22	20	6.1 U	6 U	5.4 U	5.7 U
156-60-5	TRANS-1,2-DICHLOROETHENE	µg/kg	4.6 U	5.3 U	6.4 UL	5.2 UL	6.1 U	6 U	5.4 UL	5.7 UL
10061-02-6	TRANS-1,3-DICHLOROPROPENE	µg/kg	4.6 UJ	5.3 UJ	6.4 UJ	5.2 UJ	6.1 U	6 U	5.4 UJ	5.7 UJ
79-01-6	TRICHLOROETHENE	µg/kg	380 J	5.3 UJ	720 J	370 L	21 J	6 UJ	180 J	130 J
75-69-4	TRICHLOROFLUOROMETHANE	µg/kg	4.6 U	5.3 U	6.4 UL	5.2 UL	6.1 U	6 U	5.4 UL	5.7 UL
75-01-4	VINYL CHLORIDE	µg/kg	160	5.3 U	74 L	44 L	85 L	6 UL	90 L	33 L

Notes:
J: estimated results
U: non-detect
L: biased low
UJ: estimated but non-detected
NJ: tentatively identified, estimated
UL: biased low but non-detected

Appendix C

Data Usability Summary

Appendix C
Data Usability Summary

This appendix presents the role of quality control data in achieving the objectives of the bench study.

1.0 Introduction

To support the White Chemical FS, CDM Smith performed a bench scale treatability study in accordance with EPA guidance "Guide for Conducting Treatability Study Under CERCLA – Biodegradation Remedy Selection Interim Guidance" (EPA 1993). The overall approach, rational, objectives and sampling activities are defined in the Final Quality Assurance Project Plan (QAPP) for White Chemical Superfund site, Operable Unit 3 Groundwater Remedial Investigation/Feasibility Study, August 10, 2009 and Final QAPP Addendum No. 3 – Bench Scale Treatability Study White Chemical Superfund Site, June 10, 2011.

Chemical data quality indicators (DQIs) are quantitative and qualitative goals and limits established for laboratory data that provide the means by which data reviewers can assess whether the goals of an investigation have been met. Quality Assurance (QA) indicators for measuring the study data are expressed in terms of precision, accuracy, representativeness, comparability, completeness, and sensitivity (PARCCS). The QA indicators provide a mechanism for ongoing control and evaluation of data quality throughout the project. The treatability QA/QC was assessed by internal QC checks, calibration checks, method blanks, surrogate spikes, adherence to holding times, and laboratory duplicates. The checklists used to summarize the data quality review of each sampling event identify the QC measurements with the associated PARCCS parameter they represent.

DQIs for laboratory analysis are governed by the QAPP established criteria as cited on Worksheets 12a, 12n, 12g, 12p, 12k, 12y and 15a of the final QAPP and Worksheets 12aa, 12bb and 15r of the final QAPP Addendum 3. Additional DQI clarification is included in ETL SOPs ETL-001, ETL-002 and ETL003.

2.0 Deviations from QAPP

The Final QAPP was developed to establish DQOs for samples collected in support of the RI/FS activities. These samples were subsequently submitted for analysis under the contract laboratory program (CLP) or to be analyzed under similar QA criteria to support multiple potential uses including risk assessment. Likewise analytical DQOs in QAPP addendum 3 were not modified to the extent appropriate for work pertaining to a bench scale study. As a result several of the DQIs cited in the QAPP were exceeded during analysis of the treatability products. It is inappropriate to evaluate the usability of data generated from a bench scale treatability study in the same manner as data used for an RI or risk assessment. Data from the treatability study are more akin to screening level data.

A data quality review checklist was produced to capture the QA results for each testing event. These results were compared against the DQIs from the QAPPs and the QA criteria cited in applicable laboratory SOPs. These checklists are presented in Attachment 1 to this report. Differences between the laboratory QA criteria and those contained in the QAPP are identified on the checklists. Section 3 of the Bench Study Technical Memo describes the sampling and analysis conducted during the bench study including any modifications to the initial work plan that were made during the course of the study.

3.0 Usability Summary

The analytical results collected throughout the study are usable for the purpose outlined in the QAPP; to investigate the effectiveness of the in situ remediation technologies identified to treat site contamination. The data generated during the bench study were sufficient to determine the efficacy of the various treatments.

3.1 PARCCS Summary

The summary of observations listed on the checklists generally address the QC indicators of precision (duplicates, and blanks), accuracy (calibrations, surrogate and check standards) and sensitivity (blanks). Outliers are identified on the checklists and additional details are provided in the comments section of the QA checklists.

Representativeness was achieved through consistency in sample collection as described in the QAPP.

Comparability was achieved through using standard sample preparation and analyses throughout the study.

Completeness was achieved by avoiding any catastrophic loss of sample and generally meeting the precision and accuracy requirements during the various analyses.

3.2 QC Indicators

The QC criteria are reviewed and evaluated at the time of analysis and QC criteria that are outside acceptable limits are evaluated within the context of the bench study. For example, a blank that has concentration of a target compound at 50 µg/L may seem high but when compared to the associated samples that may have concentrations in excess of 1,000 µg/L the blank contamination is of minimal concern. Similarly duplicate results that may exceed the RPD criteria are not of particular concern if the overall trend when the duplicates are compared to the control is consistent.

The analytical data collect in support of the bench scale study is essentially considered screening level data. The QA/QC findings aid in the interpretation of the study data and is used as part of the analysis. Data quality indicators that may have a potential impact on the data or help identify anomalies are discussed in greater detail in Section 4 within the context of the study.

Project:	White Chemical EAB		
Sample Event:	T=2 Days (all and 3-D only)	Date:	7/15/2011
Checklist Prepared by:	Janelle Amador, 91749	Date:	1/17/2012
Quality Review Completed by:	Mary Lou Fox	Date:	1/20/2012

By entering your name and employee ID you certify that the data is correct to the best of your knowledge and was analyzed in accordance with Bellevue Laboratory QA Manual and project specific requirements."

CDM Smith

			(Yes/No)	
Project Wide				
Line Item	**Item**	**Requirement**	**Result**	**Comment #**
1	Precision: Project Duplicates Rate	Were duplicates collected at a rate ≥5% for all analyses	Yes	
2	Precision: Project Duplicates Relative Percent Difference	Was the precision criteria of ≤20% RPD met for replicate samples	No	1
3	Accuracy: Calibration	Was the laboratory instrument calibrated in accordance with EPA methods, CDM laboratory standard operating procedures, instrument manufacturer's recommendations, and QAPP Addendum No. 3.	Yes	2
4	Representativeness: Project Samples	Was each bottle shaken before each sampling point was analyzed. This helps ensure samples collected are representative of the condition in the whole bottle.	No	3
5	Completeness: Project Data	Was 90% data completeness attained	Yes	
6	Sensitivity: Sample Carryover	Was the following performed correctly to minimize carryover on the analytical instrument due to potentially high VOC concentrations: The Bellevue laboratory should conduct several screening analyses, during the initial setup period, using the received groundwater to find the correct dilution ratio. The laboratory should first estimate the required dilution ratio, then, analyze the diluted sample followed by a blank sample using GC/MS. Results from both samples need to be reviewed and the dilution ratio adjusted as necessary to ensure no carryover has occurred. As the reaction progresses, CDM laboratory chemist must adjust the dilution ratio accordingly.	Yes	4
Analyte:	VOC Analysis	SOP Quantitative Limit:	5	ppb
		QAPP Quantitative Limits by compound:		
		Tetrachloroethene	0.75	ppb
		Trichloroethene	0.75	ppb
		cis1,2-Dichloroethene	20	ppb
		vinyl chloride	0.75	ppb
		1,1,2 -Trichloroethane	1	ppb
		1,2 -Dichloroethane	1	ppb
		Chloroethane	No Limit	ppb
		1,2-dibromoethane	No Limit	ppb
		1,2-dibromo-3-chloropropane	No Limit	ppb
Line Item	Item	Requirement	Result	Comment Ref. #
7	Hold Times	Was the following holding times met: technical 14 days 10 days VTSR Preserved; Unpreserved 7 days	Yes	
8	Precision: Duplicates	Was the following precision criteria met: RPD≤ 50% if both samples are >5x QL or ABS <2x QL if sample and/or field duplicate are ≤5x QL	No	5
9	Sensitivity: Method Blanks	Were any target compounds found in the blanks > QL	Exceeded QAPP requirements	6

10	Accuracy: Surrogates	Did more than 3 DMCs per sample may fail to meet recovery limits	Yes	7
11	Accuracy: Internal Standards	Were internal standards within the 60-140% recovery range	Yes	
12	Accuracy: Check standards	Were internal standards within the 75-125% recovery range	Yes	
Analyte:	Sulfate & Chloride	Quantitation Limit:	1	mg/L
Line Item	Item	Requirement	Result	Comment Ref. #
13	Precision: Duplicates	Was the precision criteria met for replicate samples: ≤ 20% (QAPP) and <40% (SOP)	Met 20% project-wide limit.	
14	Sensitivity: Method Blanks	Were any target compounds found in the blanks > QL	No	
15	Accuracy: Calibration Standard Verification	Were calibration checks within the 90-110% recovery range	Yes	
16	Comparability: Similar units	Were results reported in mg/L	Yes	8
17	Completeness: Data Usability	Was 90% data completeness attained	Yes	
18	Hold Time	Were the following holding times met: Sulfate: 48 hours at 4 deg C Chloride: 28 Days at 4 deg C	Yes	
Analyte:	Methane, Ethane, Ethene, Acetylene	Quantitation Limit:	1	mg/L
Line Item	Item	Requirement	Result	Comment Ref. #
19	Hold Times	Was the following holding time met: 14 Days at 4°C	Yes	
20	Precision: Duplicates	Were the precision criteria met for replicate samples: ≤ 20% (QAPP) and <25% (SOP)	Met 20% RPD limit	
21	Accuracy: Calibration Standard Verification	Were calibration checks within the 75-125% recovery range	Yes	
22	Sensitivity: Method Blanks	Were any target compounds found in the blanks > QL	No	
23	Comparability: Similar units	Were results reported in mg/L	No	9
24	Completeness: Data Usability	Was 90% data completeness attained	Yes	
Analyte:	Chemical Oxygen Demand	Quantitation Limit:	3	mg/L
Line Item	Item	Requirement	Result	Comment Ref. #
25	Hold Time	Was the following holding time met: 2 hours	Yes	
26	Precision: Duplicates	Was the following precision criteria met: ≤ 50% RPD if both results >5x QL or ABS <2x QL if sample and/or field duplicate are ≤5x QL	Yes	
27	Accuracy: Standard Recovery	Were calibration checks within the 80-120% recovery (Per QAPP WS #12aa & 28n) or 75-125% (Per QAPP WS #28z)	Yes	
28	Sensitivity: Method Blanks	Were any target compounds found in the blanks $\geq$ 0.03 mg/L	Exceeded QAPP requirements	10
29	Comparability: Similar units	Were results reported in mg/L	Yes	
30	Completeness: Data Usability	Was 90% data completeness attained	Yes	
Analyte:	pH			
Line Item	Item	Requirement	Result	Comment Ref. #
31	Accuracy: Calibrated per SOP	Was the calibration 92-102% of initial slope	Yes	
Analyte:	ORP			
Line Item	Item	Requirement	Result	Comment Ref. #

32	Accuracy: Calibrated per SOP	Were the calibration and negative reference check performed and were results within criteria.	Yes	
Analyte:	Ferrous iron	Quantitation Limit:	0.03	mg/L
Line Item	Item	Requirement	Result	Comment Ref. #
33	Hold Time	Was the holding time of 2 hours met	Yes	
34	Precision: Duplicates	Was the precision criteria met for replicate samples: ≤ 50% RPD	Yes	
35	Accuracy: Standard Recovery	Were calibration checks within the 75-125% recovery range	NA	11
36	Sensitivity: Method Blanks	Were any target compounds found in the blanks > QL	NA	11
37	Comparability: Similar units	Were results reported in mg/L	Yes	
38	Completeness: Data Usability	Was 90% data completeness attained	Yes	

Abbreviations Key	
ABS	Absolute difference
DMC	Deuterated monitoring compound
GC/MS	Gas chromatography/mass spectroscopy
mg/L	milligrams per liter
ORP	Oxidation reduction potential
ppb	parts per billion
QAPP	Quality assurance project plan
QL	Quantitation limit
RPD	Relative percent difference
SOP	Standard operating procedure
VOC	Volatile organic compound
VTSR	Verified time of sample receipt
WS	Work sheet (from QAPP)

Reference #	Comments
1	See note 5 for specific exceedances.
2	The analyst verified that this statement is true.
3	Bottles were hand shaken the morning of analysis, and then allowed to settle so that soil/turbidity would not interfere with analytics.
4	The analyst verified that this statement is true.
5	Sample 3-A and its duplicate had an calculated RPD of 56% for tetrachloroethene (both detections less than five times the QL of 125 µg/L), an RPD of 83% for cis-1,2,-dichloroethane; and a calculated RPD of 200% calculated for 1,2-dibromo-3-chloropropane (for a non-detection and a concentration of 284.4 µg/L) . The alternative criteria that the absolute difference between the two detections be less than 2x QL of 125 µg/L or for the single detection to be less than 5x the QL was met for tetrachloroethene and cis-1,2-dichloroethene. The RPD for 1,2-dibromo-3-chloropropane for sample 3-D slightly exceed the alternative criteria of the detection being < 2x QL. The RPD for vinyl chloride (29%) in sample 3-A and it duplicate exceeded only the 20% project-wide criteria. For sample 3-D and its duplicate, the RPD for 1,2-dibromo-3-chloropropane was calculated as 200% for a non-detection and a concentration of 21.2 µg/L.
6	Detections of volatile organics in the blanks ranged from 0.32 µg/L to 8.91 µg/L. The treatability laboratory runs blanks between standards and high concentration samples as checks for carryover. The analyst reviews the blanks to determine if there are any issues that would have caused high carryover. After review of the blank results, if corrective action is required it is performed and the analyses would be re-analyzed. The levels of volatile organics in these blanks did not indicate a problem with the analyses.
7	The standard operating procedure (SOPs) and quality control (QC) limits used by the treatability laboratory were not included in the project QAPP. The QC limits used by the treatability laboratory for surrogates are 60-120%. Recovery of the d4-1,2-dichloroethane surrogate in the 1-A sample was 51%, 9% below the treatability laboratory's lower limit of 60%.
8	Results are reported in µg/L, converted to mg/L by dividing µg/L by 1,000.
9	Results are reported in units of parts per million -volume (ppmV)
10	The spectrophotometer used for measurement of COD in water sample was calibrated with a blank sample of deionized water to 0. A standard COD solution of 1000 mg/L was used as a check standard. Detections of COD in blank samples ranged from 0.5 to 7 mg/L. The higher values exceed the QL of 3 mg/L and the specified criteria of 0.03 mg/L. However, the levels of COD in the treatability tests are relatively high compared to a QL of 3 mg/L; the lowest COD measurements in this treatability study ranged between 100 to 300 mg/L. Consequently, COD values in blanks below 10 mg/L do not impact data quality.
11	Accuracy checks and blanks not performed. Hach Standard Method performed.

Project:	White Chemical EAB		
Sample Event:	t= 2 Weeks	Date:	7/27/2011
Checklist Prepared by:	Janelle Amador, 91749	Date:	1/17/2012
Quality Review Completed by:	Mary Lou Fox	Date:	1/20/2012

By entering your name you agree that the data is correct to the best of your knowledge and was analyzed in accordance with Bellevue Laboratory QA Manual and project specific requirements.

			(Yes/No)	
Project Wide				
Line Item	Item	Requirement	Result	Comment #
1	Precision: Project Duplicates Rate	Were duplicates collected at a rate ≥5% for all analyses	Yes	
2	Precision: Project Duplicates Relative Percent Difference	Was the precision criteria of ≤20% RPD met for replicate samples	No	1
3	Accuracy: Calibration	Was the laboratory instrument calibrated in accordance with EPA methods, CDM laboratory standard operating procedures, instrument manufacturer's recommendations, and QAPP Addendum No. 3.	Yes	2
4	Representativeness: Project Samples	Was each bottle shaken before each sampling point was analyzed. This helps ensure samples collected are representative of the condition in the whole bottle.	No	3
5	Completeness: Project Data	Was 90% data completeness attained	Yes	
6	Precision: Sample Carryover	Was the following performed correctly to minimize carryover on the analytical instrument due to potentially high VOC concentrations: The Bellevue laboratory should conduct several screening analyses, during the initial setup period, using the received groundwater to find the correct dilution ratio. The laboratory should first estimate the required dilution ratio, then, analyze the diluted sample followed by a blank sample using GC/MS. Results from both samples need to be reviewed and the dilution ratio adjusted as necessary to ensure no carryover has occurred. As the reaction progresses, CDM laboratory chemist must adjust the dilution ratio accordingly.	Yes	4

Analyte:	VOC Analysis	SOP Quantitative Limit:	5	ppb
		QAPP Quantitative Limits by compound:		
		Tetrachloroethene	0.75	ppb
		Trichloroethene	0.75	ppb
		cis1,2-Dichloroethene	20	ppb
		vinyl chloride	0.75	ppb
		1,1,2 -Trichloroethane	1	ppb
		1,2 -Dichloroethane	1	ppb
		Chloroethane	No Limit	ppb
		1,2-dibromoethane	No Limit	ppb
		1,2-dibromo-3-chloropropane	No Limit	ppb
Line Item	Item	Requirement	Result	Comment Ref. #
7	Hold Times	Was the following holding times met: technical 14 days 10 days VTSR Preserved; Unpreserved 7 days	Yes	
8	Precision: Duplicates	Was the following precision criteria met: RPD≤ 50% if both samples are >5x QL or ABS <2x QL if sample and/or field duplicate are ≤5x QL	No	5
9	Sensitivity: Method Blanks	Were any target compounds found in the blanks > QL	Exceeded QAPP requirements	6
10	Accuracy: Surrogates	Did more than 3 DMCs per sample may fail to meet recovery limits	Yes	7
11	Accuracy: Internal Standards	Were internal standards within the 60-140% recovery range	Yes	
12	Accuracy: Check standards	Were internal standards within the 75-125% recovery range	Yes	
Analyte:	Sulfate & Chloride	Quantitation Limit:	1	mg/L
Line Item	Item	Requirement	Result	Comment Ref. #
13	Precision: Duplicates	Was the precision criteria met for replicate samples: ≤ 20% (QAPP) and <40% (SOP)	Yes	
14	Sensitivity: Method Blanks	Were any target compounds found in the blanks > QL	Yes	
15	Accuracy: Calibration Standard Verification	Were calibration checks within the 90-110% recovery range	Yes	
16	Comparability: Similar units	Were results reported in mg/L	Yes	8
17	Completeness: Data Usability	Was 90% data completeness attained	Yes	
18	Hold Time	Were the following holding times met: Sulfate: 48 hours at 4 deg C Chloride: 28 Days at 4 deg C	Yes	
Analyte:	Methane, Ethane, Ethene, Acetylene	Quantitation Limit:	1	mg/L
Line Item	Item	Requirement	Result	Comment Ref. #
19	Hold Times	Was the following holding time met: 14 Days at 4°C	Yes	
20	Precision: Duplicates	Were the precision criteria met for replicate samples: ≤ 20% (QAPP) and <25% (SOP)	No	9
21	Accuracy: Calibration Standard Verification	Were calibration checks within the 75-125% recovery range	Yes	
22	Sensitivity: Method Blanks	Were any target compounds found in the blanks > QL	Yes	
23	Comparability: Similar units	Were results reported in mg/L	No	10
24	Completeness: Data Usability	Was 90% data completeness attained	Yes	

Analyte:	Chemical Oxygen Demand	Quantitative Limit:	3	mg/L
Line Item	Item	Requirement	Result	Comment Ref. #
25	Hold Time	Was the following holding time met: 2 hours	No	11
26	Precision: Duplicates	Was the following precision criteria met: ≤ 50% RPD if both results >5x QL or ABS <2x QL if sample and/or field duplicate are ≤5x QL	Yes	
27	Accuracy: Standard Recovery	Were calibration checks within the 80-120% recovery (Per QAPP WS #12aa & 28n) or 75-125% (Per QAPP WS #28z)	Yes	
28	Sensitivity: Method Blanks	Were any target compounds found in the blanks ≥ 0.03 mg/L	Exceeded QAPP requirements	12
29	Comparability: Similar units	Were results reported in mg/L	Yes	
30	Completeness: Data Usability	Was 90% data completeness attained	Yes	
Analyte:	pH			
Line Item	Item	Requirement	Result	Comment Ref. #
31	Accuracy: Calibrated per SOP	Was the calibration 92-102% of initial slope	Yes	
Analyte:	ORP			
Line Item	Item	Requirement	Result	Comment Ref. #
32	Accuracy: Calibrated per SOP	Were the calibration and negative reference check performed and were results within criteria.	Yes	
Analyte:	Ferrous iron	Quantitative Limit:	0.03	mg/L
Line Item	Item	Requirement	Result	Comment Ref. #
33	Hold Time	Was the holding time of 2 hours met	Yes	
34	Precision: Duplicates	Was the precision criteria met for replicate samples: ≤ 50% RPD	Yes	
35	Accuracy: Standard Recovery	Were calibration checks within the 75-125% recovery range	No	13
36	Sensitivity: Method Blanks	Were any target compounds found in the blanks > QL	No	13
37	Comparability: Similar units	Were results reported in mg/L	Yes	
38	Completeness: Data Usability	Was 90% data completeness attained	Yes	

Abbreviations Key	
ABS	Absolute difference
DMC	Deuterated monitoring compound
GC/MS	Gas chromatography/mass spectroscopy
mg/L	milligrams per liter
ORP	Oxidation reduction potential
ppb	parts per billion
QAPP	Quality assurance project plan
QL	Quantitation limit
RPD	Relative percent difference
SOP	Standard operating procedure
VOC	Volatile organic compound
VTSR	Verified time of sample receipt
WS	Work sheet (from QAPP)

Reference #	Comments
1	See note 5 for specific exceedances.
2	The analyst verified that this statement is true.
3	Bottles were hand shaken the morning of analysis, and then allowed to settle so that soil/turbidity would not interfere with analytics.
4	The analyst verified that this statement is true.
5	For sample 8-A and its duplicate, the calculated RPD for cis-1,2-dichloroethene was calculated as 38% (both detections less than 5x the QL of 125 µg/L) and the RPD for vinyl chloride was 68%. The RPD for for cis-1,2-dichloroethene meets the alternative criteria of the absoulte difference being < 2 QL.
6	Detections of volatile organics in the blanks ranged from 0.9 µg/L to 20.05 µg/L. The treatability laboratory runs blanks between standards and high concentration samples as checks for carryover. The analyst reviews the blanks to determine if there are any issues that would have caused high carryover. After review of the blank results, if corrective action is required it is performed and the analyses would be re-analyzed. The levels of volatile organics in these blanks did not indicate a problem with the analyses.
7	The standard operating procedured (SOPs) and quality control (QC) limits used by the treatability laboratory were not included in the project QAPP. The QC limits used by the treatability laboratory for surrogates are 60-120%. The recovery limits of 60-120% were met for all four surrogates.
8	Results are reported in µg/L, converted to mg/L by dividing µg/L by 1,000.
9	For sample 8-A and its duplicate, the RPD for methane slightly exceeded the QAPP control limit of 20%, but was below the SOP limit of 25%.
10	Results are reported in units of parts per million -volume (ppmV)
11	The COD analyses were performed one day past when the volumes were collected. The fact that the sample were analyzed one day past collection is not believed to have an affect on the results. Anaerobic microorganisms that could have consumed carbon and lowered the COD would have been killed when exposed to the atmosphere and when the results of the control test were compared to the overall results, no affect is apparent.
12	The spectrophotometer used for measurement of COD in water samples was calibrated with a blank sample of deionized water to 0. A standard COD solution of 1000 mg/L was used as a check standard. Detection of COD in one blank sample was 6 mg/L. This value exeeds the QL of 3 mg/L and the specified criteria of 0.03 mg/L. However, the levels of COD in the treatability tests are relatively high compared to a QL of 3 mg/L; the lowest COD measurements in this treatability study ranged between 100 to 300 mg/L. Consequently, COD values in blanks below 10 mg/L do not impact data quality.
13	Accuracy checks not performed. Hach Standard Method performed.

Project:	White Chemical EAB		
Sample Event:	T=4 Weeks	Date:	8/10/2011
Checklist Prepared by:	Janelle Amador, 91749	Date:	1/17/2012
Quality Review Completed by:	Mary Lou Fox	Date:	1/20/2012

By entering your name and employee ID you certify that the data is correct to the best of your knowledge and was analyzed in accordance with Bellevue Laboratory QA Manual and project specific requirements."

CDM Smith

			(Yes/No)	
Project Wide				
Line Item	**Item**	**Requirement**	**Result**	**Comment #**
1	Precision: Project Duplicates Rate	Were duplicates collected at a rate ≥5% for all analyses	Yes	
2	Precision: Project Duplicates Relative Percent Difference	Was the precision criteria of ≤20% RPD met for replicate samples	No	1
3	Accuracy: Calibration	Was the laboratory instrument calibrated in accordance with EPA methods, CDM laboratory standard operating procedures, instrument manufacturer's recommendations, and QAPP Addendum No. 3.	Yes	2
4	Representativeness: Project Samples	Was each bottle shaken before each sampling point was analyzed. This helps ensure samples collected are representative of the condition in the whole bottle.	No	3
5	Completeness: Project Data	Was 90% data completeness attained	Yes	
6	Precision: Sample Carryover	Was the following performed correctly to minimize carryover on the analytical instrument due to potentially high VOC concentrations: The Bellevue laboratory should conduct several screening analyses, during the initial setup period, using the received groundwater to find the correct dilution ratio. The laboratory should first estimate the required dilution ratio, then, analyze the diluted sample followed by a blank sample using GC/MS. Results from both samples need to be reviewed and the dilution ratio adjusted as necessary to ensure no carryover has occurred. As the reaction progresses, CDM laboratory chemist must adjust the dilution ratio accordingly.	Yes	4

Analyte:	VOC Analysis	SOP Quantitative Limit:	5	ppb
		QAPP Quantitative Limits by compound:		
		Tetrachloroethene	0.75	ppb
		Trichloroethene	0.75	ppb
		cis1,2-Dichloroethene	20	ppb
		vinyl chloride	0.75	ppb
		1,1,2 -Trichloroethane	1	ppb
		1,2 -Dichloroethane	1	ppb
		Chloroethane	No Limit	ppb
		1,2-dibromoethane	No Limit	ppb
		1,2-dibromo-3-chloropropane	No Limit	ppb
Line Item	Item	Requirement	Result	Comment Ref. #
7	Hold Times	Was the following holding times met: technical 14 days 10 days VTSR Preserved; Unpreserved 7 days	Yes	
8	Precision: Duplicates	Was the following precision criteria met: RPD≤ 50% if both samples are >5x QL or ABS <2x QL if sample and/or field duplicate are ≤5x QL	No	5
9	Sensitivity: Method Blanks	Were any target compounds found in the blanks > QL	Exceeded QAPP requirements	6
10	Accuracy: Surrogates	Did more than 3 DMCs per sample may fail to meet recovery limits	Yes	7
11	Accuracy: Internal Standards	Were internal standards within the 60-140% recovery range	Yes	
12	Accuracy: Check standards	Were internal standards within the 75-125% recovery range	Yes	
Analyte:	Sulfate & Chloride	Quantitation Limit:	1	mg/L
Line Item	Item	Requirement	Result	Comment Ref. #
13	Precision: Duplicates	Was the precision criteria met for replicate samples: ≤ 20% (QAPP) and <40% (SOP)	Met both overall project limit of ≤ 20% and the QAPP limit of ≤40%.	
14	Sensitivity: Method Blanks	Were any target compounds found in the blanks > QL	Yes	
15	Accuracy: Calibration Standard Verification	Were calibration checks within the 90-110% recovery range	Yes	
16	Comparability: Similar units	Were results reported in mg/L	Yes	8
17	Completeness: Data Usability	Was 90% data completeness attained	Yes	
18	Hold Time	Were the following holding times met: Sulfate: 48 hours at 4 deg C Chloride: 28 Days at 4 deg C	Yes	
Analyte:	Methane, Ethane, Ethene, Acetylene	Quantitation Limit:	1	mg/L
Line Item	Item	Requirement	Result	Comment Ref. #
19	Hold Times	Was the following holding time met: 14 Days at 4°C	Yes	
20	Precision: Duplicates	Were the precision criteria met for replicate samples: ≤ 20% (QAPP) and <25% (SOP)	Met 20% RPD limit	
21	Accuracy: Calibration Standard Verification	Were calibration checks within the 75-125% recovery range	Yes	
22	Sensitivity: Method Blanks	Were any target compounds found in the blanks > QL	Yes	
23	Comparability: Similar units	Were results reported in mg/L	No	9
24	Completeness: Data Usability	Was 90% data completeness attained	Yes	

Analyte:	Chemical Oxygen Demand	Quantitation Limit:	3	mg/L
Line Item	Item	Requirement	Result	Comment Ref. #
25	Hold Time	Was the following holding time met: 2 hours	Yes	
26	Precision: Duplicates	Was the following precision criteria met: ≤ 50% RPD if both results >5x QL or ABS <2x QL if sample and/or field duplicate are ≤5x QL	Met analysis-specific QC limit of ≤ 50%, but COD RPD for sample 7_A and its duplicate exceeded the overall project QC limit of ≤ 20%.	
27	Accuracy: Standard Recovery	Were calibration checks within the 80-120% recovery (Per QAPP WS #12aa & 28n) or 75-125% (Per QAPP WS #28z)	Yes	
28	Sensitivity: Method Blanks	Were any target compounds found in the blanks ≥ 0.03 mg/L	Exceeded QAPP requirements	10
29	Comparability: Similar units	Were results reported in mg/L	Yes	
30	Completeness: Data Usability	Was 90% data completeness attained	Yes	
Analyte:	pH			
Line Item	Item	Requirement	Result	Comment Ref. #
31	Accuracy: Calibrated per SOP	Was the calibration 92-102% of initial slope	Yes	
Analyte:	ORP			
Line Item	Item	Requirement	Result	Comment Ref. #
32	Accuracy: Calibrated per SOP	Were the calibration and negative reference check performed and were results within criteria.	Yes	
Analyte:	Ferrous iron	Quantitation Limit:	0.03	mg/L
Line Item	Item	Requirement	Result	Comment Ref. #
33	Hold Time	Was the holding time of 2 hours met	Yes	
34	Precision: Duplicates	Was the precision criteria met for replicate samples: ≤ 50% RPD	Yes	
35	Accuracy: Standard Recovery	Were calibration checks within the 75-125% recovery range	NA	11
36	Sensitivity: Method Blanks	Were any target compounds found in the blanks > QL	NA	11
37	Comparability: Similar units	Were results reported in mg/L	Yes	
38	Completeness: Data Usability	Was 90% data completeness attained	Yes	

Abbreviations Key	
ABS	Absolute difference
DMC	Deuterated monitoring compound
GC/MS	Gas chromatography/mass spectroscopy
mg/L	milligrams per liter
ORP	Oxidation reduction potential
ppb	parts per billion
QAPP	Quality assurance project plan
QL	Quantitation limit
RPD	Relative percent difference
SOP	Standard operating procedure
VOC	Volatile organic compound
VTSR	Verified time of sample receipt
WS	Work sheet (from QAPP)

Reference #	Comments
1	See note 5 for specific exceedances.
2	The analyst verified that this statement is true.
3	Bottles were hand shaken the morning of analysis, and then allowed to settle so that soil/turbidity would not interfere with analytics.
4	The analyst verified that this statement is true.
5	Sample 7-A and its duplicate had an RPD of 75% for vinyl chloride. For sample B-1 and its duplicate, cis-1,2-dichloroethane had an RPD of 21%, which met the analysis specific limit of $\leq$ 50%, but exceeded the overall project QC limit of $\leq$ 20%.
6	Detections of volatile organics in the blanks ranged from 0.26 µg/L to 78.52 µg/L. The treatability laboratory runs blanks between standards and high concentration samples as checks for carryover. The analyst reviews the blanks to determine if there are any issues that would have caused high carryover. After review of the blank results, if corrective action is required it is performed and the analyses would be re-analyzed. The levels of volatile organics in these blanks did not indicate a problem with the analyses.
7	The standard operating procedured (SOPs) and quality control (QC) limits used by the treatability laboratory were not included in the project QAPP. The QC limits used by the treatability laboratory for surrogates are 60-120%. The recovery limits of 60-120% were met for all four surrogates.
8	Results are reported in µg/L, converted to mg/L by dividing µg/L by 1,000.
9	Results are reported in units of parts per million -volume (ppmV)
10	The spectrophotometer used for measurement of COD in water sample was calibrated with a blank sample of deionized water to 0. A standard COD solution of 1000 mg/L was used as a check standard. Detections of COD in blank samples ranged from 0.5 to 1 mg/L. These values do not exceed the QL of 3 mg/L , but do exceed thethe specified criteria of 0.03 mg/L. However, The levels of COD in the treatability tests are relatively high compared to a QL of 3 mg/L; the lowest COD measurements in this treatability study ranged between 100 to 300 mg/L. Consequently, COD values in blanks below 10 mg/L do not impact data quality.
11	Accuracy checks and blanks not performed. Hach Standard Method performed.

Project:	White Chemical EAB		
Sample Event:	T=6 Weeks	Date:	8/24/2011
Checklist Prepared by:	Janelle Amador, 91749	Date:	1/17/2012
Quality Review Completed by:	Mary Lou Fox	Date:	1/18/2012

By entering your name and employee ID you certify that the data is correct to the best of your knowledge and was analyzed in accordance with Bellevue Laboratory QA Manual and project specific requirements."

CDM Smith

			(Yes/No)	
Project Wide				
Line Item	**Item**	**Requirement**	**Result**	**Comment #**
1	Precision: Project Duplicates Rate	Were duplicates collected at a rate ≥5% for all analyses	Yes	
2	Precision: Project Duplicates Relative Percent Difference	Was the precision criteria of ≤20% RPD met for replicate samples	No	1
3	Accuracy: Calibration	Was the laboratory instrument calibrated in accordance with EPA methods, CDM laboratory standard operating procedures, instrument manufacturer's recommendations, and QAPP Addendum No. 3.	Yes	2
4	Representativeness: Project Samples	Was each bottle shaken before each sampling point was analyzed. This helps ensure samples collected are representative of the condition in the whole bottle.	No	3
5	Completeness: Project Data	Was 90% data completeness attained	Yes	
6	Precision: Sample Carryover	Was the following performed correctly to minimize carryover on the analytical instrument due to potentially high VOC concentrations: The Bellevue laboratory should conduct several screening analyses, during the initial setup period, using the received groundwater to find the correct dilution ratio. The laboratory should first estimate the required dilution ratio, then, analyze the diluted sample followed by a blank sample using GC/MS. Results from both samples need to be reviewed and the dilution ratio adjusted as necessary to ensure no carryover has occurred. As the reaction progresses, CDM laboratory chemist must adjust the dilution ratio accordingly.	Yes	4
Analyte:	VOC Analysis	SOP Quantitative Limit:	5	ppb
		QAPP Quantitative Limits by compound:		
		Tetrachloroethene	0.75	ppb
		Trichloroethene	0.75	ppb
		cis1,2-Dichloroethene	20	ppb
		vinyl chloride	0.75	ppb
		1,1,2 -Trichloroethane	1	ppb
		1,2 -Dichloroethane	1	ppb
		Chloroethane	No Limit	ppb
		1,2-dibromoethane	No Limit	ppb
		1,2-dibromo-3-chloropropane	No Limit	ppb
Line Item	Item	Requirement	Result	Comment Ref. #
7	Hold Times	Was the following holding times met: technical 14 days 10 days VTSR Preserved; Unpreserved 7 days	Yes	
8	Precision: Duplicates	Was the following precision criteria met: RPD≤ 50% if both samples are >5x QL or ABS <2x QL if sample and/or field duplicate are ≤5x QL	No	5
9	Sensitivity: Method Blanks	Were any target compounds found in the blanks > QL	Exceeded QAPP requirements	6

10	Accuracy: Surrogates	Did more than 3 DMCs per sample may fail to meet recovery limits	Yes	7
11	Accuracy: Internal Standards	Were internal standards within the 60-140% recovery range	Yes	
12	Accuracy: Check standards	Were internal standards within the 75-125% recovery range	Yes	
Analyte:	Sulfate & Chloride	Quantitation Limit:	1	mg/L
Line Item	Item	Requirement	Result	Comment Ref. #
13	Precision: Duplicates	Was the precision criteria met for replicate samples: ≤ 20% (QAPP) and <40% (SOP)	Yes	
14	Sensitivity: Method Blanks	Were any target compounds found in the blanks > QL	Yes	
15	Accuracy: Calibration Standard Verification	Were calibration checks within the 90-110% recovery range	Yes	
16	Comparability: Similar units	Were results reported in mg/L	Yes	8
17	Completeness: Data Usability	Was 90% data completeness attained	Yes	
18	Hold Time	Were the following holding times met: Sulfate: 48 hours at 4 deg C Chloride: 28 Days at 4 deg C	Yes	
Analyte:	Methane, Ethane, Ethene, Acetylene	Quantitation Limit:	1	mg/L
Line Item	Item	Requirement	Result	Comment Ref. #
19	Hold Times	Was the following holding time met: 14 Days at 4°C	Yes	
20	Precision: Duplicates	Were the precision criteria met for replicate samples: ≤ 20% (QAPP) and <25% (SOP)	No	9
21	Accuracy: Calibration Standard Verification	Were calibration checks within the 75-125% recovery range	Yes	
22	Sensitivity: Method Blanks	Were any target compounds found in the blanks > QL	Yes	
23	Comparability: Similar units	Were results reported in mg/L	No	10
24	Completeness: Data Usability	Was 90% data completeness attained	Yes	
Analyte:	Chemical Oxygen Demand	Quantitation Limit:	3	mg/L
Line Item	Item	Requirement	Result	Comment Ref. #
25	Hold Time	Was the following holding time met: 2 hours	Yes	
26	Precision: Duplicates	Was the following precision criteria met: ≤ 50% RPD if both results >5x QL or ABS <2x QL if sample and/or field duplicate are ≤5x QL	Met overall project limit of ≤ 20%.	
27	Accuracy: Standard Recovery	Were calibration checks within the 80-120% recovery (Per QAPP WS #12aa & 28n) or 75-125% (Per QAPP WS #28z)	Met 80-120% limits.	
28	Sensitivity: Method Blanks	Were any target compounds found in the blanks ≥ 0.03 mg/L	Exceeded QAPP requirements	11
29	Comparability: Similar units	Were results reported in mg/L	Yes	
30	Completeness: Data Usability	Was 90% data completeness attained	Yes	
Analyte:	pH			
Line Item	Item	Requirement	Result	Comment Ref. #
31	Accuracy: Calibrated per SOP	Was the calibration 92-102% of initial slope	Yes	
Analyte:	ORP			
Line Item	Item	Requirement	Result	Comment Ref. #

32	Accuracy: Calibrated per SOP	Were the calibration and negative reference check performed and were results within criteria.	Yes	
Analyte:	Ferrous iron	Quantitation Limit:	0.03	mg/L
Line Item	Item	Requirement	Result	Comment Ref. #
33	Hold Time	Was the holding time of 2 hours met	Yes	
34	Precision: Duplicates	Was the precision criteria met for replicate samples: ≤ 50% RPD	Yes	
35	Accuracy: Standard Recovery	Were calibration checks within the 75-125% recovery range	NA	12
36	Sensitivity: Method Blanks	Were any target compounds found in the blanks > QL	NA	12
37	Comparability: Similar units	Were results reported in mg/L	Yes	
38	Completeness: Data Usability	Was 90% data completeness attained	Yes	
Abbreviations Key				
ABS	Absolute difference			
DMC	Deuterated monitoring compound			
GC/MS	Gas chromatography/mass spectroscopy			
mg/L	milligrams per liter			
ORP	Oxidation reduction potential			
ppb	parts per billion			
QAPP	Quality assurance project plan			
QL	Quantitation limit			
RPD	Relative percent difference			
SOP	Standard operating procedure			
VOC	Volatile organic compound			
VTSR	Verified time of sample receipt			
WS	Work sheet (from QAPP)			

Reference #	Comments
1	See notes 5 and 8 for specific exceedances.
2	The analyst verified that this statement is true.
3	Bottles were hand shaken the morning of analysis, and then allowed to settle so that soil/turbidity would not interfere with analytics.
4	The analyst verified that this statement is true.
5	For sample 2-A and its duplicate, chloroethane had an RPD of 162%. The RPD for chloroethane does meet the alternate criteria of the absolute difference in the two concentrations being less than 2x QL of 125 µg/L. For sample 5-B and its duplicate, tetrachloroethene had a calculated RPD of 200% (a non-detection and a concentration of 3.8 µg/L); trichloroethene had an RPD of 113%, 1,1,2-trichloroethane had an RPD of 98%; and 1,2-dibromoethane had a calculated RPD of 200 % for a non-detection and a concentration of 72.4 µg/L. The RPD for trichloroethane also exceeds the alternative criteria of <2x QL of 125 µg/L for the detections being less than 5x the QL, with the absolute difference being approximatley 5x QL. The detections that were paired with non-detects in the duplicate sets met the alternative criteria of the detections being < 2x QL and the alternative criteria of the absolute difference being less than 2x QL of 125 µg/L for the detections of 1,1,2-trichloroethane. For sample 2-A and its duplicate, the RPD for 1,2-dichloroethane (22%) exceeded the overall project QC limit of $\leq$ 20%.
6	Detections of volatile organics in the blanks ranged from 0.21 µg/L to 22.73 µg/L. The treatability laboratory runs blanks between standards and high concentration samples as checks for carryover. The analyst reviews the blanks to determine if there are any issues that would have caused high carryover. After review of the blank results, if corrective action is required it is performed and the analyses would be re-analyzed. The levels of volatile organics in these blanks did not indicate a problem with the analyses.
7	The standard operating procedured (SOPs) and quality control (QC) limits used by the treatability laboratory were not included in the project QAPP. The QC limits used by the treatability laboratory for surrogates are 60-120%. The recovery limits of 60-120% were met for all four surrogates.
8	Results are reported in µg/L, converted to mg/L by dividing µg/L by 1,000.
9	For sample 2-A and its duplicate, ethane had an RPD of 39%, which exceeds both the QAPP and SOP control limits.
10	Results are reported in units of parts per million -volume (ppmV)
11	The spectrophotometer used for measurement of COD in water sample was calibrated with a blank sample of deionized water to 0. A standard COD solution of 1000 mg/L was used as a check standard. Detections of COD in blank samples were all at 3 mg/L. This value is at the QL of 3 mg/L and exceeds the specified criteria of 0.03 mg/L. However, The levels of COD in the treatability tests are relatively high compared to a QL of 3 mg/L; the lowest COD measurements in this treatability study ranged between 100 to 300 mg/L. Consequently, COD values in blanks below 10 mg/L do not impact data quality.
12	Accuracy checks and blanks not performed. Hach Standard Method performed.

Project:	White Chemical EAB		
Sample Event:	T=10 Weeks	Date:	9/19-20/2011
Checklist Prepared by:	Janelle Amador, 91749	Date:	1/17/2012
Quality Review Completed by:	Mary Lou Fox	Date:	1/20/2012

By entering your name and employee ID you certify that the data is correct to the best of your knowledge and was analyzed in accordance with Bellevue Laboratory QA Manual and project specific requirements."

CDM Smith

			(Yes/No)	
Project Wide				
Line Item	**Item**	**Requirement**	**Result**	**Comment #**
1	Precision: Project Duplicates Rate	Were duplicates collected at a rate ≥5% for all analyses	Yes	
2	Precision: Project Duplicates Relative Percent Difference	Was the precision criteria of ≤20% RPD met for replicate samples	No	1
3	Accuracy: Calibration	Was the laboratory instrument calibrated in accordance with EPA methods, CDM laboratory standard operating procedures, instrument manufacturer's recommendations, and QAPP Addendum No. 3.	Yes	2
4	Representativeness: Project Samples	Was each bottle shaken before each sampling point was analyzed. This helps ensure samples collected are representative of the condition in the whole bottle.	No	3
5	Completeness: Project Data	Was 90% data completeness attained	Yes	
6	Precision: Sample Carryover	Was the following performed correctly to minimize carryover on the analytical instrument due to potentially high VOC concentrations: The Bellevue laboratory should conduct several screening analyses, during the initial setup period, using the received groundwater to find the correct dilution ratio. The laboratory should first estimate the required dilution ratio, then, analyze the diluted sample followed by a blank sample using GC/MS. Results from both samples need to be reviewed and the dilution ratio adjusted as necessary to ensure no carryover has occurred. As the reaction progresses, CDM laboratory chemist must adjust the dilution ratio accordingly.	Yes	4

Analyte:	VOC Analysis	SOP Quantitative Limit:	5	ppb
		QAPP Quantitative Limits by compound:		
		Tetrachloroethene	0.75	ppb
		Trichloroethene	0.75	ppb
		cis1,2-Dichloroethene	20	ppb
		vinyl chloride	0.75	ppb
		1,1,2 -Trichloroethane	1	ppb
		1,2 -Dichloroethane	1	ppb
		Chloroethane	No Limit	ppb
		1,2-dibromoethane	No Limit	ppb
		1,2-dibromo-3-chloropropane	No Limit	ppb
Line Item	Item	Requirement	Result	Comment Ref. #
7	Hold Times	Was the following holding times met: technical 14 days 10 days VTSR Preserved; Unpreserved 7 days	Yes	
8	Precision: Duplicates	Was the following precision criteria met: RPD≤ 50% if both samples are >5x QL or ABS <2x QL if sample and/or field duplicate are ≤5x QL	No	5
9	Sensitivity: Method Blanks	Were any target compounds found in the blanks > QL	Exceeded QAPP requirements	6
10	Accuracy: Surrogates	Did more than 3 DMCs per sample may fail to meet recovery limits	Yes	7
11	Accuracy: Internal Standards	Were internal standards within the 60-140% recovery range	Yes	
12	Accuracy: Check standards	Were internal standards within the 75-125% recovery range	Yes	
Analyte:	Sulfate & Chloride	Quantitation Limit:	1	mg/L
Line Item	Item	Requirement	Result	Comment Ref. #
13	Precision: Duplicates	Was the precision criteria met for replicate samples: ≤ 20% (QAPP) and <40% (SOP)	Yes	
14	Sensitivity: Method Blanks	Were any target compounds found in the blanks > QL	Yes	
15	Accuracy: Calibration Standard Verification	Were calibration checks within the 90-110% recovery range	Yes	
16	Comparability: Similar units	Were results reported in mg/L	Yes	8
17	Completeness: Data Usability	Was 90% data completeness attained	Yes	
18	Hold Time	Were the following holding times met: Sulfate: 48 hours at 4 deg C Chloride: 28 Days at 4 deg C	Yes	
Analyte:	Methane, Ethane, Ethene, Acetylene	Quantitation Limit:	1	mg/L
Line Item	Item	Requirement	Result	Comment Ref. #
19	Hold Times	Was the following holding time met: 14 Days at 4°C	Yes	
20	Precision: Duplicates	Were the precision criteria met for replicate samples: ≤ 20% (QAPP) and <25% (SOP)	Met both the QAPP and SOP limits.	
21	Accuracy: Calibration Standard Verification	Were calibration checks within the 75-125% recovery range	Yes	
22	Sensitivity: Method Blanks	Were any target compounds found in the blanks > QL	Yes	
23	Comparability: Similar units	Were results reported in mg/L	No	9
24	Completeness: Data Usability	Was 90% data completeness attained	Yes	

Analyte:	Chemical Oxygen Demand	Quantitation Limit:	3	mg/L
Line Item	Item	Requirement	Result	Comment Ref. #
25	Hold Time	Was the following holding time met: 2 hours	Yes	
26	Precision: Duplicates	Was the following precision criteria met: ≤ 50% RPD if both results >5x QL or ABS <2x QL if sample and/or field duplicate are ≤5x QL	Yes	
27	Accuracy: Standard Recovery	Were calibration checks within the 80-120% recovery (Per QAPP WS #12aa & 28n) or 75-125% (Per QAPP WS #28z)	Met 80-120% limits.	
28	Sensitivity: Method Blanks	Were any target compounds found in the blanks ≥ 0.03 mg/L	Exceeded QAPP requirements	10
29	Comparability: Similar units	Were results reported in mg/L	Yes	
30	Completeness: Data Usability	Was 90% data completeness attained	Yes	
Analyte:	pH			
Line Item	Item	Requirement	Result	Comment Ref. #
31	Accuracy: Calibrated per SOP	Was the calibration 92-102% of initial slope	Yes	
Analyte:	ORP			
Line Item	Item	Requirement	Result	Comment Ref. #
32	Accuracy: Calibrated per SOP	Were the calibration and negative reference check performed and were results within criteria.	Yes	
Analyte:	Ferrous iron	Quantitation Limit:	0.03	mg/L
Line Item	Item	Requirement	Result	Comment Ref. #
33	Hold Time	Was the holding time of 2 hours met	Yes	
34	Precision: Duplicates	Was the precision criteria met for replicate samples: ≤ 50% RPD	Yes	
35	Accuracy: Standard Recovery	Were calibration checks within the 75-125% recovery range	NA	11
36	Sensitivity: Method Blanks	Were any target compounds found in the blanks > QL	NA	11
37	Comparability: Similar units	Were results reported in mg/L	Yes	
38	Completeness: Data Usability	Was 90% data completeness attained	Yes	

Abbreviations Key	
ABS	Absolute difference
DMC	Deuterated monitoring compound
GC/MS	Gas chromatography/mass spectroscopy
mg/L	milligrams per liter
ORP	Oxidation reduction potential
ppb	parts per billion
QAPP	Quality assurance project plan
QL	Quantitation limit
RPD	Relative percent difference
SOP	Standard operating procedure
VOC	Volatile organic compound
VTSR	Verified time of sample receipt
WS	Work sheet (from QAPP)

Reference #	Comments
1	See note 5 for specific exceedances.
2	The analyst verified that this statement is true.
3	Bottles were hand shaken the morning of analysis, and then allowed to settle so that soil/turbidity would not interfere with analytics.
4	The analyst verified that this statement is true.
5	For sample 3-B and its duplicate, chloroethane had an RPD of 122% (both detections less <5x QL of 125 µg/L). The RPD for chloroethane does meet the alternate criteria of the absolute difference being <2 QL. For sample 6-A and its duplicate, cis-1,2-dichloroethene had an RPD of 156% (one detection less then 5x QL) and 1,2-dichloroethane had an RPD of 196% (one detection less then 5x QL). Also for sample 6-A and its duplicate, the RPDs for vinyl chloride, 1,1,2-trichloroethane, chloroethane, and 1,2-dibromoethane were calculated as 200% for non-detections associated with detections. The alternative criteria of the detection being <2x QL was met for the 1,1,2-trichloroethane, chloroethane, vinyl chloride, and and was exceeded for the cis-1,2-dichloroethene, 1,2-dichloroethane, and 1,2-dibromoethane.
6	Detections of volatile organics in the blanks ranged from 0.21 µg/L to 30.9 µg/L. The treatability laboratory runs blanks between standards and high concentration samples as checks for carryover. The analyst reviews the blanks to determine if there are any issues that would have caused high carryover. After review of the blank results, if corrective action is required it is performed and the analyses would be re-analyzed. The levels of volatile organics in these blanks did not indicate a problem with the analyses.
7	The standard operating procedured (SOPs) and quality control (QC) limits used by the treatability laboratory were not included in the project QAPP. The QC limits used by the treatability laboratory for surrogates are 60-120%. The recovery limits of 60-120% were met for all four surrogates.
8	Results are reported in µg/L, converted to mg/L by dividing µg/L by 1,000.
9	Results are reported in units of parts per million -volume (ppmV)
10	The spectrophotometer used for measurement of COD in water samples was calibrated with a blank sample of deionized water to 0. A standard COD solution of 1000 mg/L was used as a check standard. Detection of COD in one blank sample was 6 mg/L. This value exeeds the QL of 3 mg/L and the specified criteria of 0.03 mg/L. However, The levels of COD in the treatability tests are relatively high compared to a QL of 3 mg/L; the lowest COD measurements in this treatability study ranged between 100 to 300 mg/L. Consequently, COD values in blanks below 10 mg/L do not impact data quality.
11	Accuracy checks and blanks not performed. Hach Standard Method performed.

Project:	White Chemical EAB		
Sample Event:	T=16 Weeks	Date:	10/31/2011
Checklist Prepared by:	Janelle Amador, 91749	Date:	1/17/2012
Quality Review Completed by:	Mary Lou Fox	Date:	1/20/2012

By entering your name and employee ID you certify that the data is correct to the best of your knowledge and was analyzed in accordance with Bellevue Laboratory QA Manual and project specific requirements."

CDM Smith

			(Yes/No)	
Project Wide				
Line Item	**Item**	**Requirement**	**Result**	**Comment #**
1	Precision: Project Duplicates Rate	Were duplicates collected at a rate ≥5% for all analyses	Yes	
2	Precision: Project Duplicates Relative Percent Difference	Was the precision criteria of ≤20% RPD met for replicate samples	No	1
3	Accuracy: Calibration	Was the laboratory instrument calibrated in accordance with EPA methods, CDM laboratory standard operating procedures, instrument manufacturer's recommendations, and QAPP Addendum No. 3.	Yes	2
4	Representativeness: Project Samples	Was each bottle shaken before each sampling point was analyzed. This helps ensure samples collected are representative of the condition in the whole bottle.	No	3
5	Completeness: Project Data	Was 90% data completeness attained	Yes	
6	Precision: Sample Carryover	Was the following performed correctly to minimize carryover on the analytical instrument due to potentially high VOC concentrations: The Bellevue laboratory should conduct several screening analyses, during the initial setup period, using the received groundwater to find the correct dilution ratio. The laboratory should first estimate the required dilution ratio, then, analyze the diluted sample followed by a blank sample using GC/MS. Results from both samples need to be reviewed and the dilution ratio adjusted as necessary to ensure no carryover has occurred. As the reaction progresses, CDM laboratory chemist must adjust the dilution ratio accordingly.	Yes	4

Analyte:	VOC Analysis	SOP Quantitative Limit:	5	ppb
		QAPP Quantitative Limits by compound:		
		Tetrachloroethene	0.75	ppb
		Trichloroethene	0.75	ppb
		cis1,2-Dichloroethene	20	ppb
		vinyl chloride	0.75	ppb
		1,1,2 -Trichloroethane	1	ppb
		1,2 -Dichloroethane	1	ppb
		Chloroethane	No Limit	ppb
		1,2-dibromoethane	No Limit	ppb
		1,2-dibromo-3-chloropropane	No Limit	ppb
Line Item	Item	Requirement	Result	Comment Ref. #
7	Hold Times	Was the following holding times met: technical 14 days 10 days VTSR Preserved; Unpreserved 7 days	Yes	
8	Precision: Duplicates	Was the following precision criteria met: RPD≤ 50% if both samples are >5x QL or ABS <2x QL if sample and/or field duplicate are ≤5x QL	No	5
9	Sensitivity: Method Blanks	Were any target compounds found in the blanks > QL	Exceeded QAPP requirements	6
10	Accuracy: Surrogates	Did more than 3 DMCs per sample may fail to meet recovery limits	Yes	7
11	Accuracy: Internal Standards	Were internal standards within the 60-140% recovery range	Yes	
12	Accuracy: Check standards	Were internal standards within the 75-125% recovery range	Yes	
Analyte:	Sulfate & Chloride	Quantitation Limit:	1	mg/L
Line Item	Item	Requirement	Result	Comment Ref. #
13	Precision: Duplicates	Was the precision criteria met for replicate samples: ≤ 20% (QAPP) and <40% (SOP)	Yes	
14	Sensitivity: Method Blanks	Were any target compounds found in the blanks > QL	Yes	
15	Accuracy: Calibration Standard Verification	Were calibration checks within the 90-110% recovery range	Yes	
16	Comparability: Similar units	Were results reported in mg/L	Yes	8
17	Completeness: Data Usability	Was 90% data completeness attained	Yes	
18	Hold Time	Were the following holding times met: Sulfate: 48 hours at 4 deg C Chloride: 28 Days at 4 deg C	Yes	
Analyte:	Methane, Ethane, Ethene, Acetylene	Quantitation Limit:	1	mg/L
Line Item	Item	Requirement	Result	Comment Ref. #
19	Hold Times	Was the following holding time met: 14 Days at 4°C	Yes	
20	Precision: Duplicates	Were the precision criteria met for replicate samples: ≤ 20% (QAPP) and <25% (SOP)	Met the QAPP control limit of ≤ 20%.	
21	Accuracy: Calibration Standard Verification	Were calibration checks within the 75-125% recovery range	Yes	
22	Sensitivity: Method Blanks	Were any target compounds found in the blanks > QL	Yes	
23	Comparability: Similar units	Were results reported in mg/L	No	9
24	Completeness: Data Usability	Was 90% data completeness attained	Yes	

Analyte:	Chemical Oxygen Demand	Quantitation Limit:	3	mg/L
Line Item	Item	Requirement	Result	Comment Ref. #
25	Hold Time	Was the following holding time met: 2 hours	Yes	
26	Precision: Duplicates	Was the following precision criteria met: ≤ 50% RPD if both results >5x QL or ABS <2x QL if sample and/or field duplicate are ≤5x QL	Yes	
27	Accuracy: Standard Recovery	Were calibration checks within the 80-120% recovery (Per QAPP WS #12aa & 28n) or 75-125% (Per QAPP WS #28z)	Met 80-120% limits.	
28	Sensitivity: Method Blanks	Were any target compounds found in the blanks ≥ 0.03 mg/L	Exceeded QAPP requirements	10
29	Comparability: Similar units	Were results reported in mg/L	Yes	
30	Completeness: Data Usability	Was 90% data completeness attained	Yes	
Analyte:	pH			
Line Item	Item	Requirement	Result	Comment Ref. #
31	Accuracy: Calibrated per SOP	Was the calibration 92-102% of initial slope	Yes	
Analyte:	ORP			
Line Item	Item	Requirement	Result	Comment Ref. #
32	Accuracy: Calibrated per SOP	Were the calibration and negative reference check performed and were results within criteria.	Yes	
Analyte:	Ferrous iron	Quantitation Limit:	0.03	mg/L
Line Item	Item	Requirement	Result	Comment Ref. #
33	Hold Time	Was the holding time of 2 hours met	Yes	
34	Precision: Duplicates	Was the precision criteria met for replicate samples: ≤ 50% RPD	Yes	
35	Accuracy: Standard Recovery	Were calibration checks within the 75-125% recovery range	NA	11
36	Sensitivity: Method Blanks	Were any target compounds found in the blanks > QL	NA	11
37	Comparability: Similar units	Were results reported in mg/L	Yes	
38	Completeness: Data Usability	Was 90% data completeness attained	Yes	

Abbreviations Key	
ABS	Absolute difference
DMC	Deuterated monitoring compound
GC/MS	Gas chromatography/mass spectroscopy
mg/L	milligrams per liter
ORP	Oxidation reduction potential
ppb	parts per billion
QAPP	Quality assurance project plan
QL	Quantitation limit
RPD	Relative percent difference
SOP	Standard operating procedure
VOC	Volatile organic compound
VTSR	Verified time of sample receipt
WS	Work sheet (from QAPP)

T = 16 weeks

Reference #	Comments
1	See note 5 for specific exceedances.
2	The analyst verified that this statement is true.
3	Bottles were hand shaken the morning of analysis, and then allowed to settle so that soil/turbidity would not interfere with analytics.
4	The analyst verified that this statement is true.
5	For sample 5-B and its duplicate, 1,2-dibromoethane had an RPD of 200% (for a non-detection and a detection of 200 µg/L). The RPD for 1,2-dibromoethane meets the alternative criteria that the detection be < 2x QL . For sample 7-B and its duplicate, the RPDs for vinyl chloride and 1,1,2-trichloroethane exceeded the overall project limit of ≤20 % at 26% and 23%, respectively.
6	Detections of volatile organics in the blanks ranged from 0.24 µg/L to 11.31 µg/L. The treatability laboratory runs blanks between standards and high concentration samples as checks for carryover. The analyst reviews the blanks to determine if there are any issues that would have caused high carryover. After review of the blank results, if corrective action is required it is performed and the analyses would be re-analyzed. The levels of volatile organics in these blanks did not indicate a problem with the analyses.
7	The standard operating procedured (SOPs) and quality control (QC) limits used by the treatability laboratory were not included in the project QAPP. The QC limits used by the treatability laboratory for surrogates are 60-120%. The recovery limits of 60-120% were met for all four surrogates.
8	Results are reported in µg/L, converted to mg/L by dividing µg/L by 1,000.
9	Results are reported in units of parts per million -volume (ppmV)
10	The spectrophotometer used for measurement of COD in water sample was calibrated with a blank sample of deionized water to 0. A standard COD solution of 1000 mg/L was used as a check standard. Detections of COD in blank samples ranged from 0.5 to 1 mg/L. These values are less than the QL of 3 mg/L and exceeds the specified criteria of 0.03 mg/L. However, The levels of COD in the treatability tests are relatively high compared to a QL of 3 mg/L; the lowest COD measurements in this treatability study ranged between 100 to 300 mg/L. Consequently, COD values in blanks below 10 mg/L do not impact data quality.
11	Accuracy checks and blanks not performed. Hach Standard Method performed.

Project:	White Chemical EAB		
Sample Event:	T=22 Weeks	Date:	12/12/2011
Checklist Prepared by:	Janelle Amador, 91749	Date:	1/17/2012
Quality Review Completed by:	Mary Lou Fox	Date:	1/19/2012

By entering your name and employee ID you certify that the data is correct to the best of your knowledge and was analyzed in accordance with Bellevue Laboratory QA Manual and project specific requirements."

CDM Smith

			(Yes/No)	
Project Wide				
Line Item	**Item**	**Requirement**	**Result**	**Comment #**
1	Precision: Project Duplicates Rate	Were duplicates collected at a rate ≥5% for all analyses	Yes	
2	Precision: Project Duplicates Relative Percent Difference	Was the precision criteria of ≤20% RPD met for replicate samples	No	1
3	Accuracy: Calibration	Was the laboratory instrument calibrated in accordance with EPA methods, CDM laboratory standard operating procedures, instrument manufacturer's recommendations, and QAPP Addendum No. 3.	Yes	2
4	Representativeness: Project Samples	Was each bottle shaken before each sampling point was analyzed. This helps ensure samples collected are representative of the condition in the whole bottle.	No	3
5	Completeness: Project Data	Was 90% data completeness attained	Yes	
6	Precision: Sample Carryover	Was the following performed correctly to minimize carryover on the analytical instrument due to potentially high VOC concentrations: The Bellevue laboratory should conduct several screening analyses, during the initial setup period, using the received groundwater to find the correct dilution ratio. The laboratory should first estimate the required dilution ratio, then, analyze the diluted sample followed by a blank sample using GC/MS. Results from both samples need to be reviewed and the dilution ratio adjusted as necessary to ensure no carryover has occurred. As the reaction progresses, CDM laboratory chemist must adjust the dilution ratio accordingly.	Yes	4

Analyte:	VOC Analysis	SOP Quantitative Limit:	5	ppb
		QAPP Quantitative Limits by compound:		
		Tetrachloroethene	0.75	ppb
		Trichloroethene	0.75	ppb
		cis1,2-Dichloroethene	20	ppb
		vinyl chloride	0.75	ppb
		1,1,2 -Trichloroethane	1	ppb
		1,2 -Dichloroethane	1	ppb
		Chloroethane	No Limit	ppb
		1,2-dibromoethane	No Limit	ppb
		1,2-dibromo-3-chloropropane	No Limit	ppb
Line Item	Item	Requirement	Result	Comment Ref. #
7	Hold Times	Was the following holding times met: technical 14 days 10 days VTSR Preserved; Unpreserved 7 days	Yes	
8	Precision: Duplicates	Was the following precision criteria met: RPD≤ 50% if both samples are >5x QL or ABS <2x QL if sample and/or field duplicate are ≤5x QL	No	5
9	Sensitivity: Method Blanks	Were any target compounds found in the blanks > QL	Exceeded QAPP requirements	6
10	Accuracy: Surrogates	Did more than 3 DMCs per sample may fail to meet recovery limits	Yes	7
11	Accuracy: Internal Standards	Were internal standards within the 60-140% recovery range	Yes	
12	Accuracy: Check standards	Were internal standards within the 75-125% recovery range	Yes	
Analyte:	Sulfate & Chloride	Quantitation Limit:	1	mg/L
Line Item	Item	Requirement	Result	Comment Ref. #
13	Precision: Duplicates	Was the precision criteria met for replicate samples: ≤ 20% (QAPP) and <40% (SOP)	Yes	
14	Sensitivity: Method Blanks	Were any target compounds found in the blanks > QL	Yes	
15	Accuracy: Calibration Standard Verification	Were calibration checks within the 90-110% recovery range	No	8
16	Comparability: Similar units	Were results reported in mg/L	Yes	9
17	Completeness: Data Usability	Was 90% data completeness attained	Yes	
18	Hold Time	Were the following holding times met: Sulfate: 48 hours at 4 deg C Chloride: 28 Days at 4 deg C	Yes	
Analyte:	Methane, Ethane, Ethene, Acetylene	Quantitation Limit:	1	mg/L
Line Item	Item	Requirement	Result	Comment Ref. #
19	Hold Times	Was the following holding time met: 14 Days at 4°C	Yes	
20	Precision: Duplicates	Were the precision criteria met for replicate samples: ≤ 20% (QAPP) and <25% (SOP)	No	10
21	Accuracy: Calibration Standard Verification	Were calibration checks within the 75-125% recovery range	Yes	
22	Sensitivity: Method Blanks	Were any target compounds found in the blanks > QL	Yes	
23	Comparability: Similar units	Were results reported in mg/L	Yes	11
24	Completeness: Data Usability	Was 90% data completeness attained	Yes	

Analyte:	Chemical Oxygen Demand	Quantitation Limit:	3	mg/L
Line Item	Item	Requirement	Result	Comment Ref. #
25	Hold Time	Was the following holding time met: 2 hours	Yes	
26	Precision: Duplicates	Was the following precision criteria met: ≤ 50% RPD if both results >5x QL or ABS <2x QL if sample and/or field duplicate are ≤5x QL	Yes	
27	Accuracy: Standard Recovery	Were calibration checks within the 80-120% recovery (Per QAPP WS #12aa & 28n) or 75-125% (Per QAPP WS #28z)	Yes	
28	Sensitivity: Method Blanks	Were any target compounds found in the blanks ≥ 0.03 mg/L	Exceeded QAPP requirements	12
29	Comparability: Similar units	Were results reported in mg/L	Yes	
30	Completeness: Data Usability	Was 90% data completeness attained	Yes	
Analyte:	pH			
Line Item	Item	Requirement	Result	Comment Ref. #
31	Accuracy: Calibrated per SOP	Was the calibration 92-102% of initial slope	Yes	
Analyte:	ORP			
Line Item	Item	Requirement	Result	Comment Ref. #
32	Accuracy: Calibrated per SOP	Were the calibration and negative reference check performed and were results within criteria.	Yes	
Analyte:	Ferrous iron	Quantitation Limit:	0.03	mg/L
Line Item	Item	Requirement	Result	Comment Ref. #
33	Hold Time	Was the holding time of 2 hours met	Yes	
34	Precision: Duplicates	Was the precision criteria met for replicate samples: ≤ 50% RPD	Yes	
35	Accuracy: Standard Recovery	Were calibration checks within the 75-125% recovery range	NA	13
36	Sensitivity: Method Blanks	Were any target compounds found in the blanks > QL	NA	13
37	Comparability: Similar units	Were results reported in mg/L	Yes	
38	Completeness: Data Usability	Was 90% data completeness attained	Yes	

Abbreviations Key	
ABS	Absolute difference
DMC	Deuterated monitoring compound
GC/MS	Gas chromatography/mass spectroscopy
mg/L	milligrams per liter
ORP	Oxidation reduction potential
ppb	parts per billion
QAPP	Quality assurance project plan
QL	Quantitation limit
RPD	Relative percent difference
SOP	Standard operating procedure
VOC	Volatile organic compound
VTSR	Verified time of sample receipt
WS	Work sheet (from QAPP)

Reference #	Comments
1	See notes 5 and 10 for specific exceedances.
2	The analyst verified that this statement is true.
3	Bottles were hand shaken the morning of analysis, and then allowed to settle so that soil/turbidity would not interfere with analytics.
4	The analyst verified that this statement is true.
5	For sample 2-A and its duplicate, cis-1,2-DCE had an RPD of 54% (both detections less than 5x QL of 125 µg/L) and 1,2-dibromoethane showed a calculated RPD of 200% (a non-detection and concentration 10 µg/L). The RPDs for cis-1,2-dichloroethane and 1,2-dibromoethane met the alternative QC limit < 2x QL. For sample 7-A and its duplicate, cis-1,2-DCE showed an RPD of 91% (both detections less than 5x QL). The RPD for cis-1,2-dichloroethene in sample 2-A and its duplicate meet the alternative criteria. Also, the RPDs for trichloroethene (26%), vinyl chloride (25%), and 1,2-dichloroethane (23%) for sample 2-A and its duplicate exceeded the overall project limit of < 20%.
6	Detections of volatile organics in the blanks ranged from 0.29 µg/L to 10.67 µg/L. The treatability laboratory runs blanks between standards and high concentration samples as checks for carryover. The analyst reviews the blanks to determine if there are any issues that would have caused high carryover. After review of the blank results, if corrective action is required it is performed and the analyses would be re-analyzed. The levels of volatile organics in these blanks did not indicate a problem with the analyses.
7	The standard operating procedured (SOPs) and quality control (QC) limits used by the treatability laboratory were not included in the project QAPP. The QC limits used by the treatability laboratory for surrogates are 60-120%. The recovery limits of 60-120% were met for all four surrogates.
8	The percent recovery of sulfate in one of the two standards was 89.0%, 1% below the low QC limit of 90%.
9	Results are reported in µg/L, converted to mg/L by dividing µg/L by 1,000.
10	For sample 2-A and its duplicate, ethane had an RPD of 36% and for sample 5-A and its duplicate, ethane had an RPD of 27%, which exceeded both the QAPP and SAP limits. For sample 5-A and its duplicate, methane showed an RPD of 24%, which exceeded the QAPP limit but not the SOP limit.
11	Results are reported in units of parts per million -volume (ppmV)
12	The spectrophotometer used for measurement of COD in water sample was calibrated with a blank sample of deionized water to 0. A standard COD solution of 1000 mg/L was used as a check standard. Detection of COD in blank samples ranged from1 to 3 mg/L . The 3 mg/L value is at the QL of 3 mg/L and all detections exceeded the specified criteria of 0.03 mg/L. However, the levels of COD in the treatability tests are relatively high compared to a QL of 3 mg/L; the lowest COD measurements in this treatability study ranged between 100 to 300 mg/L. Consequently, COD values in blanks below 10 mg/L do not impact data quality.
13	Accuracy checks and blanks not performed. Hach Standard Method performed.