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Revision 3, Addendum 2
Final Design Report

Conrail Railyard Superfund Site
(Drag Strip 60 Percent Design)
Elkhart, Indiana

Submission Date: January 30, 2015

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On behalf of:
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January 30, 2015

Mr. Timothy Drexler
U.S. EPA, HSRL-6J
77 West Jackson Blvd.
Chicago, IL 60604-3590

Subject: Revision 3, Addendum 2 Final Design (Drag Strip 60 Percent Design), and
Response to EPA Comment Letter dated November 4, 2014
Second Remedial Design / Remedial Action
Conrail Railyard Superfund Site
Elkhart, Indiana

Dear Mr. Drexler:

On behalf of the Settling Parties, Norfolk Southern Railway Company (Norfolk Southern) and American Premier Underwriters (APU)[1], AECOM[2] is providing the referenced submittal, referred to as the Drag Strip 60 Percent Design, to the United States Environmental Protection Agency (EPA). The Drag Strip 60 Percent Design addresses EPA comments dated July 11, 2014. The Settling Parties previously responded to the July 11, 2014 EPA comments and developed a key element of the Drag Strip design in, "*Response to EPA July 11, 2014 Comments, and Technical Memorandum: Intermediate Remediation Goal* (IRG) *Calculation, Conrail Railyard Superfund Site, Elkhart, Indiana*," dated September 19, 2014 (IRG Tech Memo).

EPA provided comments dated November 4, 2014 regarding the Settling Parties' IRG Tech Memo submittal. On December 3, 2014, EPA, Indiana Department of Environmental Management (IDEM), S.S. Papadopulos and Associates (SSPA), the Settling Parties, and AECOM discussed the EPA November 4, 2014 comments letter and the Settling Parties' initial responses.

In addition to transmitting the Drag Strip 60 Percent Design, this letter provides the Settling Parties' formal responses to EPA's November 4, 2014 comments letter. To assist in your review, quotations from the EPA comments letter dated November 4, 2014 are presented in ***boldface italic*** type with the Settling Parties' comments in plain-type text.

1. ***We consider that your responses, pending conclusive results obtained from the microcosm studies, are adequate and sufficient for moving forward with field-scale pilot testing, as soon as possible.***

Therefore:

- ***We accept the IRG calculation methodology, however, consistent with previous EPA comments, data from [redacted] and [redacted] and Drag Strip West Source Area monitoring wells should be excluded from the attenuation factor calculation; the IRGs calculated while excluding these data are <u>53.2 ug/L for CT and 14 ug/L for TCE</u>;***

[1] Pursuant to the Consent Decree regarding the Conrail Rail Yard Superfund Site between the EPA, Consolidated Rail Corporation (Conrail) and American Premier Underwriters, Inc. (APU), dated November 10, 1997, the "Settling Parties" are Conrail and APU. Norfolk Southern Railway Company (Norfolk Southern) is performing certain environmental Activities at the site under the Consent Decree on behalf of Conrail. As such, for purposes of this correspondence, "Settling Parties" refers to Norfolk Southern on behalf of Conrail and APU.

[2] URS Corporation (URS) has merged with AECOM, and URS is a wholly-owned subsidiary of AECOM.

1. EPA's previous comment is "General Comment 1.b" from the July 11, 2014 Letter:

"The proposed VISL calculation method uses grouped groundwater and residential air COC concentrations; however, some of the wells identified to be used (MW-38S, DSMW-03, MW-56S) are near/within the West Source Area, and may have groundwater concentrations that are higher than those that actually underlie the residences. This will produce groundwater-to-air attenuation factors that are potentially high (i.e. not conservative), and therefore less protective."

As the Settling Parties have already stated to EPA in the September 19, 2014 IRG Tech Memo, these buildings are less than 150 ft. from wells and are therefore useable as data pairs, per the approved Vapor Monitoring Plan. Also, EPA is extrapolating a lower concentration beneath the buildings without any basis and using that uncertainty as rationale for rejecting valid data pairs for these buildings. With this logic, all data pairs would need to be rejected because none of the wells are located within buildings.

EPA expressed concern that the wells' proximity to source areas made the groundwater data unrepresentative and introduced bias that is not protective of human health or the environment. The Settling Parties stated that the phenomenon being characterized is constituent concentration attenuation between shallow groundwater and indoor air, which is wholly dependent on observed concentrations from valid data pairs and only indirectly related to proximity to sources. The Settling Parties stated that rejecting these data based on perceived bias mischaracterizes the phenomenon that is taking place in the Vistula neighborhood, and that they have worked diligently to describe since monitoring began in 1998. The Settling Parties informed EPA that the extensive and valuable data record from these two buildings and three monitoring wells represents a significant proportion (53 percent) of the sample data available for this analysis. Furthermore, the EPA-required use of the 95th percentile statistic is inherently a biased approach because it considers only the most conservative (upper) tail of the distribution instead of the mean, which is an acceptable method for evaluations of risk.

Following the December 3, 2014 conference call and in the interest of maintaining progress with the Drag Strip remedial design, the Settling Parties agreed to remove the two buildings from the analysis and to use the revised IRGs required in EPA's November 4, 2014 letter. The IRG Tech Memo has also been revised and is provided in the attached Drag Strip 60 Percent Design.

2. ***You should now submit, for EPA and IDEM approval, a Target Zone based on the 95% upper confidence limit of the mean (UCL) concentrations of CT and TCE measured in samples from shallow wells over the last 2 years (March 2012-March 2014) to serve as a basis for remedial design, using the current monitoring well network and the updated IRGs;***

2. During the December 3, 2014 conference call, the Settling Parties reminded EPA that requiring Target Zone establishment before the delineation task is inconsistent with the approach proposed in *Revision 2, Addendum 2 Final Design Report*, dated May 16, 2014 (30 Percent Design), "Additional delineation of COCs is needed at the Drag Strip in order to refine the current treatment area footprint." In order to accurately characterize nature and extent, the delineation task is needed. In particular, plume geometry is needed in order to focus the pilot testing on the plume core while accommodating EPA's GCW operational requirement during pilot testing. EPA agreed that the delineation task is necessary to establish the Target Zone, and EPA understands that access to the Drag Strip property is necessary to perform the delineation task.

> ***3. <u>Will there be a change in flow caused by deactivation of the GCW?</u> URS acknowledges this change and proposes to use a number of wells to constrain the western plume extent (DSMW-05S, DSMW-06S, DSMW-17S, MW-59S, MW-38S, and MW-56S). We agree that DSMW-05S, DSMW-06S, and MW-38S could be used as sentry wells for changes in CT concentrations. If increases are observed in these wells, however, it is important that a contingency plan be developed. According to URS response GC-3, the GCW can remain operational during pilot testing. This response is adequate.***

3. The indoor air monitoring program will continue throughout the Drag Strip remedial action. During and after full-scale remedy implementation, contingency action would be triggered by an exceedance of a shallow groundwater action level (based on the IRG, to be determined). The contingency action would consist of a combination of groundwater and indoor air confirmatory sampling, data evaluation, and reporting. Per the indoor air monitoring program, confirmed exceedance of the indoor air action level (IAAL) for carbon tetrachloride (CT) would trigger installation of mitigation system in that building.

> ***4. Also, our review of the file "AppA Workbook Attenuation Factors.xls" identified that the Henry's Law Constants listed in worksheet "AF Calcs working", column AB, rows 683 through 880 need to be correctly assigned to the chemical listed. This correction will not impact the results as they are not included in the attenuation factor calculation.***

4. This correction has been made to the revised IRG Tech Memo provided in the attached Drag Strip 60 Percent Design.

> ***5. EPA/IDEM Comments on Microcosm Study***

5. The specific EPA/IDEM comments are addressed either in the Final Microcosm Report or in the attached Drag Strip 60 Percent Design.

Please call Tony Limke at (513) 651-3440 if you have any questions or comments.

Sincerely,
AECOM
on behalf of Norfolk Southern Railway Company,
and American Premier Underwriters

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Acronyms

Acronym	Description
AEM	Analytical Element Model
APU	American Premier Underwriters, Inc.
ft bgs	Feet below ground surface
CT	Carbon tetrachloride
CD	Consent Decree
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CF	Chloroform
COD	Chemical oxygen demand
COCs	Constituents of concern
Conrail	Consolidated Rail Corporation
CQAO	Construction Quality Assurance Plan
CSM	Conceptual site model
CVOCs	Chlorinated volatile organic compounds
DNAPL	Dense non-aqueous phase liquid
1,1-DCE	1,1-dichloroethene
cis-1,2-DCE	cis-1,2-dichloroethene
trans-1,2-DCE	trans-1,2-dichloroethene
DO	Dissolved oxygen
Drag Strip	Osceola Drag Strip
EISB	Enhanced In Situ Bioremediation
EPA	United States Environmental Protection Agency
ESTCP	Environmental Security Technology Certification Program
EVO	Emulsified vegetable oil
EVS	Environmental Visualization Systems
First RD/RA	First Remedial Design/Remedial Action
ft/day	Feet per day
GAC	Granular activated carbon
GCW	Groundwater circulating well
GMP	Groundwater Monitoring Plan
gpm	Gallons per minute
GWIASLs	Groundwater to indoor air screening levels
GWTP	Groundwater Treatment Plant
HI	Hazard index
HQ	Hazard quotient
IAAL	Indoor air action level
IASLs	Indoor air screening levels
ICs	Institutional Controls
IDEM	Indiana Department of Environmental Management
IRA	Interim Remedial Action
IRG	Intermediate remediation goal
lbs	Pounds
LR	Long-term response
MCLs	Maximum contaminant levels
Microbial	Microbial Insights
mg/L	Milligrams per liter

MNA	Monitored Natural Attenuation
msl	Mean sea level
mV	Millivolts
Norfolk Southern	Norfolk Southern Railway Company
NPL	National Priorities List
O&M	Operations and Maintenance
ORP	Oxidation-reduction potential
PCE	Tetrachloroethene
ppbv	Parts per billion by volume
Petition	Technical Impracticability Waiver and Request for Remedy Reconsideration
ppbv	Parts per billion by volume
PRPs	Potentially Responsible Parties
PRP LR	PRP Long-Term Response
PVC	Polyvinyl chloride
QA/QC	Quality assurance/quality control
Railyard	Norfolk Southern Elkhart Yard
RAO	Remedial Action Objective
RfC	Inhalation reference concentration
RI/FS	Remedial Investigation/Feasibility Study
ROD	Record of Decision
SAP	Sampling and Analysis Plan
Second RD/RA	Second Remedial Design/Remedial Action
SOW	Statement of Work
SSSLs	Sub-slab screening levels
SSPA	S.S. Papadopulos & Associates, Inc.
TCE	Trichloroethene
TCOCs	Total constituents of concern
TestAmerica	TestAmerica Laboratories
TI	Technical Impracticability Waiver
TOC	Total organic carbon
TPG	Three point gradient
1,1,1-TCA	1,1,1-Trichloroethene
UCL	Upper confidence limit
UIC	Underground injection control
µg/L	Micrograms per liter
µS/cm	Micro Siemens per centimeter
VC	Vinyl chloride
VFAs	Volatile fatty acids
VFDs	Variable frequency drives
VI	Vapor intrusion
VISL	Vapor intrusion screening level
VOCs	Volatile organic compounds
ZVI	Zero-valent iron

Executive Summary

This document presents Revision 3 to Addendum 2 to the Final Design Report for the Conrail Railyard Superfund Site in Elkhart, Indiana (Site). One purpose of this Revision 3 Addendum 2 is to present the design basis and intent for the revised remedy at the Drag Strip source areas. This submittal is considered to be a 60 percent design document. The other purpose of this submittal is to provide a "roadmap" to future Superfund programmatic activities.

The Site consists of two separate groundwater remediation areas, and each of these areas has in place an operational groundwater extraction and treatment system. The first is the groundwater pumping and containment system located at the Norfolk Southern Elkhart Yard (Railyard), and the second is the pilot-phase groundwater circulation well (GCW) located at the Osceola Drag Strip (Drag Strip). The Site also has in place a vapor mitigation and indoor air monitoring program for buildings in the Vistula Area, located downgradient of the Drag Strip.

The focus of this document is the Drag Strip, and the Settling Parties' continuing, significant efforts towards finalization of the remedial action in this portion of the Site. The revisions to the remedial action approach herein have been prepared resulting from comments and requirements received by the Settling Parties from the United States Environmental Protection Agency (EPA) and the Indiana Department of Environmental Management (IDEM), and they represent a significant change from the previously-proposed remedy. The previously-proposed remedy included a two-year performance evaluation. If the outcome of the performance evaluation was that further, active remediation of source mass was required, a contingency remedy, consisting of GCW technology to target the core of the remaining enrichment mass, would be installed.

EPA required the Settling Parties to design and install a contingency remedy in the near term because of EPA's concerns about downgradient risk for vapor intrusion (VI) and plume instability. A groundwater risk evaluation and plume stability analysis were submitted in late 2013 to address EPA's concerns.

In response to EPA's requirement, the Settling Parties will proceed with further active remediation of the Drag Strip source areas by installing a contingency remedy. In consideration of environmental, social, and economic factors, the Settling Parties have chosen to invest in a sustainable remedy for the Drag Strip. This decision is in alignment with EPA's efforts to support greener cleanups. As discussed with EPA during the meeting on February 12, 2014, the contingency remedy will consist of an enhanced in-situ bioremediation technology instead of the previously-proposed GCW technology.

Because of potential VI risk to the Vistula Area, a hot-spot remedy at the Drag Strip source areas is necessary. The sole potentially-complete exposure pathway for contaminated groundwater is the inhalation of vapor-phase constituents of concern (COCs) released from the shallow groundwater zone to indoor air of residents and commercial workers downgradient of the Drag Strip. This potential risk to human health is used to develop the design parameters for the revised contingency remedy, which are:

- Revised Drag Strip remedial action objective (RAO) based on the shallow groundwater to indoor air exposure pathway;
- Development of an intermediate remediation goal (IRG) for the Drag Strip, using an updated site-specific attenuation factor, EPA's level of acceptable risk, and EPA's vapor intrusion screening level (VISL) Calculator; and

- Development of the attainment process for the IRG, and closeout process for vapor monitoring and mitigation program.

At this 60-percent design stage, the remedy includes the following physical design elements:

- Additional delineation of total COCs to define current plume core for full-scale treatment of the hot spot;
- Bench- and pilot-scale testing to select effective injection amendments;
- Full-scale implementation of hot-spot treatment remedy, including utilization of the existing GCW to assist in distribution of amendments; and
- Remedy performance monitoring.

Because of their dependence on the delineation of COCs, full development of the pilot-scale testing program and the full-scale design will necessarily be provided in subsequent design submittals.

Prior to any onsite fieldwork for delineation, pilot testing, or full-scale construction and implementation, access to the Drag Strip property is required. A complaint was filed in Federal Court to enforce the terms of the 2001 Settlement Agreement and to obtain access to the Drag Strip for installation of wells necessary for proceeding with the remedy proposed herein. The Drag Strip property owner was named a potentially responsible party (PRP) by EPA in a letter dated November 19, 2012. The access issue is still being resolved, and it has will continue to delay implementation of the necessary fieldwork for the remedy.

1.0 Introduction

This document presents Revision 3 to Addendum 2 to the Final Design Report (URS 2003a) for the Conrail Railyard Superfund Site in Elkhart, Indiana (Site) (Figure 1). The Site is proceeding through the Second Remedial Design/Remedial Action (Second RD/RA). The United States Environmental Protection Agency (EPA) has established a groundwater remedial alternative for the Site, which is presented in a Record of Decision (ROD) Amendment dated September 27, 2000, and which modifies the Final ROD dated September 9, 1994. Work at the Site is being conducted by the Settling Parties[1] under the Consent Decree (CD), which was lodged with the court on August 12, 1997 and entered by the court on November 10, 1997 (referenced as Civil Action No. S90-56M). As will be explained in more detail in subsequent sections of this document, EPA required the Settling Parties to design and install a contingency remedy in the near term because of EPA's concerns about downgradient risk for vapor intrusion (VI) and plume instability.

The Site remedial action consists of two separate groundwater remediation areas, and each of these areas has in place an operational groundwater extraction and treatment system. The first is the groundwater pumping and containment system located at the Norfolk Southern Elkhart Yard (Railyard), and the second is the pilot-phase groundwater circulation well (GCW) located at the Osceola Drag Strip (Drag Strip). The Drag Strip property owner was named a potentially responsible party (PRP) by EPA in a letter dated November 19, 2012.

In addition to the groundwater monitoring program associated with the Railyard and Drag Strip, the Site also has in place a vapor mitigation and indoor air monitoring program for buildings in the Vistula Area, located downgradient of the Drag Strip.

The focus of this document is the Drag Strip, and the Settling Parties' continuing, significant efforts towards finalization of the remedial action in this portion of the Site. The predecessors to this document are:

- Addendum 2, Final Design Report, dated November 9, 2012 (URS 2012a);
- Revision 1, Addendum 2, Final Design Report dated April 17, 2013 (URS 2013a); and
- Revision 2, Addendum 2, Final Design Report dated May 16, 2014 (URS 2014a).

The revisions herein have been prepared resulting from comments and requirements received by the Settling Parties from the EPA and the Indiana Department of Environmental Management (IDEM) dated July 11, 2014 (EPA 2014a) and November 4, 2014 (EPA 2014b).

1.1 Purpose: Revision 3 Addendum 2 to Final Design

Whereas the Site's first addendum to the Final Design (URS 2011, see Appendix A) presented the design for the Railyard treatment system upgrades, the second addendum addresses the Drag Strip groundwater remediation area, as well as subsequent Superfund programmatic activities during the Second RD/RA. One purpose of this Revision 3 Addendum 2 is to present the next phase of design elements for the revised remedy at the Drag Strip source

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areas. Given the collaborative approach adopted by EPA and the Settling Parties for development of recent (since 2009) Site program documents, this submittal is considered to be a 60 percent design document. The other purpose of this submittal is to provide a "roadmap" to future Superfund programmatic activities such as:

- Drag Strip remediation system construction completions under the Second RD/RA;
- Updates to the long-term groundwater monitoring program for the Site; and
- Interim Remedial Action (IRA) reporting for the Site.

1.2 Report Organization

This submittal contains the following components in support of the Drag Strip remedial design and the proposed Superfund programmatic activities:

Background to Drag Strip Final Remedy Selection – Summarizes regulatory history, the requirements contained in the Superfund controlling documents, and the requirements in recent EPA communications.

Conceptual Site Model (CSM) – Presents Drag Strip and Site information regarding releases to the environment, describes the environmental setting and spatial distribution of contaminants, and identifies potential receptors and potentially complete exposure pathways.

Risk Characterization – Summarizes the assessment of potentially complete exposure pathways needed for the development of risk-based remedial decisions for the Drag Strip.

Drag Strip Remedial Design – Presents the proposed revision to the groundwater remediation contingency remedy.

Interim Remedial Action (IRA) Report – Describes the content of the IRA Report that will be submitted to the agencies upon completion of the Drag Strip Remedy.

Potentially Responsible Parties (PRPs) Long-Term Response (LR) Monitoring – Presents the conceptual groundwater monitoring program during the remedial action period following remedy construction and startup.

2.0 Background to Drag Strip Final Remedy Selection

This section summarizes regulatory history of the Site, the requirements for Drag Strip remedial action contained in the Site's controlling documents (CD and ROD Amendment), and the requirements in recent EPA communications.

The Drag Strip area is located on a 130-acre parcel of land south of County Road 16 and east of [redacted] (Figures 2 and 3). This parcel is owned and operated as a motor vehicle racing business [redacted]. The Settling Parties have no ownership of this property, and have right of access only through agreement with the property owner. Prior to 1967, the property was used as an air strip. Acreage in the eastern portion of the parcel is in agricultural use. An area in the southwestern portion of the property has been identified as being affected by groundwater contamination, including two areas referred to as the East and West Source Areas where carbon tetrachloride (CT) is present in the aquifer.

2.1 Regulatory History

The Site was first identified in 1986 when volatile organic compounds (VOCs) were identified in a residential well. Following initial assessments and investigations, the Site was proposed for the National Priorities List (NPL) in 1988. Following three phases of investigation by EPA, remedial actions were identified for the Site in the Final ROD dated September 9, 1994. Subsequent negotiations between the Settling Parties and EPA culminated in the CD and Statement of Work (SOW) in 1997.

For the Drag Strip Source Areas, the CD (Chapter VII, para. 18b) sets forth three conditions that must be true before remediation is required:

- Condition (i): "…shall remediate…or contain any source areas to the extent such source areas…contain contaminants which exceed the performance standards set for the in Table 3 of the [Statement of Work] SOW" and;
- Condition (ii): "…are determined by EPA to be recharging the known groundwater plumes, or commingled plumes, at the Site" and;
- Condition (iii): "…significantly delay the time, as determined by EPA, by which the contaminated groundwater at the Site will achieve the standards set forth in Table 3 of the SOW." The standards in Table 3 of the SOW are the maximum contaminant levels (MCLs) for the listed compounds.

To implement the SOW, the First Remedial Design/Remedial Action (First RD/RA) was completed between January 1998 and September 2000. During this period the following tasks were completed:

- Source area investigations on the Railyard;
- Source area investigations on the Drag Strip;
- Vapor sampling throughout the Site and installation of vapor mitigation systems in some buildings northwest of the Drag Strip; and
- Ecological assessment of benthic macroinvertebrate on the St. Joseph River.

The results of these investigations and remedial work were submitted to the agencies in three main reports:

- Preliminary Design Report for the First RD/RA (dated September 1998, revised December 18, 1998);
- Addendum to the Preliminary Design Report for the First RD/RA (dated December 23, 1998); and
- Vapor Remediation Report (dated September 28, 1999).

The scope of work for the indoor air monitoring program for the Superfund Site, as required under the 1994 Final ROD, was presented in the *95% Design for the First Remedial Design/Remedial Action*, dated December 1999 [95% Design Report] (URS Dames & Moore 1999). Under this approved program, the Settling Parties have been monitoring indoor air in buildings in the Vistula Area since 1999, and have installed sub slab venting systems in 10 buildings in order to mitigate potential human health risk due to VI.

On August 13, 1999, the Settling Parties submitted a Petition for Technical Impracticability (TI) Waiver and Request for Remedy Reconsideration (Petition). This document was finalized on February 3, 2000. EPA approved the Petition and the request, and the ROD Amendment initiating the Second RD/RA was then issued in September 2000. The ROD Amendment modified the Railyard remedy due to the technical impracticability of cleaning up the two dense non-aqueous phase liquid (DNAPL) source areas. Instead, that remedy was changed to hydraulic containment of the two Railyard source areas and natural gradient flushing of the dissolved portion of plume downgradient of the Railyard.

In the 2000 ROD Amendment, EPA considered that all three conditions of the CD to be true, and therefore, that remediation of the Drag Strip source areas was required. Specifically the ROD Amendment states,

> "Remedial action at the Drag Strip area could include removal of soil and/or drums, tanks, and containers and off-site disposal, soil vapor extraction, and/or hydraulic containment of the source area on the Drag Strip property."

The other component of selected remedy in the ROD Amendment is natural gradient flushing for the portion of the groundwater plume downgradient of the Railyard. Because the groundwater plume flows beneath the Drag Strip, natural gradient flushing is also a remedial action component for the contaminated groundwater at the Drag Strip.

Pre-design studies for the Railyard and Drag Strip were initiated in 2000 under the Second RD/RA, and the findings were reported in the *Second RD/RA Preliminary Design Report* (URS 2002). The final design for the Railyard remediation system was presented in URS (2003a), and the design for the pilot phase GCW, located in the Western Source Area at the Drag Strip, was presented in *Work Plan for Relocation and Pilot Testing of GCW Treatment System, Osceola Drag Strip, November 25, 2003* (URS 2003b). Construction of the Railyard remediation system and the Drag Strip pilot-phase remediation system occurred between 2003 and 2004, and both systems started up in 2004.

2.1.1 Drag Strip Pilot-Phase Remedy

Based on the pre-design investigation findings presented in URS (2002) and the work plan scope in URS (2003b), the Settling Parties installed a GCW as a pilot-phase, hydraulic containment and treatment remedy. The groundwater circulating around a GCW consists of: a) upgradient water being captured, b) captured groundwater being treated in a well head labyrinth air stripper, and c) treated groundwater being re-circulated within a circulation cell prior to being discharged downgradient of and outside of the circulation cell.

The objective for the Drag Strip pilot-phase GCW is the removal of CT, chloroform [CF] (a CT degradation product), and trichloroethene (TCE) from groundwater within the West Source Area at the Drag Strip. In URS (2003b), a successful pilot test was defined as a sustained monthly average removal rate of at least 0.5 pounds (lbs.) per day of system CT from groundwater. The GCW system was also required to maintain an average total recirculation flow rate of at least 80 gallons per minute (gpm), without excessive maintenance requirements, and at least 90 percent actual system operation time.

The GCW at the Drag Strip was installed in the West Source Area to a depth of 152 feet below ground surface (ft bgs). The GCW consists of a 10-inch well casing with three screened zones; the middle screen is the influent zone, and upper and lower screens are discharge zones. The zones within the GCW casing are separated by packer units, allowing differential pressure to be developed between the different screened zones. This flow configuration is referred to as “dual cell” or “stacked cell” because there are two individual flow cells developed in the aquifer. A sump pump provides flow to the lower screen. Flow to upper screen is by gravity overflow from the labyrinth stripper well head into the well casing and upper screen. Additional information regarding the design and construction of the GCW is provided in the GCW Pilot Testing Report, (URS 2005a).

The GCW has been remediating the Western Source Area at the Drag Strip from 2004 to the present, and the GCW has removed an estimated cumulative total of 2,445 pounds of total compounds of concern (TCOCs), including 2,200 pounds CT, since system operations began at the Drag Strip in 2004.

2.1.2 Third Five-Year Review

In 2009, EPA issued the *Third Five-Year Review Report* (EPA 2009), in which performance issues for the Railyard and Drag Strip remediation systems were identified. EPA also issued *Evaluation of Indoor Air Monitoring*, prepared by S.S. Papadopulos & Associates, Inc. (SSPA), (SSPA 2010) to evaluate the adequacy of the indoor air monitoring program. The Settling Parties worked with EPA in developing the scope of work for an investigation to address these issues, culminating in *Revision 4, Five-Year Review Investigation Work Plan*, June 8, 2010, (URS 2010a) and the *Response, Evaluation of Indoor Air Monitoring*, December 3, 2010 (URS 2010b).

The Five-Year Review Investigation began in late 2009, and investigation, data analyses, and reporting activities continued through 2012. The technical evaluations performed as part of the Five-Year Review Investigation confirmed the need to improve plume capture at the Railyard. These evaluations are summarized in the *Five-Year Review Investigation Report*, submitted to EPA on February 28, 2013 (URS 2013b). The *Five-Year Review Investigation Report* also presented the Years 6, 7, and 8 Performance Evaluations for the Site, which included analytical results for the quarterly monitoring events conducted between September 2009 and June 2012.

As part of the Third Five-Year Review, EPA required two sets of supplemental indoor air investigations. The first set of investigations consisted of indoor air sampling for COCs from up to 52 residential and commercial buildings using updated sampling and analysis procedures. The scope of work for the first supplemental investigation is presented in the EPA-approved *Addendum 1, Vapor Monitoring Plan*, dated February 29, 2012 (URS

2012c). The COCs for the supplemental indoor air monitoring events were changed to CT, TCE, CF, and vinyl chloride (VC), as required by EPA. Indoor air sampling results from the first set of investigations (conducted in the Spring and Fall 2012) are presented in Appendix M of URS (2013b).

The second set of supplemental investigations required by EPA consisted of paired indoor air and sub-slab vapor monitoring from up to 20 residential and commercial buildings. Under the existing, approved vapor monitoring program, no sub-slab vapor monitoring had been performed in the study area. Rather, the Settling Parties used indoor air quality results measured directly in targeted structures to ensure protectiveness of occupants. In 2013, EPA and IDEM identified the lack of sub-slab vapor sample results as a data gap in the overall VI pathway evaluation, and they required collection of the sub-slab vapor data. The Settling Parties agreed to collect sub-slab samples from representative buildings over the shallow CT plume in accordance with the EPA-approved *Addendum 2 to Vapor Monitoring Plan, Updated Sampling Procedures: Sub-Slab Vapor Sampling*, dated April 17, 2013 (URS 2013f). The approach to fill the data gap in the overall VI pathway evaluation is to collect indoor air and sub-slab vapor samples and compare the results with the CT action level and screening levels previously proposed for this site. A site-specific indoor air action level (IAAL) for CT was established by EPA in 1999 at 3.0 parts-per-billion on a volume basis (ppbv). EPA revised this level to 0.65 ppbv on March 28, 2012. For the other COCs, indoor air screening levels (IASLs) and sub-slab screening levels (SSSLs) were proposed in URS (2013f). As stated in EPA (2014a), the IASLs and SSSLs are not yet approved by EPA.

Two rounds of paired indoor air and sub-slab vapor sampling took place. The first round occurred in the Spring of 2014, and the second round occurred in the Fall of 2014. The results of the Spring 2014 sampling event were presented in *Technical Memorandum: Indoor Air and Sub-Slab Vapor Monitoring – Spring 2014 Event*, dated December 9, 2014 (URS, 2014e). EPA provided comments on this submittal in a letter dated January 16, 2015 (EPA, 2015), in which EPA requested that the Spring and Fall 2014 results be combined. The Settling Parties are revising this submittal to combine the results of the Spring and Fall 2014 sampling events, and this revised document will be provided separately. Based on the Spring 2014 and Fall 2014 data, observed sub-slab soil gas concentrations collected downgradient of the Drag Strip source area do not indicate a completed exposure pathway to indoor air at concentrations requiring corrective action. These findings address the data gap for sub-slab soil gas data, and they demonstrate continued protectiveness of the existing indoor air monitoring program.

2.1.3 Railyard Remedy Upgrade

The Railyard remedy upgrade design is presented in the *Addendum, Final Design Report*, dated June 30, 2011 (URS 2011) (Appendix A). Railyard upgrade construction commenced on May 23, 2012. The construction activities were substantially complete on September 18, 2012 and documented in the September 29, 2012 Substantial Completion Letter to EPA (URS 2012b). The final completion of the construction activities occurred during the week of January 14, 2013. The report, *Construction Completion Report, Groundwater Containment Pumping and Treatment System Upgrades*, dated July 25, 2013 (URS 2013c) was prepared to formally document the completion of the construction activities.

2.1.4 Drag Strip Remedy Finalization Activities

For the Drag Strip, the Five-Year Review investigation included predesign studies intended to finalize the pilot phase of the groundwater remediation system. The objectives of the investigation for the Drag Strip were to:

- Delineate the extent of VOCs released at the property;
- Characterize groundwater hydraulic behavior resulting from operation of the pilot GCW; and
- Develop performance metrics for the remediation system applicable to the Drag Strip remedial goals.

Based on the fact that VOCs at the Drag Strip consist of the sum of onsite releases plus migration from the upgradient plume, the data evaluations included separation of these contributions and the delineation of VOCs "enrichment" from onsite releases. The findings of the VOCs enrichment delineation were presented in the Five-Year Review Investigation Report (URS 2013b). The overall findings show that the highest-concentration enrichment zone (exceeding 1,000 micrograms per liter [μg/L]) occurred between approximately 80 to 90 ft, bgs at a location just east of the GCW. Lower-concentration enrichment covers a larger area, and the westernmost portion is near the former vehicle maintenance pit area. There was also a gap in the enrichment area that is attributed to the GCW operation and remediation since startup in 2004. A data gap was also identified along the downgradient property boundary; additional monitoring wells were needed for the proposed remedy performance metrics (see Section 2.1.4.2).

Hydraulic testing was conducted during the Five-Year Review Investigation to validate the dimensions of the circulation cells developed by operation of the GCW. Data input from the GCW and observation wells were used to calibrate modeling tools employing an Analytical Element Model (AEM) and a finite-difference numerical model. The modeling resulted in estimated circulation cell widths (for the Upper and Lower Circulation Cells), as well as an upgradient capture zone width of 230 feet. Specifically, the modeling results provided the following estimates for typical GCW operational flow rates:

Estimated GCW Hydraulic Dimensions

	Flow Rate (gpm)	Width (feet)
Upgradient Capture Zone (Extraction)	80	230
Upper Circulation Cell (Injection)	60	87
Lower Circulation Cell (Injection)	20	73

The development of performance metrics needed for finalization of the Drag Strip remedial action involved a significant level of effort and communication between the Settling Parties and EPA during and following the Five-Year Review Investigation period, as described in the following subsections.

2.1.4.1 Drag Strip Remedial Action Objective-2011

The Settling Parties worked with EPA during the Five-Year Review Investigation to develop a remedial action objective (RAO) for a final Drag Strip remedy. The Drag Strip RAO was derived from the CD's condition (iii) which sets forth the concept that the Drag Strip sources must not, "...significantly delay..." achievement of the overall Superfund Site RAO, which is attainment of MCLs in groundwater between the Railyard Line of Containment and the St. Joseph River. The "…significantly delay…" concept would be evaluated through the comparison of upgradient to downgradient groundwater conditions. For example, if the downgradient groundwater conditions are equivalent to upgradient conditions, then

1. The Drag Strip sources are not contributing mass to the plume;
2. There can be no "significant delay" in achieving the MCLs;
3. Condition (iii) of the CD is not true; and
4. Further remediation is not required under the CD.

The Drag Strip RAO, as agreed with EPA was, "Remediation of the Drag Strip sources to a point of equivalence to the background or upgradient plume currently flowing onto the Drag Strip property," (EPA 2011).

2.1.4.2 Previously-Proposed Drag Strip Remedy and Performance Metrics

The performance metrics were presented in the Addendum 2, Final Design Report, dated November 9, 2012 (URS 2012a). In this document, the Settling Parties proposed to transition the Drag Strip GCW from pilot-phase to final remedy, because it complies with the CD and ROD Amendment requirements, it is protective of human health, it builds upon the source cleanup accomplished by the GCW to date, and it is an appropriate response to the relatively small scale of remaining enrichment mass at the Drag Strip. The remedy performance metrics proposed for the GCW were intended to evaluate the GCW's ability to:

- Minimize potential risk to human health due to VI; and
- Achieve the Drag Strip RAO.

The remedy performance metrics included an initial 2-year remedy performance evaluation period (with the GCW shut off) during which indoor air and groundwater sample results would be used to build lines of evidence for the adequacy of groundwater remediation performed to date. To evaluate potential risk to human health due to VI, indoor air samples would be compared to the current IAAL for CT (0.65 ppbv). To evaluate achievement of the Drag Strip RAO, groundwater sample data would be used in a mass flux analysis. Mass flux, (concentration times the groundwater flow velocity), would be calculated at predefined boundaries within the evaluation domain, and the evaluation domain is an aquifer volume that encompasses the southwestern portion of the Drag Strip property where the East and West Source Areas are located. If the outcome of the two-year remedy performance evaluation was that further, active remediation of source mass was required, the Settling Parties proposed a contingency remedy, consisting of GCW technology to target the core of the remaining enrichment mass.

2.1.4.3 EPA Response to Proposed Approach

EPA responded to the Settling Parties proposed Drag Strip remedy finalization approach in letters dated July 12, 2013 and November 6, 2013. The following points summarize EPA's position:

1. Elevated upgradient VOCs concentrations seen in DSMW-07 and DSMW-08 that are flowing onto the Drag Strip represent new Site conditions, and they represent a concern for VI in the neighborhood downgradient of Drag Strip (Vistula Area).
2. Shutting off the GCW for the performance evaluation is unacceptable because of this potential VI risk to the Vistula Area.
3. EPA cannot allow an approach that makes remedial actions at the Drag Strip contingent upon the concentration difference between the upgradient and downgradient monitoring locations due to perceived unstable (i.e., increasing) upgradient concentrations.
4. Complete capture of Railyard contaminants only began in March 2013; the operational period from 2004-2013 produced incomplete capture; it is implied that the elevated concentrations seen in DSMW-07 and DSMW-08 result from incomplete capture at the Railyard.
5. Elevated upgradient concentrations seen in DSMW-07 and DSMW-08 represent unstable plume conditions downgradient of the Railyard.
6. According to EPA's interpretation of the ROD Amendment, incomplete capture at the Railyard invokes the ROD Amendment's contingency remedy requirement, i.e., the process of designing and installing a contingency remedy, which consists of additional GCW(s), would be triggered.
7. Hot-spot remediation of the Drag Strip sources is required at this time, by EPA's authority, as set forth in the following paragraphs in the CD:
    - Paragraph 14 – EPA has made the determination that achievement of the overall Superfund Site RAO (attainment of MCLs in Site groundwater) will be significantly delayed;
    - Paragraph 20 – EPA believes that the remedy as currently being implemented is not protective of human health and the environment; and
    - Paragraph 22 – EPA has made the determination that the reopener conditions in Paragraph 83 are satisfied. Specifically, conditions and information at the Site previously unknown to EPA have been discovered, and these unknown conditions and information indicate that the Remedial Action is not protective of human health or the environment.

In regards to the scope and data evaluation for the subslab vapor monitoring that was mentioned in EPA's November 6, 2013 Letter and discussed with EPA and IDEM during the meeting on February 12, 2014, EPA changed the scope for this work in an email dated February 21, 2014 (EPA 2014). Due to technical and human health concerns with collecting subslab samples from homes with operating abatement systems, EPA removed these houses from the subslab sampling scope, and instead required a minimum of 20 subslab sample locations in houses without abatement systems and that are located over the core of the shallow CT plume.

2.1.4.4 Technical Rebuttals

EPA's primary rationale for requiring immediate installation the contingency remedy at the Drag Strip is based on potential VI risk from extrapolated future groundwater concentrations from a plume declared to be unstable. With this rationale, EPA has renounced the existing Drag Strip RAO (Section 2.1.4.1) that the Settling Parties used to develop the Drag Strip Remedial

Design presented in the previous iterations of this Addendum 2 Final Design document. The Settling Parties and EPA had previously agreed that this RAO was consistent with the requirements of the CD and the ROD Amendment.

To address EPA's presumption of unacceptable risk due to VI, the Settling Parties submitted *Groundwater Risk Evaluation,* dated December 6, 2013 (URS 2013d) to support the positions that current and future risk falls within EPA's acceptable range. As will be further described in Section 4.0, the VI pathway is controlled (individual vapor mitigation systems have been installed in houses) or incomplete. Under current conditions (GCW operating), there is not a potential risk due to VI, based on the available groundwater and indoor air data. The calculated risks were within EPA's acceptable risk range (excess cancer risk within one in one million and one in ten thousand and a hazard quotient (HQ) less than 1). Moreover, under hypothetical future conditions (following GCW shutdown), there is not a potential risk due to VI. This conclusion is supported by indoor air monitoring data and shallow groundwater data collected since 1998, which demonstrates that a high level of attenuation is present at the site.

To address EPA's statements about plume stability, the Settling Parties submitted *Technical Memorandum: Groundwater Plume Stability Analysis*, dated December 13, 2013 (URS 2013e, and revised per EPA comments in URS 2014b). The stability of the plume is important because an unstable (i.e., expanding) plume would be evidence of failure of the natural gradient flushing component of the Site remedy. Specifically, if natural gradient flushing is performing inadequately, then the ROD Amendment requires a contingency remedy of additional offsite extraction wells. Failure of natural gradient flushing would be shown by an expanding, unstable plume, but, as presented in the Technical Memorandum submittal, the plume is stable.

In its November 6, 2013 letter, EPA invoked the contingency requirement due to incomplete capture by the Railyard hydraulic containment system. The Settling Parties disagree with EPA's interpretation of the requirements in the ROD Amendment. The ROD Amendment's intent is that the contingency remedy is required for inadequate performance of *natural gradient flushing* and not incomplete capture by the *hydraulic containment system*. The Settling Parties addressed incomplete capture of the Railyard hydraulic containment system by constructing the remedy upgrades in 2012 (Section 2.1.3).

2.1.4.5 Revised Drag Strip Contingency Remedy

Resulting from these communications and in recognition of EPA's authority in making determinations regarding remedy requirements, the Settling Parties are proceeding with further active remediation of the Drag Strip source areas by designing and installing a contingency remedy. In consideration of environmental, economic, and social factors that characterize the potential sustainability of such an endeavor, the Settling Parties have chosen to invest in a more sustainable remedial approach for the Drag Strip contingency remedy. This decision is in alignment with EPA's efforts to support greener cleanups, as stated in EPA (2013d):

> "Consideration of greener cleanup practices directly builds upon several of the Administrator's seven key themes for the future, including: making a visible difference in communities across the country; addressing climate change and improving air quality; and working toward a sustainable future."

As discussed with EPA during the meeting on February 12, 2014, the contingency remedy will consist of an enhanced in-situ bioremediation technology instead of the previously-proposed GCW technology.

The 30 percent design submittal, *Revision 2 Addendum 2 Final Design Report* (URS 2014a) presented design information for the in-situ remediation approach, including bench-scale microcosm testing, pilot-scale testing of amendments, and full-scale implementation. EPA provided comments on the 30 percent design in a letter dated July 11, 2014 (EPA 2014a). Concurrent with EPA's public meeting for the Fourth Five-Year Review in July 2014, the Settling Parties met with EPA to discuss the Drag Strip remedial action. During this meeting, the Settling Parties stated that a fundamental requirement for proceeding with the design and implementation of the revised Drag Strip remedy is development of an acceptable interim remediation goal (IRG). The purposes of the IRG are to define the onsite treatment area footprint and to evaluate performance of the revised contingency remedy for the Drag Strip, i.e., attainment of the IRG will indicate completion of the contingency remedy for the Drag Strip source areas.

To address this fundamental design requirement and to respond to EPA's July 11, 2014 Comments, the Settling Parties submitted *Response to EPA July 11, 2014 Comments, and Technical Memorandum: Intermediate Remediation Goal Calculation*, dated September 19, 2014 (IRG Tech Memo) (URS 2014c). EPA commented on the IRG Tech Memo in a letter dated November 4, 2014 (EPA 2014b), and EPA and the Settling Parties held a conference call on December 3, 2014 to discuss the EPA comments. Following this conference call, EPA and the Settling Parties agreed to the following items, which will be incorporated into the Drag Strip contingency remedy design herein:

- Paired indoor air and shallow groundwater data from two addresses will be removed from the IRG calculation data pool (see Section 5.3);
- The onsite treatment area footprint for the pilot test and the full-scale implementation will be defined using newly-installed monitoring wells from the Additional Delineation of Total COCs task described in Section 5.5.

The 30 percent design submittal (URS 2014a) presented the bench-scale microcosm testing plan as well as preliminary pilot-scale testing full-scale implementation approaches. The purpose of the bench-scale microcosm studies is to test a range of commercially available remedial amendments on CT and TCE-spiked groundwater and sediment samples collected from the Drag Strip. The objective is the identification of combinations of remedial amendments that could result in the complete degradation of a mixture of CT and TCE. As summarized in Section 5.6, the results of the bench-scale microcosm studies show in some cases the complete reduction of a mixture of CT and TCE to innocuous end products in less than 80 days. Based on this degradation, pilot studies are developed herein to evaluate the transferability of the microcosm results to the field, where conditions may be substantially different than a controlled laboratory environment.

2.1.5 Drag Strip Access Prohibition

On November 19, 2001, APU and Conrail entered into a Settlement Agreement with the Estate and Trust of [redacted] and [redacted] in her capacity as the Personal Representative of the Estate and Trust. To facilitate future remedial action at the Drag Strip, the Settlement Agreement permitted Conrail and APU reasonable access to the [redacted] Property to perform any response action that EPA requires Conrail and APU to perform.

In letters addressed to the Settling Parties dated August 17, 2011 and March 5, 2012, [redacted], through her attorney, advised that access to that property would no longer be allowed for installing wells or construction. EPA sent a General Notice Letter, dated November 19, 2012 to [redacted] notifying her that she was now a PRP and that she may be responsible under the Comprehensive Environmental Response, Compensation, and Liability Act

(CERCLA) for cleanup of the Superfund Site or costs EPA has incurred in cleaning up the Superfund Site.

A complaint was filed against [redacted] to enforce the terms of the 2001 Settlement Agreement to obtain access to the Drag Strip for installation of wells necessary for proceeding with the remedy proposed herein. The Notice of Complaint was filed in Federal District Court for the Northern District of Indiana on February 20, 2014. *American Premier Underwriters* Inc., et al. v. [redacted] et al., Docket No. 3:14-cv-00351-JD-JEM (N.D. Ind. Feb. 20, 2014). The initial discovery phase ended on November 1, 2014, and the discovery phase was extended to March 1, 2015. Mediation occurred on November 18, 2014, and it was unsuccessful in ending the dispute. The parties continue to serve discovery. It is clear that [redacted] plans to continue contesting access to her property which is required to effectuate the EPA-approved response action, in direct breach of the 2001 Settlement Agreement. A court resolution is anticipated to take up to a year, and potentially longer in the event of an appeal. The access issue will continue to delay implementation of the necessary fieldwork for the remedy proposed herein.

3.0 Conceptual Site Model (CSM)

To support the groundwater risk evaluation and design of the final in-situ remedy, information from the Drag Strip area, along with more general Site data, has been incorporated into a CSM. The CSM includes five primary elements:

- Environmental setting;
- Identification and characterization of known and potential source areas;
- Identification of constituents of concern (COCs) and their spatial distribution;
- Definition of primary transport mechanisms; and
- Identification of potential receptors and exposure points.

3.1 Environmental Setting

3.1.1 Site-Wide Geology

The Site lies in the floodplain of the St. Joseph River, which is underlain by a regionally extensive glacial outwash deposit. Unconsolidated sediments of the Site consist of 140 to 170 feet of glacial outwash deposits overlying approximately horizontally-bedded shale bedrock. The glacial outwash deposits are predominantly poorly graded sand with discontinuous lenses of sand and gravel. Finer grained sediment, both clay and silt, are present as discontinuous lenses and layers within the surrounding outwash sand and gravel.

During the First and Second RD/RA investigations, the proportion of fine grained silt/clay layers was observed to increase to the north and east of the Railyard at depths of 10 to 40 feet. The thicknesses of this interval of low-permeability layers range between 54 feet on the Railyard to more than 100 feet to the north and east of the Railyard. The presence of the silt/clay layers limits the transmissivity and acts as a semi-confining layer for this portion of the aquifer. Additional information regarding this low-permeability zone in the aquifer, as well as Railyard-specific lithology, is presented in the Second RD/RA Preliminary Design Report (URS 2002).

The bedrock units beneath the unconsolidated deposits are identified as the Coldwater shale of Mississippian age, and the Sunbury and Ellsworth Shales of Devonian and Mississippian age. The bedrock encountered during drilling consisted of bluish gray to greenish gray shale that was unweathered, extremely dense and with no visible free water content. The bedrock surface elevation is approximately 600 feet mean sea level (msl). Top of bedrock elevations observed during the 2001 investigations were consistent with an approximately level bedrock surface. Observed elevations across the site vary from 585 to 610 feet msl. At one location east of the Drag Strip in the River Shores neighborhood, residential water well drillers have made an isolated report of top of bedrock at elevations of approximately 545 feet msl. No reports were found indicating greater depths to bedrock anywhere within the Site.

3.1.2 Drag Strip Geology

The geology of the Drag Strip property is consistent with the Site as a whole. In this area, the silt/clay layer appears to be absent in favor of sands and gravels that extend from the ground surface to the top of a clay bed lying on bedrock at a depth of approximately 170 feet. Shale bedrock underlies the clay at depths ranging from approximately 141 to greater than 177 feet. Boring logs for the Drag Strip soil borings and wells are provided in the Five-Year Review Investigation Report (URS 2013b).

The soil lithology encountered at the Drag Strip is generally consistent with previously reported subsurface conditions. Figures 4 through 5g present lithologic cross sections through the source areas, along the upgradient property boundary, and offsite in the upgradient and downgradient directions. The Drag Strip subsurface lithology is dominated by poorly-graded and well-graded sand and gravelly sand from the surface to the top of a clay bed encountered at depths ranging from 137 to 170 feet. Isolated gravel beds occur within the sand units. The clay and shale contacts are deepest near E07 and W08 and become shallower to the east toward U01.

3.1.3 Hydrogeology

The major surface water bodies in the vicinity of the study area are the St. Joseph River and Baugo Bay. The St. Joseph River flows westward and is located a little over a mile north of the Site. Baugo Bay connects to the St. Joseph River, and is located immediately to the west of the Site. Crawford Ditch originates at the Railyard, and flows intermittently to the St. Joseph River. Floodplains and wetland areas exist along both the St. Joseph River and Baugo Bay.

The regional unconsolidated outwash deposits form a major and prolific aquifer in the unconsolidated soils overlying bedrock. The bedrock is not considered an important source of water because of its depth and relatively low yield in comparison to the glacial outwash aquifer (EPA 1994). Groundwater flow data indicate that the St. Joseph River is hydraulically connected to the outwash aquifer at the Site and is a discharge zone for this aquifer.

The aquifer has been divided into three groundwater zones at the Site. The shallow zone extends from the water table, which occurs at an average depth of 12 ft bgs, to 35 ft bgs. The intermediate zone is from 35 to 90 ft bgs. The deep zone extends from 90 ft bgs to the top of bedrock. All groundwater zones generally flow northwest from the Railyard source areas to the Drag Strip and vicinity. Groundwater is unconfined at the Drag Strip, and it flows beneath the West and East Source areas northwestward beneath the Vistula Area, and to the St. Joseph River. The lower-permeability zone to the north and east of the Railyard is anticipated to affect the direction of groundwater flow in the vicinity of the Railyard, but not in the vicinity of the Drag Strip.

Quarterly comprehensive water level measurements are analyzed with KT3D_H2O software and other data analysis tools as part of capture zone analyses for the Railyard. The horizontal hydraulic gradient is approximately 0.002 ft/ft. Vertical gradients observed in well clusters at and in the vicinity of the Drag Strip show a combination of upward and downward directions of vertical groundwater flow. Although wells in the vicinity of the GCW show variability in the direction and magnitude of the vertical gradients, in general, groundwater flows downward from the shallow zone to the intermediate zone. An upward gradient beneath the St. Joseph River, producing discharge from the aquifer to the St. Joseph River, was observed during the First RD/RA investigations in 1998.

Aquifer performance tests were performed in September 2010 and consisted of constant rate and recovery tests on two wells at the Railyard extraction well system. Analytical method selection was based on the specific geologic and hydraulic conditions observed at each extraction well. The average hydraulic conductivity estimate of 310 feet per day (ft/day) was carried forward into subsequent groundwater flow related evaluations for the Site. At the Drag Strip, GCW hydraulic testing was performed using field measurements and modeling simulations to validate the dimensions of the groundwater circulation cells. In order to develop realistic aquifer parameters from the observed head data, a small-scale numerical model was constructed using MODFLOW (McDonald and Harbaugh, 1988, Hill et.al, 2000) and the parameter estimation utility PEST (Doherty 2002). The weighted average for hydraulic conductivity of 380 ft/day from the

MODFLOW/PEST calibration is slightly greater than the value of 310 ft/day obtained for the Railyard.

Potentiometric contours, groundwater capture zones, and groundwater flow particle tracks are generated using KT3D_H2O from the comprehensive water level measurements. Particle tracking indicates that the groundwater flow velocity is approximately 850 feet per year, and the average groundwater flow direction has an azimuth of 320 degrees.

Precipitation and the many private septic systems are the only known sources of significant recharge to this outwash aquifer.

3.2 Known and Potential Source Areas

Subsurface investigations conducted during the Remedial Investigation/Feasibility Study (RI/FS), RD/RA, and Five-Year Review activities, have characterized source areas for groundwater contamination at the Railyard and Drag Strip. Areas of groundwater contamination extend from within the Railyard into residential areas designated as the County Road 1 Area and the Vistula Area (Figure 1). Remedial measures are being implemented at the Railyard, which include hydraulic containment of the two source areas (known as the Tracks 65-66 TCE Source Area and the Track 69 CT Source Area) and natural gradient flushing of the groundwater contamination plume downgradient of the hydraulic containment system.

At the Drag Strip, the first phase of the Drag Strip investigation included the installation of approximately 98 soil vapor sampling points (Dames & Moore and HSI GeoTrans, 1998). Results of soil vapor analyses delineated two distinct CT source areas identified as the East Source Area and the West Source Area (Figure 3), which are in the vicinities of former hangars and a former maintenance pit associated with the airstrip. No DNAPLs were detected in either of the source areas. The installation of four shallow monitoring wells confirmed the presence of the two CT source areas. Three of the four shallow monitoring wells contained at least one milligram per liter (mg/L) of CT in groundwater.

The predesign investigations performed during the Five-Year Review Investigation also indicate that the COCs concentrations on the order of 1,000 µg/L are migrating onto the Drag Strip from upgradient sources.

3.3 Identification and Extent of COCs

Through 2010, over 160 monitoring wells have been installed at and downgradient of the Site to characterize the nature and extent of groundwater releases. The compounds CT and TCE are understood to have been released at the Railyard, and CT is understood to have been released onsite at the Drag Strip. Currently at the Drag Strip, which is the focus of this report, quarterly groundwater monitoring is conducted at 37 wells to monitor remedy performance for CT and TCE, their associated degradation products, and other compounds required in the SOW:

- 1,1,1-Trichloroethane (1,1,1-TCA);
- 1,1-Dichloroethene (1,1-DCE);
- CT;
- CF;
- Chloromethane;
- cis-1,2-Dichloroethene (cis-1,2-DCE);
- Tetrachloroethene (PCE);

- trans-1,2-Dichloroethene (trans-1,2-DCE);
- TCE; and
- VC.

The COCs that comprise the majority of the contaminant plume mass at the Drag Strip are CT, TCE, and CF. The current distribution of the COCs results from the discrete release and migration characteristics that are known for CT and TCE, as well as operation of the GCW since 2004. The contamination in groundwater beneath the East and West Source Areas is the sum of contributions from: 1) the contaminants flowing onto the Drag Strip property from upgradient, and 2) onsite CT releases to ground surface in the East and West Source Areas. The groundwater plume flowing onto the Drag Strip property has been enriched[2] by releases at the East and West Source Areas of the Drag Strip.

Table 1 presents the shallow and intermediate-depth CT, TCE, and CF sample data for the Drag Strip and Vistula Area for an eight quarter time period from 2012-2014, as requested in EPA (2014b), and it also presents the 95 percent upper confidence limit (UCL) of these data. Figures 6a and 6b show the shallow and intermediate 2014 95 percent UCL concentration isopleths for CT. For CT, the majority of the plume mass is in the shallow and intermediate aquifer zone in the vicinity of the West Source Area. Based on concentrations in well cluster DSMW-07 along the upgradient property boundary, there is also an apparent source of CT upgradient of this well. At the Drag Strip, concentrations in the core of the shallow and intermediate zones of the CT plume decrease by nearly an order of magnitude in the vicinity of the GCW. Downgradient of the Drag Strip, the core of the shallow and intermediate zones of the CT plume, shown by the 100 µg/L contour, extends to the vicinity of MW-08S, and it parallels the locations of houses with sub-slab vapor mitigation systems.

Figures 7a and 7b show the shallow and intermediate 2014 95 percent UCL concentration isopleths for TCE for the Drag Strip and Vistula Area. For TCE, the majority of the plume mass is deeper than for CT and is located further east than the East Source Area. Based on concentrations in well clusters along the upgradient property boundary and historical data from wells located in the neighborhood between the Railyard and Drag Strip, the source of this TCE is upgradient of the Drag Strip and most likely related to the known Railyard release. At the Drag Strip, concentrations in the core of the shallow zone of the TCE plume are an order of magnitude lower than for shallow CT, and they decrease by approximately one-half in the vicinity of the GCW. Downgradient of the Drag Strip, the core of the shallow and intermediate zones of the TCE plume is represented by the 10 µg/L contour.

3.3.1 Groundwater Natural Attenuation Parameters

As part of the Five-Year Review Investigation reported in URS (2013b), field measurements and laboratory analyses were conducted to obtain a “snapshot” of existing biogeochemical conditions as they may pertain to evaluation of the effects of operating the GCW, as well as the evaluation of potentially feasible alternative remedial approaches. Field measurements of specific conductance, pH, dissolved oxygen (DO), and oxidation-reduction potential (ORP) were recorded quarterly for five consecutive monitoring events in 2011 and 2012 at key well locations at the Drag Strip and vicinity to establish a baseline for these gross indicators of groundwater

[2] Delineation of the enriched COCs was presented to EPA in the Five-Year Review Investigation Report (URS, 2013b), and it was the design basis for the previous contingency remedy proposed in Revision 1 Addendum 2 Final Design (URS, 2013a). As discussed with EPA during the meeting on February 12, 2014, total COCs will be used as the current design basis for the revised, in-situ remedy approach.

chemistry. Additionally, groundwater samples were collected in June 2011 for laboratory analyses of more direct indicators of groundwater chemistry: alkalinity, chemical oxygen demand (COD), chloride, ferrous iron, nitrate, sulfate, total organic carbon (TOC), and dissolved metabolic gases (ethene, ethane, and methane). Samples were collected at wells upgradient, cross-gradient, and downgradient of the GCW, and within and outside the extent of the enriched CT plume. Field instrument measurements and laboratory analytical results are provided in Appendix B. An interpretation of the field instrument measurements and laboratory results is provided in the Five-Year Review Report (URS 2013b), and conclusions regarding potential influence of these parameters on natural attenuation processes are provided below.

pH

The pH readings at the selected monitoring wells were slightly above neutral for the measurement events. The pH values averaged 7.3 units in the shallow, 7.4 units in the intermediate, and 7.5 units in the deep wells. This range of pH values is suitable for virtually all physical and biological attenuation processes, enhanced or otherwise.

Specific Conductance

Specific conductance values at the tested wells were generally between 500 and 1,000 micro-Siemens per centimeter (µS/cm), which is typical for groundwater from an unconfined sand and gravel aquifer. In general, the intermediate depth of the aquifer is characterized by a slightly higher average specific conductance (777 µS/cm) than the shallow (684 µS/cm) or deep (665 µS/cm) intervals, suggesting a higher concentration of ionic species at this depth (possibly attributable to an increase in pH and a decrease in DO with depth). The specific conductance at MW-05S was an outlier, with lower values between 138 and 229 µS/cm, possibly a reflection of surface water infiltration from a nearby small pond.

Oxidation-Reduction Potential (ORP)

At the tested monitoring wells, groundwater ORP values ranged from 360 millivolts [mV] (indicating aerobic conditions) to -190 mV (indicating sulfate-reducing conditions). Average ORP values range from oxygen-reducing conditions in the shallow wells through iron-reducing conditions in the intermediate wells, and sulfate-reducing conditions in the deep wells. Similar to DO, the ORP values in MW-38 and MW-56 were higher than average, likely due to their location in the GCW discharge zone.

Dissolved Oxygen (DO)

In general, oxygen concentrations decreased with depth as expected in an unperturbed aquifer. At the tested monitoring wells, DO concentrations ranged from about 0.2 mg/L in the deeper monitoring wells to near saturation in the shallower monitoring wells, averaging 5.63 mg/L in shallow, 0.83 mg/L in intermediate, and 0.65 mg/L in deeper groundwater. DSMW-03 and well clusters MW-38 and MW-56 are in the GCW discharge zone, which is affected by oxygenated GCW treatment effluent, so higher DO values detected in these wells were predictable. The elevated concentration of DO exhibited in the MW-05 well cluster is likely due to its proximity to the small pond that, as a surface water feature, is in contact with atmospheric oxygen and naturally exhibits higher levels of DO. In general, the DO concentrations at the Drag Strip do not represent a significant barrier to the application and effectiveness of remediation technologies, e.g., those designed to enhance the biodegradation of CT and TCE.

Nitrate

Nitrate was detected at only two monitoring wells, DSMW-4I and DSMW-9I, at 0.18 mg/L and 0.21 mg/L, near the laboratory detection limit of 0.10 mg/L. As such, nitrate would not be an impediment to bioremediation, and does not currently represent an impediment to the dechlorination of CT and TCE.

Ferrous Iron

Ferrous iron was detected in four deep wells at low, estimated concentrations between 0.020 and 0.030 mg/L. These results, in combination with ORP values representative of iron-reducing and sulfate reducing conditions at several wells, indicate the paucity of total iron (all species) in this setting.

Sulfate

Sulfate was detected at all of the selected monitoring wells at relatively low concentrations ranging from 18 to 30 mg/L. These sulfate concentrations do not represent a significant impediment to the biodegradation of TCE, CT, and their daughter compounds. However, they do represent the largest “sink” for biodegradable organic compounds that might be introduced to enhance biodegradation. Accordingly, any enhanced bioremediation design would be based largely on the demand of the sulfate-reducing bacteria, i.e., an excess of organic carbon would need to be applied in order to reduce analytes including oxygen, nitrate, manganese, iron, and sulfate prior to, or in conjunction with the reduction of TCE and CT.

Metabolic Gases

Metabolic gases (a.k.a., RSK 175 Gases, from the analytical method number) are dissolved ethene, ethane, and methane. The presence and abundance of ethene and ethane are evaluated as indicators of the complete dechlorination of chlorinated ethenes and chlorinated ethanes to ethene and ethane.

The presence and abundance of methane may be evaluated as an indicator of the decomposition of naturally-occurring or introduced biodegradable organic compounds by indigenous bacteria (methanogens) under anaerobic conditions, but is also an indicator of the complete dechlorination of CT (through CF and methylene chloride daughter compounds).

Ethene and ethane were not detected at any of the four wells that were sampled in June 2011, indicating that the complete degradation of chlorinated ethenes, e.g., TCE to cis-1,2-DCE to VC, and finally, ethene and ethane, does not occur under current groundwater conditions in the vicinity of these wells. Methane was detected at very low concentrations just above the laboratory quantitation limit of 0.002 mg/L at deep monitoring wells DSMW-8D and DSMW-9D, and at 0.031 mg/L in deep monitoring well DSMW-7D. The absence of methane suggests that conditions that limit the complete reduction of CT, e.g., a lack of biodegradable organic compounds, dominate in the deeper aquifer.

Alkalinity

The alkalinity of the shallow, intermediate, and deep groundwater sampled in June 2011 was typical of a sand and gravel aquifer at 230 and 280 mg/L, indicating that the aquifer has low to moderate buffering capacity.

Chloride

Chloride concentrations at the selected shallow, intermediate, and deep monitoring wells varied from 37 mg/L (at DSMW-09S) to 99 mg/L (at DSMW-07I), and chloride is consistently detected at higher concentrations in the intermediate-depth wells. Overall, the concentration and spatial distribution of chloride at the select monitoring wells was unremarkable, and does not appear to indicate substantial degradation of TCE or CT.

Total Organic Carbon (TOC)

The TOC values from the select monitoring wells were low (0.71J to 1.3 mg/L) and consistent with those expected for the sand and gravel aquifer. The recommended minimum target concentration of bioavailable TOC is approximately 20 to 50 mg/L, and current conditions indicate that insufficient TOC is available for sustained bioremediation. In general, the TOC sample values indicate that an anthropogenic source of organic carbon would need to be added to the groundwater to result in meaningful biodegradation rates.

Chemical Oxygen Demand (COD)

With the exception of monitoring well DSMW-04D at 25 mg/L, the COD values at the site wells were near or below the quantitation limits, indicating the paucity of oxidizable compounds in groundwater.

Chlorinated Volatile Organic Compounds (CVOCs)

Groundwater from the selected monitoring wells was analyzed for TCE, cis-1,2-DCE, trans-1,2-DCE, and VC; as well as CT, CF, and methylene chloride to evaluate the extent to which abiotic and biotic natural attenuation processes might be contributing to the reductive dehalogenation of the parent compounds TCE and CT. The analytical results for CVOCs are presented in *Five-Year Review Investigation Report*, dated February 28, 2013 (URS 2013b). In general, the abundance of daughter compounds indicates significant natural attenuation, whereas the paucity of daughter compounds indicates a limiting condition. These results are compared to other lines of evidence such as the biogeochemical indicators pH, ORP, DO, etc., to identify conditions that may be enhanced to promote natural attenuation processes.

The presence of daughter products CF (from CT), and cis-1,2-DCE and VC (from TCE) indicate that natural attenuation is occurring to a limited extent. CF concentrations were generally 5 to 10 percent of the corresponding CT concentrations in the same sample. TCE daughter products (primarily cis-1,2-DCE) were detected in approximately one third of the samples. Where detected, cis-1,2-DCE concentrations ranged from less than one percent to as much as 40 percent of TCE concentrations. Proportionally, the highest cis-1,2-DCE levels were observed at the intermediate depth from wells DSMW-04I and DSMW-07I. The deep wells from the DSMW-04, -07, -08, -09, and 10 clusters generally reported 2 to 6 percent cis-1,2-DCE of the corresponding TCE concentration.

Overall, the concentration of daughter compounds is low relative to the parent compounds (very low with respect to secondary daughter compounds VC and methylene chloride, as well as ethene, ethane, and methane end products), and thus current aquifer conditions are not considered conducive to complete dechlorination.

With these considerations in mind, and combined with results of a microcosm study at the Railyard describing microbial processes that result in degradation of CT, it is possible to enhance those processes by the addition of a source of organic carbon and nutrients for bacteria that promote the complete dechlorination of CT to innocuous end products.

3.3.2 COCs Summary

The following characteristics of the shallow groundwater contamination are relevant to the evaluation of risk due to VI and therefore to the development of a revised Drag Strip RAO and performance metrics for the revised in-situ remedial action approach:

- Shallow groundwater contamination in the vicinity of the Drag Strip property and in the Vistula Area is shown in Figures 6a and 7a (represented by CT and TCE isopleths), and it results from: 1) sources located at the Railyard, 2) a postulated intervening source located upgradient of DSMW-07; and, 3) the West and East Source Areas on the Drag Strip property;
- Monitoring wells MW-38S and DSMW-03 are within the shallow discharge zone of the GCW. MW-56S is likely beyond the shallow discharge zone of the GCW. These wells are in the vicinity of or are upgradient of at least three buildings in the Vistula Area for which VI is a potential concern;
- The data gaps identified in the Groundwater Risk Evaluation Report (URS, 2013d), consisting of too few shallow monitoring wells, have been addressed; five additional shallow monitoring wells and two three-well clusters of monitoring wells were installed in early 2014 in the Vistula Area to better characterize the exposure pathway through the collection of paired shallow groundwater, sub-slab and indoor air samples;
- Groundwater data from MW-38S, DSMW-03, MW-56S, and the newly-installed shallow wells (DSMW-11S, DSMW-12S, MW-57S, MW-58S, MW-59S, and MW-60S, Figure 2) were used to characterize attenuation between shallow groundwater and indoor air for the nearest downgradient buildings; and
- Field measurements and laboratory analyses indicate that the primary impediment to natural attenuation are the geochemical conditions that must initially be overcome to engender a pH-neutral, carbon-rich, anaerobic environment conducive to the bacteria that completely degrade the COCs. There is insufficient organic carbon to furnish the “food” that indigenous or introduced bacteria would need to consume the available oxygen, to denitrify nitrates, to reduce sulfates, and to sustain the sulfate-reducing conditions that are more favorable for complete reductive dechlorination. The pH levels are favorable, and in the deeper wells, ORP measurements are promisingly low.

3.4 Definition of Primary Transport Mechanisms

Groundwater migration is a potential off-Site transport pathway. Dissolved constituents in groundwater may discharge to downgradient locations, including surface water and sediment of the St. Joseph River.

The VI of volatile constituents from shallow groundwater to the indoor air of overlying occupied structures is also a potential off-Site transport pathway. Transport of these constituents in the subsurface may be controlled by four primary processes: diffusion, advection, phase partitioning, and degradation. In the subsurface away from a building, the dominant process for vapor transport is typically diffusion. However, both diffusion and advection processes may be important in the subsurface near a building (EPA, 2012b).

VOC concentrations in soil gas attenuate, or decrease, as the VOCs move from source areas through the soil and into indoor air. The extent of attenuation is related to site conditions, building properties, and chemical properties. As a result, the spatial proximity of overlying structures to potential VOC source areas is important in determining the potential for a complete VI pathway.

A site-wide indoor air evaluation was conducted in 1999 and repeated in 2012. Detectable concentrations of contaminants were documented at several locations downgradient of the Drag Strip. Vapor mitigation systems were installed at locations where indoor air action levels were exceeded, and an EPA-approved vapor monitoring program has been implemented since 2000 to evaluate performance of the mitigation systems and to assess additional buildings in the vicinity for potential VI.

3.5 Identification of Potential Receptors and Exposure Points

Potential receptors are defined as human populations or individuals and environmental systems that are susceptible to constituent exposure from the Site. Both current and future land and water use conditions downgradient of the Drag Strip area were considered in determining exposure scenarios. As a result, off-Site residents and off-Site commercial workers are considered potential receptors. Likewise, ecological receptors (terrestrial and aquatic) in the St. Joseph River are also considered potential receptors.

Figure 8 depicts exposure pathways by which potential receptors may be exposed to COCs in groundwater. An exposure pathway consists of the following:

- Source of constituents;
- Mechanism of constituent release to the environment;
- Transport or exposure medium containing the constituents;
- Exposure point where humans (receptors) can contact the exposure medium; and
- Exposure route (e.g., inhalation or ingestion).

All of these elements must be present for an exposure to occur. The model in Figure 8 shows both potentially complete and incomplete pathways, which are discussed below.

3.5.1 Potentially Complete Exposure Pathways

Potentially complete exposure pathways for groundwater are limited to the inhalation of vapor-phase chemicals released from shallow groundwater to indoor air for residents and commercial workers downgradient of the Drag Strip. As noted earlier, an indoor air monitoring program is in place for this area and a portion of the buildings have mitigation systems in place. In addition, Elkhart County requires that all new construction install a mitigation system in the area (ATSDR, 2005).

3.5.2 Incomplete Exposure Pathways

Human Health

Under current conditions, groundwater is not used on or downgradient of the Drag Strip area for potable purposes. Residences and businesses downgradient of the Site are connected to a municipal water supply and private water supply wells were abandoned during the municipal water supply connection work conducted between 1994 and 1996 by the Settling Parties. The Settling Parties and EPA are developing institutional controls (ICs) in the form of restrictive covenants and easements for both the Railyard and Drag Strip properties. The Settling Parties and EPA have also recommended that a groundwater use restrictive ordinance be promulgated for Elkhart County. St. Joseph County (on the Drag Strip western property boundary) already has in place a groundwater use restrictive ordinance. Details of the institutional controls that are proposed or in place are presented in *Revision 2, Institutional Controls Work Plan*, (URS, 2010c).

Ecological

A 5-year study was conducted from 2000 through 2004 to assess potential impact to the St. Joseph River and Baugo Bay benthic macroinvertebrate communities that may have occurred as a result of discharge of contaminated groundwater from the Site. The results of the study concluded that the St. Joseph River in the project area is characterized by moderate taxa richness, and that the analytical data did not indicate measurable effects to the river system biota due to sediment concentrations of Site COCs. Details of the study are presented in *Phase 4, Year 2004 Benthic Macroinvertebrate Annual Sampling and 2000-2004 Cumulative Assessment in the Vicinity of the Conrail Railyard Superfund Site, May 10, 2005,* (URS, 2005b).

During the sampling period 2000-2004, the groundwater concentrations of CT and TCE at the monitoring well location MW-08S, which monitors the aquifer zone interfacing with the St. Joseph River system being evaluated, had a slight downward trend since 2001. The more recent dataset (involving sampling since 2004 through June 2013) confirms the previously indicated downward trend in the groundwater CT and TCE concentrations at MW-08S. Groundwater concentrations at that location have continually decreased since 2001 and individual well concentrations are lower by as much as an order of magnitude in December 2013. Consequently, the overall conclusions regarding the previous benthic macroinvertebrate evaluations remain unaffected by the recent groundwater data.

4.0 Risk Characterization

Further assessment of potentially complete VI exposure pathways was conducted to support risk-based remedial decisions for the Drag Strip. Assessment details are presented in the Groundwater Risk Evaluation Report (URS 2013d).

The risk characterization was performed to evaluate potential risks under current (GCW operation) and hypothetical near-future (GCW shutdown) conditions at the Drag Strip. For each condition, the evaluation included the following steps:

- Quantitation of groundwater-to-indoor air risks using EPA's VISL calculator with generic and site-specific attenuation;
- Comparison of indoor air monitoring data to risk-based screening concentrations; and
- Quantitation of indoor air risks using EPA's VISL calculator.

Shallow groundwater monitoring data collected since 1987 has defined a narrow area of contamination downgradient of the Drag Strip. The pilot phase remedy (GCW) installed in 2004 has effectively reduced contaminant mass in the Drag Strip West Source Area. Potentially complete exposure pathways for potential receptors are limited to those involving VI. However, in several locations, the VI pathway is controlled (individual vapor mitigation systems have been installed in residential houses) or incomplete.

Under current conditions (GCW operating), groundwater and indoor air data does not indicate a potential risk due to VI. Calculated risks were within EPA's acceptable risk range (excess cancer risk within 10^{-6} and 10^{-4} and HQ <1). Under hypothetical future conditions (following GCW shutdown), a potential risk is also not indicated when using historical maxima of shallow groundwater concentrations. This conclusion is supported by indoor air monitoring data collected since 1998, which has demonstrated that attenuation and other subsurface conditions are influencing VI pathways at the Site. A groundwater and indoor air monitoring program is currently in place and will continue for a period of time following any future GCW shutdown to ensure that the remedy remains protective of human health and the environment.

5.0 Drag Strip Remedial Design

To comply with EPA's statement in the November 6, 2013 letter (EPA 2013c): "EPA, in consultation with IDEM, strongly believes that a complete and final hot spot remedy at the Drag Strip should be implemented immediately," the Settling Parties are proceeding with further active remediation of the Drag Strip source areas by designing and installing a contingency remedy in the Drag Strip hot spot. For the contingency remedy, the Settling Parties have chosen to invest in a more sustainable remedial approach, as discussed with EPA during the meeting on February 12, 2014. In consideration of environmental, economic, and social factors that characterize the potential sustainability of such an endeavor, the contingency remedy will consist of a combination of abiotic and microbial enhancements designed to accelerate in-situ bioremediation of the COCs, in lieu of the previously-proposed GCW technology. With regard to energy expenditure, maintenance, and transportation and disposal, GCW systems are not as sustainable as in-situ remedies that have been developed and improved in recent years. With these considerations in mind, the identified combination of enhanced abiotic and bioremediation approaches discussed with EPA are more suitable to the project's goals.

Bioremediation was evaluated beginning June 2013 in collaboration with Dr. Frank Loeffler of the University of Tennessee-Knoxville when the Settling Parties initiated a microcosm study of Railyard sediments and groundwater. The study was intended to identify microbial processes that are resulting in the substantial degradation of CT in the vicinity of extraction well EW-4 at the Railyard. The results of the study indicated that a fortuitous combination of microbial processes and abiotic processes are degrading CT, and that those processes may be enhanced by the addition of a source of organic carbon and nutrients for bacteria that promote the complete dechlorination of CT to innocuous end products.

5.1 Design Parameters

Because of potential VI risk to the Vistula Area, a hot spot remedy at the Drag Strip source areas is necessary. The sole potentially-complete exposure pathway for contaminated groundwater is the inhalation of vapor-phase COCs released from the shallow groundwater zone to indoor air of residents and commercial workers downgradient of the Drag Strip. This potential risk to human health is used to develop the design parameters for the revised contingency remedy, which are:

- Revised Drag Strip RAO based on the shallow groundwater to indoor air exposure pathway;
- Development of an IRG for the Drag Strip, using an updated site-specific attenuation factor, EPA's level of acceptable risk, and EPA's VISL Calculator; and
- Development of the attainment process for the IRG, and closeout process for vapor monitoring and mitigation program.

At this 60-percent design stage, the remedy includes the following physical design elements:

- Additional delineation of total COCs: define current plume core for full-scale treatment of the hot spot;
- Bench-scale testing to select effective injection amendments;
- Pilot-scale testing to assess injection effectiveness;

- Full-scale implementation of hot-spot treatment remedy, including utilization of the existing GCW to assist in distribution of amendments; and
- Remedy performance monitoring.

Because of their dependence on the delineation of COCs and the necessary access to the Drag Strip property, full development of the pilot-scale testing program and the full-scale design will necessarily be provided in subsequent design submittals.

The design parameters and 60-percent design elements are described further in the following sections.

5.2 Revised Drag Strip RAO

The definition of the Drag Strip RAO, with an unambiguous end point to the Drag Strip remedial action, is the most significant requirement for the remedy finalization. Downgradient potential VI risk is the primary concern for the Drag Strip, and as established in the Groundwater Risk Evaluation (URS 2013d). The revised Drag Strip RAO must also comply with the CD and ROD Amendment.

The Drag Strip RAO is:

> "Active remediation of the Drag Strip hot spot sources to the point at which shallow groundwater migrating offsite no longer represents an unacceptable potential risk for VI in the Vistula Area."

The Drag Strip RAO complies with the CD's requirements for active remediation of the Drag Strip source areas that are described in Section 2.1.4.3. As an objective for treatment of the sources at the Drag Strip, the Drag Strip RAO also complies with the requirements for active remediation stated in the ROD Amendment. Although the proposed in-situ technology differs from the possible remedial technologies listed in the ROD Amendment under Alternative 2, compliance with the ROD Amendment's source remediation intent is clear.

5.3 Intermediate Remediation Goal

In their November 6, 2013 letter (EPA 2013c), EPA set forth the need for an IRG in the statement:

> "The practical intermediate remediation goal required by EPA, in consultation with IDEM, as discussed with the Settling Parties, is to develop and achieve [groundwater to indoor air screening levels (GWIASLs)] that are protective at or below a $1x10^{-5}$ excess lifetime cancer risk. This would satisfy the established remedial action objective (RAO) to eliminate the potential for human exposure."

EPA's use of the term "GWIASL" is consistent with previous usage in Revision 1, Addendum 2, Final Design Report (URS 2013a) and earlier submittals. However, as described in Section 4.1, the calculation of a site-specific attenuation factor has been updated to be consistent with assumptions used in EPA's VI Database (EPA 2012). Also, EPA's VISL Calculator (EPA 2013a) is now used to derive the screening levels.

For the development of the IRG for the Drag Strip remedial action, the Settling Parties derived an updated site-specific groundwater-to-indoor air attenuation factor using a data set containing groundwater analytical data from the newly-installed shallow monitoring wells in the Vistula Area and current indoor air analytical data. The data set included groundwater data from wells

MW-38S, DSMW-03, MW-56S, DSMW-11S, DSMW-12S, MW-57S, MW-58S, MW-59S, and MW-60S, (Figure 2) and indoor air data from houses paired with the applicable wells.

This approach complies with EPA's requirement from the November 6, 2013 letter (EPA 2013c),

> "Determination of the GWIASLs, to be used to assess the attainment of the RAO for eliminating the potential for human exposure while natural gradient flushing takes place, will be pursued concurrently with the initiation of the final Drag Strip hot spot source remedy. Groundwater concentrations will then be monitored in the mixed commercial/residential area down gradient of the Drag Strip using existing and planned wells, as previously discussed with the Settling Parties, to monitor achievement of the GWIASLs (see Attachment A)."

From the updated site-specific groundwater-to-indoor air attenuation factor, the Settling Parties derived an updated site-specific VISL, which is established as the IRG.

The Settling Parties submitted *Response to EPA July 11, 2014 Comments, and Technical Memorandum: Intermediate Remediation Goal Calculation*, dated September 19, 2014 (IRG Tech Memo) (URS 2014c). EPA commented on the IRG Tech Memo in a letter dated November 4, 2014 (EPA 2014b), and EPA and the Settling Parties held a conference call on December 3, 2014 to discuss the EPA comments. Following this conference call, EPA and the Settling Parties agreed to the following items, which will be incorporated into the Drag Strip contingency remedy design herein:

- Paired indoor air and shallow groundwater data from two addresses will be removed from the IRG calculation data pool; and
- The onsite treatment area footprint for the pilot test and the full-scale implementation will be defined using newly-installed monitoring wells from the Additional Delineation of Total COCs task described in Section 5.5.

The Revision 1, IRG Tech Memo is presented in Appendix C. The VISLs developed in this analysis are:

Analyte	**Updated Site-Specific VISLs and IRGs (μg/L)**
CT	53.2
TCE	14.3

When viewed in the context of decreasing shallow groundwater concentrations and indoor air concentrations below the CT IAAL and the TCE indoor air screening level, demonstrate that they are conservative and protective. As set forth by EPA in the November 4, 2015 letter, these IRGs will be used to establish the onsite treatment area footprint for the Drag Strip contingency remedy, and they will be used to evaluate performance of the remedy, i.e., attainment of the IRG will indicate completion of the contingency remedy for the Drag Strip source areas.

5.4 Attainment of IRG and Closeout

This section describes the attainment process for the IRG, and closeout process for Drag Strip remedial action and the vapor monitoring and mitigation program. Contingency actions, in the case of post-close out monitoring exceedances, are also introduced here and are described more fully in Section 5.8.

Implementation of the full-scale remedy, described below in Section 5.7, is expected to reduce groundwater COCs at the Drag Strip and in the Vistula Area to levels that no longer represent a risk to VI. Groundwater concentrations will be monitored quarterly, during and after full-scale implementation, in shallow wells on the Drag Strip property and in shallow wells in the Vistula Area located downgradient of the Drag Strip. Shallow groundwater will be monitored for achievement of the revised Drag Strip RAO (Section 5.2) through comparison of concentration data to the IRG (Section 5.3). The IRGs are the site-specific VISLs calculated in Section 5.3, and they are 53.2 ug/L for CT and 14.3 ug/L for TCE.

Attainment of the IRG will be declared when:

- The 95 percent UCL of shallow groundwater concentrations of COCs in the Vistula Area wells and the onsite Drag Strip wells remain below the IRGs for eight consecutive quarters; and
- Indoor air concentrations in the buildings in the indoor air monitoring and mitigation program, as set forth in the Vapor Monitoring Plan (URS Dames & Moore, 1999), remain below the CT action level during this same time period.

Details of the remedy performance monitoring are presented below in Section 5.8.

Upon attainment of the IRG, the Settling Parties will petition EPA to close out the Drag Strip remedial action and to close out the indoor air monitoring and mitigation program.

Upon EPA approval of the Drag Strip remedial action closeout and the indoor air monitoring and remediation program closeout, groundwater monitoring for the Drag Strip and Vistula Area monitoring wells will transition to the PRP Long-Term Response (PRP LR) monitoring program, as described below in Section 7.0. For buildings with sub-slab vapor mitigation systems, these systems will be deactivated, and the mitigation system components will be “mothballed” in case future reactivation is triggered under contingency actions.

For the Drag Strip, the PRP LR monitoring program will include quarterly groundwater monitoring from shallow wells located on the Drag Strip property. These wells will continue to be monitored for compliance with the Drag Strip RAO during PRP LR monitoring. Analytical results from the shallow monitoring wells within and just downgradient of the treatment area hot spot, delineated per Section 5.5 below, will be compared to IRGs. If there is no IRG exceedance, quarterly PRP LR monitoring will continue. If there is an IRG exceedance, contingency actions will be triggered.

The contingency actions are designed to assess potential problems with Drag Strip remedy effectiveness and with protectiveness of the remedy in the downgradient Vistula Area. Contingency actions will consist of a two-step sequence of monitoring events that propagates in the downgradient direction as IRGs are exceeded. As described in Section 7.0, confirmed exceedances of IRGs could potentially result in:

- Assessment of enhanced in-situ bioremediation effectiveness with reinjection of amendments if needed; and
- Indoor air and sub-slab vapor monitoring in the Vistula Area, with reactivation/installation of sub-slab vapor mitigation systems if needed.

5.5 Additional Delineation of COCs

For the physical design of the pilot test and subsequent full-scale remedy, additional groundwater contamination delineation is needed in order to refine the current treatment area footprint. However, prior to any onsite fieldwork for delineation, pilot testing, or full-scale construction and implementation, access to the Drag Strip property is required. As described in Section 2.1.5, a complaint was filed in Federal Court to enforce the terms of the 2001 Settlement Agreement and to obtain access to the Drag Strip for installation of wells necessary for proceeding with the remedy proposed herein. The access issue is still being resolved, and it has the potential to delay implementation of the necessary fieldwork for the remedy.

The COCs that comprise the majority of the contaminant plume mass at the Drag Strip are CT, TCE, and CF. As discussed with EPA during the meeting on February 12, 2014, total COCs will be used as the current design basis for the revised, in-situ remedy approach.

Further delineation of total COCs will build upon the enrichment delineation work accomplished during the Five-Year Review Investigation in 2010. Additional monitoring wells are needed in the vicinity of the East and West Source Areas to address the EPA-recommended groundwater to indoor air risk levels (i.e., excess cancer risk less than $1x10^{-5}$) and to define the plume core for pilot- and full-scale treatment of the hot spot.

Per the CSM (Section 3.3), the current distribution of the COCs results from the discrete release and migration characteristics that are known for CT and TCE, as well as operation of the GCW since 2004. The contamination in groundwater beneath the East and West Source Areas is the sum of contributions from: 1) the contaminants flowing onto the Drag Strip property from upgradient, and 2) onsite CT releases to ground surface in the East and West Source Areas. Figures 6a and 6b show the shallow and intermediate 2012-2014 95-percent UCL concentration isopleths for CT. For CT, the majority of the plume mass is in the shallow and intermediate aquifer zone in the vicinity of the West Source Area. Figures 7a and 7b show the shallow and intermediate 2012-2014 95-percent UCL concentration isopleths for TCE for the Drag Strip and Vistula Area. For TCE, the majority of the plume mass is deeper than for CT and is located further east than the East Source Area. Based on concentrations in wells along the upgradient property boundary and historical data from wells located in the neighborhood between the Railyard and Drag Strip, the source of this TCE is upgradient of the Drag Strip and is most likely related to the known Railyard release.

Delineation of the current distribution of COCs is needed for the following areas:

- The upgradient property boundary west of DSMW-07 and southwest of the West Source Area;
- The northern vicinities of the West Source Area and East Source Area; and
- The upgradient property boundary east of DSMW-08.

To address these onsite Drag Strip data gaps, the Settling Parties propose to install up to seven monitoring well clusters in the vicinities of the existing Drag Strip East and West Source Areas at the locations shown in Figure 9. Figure 9 also shows the shallow 2012-2014 95 percent Shallow CT isopleths.

5.5.1 Well Installation

Installation of additional monitoring wells presumes that access to the Drag Strip property will be provided by the property owner.

Well installation methods will be consistent with Appendix A-1 of the approved *Second Remedial Design/Remedial Action Work Plan, Conrail Railyard Superfund Site, Elkhart, Indiana*, dated January 18, 2001 (Second RD/RA Work Plan, URS [2001]). Appendix A-1 of the Second RD/RA Work Plan is the Sampling and Analysis Plan (SAP) for the Second RD/RA. Well installation methods will include installations with two or three wells installed in a single borehole and flush-mounted wellhead completions.

Utility clearance will include contacting Indiana's public utility locating service (Indiana 811), which is generally limited to publically accessible areas. Additionally, a commercial locator service will be contracted to provide an underground utilities check for each proposed well location before drilling. The well clusters will be installed by rotosonic methods as two-well and three-well clusters to characterize the groundwater plume. Shallow, intermediate, and deep wells will be installed with 10-foot stainless steel screens at depths generally consistent with the existing Drag Strip wells: 30, 80, and 160 feet below grade. Upon completion, the well locations and elevations will be surveyed by a licensed Indiana land surveyor.

5.5.2 Sampling and Data Evaluation for COCs Delineation

The newly-installed Drag Strip delineation wells will be added to the list of monitored wells for the next quarterly monitoring event following their installation. The schedule of this quarterly event may need to be adjusted to accommodate post-development equilibration of the new wells (typically two weeks, minimum). Groundwater samples will be collected and analyzed in accordance with the procedures in the existing Groundwater Monitoring Plan (GMP) for the Site, i.e., Appendix G of URS (2003a).

Data evaluation will include preparation of:

- Updated cross sections showing lithologic data from the newly-installed delineation wells;
- Traditional groundwater concentration isopleth maps for the shallow, intermediate, and deep zones of the aquifer; and
- 3D visualizations of the Drag Strip hot spot vicinity using Environmental Visualization Systems (EVS).

These items will be used to update the CSM, refine the current treatment area footprint, and assist with design of the pilot-scale injection system layout for the in-situ remedy. Specifically, the pilot-scale testing will target the high-concentration core of the current treatment area footprint.

The current treatment area footprint will be based on the areal extent of the IRG concentration using shallow zone groundwater data.

The lowest-concentration IRG in the shallow aquifer zone will be used to delineate the proposed treatment area footprint. This approach is conservative because it will result in a larger areal extent for the treatment area delineation.

5.6 Bench-Scale Testing

The physical design of the enhanced in-situ bioremediation technology requires bench- and pilot-scale testing in order to evaluate and select amendments that will, 1) effectively degrade the targeted COCs, and 2) be effectively distributed in the subsurface during and after injection. As agreed with EPA during the February 12, 2014 meeting, the Settling Parties began bench-scale testing of a variety of potential injection amendments in March 2014.

In March 2014, the Settling Parties collected 4 gallons of groundwater and sediment from the shallow and intermediate wells at the DSMW-07 and DSMW-08 well clusters. The water and sediment were shipped to SiREM of Guelph, Ontario, where microcosm studies were conducted over a 5-month test period. The microcosm studies evaluated several remediation amendments and the rate and extent of degradation of TCE and CT by indigenous bacteria, as well as KB-1® Plus bacteria provided by SiREM. The studies included an evaluation of zero-valent iron (ZVI) and nutrient amendments that can be applied, in-situ, to substantially accelerate the rate of biological and abiotic degradation of CT and TCE at the Drag Strip.

The Settling Parties provided progress of the bench-scale microcosm studies in the *Five-Month Interim Report, Drag Strip Microcosm Study, Attachment 2 to the August 2014 Monthly Progress Report*, dated September 10, 2014 (Interim Report) (URS 2014d). EPA and IDEM commented on the Interim Report in the November 4, 2014 Letter (EPA 2014b). SiREM prepared the final microcosm study report in *Laboratory Biotreatability Study to Evaluate Remediation of VOCs in Groundwater*, dated December 18, 2014 (Microcosm Report), and this report is provided in Appendix D. The EPA and IDEM comments from EPA (2014b) are addressed either in the Microcosm Report or they are discussed below.

The objective of the microcosm studies is to assess the feasibility of anaerobic biodegradation and chemical reduction of the Site COCs. Based on these findings, the Settling Parties identified the amendments for pilot testing that are likely to result in successful in situ treatment.

As detailed in the Microcosm Report (Appendix D), the tested amendments consisted of combinations of the following materials:

- ZVI, provided as elemental iron with an average particle diameter of 2 micrometers;
- EHC®-L, a proprietary organic carbon-based liquid amended with ferrous gluconate;
- Ferrous Fumarate, a common form of bio-available iron;
- SRS™, an emulsified vegetable oil product designed to release bio-available hydrogen over an extended period of time; and
- KB-1® Plus, a natural microbial consortium containing microorganisms known to be responsible for mediating dechlorination.

All microcosms were amended with a vitamin/nutrient mixture.

Incubation, spiking, sampling, and testing of the microcosms took place over a 123-day period. All of the tested combinations of amendments, as well as intermediate-depth intrinsic control microcosms, degraded CT and TCE to various extents ranging from partial to complete dechlorination. SiREM made the following conclusion: "The results of this study indicate that both SRS™ with and without the addition of a soluble iron source (ferrous fumarate or ferrous gluconate) and EHC®-L in combination with a vitamin/mineral amendment and with KB-1® Plus bioaugmentation has the potential to be an effective remedial approach for the Site."

5.6.1 Recommended Injection Amendment

Based on the findings in the Microcosm Report, the Settling Parties have summarized the performance characteristics of the treatment amendments, as follows:

Treatment		**Bench-Scale Performance Metrics**					**Effective Treatment**
		CT and TCE Degraded (Yes / No)	**Complete Degradation? (Yes / No)**	**Methane Production (High / Low)**	**pH and ORP Favorable? (Yes / No)**	**KB-1® Plus Enhanced Reduction (Yes / No)**	
ZVI		Yes	**No**	Low	Yes	Yes	**No**
ZVI + SRS™ + Ferrous Fumarate		Yes	**No**	High	Yes	Yes	**No**
SRS™ + Ferrous Fumarate		Yes	Yes	High	Yes	Yes	Yes
SRS™		Yes	Yes	High	Yes	Yes	Yes
ZVI + EHC®-L		Yes	**No**	Low	Yes	Yes	**No**
EHC®-L		Yes	Yes	High	Yes	Yes	Yes

The findings indicated that supplemental ferrous iron may be advantageous for accelerating CT degradation, therefore SRS™ without ferrous iron was eliminated from the field test consideration. The laboratory results also suggested that the rate and completeness of degradation of COCs was better with SRS™+ferrous fumarate than EHC®-L, noting that at the conclusion of the microcosm study, at 123 days, only the microcosm containing SRS™ + ferrous fumarate + KB-1® Plus did not contain detectable COCs. Based on these findings and in consideration of the observed performance of the treatments, the Settling Parties recommend the following treatment be used for pilot testing and subsequent full-scale remedy implementation:

- SRS™ + ferrous fumarate + KB-1® Plus

5.7 Pilot-Scale Injection Testing

The Settling Parties will conduct follow-on pilot-scale testing at the Drag Strip using the recommended amendments upon completion of the additional COCs delineation task (Section 5.5), and with approval from EPA. Because the delineation task has not been started, the pilot test injection and monitoring well grid presented below is intended to be translatable, as a unit, to the core of the shallow plume defined in the additional COCs delineation task.

The pilot studies will be conducted to, 1) evaluate the extent to which favorable results from the bench-scale studies, i.e., the complete degradation of comingled CT and TCE, are transferrable to the in-situ application of similar amendments, and 2) to evaluate the deliverability, and advective and diffusive transport of remediation amendments over a 12-week test period. Based on the lithology of the aquifer sediments, i.e., unconsolidated sand and gravel deposits, the candidate remediation amendments are anticipated to be effectively delivered to the shallow and intermediate-zone aquifer via 1-inch diameter, injection wells.

The following subsections describe the injection permitting approach, pilot test basis, and implementation and monitoring procedures.

5.7.1 "Rule-Authorize" Injection Wells Used for Site Clean-Up

EPA regulates shallow disposal systems that are used as part of site cleanup activities, per http://www.epa.gov/r5water/uic/classv/index.htm#remediation. The pilot test will include injection of approved amendments as well as injection of "chase water" to help distribute the amendments further into the aquifer after injection. The Settling Parties understand, and request the EPA confirm in writing, that EPA will "rule-authorize" the use of injection wells for the purposes of the Superfund remedial action at the Drag Strip upon submittal of inventory information about the wells to the Underground Injection Control (UIC) program.

The Settling Parties further understand that after the injection activity has been completed, the UIC program will need to be notified about when and how the wells were properly abandoned

5.7.2 Pilot Test Basis

The basis for the pilot-scale injection program was developed using Site data, i.e., hydraulic conductivity, effective porosity, soil bulk density, and geochemical parameters available from the CSM. These parameters were input to "*The Substrate Estimating Tool for Enhanced Anaerobic Bioremediation of Chlorinated Solvents,*" (Parsons, 2011), which consists of a series of Excel spreadsheets developed under the Environmental Security Technology Certification Program (ESTCP) to estimate the mass of various remediation substrates (biodegradable organic carbon) that may be used, in-situ, to accelerate the dechlorination of a range of chlorinated ethenes, chlorinated ethanes, and chlorinated methanes. The Substrate Estimating Tool is designed to estimate the mass of commercially available vendor products necessary to engender conditions favorable for dechlorination to occur. These conditions include, but are not limited to, the depletion of oxygen and the reduction of sulfate, both of which are usually the more significant "sinks" for biodegradable organic carbon products. A conservative design factor of three times the estimated organic carbon requirement was used to account for "sinks" other than those included in the Substrate Estimating Tool. Based on the output from the substrate estimating tool, the theoretical volume of 60-percent-by-weight emulsified vegetable oil (EVO) required for dechlorination of the shallow and intermediate-depth aquifer COCs is approximately 520 gallons (4,150 pounds).

It should be noted that EVO is not directly available to the bacteria that degrade CVOCs. Rather, EVO slowly ferments into volatile fatty acids (VFAs) that release hydrogen, which is then utilized by a consortium of bacteria that degrade CVOCs. Because of the time it takes for EVO to ferment, vendors of EVO products like SRS™ typically add a quick-release source of biodegradable organic carbon, such as sodium lactate, as well as yeast extract and other nutrients, to "jump-start" the microbial community. As indicated in Section 5.6, the products selected for the pilot scale test include KB-1® Plus, ferrous fumarate, vitamin B2 and Terra Systems, Inc.'s SRS™, a emulsion containing 60 percent by weight vegetable oil, 6 percent by weight sodium lactate, and low concentrations of yeast extract, vitamin B12, and a blend of sources of phosphate and nitrogen. The remainder of the SRS formulation is proprietary food grade emulsifiers and water. These products performed well during the microcosm study, however their performance may be further enhanced through the use of, 1) sodium sulfite or L-cysteine, reducing agents that help to scavenge oxygen, and generate the reducing conditions favored by dechlorinating bacteria, and 2) red yeast rice extract, a newly developed product (patented by Provectus) that inhibits methane-producing microorganisms. By suppressing the methanogenic microorganisms, red yeast rice extract may make more substrate available to the dechlorinating bacteria. After a more comprehensive literature review and vendor consultation regarding the potential efficacy of

L-cysteine, a combination of the aforementioned compounds will be co-injected along with EVO during the pilot test.

As noted above, sodium sulfite or cysteine rapidly removes oxygen and creates favorable reducing conditions. Accordingly, bioaugmentation with KB-1® Plus will be conducted using anaerobic water generated with sodium sulfite or cysteine and immediately following the injection of the other substrates. Details regarding the extraction of groundwater, mixing of remediation compounds, and injection and monitoring activities are presented below.

5.7.3 Implementation

The layout of the proposed pilot test injection and performance monitoring area is presented as Figure 10. The exact location of the pilot test is to be determined based on additional delineation activities to be conducted at the Drag Strip pending approved access. As shown on Figure 10, the pilot test will be conducted in an area measuring approximately 50 x 50 feet, and it will include the following components:

- Extraction well cluster UP-1. This dual-purpose cluster of two 2-inch diameter, stainless steel extraction wells will, 1) provide geochemical data for the upgradient (untreated) shallow and intermediate zones of the aquifer, and 2) provide groundwater that will be amended with EVO prior to being injected into the pilot test treatment area. A well construction diagram is provided on Figure 11;
- Injection well clusters IW-1 and IW-2. These 1-inch diameter, injection wells will be constructed of Schedule 40 polyvinyl chloride (PVC) with 20-slot screens at injection intervals 30 – 50 feet bgs and 70 to 90 feet bgs as shown on Figure 11;
- Radius-of-influence monitoring well clusters R-1, R-2, and VR. These wells will be monitored to evaluate the radial distribution of EVO at the time of injection, as well as the persistence of related TOC and VFAs thereafter;
- Advection well clusters A15-1, A15-2, A30-1, and A30-2. These wells will be monitored to evaluate the advective transport of EVO and related VFAs;
- Advection/Diffusion well clusters AD15-1, AD15-2, AD30-1, and AD30-2. These wells will be used to evaluate the advective and diffusive transport of EVO and related VFAs; and
- Advection/Diffusion and radially overlapping well clusters ADV15, ADV30, and ADV45. These wells will be used to evaluate the advective and diffusive transport of EVO originating from overlapping radii of influence of injected EVO.

All of the extraction, injection, and monitoring wells will be installed as clusters of shallow and intermediate-depth wells. The thickness of the treated groundwater is approximately 80-feet (the treatment target zone is from approximately 20 to 100 feet in depth).

The pilot test will be initiated by filling all mixing tanks with 10 parts groundwater (from UP-1, Figure 10) to 1 part SRS™ and nutrient amendments. The compounds will be thoroughly mixed, and then injected into shallow and intermediate-zone wells at rates of approximately 10 to 20 gallons per minute. Approximately 130 gallons of SRS™ and 1300 gallons of groundwater will be injected at each of wells IW-1S, IW-1I, IW-2S, and IW-2I. Once all of the amendments have been delivered, five liters of KB-1® Plus will be pumped into each injection well and "chased" with 250 gallons each of anaerobic groundwater that has an adjusted ORP of no greater than - 100 mV. The injection program will be implemented adaptively at the locations shown on Figure 10, beginning with the intermediate-depth injection intervals, and finishing with the shallow injection intervals. The time and duration of injection, applied pressure, volume of remediation amendments applied, and other notes will be documented in a field log.

5.7.4 Performance Monitoring

As outlined on Table 2, performance monitoring will be conducted to evaluate the deliverability, and subsequent advective and diffusive transport of EVO, VFAs, and nutrients, as well as the spatial and temporal changes in the concentration of COCs and microbial members over a 12-week period. This is the minimum time-frame for observing biological degradation effects, and the need for continued monitoring will be evaluated after the week-12 analyses. Baseline groundwater samples will be collected from all monitoring wells for VOCs analysis approximately one week prior to conducting the pilot-scale injection program.

Performance monitoring events will be conducted at approximately 2, 4, 8, and 12 weeks following completion of the pilot-scale injection program. Performance monitoring samples will be collected at select wells for VOCs, RSK 175 gases (ethene, ethane, and methane), VFAs, TOC, sulfate, anions, ferrous iron, and microbial members at the frequencies and locations shown in Table 2 and Figure 10. All groundwater samples will be shipped to TestAmerica Laboratories (TestAmerica) of North Canton, Ohio and Microbial Insights (Microbial) of Knoxville, Tennessee (or SiREM of Guelph, Ontario). Dissolved (ferrous) iron concentrations will be measured in the field during each monitoring event using a Hach test kit. Sample collection and analysis requirements, quality assurance, and quality control (QA/QC) will be met, as appropriate and relevant, in accordance with the approved SAP.

Field instrument measurements of temperature, pH, ORP, specific conductivity, and DO concentration will be recorded at all pilot test extraction, injection, and monitoring wells on a biweekly basis. Water levels will be also be recorded on a biweekly basis.

Key elements to be evaluated by the pilot studies will include the following:

- Injection well layout geometry and the ability to effectively inject and distribute remediation amendments throughout the targeted aquifer volume;
- Advective dispersion of remediation amendments and related effects over the study period; and
- Initial indications of biodegradation which may include changes in ORP, formation of CVOC or EVO degradation products, or detections of hydrocarbon gases.

In addition to the evaluations indicated above, the data may be helpful with assessing reaction kinetics (COC degradation rates) and dosages of remediation amendments necessary to fully degrade COCs. Results of the pilot test will be provided in a written report along with recommendations for full-scale application.

As indicated above, the layout of the pilot test injection and monitoring well grid (Figure 10) presented herein is intended to be translatable, as a unit, to the core of the shallow plume defined in the additional COCs delineation task. In addition, the location of the pilot test injection and monitoring well grid will need to accommodate EPA's requirement to maintain operation of the GCW during the pilot test.

5.8 Full-Scale Injection Remedy Implementation

The Settling Parties will conduct follow-on full-scale implementation of the in-situ remedy at the Drag Strip using:

- Current treatment area footprint and core of the shallow total COCs plume, based on results and findings of the COCs delineation task (Section 5.5);
- Approved amendments that effectively destroy/degrade CT and TCE, based on results and findings from the bench-scale microcosms testing (Section 5.6.1); and
- Injection well layout geometry and effective dosages of remediation amendments, both based on results and findings of the pilot-scale injection testing (Section 5.7).

At this stage in the remedy design process, it is envisioned that the full-scale remedy will consist of one or more arrays of injection wells and sufficient monitoring wells to evaluate performance towards the IRG. Layout of the injection well array(s) will utilize the pilot-scale test wells, and it will be expanded to provide sufficient coverage of the Drag Strip hot-spot sources. The layout will consider the estimated advective dispersion of remediation amendments and estimated reaction kinetics relative to the observed groundwater flow velocity. The time frame for achieving the IRG at the Drag Strip, as discussed during the February 12, 2014 meeting, is 2-3 years.

The array(s) of injection wells will remain in place at the Drag Strip throughout the PRP LR monitoring period, in the event that contingency actions outlined in Section 5.4 include future, supplemental injections of amendments.

5.9 Remedy Performance Monitoring

During and after full-scale implementation of the in-situ remedy, groundwater concentrations will be monitored quarterly in shallow wells on the Drag Strip property and in shallow wells in the Vistula Area located downgradient of the Drag Strip. Concurrent with the full-scale implementation of the Drag Strip in-situ remedy, routine groundwater monitoring will also be taking place under the existing GMP for the Site, i.e., Appendix G of URS (2003a), which has been modified to include additional wells needed to support the 2009 Five Year Review Investigation and the Drag Strip remedial design efforts. Also, indoor air samples will continue to be collected under the ongoing indoor air monitoring and mitigation program, as set forth in the Vapor Monitoring Plan (URS Dames & Moore, 1999). Analytical data from these sampling efforts will be used for remedy performance monitoring. Table 3 presents the list of wells that will be sampled under the remedy performance monitoring program, and it also presents the list of buildings that will be sampled for indoor air under the remedy performance monitoring program.

As described in Section 5.4, shallow groundwater will be monitored for achievement of the revised Drag Strip RAO through comparison of concentration data to the IRG. The IRGs are the site-specific VISLs calculated in Section 5.3, and they are 53.2 ug/L for CT and 14.3 ug/L for TCE.

Attainment of the IRG will be declared when:

- The 95 percent UCL of shallow groundwater concentrations of COCs in the Vistula Area wells and the onsite Drag Strip wells remain below the IRGs for eight consecutive quarters; and
- Indoor air concentrations in the buildings in the indoor air monitoring and mitigation program, as set forth in the Vapor Monitoring Plan (URS Dames & Moore, 1999), remain below the CT action level during this same time period.

The locations of wells and buildings that will be used for remedy performance monitoring are shown in Figure 12, and the well IDs and building addresses are listed in Table 3. Only shallow monitoring wells are used for testing for attainment of the IRG because the sole potentially complete exposure pathway for groundwater is inhalation of vapor-phase COCs released from shallow groundwater to indoor air for residents and commercial workers downgradient of the Drag Strip (Section 3.5.1).

For comparison to the IRG, the selection of shallow wells for UCL testing, (displayed with green shading on Table 3), was based on their locations within and downgradient of the known extent of the treatment area footprint. Based on the findings of the COCs delineation task (Section 5.5), the selection of the UCL testing wells may be adjusted. Wells along the upgradient Drag Strip property boundary are not used for UCL testing because they are upgradient of the release areas (i.e., East and West Source Areas), but they will continue to be monitored as required by EPA (2013c).

Following full-scale injection of amendments into the arrays of injection wells, the 95-percent UCLs for CT, TCE and CF will be calculated using EPA's Pro UCL software (currently version 5.0) and using the most recent eight quarters of analytical data from the subset of UCL testing wells. As recommended by EPA (2009a) for corrective action monitoring, the null hypothesis of the presence of contamination is rejected when the entire confidence interval is below the standard, or in other words, when the UCL is below the IRG. The false positive rate will be fixed at 0.05, which results in a confidence level of 95 percent for the tests. Furthermore, statistical power is increased by increasing the sample size to eight observations per test.

The wells used for UCL testing are:

Onsite Drag Strip UCL Testing Wells	***Vistula Area UCL Testing Wells***
DSMW-02	DSMW-11S
DSMW-03	DSMW-12S
DSMW-04S	MW-57S
DSMW-09S	MW-58S
DSMW-13S	MW-59S
DSMW-14S	MW-60S
DSMW-15S	MW-08S
MW-56S	

Indoor air CT concentrations from the buildings listed in Table 3 will be compared directly to the CT indoor air action level of 0.65 ppbv, established by EPA in March 2012, (EPA 2012a). Per the Vapor Monitoring Plan (URS Dames & Moore, 1999), semiannual indoor air monitoring data will continue to be used to test for potential risk due to VI. In accordance with the indoor air monitoring program, if an exceedance of the CT IAAL occurs, confirmation sampling will occur as soon as practical, and if the exceedance is confirmed, a vapor mitigation system will be installed at the location.

The table below summarizes remedy performance monitoring criteria, possible outcomes for the statistical testing and indoor air comparisons, and resulting decisions regarding the remedy performance monitoring program.

Criteria	***Duration***	***Outcome***	***Decision***	***Remedy Performance Monitoring Status***
Site-specific IRGs for COCs, ***AND*** IAAL for CT	For Close Out: Eight Consecutive Quarters	Indoor Air > IAAL, ***AND*** 95% UCL > IRG, ***OR*** 95% UCL < IRG	Confirm IAAL Exceedance, per Vapor Monitoring Plan	Continue Monitoring Program
		Indoor Air < IAAL ***AND*** 95% UCL > IRG	Shallow Groundwater Contamination Remains	Continue Monitoring Program
		Indoor Air < IAAL ***AND*** 95% UCL < IRG	IRG Attained	Petition EPA for Close Out

Upon attainment of the IRG, the Settling Parties will petition EPA to close out the Drag Strip remedial action and to close out the indoor air monitoring and mitigation program. Upon EPA approval of the Drag Strip remedial action closeout and the indoor air monitoring and remediation program closeout, groundwater monitoring at and downgradient of the Drag Strip will transition to the PRP LR monitoring program, as described below in Section 7.0. For buildings with sub-slab vapor mitigation systems, these systems will be deactivated, and the mitigation system components will be “mothballed” in case future reactivation is triggered under contingency actions.

Drag Strip remedial action close out will also be the milestone at which the Site’s IRA Report is prepared and submitted, as described in the following section.

6.0 Interim Remedial Action Report – Conrail Railyard Superfund Site

Following demonstration that the hot-spot remediation is complete at the Drag Strip and that the containment objective is achieved at the Railyard, an IRA Report will be submitted to the EPA. Railyard groundwater treatment system expansion and upgrading was completed in 2013. Drag Strip remedial action completion will be determined following the activities described in Section 5.8. The IRA Report will be generally consistent with Superfund program requirements and will include discussion of the remediation systems as outlined in the following sections.

6.1 Remedial Action Progress

The IRA Report will include a summary of the progress to date for the Railyard and Drag Strip remediation systems. This section will provide general discussion of both systems from installation and startup in 2004 to IRA Report preparation.

The report will summarize the significant Drag Strip investigation findings and remedial actions outlined below.

- Chronology of significant Drag Strip events, from the identification of elevated CT in soil gas in 1998 and 2001, to GCW construction activities and pilot-phase operation beginning in 2004, to delineation of COC enrichment in the 2009 Five-Year Review Investigation, and implementation of the in-situ remedy;
- Discussion of performance standards and cleanup goals for Drag Strip hot spot as presented in this design submittal, and as they relate to the 1997 CD, 2000 ROD Amendment, and subsequent EPA requirements; and
- Source remediation data analysis summary; comparison to the Drag Strip remedy performance metrics and determination of remediation completion.

The report will summarize the significant Railyard investigation findings and remedial actions outlined below.

- Chronology of significant Railyard events following the 2004 startup of the remedial system – including conclusions of hydraulic testing and capture analysis conducted during the 2009 Five-Year Review Investigation, upgrade design information from the 2011 Addendum to the 2003 Final Design, and construction of the upgraded groundwater treatment plant (GWTP);
- Discussion of performance standards and cleanup goals for Railyard source areas as defined in the 1997 CD and 2000 ROD Amendment;
- Discussion of the Railyard Construction Completion and Certification Reports, (2005 and 2013); and
- Discussion of progress towards achieving sitewide groundwater cleanup requirements, i.e., attainment of MCLs, per the 2000 ROD Amendment. The evaluation will include trend analysis of relevant monitoring wells near the Line of Containment and downgradient monitoring locations, demonstration of contaminant capture, and demonstration of hydraulic capture.

6.2 PRP LR Requirements

As can be seen in Section 6.1, the Drag Strip and Railyard remedial actions are proceeding independently of each other and under separate timeframes: the Railyard remediation system upgrade completion occurred before the Drag Strip remedy completion. It is anticipated that the PRP LR monitoring for the Railyard will begin first. Because the Settling Parties propose to prepare a single IRA Report for the Site, the IRA Report will address PRP LR progress for the Railyard conducted to date.

7.0 PRP Long-Term Response Monitoring

This section presents a conceptual PRP LR monitoring scope for the Railyard and Drag Strip remedial actions. A revised GMP, which will provide a detailed scope of work for the PRP LR program, technical justification for sampling/monitoring optimization, and contingencies for concerning results, will be provided separately.

In EPA's Letter dated November 6, 2013, (EPA 2013c), the Settling Parties are required to continue the current sampling scope until after completion of the 2014 Five-Year Review. Implementation of the current site-wide groundwater monitoring scope will continue until it is replaced by PRP LR monitoring, which will follow the implementation of the Railyard and Drag Strip remedies and approval by EPA.

Because the Drag Strip and Railyard remedial actions are proceeding independently of each other and under separate timeframes, the PRP LR monitoring will also be implemented in phases. These phases are described in Sections 7.3 and 7.4 as they relate to the progress of both remedial actions. The monitoring scope, including the locations and frequency of sampling, may be modified based on the results and findings of the remedial activities leading up to full scale implementation of the in-situ remedy.

7.1 Current Groundwater Monitoring Scope

The current groundwater monitoring scope is a continuation of the first phase of restoration performance monitoring described in the GMP (Appendix G to the 2003 Final Design). The monitoring scope has evolved and expanded since system startup in 2004, and it is derived from the following sources:

- First phase of Restoration Performance Monitoring: quarterly monitoring of selected Railyard, neighborhood, and Drag Strip monitoring wells. The Restoration Performance Monitoring program is designed to confirm the effectiveness of the remedial action to eventually restore the aquifer outside of the TI Waiver Area, and to confirm that the region of contaminated water is not expanding. The second phase of restoration performance monitoring, consisting of a change in monitoring frequency to a 15-month interval, is in the GMP, but it has not been implemented yet;
- Downgradient Groundwater Action Plan submitted to the EPA on February 16, 2007 (URS 2007): maintain quarterly monitoring frequency and expand the scope of the sampled wells in response to EPA and IDEM concerns about COCs concentrations in the MW-23/MW-41 vicinity;
- Railyard remedy upgrade: addition of 14 non-GMP wells for potentiometric analyses and water quality monitoring along the Line of Containment. The extraction wells are located along the Line of Containment, which traces the hydraulically downgradient northern border of the TI Waiver Area (Figure 13);
- Five-Year Review Investigation: maintain quarterly monitoring frequency, addition of 27 non-GMP wells to accumulate sufficient data to evaluate Drag Strip remedy performance, mass flux, refined shallow groundwater COCs distribution, and potential remedy alternatives; and
- Drag Strip remedial design: addition of 10 non-GMP wells in the Vistula Area to collect data that is co-located with indoor air monitoring buildings.

The first phase of restoration performance monitoring described in the GMP also incorporates an annual reporting task. The annual Performance Evaluation Reports present the findings from the quarterly site-wide groundwater monitoring program, comprehensive groundwater potentiometry events, and indoor air monitoring events for program years that span from September through August of each calendar year since operations and maintenance (O&M) began in 2004.

7.2 PRP LR Monitoring Objectives

The objectives of the current groundwater monitoring scope have expanded from the objectives of the original Restoration Performance Monitoring program in the GMP because of data needs in support of EPA/IDEM concerns, the 2009 Five-Year Review Investigation, the Railyard remedy upgrade design, and the Drag Strip remedial design. With the Railyard upgrade construction complete and following full-scale implementation of the Drag Strip in-situ remedy, all of these expanded objectives will no longer be necessary. Therefore, for the purposes of the PRP LR monitoring program, the objectives will revert to those of the GMP, namely:

> “To confirm the effectiveness of the remedial action to eventually restore the aquifer outside of the TI Waiver Area, and to confirm that the region of contaminated water is not expanding”

The performance standard for demonstrating containment will be based upon weight-of-evidence analysis, considering evaluation of potentiometric surface maps based on measured water levels in the vicinity of the containment system, comparison of trends in concentration in upgradient and downgradient wells, and groundwater modeling. The overall Superfund Site RAO remains unchanged from that set forth in the CD and ROD Amendment, and it is:

> “Attainment of MCLs in groundwater between the Railyard Line of Containment and the St. Joseph River.”

The PRP LR monitoring will continue until the overall Superfund Site RAO is attained.

The PRP LR monitoring program will also undergo optimization with the intent to provide efficient data collection, in which sufficient data are collected in order to make accurate decisions in a cost-effective manner. The optimization objective is to reduce temporal and spatial redundancy in the monitoring network while retaining sufficient data needed to evaluate the PRP LR monitoring objectives. The analytical scope will continue to be the Site COCs.

Because of the different remedial action alternatives in place for the Railyard (hydraulic containment and natural gradient flushing) and Drag Strip (in-situ enhanced bioremediation), different scopes of work and different performance metrics will be necessary, as described in the following sections.

7.3 Railyard PRP LR Monitoring

The Railyard RAO, per the ROD Amendment, is containment of groundwater with significant concentrations of TCE and CT from the Track 65-66 and Track 69 Source Areas, and natural gradient flushing of the dissolved portion of the contaminant plume downgradient of the Line of Containment (Figure 13).

The Railyard PRP LR Monitoring will commence upon EPA approval of the revised GMP. For the Railyard, PRP LR monitoring will be a modification of the second phase restoration performance monitoring program from the existing GMP. The PRP LR monitoring will include comprehensive potentiometric measurements from all accessible Site wells and groundwater sample collection from selected shallow, intermediate, and deep wells at and downgradient of the Railyard, along the upgradient Drag Strip property boundary, and along the St. Joseph River. The

PRP LR monitoring will be conducted from selected wells on an optimized 15-month frequency, which will be set forth in the revised GMP. The findings from the contaminant and hydraulic capture assessments will be reported on the same optimized frequency, and the report will be submitted 90 days following the sampling event.

The performance of the Railyard remedy will be evaluated for the effectiveness of hydraulic capture and concentration trends. Groundwater capture will be evaluated using the modeling program KT3D_H2O, and concentration trends will be reviewed to determine compliance with the overall Superfund Site RAO.

Monthly O&M monitoring, set forth in the approved Final Design, will continue throughout the system's operation. Monthly O&M monitoring will also include potentiometric measurements from a subset of Railyard monitoring wells and three point gradient (TPG) analysis to monitor for water level anomalies in the vicinity of the capture zones. The TPG techniques were used in support of flow rate optimization efforts following startup of the upgraded Railyard system in 2012 and 2013 (URS 2014). Anomalous TPG findings will trigger contingency actions including confirmation of water levels, review of applicable Railyard system operational data, review of background water level transducer data, and potentially a comprehensive water level measurement event with KT3D_H2O capture analysis. Contingency actions in the event of concentration anomalies and other concerning COCs analytical results may include similar hydraulic evaluations plus resampling the affected well(s), COCs data analyses, and potentially an interim sampling event for a larger group of monitoring wells.

7.4 Drag Strip PRP LR Monitoring

The Drag Strip RAO is:

> "Active remediation of the Drag Strip hot spot sources to the point at which shallow groundwater migrating offsite no longer represents an unacceptable potential risk for VI in the Vistula Area."

Upon attainment of the IRG, per the process in Section 5.9, the Settling Parties will petition EPA to close out the Drag Strip remedial action and to close out the indoor air monitoring and mitigation program. Upon EPA approval of the Drag Strip remedial action closeout and the indoor air monitoring and remediation program closeout, groundwater monitoring at and downgradient of the Drag Strip will transition to the PRP LR monitoring program.

For the Drag Strip, the PRP LR monitoring program will include an initial 2-year period of quarterly groundwater monitoring from all shallow wells located on the Drag Strip property. Following this initial period, and assuming no contingency action is triggered, the Drag Strip PRP LR monitoring will revert to the same 15-month frequency as the Railyard PRP LR monitoring program. The Drag Strip PRP LR monitoring will include comprehensive potentiometric measurements from all accessible Site wells and groundwater sample collection from selected shallow, intermediate, and deep wells located on the Drag Strip property and in the Vistula Area.

The shallow Drag Strip wells will continue to be monitored for compliance with the Drag Strip RAO during PRP LR monitoring. Analytical results from the shallow monitoring wells within and just downgradient of the treatment area hot spot will be compared to IRGs. If there is no IRG exceedance, PRP LR monitoring will continue. If there is an IRG exceedance, contingency actions will be triggered. The contingency actions are designed to assess potential problems with Drag Strip remedy effectiveness and with protectiveness of the remedy in the downgradient Vistula Area.

7.4.1 Contingency for IRG Exceedance

An exceedance of an IRG in a Drag Strip shallow monitoring well will be confirmed by resampling the affected well. A confirmed exceedance of an IRG will trigger quarterly monitoring of shallow wells in the Vistula Area for a period of eight quarters; the 2-year duration accounts for the groundwater flow velocity of approximately 850 feet per year (Section 3.1.3), and the approximately 1,600-ft distance (along the direction of groundwater flow through the Vistula Area) from the western edge of the West Source Area to the St. Joseph River. During this 2-year contingency monitoring period, reassessment of the effectiveness of the Drag Strip hot spot remedy will also take place. The reassessment will include sample collection and data evaluation intended to address:

- Potential changes in upgradient COCs concentration trends for groundwater flowing onto the Drag Strip property,
- Potential changes in groundwater hydraulics; and
- Potential changes in groundwater biogeochemistry.

Results and findings of the reassessment investigation(s) will be used to develop a course of action for maintaining protectiveness of the in-situ remedy, up to and including conducting a supplemental injection event.

An exceedance of an IRG in the Vistula Area will be confirmed by resampling the affected well. A confirmed exceedance of an IRG in the Vistula Area will trigger indoor air and sub-slab vapor sampling requests to the property owners within a 150-ft radius of the affected well. Where property owners have agreed to indoor air and sub-slab sampling, indoor air samples will be collected in accordance with Addendum 1 Vapor Monitoring Plan, (URS 2012c), and sub-slab samples will be collected in accordance with Addendum 2 Vapor Monitoring Plan, (URS 2013f). The validated sample results will be compared to the current IAAL for CT (0.65 ppbv), to IASLs for TCE and VC, and to sub-slab screening levels (SSSLs). The IASLs and SSSLs were proposed in Addendum 2 Vapor Monitoring Plan (URS 2013f).

The validated sub-slab and paired indoor air results will undergo the following comparisons:

CT		
Criteria	***Outcome***	***Decision***
IAAL: 0.65 ppbv SSSL: 32.5 ppbv	Indoor Air > IAAL, ***AND*** Sub-Slab > SSSL, ***OR*** Sub-Slab < SSSL	Confirm IAAL exceedance, per Vapor Monitoring Plan* requirements.
	Indoor Air < IAAL Sub-Slab > 10xSSSL	Begin semi-annual monitoring at location
	Indoor Air < IAAL Sub-Slab < 10xSSSL	No further action at location

* URS Dames & Moore, (1999)

TCE and VC						
Criteria					***Outcome***	***Decision***
COC	***Residential****		***Industrial****			
	IASL	***SSSL***	***IASL***	***SSSL***		
TCE VC	0.4 0.62	20 31	1.61 10.8	805 5.4e3	Indoor Air > IASL Sub-Slab > SSSL	Re-inspect location, review groundwater data, resample (if needed)
					Indoor Air < IASL Sub-Slab > 10xSSSL	Begin semi-annual monitoring at location
					Indoor Air < IASL Sub-Slab < 10xSSSL	No further action at location

CF will be assessed on a case-by-case basis due to its prevalence in indoor air.
** Screening levels will be based on the location type. Commercial locations will be compared to Industrial indoor air and sub-slab screening levels.

An exceedance of the indoor air action level for CT will be confirmed by resampling the affected building. A confirmed exceedance of the CT indoor air action level will trigger installation of (or reactivation of) a sub-slab vapor mitigation system in accordance with the indoor air monitoring and mitigation program (URS Dames & Moore, 1999).

Indoor air sample results will also be compared to the IASLs, and if an exceedance occurs for one or more compounds, further evaluation of the specific situation will be implemented such as re-inspection of the premises, review of groundwater data, or confirmation sampling.

Sub-slab sample results will be compared to SSSLs for the COCs, and as shown in the matrix above, an exceedance of 10-times the SSSL will trigger semiannual indoor air and sub-slab monitoring at that location. Semiannual monitoring events will take place during the Winter and Summer seasons, and will occur for a minimum of 2 years following the last triggering sub-slab sample result.

7.5 PRP LR Monitoring Reporting

7.5.1 Monthly Reporting

Monthly progress reporting will continue for the Superfund Site during LR period. This report is submitted in compliance with Section XI of the CD, and it will include a summary of remedial system performance, data and findings from remedial action activities, deliverables, significant project communications and contacts, anticipated project activities in the coming weeks, and a discussion of potential problems encountered that could impact the project schedule. The monthly report will be submitted by the tenth day of every month during the implementation of remedial actions.

7.5.2 PRP LR Monitoring

A groundwater monitoring report will be submitted after the completion of optimized-frequency Railyard groundwater sampling event. This report will present the findings from the monitoring activities within the reporting period. All groundwater analytical results, potentiometric data, TPG evaluations, and KT3D_H2O capture analyses will be provided. Railyard O&M summary will be included. The cumulative progress towards achievement of site-wide RAO will be reported, and the evaluation will include, at a minimum, analyses of temporal trends of COCs.

7.5.3 Other Reports

Groundwater analytical data, potentiometric data, and O&M data will be uploaded to EPA's online EquIS database at approximately 6-month intervals.

The IC Report will be prepared in accordance with the approved IC Work Plan, dated April 1, 2011.

8.0 Project Schedule

A conceptual project schedule is presented in Table 4 for the Railyard and Drag Strip remedial action activities described herein. The anticipated schedule for the Railyard is simple because the only remaining task is preparation and submittal and EPA approval of a revised GMP necessary for implementing the PRP LR monitoring program.

For the Drag Strip, the schedule is currently determined by the timing of access approval necessary for the installation of the proposed new delineation monitoring well clusters, as mentioned in Section 5.5. The durations of subsequent remedial action activities that can be estimated at this time are also shown in Table 4.

9.0 References

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Tables

Table 1

Shallow and Intermediate-Depth Constituents of Concern Data
Addendum 2 Final Design (60 Percent Design)
Conrail Railyard Superfund Site

Carbon Tetrachloride (CT)

Well ID	12/12/12	3/14/13	6/20/13	9/30/13	12/13/13	3/28/14	6/13/14	9/12/14	Mean	95% Confidence Interval	95% UCL, CT
DSMW-01	70	73	51	61	63	53	49	56	59.5	3.55	63
DSMW-02	190	180	110	170	130	170	250	180	172	30.0	202
DSMW-03	35	32	67.5	88	52	29	41	67	51.4	9.71	61.1
DSMW-04I	680	990	970	450	510	820	660	700	722	76.8	799
DSMW-04S	710	500	470	630	610	610	440	680	581	61.3	643
DSMW-07I	1400	900	975	1250	1100	1300	1100	1500	1,191	115	1306
DSMW-07S	1300	890	700	1100	910	750	570	1000	902	113	1016
DSMW-08I	95	95.5	69	92	72	90	81	91	85.7	5.33	91
DSMW-08S	33	29	25	37	26	31	27	34	30.2	2.22	32.5
DSMW-09I	330	180	260	440	420	390	340	460	352	30.4	383
DSMW-09S	19	23	16	28	25	22	16	18	20.9	2.42	23.3
DSMW-10I	4.15	7	3.55	3.35	2.1	1.45	5	5	3.95	1.13	5.08
DSMW-10S	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	-	1 U
DSMW-11I							280	390	335	76.2	411
DSMW-11S							68	130	99.0	43.0	142
DSMW-12I							180	330	255	104	359
DSMW-12S							9.3	13	11.2	2.56	13.7
MW-05D	8.2	7.6	7	8.7	9.5	8.2	7.4	11	8.45	0.946	9.4
MW-05S	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	-	1 U
MW-07S	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	-	1 U
MW-08D	80	84	66	79	80	67	56	63	71.9	6.05	77.9
MW-08S	100	77	72	87	92	29	40	53	68.8	16.5	85.2
MW-09S	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	-	1 U
MW-38D	190	160	165	150	120	150	110	210	157	27.0	184
MW-38S	65	26	36	72	50	23	30	100	50.2	20.9	71.1
MW-56I	170	94	120	150	180	150	80	80	128	30.4	158
MW-56S	100	48	130	160	140	110	46	120	107	24.4	131
MW-57S						1 U	1 U	1 U	1 U	-	1 U
MW-58S						91	75	89	85.0	8.05	93.1
MW-59S						1 U	1 U	1 U	1 U	-	1 U
MW-60S						88	73	84	81.7	7.18	88.8

Table 1

Shallow and Intermediate-Depth Constituents of Concern Data
Addendum 2 Final Design (60 Percent Design)
Conrail Railyard Superfund Site

Trichloroethene (TCE)

Well ID	12/12/12	3/14/13	6/20/13	9/30/13	12/13/13	3/28/14	6/13/14	9/12/14	Mean	95% Confidence Interval	95% UCL, TCE
DSMW-01	140	120	120	110	100	110	110	130	117	7.551268395	125
DSMW-02	20	25	13	19	12	22	25	17	19.1	3.43	22.6
DSMW-03	6.7	6.2	10.5	8.6	7.9	4.9	7.7	9	7.69	1.05	8.74
DSMW-04I	20	22	24	10	18	25	19	15	19.1	2.52	21.6
DSMW-04S	35	34	32	32	31	33	24	31	31.5	2.37	33.9
DSMW-07I	34	33	35.5	26.5	27	33	24	26	29.9	2.32	32.2
DSMW-07S	110	89	76	88	79	65	51	71	78.6	7.09	85.7
DSMW-08I	810	715	750	750	700	840	680	830	759	50.5	810
DSMW-08S	38	30	29	24	23	30	22	22	27.2	2.32	29.6
DSMW-09I	910	800	860	730	720	720	630	770	768	35.0	802
DSMW-09S	61	90	59	77	83	75	46	62	69.1	9.71	78.8
DSMW-10I	3200	2800	2700	2500	2300	2600	2500	2800	2,675	125	2,800
DSMW-10S	1.3	0.24	0.64	1.2	0.98	0.5	0.28	0.42	0.695	0.182	0.877
DSMW-11I							38	44	41.0	4.16	45.2
DSMW-11S							15	18	16.5	2.08	18.6
DSMW-12I							43	61	52.0	12.5	64.5
DSMW-12S							8.3	9.7	9.00	0.970	9.97
MW-05D	16	19	17	16	15	18	14	19	16.8	1.43	18.2
MW-05S	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	-	1 U
MW-07S	0.5	0.5	0.5	0.5	0.5	0.45	0.5	0.5	0.494	0.015	0.509
MW-08D	13	12	12	11	10	10	11	10	11.1	0.300	11.4
MW-08S	12	7.4	11	19.7	8.8	2.6	4.3	6.9	9.09	1.65	10.7
MW-09S	0.5	0.5	0.5	0.5	0.5	0.22	0.5	0.71	0.491	0.121	0.612
MW-38D	28	25	21.5	15	17	11	10	15	17.8	1.98	19.8
MW-38S	7.3	5.1	6.2	8.3	8	4.4	5.1	12	7.05	2.07	9.12
MW-56I	22	18	14	14	17	17	13	9.2	15.5	2.25	17.8
MW-56S	11	8.1	13	14	12	11	7	13	11.1	1.58	12.7
MW-57S						1 U	1 U	1 U	1 U	-	1 U
MW-58S						14	12	15	13.7	1.41	15.1
MW-59S						1 U	1 U	1 U	1 U	-	1 U
MW-60S						9.3	8.3	10	9.20	0.789	9.99

Table 1

Shallow and Intermediate-Depth Constituents of Concern Data
Addendum 2 Final Design (60 Percent Design)
Conrail Railyard Superfund Site

Chloroform (CF)

Well ID	12/12/12	3/14/13	6/20/13	9/30/13	12/13/13	3/28/14	6/13/14	9/12/14	Mean	95% Confidence Interval	95% UCL, CF
DSMW-01	3.2	3	3	2.6	2.9	2.2	2.8	3.1	2.85	0.232	3.08
DSMW-02	5.4	5	5.7	5.4	7.2	4.5	6.2	6.2	5.70	0.673	6.37
DSMW-03	11	11	18	15	13	12	13	14	13.4	0.490	13.9
DSMW-04I	91	110	120	82	94	120	100	100	102	6.82	109
DSMW-04S	37	37	34	35	31	39	23	33	33.6	3.97	37.6
DSMW-07I	31	32	36	45	56	74	71	91	54.5	8.61	63.1
DSMW-07S	21	21	15	12	12	13	11	14	14.9	0.775	15.6
DSMW-08I	17	15	18	17	17	20	16	20	17.5	1.24	18.7
DSMW-08S	2.6	2.6	3	3.1	2.8	3.1	2.6	3	2.85	0.133	2.98
DSMW-09I	33	36	40	42	47	50	42	47	42.1	1.99	44.1
DSMW-09S	1.8	1.9	1.5	2.2	2.2	2.2	1.4	2	1.90	0.227	2.13
DSMW-10I	4.15	7	3.55	3.35	1.2	1.45	5	5	3.84	1.27	5.11
DSMW-10S	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	-	1 U
DSMW-11I							32	39	35.5	4.85	40.4
DSMW-11S							23	17	20.0	4.16	24.2
DSMW-12I							50	39	44.5	7.62	52.1
DSMW-12S							3.4	2.5	2.95	0.624	3.57
MW-05D	16	3.8	3.7	3.6	4	4.8	3.6	4.5	5.50	0.319	5.82
MW-05S	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	-	1 U
MW-07S	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	-	1 U
MW-08D	13	15	14	14	14	13	14	14	13.9	0.300	14.2
MW-08S	12	9.7	9	9.6	9.3	4.3	4.5	8	8.30	1.51	9.81
MW-09S	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	-	1 U
MW-38D	28	38	34	17	15	15	10	20	22.1	2.45	24.6
MW-38S	7.3	15	18	14	15	13	16	15	14.2	0.755	14.9
MW-56I	22	23	16	16	16	18	15	12	17.2	1.50	18.8
MW-56S	11	12	14	17	15	11	11	16	13.4	1.58	15.0
MW-57S						1 U	1 U	1 U	1 U	-	1 U
MW-58S						5.4	5.2	6.9	5.83	0.858	6.69
MW-59S						1 U	1 U	1 U	1 U	-	1 U
MW-60S						11	11	13	11.7	1.07	12.7

UCL = Upper Confidence Level
U = Not detected at the reporting limit shown
"-" = Not detected

Table 2
Monitoring Parameters and Pilot Test Sampling Plan
Addendum 2 Final Design (60 Percent Design)
Conrail Railyard Superfund Site

Analyses	**Pilot Test Monitoring Wells - Sampling Schedule For Shallow and Intermediate Zone Wells**					
	Extraction	Injection	Radius of Influence	Advection	Advection and diffusion	ROI Overlap, Advection, and Diffusion
Aqueous Chemistry	UP-1	IW-1 IW-2	R-1 R-2 VR	A15-1 A15-2 A30-1 A30-2	AD15-1 AD15-2 AD30-1 AD30-2	ADV15 ADV30 ADV45
COCs	D	C	C	C	C	C
RSK-175 Gases	D	C	C	C	C	C
VFAs	D	B	C	B	C	C
TOC	D	B	C	B	C	C
Anions*	D	D	D	C	D	B
Ferrous Iron	D	B	B	B	B	B
Bicarbonate Alkalinity	nc	E	nc	nc	nc	nc
Microbial Members						
DHC, DHB, DSM, DSB	F	E	E	C	E	E
Field Monitoring						
Temperature	A	A	A	A	A	A
pH	A	A	A	A	A	A
ORP	A	A	A	A	A	A
Sp. Conductivity	A	A	A	A	A	A
DO	A	A	A	A	A	A

Notes:

Schedule A = Baseline, and every two weeks through week 12
Schedule B = Baseline, and at 2, 4, 8, and 12 weeks
Schedule C = Baseline, and at 4, 8, and 12 weeks
Schedule D = Baseline, and at 8 and 12 weeks
Schedule E = Baseline and at 12 weeks
Schedule F = Baseline only
nc = not collected

COCs = Constituents of concern:

Carbon tetrachloride	trans-1,2-Dichloroethene
Chloroform	Tetrachloroethene
Chloromethane	1,1,1-Trichloroethane
1,1-Dichloroethene	Trichloroethene
cis-1,2-Dichloroethene	Vinyl chloride

Microbial Members Include:
- DHC - *Dehalococcoides* spp., including functional genes
- DHB - *Dehalobacter* spp.
- DSM - *Desulfuromonas* spp.
- DSB - *Desulfitobacterium* spp.

VFAs = Volatile fatty acids
ORP = Oxidation-reduction potential
*Anions = Chloride, Nitrate-N, Nitrite-N, Sulfate, Phosphate
Baseline = Before injection
RSK 175 gases are ethene, ethane, and methane
Inject = Delivery of selected compounds to the aquifer
Bioaugment = Injection of KB-1 Plus will be conducted at the time of injection and re-evaluated for reapplication based on microbial member analyses at 4 weeks.

NOTE 1: Field monitoring results will be used to evaluate pH and ORP, and to make adaptive modifications to the monitoring schedule as needed.
NOTE 2: The length of the pilot test may be shorter or longer than shown here depending on real-time evaluation of monitoring wells.

Table 3
Drag Strip Remedy Performance Monitoring Scope
Addendum 2 Final Design (60 Percent Design)
Conrail Railyard Superfund Site

Quarterly Groundwater Monitoring Scope:	
Wells specified in Groundwater Monitoring Plan (Appendix G to 2003 Final Design)	
MW-02S	DSMW-01
MW-02D	DSMW-02
MW-02BR	DSMW-03
MW-3I	DSMW-04S
MW-3D	MW-05S
MW-07S	MW-05D
MW-07D	MW-09D
MW-08S	MW-38S
MW-08D	MW-38D
MW-08BR	MW-56S
MW-43BR	MW-56I
	MW-56D
Supplemental, Five-Year Review Investigation Wells, and Drag Strip Remedial Design Wells:	
DSMW-04I	DSMW-10S
DSMW-04D	DSMW-10I
DSMW-07S	DSMW-10D
DSMW-07I	DSMW-11S
DSMW-07D	DSMW-11I
DSMW-08S	DSMW-11D
DSMW-08I	DSMW-12S
DSMW-08D	DSMW-12I
DSMW-09S	DSMW-12D
DSMW-09I	MW-09S
DSMW-09D	MW-44D
DSMW-05S	MW-50
DSMW-05I	MW-03
DSMW-05D	
MW-57S	MW-59S
MW-58S	MW-60S
Proposed, Drag Strip Delineation Wells:	
DSMW-13S	DSMW-14S
DSMW-15S	

[green shading] = Drag Strip and Vistula Area wells subject to statistical testing (UCLs) for Drag Strip RAO attainment

(Green-shaded wells: DSMW-02, DSMW-03, DSMW-04S, MW-08S, MW-56S, DSMW-11S, DSMW-12S, DSMW-09S, MW-57S, MW-59S, MW-58S, MW-60S, DSMW-13S, DSMW-14S, DSMW-15S)

Groundwater samples analyzed for program-list Constituents of Concern (Method 8260B), specified in Groundwater Monitoring Plan

Well and building locations shown on Figure 12

TABLE 3

DRAG STRIP REMEDY PERFORMANCE MONITORING SCOPE

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TABLE 4

Conceptual Project Schedule
Rail Yard and Drag Strip Remedial Activities
Addendum 2 Final Design (60 Percent Design)
Conrail Railyard Superfund Site

RAILYARD

Component	**Anticipated Schedule**
Begin Potentially Responsible Party Long-Term Response (PRP LR) Monitoring	Upon United States Environmental Protection Agency (EPA) Approval of Revised Groundwater Monitoring Plan

DRAG STRIP

Component	**Schedule**
EPA Approval of Drag Strip Remedial Action Approach	February 2014
Revision 2, Addendum 2 Submission (30 Percent Design)	May 2014
Complete Bench-Scale Testing	August 2014
IRG Tech Memo Submittal	September 2014
Revision 3, Addendum 2 Submission (60 Percent Design) and Responses	January 2015
Access Prohibition Lifted	“X”
Hot Spot Delineation Completion	“X” + 8 weeks
Pilot-Scale Testing Completion	4 Months After Hot Spot Delineation
Full-Scale Remedy Completion	3 Years After Pilot-Scale Testing
Begin PRP LR Monitoring	Upon EPA Approval of Full-Scale Remedy Completion

Figures

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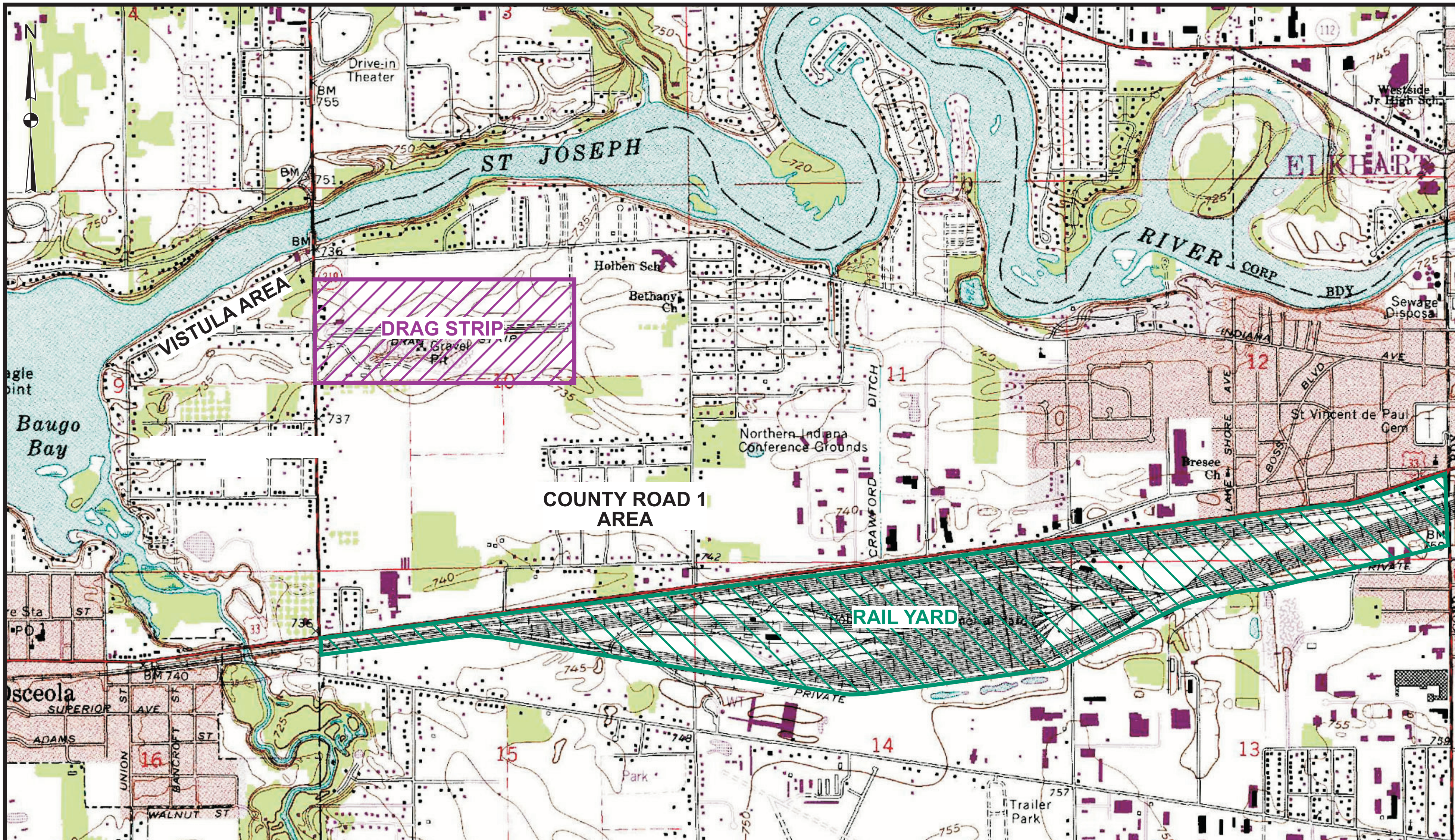


BASE MAP SOURCE: USGS 7½ minute topographic quadrangle map Osceola, Indiana 1969, revised 1994.

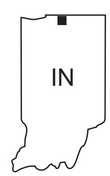
0 2,000 4,000

APPROXIMATE SCALE IN FEET

LEGEND:

Approximate Osceola Drag Strip Property Boundary

Approximate NS Railyard Property Boundary



Quadrangle Location

CONRAIL RAILYARD SITE

ELKHART, INDIANA

FIGURE 1
SITE VICINITY MAP

JOB NO. 14951501

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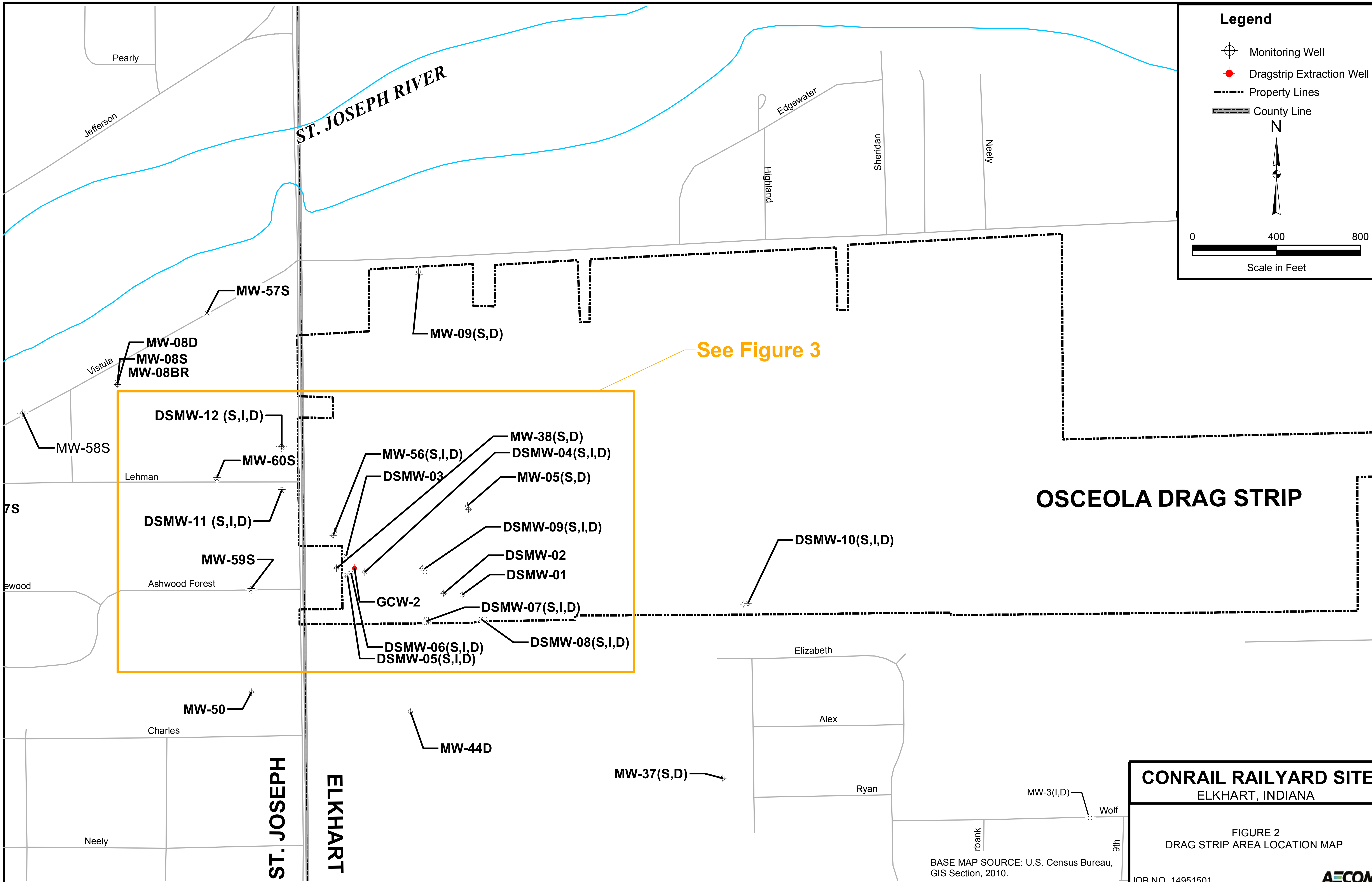

CONRAIL RAILYARD SITE
ELKHART, INDIANA

FIGURE 2
DRAG STRIP AREA LOCATION MAP

JOB NO. 14951501

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FIGURE 3: DRAG STRIP AREA MAP
WITH WELL AND SOIL GAS SAMPLE LOCATIONS

AND

FIGURE 4: DRAG STRIP PROPERTY WITH
CROSS-SECTION LOCATIONS

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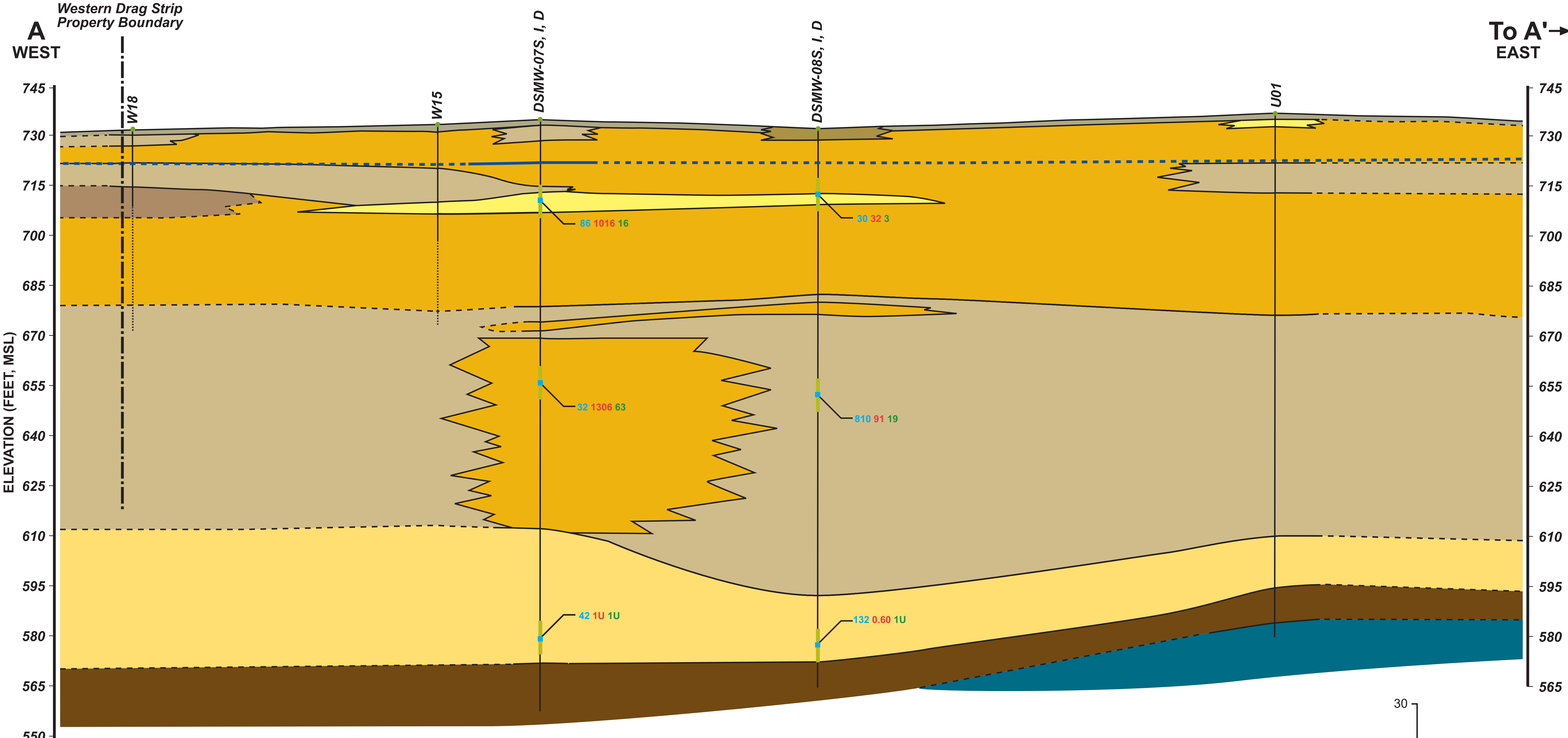

LEGEND:

- Approximate Potentiometric Surface (Measured December 2013), Dashed Where Inferred
- Monitoring Well Groundwater Sample
- 2010 Soil Boring Location (Dashed Where Only Groundwater Sample Collected, No Lithologic Characterization)
- Well Location
- Screened Interval

- 23 — Trichloroethene (TCE) Groundwater Concentration (µg/L)(95% UCL 2012-2014)
- 1U — Carbon Tetrachloride (CT) Groundwater Reporting Limit and Non-Detect Flag (µg/L)
- 36 — Chloroform Groundwater Concentration (µg/L)(95% UCL 2012-2014)

GP	Poorly-Graded Gravels
GW	Well-Graded Gravels
Lower Unit	Spatially Variable Sand/Gravel Mixtures
SP	Poorly-Graded Sands
SW	Well-Graded Sands
SM	Silty Sands
SC	Sand with Clay
ML	Silt
CL	Clay
SH	Shale

NOTE:
- Cross-Section location shown on Figure 4.
- The depth and thickness of the strata indicated on the subsurface section were obtained by interpolating between test borings. Information on actual conditions exists only at the locations of the test borings and it is possible that the conditions may vary from those indicated.

CONRAIL RAILYARD SITE
ELKHART, INDIANA

FIGURE 5A
CROSS-SECTION A-A' - SECTION 1

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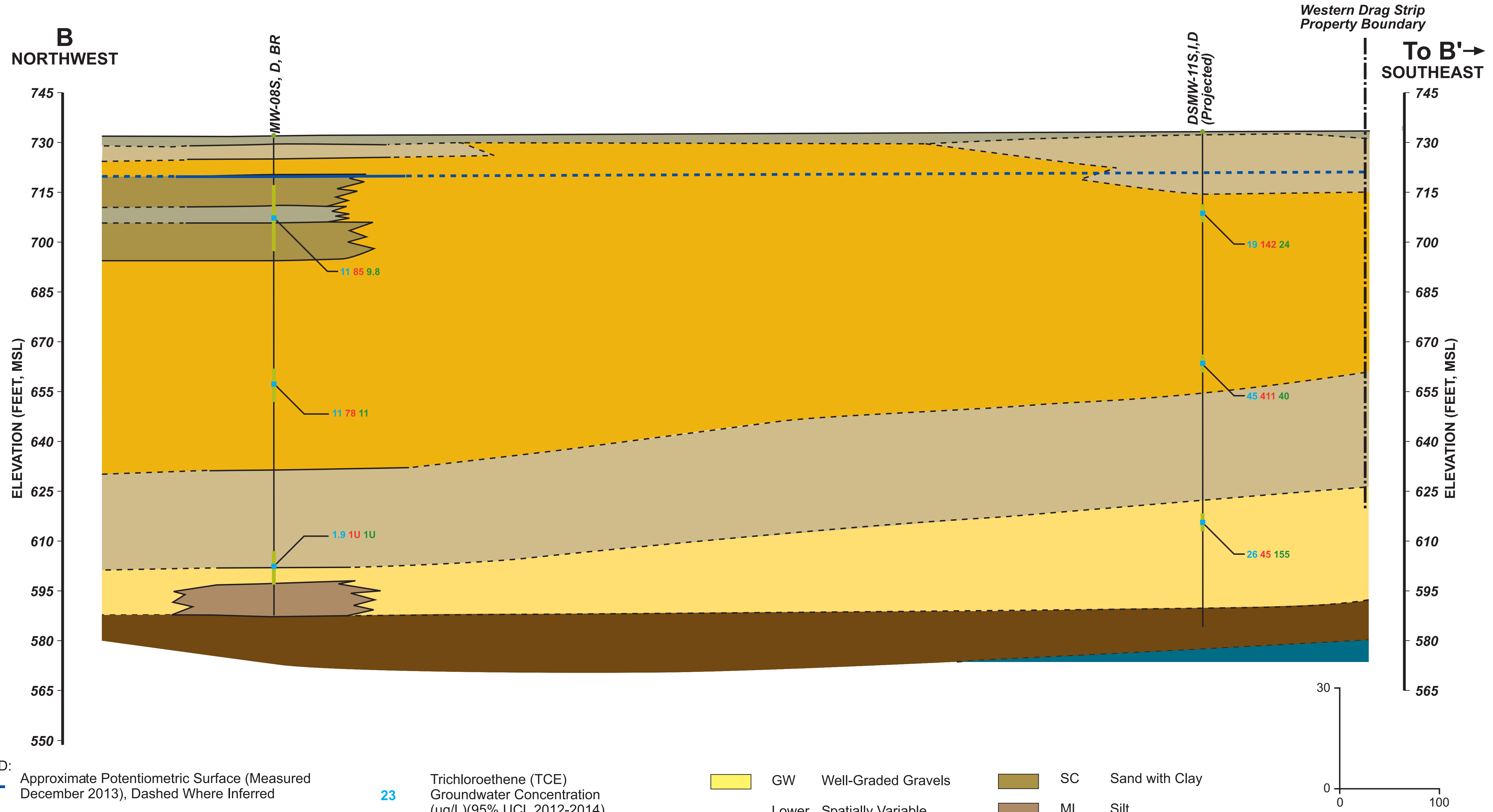

LEGEND:

- Approximate Potentiometric Surface (Measured December 2013), Dashed Where Inferred
- Monitoring Well Groundwater Sample
- 2010 Soil Boring Location (Dashed Where Only Groundwater Sample Collected, No Lithologic Characterization)
- Well Location
- Screened Interval

- 23 — Trichloroethene (TCE) Groundwater Concentration (µg/L)(95% UCL 2012-2014)
- 1U — Carbon Tetrachloride (CT) Groundwater Reporting Limit and Non-Detect Flag (µg/L)
- 36 — Chloroform Groundwater Concentration (µg/L)(95% UCL 2012-2014)

GW	Well-Graded Gravels
Lower Unit	Spatially Variable Sand/Gravel Mixtures
SP	Poorly-Graded Sands
SW	Well-Graded Sands
SM	Silty Sands
SC	Sand with Clay
ML	Silt
CL	Clay
SH	Shale

NOTE:
- Cross-Section location shown on Figure 4.
- The depth and thickness of the strata indicated on the subsurface section were obtained by interpolating between test borings. Information on actual conditions exists only at the locations of the test borings and it is possible that the conditions may vary from those indicated.

CONRAIL RAILYARD SITE
ELKHART, INDIANA

FIGURE 5B
CROSS-SECTION B-B' - SECTION 1

JOB NO. 14951501 AECOM

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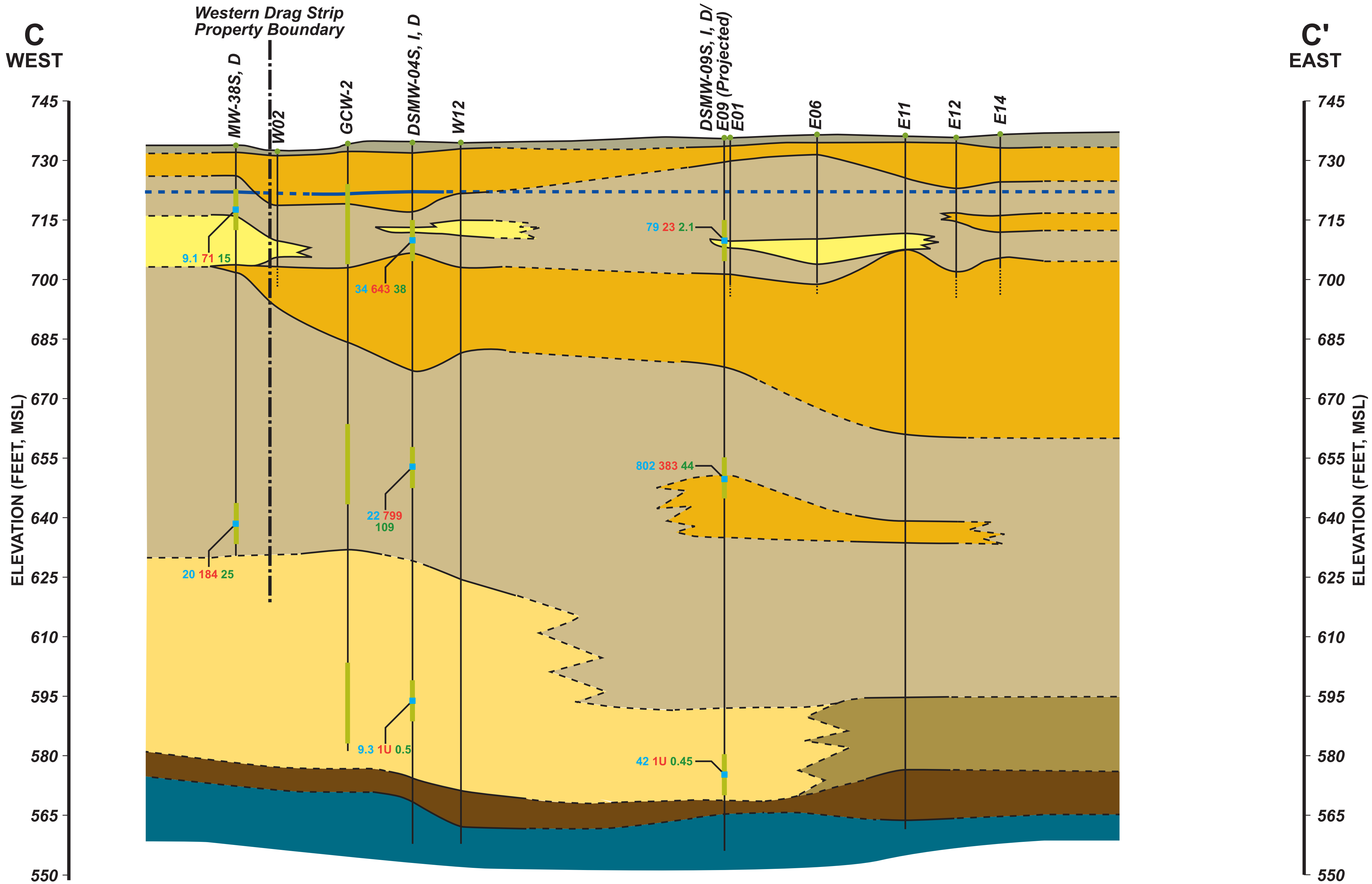

30

0

0 100

SCALE IN FEET

VERTICAL EXAGGERATION = 3.33x

LEGEND:

Approximate Potentiometric Surface (Measured December 2013), Dashed Where Inferred

Monitoring Well Groundwater Sample

2010 Soil Boring Location (Dashed Where Only Groundwater Sample Collected, No Lithologic Characterization)

Well Location

Screened Interval

23 Trichloroethene (TCE) Groundwater Concentration (µg/L)(95% UCL 2012-2014)

1U Carbon Tetrachloride (CT) Groundwater Reporting Limit and Non-Detect Flag (µg/L)

36 Chloroform Groundwater Concentration (µg/L)(95% UCL 2012-2014)

GW	Well-Graded Gravels
Lower Unit	Spatially Variable Sand/Gravel Mixtures
SP	Poorly-Graded Sands
SW	Well-Graded Sands
SC	Sand with Clay
ML	Silt
CL	Clay
SH	Shale

NOTE:
- Cross-Section location shown on Figure 4.
- The depth and thickness of the strata indicated on the subsurface section were obtained by interpolating between test borings. Information on actual conditions exists only at the locations of the test borings and it is possible that the conditions may vary from those indicated.

CONRAIL RAILYARD SITE
ELKHART, INDIANA

FIGURE 5C
CROSS-SECTION C-C'

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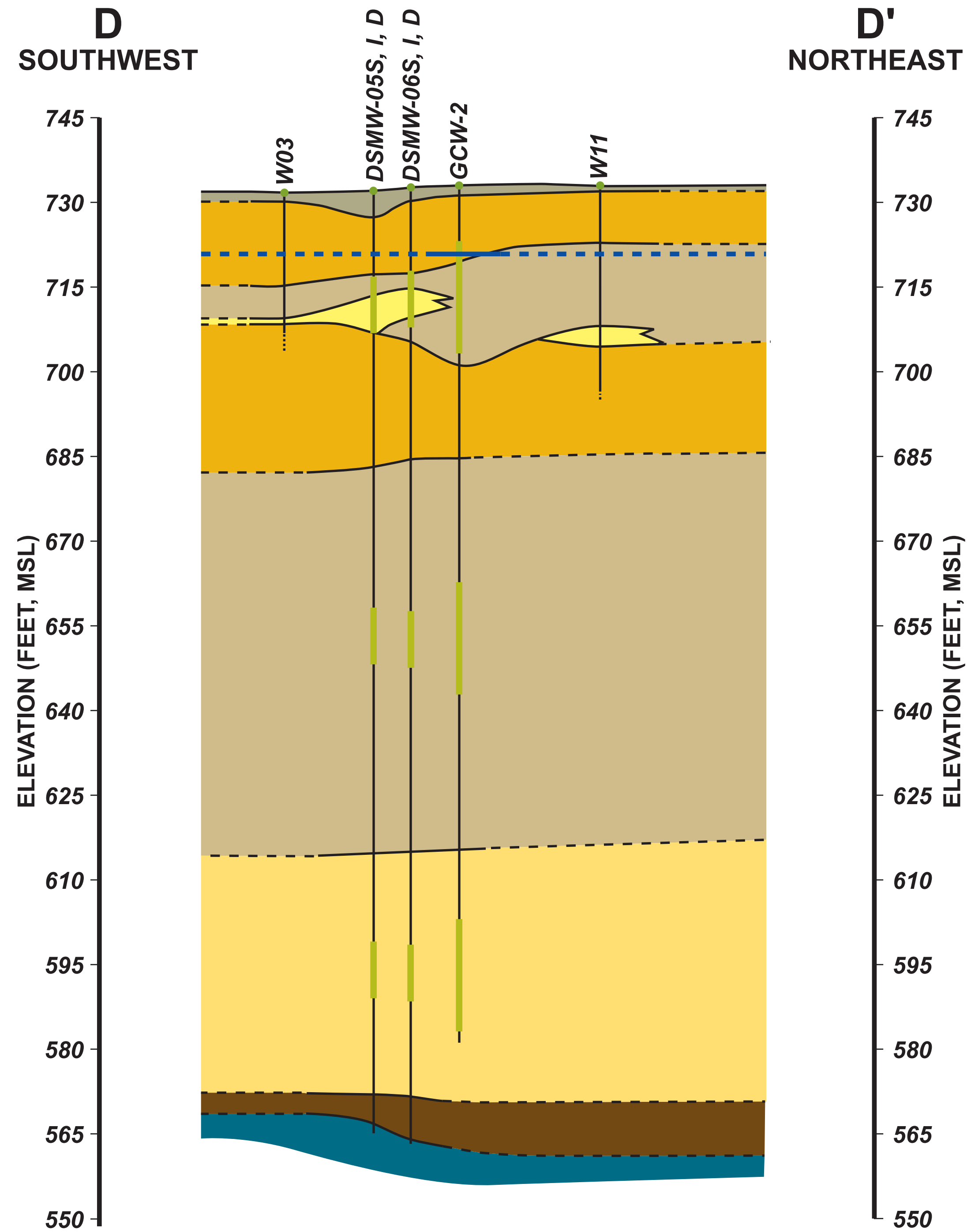
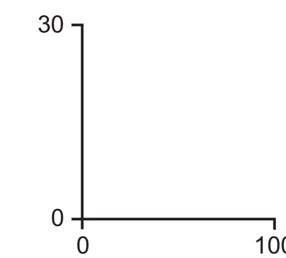


LEGEND:

- Approximate Potentiometric Surface (Measured December 2013), Dashed Where Inferred
- Monitoring Well Groundwater Sample
- 2010 Soil Boring Location (Dashed Where Only Groundwater Sample Collected, No Lithologic Characterization)
- Well Location
- Screened Interval

	GW	Well-Graded Gravels
	Lower Unit	Spatially Variable Sand/Gravel Mixtures
	SP	Poorly-Graded Sands
	SW	Well-Graded Sands
	SM	Silty Sands
	CL	Clay
	SH	Shale



SCALE IN FEET
VERTICAL EXAGGERATION = 3.33x

NOTE:
- Cross-Section location shown on Figure 4.
- The depth and thickness of the strata indicated on the subsurface section were obtained by interpolating between test borings. Information on actual conditions exists only at the locations of the test borings and it is possible that the conditions may vary from those indicated.

CONRAIL RAILYARD SITE
ELKHART, INDIANA

FIGURE 5D
CROSS-SECTION D-D'

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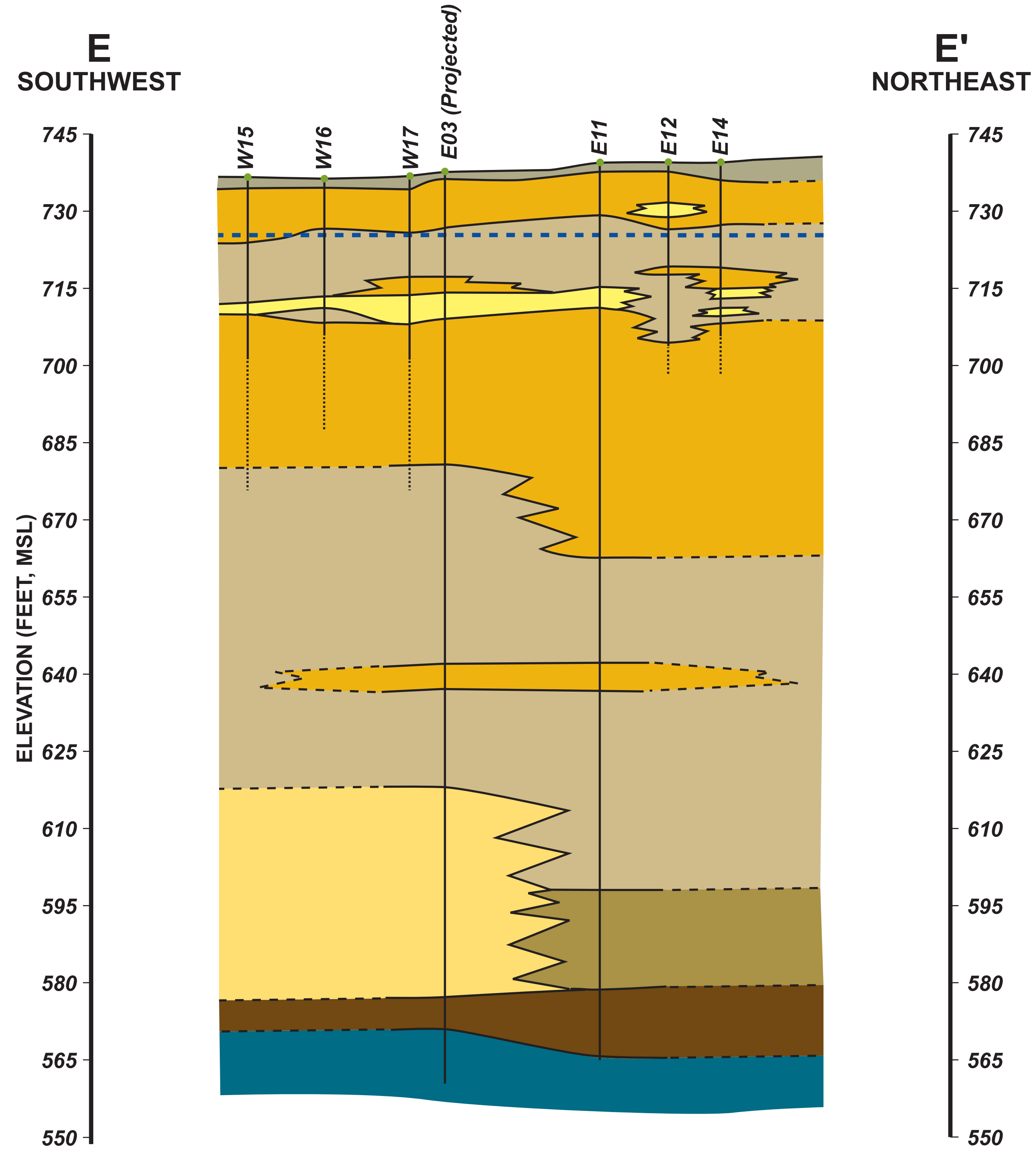
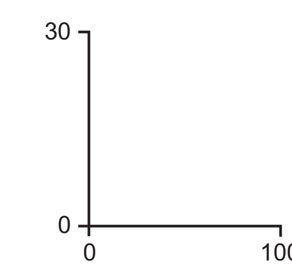


LEGEND:

- Approximate Potentiometric Surface (Measured December 2013), Dashed Where Inferred
- Monitoring Well Groundwater Sample
- 2010 Soil Boring Location (Dashed Where Only Groundwater Sample Collected, No Lithologic Characterization)
- Well Location
- Screened Interval

GW	Well-Graded Gravels
Lower Unit	Spatially Variable Sand/Gravel Mixtures
SP	Poorly-Graded Sands
SW	Well-Graded Sands
SM	Silty Sands
SC	Sand with Clay
CL	Clay
SH	Shale



SCALE IN FEET
VERTICAL EXAGGERATION = 3.33x

NOTE:
• Cross-Section location shown on Figure 4.
• The depth and thickness of the strata indicated on the subsurface section were obtained by interpolating between test borings. Information on actual conditions exists only at the locations of the test borings and it is possible that the conditions may vary from those indicated.

CONRAIL RAILYARD SITE
ELKHART, INDIANA

FIGURE 5E
CROSS-SECTION E-E'

JOB NO. 14951501

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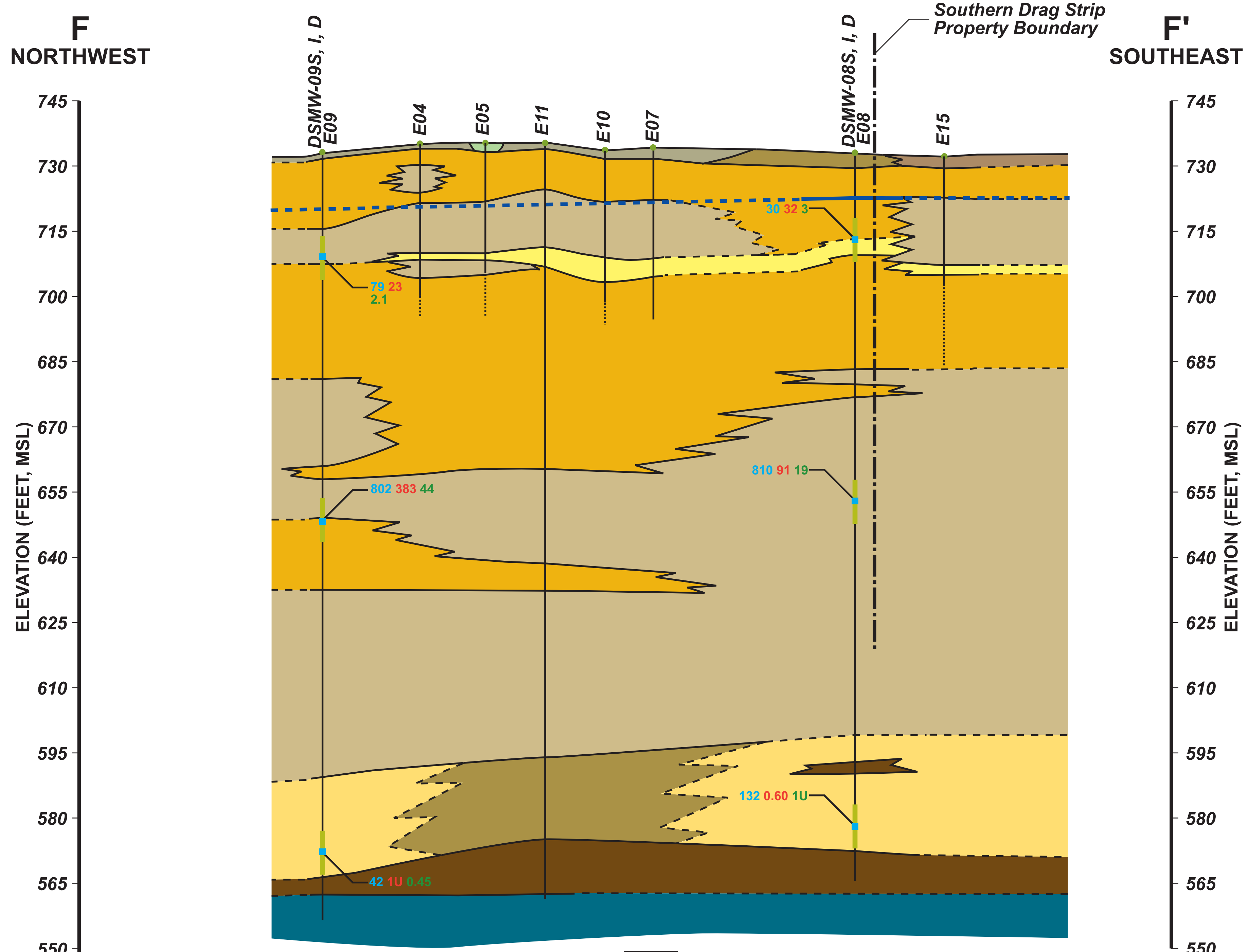

	Fill	
GW	Well-Graded Gravels	
Lower Unit	Spatially Variable Sand/Gravel Mixtures	
SP	Poorly-Graded Sands	
SW	Well-Graded Sands	
SM	Silty Sands	
SC	Sand with Clay	
CL	Clay	
SH	Shale	

LEGEND:

- Approximate Potentiometric Surface (Measured December 2013), Dashed Where Inferred
- Monitoring Well Groundwater Sample
- 2010 Soil Boring Location (Dashed Where Only Groundwater Sample Collected, No Lithologic Characterization)
- Well Location
- Screened Interval

23 Trichloroethene (TCE) Groundwater Concentration (µg/L)(95% UCL 2012-2014)

1U Carbon Tetrachloride (CT) Groundwater Reporting Limit and Non-Detect Flag (µg/L)

36 Chloroform Groundwater Concentration (µg/L)(95% UCL 2012-2014)

NOTE:
- Cross-Section location shown on Figure 4.
- The depth and thickness of the strata indicated on the subsurface section were obtained by interpolating between test borings. Information on actual conditions exists only at the locations of the test borings and it is possible that the conditions may vary from those indicated.
- DSMW-09S, I and D were installed in September 2010. July 2010 Groundwater elevation data is interpolated at this well cluster.

30 0 100
SCALE IN FEET
VERTICAL EXAGGERATION = 3.33x

CONRAIL RAILYARD SITE
ELKHART, INDIANA

FIGURE 5F
CROSS-SECTION F-F'

JOB NO. 14951501

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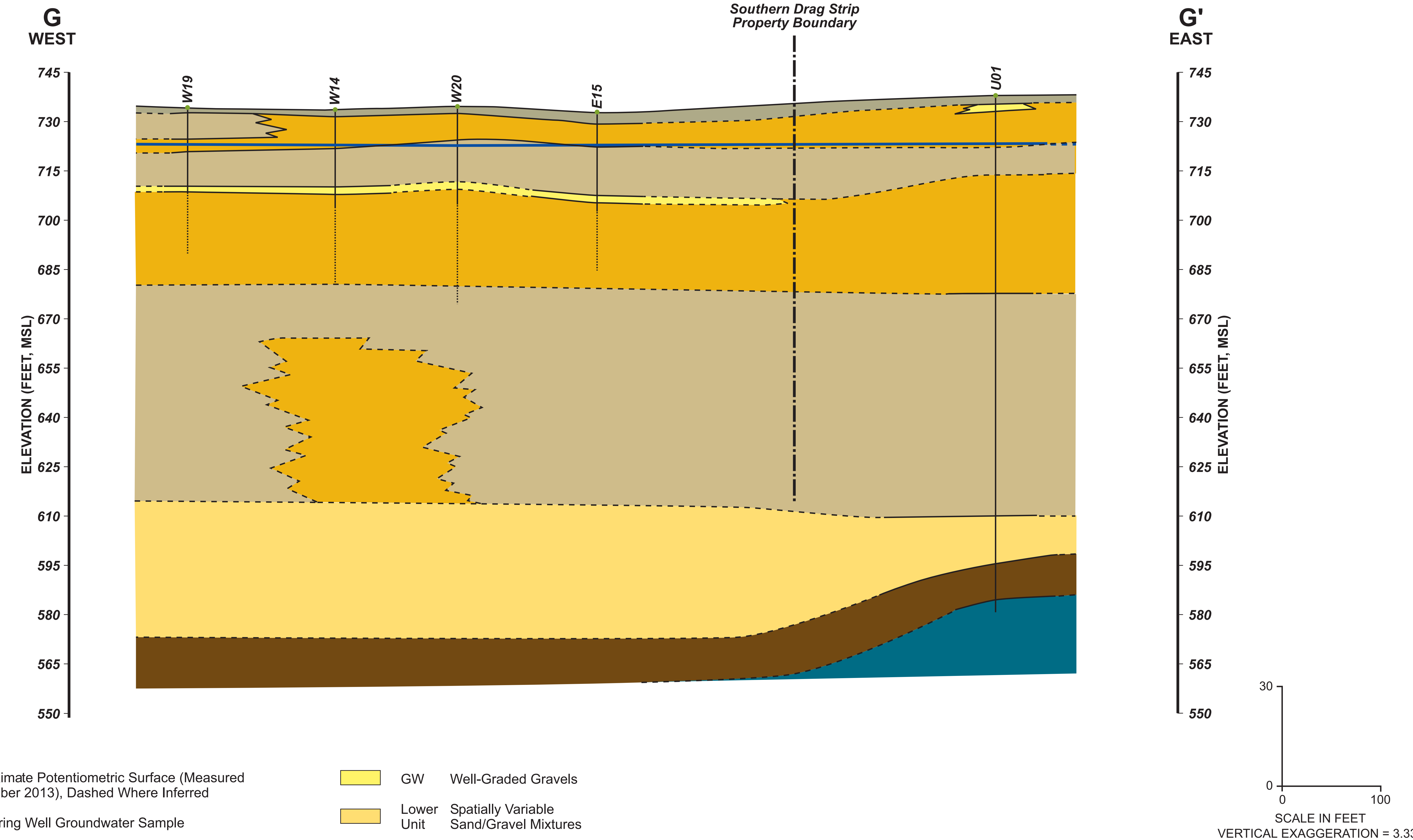

LEGEND:

- Approximate Potentiometric Surface (Measured December 2013), Dashed Where Inferred
- Monitoring Well Groundwater Sample
- 2010 Soil Boring Location (Dashed Where Only Groundwater Sample Collected, No Lithologic Characterization)
- Well Location
- Screened Interval

	GW	Well-Graded Gravels
	Lower Unit	Spatially Variable Sand/Gravel Mixtures
	SP	Poorly-Graded Sands
	SW	Well-Graded Sands
	SM	Silty Sands
	CL	Clay
	SH	Shale

NOTE:
- Cross-Section location shown on Figure 4.
- The depth and thickness of the strata indicated on the subsurface section were obtained by interpolating between test borings. Information on actual conditions exists only at the locations of the test borings and it is possible that the conditions may vary from those indicated.

CONRAIL RAILYARD SITE
ELKHART, INDIANA

FIGURE 5G
CROSS-SECTION G-G'

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FIGURES 6-A, 6-B, 7-A, AND 7-B

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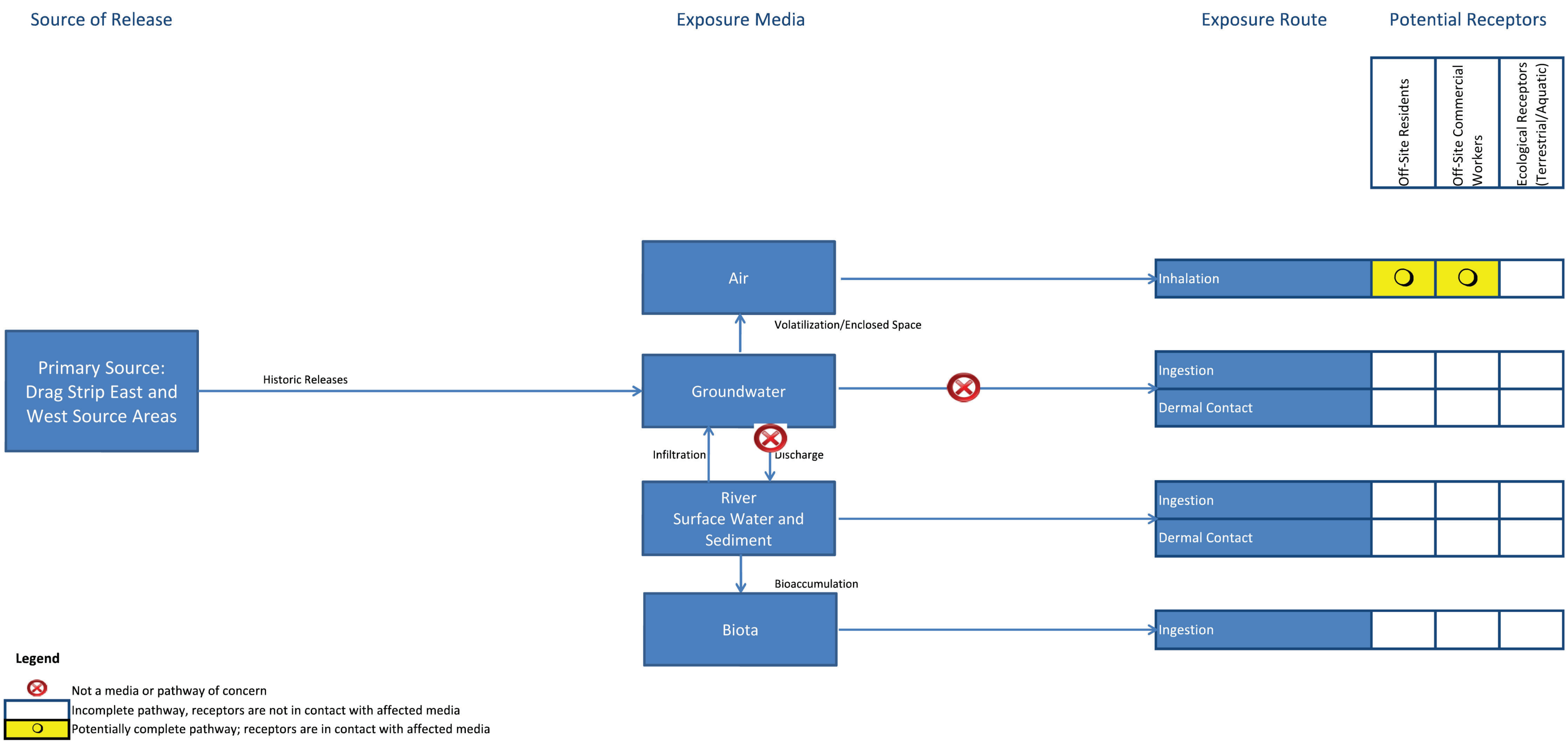

CONRAIL RAILYARD SITE
ELKHART, INDIANA

FIGURE 8
CONCEPTUAL EXPOSURE MODEL

JOB NO. 14951501

AECOM

FIGURE 9: PROPOSED WELL NEST LOCATIONS AND SHALLOW GROUNDWATER CARBON TETRACHLORIDE (CT) ISOPLETHS

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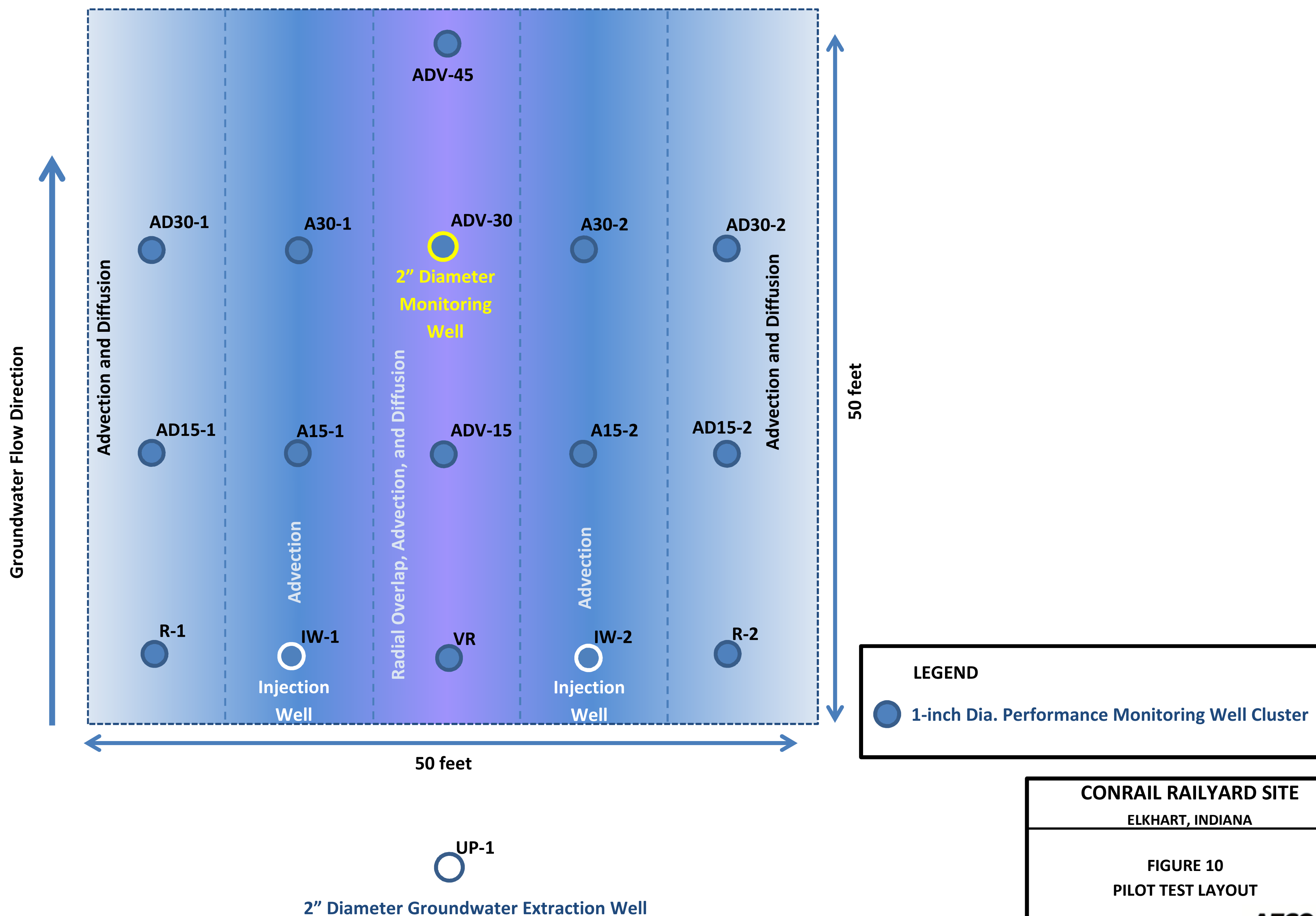
Drag Strip Pilot Test Treatment Area



CONRAIL RAILYARD SITE
ELKHART, INDIANA

FIGURE 10
PILOT TEST LAYOUT

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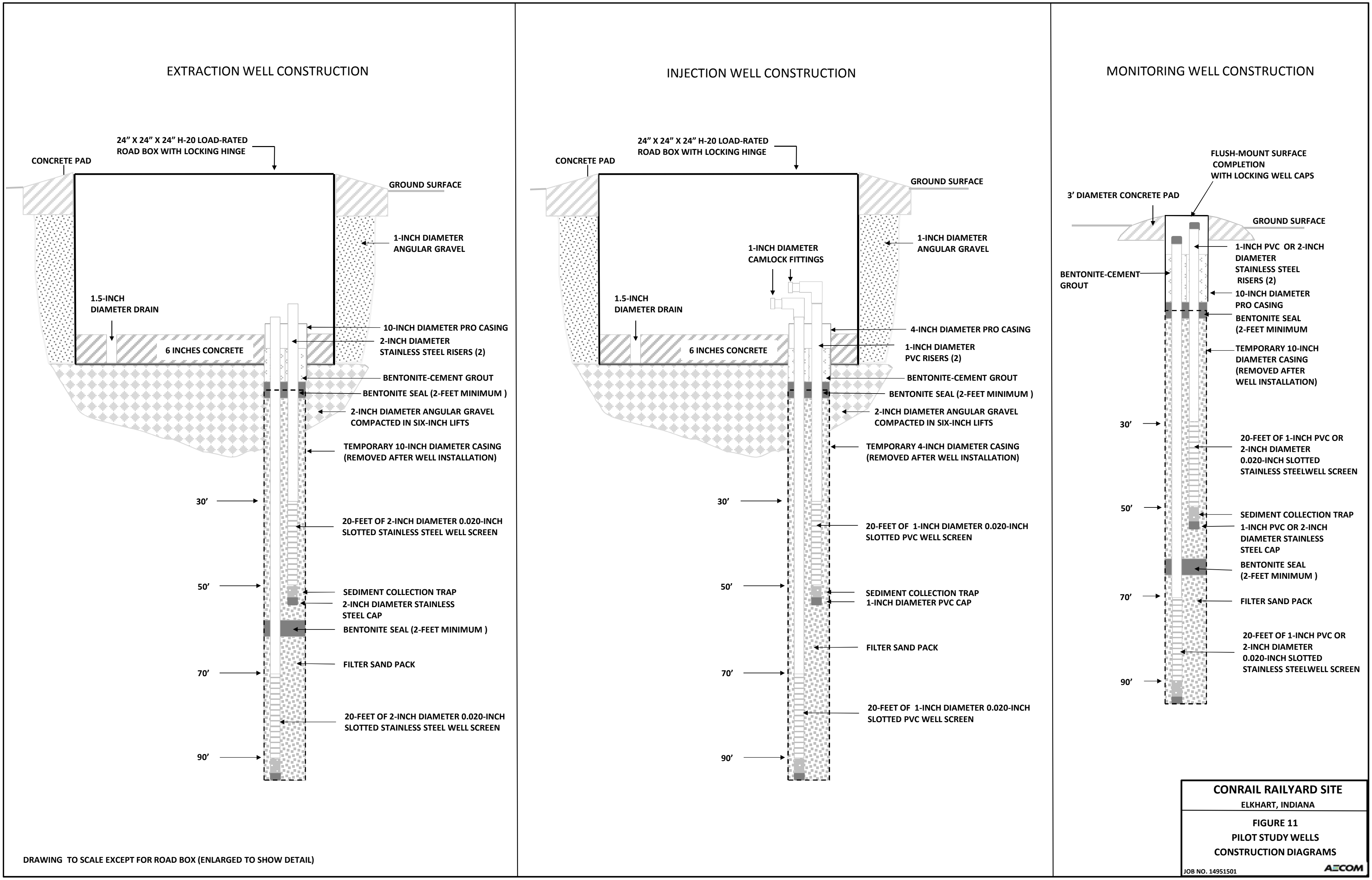

CONRAIL RAILYARD SITE
ELKHART, INDIANA

FIGURE 11
PILOT STUDY WELLS
CONSTRUCTION DIAGRAMS

JOB NO. 14951501
AECOM

FIGURE 12

REMEDY PERFORMANCE MONITORING WELL LOCATIONS

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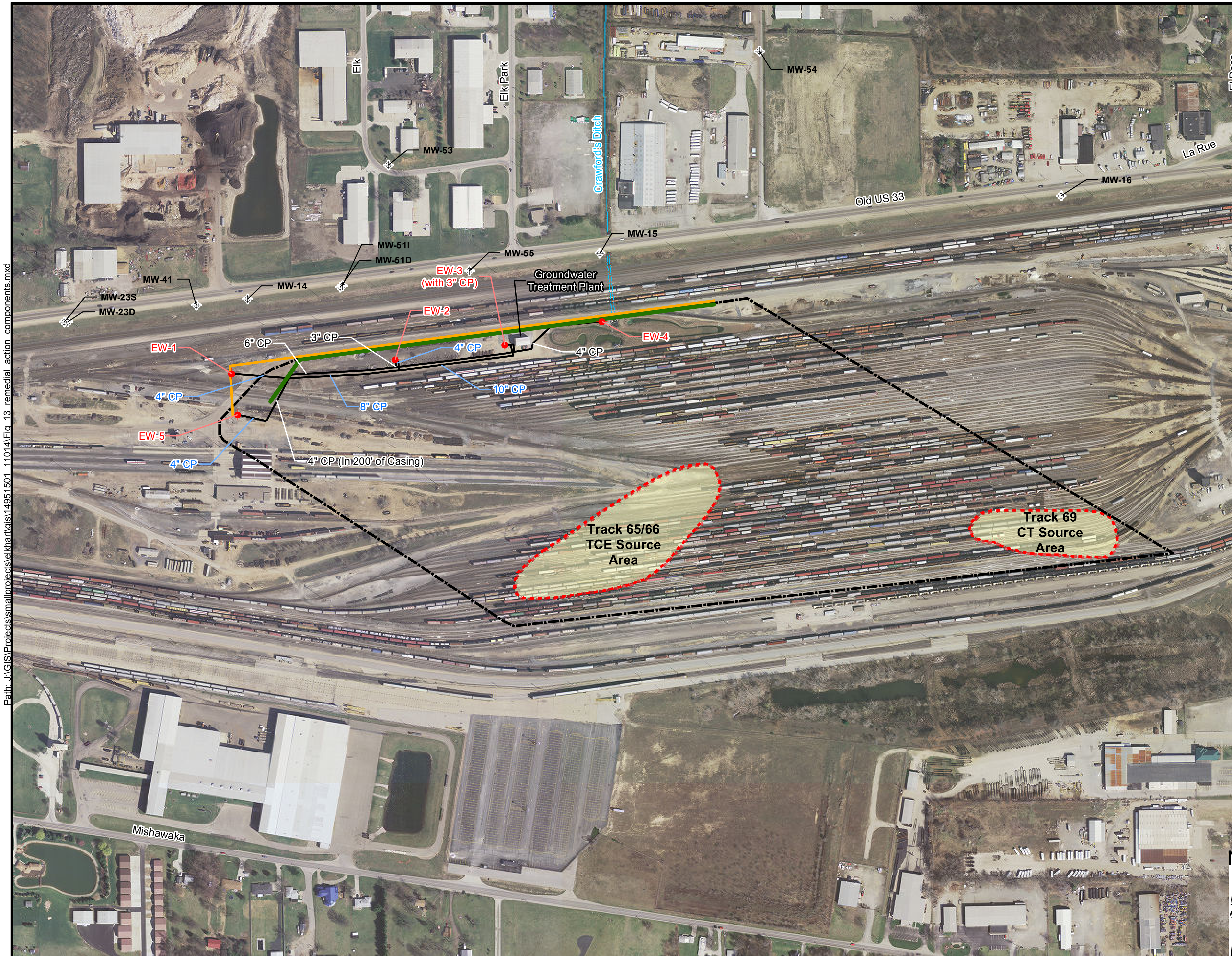

LEGEND:

- Approximate Extent of Source Area
- Groundwater Extraction and Conveyance System (Approximate Location)
- Groundwater Extraction Well (EW)
- Offsite Monitoring Well in Monitoring Program
- TI Waiver Area
- Line of Containment (2003 Final Design)
- Updated Line of Containment
- CP Conveyance Piping (Double-Walled HDPE)

0 400 800

Scale in Feet

CONRAIL RAILYARD SITE

ELKHART, INDIANA

FIGURE 13
RAILYARD REMEDY LAYOUT

JOB NO. 14951501

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Appendix A

Addendum Final Design Report, June 30, 2011

URS

June 30, 2011

Timothy Drexler
U.S. EPA Region V
SR-6J
77 West Jackson Blvd.
Chicago, IL 60604-3590

Re: Addendum
Final Design Report
Containment Groundwater Pumping and Treatment System
Conrail Railyard Superfund Site
Elkhart, Indiana

Dear Mr. Drexler:

On behalf of the Settling Parties, this letter transmits the *Addendum, Final Design Report Containment Groundwater Pumping and Treatment System* at the Conrail Railyard Superfund Site in Elkhart, Indiana.

Please call the undersigned if you have any questions or comments.

Sincerely,

URS
on behalf of Norfolk Southern Railway Company,
and American Premier Underwriters

Thomas W. Hudson, C.P.G.
Project Manager

John D. Priebe, P.E.
Principal Engineer

Anthony J. Limke, C.P.G.
Program Manager

14949039.53000
Attachment

cc: Kevin Herron, IDEM
Margaret A. Hill, Blank Rome, LLP
Todd E. Wentz, Norfolk Southern Railway Company
L. Christopher Oakes, Norfolk Southern Railway Company
Karin L. Stamy, Norfolk Southern Railway Company
Helen M. Hart, Norfolk Southern Railway Company
John Warner, Weaver Boos

URS Corporation
36 East 7th Street, Suite 2300
Cincinnati, Ohio 45202
Tel: 513.651.3440
Fax: 513.651.3452

Addendum

Final Design Report

Conrail Railyard Superfund Site
Containment Groundwater Pumping and Treatment System
Elkhart, Indiana

Submission Date: June 30, 2011

Prepared by:
URS
36 East Seventh Street, Suite 2300
Cincinnati, OH 45202

On behalf of:
Settling Parties:
American Premier Underwriters, and
Norfolk Southern Railway Company

Table of Contents

Tables

Figures

Appendix

1.0 Introduction

This document presents an Addendum to the Final Design Report (URS 2003) for the containment pumping and treatment system in operation at the Conrail Railyard Superfund Site in Elkhart, Indiana (Site), and it is part of the Second Remedial Design/Remedial Action (Second RD/RA). The system is a part of the United States Environmental Protection Agency's (EPA's) groundwater remedial alternative for the Site, as presented in a Record of Decision (ROD) Amendment dated September 28, 2000, and which modifies the Final ROD dated September 9, 1994.

The Site consists of two separate groundwater remediation areas. The first is located at the Elkhart Railyard, and the second is located at the Osceola Drag Strip (Drag Strip). The Railyard pumping and treatment system is shown on Figure 1. This addendum addresses the Railyard system, and does not include discussion of the Drag Strip system.

The purpose of this Addendum is to present the design basis and intent (including appropriate supporting information and calculations) for an expansion of the current Railyard groundwater remediation system. The current system includes three extraction wells (EW-2, EW-3, and EW-4) and a groundwater treatment system. Expansion of the Railyard system is being implemented in order to address EPA concerns associated with plume capture that have been identified in the technical evaluations performed as part of the Third Five-Year Review Investigation.

2.0 Background

Site background information consisting of regulatory history, physical setting, and the nature and extent of groundwater impact are presented in detail in the Second RD/RA Preliminary Design Report (URS 2002) and are not repeated herein.

Groundwater contamination, consisting of trichloroethene [TCE] (from the Track 65-66 Source Area), carbon tetrachloride [CCl_4] (from the Track 69 Source Area), and degradation products of both compounds, are present in the subsurface of the Railyard Classification Yard, where railcars are processed and trains "built" before dispatch. The EPA-approved remedy includes containment of groundwater with significant concentrations of the contaminants from the Track 65-66 and Track 69 Source Areas. The estimated extents of these source areas are shown in Figure 1. The Final Design for the groundwater remediation system consists of installation of up to five extraction wells (for containment), pumping and conveyance of groundwater via underground conveyance lines to a treatment plant wherein the volatile constituents are removed by air stripping. The treated water is discharged to Crawford Ditch exhaust air from the stripper is treated by passing it through granular activated carbon (GAC) under the terms of Indiana Department of Environmental Management (IDEM) air registration R 039-18602-00596.

Construction of the remediation system is being performed in phases. The first phase was completed in 2004, and consisted of the construction of the treatment plant and installation of three extraction wells (EW-3, EW-4, and EW-2). System commissioning began June 28, 2004, and operational and equipment issues were resolved during the subsequent weeks, leading to the issuance of Substantial Completion Report on September 21, 2004. The Railyard system is currently in Year 7 of operation and maintenance (O&M).

The second phase of remediation system construction is addressed in this submittal. EPA published the Third Five-Year Review Report for the Site on June 15, 2009, in which the performance of the Railyard groundwater containment system was identified as needing further investigation. Other issues identified in EPA's Five-Year Review Report, which are not addressed herein, are related to the Drag Strip remediation area. To address the identified issues, the Settling Parties prepared four revisions to the Five-Year Review Investigation Work Plan, and implemented the approved scope of work. Technical evaluations and reporting for the Five-Year Review Investigation are ongoing, including interim submittals of technical memoranda (Tech Memos) to EPA.

For the Railyard performance evaluation, the Settling Parties conducted a hydraulic testing task that resulted in an updated estimate for hydraulic conductivity and estimates for groundwater capture zones. The findings were submitted to EPA in two Tech Memos:

- *Analyses of Pumping and Recovery Tests at EW-2 and EW-4, Revision 1* for the Conrail Rail Yard Site, Elkhart, Indiana, dated March 4, 2011 (Railyard Hydraulic Test Tech Memo); and

- *Railyard Capture Zone Analysis*, for the Conrail Rail Yard Site, Elkhart, Indiana, dated March 4, 2011 (Capture Zone Tech Memo).

Using a weight-of-evidence approach, the Capture Zone Tech Memo concluded that incomplete groundwater capture of Track 65-66 TCE Source Area may be occurring. Although contaminant concentrations in wells downgradient of the extraction wells and the timing of these changes indicate full capture of the Track 69 CCl_4 Source Area, EPA has previously stated that it considers capture of this area to be incomplete based on a purely hydraulic evaluation.

3.0 Remedial Action Objectives

The objective of the Remedial Action, consistent with the 2000 ROD Amendment, is containment of groundwater with significant concentrations of TCE and CCl_4 from the Track 65-66 and Track 69 Source Areas at the Railyard, and natural gradient flushing of the dissolved portion of the contaminant plume downgradient of the line of containment. As shown on Figure 1, the line of containment is located parallel to the main rail track alignment near the north boundary of the Railyard.

The Settling Parties' approach for achieving the Remedial Action objectives consists of the following general steps:

1) Upgrade the current containment system through the installation of additional extraction wells, improvements to the groundwater conveyance system, and modifications to the internal treatment plant piping and related components, and as necessary, well screen modifications to the existing wells, and/or pump upgrade/replacement and control improvements.

2) Optimize the system collection scheme through adjustments to pumping/flow rates based on potentiometric measurements and continuing evaluation of capture performance. The upgrade of the containment system is intended to provide operational flexibility in order to allow for system optimization as limited by flow capacities.

This approach represents direct and tangible progress towards addressing the containment issue, including infrastructure enhancement, an increase in containment and treatment volumes, additional operational flexibility, and performance data collection and evaluation. The performance evaluation methods, described in Revision 4, Five-Year Review Investigation Work Plan (URS 2010), include the use of potentiometric measurements to evaluate potentiometric contours and groundwater flow lines (i.e., from particle tracking). The performance evaluation methods also rely on chemical concentration data, as part of an overall weight-of-evidence approach set forth in the approved Final Design.

It is understood that if system performance, as measured by weight-of-evidence standards, does not indicate achievement of the Remedial Action objectives, then the two general steps listed above (or some applicable portion thereof) may need to be repeated or further refined.

4.0 Remedial Design for Railyard Pumping and Treatment System Expansion

Based on the findings of the Capture Zone Tech Memo, additional action in the form of improvements to the Railyard groundwater remediation system will be implemented. The proposed improvements will consist of upgrades to the current containment system (installation of additional extraction wells, etc.), and optimization of the current collection scheme (pumping/flow rates). The design objectives and assumptions related to these improvements are described in this section. In addition, preliminary design information and calculations are summarized below. More detailed design activities will commence following approval of the design concepts in this submittal and are anticipated to be presented in the form of design drawings and technical specifications.

4.1 Remedial Design Objectives

The following objectives have been developed for improvements to the Railyard groundwater remediation system:

- In order to improve hydraulic capture downgradient of the Track 65-66 TCE Source Area, install two additional extraction wells, EW-1 and EW-5, on the western end of the line of containment.

- Increase the current infrastructure capacity (i.e., conveyance and treatment systems) in order to accommodate the additional flows from the upgraded EW-2 and the new EW-1 and EW-5.

- Optimize the pumping system through adjustments to pumping/flow rates in response to potentiometric measurements and continuing evaluation of capture performance.

- If needed to further enhance contaminant removal while minimizing extraction of clean water, preferentially extract pump groundwater from the higher-contamination depth zones in the aquifer. This upgrade will entail modifying extraction depths for the existing pumping wells based on volatile organic compound (VOC) profiling data obtained from observation wells.

- If needed to further improve hydraulic capture of downgradient of the Track 65-66 TCE Source Area, increase extraction capacity at EW-2 through pumping and/or conveyance-system improvements.

The preliminary design information and associated design assumptions are further documented below.

4.2 Design Assumptions

The design assumptions for the construction of the currently-operating containment pumping and treatment system are presented in Section 3.0 of the Final Design. For the purposes of this Addendum, Table 1 presents the assumptions associated with the remediation system improvements.

4.3 Installation of Two Extraction Wells

Two new extraction wells (EW-1 and EW-5) will be installed on the western end of the current line of containment (Figure 1). The line of containment was originally proposed in the TI Waiver Petition (GeoTrans 2000). This line was reproduced in the ROD Amendment, and it was incorporated into the design basis for the 2003 Final Design for achieving the Railyard Remedial Action objective stated in Section 3.0. For the location of EW-1, the Settling Parties propose to adjust its position in response to IDEM concerns over groundwater concentrations in MW-41; this issue is described in the Downgradient Action Plan (URS 2007). Specifically, EW-1 is proposed to be installed closer to MW-41 (west of the existing access road), which would result in the updated line of containment shown in Figure 1. EW-5 will be installed at the location identified in the Second RD/RA Final Design. Figure 1 also shows the TI Waiver Area as originally proposed in the TI Waiver Petition and reproduced in the ROD Amendment.

Pilot soil borings will be advanced to bedrock at each proposed location in order to characterize lithology and contaminant distribution with depth. Borings will be advanced using a Rotosonic drill rig, and continuous soil cores will be collected for lithologic characterization. Select soil samples will also be collected for grain size analysis. Groundwater profile sampling will be conducted at each proposed location. Profiling data will be used for evaluation of potential screen isolation to preferentially pump groundwater from the higher-contamination depth zones in the aquifer. Sample collection methods are described in the Construction Quality Assurance Plan (CQAP) presented in the Second RD/RA Final Design (see also Section 5.1). Nested piezometers will be installed in each pilot boring after sampling activities are completed. Piezometer construction will follow existing approved methods for the site, and screened intervals will monitor the shallow, intermediate and deep portions of the aquifer, similarly to the existing OW-wells.

Each extraction well will be installed at the pilot location using cable-tool methods. The well boring will have a minimum diameter of 14 inches. Each extraction well will have an 8-inch diameter casing, and will be constructed per the technical specifications outlined in *Section 02011- Extraction Well Installation* from the 2003 Railyard Bid Specification Package and its associated documents. It is anticipated that the grain size analyses will confirm the original well filtration design (i.e., 30-slot screen and Global #5 filter-pack) for the new wells. If the grain size data show significantly different characteristics than for the existing pumping well locations, then the well filtration system design will be adjusted. It is anticipated that each well will be constructed with a 100-foot length screened interval in order to provide operating flexibility during extraction system optimization (including potential screen modifications as discussed in Section 4.6 below). Screened intervals, and screen length may be adjusted in the field, based on lithologic observations during the pilot boring phase.

After well installation, each extraction well will be developed and tested for hydraulic performance. The performance testing will be conducted to estimate maximum sustained yield for the completed installation. Based on a comparison of step-test data for EW-2 from 2003 to pumping rate and water level data from 2009 and 2011, it is anticipated that the pumping depth to water in the newly installed extraction wells will be approximately 15 to 20 feet below ground surface (bgs) for a pumping range of 250 to 250 gallons per minute (gpm). These values will be refined as part of the performance testing process. Details of the development and performance testing processes are outlined in *Section 02011- Extraction Well Installation* from the 2003 Railyard Bid Specification Package and its associated documents.

During the detailed design activities, current uncertainties about contaminant distribution and lithologic characteristics will be further refined to support engineering of the pumping system expansion. Pumps will be selected for the new wells, and design activities related to the electrical and control systems will be conducted. The pumping capacity at EW-5 is constrained by the existing 4-inch line beneath the railroad tracks (maximum rate of 350 gpm). At EW-1, a 6-inch line will be installed. Similar to EW-2, it is proposed that pumps with variable-frequency drives (VFDs) be installed at the new wells to allow for flow rates to be increased or decreased within a defined range. Currently, it is anticipated that the flow ranges from EW-1 and EW-5 each will be 250 to 350 gpm.

4.4 Treatment System Flow Capacity Upgrades

The proposed infrastructure improvements consist of the installation of larger diameter conveyance piping (8-inch and 10-inch), larger diameter process piping (10-inch), and upgrades to the bag filter system to accommodate the larger process piping. As presented in Table 1, the total collection rate from the extraction well system is constrained by the capacity of the treatment system. The collected groundwater enters the treatment building and flows via 6-inch pipe through a bag filter system and ultimately to an air stripper (with associated blower equipment). Treated groundwater is discharged via a storm sewer to Crawford Ditch. Exhaust air from the stripper is treated by passing it through GAC under the terms of IDEM air registration R 039-18602-00596.

The current system flow capacities are summarized in Table 2. As demonstrated by this table, the ultimate capacity of the system to contain, collect, and treat groundwater at the Railyard is first limited by the pump and piping system capacities, followed by the capacities of the bag filters, blower, and ultimately the air stripper. The air stripper and blower are constrained by a combination of hydraulic and contaminant removal capacities. The downstream system components are the 10-inch gravity discharge piping to Crawford Ditch, and the outfall piping under the main tracks, which also receives the stormwater flows from the classification yard. These components are not anticipated to affect the system operational capacities.

A review of the current system pumping, conveyance and treatment capacities, physical limitations of the groundwater treatment building, and general economic considerations indicates that a reasonable approach to system improvement is upgrade the extraction capacity to meet the current system blower capacity (800 gpm). The remedial design objectives described in Section 4.1 indicate that the pumping capacity at the western end of the line of containment should be increased. Assuming that the operating flow rates of EW-3 and EW-4 are not modified (50 to 200 gpm each well) this allows for a total of 400 gpm to 700 gpm to be collected from the remaining three extraction wells (existing well EW-2 and new wells EW-1 and EW-5).

Modifications to the conveyance system are proposed in order to improve capacity and reduce energy consumption associated with velocity. The conveyance system upgrades will also enable future operational flexibility. The proposed locations of EW-1 and EW-5 and the proposed piping system are depicted on Figure 1. Preliminary calculations have been developed to evaluate the system heads and are included in Appendix A. These calculations will be further developed during the detailed design phase.

The installation of a new 8-inch line from EW-1 to EW-2 is proposed, and installation of a 10-inch line from EW-2 to the treatment system is also proposed. These lines will allow for flow rates in excess of 900 gpm. It should also be noted that it is proposed to leave the existing 6-inch line from EW-1 to the treatment system in place in order to allow future operational flexibility.

Table 2 also presents the potential containment and treatment system capacities following the proposed upgrade activities. The proposed piping system capacities will exceed the current treatment/hydraulic capacity of the existing air stripper and associated blower. The system piping upgrade will require the interior process piping and bag filter system for the treatment system to also be upgraded. These treatment system upgrades will be implemented in order to further reduce energy use as well as accommodate higher flow rates used in this design.

In summary, the proposed infrastructure improvements consist of the installation of larger diameter conveyance piping (8-inch and 10-inch), larger diameter process piping (10-inch), and upgrades to the bag filter system. These improvements will allow additional groundwater to be collected and treated at the air stripper (maximum capacity under current design assumptions is 800 gpm).

4.5 Pumping System Optimization

In consideration of the Remedial Action objective of containment of groundwater with significant concentrations of TCE and CCl_4 from the Track 65-66 and Track 69 Source Areas at the Railyard, pumping rates for the expanded system will be optimized. Optimization will consist of an iterative process of potentiometric measurements, containment/capture performance assessment, and pumping rate adjustments. Capture performance assessment will be performed as described in the Capture Zone Tech Memo, (i.e, use of KT3D_H2O to display potentiometric contours and particle tracks).

4.6 Potential Modification of Screen Lengths in Existing Extraction Wells

In an effort to enhance contaminant removal while minimizing extraction of clean water, the screened intervals of the existing extraction wells (EW-2, EW-3, and EW-4) may be shortened to preferentially extract from the higher-contamination depth zones in the aquifer. To characterize the contaminant profile at the existing pumping wells, groundwater samples will be collected from the monitoring and observation wells in the vicinity of each extraction well using passive diffusion samplers during normal system operation. Table 3 contains the list of wells to be sampled, which are also shown on Figure 2.

Analytical data will be used to construct a chemical “profile” for the shallow, intermediate, and deep depths in the vicinity of each extraction well to assist with determining which zones in the aquifer are higher in contaminant concentration.

Screened interval modifications for each extraction well may be implemented based on the chemical “profile” data in consideration of the Remedial Action objective of containment of groundwater with significant concentrations of TCE and CCl_4 from the Track 65-66 and Track 69 Source Areas at the Railyard. If conducted, screened sections that are currently pumping groundwater containing contaminant concentrations below the site performance standards (Maximum Contaminant Levels [MCLs]) would be blanked off with removable steel casing. The appropriate open screened length in each well will be maintained to ensure screen entrance velocities are kept in laminar flow condition.

Potentiometric monitoring will be used to evaluate containment performance during screen length modifications, as part of continuing pumping system optimization efforts. Potential containment issues identified during optimization will be addressed as appropriate.

4.7 Potential Extraction Well EW-2 Pump Upgrade

The pump currently installed at EW-2 is designed to operate at an average capacity of 150 gpm, with flows ranging from 50 to 200 gpm. Capture zone analysis suggests that containment of the Track 65-66 TCE Source Area could be improved by increasing the pumping capacity at EW-2. Optimization findings will show whether or not EW-2 pumping capacity increases are necessary.

In order to maximize operational flexibility and given the information presented in Section 4.4, it is currently proposed to upgrade the piping diameter from EW-2 to the main piping system. The installation of larger piping will allow the total collection rate from EW-2 to exceed 220 gpm. The pump selection activities will occur during detailed design. Currently it is anticipated that the upgraded pump will include a VFD to allow for flow rate adjustments during system operation. Flow rate adjustments would be based on potentiometric surface information and monitoring data collected during continuing optimization efforts. The proposed range for this pump is anticipated to be 250 to 350 gpm, which may be further refined during detailed design activities. The electrical and control system at EW-2 will also be improved to accommodate the new pump.

4.8 Summary

The remedial action objectives presented in Section 3.0 are related to upgrades to the current containment system and the optimization of flows from each extraction well. The design information presented in Section 4.0 defines the current system constraints and design assumptions and describes the proposed system improvements. The treatment capacity of the current system is constrained by the air stripper system and associated blower under the current design assumptions (800 gpm).

The proposed system improvements include the installation of new, larger diameter conveyance piping to increase the capacity of this infrastructure (8- and 10-inch pipe), larger diameter treatment system process piping (10 inch) and upgrades to the existing bag filter system to accommodate the increased flows and process piping. The proposed system improvements also include the installation of new wells and pumps at EW-1 and EW-5. The pumps at EW-1, EW-2, and EW-5 will be selected during the detailed design activities and are anticipated to consist of pumps with VFDs to allow the flows from these wells to be adjusted between 250 and 350 gpm. The pumping capacity at EW-3 and EW-4 will remain unchanged and will vary between 50 and 200 gpm. Based on system optimization efforts, it may be recommended to modify the screen lengths in the existing extraction wells and/or the upgrade the pump at EW-2.

The system pumping rates will then be optimized during operation such that the total containment rate from all extraction wells meets the system operating capacity of 800 gpm. The estimated construction costs to conduct these system improvements are presented in Section 6.0.

5.0 Other Plans and Information

This section presents an overview of additional plans that are anticipated to be required in order to implement the remedial design activities. These plans are intended to provide provisions to support:

1) The completion of construction activities in accordance with the future detailed design documents (technical specifications),

2) The implementation of construction and observation activities in a safe manner and in accordance with applicable Federal, State, and client requirements, and

3) Emergency response activities in the event of spills or other site emergencies during construction activities.

In addition, expansion of the groundwater treatment system at the Railyard will result in changes to the parameters underlying this system's air registration.

5.1 Construction Quality Assurance Plan (CQAP)

The Second RD/RA Final Design provides a CQAP to document the minimum required quality control testing, observations and standards that are required to be implemented during the construction activities. The minimum standards provided in the existing, approved CQAP will be implemented during the proposed remedial action activities for applicable components. In addition, the CQAP will be reviewed and updated during the detailed design activities to reflect additional standards and requirements indicated in the technical specifications to be prepared as part of those activities.

5.2 Health and Safety Plan (HASP)

URS will use the current HASP for the Conrail Railyard Superfund Site dated February 18, 2011 as the Primary HASP for activities related to the system expansion and upgrades. An addendum to the Primary HASP will be prepared, if necessary, to address activities and potential associated risks not discussed in the primary HASP. The HASP Addendum, if required, will be prepared as part of the detailed design activities and submitted to EPA for consideration.

All construction contractors and subcontractors will also be required to develop their own HASPs and will be responsible for implementation of their plans. These contractors will also be responsible for compliance with applicable safety standards set forth by Norfolk Southern for work at the Elkhart Railyard.

5.3 Contingency Plan

The contingency plan prepared as part of the Second RD/RA Final Design provides a description of the actions that will be implemented in the event of a spill or other emergency. This plan is also intended to prevent and minimize the impact of potential spills or other unplanned site emergencies. The Contingency Plan will also be updated during detailed design activities, if necessary, and will be revised during the construction activities if warranted by changes in Site conditions.

5.4 Air Registration Update

Air registration R 039-18602-00596 was approved by the IDEM Office of Air Quality on May 27, 2004. Per 325 IAC 2-5.5-6(d)(10), notification to IDEM within 30 days of the system change is all that is required if estimated potential emissions from the upgraded system remain less than 10 tons/year of any single hazardous air pollutant (HAP) and less than 25 tons/year of combined HAPs. The Settling Parties anticipate that this will be the case.

The Settling Parties will estimate potential emissions from the groundwater treatment system with flow upgraded to 800 and 1,000 gpm, using estimated maximum contaminant concentrations for the upgraded system.

The Settling Parties will then prepare a notification meeting the requirements of 325 IAC 2-5.5-6(d)(10), including: Company name and address, a description of the nature and location of the proposed construction or modification, the design capacity and typical operating schedule, a description of the source and the emissions unit or units comprising the source, a description of any emission control equipment, including design specifications, a schedule for construction or modification of the source, information on the nature and amount of pollutants to be emitted, and the required certification for signature by the authorized individual.

6.0 Cost Estimate

The cost estimate provided in Table 4 has been developed to present a preliminary design level, order of magnitude estimate of the costs associated with implementation of the remedial design activities. These costs are based on the estimated construction costs from 2003 Final Design bid package, with adjustments applied for inflation (2011 dollars) and for the proposed system improvements (such as increases in pipe size). Given the preliminary nature of this cost estimate, markups are also provided (engineering, miscellaneous, and contingency). Actual costs for the scope of work contained in this design addendum will be determined during the bidding process.

7.0 Project Schedule

The anticipated project schedule is presented in Table 5. The critical path items associated with the project schedule presented above are primarily related to approval of the Remedial Design Addendum. The detailed design phase is anticipated to be conducted concurrently with the review period, but comments on this submittal may result in a need to revise some design components resulting in a delay to the bidding activities and subsequent activities. In addition, the construction duration is anticipated to be approximately 3 months and if construction cannot commence on or about September 14, it is possible that there will be construction delays related to weather conditions.

The actual construction schedule will be provided by the Contractor as part of bidding activities.

8.0 References

Army and Air Force Publication, March 1985. Sanitary and Industrial Wastewater Collection – Pumping Stations and Force Mains, (Army TM 5-814-2/Air Force AFM 88-11, Vol. 2, Army Publishing Directorate.)

HIS GeoTrans, Inc., 2000. Petition for a Technical Impracticability Waiver and Request for Remedy Reconsideration, Conrail Railyard Superfund Site, Elkhart, Indiana.

URS, 2002. Second Remedial Design/Remedial Action Preliminary Design Report, Conrail Railyard Superfund Site, Elkhart, Indiana.

URS, 2003. Final Design Report, Conrail Ralyard Superfund Site Containment Groundwater Pumping and Treatment System, Elkhart, Indiana.

URS, 2007. Downgradient Groundwater Action Plan, Second Remedial Design/Remedial Action, Conrail Railroad Superfund Site, Elkhart, Indiana.

URS, 2010. Revision 4, Five-Year Review Investigation Work Plan, Conrail Railyard Superfund Site, Elkhart, Indiana.

URS, 2011. Technical Memorandum: Analyses of Pumping and Recovery Tests at EW-2 and EW-4, Revision 1for the Conrail Rail Yard Site, Elkhart, Indiana.

URS, 2011. Technical Memorandum: Railyard Capture Zone Analysis, for the Conrail Rail Yard Site, Elkhart, Indiana.

U.S. EPA, 2000. Superfund Record of Decision (ROD) Amendment: Conrail Railyard (Elkhart) EPA ID: IND000715490 OU 02, Elkhart, Indiana.

Tables

Table 1
Design Assumptions
Conrail Railyard Superfund Site
Elkhart, Indiana

Assumption	**Basis**
Vertical extent of contaminants in groundwater is from approximately 45 feet to 110 feet depth below ground surface (bgs), extending to approximately 140 feet at pumping well EW-3.	Concentrations in groundwater within borings and monitoring wells during investigations beginning in 1998 (URS 2002), and monitoring program data continuing through 2010. Depths will be confirmed via a profiling investigation using groundwater sample data from observation wells and monitoring wells in Table 4.
Influent total volatile organic compounds (VOCs) concentrations to plant estimated to range from 0.2 to 1.5 milligrams per liter (mg/L)	Concentrations in treatment system influent between 2004 and 2011 range between 0.2 and 0.8 mg/L. Focusing extraction from higher-concentration depths has the potential to increase influent concentrations.
EW-1 location moved westward to address groundwater concentrations detected in MW-41.	Indiana Department of Environmental Management (IDEM) concerns over this issue described in Downgradient Action Plan (URS 2007).
Average long-term system total collection rate 800 gallons per minute (gpm).	The total collection rate is constrained by the hydraulic capacity of the existing blower for the air stripper system for the influent concentrations assumed in the Final Design (URS, 2003).
Collection rate for EW-5 and EW-1 variable between approximately 250 and 350 gpm.	The potential collection rate is constrained by the ultimate hydraulic capacity of the treatment system (above) and the installed pumping, conveyance, and discharge systems. Design to allow for some flow adjustments during iterative system optimization activities in relation to the existing extraction wells.
Piping system design velocity 5.5 fps	Based on the Army and Air Force publication Army TM 5-814-2/ AF AFM 88-11, piping system design velocities will be limited to 2.5 fps (minimum to prevent sediment build-up) to 9 fps (maximum to avoid excessive energy use) with an average design velocity of 5.5 fps.

Table 2
Current and Proposed Containment and Treatment System Hydraulic Capacities
Conrail Railyard Superfund Site
Elkhart, Indiana

Remediation System Component	**Current Collection and Treatment System Maximum Capacity**	**Upgraded Remediation System Component**	**Proposed Collection and Treatment System Maximum Capacity**
Extraction Well Pumps, EW-2, EW-3, EW-4	200 gpm/each well = 600 gpm	New Extraction Wells, EW-1, EW-5	250 to 350 gpm
3-inch Extraction Well Piping 4-inch Extraction Well Piping 6-inch Extraction Well Piping	200 gpm 350 gpm 800 gpm	EW-1 to EW-2 Piping (8-inch), includes flows from EW-5	800 gpm
Treatment System Piping (6-inch)	800 gpm	EW-2 to Treatment System Piping (10 inch), includes flows from EW-5, EW-1, EW-3 and EW-4	1,300 gpm
Blower	800 gpm	Existing Blower	800 gpm
Air Stripper	1000 gpm	Existing Air Stripper	1000 gpm

gpm = gallons per minute

Table 3
Chemical Profile Sample Locations
Conrail Railyard Superfund Site
Elkhart, Indiana

Extraction Well ID	Screen Interval (feet bgs)	Sample Location ID	Screen Interval (feet bgs)
EW-2	42-142	OW2-3S	41-51
		GS-2	75-85
		OW2-3D	130-140
		OW2-2S	41-51
		OW2-2I	75-85
		OW2-2D	130-140
EW-3*	49-59	-	-
	91-106	OW3-1I	91-101
	126-136	OW3-1D	126-136
EW-4	51-144	OW4-1S	51-61
		OW4-1I	90-100
		OW4-1D	130-140

Well locations shown on Figure 2
*EW-3 is a multi-screened well
bgs – below ground surface

Table 4
Cost Estimate
Conrail Railyard Superfund Site
Elkhart, Indiana

Task Description	Amount	Unit	Cost ($)	Total ($)
1) Project Management (Submittals, Health and Safety Plan (HASP), Coordination, etc.)	1	LS	$10,000	$10,000
2) Installation of Two New Extraction Wells (EW-1 and EW-5)				
Pilot Soil Borings and Sampling	2	LS	$30,000	$60,000
Well Installation & Development	2	EA	$50,000	$100,000
Pumps & Controls	2	EA	$10,000	$20,000
3) Treatment System Flow Capacity Upgrade				
Mobilization	1	LS	$7,500	$7,500
Site Preparation and Restoration	1	LS	$10,000	$10,000
New Extraction Wells (EW-1 & EW-5)				
Wellhead Completion, Manhole, Valves, & Meter	2	EA	$15,000	$30,000
Electrical Service to EW-1 and EW-5	1	LS	$20,000	$20,000
Conveyance Lines				
2" Cleaning Water Line to EW-1	200	LF	$20	$4,000
6" Line from EW-1	200	LF	$50	$10,000
8" Line from EW-1/EW-5 to EW-2	500	LF	$65	$32,500
10" Line from EW-2 to GWTP	600	LF	$85	$51,000
Groundwater Treatment Plant (GWTP)				
10" Process Water Line (inside GWTP)	200	LF	$50	$10,000
Bag Filter System Replacement	1	LS	$30,000	$30,000
Instrumentation Upgrades (Valves, Flow Meters, Etc.)	1	LS	$20,000	$20,000
Optional Tasks				
Pump Upgrade at EW-2 & Controls	1	LS	$10,000	$10,000
Screen Blanking - EW-2, EW-3, EW-4	1	LS	$50,000	$50,000

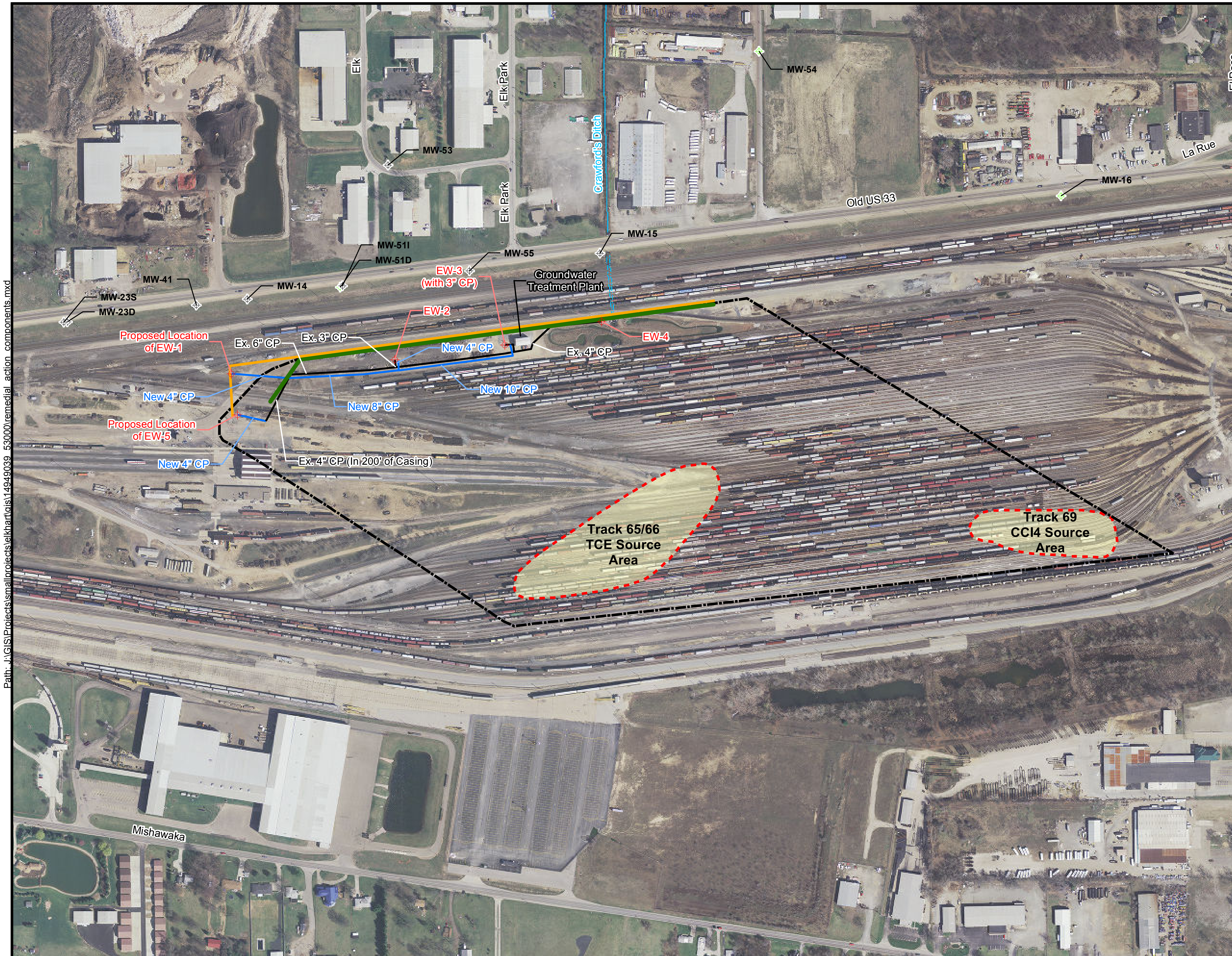
Subtotal:	**$475,000**
Engineering (15%):	$71,300
Contingency (20%):	$95,000
Preliminary Design Total Estimated Cost:	**$641,300**

Budgetary estimates only; actual cost estimates will be based on receipt of bids.

Table 5
Anticipated Project Schedule
Conrail Railyard Superfund Site
Elkhart, Indiana

Component	**Anticipated Schedule**
Design Addendum Submission	July 1, 2011
Observation Well Profiling Investigation (Table 4)	June 20 through July 1, 2011
Extraction Wells EW-1 and EW-5 Profiling Investigation	July 1 through August 1, 2011
Design Addendum Approval	August 1, 2011
Detailed Design Phase	July 1 through August 15, 2011
Bidding	August 15 through September 7, 2011
Bid Evaluation and Contract Award	September 14, 2011
Construction	September 14 through December 15, 2011
System Start-up and Troubleshooting	December 15, 2011 through January 15, 2012

Figures



LEGEND:
- Approximate Extent of DNAPL Source Area
- Existing Groundwater Extraction and Conveyance System (Approximate Location)
- Proposed Groundwater Extraction and Conveyance System (Approximate Location)
- Ex. Existing Remedial Action Component
- New New Remedial Action Component
- CP Conveyance Piping (Double-Walled HDPE)
- Groundwater Extraction Well (EW)
- Offsite Monitoring Well in Monitoring Program
- Offsite Historic Monitoring Well
- TI Waiver Area
- Line of Containment (2003 Final Design)
- Updated Line of Containment

0 400 800
Scale in Feet

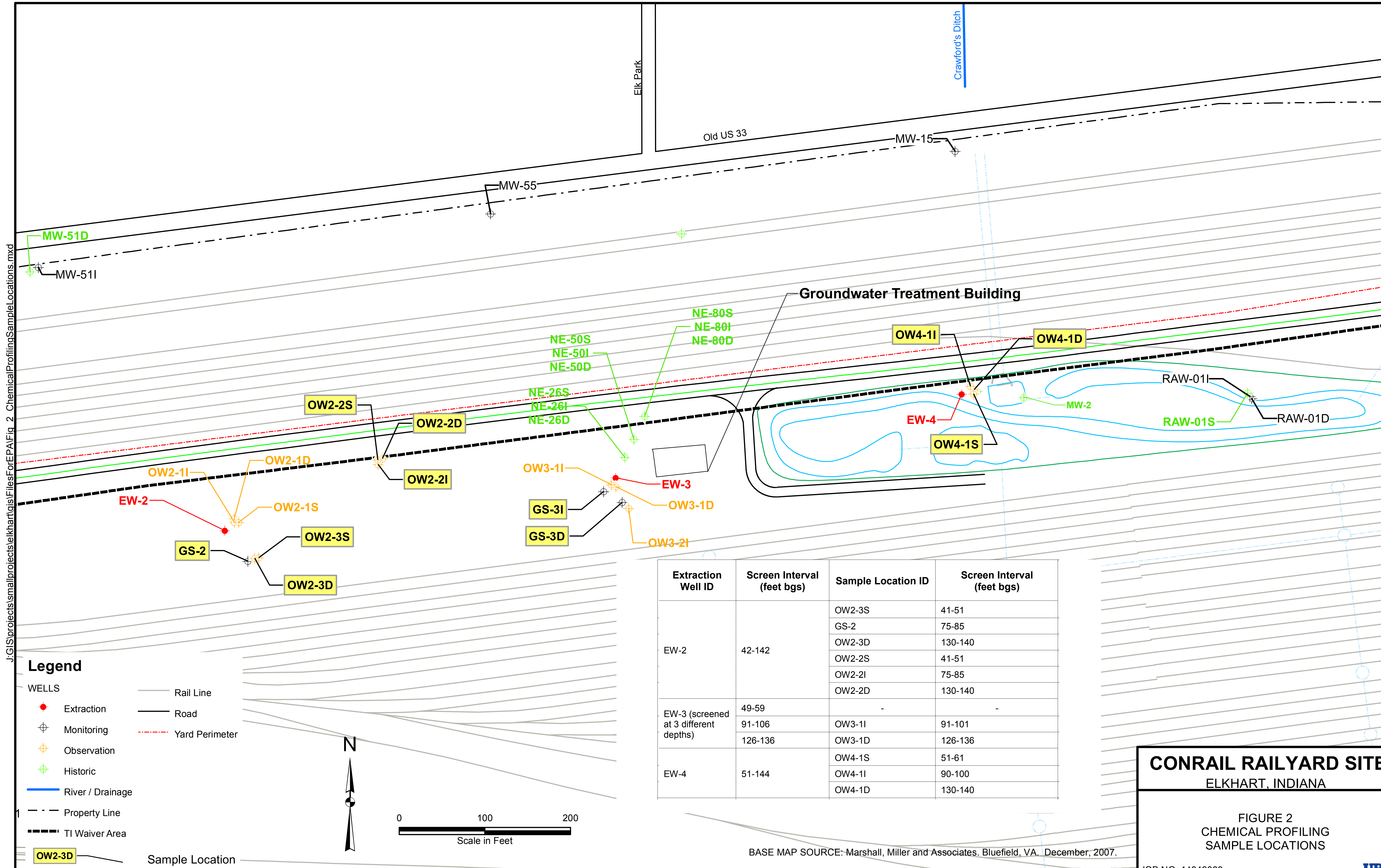
CONRAIL RAILYARD SITE
ELKHART, INDIANA

FIGURE 1
SITE PLAN WITH EXISTING AND PROPOSED REMEDIAL ACTION COMPONENTS

JOB NO. 14949039

URS

Path: J:\GIS\Projects\smallprojects\elkhart\gis\14949039_53000\remedial_action_components.mxd



Extraction Well ID	Screen Interval (feet bgs)	Sample Location ID	Screen Interval (feet bgs)
EW-2	42-142	OW2-3S	41-51
		GS-2	75-85
		OW2-3D	130-140
		OW2-2S	41-51
		OW2-2I	75-85
		OW2-2D	130-140
EW-3 (screened at 3 different depths)	49-59	-	-
	91-106	OW3-1I	91-101
	126-136	OW3-1D	126-136
EW-4	51-144	OW4-1S	51-61
		OW4-1I	90-100
		OW4-1D	130-140

BASE MAP SOURCE: Marshall, Miller and Associates. Bluefield, VA. December, 2007.

CONRAIL RAILYARD SITE

ELKHART, INDIANA

FIGURE 2
CHEMICAL PROFILING
SAMPLE LOCATIONS

JOB NO. 14949039

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Appendix A

Preliminary Engineering Calculations

URS

				Page	1 of 1
Job	Conrail Elkhart 2009-2010 Asst	Project No.	14949039	Sheet	1 of 1
Description	Minimum and Maximum Flow Rates in Pipes of Various Sizes	Computed by	SaR	Date	6/1/2011
		Checked by	AS	Date	6/1/11

OBJECTIVE

The objective of these calculations is to estimate the minimum, maximum, and average flow rates in pressure pipe of various diameters under assumed velocity conditions.

METHODOLOGY

The continuity equation (Q=VA, where Q is volumetric flow rate, V is velocity, and A is cross sectional area) is used to estimate the flow rates using the following formula:

$$Q(cfs) = VA = V \times \left[\pi \times \frac{\left(D/_{12}\right)^2}{4} \right]$$

$$Q(gpm) = Q(cfs) \times \frac{7.48gal}{ft^3} \times \frac{60sec}{min}$$

Where:

$$Q(cfs) = flow\ rate\ in\ cubic\ feet\ per\ second$$
$$Q(gpm) = flow\ rate\ in\ gallons\ per\ minute$$
$$D = Diameter\ of\ pipe\ in\ inches$$
$$V = Velocity\ of\ water\ in\ feet\ per\ second$$

ASSUMPTIONS

1. The minimum estimated velocity is 2.5 feet per second
2. The maximum estimated velocity is 9 feet per second
3. The average estimated velocity is 5.5 feet per second

These assumed minimum and maximum velocities are based on guidance provided by the Departments of the Army and the Air Force publication *"Sanitary and Industrial Wastewater Collection – Pumping Stations and Force Mains"* (Army TM 5-814-2/Air Force AFM 88-11, Vol. 2, Army Publishing Directorate, March 1985).

ESTIMATATED FLOW RATES

Using the aforementioned methodology and assumptions, the following flow rates are estimated:

Pipe Size (in)	Flow (gpm) at Minimum Velocity (2.5 fps)	Flow (gpm) at Average Velocity (5.5 fps)	Flow (gpm) at Maximum Velocity (9 fps)
2	24	54	88
3	55	121	198
4	98	215	352
6	220	485	793
8	392	862	1,410
10	612	1,346	2,203
12	881	1,939	3,172

OBJECTIVE

The objective of these calculations is to estimate the total system head (static and dynamic) from each extraction well to the treatment system at the Conrail Railyard Superfund Site, Containment Groundwater Pumping and Treatment System, located in Elkhart, Indiana. These calculations have been prepared as part of the preliminary design activities for planning purposes, and will ultimately support the selection of pumps to be installed at existing extraction well EW-2 and new extraction wells EW-1 and EW-5 during the detailed design phase.

NOTE: Conceptual calculations. To be refined during detailed design phase.

METHODOLOGY

In pressure pipe systems, head losses are associated with either static head (absolute change in elevation) or dynamic head (due to flow of fluid in the pipe). The static head will be estimated based on actual field conditions. The dynamic head will be estimated using the Hazen-Williams formula.

ASSUMPTIONS

1. The extraction well pumps are installed approximately 40-feet below grade. The process water piping within the Groundwater Treatment Building is above grade. Assume that the total static head at each extraction well is approximately 50-feet.
2. Extraction wells EW-2, EW-3, and EW-4 are currently installed and operational. Extraction wells EW-1 and EW-5 will be installed as part of the proposed upgrade activities. It is currently assumed that the new EW-1 and EW-5 (and associated components) will be similar to those at EW-2, EW-3 and EW-4.
3. The new extraction wells EW-1 and EW-5 will have wellheads similar to EW-2 and EW-3.
4. The line conveyance lines will be dual wall HDPE pipe with a working pressure of at least 150 psi.
5. The Hazen-Williams coefficient (C) is 150 for thermoplastic pipe (Plastics Pipe Institute, Technical Release 14 – Page 2).
6. Fitting coefficients for use with the Equivalent Pipe Method are:
   a. 180°-Elbow: 45
   b. 90°-Elbow: 30
   c. 45°-Elbow: 16
   d. Outlet Tee Run/Run: 20
   e. Outlet Tee Run/Branch: 60
   f. Ball Valve: 6
   g. Gate Valve: 8

ESTIMATATED HEAD LOSS

As part of this preliminary assessment, the total head resulting from the current system configurations and also proposed or potential upgrades were evaluated. In general, these estimates were completed by evaluating a range of flow rates (from each extraction well) and conveyance line sizes. The head loss calculations will be further evaluated during the detailed design phase.

As noted above, the friction losses have been calculated using the Hazen-Williams formula. This formula can be expressed as (Uni-Bell Plastic Pipe Association PVC Pipe Handbook, Chapter 10):

$$f = 0.2083\left({}^{100}/_{C}\right)^{1.85} \times {}^{Q^{1.85}}/_{d_i^{4.87}}$$

$Where:$

$f = friction\ loss, in\ feet\ of\ water\ per\ 100\ feet\ of\ pipe\ \left(\frac{ft}{100ft}\right)$

$C = Hazen - Williams\ Flow\ coefficient$

$Q = flow\ rate, in\ gallons\ per\ minute\ (gpm)$

$d_i = internal\ diameter\ of\ pipe, in\ inches\ (in)$

The estimated head loss will be used to select pumps for the upgrade of EW-2 and the new EW-1 and EW-5.

CONCLUSIONS

The purpose of these calculations was to estimate and evaluate total system heads at the existing Conrail Railyard Superfund Site, Containment Groundwater Pumping and Treatment System. The estimates provided in this calculation are part of the preliminary design effort, and will be further evaluated during the detailed design phase. The total system heads will ultimately be used to select and prepare technical specifications for the extraction well pump systems.

EW-1

EW-1 Well to Trunk (4" Line)	**Location**	**Length or Dia (in)**	**Length or Dia (ft)**	**# of Fittings**	**Fitting Coefficient**	**Equivalent Pipe Length (ft)**
Pipe			122.5	1	1	123
Ball Valve	Wellhead	3	0.25	1	6	2
90-deg Elbow	Wellhead	3	0.25	4	30	30
45-deg Elbow	Wellhead	3	0.25	0	16	0
Outlet Tee - run/run	Wellhead	3	0.25	1	20	5
Outlet Tee - run/branch	Wellhead	3	0.25	0	60	0
Ball Valve	Line	4	0.33	0	6	0
90-deg Elbow	Line	4	0.33	0	30	0
45-deg Elbow	Line	4	0.33	0	16	0
Outlet Tee - run/run	Line	4	0.33	1	20	7
Outlet Tee - run/branch	Line	4	0.33	0	60	0
			Total Equivalent Pipe Length =			167

EW-1 Well to Trunk (6" Line)	**Location**	**Length or Dia (in)**	**Length or Dia (ft)**	**# of Fittings**	**Fitting Coefficient**	**Equivalent Pipe Length (ft)**
Pipe			122.5	1	1	123
Ball Valve	Wellhead	3	0.25	1	6	2
90-deg Elbow	Wellhead	3	0.25	4	30	30
45-deg Elbow	Wellhead	3	0.25	0	16	0
Outlet Tee - run/run	Wellhead	3	0.25	1	20	5
Outlet Tee - run/branch	Wellhead	3	0.25	0	60	0
Ball Valve	Line	6	0.5	0	6	0
90-deg Elbow	Line	6	0.5	0	30	0
45-deg Elbow	Line	6	0.5	0	16	0
Outlet Tee - run/run	Line	6	0.5	1	20	10
Outlet Tee - run/branch	Line	6	0.5	0	60	0
			Total Equivalent Pipe Length =			170

EW-2

EW-2 Well to Trunk (3" Line)	Location	Length or Dia (in)	Length or Dia (ft)	# of Fittings	Fitting Coefficient	Equivalent Pipe Length (ft)
Pipe			52.25	1	1	53
Ball Valve	Wellhead	3	0.25	1	6	2
90-deg Elbow	Wellhead	3	0.25	4	30	30
45-deg Elbow	Wellhead	3	0.25	0	16	0
Outlet Tee - run/run	Wellhead	3	0.25	1	20	5
Outlet Tee - run/branch	Wellhead	3	0.25	0	60	0
Ball Valve	Line	3	0.25	0	6	0
90-deg Elbow	Line	3	0.25	0	30	0
45-deg Elbow	Line	3	0.25	0	16	0
Outlet Tee - run/run	Line	3	0.25	0	20	0
Outlet Tee - run/branch	Line	3	0.25	1	60	15
					Total Equivalent Pipe Length =	105

EW-2 Well to Trunk (4" Line)	Location	Length or Dia (in)	Length or Dia (ft)	# of Fittings	Fitting Coefficient	Equivalent Pipe Length (ft)
Pipe			52.25	1	1	53
Ball Valve	Wellhead	3	0.25	1	6	2
90-deg Elbow	Wellhead	3	0.25	4	30	30
45-deg Elbow	Wellhead	3	0.25	0	16	0
Outlet Tee - run/run	Wellhead	3	0.25	1	20	5
Outlet Tee - run/branch	Wellhead	3	0.25	0	60	0
Ball Valve	Line	4	0.33	0	6	0
90-deg Elbow	Line	4	0.33	0	30	0
45-deg Elbow	Line	4	0.33	0	16	0
Outlet Tee - run/run	Line	4	0.33	0	20	0
Outlet Tee - run/branch	Line	4	0.33	1	60	20
					Total Equivalent Pipe Length =	110

EW-2 Well to Trunk (6" Line)	Location	Length or Dia (in)	Length or Dia (ft)	# of Fittings	Fitting Coefficient	Equivalent Pipe Length (ft)
Pipe			52.25	1	1	53
Ball Valve	Wellhead	3	0.25	1	6	2
90-deg Elbow	Wellhead	3	0.25	4	30	30
45-deg Elbow	Wellhead	3	0.25	0	16	0
Outlet Tee - run/run	Wellhead	3	0.25	1	20	5
Outlet Tee - run/branch	Wellhead	3	0.25	0	60	0
Ball Valve	Line	6	0.50	0	6	0
90-deg Elbow	Line	6	0.50	0	30	0
45-deg Elbow	Line	6	0.50	0	16	0
Outlet Tee - run/run	Line	6	0.50	0	20	0
Outlet Tee - run/branch	Line	6	0.50	1	60	30
					Total Equivalent Pipe Length =	120

EW-3

EW-3 Well to Trunk (3" Line)	Location	Length or Dia (in)	Length or Dia (ft)	# of Fittings	Fitting Coefficient	Equivalent Pipe Length (ft)
Pipe			26.5	1	1	27
Ball Valve	Wellhead	3	0.25	1	6	2
90-deg Elbow	Wellhead	3	0.25	4	30	30
45-deg Elbow	Wellhead	3	0.25	0	16	0
Outlet Tee - run/run	Wellhead	3	0.25	1	20	5
Outlet Tee - run/branch	Wellhead	3	0.25	0	60	0
Ball Valve	Line	3	0.25	0	6	0
90-deg Elbow	Line	3	0.25	0	30	0
45-deg Elbow	Line	3	0.25	0	16	0
Outlet Tee - run/run	Line	3	0.25	0	20	0
Outlet Tee - run/branch	Line	3	0.25	1	60	15
			Total Equivalent Pipe Length =			79

EW-4

EW-4 Well to Trunk (4" Line)	Location	Length or Dia (in)	Length or Dia (ft)	# of Fittings	Fitting Coefficient	Equivalent Pipe Length (ft)
Pipe			445	1	1	445
Ball Valve	Wellhead	3	0.25	1	6	2
90-deg Elbow	Wellhead	3	0.25	6	30	45
45-deg Elbow	Wellhead	3	0.25	0	16	0
Outlet Tee - run/run	Wellhead	3	0.25	1	20	5
Outlet Tee - run/branch	Wellhead	3	0.25	0	60	0
Ball Valve	Line	4	0.33	0	6	0
90-deg Elbow	Line	4	0.33	1	30	10
45-deg Elbow	Line	4	0.33	2	16	11
Outlet Tee - run/run	Line	4	0.33	0	20	0
Outlet Tee - run/branch	Line	4	0.33	1	60	20
			Total Equivalent Pipe Length =			538

EW-5

EW-5 Well to Trunk (4" Line)	Location	Length or Dia (in)	Length or Dia (ft)	# of Fittings	Fitting Coefficient	Equivalent Pipe Length (ft)
Pipe			280.5	1	1	281
Ball Valve	Wellhead	3	0.25	1	6	2
90-deg Elbow	Wellhead	3	0.25	4	30	30
45-deg Elbow	Wellhead	3	0.25	0	16	0
Outlet Tee - run/run	Wellhead	3	0.25	1	20	5
Outlet Tee - run/branch	Wellhead	3	0.25	0	60	0
Ball Valve	Line	4	0.33	0	6	0
90-deg Elbow	Line	4	0.33	1	30	10
45-deg Elbow	Line	4	0.33	0	16	0
Outlet Tee - run/run	Line	4	0.33	0	20	0
Outlet Tee - run/branch	Line	4	0.33	1	60	20
				Total Equivalent Pipe Length =		348

EW-5 Well to Trunk (6" Line)	Location	Length or Dia (in)	Length or Dia (ft)	# of Fittings	Fitting Coefficient	Equivalent Pipe Length (ft)
Pipe			280.5	1	1	281
Ball Valve	Wellhead	3	0.25	1	6	2
90-deg Elbow	Wellhead	3	0.25	4	30	30
45-deg Elbow	Wellhead	3	0.25	0	16	0
Outlet Tee - run/run	Wellhead	3	0.25	1	20	5
Outlet Tee - run/branch	Wellhead	3	0.25	0	60	0
Ball Valve	Line	6	0.50	0	6	0
90-deg Elbow	Line	6	0.50	1	30	15
45-deg Elbow	Line	6	0.50	0	16	0
Outlet Tee - run/run	Line	6	0.50	0	20	0
Outlet Tee - run/branch	Line	6	0.50	1	60	30
				Total Equivalent Pipe Length =		363

Trunk to GWTP

Trunk Segment 1 (6" Line)	**Location**	**Length or Dia (in)**	**Length or Dia (ft)**	**# of Fittings**	**Fitting Coefficient**	**Equivalent Pipe Length (ft)**
Pipe			484	1	1	484
90-deg Elbow	Line	6	0.50	0	30	0
45-deg Elbow	Line	6	0.50	0	16	0
Outlet Tee - run/run	Line	6	0.50	1	20	10
Outlet Tee - run/branch	Line	6	0.50	0	60	0
				Total Equivalent Pipe Length =		494

Trunk Segment 1 (8" Line)	**Location**	**Length or Dia (in)**	**Length or Dia (ft)**	**# of Fittings**	**Fitting Coefficient**	**Equivalent Pipe Length (ft)**
Pipe			484	1	1	484
90-deg Elbow	Line	8	0.67	0	30	0
45-deg Elbow	Line	8	0.67	0	16	0
Outlet Tee - run/run	Line	8	0.67	1	20	14
Outlet Tee - run/branch	Line	8	0.67	0	60	0
				Total Equivalent Pipe Length =		498

Trunk to Segment 1 (10" Line)	**Location**	**Length or Dia (in)**	**Length or Dia (ft)**	**# of Fittings**	**Fitting Coefficient**	**Equivalent Pipe Length (ft)**
Pipe			484	1	1	484
90-deg Elbow	Line	10	0.83	0	30	0
45-deg Elbow	Line	10	0.83	0	16	0
Outlet Tee - run/run	Line	10	0.83	1	20	17
Outlet Tee - run/branch	Line	10	0.83	0	60	0
				Total Equivalent Pipe Length =		501

Trunk Segment 2 (6" Line)	**Location**	**Length or Dia (in)**	**Length or Dia (ft)**	**# of Fittings**	**Fitting Coefficient**	**Equivalent Pipe Length (ft)**
Pipe			494	1	1	494
90-deg Elbow	Line	6	0.50	1	30	15
45-deg Elbow	Line	6	0.50	0	16	0
Outlet Tee - run/run	Line	6	0.50	1	20	10
Outlet Tee - run/branch	Line	6	0.50	0	60	0
				Total Equivalent Pipe Length =		519

Trunk Segment 2 (8" Line)	**Location**	**Length or Dia (in)**	**Length or Dia (ft)**	**# of Fittings**	**Fitting Coefficient**	**Equivalent Pipe Length (ft)**
Pipe			494	1	1	494
90-deg Elbow	Line	8	0.67	1	30	20
45-deg Elbow	Line	8	0.67	0	16	0
Outlet Tee - run/run	Line	8	0.67	1	20	14
Outlet Tee - run/branch	Line	8	0.67	0	60	0
				Total Equivalent Pipe Length =		528

Trunk Segment 2 (10" Line)	**Location**	**Length or Dia (in)**	**Length or Dia (ft)**	**# of Fittings**	**Fitting Coefficient**	**Equivalent Pipe Length (ft)**
Pipe			494	1	1	494
90-deg Elbow	Line	10	0.83	1	30	25
45-deg Elbow	Line	10	0.83	0	16	0
Outlet Tee - run/run	Line	10	0.83	1	20	17
Outlet Tee - run/branch	Line	10	0.83	0	60	0
				Total Equivalent Pipe Length =		536

Trunk to GWTP

Trunk Segment 3 (6" Line)	Location	Length or Dia (in)	Length or Dia (ft)	# of Fittings	Fitting Coefficient	Equivalent Pipe Length (ft)
Pipe			22	1	1	22
90-deg Elbow	Line	6	0.50	0	30	0
45-deg Elbow	Line	6	0.50	0	16	0
Outlet Tee - run/run	Line	6	0.50	1	20	10
Outlet Tee - run/branch	Line	6	0.50	0	60	0
				Total Equivalent Pipe Length =		32

Trunk Segment 3 (8" Line)	Location	Length or Dia (in)	Length or Dia (ft)	# of Fittings	Fitting Coefficient	Equivalent Pipe Length (ft)
Pipe			22	1	1	22
90-deg Elbow	Line	8	0.67	0	30	0
45-deg Elbow	Line	8	0.67	0	16	0
Outlet Tee - run/run	Line	8	0.67	1	20	14
Outlet Tee - run/branch	Line	8	0.67	0	60	0
				Total Equivalent Pipe Length =		36

Trunk Segment 3 (10" Line)	Location	Length or Dia (in)	Length or Dia (ft)	# of Fittings	Fitting Coefficient	Equivalent Pipe Length (ft)
Pipe			22	1	1	22
90-deg Elbow	Line	10	0.83	0	30	0
45-deg Elbow	Line	10	0.83	0	16	0
Outlet Tee - run/run	Line	10	0.83	1	20	17
Outlet Tee - run/branch	Line	10	0.83	0	60	0
				Total Equivalent Pipe Length =		39

Trunk Segment 4 (6" Line)	Location	Length or Dia (in)	Length or Dia (ft)	# of Fittings	Fitting Coefficient	Equivalent Pipe Length (ft)
Pipe			19	1	1	19
90-deg Elbow	Line	6	0.50	1	30	15
45-deg Elbow	Line	6	0.50	0	16	0
Outlet Tee - run/run	Line	6	0.50	0	20	0
Outlet Tee - run/branch	Line	6	0.50	0	60	0
				Total Equivalent Pipe Length =		34

Trunk Segment 4 (8" Line)	Location	Length or Dia (in)	Length or Dia (ft)	# of Fittings	Fitting Coefficient	Equivalent Pipe Length (ft)
Pipe			19	1	1	19
90-deg Elbow	Line	8	0.67	1	30	20
45-deg Elbow	Line	8	0.67	0	16	0
Outlet Tee - run/run	Line	8	0.67	0	20	0
Outlet Tee - run/branch	Line	8	0.67	0	60	0
				Total Equivalent Pipe Length =		39

Trunk Segment 4 (10" Line)	Location	Length or Dia (in)	Length or Dia (ft)	# of Fittings	Fitting Coefficient	Equivalent Pipe Length (ft)
Pipe			19	1	1	19
90-deg Elbow	Line	10	0.83	1	30	25
45-deg Elbow	Line	10	0.83	0	16	0
Outlet Tee - run/run	Line	10	0.83	0	20	0
Outlet Tee - run/branch	Line	10	0.83	0	60	0
				Total Equivalent Pipe Length =		44

GWTP Internal - Bag 1 Path

GWTP Internal (6" Line)	Location	Length or Dia (in)	Length or Dia (ft)	# of Fittings	Fitting Coefficient	Equivalent Pipe Length (ft)
Pipe			79.5	1	1	80
Gate Valve	GWTP	6	0.50	5	8	20
90-deg Elbow	GWTP	6	0.50	10	30	150
180-deg Elbow	GWTP	6	0.50	1	45	23
Outlet Tee - run/run	GWTP	6	0.50	0	20	0
Outlet Tee - run/branch	GWTP	6	0.50	3	60	90
					Total Equivalent Pipe Length =	363

GWTP Internal (8" Line)	Location	Length or Dia (in)	Length or Dia (ft)	# of Fittings	Fitting Coefficient	Equivalent Pipe Length (ft)
Pipe			79.5	1	1	80
Gate Valve	GWTP	8	0.67	5	8	27
90-deg Elbow	GWTP	8	0.67	10	30	200
180-deg Elbow	GWTP	8	0.67	1	45	30
Outlet Tee - run/run	GWTP	8	0.67	0	20	0
Outlet Tee - run/branch	GWTP	8	0.67	3	60	120
					Total Equivalent Pipe Length =	457

GWTP Internal (10" Line)	Location	Length or Dia (in)	Length or Dia (ft)	# of Fittings	Fitting Coefficient	Equivalent Pipe Length (ft)
Pipe			79.5	1	1	80
Gate Valve	GWTP	10	0.83	5	8	34
90-deg Elbow	GWTP	10	0.83	10	30	250
180-deg Elbow	GWTP	10	0.83	1	45	38
Outlet Tee - run/run	GWTP	10	0.83	0	20	0
Outlet Tee - run/branch	GWTP	10	0.83	3	60	150
					Total Equivalent Pipe Length =	552

GWTP Internal - Bag 2 Path

GWTP Internal (6" Line)	Location	Length or Dia (in)	Length or Dia (ft)	# of Fittings	Fitting Coefficient	Equivalent Pipe Length (ft)
Pipe			81.75	1	1	82
Gate Valve	GWTP	6	0.50	5	8	20
90-deg Elbow	GWTP	6	0.50	11	30	165
180-deg Elbow	GWTP	6	0.50	1	45	23
Outlet Tee - run/run	GWTP	6	0.50	0	20	0
Outlet Tee - run/branch	GWTP	6	0.50	2	60	60
				Total Equivalent Pipe Length =		350

GWTP Internal (8" Line)	Location	Length or Dia (in)	Length or Dia (ft)	# of Fittings	Fitting Coefficient	Equivalent Pipe Length (ft)
Pipe			81.75	1	1	82
Gate Valve	GWTP	8	0.67	5	8	27
90-deg Elbow	GWTP	8	0.67	11	30	220
180-deg Elbow	GWTP	8	0.67	1	45	30
Outlet Tee - run/run	GWTP	8	0.67	0	20	0
Outlet Tee - run/branch	GWTP	8	0.67	2	60	80
				Total Equivalent Pipe Length =		439

GWTP Internal (10" Line)	Location	Length or Dia (in)	Length or Dia (ft)	# of Fittings	Fitting Coefficient	Equivalent Pipe Length (ft)
Pipe			81.75	1	1	82
Gate Valve	GWTP	10	0.83	5	8	34
90-deg Elbow	GWTP	10	0.83	11	30	275
180-deg Elbow	GWTP	10	0.83	1	45	38
Outlet Tee - run/run	GWTP	10	0.83	0	20	0
Outlet Tee - run/branch	GWTP	10	0.83	2	60	100
				Total Equivalent Pipe Length =		529

Head Loss

Segment	Pipe Diameter (Inches)	Flow (GPM)	C-Value	Velocity (FPS)	Vel Head (FEET)	Head Loss (FT/100')	Head Loss (FT/1000')	Equivalent Pipe Length (FT)	Head Loss (FT)	Head Loss (PSI)
EW-1 Pump to Trunk	4	50	150	1.28	0.03	0.16	1.60	167	0.27	0.12
	4	100	150	2.55	0.10	0.58	5.77	167	0.96	0.42
	4	150	150	3.83	0.23	1.22	12.21	167	2.04	0.88
	6	50	150	0.57	0.00	0.02	0.22	170	0.04	0.02
	6	100	150	1.13	0.02	0.08	0.80	170	0.14	0.06
	6	150	150	1.70	0.04	0.17	1.69	170	0.29	0.13
EW-2 Pump to Trunk	3	50	150	2.27	0.08	0.65	6.49	105	0.68	0.30
	3	100	150	4.54	0.32	2.34	23.41	105	2.46	1.07
	3	150	150	6.81	0.72	4.96	49.56	105	5.20	2.26
	4	50	150	1.28	0.03	0.16	1.60	110	0.18	0.08
	4	100	150	2.55	0.10	0.58	5.77	110	0.63	0.28
	4	150	150	3.83	0.23	1.22	12.21	110	1.34	0.58
	6	50	150	0.57	0.00	0.02	0.22	120	0.03	0.01
	6	100	150	1.13	0.02	0.08	0.80	120	0.10	0.04
	6	150	150	1.70	0.04	0.17	1.69	120	0.20	0.09
EW-3 Pump to Trunk	3	50	150	2.27	0.08	0.65	6.49	79	0.51	0.22
	3	100	150	4.54	0.32	2.34	23.41	79	1.85	0.80
	3	150	150	6.81	0.72	4.96	49.56	79	3.92	1.70
EW-4 Pump to Trunk	4	50	150	1.28	0.03	0.16	1.60	538	0.86	0.37
	4	100	150	2.55	0.10	0.58	5.77	538	3.10	1.35
	4	150	150	3.83	0.23	1.22	12.21	538	6.57	2.85
EW-5 Pump to Trunk	4	50	150	1.28	0.03	0.16	1.60	348	0.56	0.24
	4	100	150	2.55	0.10	0.58	5.77	348	2.01	0.87
	4	150	150	3.83	0.23	1.22	12.21	348	4.25	1.84
	6	50	150	0.57	0.00	0.02	0.22	363	0.08	0.03
	6	100	150	1.13	0.02	0.08	0.80	363	0.29	0.13
	6	150	150	1.70	0.04	0.17	1.69	363	0.62	0.27
Trunk to GWTP Segment 1	6	100	150	1.13	0.02	0.08	0.80	494	0.40	0.17
	6	200	150	2.27	0.08	0.29	2.89	494	1.43	0.62
	6	300	150	3.40	0.18	0.61	6.11	494	3.02	1.31
	8	100	150	0.64	0.01	0.02	0.20	498	0.10	0.04
	8	200	150	1.28	0.03	0.07	0.71	498	0.35	0.15
	8	300	150	1.91	0.06	0.15	1.51	498	0.75	0.33
	10	100	150	0.41	0.00	0.01	0.07	501	0.03	0.01
	10	200	150	0.82	0.01	0.02	0.24	501	0.12	0.05
	10	300	150	1.23	0.02	0.05	0.51	501	0.25	0.11
Trunk to GWTP Segment 2	6	150	150	1.70	0.04	0.17	1.69	519	0.88	0.38
	6	300	150	3.40	0.18	0.61	6.11	528	3.23	1.40
	6	450	150	5.11	0.40	1.29	12.94	536	6.93	3.01
	8	150	150	0.96	0.01	0.04	0.42	519	0.22	0.09
	8	300	150	1.91	0.06	0.15	1.51	528	0.79	0.34
	8	450	150	2.87	0.13	0.32	3.19	536	1.71	0.74
	10	150	150	0.61	0.01	0.01	0.14	519	0.07	0.03
	10	300	150	1.23	0.02	0.05	0.51	528	0.27	0.12
	10	450	150	1.84	0.05	0.11	1.07	536	0.58	0.25

Head Loss

Segment	Pipe Diameter (Inches)	Flow (GPM)	C-Value	Velocity (FPS)	Vel Head (FEET)	Head Loss (FT/100')	Head Loss (FT/1000')	Equivalent Pipe Length (FT)	Head Loss (FT)	Head Loss (PSI)
Trunk to GWTP Segment 3	6	200	150	2.27	0.08	0.29	2.89	32	0.09	0.04
	6	400	150	4.54	0.32	1.04	10.40	36	0.37	0.16
	6	600	150	6.81	0.72	2.20	22.02	39	0.86	0.37
	8	200	150	1.28	0.03	0.07	0.71	32	0.02	0.01
	8	400	150	2.55	0.10	0.26	2.56	36	0.09	0.04
	8	600	150	3.83	0.23	0.54	5.43	39	0.21	0.09
	10	200	150	0.82	0.01	0.02	0.24	32	0.01	0.00
	10	400	150	1.63	0.04	0.09	0.86	36	0.03	0.01
	10	600	150	2.45	0.09	0.18	1.83	39	0.07	0.03
Trunk to GWTP Segment 4	6	250	150	2.84	0.12	0.44	4.36	34	0.15	0.06
	6	500	150	5.67	0.50	1.57	15.72	39	0.61	0.27
	6	750	150	8.51	1.12	3.33	33.28	44	1.46	0.64
	8	250	150	1.60	0.04	0.11	1.07	34	0.04	0.02
	8	500	150	3.19	0.16	0.39	3.87	39	0.15	0.07
	8	750	150	4.79	0.36	0.82	8.20	44	0.36	0.16
	10	250	150	1.02	0.02	0.04	0.36	34	0.01	0.01
	10	500	150	2.04	0.06	0.13	1.31	39	0.05	0.02
	10	750	150	3.06	0.15	0.28	2.77	44	0.12	0.05
GWTP Bag Filter 1 Path	6	250	150	2.84	0.12	0.44	4.36	363	1.58	0.69
	6	500	150	5.67	0.50	1.57	15.72	363	5.71	2.48
	6	750	150	8.51	1.12	3.33	33.28	363	12.08	5.24
	8	250	150	1.60	0.04	0.11	1.07	457	0.49	0.21
	8	500	150	3.19	0.16	0.39	3.87	457	1.77	0.77
	8	750	150	4.79	0.36	0.82	8.20	457	3.75	1.63
	10	250	150	1.02	0.02	0.04	0.36	552	0.20	0.09
	10	500	150	2.04	0.06	0.13	1.31	552	0.72	0.31
	10	750	150	3.06	0.15	0.28	2.77	552	1.53	0.66
GWTP Bag Filter 2 Path	6	250	150	2.84	0.12	0.44	4.36	350	1.53	0.66
	6	500	150	5.67	0.50	1.57	15.72	350	5.50	2.39
	6	750	150	8.51	1.12	3.33	33.28	350	11.65	5.06
	8	250	150	1.60	0.04	0.11	1.07	439	0.47	0.20
	8	500	150	3.19	0.16	0.39	3.87	439	1.70	0.74
	8	750	150	4.79	0.36	0.82	8.20	439	3.60	1.56
	10	250	150	1.02	0.02	0.04	0.36	529	0.19	0.08
	10	500	150	2.04	0.06	0.13	1.31	529	0.69	0.30
	10	750	150	3.06	0.15	0.28	2.77	529	1.46	0.63
Bag Filter	-	-	-	-	-	-	-	-	11.52	5

Appendix B

Summary of Groundwater Wet Chemistry Analytical and Field Parameter Results

APPENDIX B

SUMMARY OF GROUNDWATER WET CHEMISTRY ANALYTICAL AND FIELD PARAMETER RESULTS
DRAG STRIP-SUPPLEMENTAL 2011-2012 GROUNDWATER MONITORING

CONRAIL RAILYARD SUPERFUND SITE - ELKHART, INDIANA

Well ID	General Chemistry (mg/L)							Dissolved Gases (µg/L)			Temperature (ºF)					pH (SU)				
	Alkalinity	COD	Chloride	Ferrous Iron	Nitrate	Sulfate	TOC	Methane	Ethane	Ethene										
	06/11	06/11	06/11	06/11	06/11	06/11	06/11	06/11	06/11	06/11	06/11	09/11	12/11	3/12	06/12	06/11	09/11	12/11	3/12	06/12
DSMW-01	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	55.63	50.04	53.58	57.5	NA	7.37	7.43	7.35	7.23
DSMW-02	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	55.01	52.04	51.64	54.1	NA	7.31	7.37	6.61	7.25
DSMW-03	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	57.58	51.47	51.41	56.6	NA	7.68	7.75	7.42	7.58
DSWM-04S	250	13 J	52	0.050 U HF	0.10 U	21	0.71 J	2.0 U	4.0 U	3.0 U	57.6	56.18	52.26	52.39	58.0	7.55	7.35	7.46	6.65	7.39
DSWM-04I	230	10 J	70	0.050 U HF	0.18	28	1.1	2.0 U	4.0 U	3.0 U	57.6	54.34	51.04	52.67	50.2	7.60	7.53	7.38	7.37	7.00
DSWM-04D	230	25	51	0.020 J HF	0.10 U	28	0.83 J	2.0 U	4.0 U	3.0 U	56.8	58.75	50.16	53.36	52.3	7.59	7.56	7.60	7.49	7.51
DSMW-07S	250	10 J	59	0.050 U HF	0.10 U	24	0.57 J	2.0 U	4.0 U	3.0 U	55.3	55.63	50.95	51.14	56.1	7.21	7.32	7.36	7.25	7.33
DSMW-07I	280	12 J	99	0.050 U HF	0.10 U	30	0.99 J	2.0 U	4.0 U	3.0 U	56.5	55.18	49.99	51.96	56.9	7.34	7.33	7.41	6.74	7.28
DSMW-07D	240	10 J	80	0.020 J HF	0.10 U	26	0.71 J	31	4.0 U	3.0 U	55.6	55.29	52.26	50.95	51.0	7.90	7.62	7.64	7.59	7.56
DSMW-08S	230	12 J	39	0.050 U HF	0.10 U	21	0.54 J	2.0 U	4.0 U	3.0 U	52.9	55.67	52.03	50.95	58.4	6.90	7.31	7.28	7.31	7.18
DSMW-08I	260	20 U	84	0.050 U HF	0.10 U	27	1.2	2.0 U	4.0 U	3.0 U	56.1	54.49	52.38	52.47	58.6	7.39	7.47	7.52	7.29	7.28
DSMW-08D	240	20 U	40	0.030 J HF	0.10 U	30	0.71 J	2.7	4.0 U	3.0 U	57.0	55.97	50.68	50.97	57.4	7.62	7.66	7.66	7.44	7.52
DSMW-09S	230	10 J	37	0.050 U HF	0.10 U	18	0.68 J	2.0 U	4.0 U	3.0 U	55.7	54.71	51.09	52.7	58.1	7.62	7.46	7.41	6.27	7.25
DSMW-09I	280	10 J	73	0.050 U HF	0.21	30	1.3	2.0 U	4.0 U	3.0 U	58.2	57.95	52.50	54.21	59.1	7.59	7.48	7.35	7.32	7.32
DSMW-09D	250	10 J	51	0.020 J HF	0.10 U	30	0.78 J	2.2	4.0 U	3.0 U	56.7	56.88	50.69	51.33	53.2	7.85	7.73	7.65	7.49	7.51
DSMW-10S	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	56.4	56.30	52.57	51.15	52.8	7.11	7.13	7.18	6.94	7.10
DSMW-10I	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	57.1	56.20	51.65	52.92	54.5	7.51	7.50	7.60	7.49	7.41
DSMW-10D	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	56.8	54.96	54.12	52.49	57.1	7.65	7.62	7.65	7.45	7.52
MW-05S	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	61.81	49.86	48.70	63.6	NA	7.83	7.97	7.24	7.83
MW-05D	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	56.94	49.98	53.26	62.2	NA	7.39	7.53	7.33	7.46
MW-09S	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	55.00	51.86	51.13	57.6	NA	7.31	7.42	7.20	7.27
MW-09D	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	57.04	53.21	63.01	55.4	NA	7.54	7.46	7.38	7.47
MW-38S	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	57.46	49.77	49.11	59.0	NA	7.42	7.46	7.29	7.34
MW-38D	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	53.65	49.17	51.67	55.1	NA	7.47	7.50	7.41	7.41
MW-44D	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	55.33	50.17	52.15	59.3	NA	7.49	7.46	7.36	7.41
MW-50	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	56.09	50.15	53.46	56.5	NA	7.47	7.55	7.32	7.47
MW-56S	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	54.26	51.46	49.83	52.3	NA	7.41	7.52	7.28	7.33
MW-56I	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	54.19	52.65	51.13	56.1	NA	7.43	7.35	7.43	7.22
MW-56D	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	53.88	51.42	51.41	51.0	NA	7.51	7.55	7.36	7.40

Notes:
Samples collected and field parameters measured June 22-23, 2011,
September 20-21, 2011, December 13-16, 2011, March 21-25, 2012, and June 19, 2012.
ºF = Degrees Fahrenheit
SU = Standard units
mg/L = Milligrams per liter
µg/L = Micrograms per liter
mV = Millivolts
U = Not detected above the Reporting Limit shown
J = Estimated concentration
HF = Lab result for field parameter with a holding of 15 minutes
NA = Not analyzed

Abbreviations

COD	=	chemical oxygen demand
TOC	=	total organic carbon
ORP	=	oxidation-reduction potential

Average

pH	Shallow	7.285	omit 5S
	Intermediate	7.375	
	Deep	7.526	

APPENDIX B (Continued)

Well ID	Specific Conductance (µS/cm)					Dissolved Oxygen (mg/L)					ORP (mV)				
	06/11	09/11	12/11	3/12	06/12	06/11	09/11	12/11	3/12	06/12	06/11	09/11	12/11	3/12	06/12
DSMW-01	NA	807	808	832	808	NA	3.46	3.89	4.08	2.73	NA	136.6	83.5	131.2	224.7
DSMW-02	NA	736	729	503	739	NA	5.38	4.57	6.01	4.84	NA	136.5	49.3	361.3	228.9
DSMW-03	NA	703	693	777	647	NA	11.75	10.68	3.38	9.84	NA	110.3	156.2	5.3	148.5
DSWM-04S	680	664	694	514	734	3.15	5.14	3.03	5.72	5.84	265	180.4	165.1	315.3	175.5
DSWM-04I	698	772	791	858	962	0.57	0.75	0.36	0.50	0.49	132	-15.4	91.9	47.7	-151.6
DSWM-04D	665	630	655	732	628	0.00	0.45	0.22	0.46	0.56	-76	-58.7	23.2	-82.2	29.6
DSMW-07S	744	742	750	827	772	4.03	5.26	4.99	6.19	6.55	-50	-40.2	-28.5	1.6	37.0
DSMW-07I	874	934	948	710	977	0.51	0.68	0.35	0.60	0.51	106	115.0	141.8	61.3	160.0
DSMW-07D	661	696	685	723	681	0.39	0.49	0.31	0.64	0.37	-165	-149.7	-133.9	-187.3	-108.6
DSMW-08S	697	685	709	489	683	4.66	6.85	6.15	6.42	7.62	51	25.0	-10.3	8.4	2.6
DSMW-08I	815	811	873	972	928	0.32	0.59	0.06	0.68	0.41	119	78.3	148.1	146.3	250.6
DSMW-08D	608	636	634	662	595	0.24	0.40	0.19	0.58	0.31	-146	-139.7	-144.5	-144.8	-157.8
DSMW-09S	668	693	690	510	687	3.42	5.02	4.66	4.90	3.43	102	59.5	163.5	326.8	181.3
DSMW-09I	765	759	790	864	806	0.34	0.43	0.47	1.02	0.54	107	-12.9	45.9	-6.6	166.2
DSMW-09D	593	656	637	683	630	0.30	0.73	0.26	0.67	0.39	-160	-178.9	-156.7	-184.4	-109.0
DSMW-10S	726	744	714	829	691	4.42	8.51	6.33	2.38	6.98	217	145.4	107.9	179.3	115.2
DSMW-10I	617	675	662	500	685	0.23	0.73	0.23	0.19	0.30	-59	35.0	-48.5	-6.9	41.5
DSMW-10D	554	599	597	632	570	0.26	0.38	0.53	0.86	0.29	-114	-72.9	-55.7	-62.5	-70.5
MW-05S	NA	229	228	138	215	NA	11.37*	10.53*	9.85*	10.54*	NA	108.2	81.4	322.6	219.4
MW-05D	NA	845	804	879	839	NA	2.16	2.24	3.14	2.69	NA	60.4	103.2	60.9	181.9
MW-09S	NA	500	485	510	466	NA	4.15	6.59	5.88	3.44	NA	99.5	146.2	181.1	189.9
MW-09D	NA	634	628	647	625	NA	0.68	0.40	0.75	0.50	NA	94.9	159.2	113.3	117.2
MW-38S	NA	704	690	627	717	NA	12.63*	9.52	6.89	7.63	NA	156.8	131.4	168.9	183.3
MW-38D	NA	691	703	491	728	NA	0.62	0.33	0.20	0.66	NA	100.1	123.8	182.2	201.3
MW-44D	NA	756	759	776	696	NA	0.64	0.62	0.62	0.43	NA	-9.0	-36.2	-61.1	-54.2
MW-50	NA	689	695	701	661	NA	1.85	1.71	1.59	1.57	NA	25.7	-10	-20.9	-12.9
MW-56S	NA	694	691	686	718	NA	11.21*	9.64	5.72	9.56	NA	67.7	62.2	41.7	190.7
MW-56I	NA	704	716	495	703	NA	12.01*	9.74	2.91	4.89	NA	98.4	115.2	144.6	158.3
MW-56D	NA	686	651	665	583	NA	0.55	0.28	0.81	0.46	NA	107.4	22.0	74.3	205.5

Average

		Average	
Sp. Cond.	Shallow	**684**	omit 5S
	Intermediate	**777**	
	Deep	**665**	

		Average	
DO	Shallow	**5.629**	omit 5S,38S,56S
	Intermediate	**0.838**	omit 38D,56I
	Deep	**0.647**	omit 56D

		Average	
ORP	Shallow	**124.994**	omit 5S,38S,56S
	Intermediate	**70.588**	omit 38D,56I
	Deep	**-82.986**	omit 56D

Notes:

Samples collected and field parameters measured June 22-23, 2011,
September 20-21, 2011, December 13-16, 2011, March 21-25, 2012, and June 19, 2012.
mg/L = Milligrams per liter
mV = Millivolts
NA = Not analyzed
ORP = Oxidation-reduction potential
* = Anomalous reading

MW-38, 56 (DO)	
Shallow	**8.160**
Intermediate	**2.764**
Deep	**0.525**

MW-38, 56 (ORP)	
Shallow	**125.338**
Intermediate	**140.488**
Deep	**102.300**

Appendix C

Revision 1, Technical Memorandum: Intermediate Remediation Goal Calculation

TECHNICAL MEMORANDUM:

INTERIM REMEDIATION GOAL CALCULATION

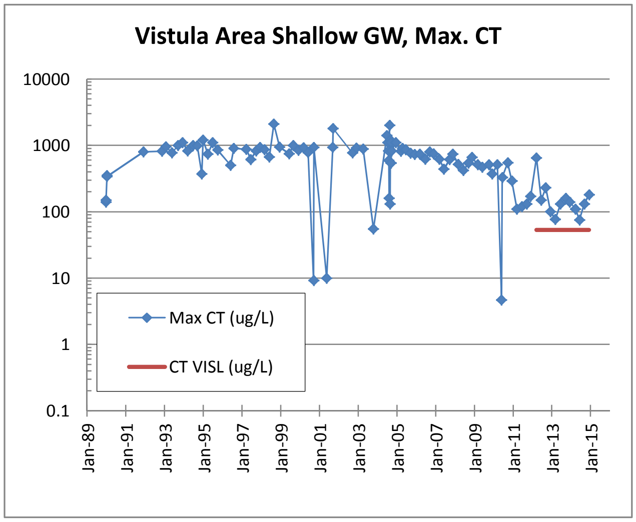
HAS BEEN REDACTED – TEN PAGES

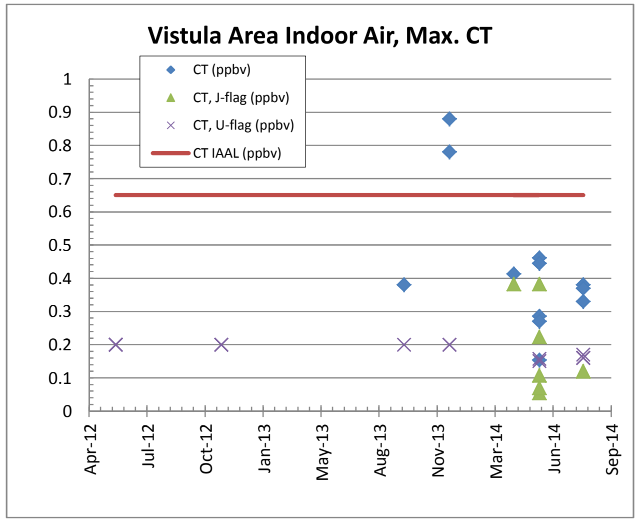
FIGURES

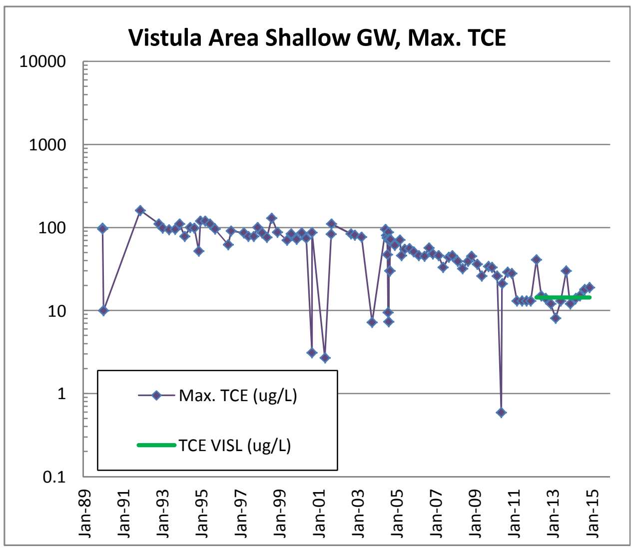
FIGURES 1-2

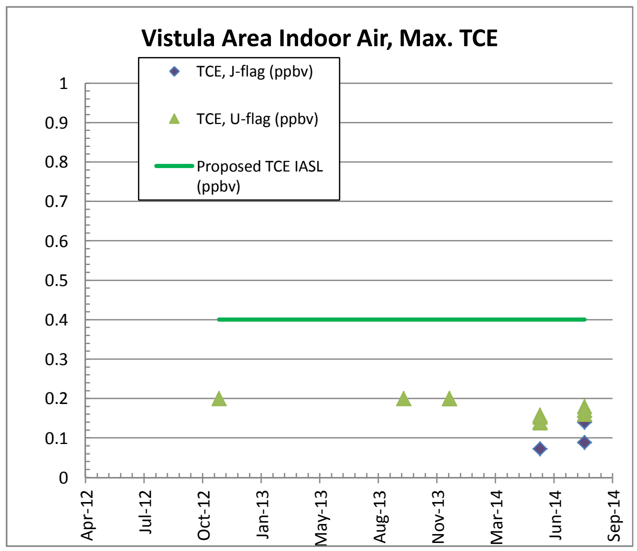
HAVE BEEN REDACTED – TWO PAGES

CONTAINS POTENIAL PERSONALLY-IDENTIFYING INFORMATION









CONRAIL RAILYARD SUPERFUND SITE

ELKHART, IN

FIGURE 3

COMPARISION OF CONCENTRATIONS VS. SCREENING LEVELS AND ACTION LEVEL

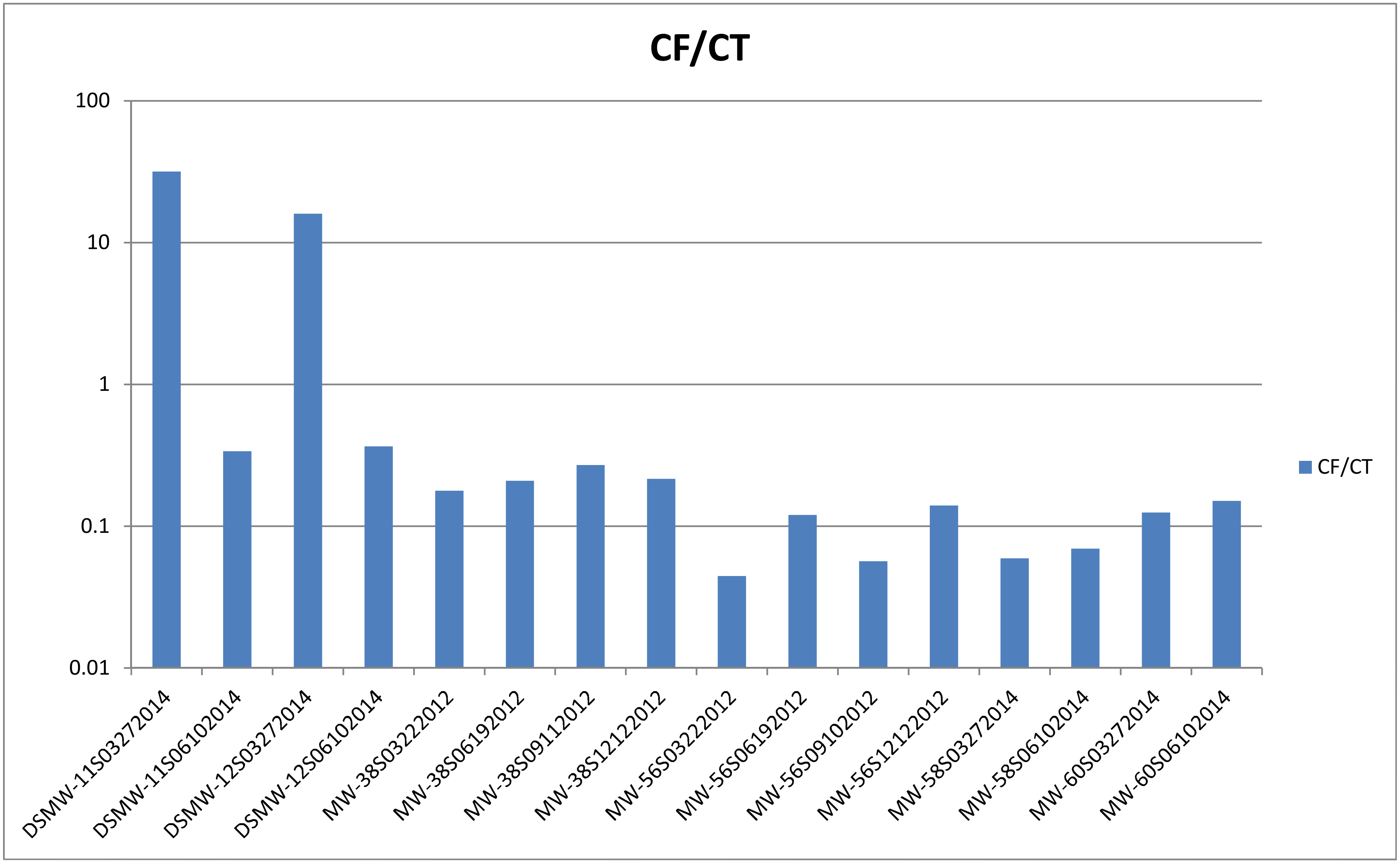
14951501

AECOM

ATTACHMENT A

(PROVIDED ELECTRONICALLY)

ATTACHMENT B



CF/CT
100
10
1
0.1
0.01
DSMW-11S03272014
DSMW-11S06102014
DSMW-12S03272014
DSMW-12S06102014
MW-38S03222012
MW-38S06192012
MW-38S09112012
MW-38S12122012
MW-56S03222012
MW-56S06192012
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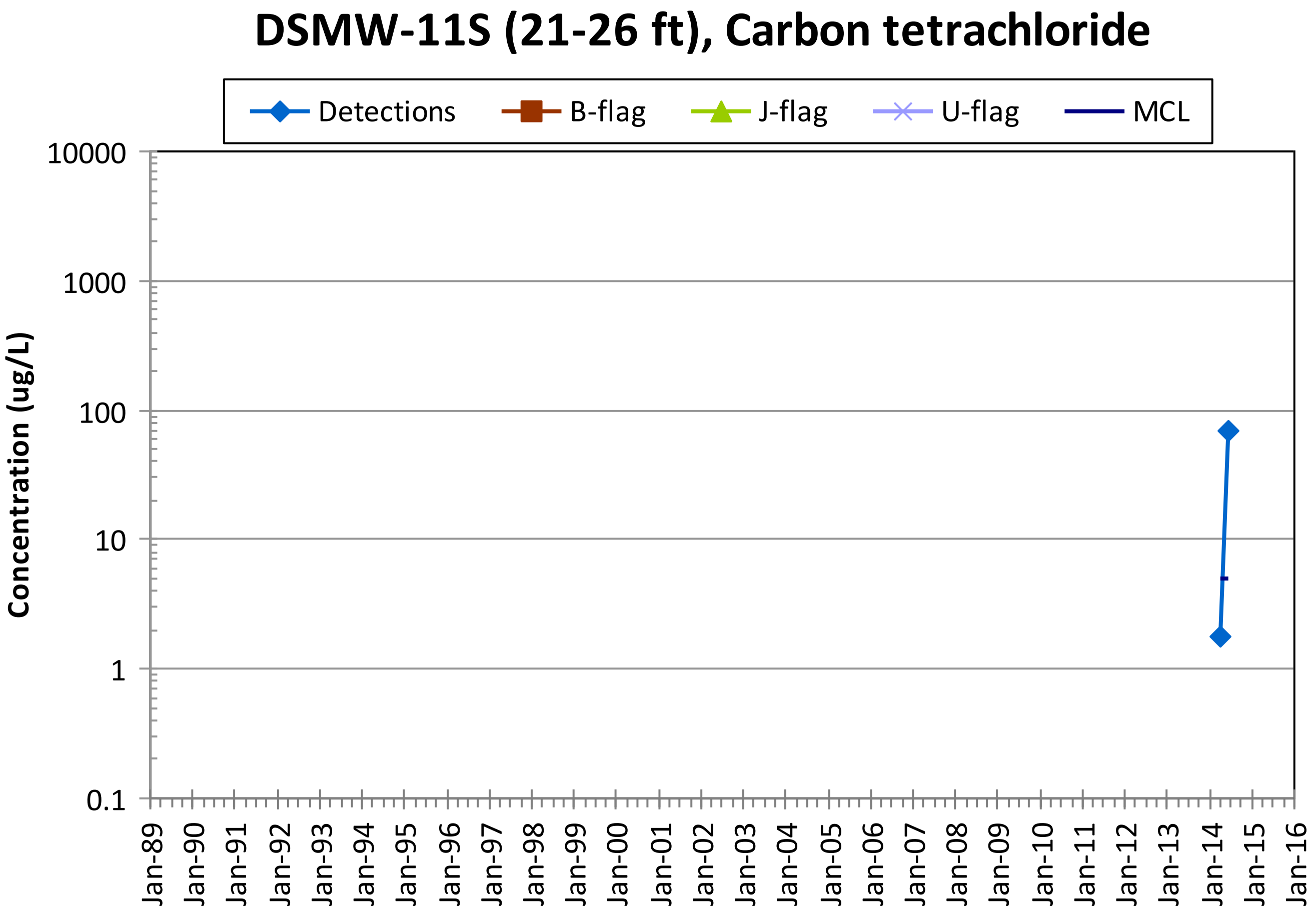
MW-60S06102014
CF/CT



DSMW-11S (21-26 ft), Carbon tetrachloride
Detections
B-flag
J-flag
U-flag
MCL
Concentration (ug/L)
10000
1000
100
10
1
0.1
Jan-89
Jan-90
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
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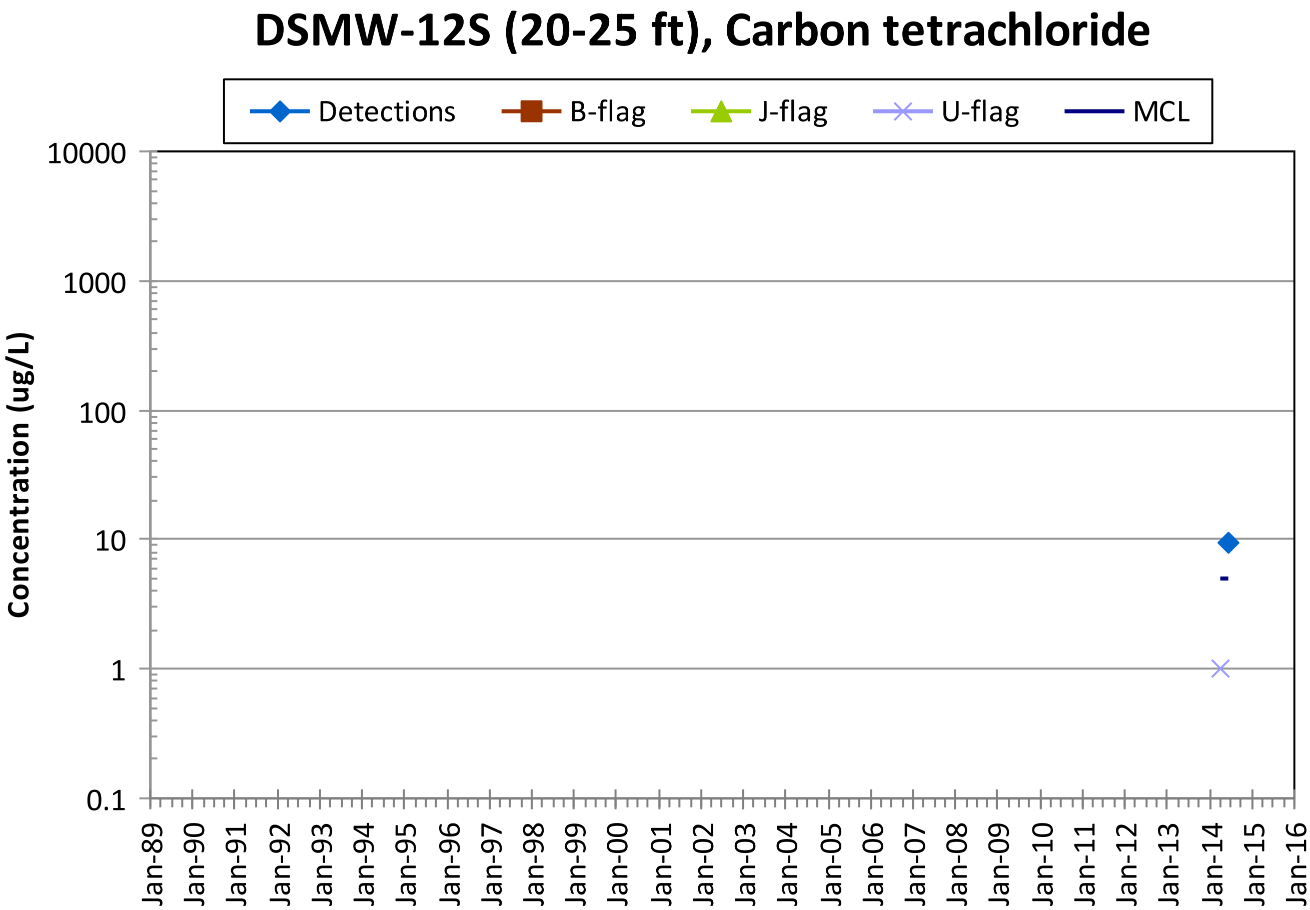
Jan-14
Jan-15
Jan-16



DSMW-12S (20-25 ft), Carbon tetrachloride
Detections
B-flag
J-flag
U-flag
MCL
Concentration (ug/L)
10000
1000
100
10
1
0.1
Jan-89
Jan-90
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
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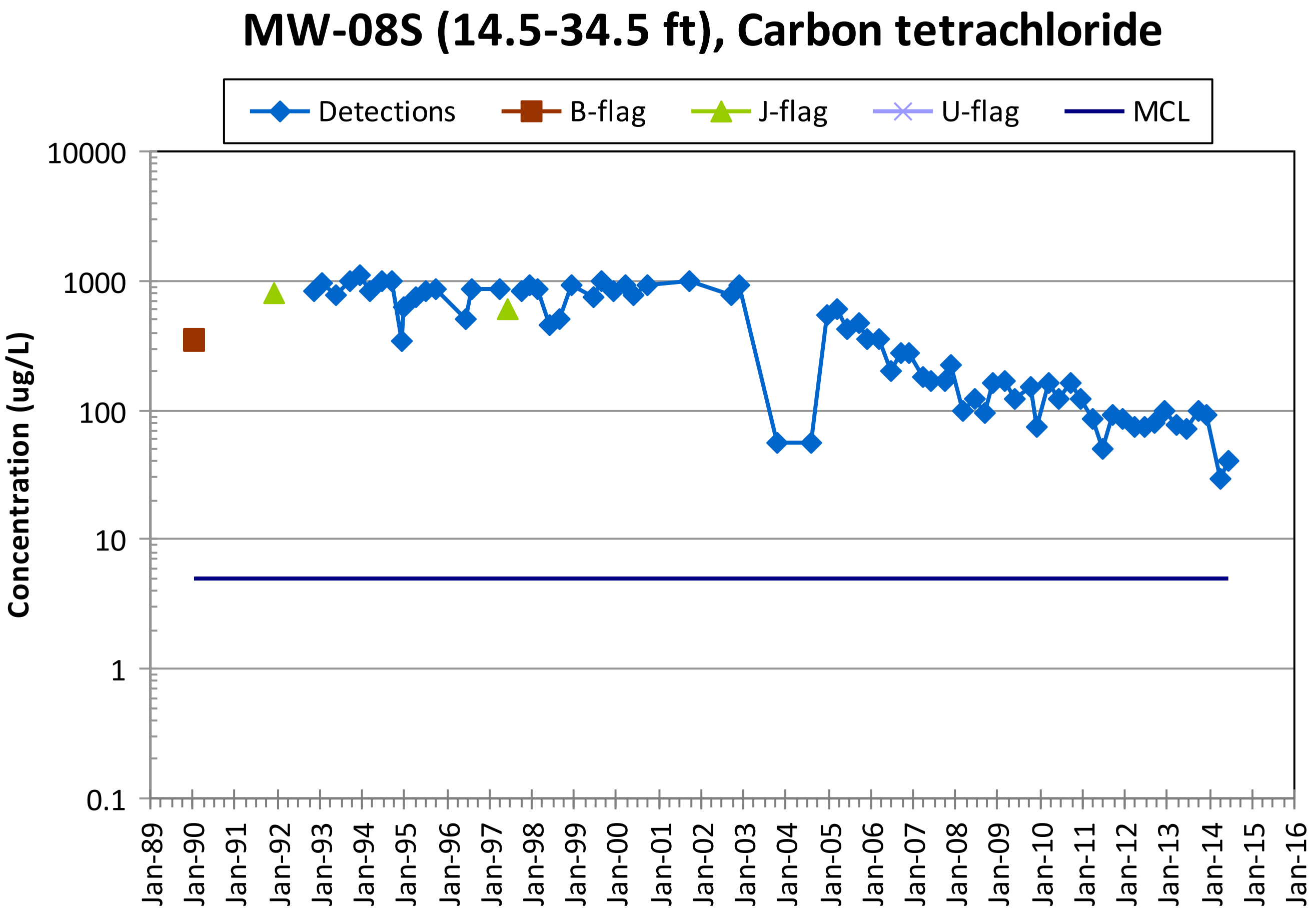
Jan-14
Jan-15
Jan-16



MW-08S (14.5-34.5 ft), Carbon tetrachloride
Detections
B-flag
J-flag
U-flag
MCL
Concentration (ug/L)
10000
1000
100
10
1
0.1
Jan-89
Jan-90
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
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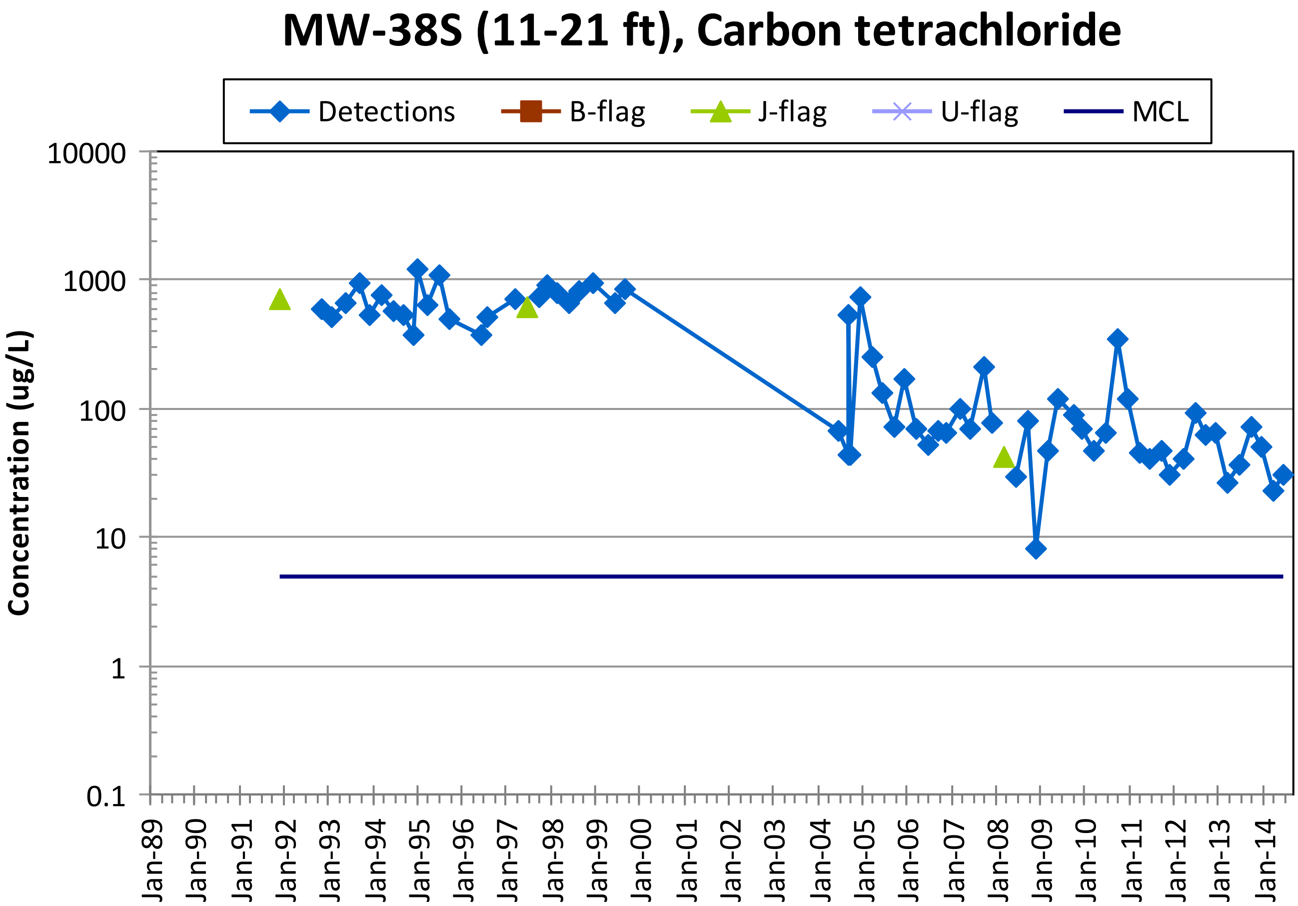
Jan-14
Jan-15
Jan-16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Detections
B-flag
J-flag
U-flag
MCL
Concentration (ug/L)
10000
1000
100
10
1
0.1
Jan-89
Jan-90
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
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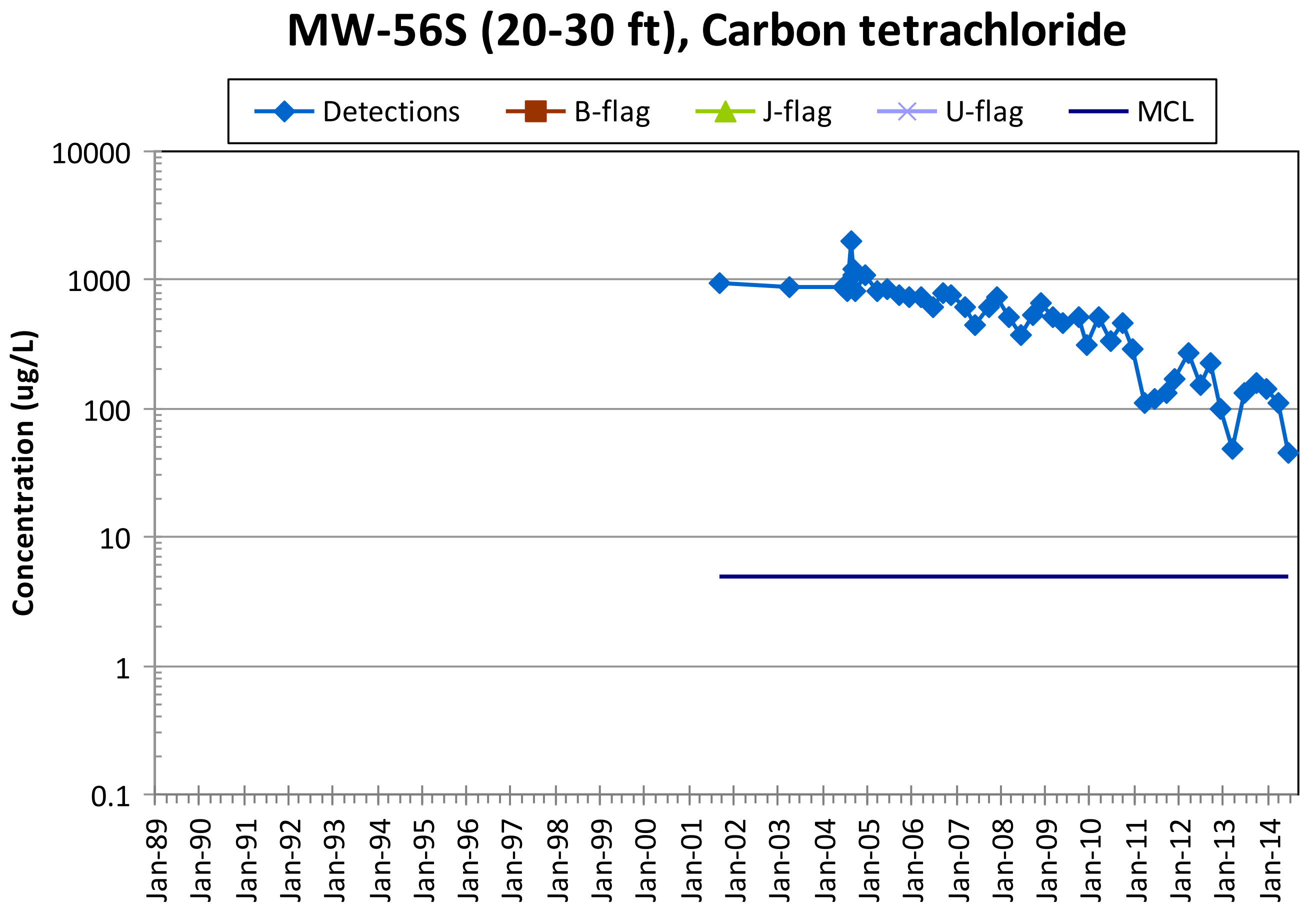
Jan-13
Jan-14



MW-56S (20-30 ft), Carbon tetrachloride
Detections
B-flag
J-flag
U-flag
MCL
Concentration (ug/L)
10000
1000
100
10
1
0.1
Jan-89
Jan-90
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
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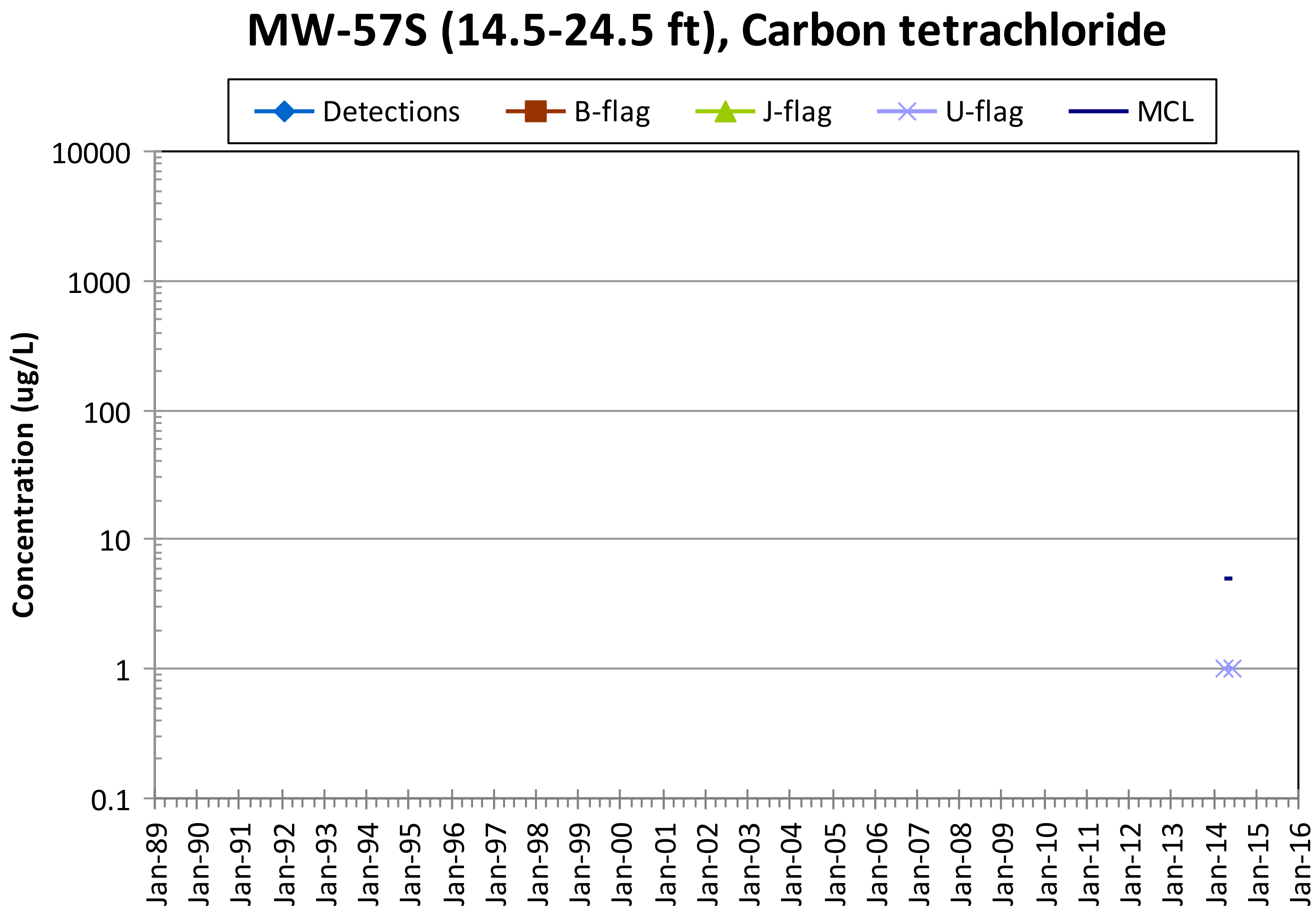
Jan-13
Jan-14



MW-57S (14.5-24.5 ft), Carbon tetrachloride
Detections
B-flag
J-flag
U-flag
MCL
Concentration (ug/L)
10000
1000
100
10
1
0.1
Jan-89
Jan-90
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
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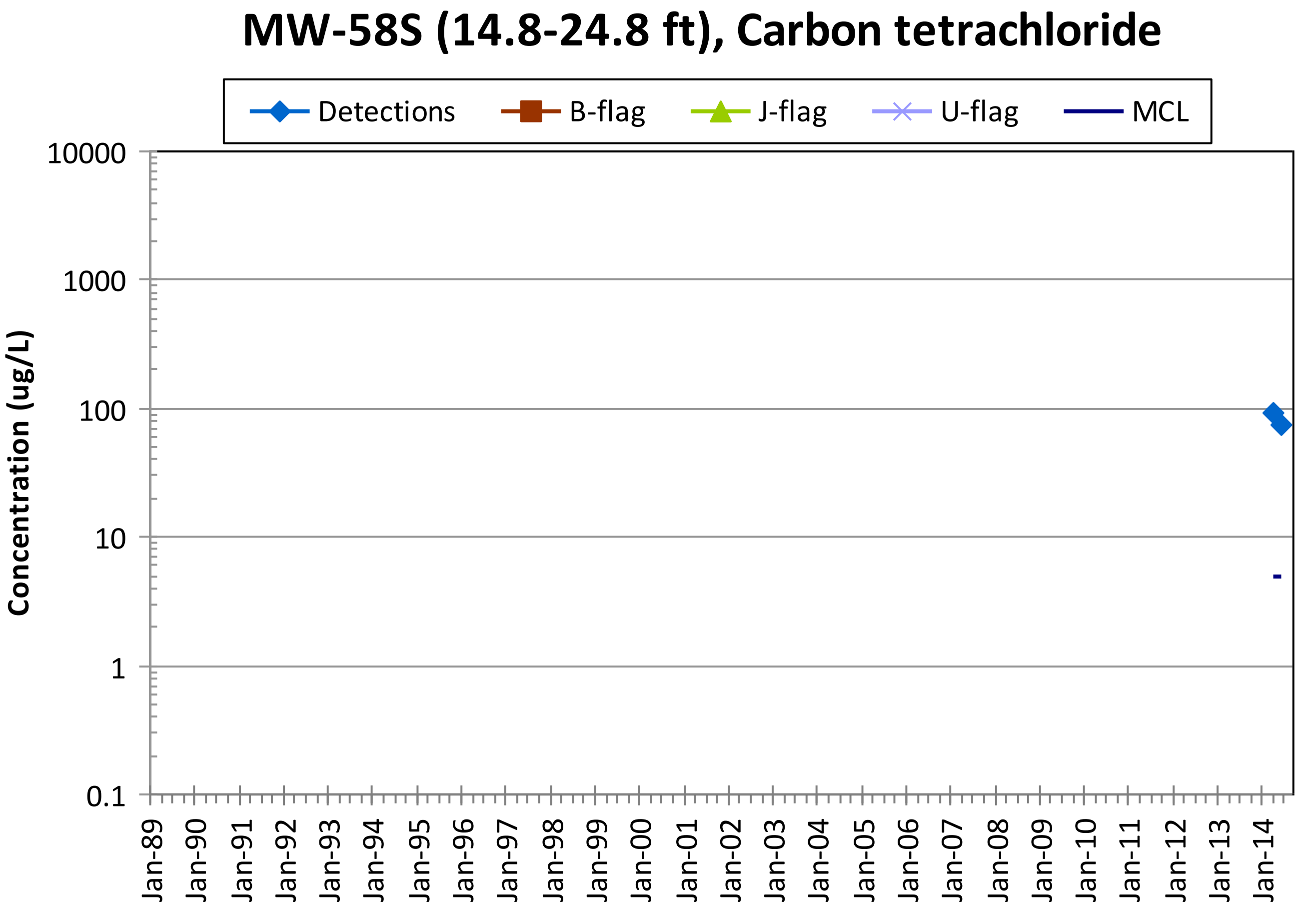
Jan-16



MW-58S (14.8-24.8 ft), Carbon tetrachloride
Detections
B-flag
J-flag
U-flag
MCL
Concentration (ug/L)
10000
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0.1
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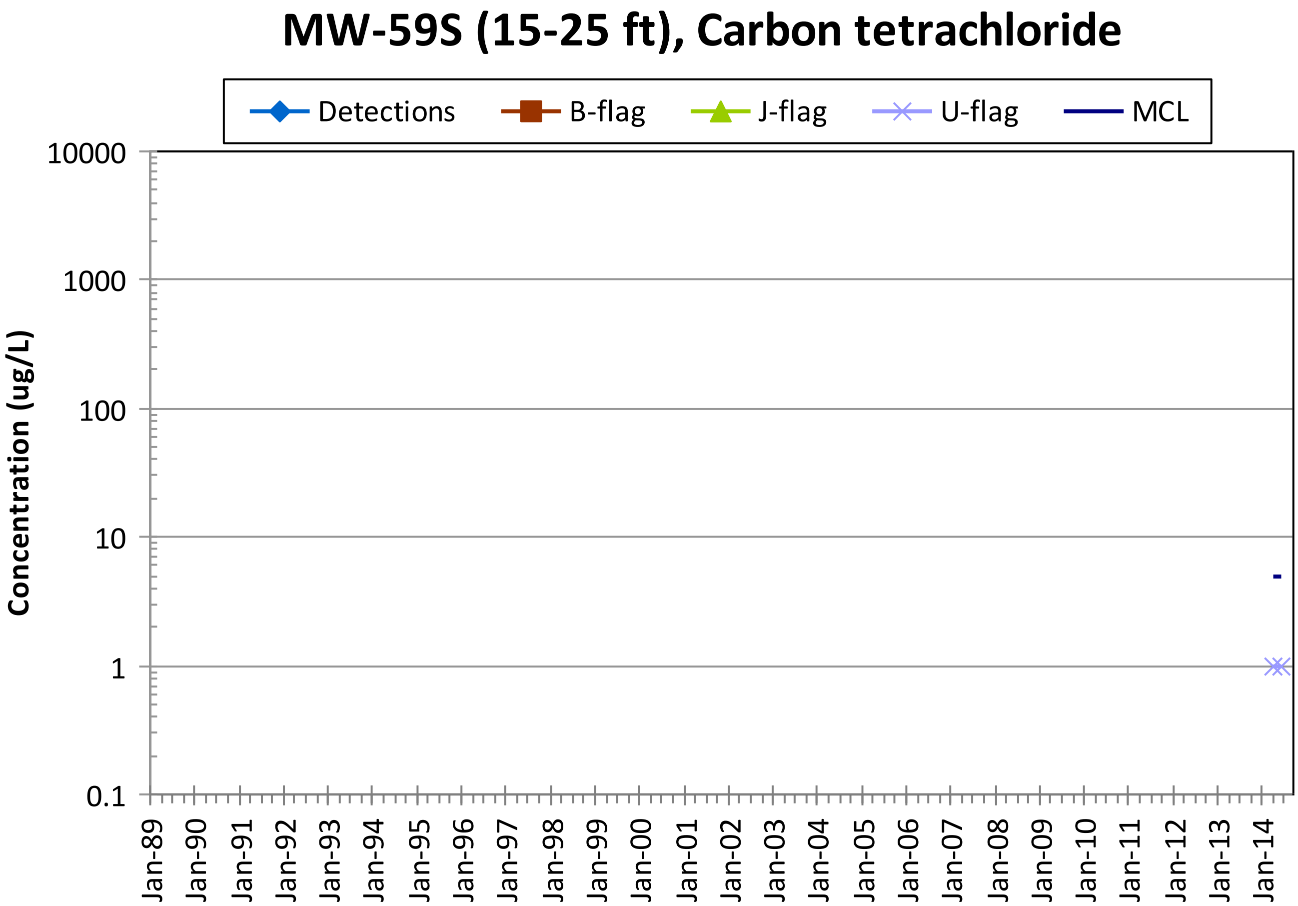

MW-59S (15-25 ft), Carbon tetrachloride
Detections
B-flag
J-flag
U-flag
MCL
Concentration (ug/L)
10000
1000
100
10
1
0.1
Jan-89
Jan-90
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
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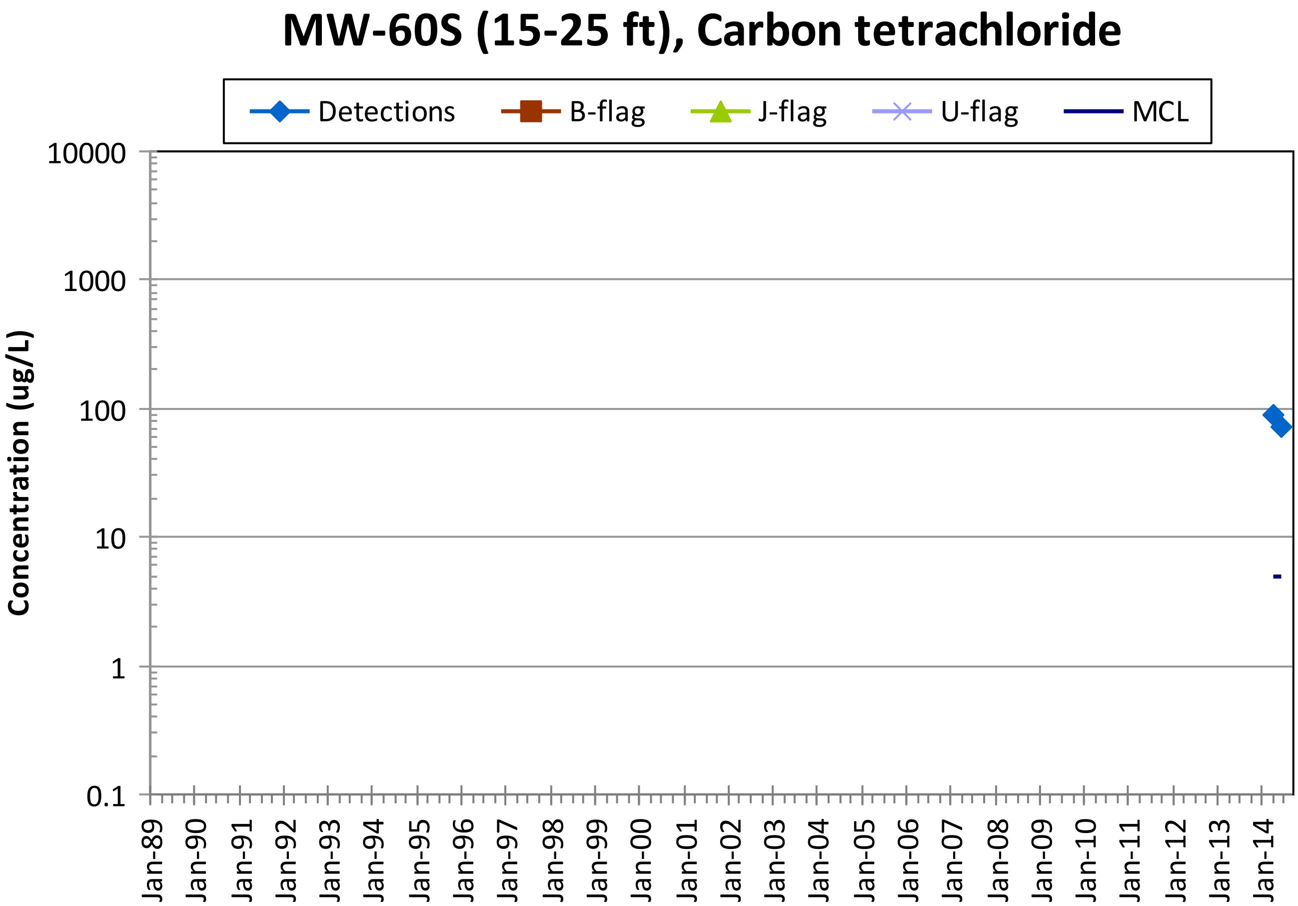
Jan-14



MW-60S (15-25 ft), Carbon tetrachloride
Detections
B-flag
J-flag
U-flag
MCL
Concentration (ug/L)
10000
1000
100
10
1
0.1
Jan-89
Jan-90
Jan-91
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Jan-93
Jan-94
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ATTACHMENT C

OSWER VAPOR INTRUSION ASSESSMENT
Vapor Intrusion Screening Level (VISL) Calculator Version 3.3.1, May 2014 RSLs

Parameter	Symbol	Value	Instructions
Exposure Scenario	Scenario	Residential	Select residential or commercial scenario from pull down list
Target Risk for Carcinogens	TCR	1.00E-05	Enter target risk for carcinogens
Target Hazard Quotient for Non-Carcinogens	THQ	1	Enter target hazard quotient for non-carcinogens
Average Groundwater Temperature (^oC)	Tgw	25	Enter average of the stabilized groundwater temperature to correct Henry's Law Constant for groundwater target concentrations

	CAS	Chemical Name	Is Chemical Sufficiently Volatile and Toxic to Pose Inhalation Risk Via Vapor Intrusion from Soil Source?	Is Chemical Sufficiently Volatile and Toxic to Pose Inhalation Risk Via Vapor Intrusion from Groundwater Source?	Target Indoor Air Conc. @ TCR = 10E-06 or THQ = 1	Toxicity Basis	Target Sub-Slab and Exterior Soil Gas Conc. @ TCR = 10E-06 or THQ = 1	Target Ground Water Conc. @ TCR = 10E-06 or THQ = 1	Is Target Ground Water Conc. < MCL?	Temperature for Groundwater Vapor Conc.	Lower Explosive Limit**	LEL Source	Inhalation Unit Risk	IUR Source*	Reference Concentration	RFC Source*	Mutagenic Indicator	Target Indoor Air Conc. for Carcinogens @ TCR = 10E-06	Target Indoor Air Conc. for Non-Carcinogens @ THQ = 1
			Cvp > Cia,target?	Chc > Cia,target?	MIN(Cia,c;Cia,nc)		Csg	Cgw	Cgw<MCL?	Tgw or 25	LEL		IUR		RfC		i	Cia,c	Cia,nc
			Yes/No	Yes/No	(ug/m^3)	C/NC	(ug/m^3)	(ug/L)	Yes/No (MCL ug/L)	C	(% by vol)		(ug/m^3)$^{-1}$		(mg/m^3)			(ug/m^3)	(ug/m^3)
x	56-23-5	Carbon Tetrachloride	Yes	Yes	4.7E+00	C	4.7E+01	53.2	No (5)	25			6.00E-06	I	1.00E-01	I		4.7E+00	1.0E+02

Notes:

(1) **Inhalation Pathway Exposure Parameters (RME):**

Exposure Scenario	Units	Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario in cell E5) Symbol	Selected Value
Averaging time for carcinogens	(yrs)	ATc_R	70	ATc_C	70	ATc	70
Averaging time for non-carcinogens	(yrs)	ATnc_R	26	ATnc_C	25	ATnc	26
Exposure duration	(yrs)	ED_R	26	ED_C	25	ED	26
Exposure frequency	(days/yr)	EF_R	350	EF_C	250	EF	350
Exposure time	(hr/day)	ET_R	24	ET_C	8	ET	24

(2) **Generic Attenuation Factors:**

Source Medium of Vapors	Units	Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario in cell E5) Symbol	Selected Value
Groundwater	(-)	AFgw_R	7.79292E-05	AFgw_C	0.001	AFgw	7.793E-05
Sub-Slab and Exterior Soil Gas	(-)	AFss_R	0.1	AFss_C	0.1	AFss	0.1

(3) **Formulas**

Cia, target = MIN(Cia,c; Cia,nc)
Cia,c (ug/m3) = TCR x ATc x (365 days/yr) x (24 hrs/day) / (ED x EF x ET x IUR)
Cia,nc (ug/m3) = THQ x ATnc x (365 days/yr) x (24 hrs/day) x RfC x (1000 ug/mg) / (ED x EF x ET)

(4) **Special Case Chemicals**

Trichloroethylene	Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario in cell E5) Symbol	Selected Value
	mIURTCE_R	1.00E-06	mIURTCE_C	0.00E+00	mIURTCE	1.00E-06
	IURTCE_R	3.10E-06	IURTCE_C	4.10E-06	IURTCE	3.10E-06

Mutagenic Chemicals — The exposure durations and age-dependent adjustment factors for mutagenic-mode-of-action are listed in the table below:

Note: This section applies to trichloroethylene and other mutagenic chemicals, but not to vinyl chloride.

Age Cohort	Exposure Duration (years)	Age-dependent adjustment factor
0 - 2 years	2	10
2 - 6 years	4	3
6 - 16 years	10	3
16 - 26 years	10	1

Mutagenic-mode-of-action (MMOA) adjustment factor 72 This factor is used in the equations for mutagenic chemicals.

Vinyl Chloride — See the Navigation Guide equation for Cia,c for vinyl chloride.

Notation:
NVT = Not sufficiently volatile and/or toxic to pose inhalation risk in selected exposure scenario for the indicated medium
C = Carcinogenic
NC = Non-carcinogenic
I = IRIS: EPA Integrated Risk Information System (IRIS). Available online at: http://www.epa.gov/iris/subst/index.html
P = PPRTV. EPA Provisional Peer Reviewed Toxicity Values (PPRTVs). Available online at: http://hhpprtv.ornl.gov/pprtv.shtml
A = Agency for Toxic Substances and Disease Registry (ATSDR) Minimum Risk Levels (MRLs). Available online at: http://www.atsdr.cdc.gov/mrls/index.html
CA = California Environmental Protection Agency/Office of Environmental Health Hazard Assessment assessments. Available online at:
H = HEAST. EPA Superfund Health Effects Assessment Summary Tables (HEAST) database. Available online at: http://epa-heast.ornl.gov/heast.shtml
S = See RSL User Guide, Section 5
X = PPRTV Appendix
E = The Engineering ToolBox. Available online at http://www.engineeringtoolbox.com/explosive-concentration-limits-d_423.html
N = Centers for Disease Control and Prevention (CDC) National Institute for Occupational Safety and Health (NIOSH). Pocket Guide to Chemical Hazards. Available online at: http://www.cdc.gov/niosh/npg/default.html
M = Chemical-specific MSDS
Mut = Chemical acts according to the mutagenic-mode-of-action, special exposure parameters apply (see footnote (4) above).
VC = Special exposure equation for vinyl chloride applies (see Navigation Guide for equation).
TCE = Special mutagenic and non-mutagenic IURs for trichloroethylene apply (see footnote (4) above).
Yellow highlighting indicates site-specific parameters that may be edited by the user.
Blue highlighting indicates exposure factors that are based on Risk Assessment Guidance for Superfund (RAGS) or EPA vapor intrusion guidance, which generally should not be changed.
**Lower explosive limit is the minimum concentration of the compound in air (% by volume) that is needed for the gas to ignite and explode.

OSWER VAPOR INTRUSION ASSESSMENT
Vapor Intrusion Screening Level (VISL) Calculator Version 3.3.1, May 2014 RSLs

Parameter	Symbol	Value	Instructions
Exposure Scenario	Scenario	Residential	Select residential or commercial scenario from pull down list
Target Risk for Carcinogens	TCR	1.00E-05	Enter target risk for carcinogens
Target Hazard Quotient for Non-Carcinogens	THQ	1	Enter target hazard quotient for non-carcinogens
Average Groundwater Temperature (^{o}C)	Tgw	25	Enter average of the stabilized groundwater temperature to correct Henry's Law Constant for groundwater target concentrations

	CAS	Chemical Name	Is Chemical Sufficiently Volatile and Toxic to Pose Inhalation Risk Via Vapor Intrusion from Soil Source?	Is Chemical Sufficiently Volatile and Toxic to Pose Inhalation Risk Via Vapor Intrusion from Groundwater Source?	Target Indoor Air Conc. @ TCR = 10E-06 or THQ = 1	Toxicity Basis	Target Sub-Slab and Exterior Soil Gas Conc. @ TCR = 10E-06 or THQ = 1	Target Ground Water Conc. @ TCR = 10E-06 or THQ = 1	Is Target Ground Water Conc. < MCL?	Temperature for Groundwater Vapor Conc.	Lower Explosive Limit**	LEL Source	Inhalation Unit Risk	IUR Source*	Reference Concentration	RFC Source*	Mutagenic Indicator	Target Indoor Air Conc. for Carcinogens @ TCR = 10E-06	Target Indoor Air Conc. for Non-Carcinogens @ THQ = 1
			Cvp > Cia,target?	Chc > Cia,target?	MIN(Cia,c;Cia,nc)		Csg	Cgw	Cgw<MCL?	Tgw or 25	LEL		IUR		RfC		i	Cia,c	Cia,nc
			Yes/No	Yes/No	(ug/m^3)	C/NC	(ug/m^3)	(ug/L)	Yes/No (MCL ug/L)	C	(% by vol)		(ug/m^3)$^{-1}$		(mg/m^3)			(ug/m^3)	(ug/m^3)
x	79-01-6	Trichloroethylene	Yes	Yes	2.1E+00	NC	2.1E+01	14.3	No (5)	25	8	N	see note	I	2.00E-03	I	TCE	4.8E+00	2.1E+00

Notes:

(1) **Inhalation Pathway Exposure Parameters (RME):**

Exposure Scenario	Units	Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario in cell E5) Symbol	Selected Value
Averaging time for carcinogens	(yrs)	ATc_R	70	ATc_C	70	ATc	70
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Exposure duration	(yrs)	ED_R	26	ED_C	25	ED	26
Exposure frequency	(days/yr)	EF_R	350	EF_C	250	EF	350
Exposure time	(hr/day)	ET_R	24	ET_C	8	ET	24

(2) **Generic Attenuation Factors:**

Source Medium of Vapors	Units	Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario in cell E5) Symbol	Selected Value
Groundwater	(-)	AFgw_R	0.000361151	AFgw_C	0.001	AFgw	0.0003612
Sub-Slab and Exterior Soil Gas	(-)	AFss_R	0.1	AFss_C	0.1	AFss	0.1

(3) **Formulas**

Cia, target = MIN(Cia,c; Cia,nc)
Cia,c (ug/m3) = TCR x ATc x (365 days/yr) x (24 hrs/day) / (ED x EF x ET x IUR)
Cia,nc (ug/m3) = THQ x ATnc x (365 days/yr) x (24 hrs/day) x RfC x (1000 ug/mg) / (ED x EF x ET)

(4) **Special Case Chemicals**

	Residential Symbol	Residential Value	Commercial Symbol	Commercial Value	Selected (based on scenario in cell E5) Symbol	Selected Value
Trichloroethylene	mIURTCE_R	1.00E-06	mIURTCE_C	0.00E+00	mIURTCE	1.00E-06
	IURTCE_R	3.10E-06	IURTCE_C	4.10E-06	IURTCE	3.10E-06

Mutagenic Chemicals — The exposure durations and age-dependent adjustment factors for mutagenic-mode-of-action are listed in the table below:

Note: This section applies to trichloroethylene and other mutagenic chemicals, but not to vinyl chloride.

Age Cohort	Exposure Duration (years)	Age-dependent adjustment factor
0 - 2 years	2	10
2 - 6 years	4	3
6 - 16 years	10	3
16 - 26 years	10	1

Mutagenic-mode-of-action (MMOA) adjustment factor 72 This factor is used in the equations for mutagenic chemicals.

Vinyl Chloride — See the Navigation Guide equation for Cia,c for vinyl chloride.

Notation:
NVT = Not sufficiently volatile and/or toxic to pose inhalation risk in selected exposure scenario for the indicated medium
C = Carcinogenic
NC = Non-carcinogenic
I = IRIS: EPA Integrated Risk Information System (IRIS). Available online at: http://www.epa.gov/iris/subst/index.html
P = PPRTV. EPA Provisional Peer Reviewed Toxicity Values (PPRTVs). Available online at: http://hhpprtv.ornl.gov/pprtv.shtml
A = Agency for Toxic Substances and Disease Registry (ATSDR) Minimum Risk Levels (MRLs). Available online at: http://www.atsdr.cdc.gov/mrls/index.html
CA = California Environmental Protection Agency/Office of Environmental Health Hazard Assessment assessments. Available online at:
H = HEAST. EPA Superfund Health Effects Assessment Summary Tables (HEAST) database. Available online at: http://epa-heast.ornl.gov/heast.shtml
S = See RSL User Guide, Section 5
X = PPRTV Appendix
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N = Centers for Disease Control and Prevention (CDC) National Institute for Occupational Safety and Health (NIOSH). Pocket Guide to Chemical Hazards. Available online at: http://www.cdc.gov/niosh/npg/default.html
M = Chemical-specific MSDS
Mut = Chemical acts according to the mutagenic-mode-of-action, special exposure parameters apply (see footnote (4) above).
VC = Special exposure equation for vinyl chloride applies (see Navigation Guide for equation).
TCE = Special mutagenic and non-mutagenic IURs for trichloroethylene apply (see footnote (4) above).
Yellow highlighting indicates site-specific parameters that may be edited by the user.
Blue highlighting indicates exposure factors that are based on Risk Assessment Guidance for Superfund (RAGS) or EPA vapor intrusion guidance, which generally should not be changed.
**Lower explosive limit is the minimum concentration of the compound in air (% by volume) that is needed for the gas to ignite and explode.

Appendix D

Laboratory Biotreatibility Study (SiREM, January 2015)

Prepared for:

Geosyntec
2240 Sutherland Avenue, Suite 107
Knoxville, TN 37919

Final

Laboratory Biotreatability Study to Evaluate Remediation of VOCs in Groundwater

Conrail Railyard Site, Elkhart, Indiana

Prepared by:

SiREM

130 Research Lane, Suite 2
Guelph, Ontario N1G 5G3

SiREM Ref: GR5218.08

14 January 2015

siremlab.com

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1,1-DCE	1,1-dichloroethene
CO_2	carbon dioxide
CTC	carbon tetrachloride
cVOC	chlorinated volatile organic compound
CF	chloroform
CM	chloromethane
cDCE	cis-1,2-dichloroethene
°C	degrees Celsius
°C/min	degrees Celsius per minute
DI	deionized
DCM	dichloromethane
DHG	dissolved hydrocarbon gases
ERD	enhanced reductive dechlorination
Fe_2O_3	hematite
Fe_3O_4	magnetite
Fe^{3+}	ferric iron
Fe^{2+}	ferrous iron
FeS_2	pyrite
GC	gas chromatograph
g/L	grams per liter
IC	ion chromatograph
Mn^{4+}/Mn^{2+}	manganese
µL	microliter
µm	micrometer
min	minutes
mg/L	milligrams per liter
mL	milliliters
mL/min	milliliters per minute
mM	millimolar
mmol/bottle	millimoles per microcosm bottle
mV	millivolts
ORP	oxidation reduction potential
%	percent
PSI	pounds per square inch
QL	quantitation limit
RPM	revolutions per minute
SiREM	SiREM Laboratory
PCE	tetrachloroethene
TOC	total organic carbon
TCE	trichloroethene
URS	URS Corporation
VC	vinyl chloride

VFAs	volatile fatty acids
VOC	volatile organic compound
ZVI	zero valent iron

1. INTRODUCTION

Geosyntec retained SiREM Laboratory (SiREM) on behalf of URS Corporation (URS) and the Settling Parties (Norfolk Southern Railway Company [NSRC] and American Premier Underwriters [APU]) to perform a laboratory treatability study. The potential for in situ bioremediation and zero valent iron (ZVI) to treat chlorinated volatile organic compounds (cVOCs) in groundwater was evaluated for the NSRC site in Elkhart, Indiana (the Site). The purpose of the study was to assess anaerobic biodegradation and chemical reduction of the Site chemicals of potential concern, namely carbon tetrachloride (CTC) and trichloroethene (TCE), and their breakdown products chloroform (CF), dichloromethane (DCM), and cis-1,2-dichloroethene (cDCE) and vinyl chloride (VC), respectively.

Site geologic material (soil) was collected from DSMW-11 on 27 February 2014 and was received at SiREM on 28 February 2014. The study was conducted using materials collected from two groundwater depth intervals (shallow and intermediate). Groundwater samples (which included well sediment) were collected from 2 shallow wells (DSMW-7S, DSMW-08S) and 2 intermediate wells (DSMW-7I, DSMW-08I) by URS personnel on 5 March 2014 and were received by SiREM on 7 March 2014. The chain of custody documentation received with the samples is provided in Appendix A.

The remainder of this report contains a summary of key degradation processes (Section 1.1), the experimental materials, methods, and visual appearances (Section 2), the results and discussion of the microcosm study (Section 3), conclusions (Section 4) and report references (Section 5).

1.1 Summary of Degradation Processes

The two main compounds (CTC and TCE) present in groundwater at the Site can be degraded by both abiotic and biotic processes. Biological CTC degradation is proposed to occur via reductive dechlorination to CF although is not typically observed. Reductive dechlorination of CF to DCM which is further degraded via an anaerobic fermentation pathway to carbon dioxide (CO_2) and organic acids has been reported (Lee at al., 2011). Chloromethane (CM) and methane may also be produced, but are not the major degradation products typically observed. TCE is anaerobically degraded through reductive dechlorination to cDCE, VC and to the fully dechlorinated end product ethene. Figure 1 provides the biological degradation pathway for the chlorinated methanes, and Figure 2 provides the dechlorination pathways for the chlorinated ethenes.

Abiotic degradation of TCE in the presence of iron occurs via two dominant pathways that involve hydrogenolysis and reductive β-elimination (Gillham et al., 2010). Abiotic degradation of CTC can occur via 2 main pathways: 1) hydrogenolysis to produce chloroform and 2) dichloroelimination forming a dichlorocarbene that can be hydrolysed to carbon monoxide and formate. These pathways are often accompanied by other parallel, complex microbially mediated processes, including those (carbene hydrolysis and carbene reduction) occurring in the presence of biologically activated minerals formed by iron-reducing bacteria (e.g., *Geobacter metallireducens*).[1] Figures 3 and 4 provide the ZVI mediated transformation mechanisms for TCE and CTC respectively.

1.1.1 Elemental Iron Reactions

After oxygen, silicon, and aluminium, iron is the fourth most abundant element in the earth's crust, and is a commonly occurring metallic element at concentrations that can vary significantly, even within localized areas, based on soil type and the presence of other iron-bearing minerals. Iron typically occurs in either the divalent (ferrous or Fe^{+2}) or trivalent (ferric or Fe^{+3}) states under typical environmental conditions. The valence state is determined by the pH and ORP of the system, and the resultant iron-bearing compound is dependent upon the availability of other chemicals (e.g., sulfur is required to produce pyrite [FeS_2]). Most of the iron in the earth's crust is combined with oxygen in minerals such as hematite (Fe_2O_3) and magnetite (Fe_3O_4).

The presence of elemental (zero-valent) iron (ZVI, or Fe^0), promotes direct abiotic dechlorination of chlorinated compounds. Under reducing conditions, elemental iron reacts with water (known as corrosion) to form Fe^{2+} and hydrogen, both of which are candidate reducing agents for contaminants such as chlorinated solvents. The corrosion of the ZVI also results in significantly reducing the groundwater redox conditions (on the order of tens to hundreds of millivolts (mV), depending on other species); the hydrogen generated may also be fortuitously used by bacteria for biological reduction of certain chlorinated organic solvents.

1.1.2 Soluble Iron Reactions

Soluble iron (ferrous gluconate) is part of the EHC®-L formulation to promote direct chemical reduction and abiotic degradation of CTC and TCE via microbially-mediated catalytic reduction processes. Similarly, SRS™, a 60 percent by weight emulsified vegetable oil-based product combined with sodium lactate, was tested individually and as combined with ZVI and soluble iron (ferrous fumarate) in this study so that the results of different combinations of amendments could be compared to observe the presence/formation of magnetically susceptible material and evaluate the effect of ZVI and soluble iron on the abiotic and biotic degradation of the target compounds at the Site.

1.1.3 Bioaugmentation

Bioaugmentation is the process in which a microbial population known to promote enhanced reductive dechlorination (ERD) or other biodegradation processes is introduced to groundwater to enhance the rate or extent of biodegradation. The KB-1® Plus formulation used in this study is a natural microbial consortium containing microorganisms (e.g., *Dehalobacter*) known to be responsible for mediating the dechlorination of CF to DCM (Grostern et al., 2010) and further to non-chlorinated end products (SiREM, unpublished). The consortium also contains other microorganisms (e.g., *Dehalococcoides*) known to be responsible for mediating the complete dechlorination of tetrachloroethene (PCE), TCE, cDCE, 1,1-dichloroethene (1,1-DCE) and VC to ethene (Major et al., 2002; Duhamel et al., 2002). The diverse microbial community of KB-1®

Plus also contains numerous other species that support reductive dechlorination, sulfate reduction and other community roles; these include: *Desulforomonas* (sulfate reduction) and Geobacter (iron reducers) that are also implicated in the abiotic and abiotic degradation of CTC and other chlorinated species.

2. MATERIALS AND METHODS

The following sections describe the materials and methods used for microcosm construction and incubation (Section 2.1), and microcosm sampling and analysis (Section 2.2).

2.1 Microcosm Construction and Incubation

2.1.1 Microcosm Construction

Biotreatability microcosms were constructed in a disposable anaerobic glove bag containing the Site groundwater and all the materials required to construct all treatment and control microcosms. The glove bag was purged with nitrogen gas to create an anaerobic environment and to protect any microorganisms present in the site materials from oxygen exposure. In consultation with Geosyntec and URS, samples from two depths were selected for evaluation: Shallow and Intermediate Depths. The Shallow Depth groundwater, which also contained aquifer fines (sediment), was collected from 2 wells (DSMW-7S and DSMW-8S). The Intermediate Depth groundwater, also containing some sediment, was collected from two wells (DSMW-7I and DSMW-8I). Three containers of site geological material (DSMW-11) were manually mixed together to improve reproducibility between replicates and was used as the aquifer material to construct both the Shallow and Intermediate Depth microcosms. During microcosm construction, the Site water was mixed in a 7L Nalgene container to ensure reproducibility between replicates.

Microcosms were constructed by filling sterile 250 milliliter (mL) (nominal volume) screw cap Boston round clear glass bottles (Systems Plus, New Hamburg, ON) with 30 mL (approximately 60 grams) of Site geologic materials and 200 mL of Site groundwater as outlined above. The bottles were capped with Mininert^{TM} (VICI Valco, Canada, Brockville, Ontario) closures to allow repetitive sampling with minimal chlorinated volatile organic compound loss and to allow nutrient amendment, as needed, throughout the incubation period. All controls and treatments were constructed in triplicate. Tables 1A (Shallow) and 1B (Intermediate) summarize the details of microcosm construction and the amendments used for the treatment and control microcosms.

Anaerobic sterile control microcosms were constructed to quantify potential abiotic and experimental cVOC losses from the microcosms. The sterile controls were constructed by autoclaving the Site geologic materials at 121 degrees Celsius (°C) and 15 pounds per square inch (PSI) pressure for 45 to 60 minutes (min). After autoclaving, the sterile control microcosms were returned to the anaerobic chamber, filled with 200 mL of Site groundwater and amended with mercuric chloride and sodium azide as described in Tables 1A and 1B. Note that only one set of Anaerobic Sterile Controls was prepared from Site water DSMW-7S and DSMW-8S, and site geologic materials DSMW-11.

2.1.2 Microcosm Amendments and Incubation

All microcosms were sampled and incubated in an anaerobic chamber (Coy Laboratory Products, Grass Lake, MI) filled with an atmosphere of approximately 80 percent (%) nitrogen, 10% CO_2 and 10% hydrogen (Linde Gases, Guelph, ON). Hydrogen in the anaerobic chamber functions to scavenge trace oxygen via a palladium catalyst. Anaerobic conditions in the anaerobic chamber were verified using an indicator containing resazurin (Sigma, St. Louis, MO) in a mineral medium, which turns pink in the presence of oxygen. During quiescent incubation, all microcosms were covered to minimize photodegradation, and stored horizontally to minimize cVOC losses via the (submerged) Mininert^{TM} closure. Microcosms were incubated for a period of up to 123 days at approximately 22 °C (room temperature).

Geosyntec (in consultation with URS) specified that the initial CTC and TCE concentrations in the microcosms should be 2 milligrams per liter (mg/L), to represent concentrations measured at the Site. The initial concentrations measured in the prepared microcosms were not at these target concentrations; therefore, on 27 March 2014 (Day -1), the microcosms were amended with 562 microliters (µL) of a saturated CTC stock and 397 µL of a saturated TCE stock solution to reach the target concentrations in the microcosms. The measured concentration of CTC at time zero ranged from 1 to 2 mg/L and for TCE from 2.9 to 3.4 mg/L. The wider range of initial CTC concentrations may have resulted from instantaneous abiotic reactions. Lower concentrations were observed in the SRS amended microcosms, which contain oil that the CTC and TCE may partition into. Re-spiking with CTC to a target concentration of 2 mg/L to all treatments bottles (controls were omitted) occurred on Day 20. An additional CTC and TCE re-spike to target concentrations of 2 mg/L each occurred to the shallow treatment only on Day 90. The re-spikes were recorded in Tables 1A and 1B.

Treatment microcosms received amendments on 28 March 2014 (Day 0) as outlined in Table 1. Zero Valent Iron (ZVI) (Innovative Environmental Technologies, Pipersville, PA) was provided as elemental iron with an average particle diameter of 2 micrometers. The ZVI was amended at 1 g to target a final concentration of 5 grams per liter (g/L). EHC®-L (PeroxyChem, Philadelphia, PA) is a proprietary organic carbon-based liquid amended with ferrous gluconate and was amended from a 50 % stock solution (145,625 mg/L) at 1.373 mL targeting a final concentration of 1 g/L. Ferrous fumarate (Spectrum Chemical, California) is a common form of bio-available iron and was amended at 36 mg to target a final concentration of 180 mg/L (A 3X safety factor was used based on 60 mg/L calculation provided by URS). SRS™ (Terra Systems Inc., Wilmington, DE) is an emulsified vegetable oil designed to release bio-available hydrogen over an extended period of time. SRS™ was amended at 333 µL to a target concentration of 0.1 % as oil.

All microcosms were also amended with 2 mL of 100 X strength vitamin/nutrient mixture (provided by Terra Systems). The stock solution prepared by Terra Systems contained the following ingredients: 5,000 mg/L yeast extract, 1,000 mg/L ammonium nitrogen, 1,100 mg/L phosphate, 650 mg/L vitamin B12 and 376 mg/L vitamin B2.

One microcosm bottle from each active and control treatment was amended with resazurin (Sigma, St. Louis, MO) to monitor redox conditions. Resazurin turns from pink to clear in the absence of oxygen and can be used to indicate the on-set of reducing conditions. Details of electron donor addition and resazurin amendment are provided in Table 1A and Table 1B.

Bioaugmentation may improve the extent and rate of TCE dechlorination. Microcosms are typically bioaugmented after reducing conditions required by the KB-1® Plus culture are achieved. Due to the low total organic carbon (TOC) concentration of 1.03 % (Appendix D), the low concentration of intrinsic bacteria (Microbial Insights report, not provided) indicated the need for bioaugmentation in all treatments as outlined in Table 1A and 1B. Suitable reducing conditions are typically achieved after electron donor addition and are indicated by oxidation reduction potentials (ORP) less than -75 mV. Negative ORP can also be assessed qualitatively by both changes in the resazurin indicator color (from pink to clear) and the on-set of sulfate reduction as indicated by the formation of black precipitates. After consultation with Geosyntec and URS, it was decided to bioaugment with KB-1® Plus (CF formulation) on 25 April 2014 (Day 28). Although the ORP values were not below -75 mV at the time of bioaugmentation, it was decided to bioaugment to accelerate the onset of reducing conditions. Refer to Table 5 for ORP values.

2.2 Microcosm Sampling and Analysis

2.2.1 Microcosm Sampling

Aqueous samples were collected from the control and treatment microcosms every two to three weeks for analysis of cVOCs, dissolved hydrocarbon gases (DHGs – ethene, ethane, propene and methane) and anions (sulfate, nitrate, nitrite, chloride, phosphate, bromide). Aqueous samples were also collected on a less frequent basis for analysis of volatile fatty acids (VFAs – lactate, acetate, propionate, formate, butyrate and pyruvate) and pH. The microcosms were sampled using gas-tight 1 mL Hamilton glass syringes. Separate sets of syringes were used for the bioaugmented and non-bioaugmented treatments to minimize the potential for transfer of KB-1® Plus microorganisms from bioaugmented to non-bioaugmented treatments. Syringes were cleaned with acidified water (pH ~2) and rinsed 10 times with deionized (DI) water between samples to ensure that VOCs and microorganisms were not transferred between different samples or treatments.

Following review of the Day 113 data, it was decided, in consultation with Geosyntec and URS, to continue to sample the microcosms from the Shallow Depth and to suspend sampling of the microcosms from the Intermediate Depth. This decision was to allow additional spiking and sampling events to obtain a better understanding of the conditions at the Site and to obtain a bigger picture on the effects of bioaugmentation and amendment additions. The analytical methods employed by SiREM are described below.

2.2.2 Analysis of VOCs and Dissolved Hydrocarbon Gases

This section describes the methods used to quantify the cVOCs. The quantitation limits (QL) for the chlorinated ethenes were typically 0.1 mg/L in the microcosms based on the lowest concentration standards that were included in the linear calibration trend.

Aqueous cVOC concentrations in the microcosms were measured using a Hewlett-Packard (Hewlett Packard 7890) gas chromatograph (GC) equipped with a flame ionization detector and an auto sampler (Hewlett Packard G1888) programmed to heat each sample vial to 75°C for 45 min prior to headspace injection into a GSQ Plot column (0.53 millimeters x 30 meters, J&W) and a flame ionization detector. Sample vials were heated to ensure that all VOCs in the aqueous sample would partition into the headspace. The injector temperature was 200°C, and the detector temperature was 250°C. The oven temperature was programmed as follows: 35°C for 2 min, increased to 100°C at 30 degrees Celsius per minute (°C/min), then increased to 185°C at 25°C/min and held at 185°C for 7.0 min. The carrier gas was helium at a flow rate of 11 milliliters per minute (mL/min).

After withdrawing a 0.5 mL sample (as described in section 2.2.1), the sample was injected into a 10 mL auto sampler vial containing 5.5 mL of acidified de-ionized water (pH ~2). The water was acidified to inhibit microbial activity between microcosm sampling and GC analysis. The vial was sealed with an inert Teflon®-coated septum and aluminium crimp cap for automated injection of 3 mL of headspace onto the GC. One cVOC standard was analysed with each set of samples to verify instrument calibration. Calibration was performed using external standard solutions (Sigma, St Louis, MO). Measured volumes of standard solutions were added to acidified water in auto sampler vials and analysed as described above for microcosm samples. Data were integrated using Chemstation Software (Agilent Technologies, Santa Clara, CA).

2.2.3 Analysis of Total Volatile Fatty Acids and Anions

Anions and total VFA analysis was performed on a Thermo-Fisher ICS-2100 ion chromatograph (IC) equipped with a Thermo-Fisher AS-DV auto sampler and an AS18 column. The sample loop volume was 25 µL. An isocratic separation was performed using 33 millimolar (mM) reagent grade sodium hydroxide (Thermo Scientific, Oakville, ON) eluent for 15 min. One standard was analysed with each set of samples tested in order to verify the seven-point calibration using external standards of known concentrations. External standards were prepared gravimetrically using chemicals of the highest purity available (Sigma St Louis, MO or Bioshop, Burlington, ON). Data were integrated using Chromeleon 7 Chromatography software (Thermo Scientific, Oakville, ON). The QLs were as follows: 0.07 mg/L total VFA, 0.07 mg/L chloride, 0.09 mg/L nitrite, 0.09 mg/L nitrate, 0.07 mg/L sulfate, 0.07 mg/L phosphate and 0.08 mg/L bromide. The total VFA value includes lactate, formate, acetate, propionate, pyruvate and butyrate. The VFA method described below (Section 2.2.4) is used to quantify individual VFAs.

A 0.5 mL sample was withdrawn (as described in section 2.2.1), after which the sample was placed in a 1.5 mL micro-centrifuge tube. Samples were centrifuged for five minutes at 13,000 revolutions per minute (RPM) to remove solids. The supernatant was removed, diluted 50-fold in DI water and placed in a Thermo-Fisher auto sampler vial with a cap that filters the sample during automated injection onto the IC.

2.2.4 Analysis of Volatile Fatty Acids

Individual VFAs (lactate, acetate, propionate, formate, butyrate and pyruvate) analysis was performed on a Thermo-Fisher ICS-2100 IC equipped with a Thermo-Fisher AS-DV auto sampler and an AS11-HC column, the sample loop volume was 25 µL. A gradient separation was performed using the following eluent profile; 1.0 mM sodium hydroxide for 8.0 min to 15 mM at 18.0 min and proceeding to 30 mM at 28.0 min with a flow rate of 0.25 mL/min.

Calibration was performed using external standards of known concentrations. One standard was analysed with each set of samples to verify the instrument's seven-point calibration curve produced using external standards of known concentrations. External standards were prepared gravimetrically using chemicals of the highest purity available (Sigma St Louis, MO or Bioshop, Burlington, ON). Data were integrated using Chromeleon 7 chromatography software (Thermo Scientific, Oakville, ON). The QLs were as follows: lactate 0.40 mg/L, acetate 0.54 mg/L, propionate 0.31 mg/L, formate 0.23 mg/L, butyrate 0.41 mg/L and pyruvate 0.69 mg/L.

A 0.5 mL sample was withdrawn (as described in section 2.2.1), after which the sample was placed in a 1.5 mL micro-centrifuge tube. Samples were centrifuged for five minutes at 13,000 RPM in a micro-centrifuge to remove solids. The supernatant was removed, diluted 50-fold in D water and placed in a Thermo-Fisher auto sampler vial with a cap that filters the sample during automated injection onto the IC.

2.2.5 Analysis of pH

The pH measurements were performed on the lab bench using an Oakton pH spear with combination pH electrode (Oakton, Vernon Hills, Illinois) which allowed measurement of small sample volumes compared to standard pH electrodes. A 500 microliter (µL) sample was collected using a 1,000 µL Hamilton glass syringe. Separate sets of syringes were used for the different reactors to reduce the potential for cross contamination. Syringes were cleaned with acidified water (pH ~2) and rinsed 10 times with DI water between samples. The pH spear was calibrated weekly according to the manufacturer's instructions using pH 4.0, 7.0 and 10 standards.

2.2.6 Ferrous Iron Analysis

Samples for ferrous iron analysis were taken at baseline from both the Shallow and Intermediate Depths. 25 mL aqueous samples were removed from the sediment water and placed in a glass beaker. These samples were then filtered with a 0.45 micrometer (µm) filter (Fisher Scientific, Toronto). Ferrous iron was quantified using a HACH kit (Hach Company, Loveland, CO). Refer to Appendix C for the HACH Ferrous iron test kit procedure.

2.2.7 Visual Determination of Magnetically Susceptible Material

A rare earth magnet was held to the outside of the microcosms periodically throughout the incubation period to determine if magnetite was present, or potentially being formed. Magnetically susceptible material, assumed to be magnetite, appears to have formed in all of the microcosm bottles via the microbially-induced transformation of iron-bearing minerals in the sediment.

2.2.8 External Laboratory Analyses

Baseline Site geologic materials were sampled for total iron, manganese and TOC on 26 March 2014 and sent to SGS Environmental Services (Lakefield, Ontario) for analysis. Refer to Appendix D for results.

3. RESULTS AND CONCLUSIONS

The following sections present and discuss the results of the biotreatability study:

- Redox processes (Section 3.1),
- cVOC biodegradation results (Section 3.2),
- Degradation half-lives for cVOCs (Section 3.3),
- Anion and VFA Results (Section 3.4),
- pH Results (Section 3.5), and
- External Laboratory Results (Section 3.7)

Tables 2, 3, 4 and 5 provide cVOC, DHG, anion, VFA and pH data from the triplicate control and treatment microcosms over the incubation period (123 days) for the study. Variability between the triplicates is generally limited (<20%) and can attributed to sampling and analytical variability. In some cases differences in changes in cVOC concentrations amongst triplicates is observed and may be related to the heterogeneity of the homogenized Site geological materials used to construct the microcosms and the distribution of intrinsic microbes and reactive minerals. The averaged results were used for discussion of the observed trends. ORP results are also provided in Table 5 and were taken from single microcosms rather than triplicates due to the larger sample volumes required for this analysis.

All cVOC and DHG concentrations are presented in units of mg/L and millimoles per microcosm bottle (mmol/bottle) to demonstrate mass balances on a molar basis. Concentrations were converted from mg/L to mmol/bottle using Henry's Law as demonstrated in Appendix B. Table 6 presents the cVOC half-lives. Figures 5 through 19 present trends in the concentrations of cVOCs and ethene in the control and treatment microcosms over the incubation period for the study. The external laboratory results are provided in D.

3.1 Redox Processes

The addition of electron donor typically results in microbial activity that promotes changes in the redox conditions in groundwater. Aerobic or mildly reducing redox conditions will be reduced, resulting in the more strongly reducing conditions required to support anaerobic degradation of cVOCs.

Measuring dissolved oxygen and ORP (primary indicators of redox status) directly in microcosms is challenging due to the high sample volume requirements for these analyses and the relatively small aqueous volumes associated with batch microcosms. ORP samples were collected from single microcosms from each treatment of each location on Day 42. The ORP for the sterile control was +230 mV, indicating aerobic conditions as expected due to the addition of mercuric chloride and sodium azide. Active controls from the shallow and intermediate depths had ORP values of -92 and -69 mV, respectively, indicating reducing conditions. The remaining treatments all had ORP values below -100 mV, clearly indicating that reducing conditions had been established. Other indicators of reducing conditions (e.g., changes in redox sensitive chemical species) were also monitored during this biotreatability study.

The sequence of redox reactions in groundwater is well known (Appelo and Postma, 1994). Oxygen is first consumed, followed by nitrate (denitrification), manganese, iron, and sulfate reduction. Manganese (Mn^{4+}) is reduced to manganese (Mn^{2+}), ferric iron (Fe^{3+}) is reduced to ferrous iron (Fe^{2+}), and sulfate is reduced to sulfide. The final step is carbon dioxide reduction producing methane (methanogenesis). The consumption of each species in sequence indicates that conditions are becoming increasingly reducing. Dechlorination of chlorinated solvents typically occurs in the range of sulfate reducing to methanogenic conditions.

At Time 0, nitrate concentrations in the active control microcosms were low in both the shallow (12 mg/L) and intermediate (3.4 mg/L) depths. Sulfate concentrations in the active controls were 27 mg/L and 24 mg/L, respectively, for the shallow and intermediate depths (Table 3).

Low sulfate and nitrate concentrations throughout the study reflected a reduced environment from Day 0.

An initial manganese concentration of 140 µg/g was observed (SGS, Lakefield, Ontario) Aqueous ferrous iron in the Shallow and Intermediate groundwater was not detected at time 0. Refer to Appendix C for the Ferrous Iron Testing procedure and Appendix D for the External Laboratory Reports and Results.

Production of magnetic materials (indicative of ferric iron and/or ferrous oxide mineral) was observed in this study (Appendix E – photos) as well as in the published literature, to catalyze the abiotic reductive dechlorination of CTC to CF. The amount of material attracted to the magnet was not quantified; however all of the microcosms, including the anaerobic controls, appeared to contain magnetically susceptible materials – presumably magnetite. Additionally, the photos indicated that more magnetic material was observed on the non-sterile microcosms, than not. The photos also indicated that, visually, more magnetic material was present in the SRS/Ferrous iron bottles than any other. Darkening of the soil material typically associated with iron sulfide production was also observed.

3.1.1 Shallow Depth

In the shallow microcosms at Time 0, sulfate concentrations were approximately 27 mg/L. All of the treatments showed reduction of sulfate by Day 42 with the exception of the ZVI Amended/KB-1® Plus Bioaugmented microcosms and the SRS™/Ferrous Fumarate/KB-1® Plus Bioaugmented microcosms. Sulfate concentrations in both of these treatments remained stable. Nitrate concentrations, derived from the nutrient amendments, in the shallow depth microcosms at Time 0 were around 12 mg/L and decreased in all treatments by Day 42 to near non-detect levels.

Methane concentrations remained stable in the Sterile and Active controls indicating the absence of methanogenic microorganisms in the Site materials. Methane concentrations were observed to increase in all treatments. Increases in methane concentrations were approximately 25 times higher, on average, in the treatments that did not contain ZVI as follows:

SRS™/Ferrous Fumarate Amended/KB-1® Plus Bioaugmented, SRS™ Amended/ KB-1® Plus Bioaugmented and EHC®-L Amended/KB-1® Plus Bioaugmented Microcosms. Final methane concentrations were 11, 9.3 and 22 mg/L, respectively. These results suggest that methanogenic organisms were present in the microcosms and consumed a portion of the electron donor, and that the presence of ZVI and/or its reaction intermediates appeared to inhibit the formation of methane. The KB-1® Plus culture contains methanogens.

3.1.2 Intermediate Depth

In the intermediate microcosms at Time 0, sulfate concentrations were approximately 24 mg/L. Reduction to low levels was observed in all treatments by the Day 42 sampling event. Nitrate concentrations (again, derived from the addition of nutrients) in the intermediate depth microcosms at Time 0 were around 3.2 mg/L and decreased in all treatments by Day 42 to near non-detect levels.

Methane concentrations remained stable in the Sterile and Active controls indicating the absence of methanogenic microorganisms in the Site materials. Methane concentrations were observed to increase in all treatments with the greatest increases occurring in the following treatments: SRS™/Ferrous Fumarate Amended/KB-1® Plus Bioaugmented, SRS™ Amended/ KB-1® Plus Bioaugmented and EHC®-L Amended/KB-1® Plus Bioaugmented Microcosms. Final methane concentrations were 6.9, 6.1 and 5.5 mg/L, respectively. Final average methane concentrations in the ZVI amended treatments were observed to increase to only 0.11 mg/L, 0.18 mg/L, and 0.75 mg/L in the ZVI Amended/KB-1® Plus Bioaugmented, the SRS™/ZVI/Ferrous Fumarate Amended/KB-1® Bioaugmented, and the EHC®-L/ZVI Amended/KB-1® Plus Bioaugmented microcosms, respectively. These results suggest that methanogenic organisms were present in the microcosms and consumed a portion of the electron donor, and that the presence of ZVI appeared to inhibit the formation of methane. The KB-1® Plus culture contains methanogens.

The decrease in sulfate concentrations and increase in methane in the shallow and intermediate depth microcosms indicate that strongly reducing conditions required for cVOC dechlorination were achieved in the microcosms after electron donor addition and bioaugmentation with KB-1® Plus.

3.2 cVOC Biodegradation Results

All microcosms were spiked on Day 0 with CTC and TCE to target concentrations of 2 mg/L each, on Day 20 with CTC to 2 mg/L and on Day 90 (Shallow Depth only) with CTC and TCE to a target concentration of 2 mg/L each. Bioaugmentation with KB-1® Plus (CF formulation) occurred on Day 28 in all treatment microcosms. All microcosms, including the controls, were amended with 2 mL of a vitamin/mineral solution as previously outlined.

The following discussion of the cVOC biodegradation results will pair both the shallow and intermediate depths together as their results were similar.

Following review of the Day 113 results, it was decided, in consultation with Geosyntec and URS, to continue to sample the microcosms from the Shallow Depth and to put the microcosms from the Intermediate Depth on hold. This decision allowed additional spiking and sampling events for the Shallow Depth microcosms to further study the effects of bioaugmentation and amendment additions.

3.2.1 Sterile and Active Controls (Shallow and Intermediate Depth)

The cVOC concentrations in the Sterile and Active Control microcosms (Shallow Depth) remained generally stable for the duration of the study. A slight drop in CTC concentrations and a small increase in CF concentrations were observed in the Active Control microcosms. Unlike the Shallow Depth microcosms, CTC in the Active Control Microcosms from the Intermediate Depth samples was rapidly reduced to non-detect levels (no sterile controls were constructed for the Intermediate Depth treatments). Slight increases in both CF and DCM were also observed suggesting that some limited biological degradation may have occurred. TCE concentrations also declined; however, increases in cDCE were not stoichiometric and no production of VC or ethene was observed within the incubation period (Table 2 and Figures 5, 6 and 13). The CTC and TCE losses in the absence of strong indicators of biological activity may be due to abiotic reactions with mineral species, e.g., iron and magnetite, naturally present in the Site materials.

In summary, in the Shallow Depth microcosms, there was little mass loss in the sterile and active controls attributable to abiotic degradation or experimental losses (e.g., sorption or loss through microcosm closures) during the incubation period. The mass loss observed in the active controls from the Intermediate Depth microcosms was primarily due to abiotic reactions.

3.2.2 ZVI Amended/KB-1® Plus Bioaugmented Microcosms (Shallow and Intermediate depths)

Results from microcosms from both the shallow and intermediate depths amended with ZVI, demonstrated an initial reduction of CTC to non-detect levels without the production of biological daughter products (i.e., CF and DCM). TCE was also reduced in the microcosms following the first spike, with low concentrations of cDCE and VC observed throughout the duration of the incubation period. Following a second spiking of CTC into the microcosms on Day 20, CTC was once again reduced to non-detect levels; however, the degradation product, DCM, was observed and remained throughout the remainder of the incubation period (Table 2, Figures 7 and 14). Bioaugmentation with KB-1® Plus was not effective at reducing DCM concentrations in these microcosms. The rapid dechlorination by ZVI reduced the cVOC concentrations and the remaining low concentrations of DCM may not have been high enough to support biological activity. Alternatively, given that DCM accumulated only in the microcosms containing ZVI, it is possible that the initial abiotic degradation of CTC created toxic or inhibitory byproducts, e.g., the trichloromethyl free radical, that inhibited bacteria that may otherwise have degraded DCM.

A third spiking of CTC and TCE occurred on Day 90 (shallow depth only) to assess the reactivity of the ZVI in the microcosms. Both CTC and TCE were substantially reduced with some increases in both DCM and cDCE.

In summary, the cVOC results for the ZVI amended treatments suggest that amendment with ZVI alone was capable of promoting reduction of both CTC and TCE (Figures 7 and 14). However, ZVI did not effectively reduce DCM, and biological degradation, whether by intrinsic or bioaugmented microorganisms, was not an effective complement for the degradation of DCM.

This is in contrast to the amendments without ZVI where complete DCM degradation was observed.

3.2.3 SRS™/ZVI/Ferrous Fumarate Amended/KB-1® Bioaugmented Microcosms (Shallow and Intermediate depths)

Following the first spike, results from microcosms from both depths that were amended with SRS™, ZVI and a soluble iron in the form of ferrous fumarate demonstrated a reduction of CTC to non-detect without the production of degradation products. Following a second spiking of CTC into both the Shallow and Intermediate Depth microcosms on Day 20, CTC was once again reduced to non-detect levels; however, this time the degradation product DCM was observed. DCM remained throughout the incubation period. A slight decrease in the DCM concentration occurred following the bioaugmentation with KB-1® Plus (CF formulation).

TCE was reduced in the microcosms following the first spike, resulting in low concentrations of cDCE and VC. Following a second spike of TCE to the Shallow Depth microcosms, TCE decreased by the end of the incubation period without significant production of cDCE and VC.

Following a third spiking of CTC and TCE on Day 90 (shallow depth microcosms only) an initial increase and subsequent decrease in TCE was observed along with an increase in ethene. DCM was again observed to increase and remain stable.

These data (Figures 8 and 15) suggest that amendment with SRS™/ZVI and ferrous fumarate and bioaugmentation with KB-1® Plus was capable of promoting combined abiotic and biological reduction of both CTC and TCE but was not effective at reducing concentrations of DCM, potentially due to toxicity / inhibitory effects exhibited in all microcosms amended with ZVI as discussed in section 2.2.2 above.

3.2.4 SRS™/Ferrous Fumarate Amended/KB-1® Bioaugmented Microcosms (Shallow and Intermediate depths)

Results from microcosms from both depths that were amended with SRS™ and a soluble iron in the form of ferrous fumarate, demonstrated a reduction to non-detect levels of CTC (first spike) with the production of CF. Following a second CTC spiking event on Day 20, CTC was not detected and the CF concentration initially increased, and then decreased following the addition of KB-1® Plus on Day 28. Methane concentrations increased over the duration of the study to a final concentration of 11 mg/L in the Shallow Depth microcosms and 6.9 mg/L in the Intermediate Depth microcosms. A third spike of CTC and TCE (shallow depth only) resulted in increases in methane and ethene at the first sampling event (Day 104) following the spike.

TCE showed a slight decrease in concentration following the first spike. It was not until after bioaugmentation with KB-1® Plus culture that TCE concentrations decreased to non-detect with the production of both cDCE and VC. Ethene concentrations increased to 0.46 mg/L in the Shallow Depth microcosms and 0.22 mg/L in the Intermediate Depth microcosms. Following a second spike of TCE to the Shallow Depth microcosms, TCE decreased by the end of the incubation period with production of cDCE and VC, as well as an increase in ethene concentrations.

In summary, the cVOC results for the SRS™/Ferrous Fumarate Amended/KB-1® Bioaugmented microcosms suggest that amendment with SRS™ and ferrous fumarate and bioaugmentation with KB-1® Plus were capable of promoting combined abiotic and biological reduction of both CTC and TCE to non-chlorinated end products (Figures 9 and 16).

3.2.5 SRS™ Amended/KB-1® Bioaugmented Microcosms (Shallow and Intermediate depths)

Results from microcosms from both depths amended with SRS™ demonstrated reduction of CTC concentrations to non-detect after the first spike with production of CF. Following a second CTC spiking event on Day 20, CTC was not detected and CF did not increase. CF decreased following the addition of KB-1® Plus on Day 28, and DCM did not accumulate. Methane concentrations increased over the duration of the study to a final concentration of 9.3 mg/L in the Shallow Depth microcosms and 6.1 mg/L in the Intermediate Depth microcosms. A third spike of CTC and TCE (shallow depth only) produced trace amounts of cDCE, ethene and a further increase in methane.

TCE showed a slight decrease in concentration following the first spike. It was not until after bioaugmentation with KB-1® Plus culture that TCE decreased to non-detect levels with the production of both cDCE and VC. Ethene concentrations increased following decreases in cDCE and VC to 0.30 mg/L in the Shallow Depth microcosms and 0.26 mg/L in the Intermediate Depth microcosms.

In summary, the cVOC results for the SRS™ Amended/KB-1® Bioaugmented Microcosms suggest that amendment with SRS™ as an electron donor and KB-1® Plus promoted both abiotic and biological reduction of both CTC and TCE (Figures 10 and 17).

3.2.6 EHC®-L Amended/KB-1® Plus Bioaugmented Microcosms (Shallow and Intermediate depths)

Results from microcosms from both depths that were amended with EHC®-L demonstrated a reduction of CTC to non-detect levels with the production of CF. Following a second CTC spiking event on Day 20, CF and DCM concentrations increased. After the addition of KB-1® Plus on Day 28, both CF and DCM concentrations decreased, while methane concentrations increased. A methane concentration of 22 mg/L was reached in the Shallow Depth microcosms by the end of the study and 5.5 mg/L in the Intermediate Depth microcosms. A third spike of CTC (shallow depth only) resulted in production of trace amounts of cDCE and ethene and a further increase in methane concentrations.

In the Shallow depth treatment microcosms, TCE concentrations did not decline until after bioaugmentation with KB-1® Plus with the production of cDCE, VC and ethene. TCE concentrations declined initially in the intermediate depth microcosms with production of cDCE. TCE and cDCE were rapidly degraded after bioaugmentation with KB-1® Plus on Day 28, with the subsequent increase of ethene over the remainder of the incubation period. Following a second spike of TCE to the Shallow Depth microcosms, TCE was not detected while low concentrations of cDCE and VC, along with an increase in ethene were observed.

In summary, the cVOC results for the EHC®-L Amended/KB-1® Plus Bioaugmented Microcosms suggest that amendment with EHC®-L as an electron donor was capable of promoting both abiotic and biotic reduction of CTC with production of CF and partial TCE reduction to cDCE (Figures 11 and 18). Addition of KB-1® Plus promoted complete biological reduction of CF and reductive dechlorination of TCE to ethene.

3.2.7 EHC®-L/ZVI Amended/KB-1® Plus Bioaugmented Microcosms (Shallow and Intermediate depths)

Results of microcosms from both depths amended with both EHC®-L and ZVI demonstrated reduction of CTC to non-detectable levels without the production of chlorinated degradation products. Following a second spiking of CTC into the microcosms on Day 20, CTC was once again reduced to non-detectable levels; however, this time, DCM was observed and remained throughout the incubation period as was also observed in the ZVI only treatment. DCM concentrations declined slightly following bioaugmentation with KB-1® Plus. Following a third spiking of CTC on Day 90 (Shallow Depth only), DCM concentrations increased and subsequently slightly decreased. This observation suggests that the presence of ZVI was not effective at reducing concentrations of DCM, potentially due to toxicity / inhibitory effects exhibited in all microcosms amended with ZVI as discussed in section 2.2.2 above.

TCE concentrations decreased following the first spike with low concentrations of cDCE and ethene being produced. Following bioaugmentation with KB-1® Plus, cDCE concentrations decreased, however, no increases in ethene were observed. Following a second spike of TCE to the Shallow Depth microcosms, only an increase in ethene was observed, indicating the TCE was rapidly dechlorinated to ethene.

In summary, the cVOC results for the EHC®-L/ZVI Amended/KB-1® Plus Bioaugmented suggest that amendment with EHC®-L/ZVI as an electron donor was capable of promoting reduction of both CTC and TCE; however, DCM was not reduced, even with the addition of KB-1® Plus (Figures 12 and 19). Addition of KB-1® Plus promoted reductive dechlorination of TCE to ethene after the second TCE spike.

3.3 Degradation Half-Lives for cVOCs

cVOC half-lives were calculated based on the average dechlorination observed in the treatment microcosms. First order reaction kinetics were assumed for all calculations as described in Newell et al, 2002. The half-lives were calculated using the following relationship:

$$\text{Half-life} = \frac{\ln(2)}{\left[\frac{\ln\left(\frac{C_2}{C_1}\right)}{t_2 - t_1}\right]}$$

where,

C_1 is the concentration at early time (t_1 days)

C_2 is the concentration at later time (t_2 days)

Based on the data collected from each location, the dechlorination half-lives for CTC and TCE were calculated (Table 6). Half-lives of 225 and 343 days for CTC and TCE, respectively, were observed in the Shallow Depth sterile controls.

Losses of CTC observed in the Active controls are reflected in the half-life values of 93 days for the Shallow Depth location and 2.4 days for the Intermediate Depth location. CTC was degraded before bioaugmentation and its half-life was less than one day in all treatments (Table 6) for both locations. TCE half-life values in the Active controls were 724 days for the Shallow Depth location and 41 days for the Intermediate Depth location. Losses of TCE were observed in all treatments and were quantified before and after bioaugmentation. TCE half-life values before bioaugmentation ranged from 4.9 to 294 days in the various treatments and from 3.1 to 7.9 days after bioaugmentation (Table 6). TCE half-lives decreased in the treatments after bioaugmentation.

3.4 VFAs

Increased concentrations of total volatile fatty acids (Table 3) were observed in all treatment microcosms from Day 0 to Day 42, specifically increases in acetate, propionate and butyrate (Table 4). Acetate increased nominally in the ZVI only treatments. The largest increases in VFAs were observed in the SRS™ and EHC®-L amended treatments as expected. SRS™ contains 4% sodium lactate, providing a soluble and easily fermentable electron donor source to increase microbial activity when initially added. The fermentation of both lactate and soybean oil in SRS™ and soluble organic carbon in EHC®-L results in the production of hydrogen, which is the electron donor ultimately used by dechlorinating bacteria.

These results suggest that fermentation of the added electron donors occurred, and was at no time, rate-limiting throughout the study.

3.5 pH Results

The pH was monitored in all controls and treatment microcosms over the incubation period (Table 5) for both Site locations.

3.5.1 Shallow Depth

The initial pH of the groundwater in the constructed microcosms was approximately 6.58. The pH of the sterile and active controls remained relatively unchanged over the incubation period dropping slightly to 6.43 and 6.52, respectively. Throughout the incubation period and after several re-spikes, most pH values in the treatment microcosms dropped to around pH 6.3 and remained stable to Day 123. Both treatments amended with ZVI (ZVI and EHC®-L/ZVI) had final pH values slightly above the other treatments and closer to those values recorded from the controls at 6.51 and 6.58, respectively.

3.5.2 Intermediate Depth

The initial pH of the groundwater in the constructed microcosms was approximately 6.67. The pH of the active controls decreased slightly over the incubation period to 6.38. Throughout the incubation period and after only one re-spike, the pH values for most of the treatment microcosms decreased to around 6.3 where they remained stable to Day 74. Both treatments amended with ZVI (ZVI and EHC®-L/ZVI) had slight increases to 7.01 and 6.77 over the incubation period, respectively.

These data indicate that the acid buffering properties of the Site groundwater were sufficient to maintain a pH just below neutral during reductive dechlorination and electron donor fermentation (both acid producing processes) for both Site locations. The optimum pH for reductive dechlorination is 6.8 to 7.5 (Middledorp et al., 1999) and complete dechlorination can occur between a pH range of 6.0 and 8.0 (SiREM, unpublished data).

4. CONCLUSIONS

The following conclusions can be drawn from the laboratory biotreatability study results:

1. Abiotic degradation of CTC and TCE under intrinsic conditions was observed at the Intermediate depth location only, suggesting that naturally occurring reduced minerals were capable of promoting conditions suitable for abiotic degradation.

2. ZVI amendment promoted rapid abiotic degradation of CTC and TCE in both the Shallow and Intermediate Depth locations with some production of DCM, which was not further degraded with the amendment of electron donor or bioaugmentation culture. The presence of ZVI or its degradation intermediates appeared to inhibit the biodegradation of DCM by KB-1® Plus. The ZVI amendment continued to promote rapid abiotic degradation following multiple additions of CTC and TCE.

3. The addition of a slow release electron donor (i.e., SRS™) both with and without added soluble iron and the KB-1® Plus bioaugmentation culture promoted both abiotic and biological degradation of the cVOCs to non-detectable concentrations in both the Shallow and Intermediate Depth locations.

4. The addition of EHC®-L (which contains soluble iron) and the KB-1® Plus bioaugmentation culture promoted both abiotic and biological degradation of the cVOCs to non-detectable concentrations in both the Shallow and Intermediate Depth locations.

5. The addition of KB-1® Plus resulted in reductive dechlorination of chlorinated ethenes to ethene and reductive dechlorination and fermentation of chlorinated methanes to non-chlorinated end products.

6. pH adjustment was not required to maintain the pH in the desired range for dechlorination (6.0 to 8.0).

7. Production of magnetic materials (indicative of ferrous/ferric iron oxide mineral) was observed in this study.

The results of this study indicate that both SRS™ with and without the addition of a soluble iron source (ferrous fumarate or ferrous gluconate) and EHC®-L in combination with a vitamin/mineral amendment and with KB-1® Plus bioaugmentation has the potential to be an effective remedial approach for the Site.

5. REFERENCES

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TABLES

TABLE 1A: SUMMARY OF DECHLORINATION ASSAY CONTROL, TREATMENT AND AMENDMENTS (SHALLOW DEPTH)
Elkhart, Indiana

Zone	Treatment/Control	Assigned Bottle Number	Number of Microcosms	Geologic Material (g)	Groundwater (mL)	Headspace (mL)	Sodium Azide	Mercuric Chloride	Rezasurin	VOCs	Vitamin/Mineral Solution	ZVI	SRS®	Soluble Iron	EHC®-L	KB-1® Plus
Shallow Depth	Anaerobic Sterile Control	1 to 3	3	60	200	20	Amended with 0.5 mL of a 5% solution.	Amended with 2.8 mL of a 2.7% solution	Amended Replicate #1 with 100 µL of a 1,000 mg/L solution on Day 0.	Spiked with 397 µL of saturated CTC solution and with 562 µL of saturated TCE solution to target 2 mg/L of both compounds on Day -1.	Amended with 2 mL of a vitamin/mineral solution on Day 0.	NA	NA	NA	NA	NA
	Anaerobic Active Control	4 to 6	3	60	200	20	NA	NA	Amended Replicate #1 with 100 µL of a 1,000 mg/L solution on Day 0.	Spiked with 397 µL of saturated CTC solution and with 562 µL of saturated TCE solution to target 2 mg/L of both compounds on Day -1. Re-spiked with CTC to a target concentration of 2 mg/L on Day 20.	Amended with 2 mL of a vitamin/mineral solution on Day 0.	NA	NA	NA	NA	NA
	ZVI Amended/KB-1® Plus Bioaugmented	7 to 9	3	60	200	20	NA	NA	Amended Replicate #1 with 100 µL of a 1,000 mg/L solution on Day 0.	Spiked with 397 µL of saturated CTC solution and with 562 µL of saturated TCE solution to target 2 mg/L of both compounds on Day -1. Re-spiked with CTC to a target concentration of 2 mg/L on Day 20 and Day 90 and with TCE to a target concentration of 2 mg/L on Day 90.	Amended with 2 mL of a vitamin/mineral solution on Day 0.	Amended with 1.0 g of ZVI to target a final target concentration of 5g/L on Day 0.	NA	NA	NA	Bioaugmented with KB-1® Plus on Day 28.
	SRS®/ZVI and Ferrous Fumarate Amended/KB-1® Plus Bioaugmented	10 to 12	3	60	200	20	NA	NA	Amended Replicate #1 with 100 µL of a 1,000 mg/L solution on Day 0.	Spiked with 397 µL of saturated CTC solution and with 562 µL of saturated TCE solution to target 2 mg/L of both compounds on Day -1. Re-spiked with CTC to a target concentration of 2 mg/L on Day 20 and Day 90 and with TCE to a target concentration of 2 mg/L on Day 90.	Amended with 2 mL of a vitamin/mineral solution on Day 0.	Amended with 1.0 g of ZVI to target a final target concentration of 5g/L on Day 0.	Amended with 333 µL to target a final concentration of 0.1 % as oil on Day 0.	Amended with 36 mg of ferrous fumarate to target a final concentration of 180 mg/L on Day 7.	NA	Bioaugmented with KB-1® Plus on Day 28.
	SRS® and Ferrous Fumarate Amended/KB-1® Plus Bioaugmented	13 to 15	3	60	200	20	NA	NA	Amended Replicate #1 with 100 µL of a 1,000 mg/L solution on Day 0.	Spiked with 397 µL of saturated CTC solution and with 562 µL of saturated TCE solution to target 2 mg/L of both compounds on Day -1. Re-spiked with CTC to a target concentration of 2 mg/L on Day 20 and Day 90 and with TCE to a target concentration of 2 mg/L on Day 90.	Amended with 2 mL of a vitamin/mineral solution on Day 0.	NA	Amended with 333 µL to target a final concentration of 0.1 % as oil on Day 0.	Amended with 36 mg of ferrous fumarate to target a final concentration of 180 mg/L on Day 0.	NA	Bioaugmented with KB-1® Plus on Day 28.
	SRS® Amended/KB-1® Plus Bioaugmented	16 to 18	3	60	200	20	NA	NA	Amended Replicate #1 with 100 µL of a 1,000 mg/L solution on Day 0.	Spiked with 397 µL of saturated CTC solution and with 562 µL of saturated TCE solution to target 2 mg/L of both compounds on Day -1. Re-spiked with CTC to a target concentration of 2 mg/L on Day 20 and Day 90 and with TCE to a target concentration of 2 mg/L on Day 90.	Amended with 2 mL of a vitamin/mineral solution on Day 0.	NA	Amended with 333 µL to target a final concentration of 0.1 % as oil on Day 0.	NA	NA	Bioaugmented with KB-1® Plus on Day 28.
	EHC®-L Amended/KB-1® Plus Bioaugmented	19 to 21	3	60	200	20	NA	NA	Amended Replicate #1 with 100 µL of a 1,000 mg/L solution on Day 0.	Spiked with 397 µL of saturated CTC solution and with 562 µL of saturated TCE solution to target 2 mg/L of both compounds on Day -1. Re-spiked with CTC to a target concentration of 2 mg/L on Day 20 and Day 90 and with TCE to a target concentration of 2 mg/L on Day 90.	Amended with 2 mL of a vitamin/mineral solution on Day 0.	NA	NA	NA	Amended with 1.4 mL of EHC-L to target a final concentration of 1 g/L on Day 0.	Bioaugmented with KB-1® Plus on Day 28.
	EHC®-L and ZVI Amended/KB-1® Plus Bioaugmented	22 to 24	3	60	200	20	NA	NA	Amended Replicate #1 with 100 µL of a 1,000 mg/L solution on Day 0.	Spiked with 397 µL of saturated CTC solution and with 562 µL of saturated TCE solution to target 2 mg/L of both compounds on Day -1. Re-spiked with CTC to a target concentration of 2 mg/L on Day 20 and Day 90 and with TCE to a target concentration of 2 mg/L on Day 90.	Amended with 2 mL of a vitamin/mineral solution on Day 0.	Amended with 1.0 g of ZVI to target a final target concentration of 5g/L on Day 0.	NA	NA	Amended with 1.4 mL of EHC-L to target a final concentration of 1 g/L on Day 0.	Bioaugmented with KB-1® Plus on Day 28.

Notes:

% - percent
µL - microliters
CF - chloroform
CTC - carbon tetrachloride
g - grams
g/L - grams per liter
mg/L - milligrams per liter
mL - milliliters
NA - not applicable
TCE - trichloroethene
VOCs - volatile organic compounds

TABLE 1B: SUMMARY OF DECHLORINATION ASSAY CONTROL, TREATMENT AND AMENDMENTS (INTERMEDIATE DEPTH)
Elkhart, Indiana

Zone	Treatment/Control	Assigned Bottle Number	Number of Microcosms	Geologic Material (g)	Groundwater (mL)	Headspace (mL)	Sodium Azide	Mercuric Chloride	Rezasurin	VOCs	Vitamin/Mineral Solution	ZVI	SRS®	Soluble Iron	EHC®-L	KB-1® Plus
Intermediate Depth	Anaerobic Active Control	25 to 27	3	60	200	20	NA	NA	Amended Replicate #1 with 100 µL of a 1,000 mg/L solution on Day 0.	Spiked with 397 µL of saturated CTC solution and with 562 µL of saturated TCE solution to target 2 mg/L of both compounds on Day -1. Re-spiked with CTC to a target concentration of 2 mg/L on Day 20.	Amended with 2 mL of a vitamin/mineral solution on Day 0.	NA	NA	NA	NA	NA
	ZVI Amended/KB-1® Plus Bioaugmented	28 to 30	3	60	200	20	NA	NA	Amended Replicate #1 with 100 µL of a 1,000 mg/L solution on Day 0.	Spiked with 397 µL of saturated CTC solution and with 562 µL of saturated TCE solution to target 2 mg/L of both compounds on Day -1. Re-spiked with CTC to a target concentration of 2 mg/L on Day 20.	Amended with 2 mL of a vitamin/mineral solution on Day 0.	Amended with 1.0 g of ZVI to target a final target concentration of 5g/L on Day 0.	NA	NA	NA	Bioaugmented with KB-1® Plus on Day 28.
	SRS®/ZVI and Ferrous Fumarate Amended/KB-1® Plus Bioaugmented	31 to 33	3	60	200	20	NA	NA	Amended Replicate #1 with 100 µL of a 1,000 mg/L solution on Day 0.	Spiked with 397 µL of saturated CTC solution and with 562 µL of saturated TCE solution to target 2 mg/L of both compounds on Day -1. Re-spiked with CTC to a target concentration of 2 mg/L on Day 20.	Amended with 2 mL of a vitamin/mineral solution on Day 0.	Amended with 1.0 g of ZVI to target a final target concentration of 5g/L on Day 0.	Amended with 333 µL to target a final concentration of 0.1 % as oil on Day 0.	Amended with 36 mg of fumerous fumarate to target a final concentration of 180 mg/L on Day 7.	NA	Bioaugmented with KB-1® Plus on Day 28.
	SRS® and Ferrous Fumarate Amended/KB-1® Plus Bioaugmented	34 to 36	3	60	200	20	NA	NA	Amended Replicate #1 with 100 µL of a 1,000 mg/L solution on Day 0.	Spiked with 397 µL of saturated CTC solution and with 562 µL of saturated TCE solution to target 2 mg/L of both compounds on Day -1. Re-spiked with CTC to a target concentration of 2 mg/L on Day 20.	Amended with 2 mL of a vitamin/mineral solution on Day 0.	NA	Amended with 333 µL to target a final concentration of 0.1 % as oil on Day 0.	Amended with 36 mg of fumerous fumarate to target a final concentration of 180 mg/L on Day 0.	NA	Bioaugmented with KB-1® Plus on Day 28.
	SRS® Amended/KB-1® Plus Bioaugmented	37 to 39	3	60	200	20	NA	NA	Amended Replicate #1 with 100 µL of a 1,000 mg/L solution on Day 0.	Spiked with 397 µL of saturated CTC solution and with 562 µL of saturated TCE solution to target 2 mg/L of both compounds on Day -1. Re-spiked with CTC to a target concentration of 2 mg/L on Day 20.	Amended with 2 mL of a vitamin/mineral solution on Day 0.	NA	Amended with 333 µL to target a final concentration of 0.1 % as oil on Day 0.	NA	NA	Bioaugmented with KB-1® Plus on Day 28.
	EHC®-L Amended/KB-1® Plus Bioaugmented	40 to 42	3	60	200	20	NA	NA	Amended Replicate #1 with 100 µL of a 1,000 mg/L solution on Day 0.	Spiked with 397 µL of saturated CTC solution and with 562 µL of saturated TCE solution to target 2 mg/L of both compounds on Day -1. Re-spiked with CTC to a target concentration of 2 mg/L on Day 20.	Amended with 2 mL of a vitamin/mineral solution on Day 0.	NA	NA	NA	Amended with 1.4 mL of EHC-L to target a final concentration of 1 g/L on Day 0.	Bioaugmented with KB-1® Plus on Day 28.
	EHC®-L and ZVI Amended/KB-1® Plus Bioaugmented	43 to 45	3	60	200	20	NA	NA	Amended Replicate #1 with 100 µL of a 1,000 mg/L solution on Day 0.	Spiked with 397 µL of saturated CTC solution and with 562 µL of saturated TCE solution to target 2 mg/L of both compounds on Day -1. Re-spiked with CTC to a target concentration of 2 mg/L on Day 20.	Amended with 2 mL of a vitamin/mineral solution on Day 0.	Amended with 1.0 g of ZVI to target a final target concentration of 5g/L on Day 0.	NA	NA	Amended with 1.4 mL of EHC-L to target a final concentration of 1 g/L on Day 0.	Bioaugmented with KB-1® Plus on Day 28.

Notes:

% - percent
µL - microliters
CF - chloroform
CTC - carbon tetrachloride
g - grams
g/L - grams per liter
mg/L - milligrams per liter
mL - milliliters
NA - not applicable
TCE - trichloroethene
VOCs - volatile organic compounds

Treatment	Date	Day	Replicate	Chlorinated Ethenes					Chlorinated Ethanes						Comment
				TCE	cDCE	VC	Ethene	Total Ethenes	Ethane	CTC	CF	DCM	CM	Methane	
				mg/L	mg/L	mg/L	mg/L	mmol/bottle	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	
Anaerobic Sterile Control	27-Mar-14	-1													Spiked with TCE and CTC to target concentrations of 2 mg/L each.
(Shallow)	28-Mar-14	0													Amended the first replicate with 100 uL of resazurin.
															Amended with 2 mL of a vitamin/mineral solution.
															Poisoned with mecuric chloride and sodium azide.
			ANSC (Shallow)-1	3.2	<0.020	<0.020	<0.020	--	<0.020	1.4	<0.020	<0.020	<0.020	0.043	
			ANSC (Shallow)-2	3.1	<0.020	<0.020	<0.020	--	<0.020	1.3	<0.020	<0.020	<0.020	0.041	
			ANSC (Shallow)-3	3.0	<0.020	<0.020	<0.020	--	<0.020	1.3	<0.020	<0.020	<0.020	0.041	
			Average Concentration (mg/L)	3.1	ND	ND	ND	--	ND	1.3	ND	ND	ND	0.042	
			Standard Deviation (mmoles)	1.2E-04	0.0E+00	0.0E+00	0.0E+00	--	0.0E+00	8.7E-05	0.0E+00	0.0E+00	0.0E+00	5.5E-05	
			Average Total mmoles	**0.0050**	**ND**	**ND**	**ND**	**5.0E-03**	**ND**	**0.0019**	**ND**	**ND**	**ND**	**0.0019**	
	04-Apr-14	7	ANSC (Shallow)-1	2.6	<0.020	<0.020	<0.020	--	<0.020	1.0	<0.020	<0.020	<0.020	0.041	
			ANSC (Shallow)-2	2.7	<0.020	<0.020	<0.020	--	<0.020	1.1	<0.020	<0.020	<0.020	0.039	
			ANSC (Shallow)-3	2.8	<0.020	<0.020	<0.020	--	<0.020	1.1	0.044	<0.020	<0.020	0.039	
			Average Concentration (mg/L)	2.7	ND	ND	ND	--	ND	1.1	0.015	ND	ND	0.040	
			Standard Deviation (mmoles)	2.0E-04	0.0E+00	0.0E+00	0.0E+00	--	0.0E+00	9.6E-05	4.3E-05	0.0E+00	0.0E+00	4.4E-05	
			Average Total mmoles	**0.0043**	**ND**	**ND**	**ND**	**4.3E-03**	**ND**	**0.0015**	**0.000025**	**ND**	**ND**	**0.0018**	
	25-Apr-14	28	ANSC (Shallow)-1	2.4	<0.020	<0.020	<0.020	--	<0.020	0.97	<0.020	<0.020	<0.020	0.044	
			ANSC (Shallow)-2	2.7	<0.020	<0.020	<0.020	--	<0.020	1.1	<0.020	<0.020	<0.020	0.051	
			ANSC (Shallow)-3	2.7	<0.020	<0.020	<0.020	--	<0.020	1.1	<0.020	<0.020	<0.020	0.046	
			Average Concentration (mg/L)	2.6	ND	ND	ND	--	ND	1.1	ND	ND	ND	0.047	
			Standard Deviation (mmoles)	1.9E-04	0.0E+00	0.0E+00	0.0E+00	--	0.0E+00	1.1E-04	0.0E+00	0.0E+00	0.0E+00	1.7E-04	
			Average Total mmoles	**0.0041**	**ND**	**ND**	**ND**	**4.1E-03**	**ND**	**0.0015**	**ND**	**ND**	**ND**	**0.0022**	
	23-May-14	56	ANSC (Shallow)-1	2.2	<0.020	<0.020	<0.020	--	<0.020	0.78	<0.020	<0.020	<0.020	0.054	
			ANSC (Shallow)-2	2.4	<0.020	<0.020	<0.020	--	<0.020	0.98	<0.020	<0.020	<0.020	0.042	
			ANSC (Shallow)-3	2.6	<0.020	<0.020	<0.020	--	<0.020	1.0	<0.020	<0.020	<0.020	0.041	
			Average Concentration (mg/L)	2.4	ND	ND	ND	--	ND	0.92	ND	ND	ND	0.046	
			Standard Deviation (mmoles)	2.8E-04	0.0E+00	0.0E+00	0.0E+00	--	0.0E+00	1.8E-04	0.0E+00	0.0E+00	0.0E+00	3.4E-04	
			Average Total mmoles	**0.0038**	**ND**	**ND**	**ND**	**3.8E-03**	**ND**	**0.0013**	**ND**	**ND**	**ND**	**0.0021**	
	29-Jul-14	123	ANSC (Shallow)-1	2.2	<0.020	<0.020	<0.020	--	<0.020	0.71	<0.020	<0.020	<0.020	0.057	
			ANSC (Shallow)-2	2.5	<0.020	<0.020	<0.020	--	<0.020	1.1	<0.020	<0.020	<0.020	0.043	
			ANSC (Shallow)-3	2.6	<0.020	<0.020	<0.020	--	<0.020	1.1	<0.020	<0.020	<0.020	0.056	
			Average Concentration (mg/L)	2.4	ND	ND	ND	--	ND	0.95	ND	ND	ND	0.052	
			Standard Deviation (mmoles)	3.3E-04	0.0E+00	0.0E+00	0.0E+00	--	0.0E+00	2.9E-04	0.0E+00	0.0E+00	0.0E+00	3.7E-04	
			Average Total mmoles	**0.0039**	**ND**	**ND**	**ND**	**4.0E-03**	**ND**	**0.0013**	**ND**	**ND**	**ND**	**0.0024**	
Anaerobic Active Control	27-Mar-14	-1													Spiked with TCE and CTC to target concentrations of 2 mg/L each.
(Shallow)	28-Mar-14	0													Amended with 2 mL of a vitamin/mineral solution.
															Amended the first replicate with 100 uL of resazurin.
			ANAC (Shallow)-1	3.4	<0.020	<0.020	<0.020	--	<0.020	1.4	<0.020	<0.020	<0.020	0.043	
			ANAC (Shallow)-2	3.4	<0.020	<0.020	<0.020	--	<0.020	1.4	<0.020	<0.020	<0.020	0.045	
			ANAC (Shallow)-3	3.3	<0.020	<0.020	<0.020	--	<0.020	1.5	<0.020	<0.020	<0.020	0.047	
			Average Concentration (mg/L)	3.4	ND	ND	ND	--	ND	1.4	ND	ND	ND	0.045	
			Standard Deviation (mmoles)	1.2E-04	0.0E+00	0.0E+00	0.0E+00	--	0.0E+00	6.9E-05	0.0E+00	0.0E+00	0.0E+00	9.4E-05	
			Average Total mmoles	**0.0054**	**ND**	**ND**	**ND**	**5.4E-03**	**ND**	**0.0020**	**ND**	**ND**	**ND**	**0.0021**	
	04-Apr-14	7	ANAC (Shallow)-1	3.2	<0.020	<0.020	<0.020	--	<0.020	1.1	<0.020	<0.020	<0.020	0.040	
			ANAC (Shallow)-2	3.1	<0.020	<0.020	<0.020	--	<0.020	1.2	0.020	<0.020	<0.020	0.042	
			ANAC (Shallow)-3	3.0	<0.020	<0.020	<0.020	--	<0.020	1.2	0.023	<0.020	<0.020	0.044	
			Average Concentration (mg/L)	3.1	ND	ND	ND	--	ND	1.2	0.014	ND	ND	0.042	
			Standard Deviation (mmoles)	1.5E-04	0.0E+00	0.0E+00	0.0E+00	--	0.0E+00	7.9E-05	2.1E-05	0.0E+00	0.0E+00	9.7E-05	
			Average Total mmoles	**0.0050**	**ND**	**ND**	**ND**	**5.0E-03**	**ND**	**0.0017**	**0.000024**	**ND**	**ND**	**0.0019**	
	17-Apr-14	20	ANAC (Shallow)-1	3.1	0.022	<0.020	<0.020	--	<0.020	0.99	0.030	<0.020	<0.020	0.047	
			ANAC (Shallow)-2	3.4	<0.020	<0.020	<0.020	--	<0.020	1.2	0.054	<0.020	<0.020	0.046	
			ANAC (Shallow)-3	3.2	<0.020	<0.020	<0.020	--	<0.020	1.3	0.059	<0.020	<0.020	0.048	
			Average Concentration (mg/L)	3.2	0.0074	ND	ND	--	ND	1.2	0.048	ND	ND	0.047	
			Standard Deviation (mmoles)	2.0E-04	2.7E-05	0.0E+00	0.0E+00	--	0.0E+00	2.1E-04	2.6E-05	0.0E+00	0.0E+00	3.4E-05	
			Average Total mmoles	**0.0052**	**0.000016**	**ND**	**ND**	**5.2E-03**	**ND**	**0.0016**	**0.000081**	**ND**	**ND**	**0.0022**	
															Spiked with CTC to target concentrations of 2 mg/L.
	25-Apr-14	28	ANAC (Shallow)-1	3.0	0.42	<0.020	<0.020	--	<0.020	1.2	0.024	<0.020	<0.020	0.050	
			ANAC (Shallow)-2	3.0	<0.020	<0.020	<0.020	--	<0.020	1.1	0.031	0.021	<0.020	0.043	
			ANAC (Shallow)-3	2.9	<0.020	<0.020	<0.020	--	<0.020	1.2	0.032	<0.020	<0.020	0.050	
			Average Concentration (mg/L)	3.0	0.14	ND	ND	--	ND	1.2	0.029	0.0070	ND	0.048	
			Standard Deviation (mmoles)	7.4E-05	5.1E-04	0.0E+00	0.0E+00	--	0.0E+00	4.2E-05	7.8E-06	3.0E-05	0.0E+00	1.8E-04	
			Average Total mmoles	**0.0048**	**0.00030**	**ND**	**ND**	**5.1E-03**	**ND**	**0.0016**	**0.000050**	**0.000017**	**ND**	**0.0022**	

Treatment	Date	Day	Replicate	Chlorinated Ethenes					Chlorinated Ethanes						Comment
				TCE	cDCE	VC	Ethene	Total Ethenes	Ethane	CTC	CF	DCM	CM	Methane	
				mg/L	mg/L	mg/L	mg/L	mmol/bottle	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	
Anaerobic Active Control	23-May-14	56	ANAC (Shallow)-1	2.9	0.038	<0.020	<0.020	--	<0.020	0.98	0.025	0.025	<0.020	0.041	
(Shallow)			ANAC (Shallow)-2	3.1	<0.020	<0.020	<0.020	--	<0.020	1.2	0.024	0.025	<0.020	0.042	
Continued			ANAC (Shallow)-3	2.8	<0.020	<0.020	<0.020	--	<0.020	1.1	0.024	0.023	<0.020	0.043	
			Average Concentration (mg/L)	3.0	0.013	ND	ND	--	ND	1.1	0.024	0.024	ND	0.042	
			Standard Deviation (mmoles)	2.3E-04	4.7E-05	0.0E+00	0.0E+00	--	0.0E+00	1.5E-04	9.1E-07	3.9E-06	0.0E+00	4.8E-05	
			Average Total mmoles	**0.0047**	**0.000027**	**ND**	**ND**	**4.7E-03**	**ND**	**0.0015**	**0.000042**	**0.00006**	**ND**	**0.0020**	
	29-Jul-14	123	ANAC (Shallow)-1	3.0	0.051	<0.020	<0.020	--	<0.020	0.86	0.040	0.034	<0.020	0.055	
			ANAC (Shallow)-2	3.1	<0.020	<0.020	<0.020	--	<0.020	0.84	0.065	0.030	<0.020	0.045	
			ANAC (Shallow)-3	2.9	<0.020	<0.020	<0.020	--	<0.020	<0.020	0.11	0.028	<0.020	0.051	
			Average Concentration (mg/L)	3.0	0.017	ND	ND	--	ND	0.57	0.070	0.031	ND	0.050	
			Standard Deviation (mmoles)	1.9E-04	6.3E-05	0.0E+00	0.0E+00	--	0.0E+00	6.9E-04	5.6E-05	7.2E-06	0.0E+00	2.2E-04	
			Average Total mmoles	**0.0048**	**0.000036**	**ND**	**ND**	**4.8E-03**	**ND**	**0.00080**	**0.00012**	**0.000075**	**ND**	**0.0023**	
ZVI Amended/KB-1® Plus Bioaugmented	27-Mar-14	-1													Spiked with TCE and CTC to target concentrations of 2 mg/L each.
(Shallow)	28-Mar-14	0													Amended the first replicate with 100 uL of resazurin.
															Amended with 2 mL of a vitamin/mineral solution.
															Amended with 1 g of ZVI to target a final concentration of 5 g/L.
			ZVI (Shallow)-1	3.2	<0.020	<0.020	<0.020	--	<0.020	1.4	<0.020	<0.020	<0.020	0.051	
			ZVI (Shallow)-2	3.3	<0.020	<0.020	<0.020	--	<0.020	1.4	<0.020	<0.020	<0.020	0.055	
			ZVI (Shallow)-3	3.3	<0.020	<0.020	<0.020	--	<0.020	2.0	0.31	<0.020	<0.020	0.052	
			Average Concentration (mg/L)	3.3	ND	ND	ND	--	ND	1.6	0.10	ND	ND	0.052	
			Standard Deviation (mmoles)	1.3E-04	0.0E+00	0.0E+00	0.0E+00	--	0.0E+00	5.1E-04	3.0E-04	0.0E+00	0.0E+00	1.1E-04	
			Average Total mmoles	**0.0052**	**ND**	**ND**	**ND**	**5.2E-03**	**ND**	**0.0023**	**0.00018**	**ND**	**ND**	**0.0024**	
	04-Apr-14	7	ZVI (Shallow)-1	2.2	<0.020	<0.020	0.046	--	0.037	<0.020	<0.020	<0.020	<0.020	0.083	
			ZVI (Shallow)-2	1.8	0.031	<0.020	0.034	--	<0.020	<0.020	<0.020	<0.020	<0.020	0.065	
			ZVI (Shallow)-3	2.2	0.11	<0.020	0.059	--	0.036	<0.020	<0.020	<0.020	<0.020	0.081	
			Average Concentration (mg/L)	2.1	0.047	ND	0.046	--	0.024	ND	ND	ND	ND	0.076	
			Standard Deviation (mmoles)	3.5E-04	1.2E-04	0.0E+00	1.7E-04	--	4.2E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	4.6E-04	
			Average Total mmoles	**0.0033**	**0.00010**	**ND**	**0.00061**	**4.0E-03**	**0.00048**	**ND**	**ND**	**ND**	**ND**	**0.0035**	
	17-Apr-14	20	ZVI (Shallow)-1	0.89	0.028	<0.020	0.10	--	0.056	<0.020	<0.020	<0.020	<0.020	0.094	
			ZVI (Shallow)-2	1.1	0.031	<0.020	0.09	--	0.046	<0.020	<0.020	<0.020	<0.020	0.091	
			ZVI (Shallow)-3	0.78	0.21	<0.020	0.10	--	0.090	<0.020	<0.020	<0.020	<0.020	0.10	
			Average Concentration (mg/L)	0.93	0.088	ND	0.098	--	0.064	ND	ND	ND	ND	0.096	
			Standard Deviation (mmoles)	2.8E-04	2.2E-04	0.0E+00	9.7E-05	--	4.6E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	3.1E-04	
			Average Total mmoles	**0.0015**	**0.00019**	**ND**	**0.0013**	**3.0E-03**	**0.0013**	**ND**	**ND**	**ND**	**ND**	**0.0045**	
															Spiked with CTC to target concentrations of 2 mg/L.
	25-Apr-14	28	ZVI (Shallow)-1	0.33	0.020	<0.020	0.11	--	0.067	<0.020	<0.020	0.41	0.031	0.14	
			ZVI (Shallow)-2	0.55	0.026	<0.020	0.15	--	0.13	<0.020	<0.020	0.45	<0.020	0.40	
			ZVI (Shallow)-3	0.25	0.25	<0.020	0.12	--	0.10	0.21	<0.020	0.45	0.029	0.10	
			Average Concentration (mg/L)	0.38	0.10	ND	0.13	--	0.10	0.068	ND	0.43	0.020	0.21	
			Standard Deviation (mmoles)	2.5E-04	2.8E-04	0.0E+00	2.4E-04	--	6.5E-04	1.7E-04	0.0E+00	4.9E-05	6.9E-05	7.4E-03	
			Average Total mmoles	**0.00060**	**0.00021**	**ND**	**0.0017**	**2.5E-03**	**0.0020**	**0.000096**	**ND**	**0.0011**	**0.000079**	**0.010**	
															Bioaugmented with KB-1® Plus (CF formulation).
	09-May-14	42	ZVI (Shallow)-1	0.069	<0.020	<0.020	0.12	--	0.065	<0.020	<0.020	0.33	0.023	0.11	
			ZVI (Shallow)-2	0.25	0.022	<0.020	0.12	--	0.053	<0.020	<0.020	0.35	0.022	0.091	
			ZVI (Shallow)-3	0.028	0.30	<0.020	0.13	--	0.11	<0.020	<0.020	0.38	0.027	0.10	
			Average Concentration (mg/L)	0.11	0.11	ND	0.13	--	0.076	ND	ND	0.35	0.024	0.10	
			Standard Deviation (mmoles)	1.8E-04	3.5E-04	0.0E+00	8.1E-05	--	5.9E-04	0.0E+00	0.0E+00	7.1E-05	1.2E-05	4.8E-04	
			Average Total mmoles	**0.00018**	**0.00023**	**ND**	**0.0017**	**2.1E-03**	**0.0015**	**ND**	**ND**	**0.00086**	**0.000096**	**0.0047**	
	23-May-14	56	ZVI (Shallow)-1	<0.020	<0.020	<0.020	0.12	--	0.063	<0.020	<0.020	0.25	0.023	0.098	
			ZVI (Shallow)-2	0.084	0.029	<0.020	0.13	--	0.067	<0.020	<0.020	0.28	0.024	0.12	
			ZVI (Shallow)-3	<0.020	0.28	<0.020	0.13	--	0.12	<0.020	<0.020	0.33	0.025	0.12	
			Average Concentration (mg/L)	0.028	0.10	ND	0.13	--	0.083	ND	ND	0.29	0.024	0.11	
			Standard Deviation (mmoles)	7.7E-05	3.3E-04	0.0E+00	1.2E-04	--	6.1E-04	0.0E+00	0.0E+00	1.0E-04	4.7E-06	4.9E-04	
			Average Total mmoles	**0.000045**	**0.00022**	**ND**	**0.0017**	**2.0E-03**	**0.0016**	**ND**	**ND**	**0.00071**	**0.000096**	**0.0051**	
	10-Jun-14	74	ZVI (Shallow)-1	<0.020	<0.020	<0.020	0.11	--	0.076	<0.020	<0.020	0.19	<0.020	0.17	
			ZVI (Shallow)-2	0.031	<0.020	<0.020	0.12	--	0.074	<0.020	<0.020	0.21	0.024	0.18	
			ZVI (Shallow)-3	<0.020	0.32	<0.020	0.12	--	0.13	<0.020	<0.020	0.29	<0.020	0.13	
			Average Concentration (mg/L)	0.010	0.11	ND	0.12	--	0.094	ND	ND	0.23	0.008	0.16	
			Standard Deviation (mmoles)	2.9E-05	3.9E-04	0.0E+00	5.3E-05	--	6.4E-04	0.0E+00	0.0E+00	1.2E-04	5.5E-05	1.2E-03	
			Average Total mmoles	**0.000017**	**0.00022**	**ND**	**0.0016**	**1.8E-03**	**0.0019**	**ND**	**ND**	**0.00056**	**0.000032**	**0.0075**	

Treatment	Date	Day	Replicate	Chlorinated Ethenes					Chlorinated Ethanes						Comment
				TCE	**cDCE**	**VC**	**Ethene**	**Total Ethenes**	**Ethane**	**CTC**	**CF**	**DCM**	**CM**	**Methane**	
				mg/L	**mg/L**	**mg/L**	**mg/L**	**mmol/bottle**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	
ZVI Amended/KB-1® Plus Bioaugmented	25-Jun-14	89	ZVI (Shallow)-1	<0.020	<0.020	<0.020	0.11	--	0.076	<0.020	<0.020	0.14	<0.020	0.14	
(Shallow)			ZVI (Shallow)-2	<0.020	<0.020	<0.020	0.12	--	0.072	<0.020	<0.020	0.16	0.022	0.14	
Continued			ZVI (Shallow)-3	<0.020	0.22	<0.020	0.15	--	0.18	<0.020	<0.020	0.24	<0.020	0.16	
			Average Concentration (mg/L)	ND	0.073	ND	0.13	--	0.11	ND	ND	0.18	0.0072	0.15	
			Standard Deviation (mmoles)	0.0E+00	2.7E-04	0.0E+00	2.1E-04	--	1.3E-03	0.0E+00	0.0E+00	1.3E-04	5.0E-05	5.8E-04	
			Average Total mmoles	**ND**	**0.00015**	**ND**	**0.0017**	**2.2E-03**	**0.0022**	**ND**	**ND**	**0.00044**	**0.000029**	**0.0069**	
	26-Jun-14	90													Spiked with TCE and CTC to target concentrations of 2 mg/L each.
	10-Jul-14	104	ZVI (Shallow)-1	0.54	0.023	<0.020	0.19	--	0.077	<0.020	<0.020	0.47	0.032	0.16	
			ZVI (Shallow)-2	0.78	0.025	<0.020	0.20	--	0.073	<0.020	<0.020	0.58	0.033	0.12	
			ZVI (Shallow)-3	0.38	0.21	<0.020	0.23	--	0.16	<0.020	<0.020	0.62	0.034	0.12	
			Average Concentration (mg/L)	0.57	0.087	ND	0.21	--	0.10	ND	ND	0.56	0.033	0.13	
			Standard Deviation (mmoles)	3.2E-04	2.3E-04	0.0E+00	2.8E-04	--	9.9E-04	0.0E+00	0.0E+00	1.8E-04	3.9E-06	1.0E-03	
			Average Total mmoles	**0.00091**	**0.00018**	**ND**	**0.0027**	**3.8E-03**	**0.0021**	**ND**	**ND**	**0.0014**	**0.00013**	**0.0061**	
	29-Jul-14	123	ZVI (Shallow)-1	<0.020	0.18	<0.020	0.22	--	0.21	<0.020	<0.020	0.49	0.039	0.19	
			ZVI (Shallow)-2	0.032	0.033	<0.020	0.20	--	0.11	<0.020	<0.020	0.27	<0.020	0.16	
			ZVI (Shallow)-3	<0.020	0.12	<0.020	0.19	--	0.061	<0.020	<0.020	0.32	0.028	0.12	
			Average Concentration (mg/L)	0.011	0.11	ND	0.21	--	0.13	ND	ND	0.36	0.022	0.16	
			Standard Deviation (mmoles)	2.9E-05	1.6E-04	0.0E+00	2.1E-04	--	1.5E-03	0.0E+00	0.0E+00	2.8E-04	8.0E-05	1.8E-03	
			Average Total mmoles	**0.000017**	**0.00024**	**ND**	**0.0027**	**3.0E-03**	**0.0025**	**ND**	**ND**	**0.00088**	**0.000089**	**0.0073**	
SRS™/ZVI and Ferrous Fumarate Amended/KB-1®	27-Mar-14	-1													Spiked with TCE and CTC to target concentrations of 2 mg/L each.
Plus Bioaugmented	28-Mar-14	0													Amended with 2 mL of a vitamin/mineral solution.
(Shallow)															Amended with 333 uL of SRS™ to target a final concentration of 0.1 % as oil.
															Amended the first replicate with 100 uL of resazurin.
															Amended with 1 g of ZVI to target a final concentration of 5 g/L.
			SRS/ZVI (Shallow)-1	2.9	<0.020	<0.020	<0.020	--	<0.020	1.0	0.21	<0.020	<0.020	0.062	
			SRS/ZVI (Shallow)-2	3.1	<0.020	<0.020	<0.020	--	<0.020	0.98	0.33	<0.020	<0.020	0.057	
			SRS/ZVI (Shallow)-3	3.0	<0.020	<0.020	<0.020	--	<0.020	1.3	0.03	<0.020	<0.020	0.051	
			Average Concentration (mg/L)	3.0	ND	ND	ND	--	ND	1.1	0.19	ND	ND	0.057	
			Standard Deviation (mmoles)	1.4E-04	0.0E+00	0.0E+00	0.0E+00	--	0.0E+00	2.4E-04	2.6E-04	0.0E+00	0.0E+00	2.6E-04	
			Average Total mmoles	**0.0048**	**ND**	**ND**	**ND**	**4.8E-03**	**ND**	**0.0015**	**0.00033**	**ND**	**ND**	**0.0026**	
	04-Apr-14	7	SRS/ZVI (Shallow)-1	2.1	<0.020	<0.020	0.034	--	0.035	<0.020	0.025	<0.020	<0.020	0.074	
			SRS/ZVI (Shallow)-2	1.9	<0.020	<0.020	0.033	--	0.024	<0.020	<0.020	<0.020	<0.020	0.067	
			SRS/ZVI (Shallow)-3	1.9	<0.020	<0.020	0.038	--	0.041	<0.020	<0.020	<0.020	<0.020	0.10	
			Average Concentration (mg/L)	2.0	ND	ND	0.035	--	0.033	ND	0.0085	ND	ND	0.081	
			Standard Deviation (mmoles)	2.1E-04	0.0E+00	0.0E+00	3.2E-05	--	1.7E-04	0.0E+00	2.5E-05	0.0E+00	0.0E+00	9.0E-04	
			Average Total mmoles	**0.0032**	**ND**	**ND**	**0.00046**	**3.7E-03**	**0.00066**	**ND**	**0.000014**	**ND**	**ND**	**0.0038**	
															Amended with 36 mg of fumerous fumarate to target a final concentration of 180 mg/L.
	17-Apr-14	20	SRS/ZVI (Shallow)-1	0.93	0.026	<0.020	0.10	--	0.093	<0.020	<0.020	<0.020	<0.020	0.22	
			SRS/ZVI (Shallow)-2	0.87	0.031	<0.020	0.078	--	0.042	<0.020	<0.020	<0.020	<0.020	0.079	
			SRS/ZVI (Shallow)-3	0.53	0.080	<0.020	0.065	--	0.038	<0.020	<0.020	<0.020	<0.020	0.073	
			Average Concentration (mg/L)	0.78	0.046	ND	0.081	--	0.058	ND	ND	ND	ND	0.13	
			Standard Deviation (mmoles)	3.4E-04	6.3E-05	0.0E+00	2.5E-04	--	6.1E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	4.0E-03	
			Average Total mmoles	**0.0012**	**0.000098**	**ND**	**0.0011**	**2.4E-03**	**0.0011**	**ND**	**ND**	**ND**	**ND**	**0.0058**	
															Spiked with CTC to target concentrations of 2 mg/L.
	25-Apr-14	28	SRS/ZVI (Shallow)-1	0.31	<0.020	<0.020	0.11	--	0.071	<0.020	<0.020	0.34	0.027	0.094	
			SRS/ZVI (Shallow)-2	0.38	0.052	<0.020	0.099	--	0.047	<0.020	<0.020	0.35	<0.020	0.086	
			SRS/ZVI (Shallow)-3	0.16	0.074	<0.020	0.075	--	0.040	<0.020	<0.020	0.31	<0.020	0.081	
			Average Concentration (mg/L)	0.28	0.042	ND	0.094	--	0.053	ND	ND	0.33	0.0090	0.087	
			Standard Deviation (mmoles)	1.8E-04	8.1E-05	0.0E+00	2.3E-04	--	3.3E-04	0.0E+00	0.0E+00	4.4E-05	6.2E-05	3.2E-04	
			Average Total mmoles	**0.00045**	**0.000089**	**ND**	**0.0012**	**1.7E-03**	**0.001**	**ND**	**ND**	**0.00082**	**0.000036**	**0.0040**	
															Bioaugmented with KB-1® Plus (CF formulation).
	09-May-14	42	SRS/ZVI (Shallow)-1	0.024	<0.020	<0.020	0.12	--	0.082	<0.020	<0.020	0.3	0.027	0.13	
			SRS/ZVI (Shallow)-2	0.059	0.061	<0.020	0.10	--	0.055	<0.020	<0.020	0.32	0.023	0.13	
			SRS/ZVI (Shallow)-3	<0.020	0.065	<0.020	0.077	--	0.04	<0.020	<0.020	0.28	<0.020	0.12	
			Average Concentration (mg/L)	0.028	0.042	ND	0.10	--	0.059	ND	ND	0.3	0.0170	0.13	
			Standard Deviation (mmoles)	4.7E-05	7.8E-05	0.0E+00	2.9E-04	--	4.2E-04	0.0E+00	0.0E+00	5.4E-05	5.8E-05	2.6E-04	
			Average Total mmoles	**0.000044**	**0.000089**	**ND**	**0.0013**	**1.4E-03**	**0.0012**	**ND**	**ND**	**0.00073**	**0.000066**	**0.0060**	
	23-May-14	56	SRS/ZVI (Shallow)-1	<0.020	<0.020	<0.020	0.12	--	0.096	<0.020	<0.020	0.26	0.031	0.18	
			SRS/ZVI (Shallow)-2	<0.020	0.053	<0.020	0.096	--	0.045	<0.020	<0.020	0.30	<0.020	0.12	
			SRS/ZVI (Shallow)-3	<0.020	0.062	<0.020	0.077	--	0.04	<0.020	<0.020	0.27	<0.020	0.13	
			Average Concentration (mg/L)	ND	0.038	ND	0.099	--	0.06	ND	ND	0.28	0.010	0.14	
			Standard Deviation (mmoles)	0.0E+00	7.1E-05	0.0E+00	3.1E-04	--	6.1E-04	0.0E+00	0.0E+00	5.1E-05	7.1E-05	1.5E-03	
			Average Total mmoles	**ND**	**0.000081**	**ND**	**0.0013**	**1.4E-03**	**0.0012**	**ND**	**ND**	**0.00067**	**0.000041**	**0.0065**	

Treatment	Date	Day	Replicate	Chlorinated Ethenes					Chlorinated Ethanes						Comment
				TCE	cDCE	VC	Ethene	Total Ethenes	Ethane	CTC	CF	DCM	CM	Methane	
				mg/L	mg/L	mg/L	mg/L	mmol/bottle	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	
SRS™/ZVI and Ferrous Fumarate Amended/KB-1® Plus Bioaugmented	10-Jun-14	74	SRS/ZVI (Shallow)-1	0.031	<0.020	<0.020	0.12	--	0.091	<0.020	<0.020	0.19	<0.020	0.16	
(Shallow)			SRS/ZVI (Shallow)-2	<0.020	0.065	<0.020	0.09	--	0.047	<0.020	<0.020	0.26	<0.020	0.12	
Continued			SRS/ZVI (Shallow)-3	<0.020	0.088	<0.020	0.081	--	0.048	<0.020	<0.020	0.24	<0.020	0.16	
			Average Concentration (mg/L)	0.010	0.051	ND	0.096	--	0.062	ND	ND	0.23	ND	0.15	
			Standard Deviation (mmoles)	2.9E-05	9.8E-05	0.0E+00	2.6E-04	--	5.0E-04	0.0E+00	0.0E+00	8.4E-05	0.0E+00	1.0E-03	
			Average Total mmoles	**0.000017**	**0.00011**	**ND**	**0.0013**	**1.4E-03**	**0.0012**	**ND**	**ND**	**0.00056**	**ND**	**0.0070**	
	25-Jun-14	89	SRS/ZVI (Shallow)-1	<0.020	<0.020	<0.020	0.12	--	0.10	<0.020	<0.020	0.14	<0.020	0.16	
			SRS/ZVI (Shallow)-2	<0.020	0.036	<0.020	0.093	--	0.05	<0.020	<0.020	0.21	<0.020	0.12	
			SRS/ZVI (Shallow)-3	<0.020	0.043	<0.020	0.086	--	0.056	<0.020	<0.020	0.19	<0.020	0.18	
			Average Concentration (mg/L)	ND	0.026	ND	0.10	--	0.069	ND	ND	0.18	ND	0.15	
			Standard Deviation (mmoles)	0.0E+00	4.9E-05	0.0E+00	2.7E-04	--	5.7E-04	0.0E+00	0.0E+00	8.4E-05	0.0E+00	1.3E-03	
			Average Total mmoles	**ND**	**0.000056**	**ND**	**0.0013**	**1.5E-03**	**0.0014**	**ND**	**ND**	**0.00043**	**ND**	**0.0072**	
	26-Jun-14	90													Spiked with TCE and CTC to target concentrations of 2 mg/L each.
	10-Jul-14	104	SRS/ZVI (Shallow)-1	0.29	0.089	<0.020	0.16	--	0.052	<0.020	<0.020	0.40	0.041	0.099	
			SRS/ZVI (Shallow)-2	0.52	0.020	<0.020	0.18	--	0.10	<0.020	<0.020	0.39	0.035	0.14	
			SRS/ZVI (Shallow)-3	0.066	0.043	<0.020	0.13	--	0.055	<0.020	<0.020	0.34	0.025	0.14	
			Average Concentration (mg/L)	0.29	0.051	ND	0.16	--	0.069	ND	ND	0.38	0.034	0.13	
			Standard Deviation (mmoles)	3.6E-04	7.4E-05	0.0E+00	3.3E-04	--	5.4E-04	0.0E+00	0.0E+00	8.1E-05	3.2E-05	1.1E-03	
			Average Total mmoles	**0.00046**	**0.00011**	**ND**	**0.0021**	**2.7E-03**	**0.0014**	**ND**	**ND**	**0.00092**	**0.00014**	**0.0059**	
	29-Jul-14	123	SRS/ZVI (Shallow)-1	0.042	0.024	<0.020	0.22	--	0.094	<0.020	<0.020	0.32	0.026	0.17	
			SRS/ZVI (Shallow)-2	0.12	<0.020	<0.020	0.22	--	0.087	<0.020	<0.020	0.42	0.031	0.15	
			SRS/ZVI (Shallow)-3	0.15	<0.020	<0.020	0.16	--	0.071	<0.020	<0.020	0.25	0.020	0.18	
			Average Concentration (mg/L)	0.11	0.0080	ND	0.20	--	0.084	ND	ND	0.33	0.026	0.16	
			Standard Deviation (mmoles)	9.1E-05	2.9E-05	0.0E+00	4.3E-04	--	2.3E-04	0.0E+00	0.0E+00	2.1E-04	2.1E-05	7.0E-04	
			Average Total mmoles	**0.00017**	**0.000017**	**ND**	**0.0026**	**2.8E-03**	**0.0017**	**ND**	**ND**	**0.00080**	**0.00010**	**0.0076**	
SRS™ and Ferrous Fumarate Amended/KB-1® Plus Bioaugmented	27-Mar-14	-1													Spiked with TCE and CTC to target concentrations of 2 mg/L each.
(Shallow)	28-Mar-14	0													Amended the first replicate with 100 uL of resazurin.
															Amended with 36 mg of fumerous fumarate to target a final concentration of 180 mg/L.
															Amended with 333 uL of SRS™to target a final concentration of 0.1 % as oil.
															Amended with 2 mL of a vitamin/mineral solution.
			SRS/solFe (Shallow)-1	3.1	<0.020	<0.020	<0.020	--	<0.020	1.4	0.031	<0.020	<0.020	0.041	
			SRS/solFe (Shallow)-2	3.0	<0.020	<0.020	<0.020	--	<0.020	1.4	0.033	<0.020	<0.020	0.042	
			SRS/solFe (Shallow)-3	3.0	<0.020	<0.020	<0.020	--	<0.020	1.3	0.033	<0.020	<0.020	0.042	
			Average Concentration (mg/L)	3.0	ND	ND	ND	--	ND	1.3	0.032	ND	ND	0.042	
			Standard Deviation (mmoles)	7.1E-05	0.0E+00	0.0E+00	0.0E+00	--	0.0E+00	4.3E-05	2.3E-06	0.0E+00	0.0E+00	3.0E-05	
			Average Total mmoles	**0.0048**	**ND**	**ND**	**ND**	**4.8E-03**	**ND**	**0.0019**	**0.000055**	**ND**	**ND**	**0.0019**	
	04-Apr-14	7	SRS/solFe (Shallow)-1	2.4	<0.020	<0.020	<0.020	--	<0.020	<0.020	0.45	<0.020	<0.020	0.043	
			SRS/solFe (Shallow)-2	2.3	<0.020	<0.020	<0.020	--	<0.020	<0.020	0.50	<0.020	<0.020	0.043	
			SRS/solFe (Shallow)-3	2.4	<0.020	<0.020	<0.020	--	<0.020	<0.020	0.22	<0.020	<0.020	0.042	
			Average Concentration (mg/L)	2.4	ND	ND	ND	--	ND	ND	0.39	ND	ND	0.043	
			Standard Deviation (mmoles)	4.4E-05	0.0E+00	0.0E+00	0.0E+00	--	0.0E+00	0.0E+00	2.5E-04	0.0E+00	0.0E+00	3.9E-05	
			Average Total mmoles	**0.0038**	**ND**	**ND**	**ND**	**3.8E-03**	**ND**	**ND**	**0.00067**	**ND**	**ND**	**0.0020**	
	17-Apr-14	20	SRS/solFe (Shallow)-1	2.4	<0.020	<0.020	<0.020	--	<0.020	<0.020	0.19	<0.020	<0.020	0.043	
			SRS/solFe (Shallow)-2	2.3	<0.020	<0.020	<0.020	--	<0.020	<0.020	0.12	<0.020	<0.020	0.045	
			SRS/solFe (Shallow)-3	2.3	<0.020	<0.020	<0.020	--	<0.020	<0.020	0.028	<0.020	<0.020	0.044	
			Average Concentration (mg/L)	2.3	ND	ND	ND	--	ND	ND	0.11	ND	ND	0.044	
			Standard Deviation (mmoles)	8.9E-05	0.0E+00	0.0E+00	0.0E+00	--	0.0E+00	0.0E+00	1.4E-04	0.0E+00	0.0E+00	3.9E-05	
			Average Total mmoles	**0.0038**	**ND**	**ND**	**ND**	**3.8E-03**	**ND**	**ND**	**0.00019**	**ND**	**ND**	**0.0020**	
															Spiked with CTC to target concentrations of 2 mg/L.
	25-Apr-14	28	SRS/solFe (Shallow)-1	2.4	<0.020	<0.020	<0.020	--	<0.020	<0.020	0.95	0.071	<0.020	0.042	
			SRS/solFe (Shallow)-2	2.3	<0.020	<0.020	<0.020	--	<0.020	<0.020	0.45	<0.020	<0.020	0.042	
			SRS/solFe (Shallow)-3	2.2	<0.020	<0.020	<0.020	--	<0.020	<0.020	0.93	0.094	<0.020	0.041	
			Average Concentration (mg/L)	2.3	ND	ND	ND	--	ND	ND	0.77	0.055	ND	0.042	
			Standard Deviation (mmoles)	1.6E-04	0.0E+00	0.0E+00	0.0E+00	--	0.0E+00	0.0E+00	4.8E-04	1.2E-04	0.0E+00	1.2E-05	
			Average Total mmoles	**0.0037**	**ND**	**ND**	**ND**	**3.7E-03**	**ND**	**ND**	**0.0013**	**0.00013**	**ND**	**0.0019**	
															Bioaugmented with KB-1® Plus (CF formulation).
	09-May-14	42	SRS/solFe (Shallow)-1	2.2	0.021	<0.020	<0.020	--	<0.020	<0.020	<0.020	<0.020	<0.020	0.20	
			SRS/solFe (Shallow)-2	2.0	0.069	<0.020	<0.020	--	<0.020	<0.020	<0.020	<0.020	<0.020	0.25	
			SRS/solFe (Shallow)-3	2.1	0.069	<0.020	<0.020	--	<0.020	<0.020	<0.020	0.15	<0.020	0.15	
			Average Concentration (mg/L)	2.1	0.053	ND	ND	--	ND	ND	ND	0.051	ND	0.20	
			Standard Deviation (mmoles)	1.8E-04	6.0E-05	0.0E+00	0.0E+00	--	0.0E+00	0.0E+00	0.0E+00	2.2E-04	0.0E+00	2.4E-03	
			Average Total mmoles	**0.0034**	**0.00011**	**ND**	**ND**	**3.5E-03**	**ND**	**ND**	**ND**	**0.00013**	**ND**	**0.0093**	

Treatment	Date	Day	Replicate	Chlorinated Ethenes					Chlorinated Ethanes						Comment
				TCE	cDCE	VC	Ethene	Total Ethenes	Ethane	CTC	CF	DCM	CM	Methane	
				mg/L	mg/L	mg/L	mg/L	mmol/bottle	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	
SRS™ and Ferrous Fumarate Amended/KB-1® Plus Bioaugmented (Shallow) Continued	23-May-14	56	SRS/solFe (Shallow)-1	<0.020	0.37	0.048	<0.020	--	<0.020	<0.020	<0.020	<0.020	<0.020	0.55	
			SRS/solFe (Shallow)-2	<0.020	0.26	1.5	<0.020	--	<0.020	<0.020	<0.020	<0.020	<0.020	0.74	
			SRS/solFe (Shallow)-3	1.5	0.46	0.21	<0.020	--	<0.020	<0.020	<0.020	0.099	<0.020	0.14	
			Average Concentration (mg/L)	0.48	0.36	0.59	ND	--	ND	ND	ND	0.033	ND	0.48	
			Standard Deviation (mmoles)	1.3E-03	2.0E-04	2.8E-03	0.0E+00	--	0.0E+00	0.0E+00	0.0E+00	1.4E-04	0.0E+00	1.4E-02	
			Average Total mmoles	**0.00077**	**0.00077**	**0.0021**	**ND**	**3.6E-03**	**ND**	**ND**	**ND**	**0.000081**	**ND**	**0.022**	
	10-Jun-14	74	SRS/solFe (Shallow)-1	<0.020	<0.020	<0.020	0.24	--	<0.020	<0.020	<0.020	<0.020	<0.020	5.3	
			SRS/solFe (Shallow)-2	<0.020	<0.020	<0.020	0.21	--	<0.020	<0.020	<0.020	<0.020	<0.020	4.8	
			SRS/solFe (Shallow)-3	<0.020	<0.020	0.047	0.21	--	<0.020	<0.020	<0.020	<0.020	<0.020	0.18	
			Average Concentration (mg/L)	ND	ND	0.016	0.22	--	ND	ND	ND	ND	ND	3.4	
			Standard Deviation (mmoles)	0.0E+00	0.0E+00	9.5E-05	2.1E-04	--	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.3E-01	
			Average Total mmoles	**ND**	**ND**	**0.000055**	**0.0029**	**3.0E-03**	**ND**	**ND**	**ND**	**ND**	**ND**	**0.16**	
	25-Jun-14	89	SRS/solFe (Shallow)-1	<0.020	<0.020	<0.020	0.23	--	<0.020	<0.020	<0.020	<0.020	<0.020	9.0	
			SRS/solFe (Shallow)-2	<0.020	<0.020	<0.020	0.19	--	<0.020	<0.020	<0.020	<0.020	<0.020	7.9	
			SRS/solFe (Shallow)-3	<0.020	<0.020	<0.020	0.21	--	<0.020	<0.020	<0.020	<0.020	<0.020	0.28	
			Average Concentration (mg/L)	ND	ND	ND	0.21	--	ND	ND	ND	ND	ND	5.8	
			Standard Deviation (mmoles)	0.0E+00	0.0E+00	0.0E+00	2.8E-04	--	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	2.2E-01	
			Average Total mmoles	**ND**	**ND**	**ND**	**0.0027**	**2.8E-03**	**ND**	**ND**	**ND**	**ND**	**ND**	**0.27**	
	26-Jun-14	90													Spiked with TCE and CTC to target concentrations of 2 mg/L each.
	10-Jul-14	104	SRS/solFe (Shallow)-1	<0.020	<0.020	<0.020	0.45	--	<0.020	<0.020	<0.020	<0.020	<0.020	7.8	
			SRS/solFe (Shallow)-2	<0.020	<0.020	<0.020	0.42	--	<0.020	<0.020	<0.020	<0.020	<0.020	8.7	
			SRS/solFe (Shallow)-3	<0.020	<0.020	<0.020	0.45	--	<0.020	<0.020	<0.020	<0.020	<0.020	0.68	
			Average Concentration (mg/L)	ND	ND	ND	0.44	--	ND	ND	ND	ND	ND	5.7	
			Standard Deviation (mmoles)	0.0E+00	0.0E+00	0.0E+00	2.3E-04	--	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	2.0E-01	
			Average Total mmoles	**ND**	**ND**	**ND**	**0.0058**	**5.8E-03**	**ND**	**ND**	**ND**	**ND**	**ND**	**0.26**	
	29-Jul-14	123	SRS/solFe (Shallow)-1	<0.020	<0.020	<0.020	0.49	--	<0.020	<0.020	<0.020	<0.020	<0.020	16	
			SRS/solFe (Shallow)-2	<0.020	<0.020	<0.020	0.42	--	<0.020	<0.020	<0.020	<0.020	<0.020	15	
			SRS/solFe (Shallow)-3	<0.020	<0.020	<0.020	0.48	--	<0.020	<0.020	<0.020	<0.020	<0.020	3.1	
			Average Concentration (mg/L)	ND	ND	ND	0.46	--	ND	ND	ND	ND	ND	11	
			Standard Deviation (mmoles)	0.0E+00	0.0E+00	0.0E+00	4.5E-04	--	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	3.3E-01	
			Average Total mmoles	**ND**	**ND**	**ND**	**0.0061**	**6.1E-03**	**ND**	**ND**	**ND**	**ND**	**ND**	**0.52**	
SRS™ Amended/KB-1® Plus Bioaugmented (Shallow)	27-Mar-14	-1													Spiked with TCE and CTC to target concentrations of 2 mg/L each.
	28-Mar-14	0													Amended with 2 mL of a vitamin/mineral solution.
															Amended the first replicate with 100 uL of resazurin.
															Amended with 333 uL of SRS™ to target a final concentration of 0.1 % as oil.
			SRS (Shallow)-1	3.0	<0.020	<0.020	<0.020	--	<0.020	1.4	0.033	<0.020	<0.020	0.042	
			SRS (Shallow)-2	3.2	<0.020	<0.020	<0.020	--	<0.020	1.4	0.033	<0.020	<0.020	0.041	
			SRS (Shallow)-3	3.0	<0.020	<0.020	<0.020	--	<0.020	1.3	0.038	<0.020	<0.020	0.044	
			Average Concentration (mg/L)	3.1	ND	ND	ND	--	ND	1.4	0.035	ND	ND	0.042	
			Standard Deviation (mmoles)	1.6E-04	0.0E+00	0.0E+00	0.0E+00	--	0.0E+00	9.2E-05	4.7E-06	0.0E+00	0.0E+00	5.6E-05	
			Average Total mmoles	**0.0049**	**ND**	**ND**	**ND**	**4.9E-03**	**ND**	**0.0019**	**0.000059**	**ND**	**ND**	**0.0020**	
	04-Apr-14	7	SRS (Shallow)-1	2.5	<0.020	<0.020	<0.020	--	<0.020	0.036	0.44	<0.020	<0.020	0.040	
			SRS (Shallow)-2	2.6	<0.020	<0.020	<0.020	--	<0.020	0.57	0.25	<0.020	<0.020	0.041	
			SRS (Shallow)-3	2.7	<0.020	<0.020	<0.020	--	<0.020	0.049	0.60	<0.020	<0.020	0.041	
			Average Concentration (mg/L)	2.6	ND	ND	ND	--	ND	0.22	0.43	ND	ND	0.041	
			Standard Deviation (mmoles)	1.0E-04	0.0E+00	0.0E+00	0.0E+00	--	0.0E+00	4.2E-04	3.0E-04	0.0E+00	0.0E+00	3.3E-05	
			Average Total mmoles	**0.0041**	**ND**	**ND**	**ND**	**4.1E-03**	**ND**	**0.00030**	**0.00073**	**ND**	**ND**	**0.0019**	
	17-Apr-14	20	SRS (Shallow)-1	2.4	<0.020	<0.020	<0.020	--	<0.020	<0.020	0.36	<0.020	<0.020	0.042	
			SRS (Shallow)-2	2.3	<0.020	<0.020	<0.020	--	<0.020	<0.020	0.18	<0.020	<0.020	0.023	
			SRS (Shallow)-3	2.5	<0.020	<0.020	<0.020	--	<0.020	<0.020	0.52	<0.020	<0.020	0.047	
			Average Concentration (mg/L)	2.4	ND	ND	ND	--	ND	ND	0.35	ND	ND	0.037	
			Standard Deviation (mmoles)	1.7E-04	0.0E+00	0.0E+00	0.0E+00	--	0.0E+00	0.0E+00	2.9E-04	0.0E+00	0.0E+00	5.9E-04	
			Average Total mmoles	**0.0038**	**ND**	**ND**	**ND**	**3.8E-03**	**ND**	**ND**	**0.00060**	**ND**	**ND**	**0.0017**	
															Spiked with CTC to target concentrations of 2 mg/L.
	25-Apr-14	28	SRS (Shallow)-1	2.3	<0.020	<0.020	<0.020	--	<0.020	<0.020	0.36	0.045	<0.020	0.041	
			SRS (Shallow)-2	2.2	<0.020	<0.020	<0.020	--	<0.020	<0.020	0.31	0.13	<0.020	0.043	
			SRS (Shallow)-3	2.4	<0.020	<0.020	<0.020	--	<0.020	<0.020	0.62	<0.020	<0.020	0.040	
			Average Concentration (mg/L)	2.3	ND	ND	ND	--	ND	ND	0.43	0.058	ND	0.041	
			Standard Deviation (mmoles)	1.4E-04	0.0E+00	0.0E+00	0.0E+00	--	0.0E+00	0.0E+00	2.8E-04	1.6E-04	0.0E+00	8.4E-05	
			Average Total mmoles	**0.0036**	**ND**	**ND**	**ND**	**3.6E-03**	**ND**	**ND**	**0.00073**	**0.00014**	**ND**	**0.0019**	
															Bioaugmented with KB-1® Plus (CF formulation).

Treatment	Date	Day	Replicate	Chlorinated Ethenes					Chlorinated Ethanes						Comment
				TCE	**cDCE**	**VC**	**Ethene**	**Total Ethenes**	**Ethane**	**CTC**	**CF**	**DCM**	**CM**	**Methane**	
				mg/L	**mg/L**	**mg/L**	**mg/L**	**mmol/bottle**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	
SRS™ Amended/KB-1® Plus Bioaugmented	09-May-14	42	SRS (Shallow)-1	2.1	<0.020	<0.020	<0.020	--	<0.020	<0.020	<0.020	<0.020	<0.020	0.072	
(Shallow)			SRS (Shallow)-2	2.1	<0.020	<0.020	<0.020	--	<0.020	<0.020	<0.020	0.088	<0.020	0.059	
Continued			SRS (Shallow)-3	2.2	<0.020	<0.020	<0.020	--	<0.020	<0.020	<0.020	<0.020	<0.020	0.070	
			Average Concentration (mg/L)	2.2	ND	ND	ND	--	ND	ND	ND	0.029	ND	0.067	
			Standard Deviation (mmoles)	8.0E-05	0.0E+00	0.0E+00	0.0E+00	--	0.0E+00	0.0E+00	0.0E+00	1.2E-04	0.0E+00	3.1E-04	
			Average Total mmoles	**0.0035**	**ND**	**ND**	**ND**	**3.5E-03**	**ND**	**ND**	**ND**	**0.000072**	**ND**	**0.0031**	
	23-May-14	56	SRS (Shallow)-1	2.0	0.14	0.027	<0.020	--	<0.020	<0.020	<0.020	<0.020	<0.020	0.15	
			SRS (Shallow)-2	2.1	0.054	<0.020	<0.020	--	<0.020	<0.020	<0.020	0.038	<0.020	0.075	
			SRS (Shallow)-3	<0.020	2.0	0.27	<0.020	--	<0.020	<0.020	<0.020	<0.020	<0.020	0.18	
			Average Concentration (mg/L)	1.4	0.74	0.1	ND	--	ND	ND	ND	0.013	ND	0.14	
			Standard Deviation (mmoles)	1.9E-03	2.4E-03	5.3E-04	0.0E+00	--	0.0E+00	0.0E+00	0.0E+00	5.4E-05	0.0E+00	2.6E-03	
			Average Total mmoles	**0.0022**	**0.0016**	**0.00035**	**ND**	**4.2E-03**	**ND**	**ND**	**ND**	**0.000031**	**ND**	**0.0063**	
	10-Jun-14	74	SRS (Shallow)-1	<0.020	<0.020	1.6	0.053	--	<0.020	<0.020	<0.020	<0.020	<0.020	2.3	
			SRS (Shallow)-2	<0.020	<0.020	0.093	0.21	--	<0.020	<0.020	<0.020	<0.020	<0.020	1.0	
			SRS (Shallow)-3	<0.020	<0.020	<0.020	0.20	--	<0.020	<0.020	<0.020	<0.020	<0.020	2.3	
			Average Concentration (mg/L)	ND	ND	0.57	0.16	--	ND	ND	ND	ND	ND	1.9	
			Standard Deviation (mmoles)	0.0E+00	0.0E+00	3.2E-03	1.2E-03	--	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	3.4E-02	
			Average Total mmoles	**ND**	**ND**	**0.0020**	**0.0021**	**4.1E-03**	**ND**	**ND**	**ND**	**ND**	**ND**	**0.087**	
	25-Jun-14	89	SRS (Shallow)-1	<0.020	<0.020	0.082	0.22	--	<0.020	<0.020	<0.020	<0.020	<0.020	6.7	
			SRS (Shallow)-2	<0.020	<0.020	<0.020	0.12	--	<0.020	<0.020	<0.020	<0.020	<0.020	5.9	
			SRS (Shallow)-3	<0.020	<0.020	<0.020	0.21	--	<0.020	<0.020	<0.020	<0.020	<0.020	5.8	
			Average Concentration (mg/L)	ND	ND	0.027	0.18	--	ND	ND	ND	ND	ND	6.1	
			Standard Deviation (mmoles)	0.0E+00	0.0E+00	1.7E-04	6.9E-04	--	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	2.4E-02	
			Average Total mmoles	**ND**	**ND**	**0.000096**	**0.0024**	**2.8E-03**	**ND**	**ND**	**ND**	**ND**	**ND**	**0.28**	
	26-Jun-14	90													Spiked with TCE and CTC to target concentrations of 2 mg/L each.
	10-Jul-14	104	SRS (Shallow)-1	<0.020	<0.020	<0.020	0.44	--	<0.020	<0.020	<0.020	0.097	<0.020	8.2	
			SRS (Shallow)-2	<0.020	<0.020	<0.020	0.33	--	<0.020	<0.020	<0.020	<0.020	<0.020	6.3	
			SRS (Shallow)-3	<0.020	<0.020	<0.020	0.42	--	<0.020	<0.020	<0.020	0.076	<0.020	7.2	
			Average Concentration (mg/L)	ND	ND	ND	0.40	--	ND	ND	ND	0.058	ND	7.2	
			Standard Deviation (mmoles)	0.0E+00	0.0E+00	0.0E+00	7.7E-04	--	0.0E+00	0.0E+00	0.0E+00	1.2E-04	0.0E+00	4.5E-02	
			Average Total mmoles	**ND**	**ND**	**ND**	**0.0052**	**5.2E-03**	**ND**	**ND**	**ND**	**0.00014**	**ND**	**0.34**	
	29-Jul-14	123	SRS (Shallow)-1	<0.020	<0.020	<0.020	0.44	--	<0.020	<0.020	<0.020	0.073	<0.020	12	
			SRS (Shallow)-2	<0.020	<0.020	<0.020	0.054	--	<0.020	<0.020	<0.020	<0.020	<0.020	4.3	
			SRS (Shallow)-3	<0.020	<0.020	<0.020	0.40	--	<0.020	<0.020	<0.020	<0.020	<0.020	11	
			Average Concentration (mg/L)	ND	ND	ND	0.30	--	ND	ND	ND	0.024	ND	9.3	
			Standard Deviation (mmoles)	0.0E+00	0.0E+00	0.0E+00	2.8E-03	--	0.0E+00	0.0E+00	0.0E+00	1.0E-04	0.0E+00	2.0E-01	
			Average Total mmoles	**ND**	**ND**	**ND**	**0.0039**	**3.9E-03**	**ND**	**ND**	**ND**	**0.00006**	**ND**	**0.43**	
EHC®-L Amended/KB-1® Plus Bioaugmented	27-Mar-14	-1													Spiked with TCE and CTC to target concentrations of 2 mg/L each.
(Shallow)	28-Mar-14	0													Amended the first replicate with 100 uL of resazurin.
															Amended with 1.37 mL of EHC®-L to target a final concentration of 1 g/L.
															Amended with 2 mL of a vitamin/mineral solution.
			EHC (Shallow)-1	3.0	<0.020	<0.020	<0.020	--	<0.020	1.3	<0.020	<0.020	<0.020	0.041	
			EHC (Shallow)-2	2.9	<0.020	<0.020	<0.020	--	<0.020	1.3	<0.020	<0.020	<0.020	0.041	
			EHC (Shallow)-3	2.9	<0.020	<0.020	<0.020	--	<0.020	1.3	0.024	<0.020	<0.020	0.043	
			Average Concentration (mg/L)	2.9	ND	ND	ND	--	ND	1.3	0.0081	ND	ND	0.042	
			Standard Deviation (mmoles)	4.0E-05	0.0E+00	0.0E+00	0.0E+00	--	0.0E+00	2.5E-05	2.4E-05	0.0E+00	0.0E+00	5.8E-05	
			Average Total mmoles	**0.0047**	**ND**	**ND**	**ND**	**4.7E-03**	**ND**	**0.0018**	**0.000014**	**ND**	**ND**	**0.0019**	
	04-Apr-14	7	EHC (Shallow)-1	2.8	<0.020	<0.020	<0.020	--	<0.020	<0.020	0.61	<0.020	<0.020	0.039	
			EHC (Shallow)-2	2.8	<0.020	<0.020	<0.020	--	<0.020	<0.020	0.49	<0.020	<0.020	0.040	
			EHC (Shallow)-3	2.8	<0.020	<0.020	<0.020	--	<0.020	<0.020	0.59	<0.020	<0.020	0.041	
			Average Concentration (mg/L)	2.8	ND	ND	ND	--	ND	ND	0.57	ND	ND	0.040	
			Standard Deviation (mmoles)	3.8E-05	0.0E+00	0.0E+00	0.0E+00	--	0.0E+00	0.0E+00	1.1E-04	0.0E+00	0.0E+00	4.0E-05	
			Average Total mmoles	**0.0045**	**ND**	**ND**	**ND**	**4.5E-03**	**ND**	**ND**	**0.00096**	**ND**	**ND**	**0.0019**	
	17-Apr-14	20	EHC (Shallow)-1	2.8	<0.020	<0.020	<0.020	--	<0.020	<0.020	0.089	<0.020	<0.020	0.047	
			EHC (Shallow)-2	2.8	0.023	<0.020	<0.020	--	<0.020	<0.020	0.14	<0.020	<0.020	0.042	
			EHC (Shallow)-3	2.9	<0.020	<0.020	<0.020	--	<0.020	<0.020	0.24	<0.020	<0.020	0.046	
			Average Concentration (mg/L)	2.8	0.0078	ND	ND	--	ND	ND	0.16	ND	ND	0.045	
			Standard Deviation (mmoles)	6.9E-05	2.9E-05	0.0E+00	0.0E+00	--	0.0E+00	0.0E+00	1.3E-04	0.0E+00	0.0E+00	1.1E-04	
			Average Total mmoles	**0.0045**	**0.000017**	**ND**	**ND**	**4.5E-03**	**ND**	**ND**	**0.00027**	**ND**	**ND**	**0.0021**	
															Spiked with CTC to target concentrations of 2 mg/L.

Treatment	Date	Day	Replicate	Chlorinated Ethenes					Chlorinated Ethanes						Comment
				TCE	cDCE	VC	Ethene	Total Ethenes	Ethane	CTC	CF	DCM	CM	Methane	
				mg/L	mg/L	mg/L	mg/L	mmol/bottle	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	
EHC®-L Amended/KB-1® Plus Bioaugmented	25-Apr-14	28	EHC (Shallow)-1	2.7	<0.020	<0.020	<0.020	--	<0.020	<0.020	0.19	0.12	0.025	0.042	
(Shallow)			EHC (Shallow)-2	2.7	0.029	<0.020	<0.020	--	<0.020	<0.020	0.38	0.23	0.022	0.043	
Continued			EHC (Shallow)-3	2.8	<0.020	<0.020	<0.020	--	<0.020	<0.020	0.55	0.077	<0.020	0.044	
			Average Concentration (mg/L)	2.8	0.0097	ND	ND	--	ND	ND	0.37	0.14	0.016	0.043	
			Standard Deviation (mmoles)	8.0E-05	3.6E-05	0.0E+00	0.0E+00	--	0.0E+00	0.0E+00	3.0E-04	1.9E-04	5.5E-05	3.6E-05	
			Average Total mmoles	**0.0044**	**0.000021**	**ND**	**ND**	**4.4E-03**	**ND**	**ND**	**0.00063**	**0.00035**	**0.000063**	**0.0020**	
															Bioaugmented with KB-1® Plus (CF formulation).
	09-May-14	42	EHC (Shallow)-1	2.3	0.26	<0.020	<0.020	--	<0.020	<0.020	<0.020	<0.020	<0.020	1.4	
			EHC (Shallow)-2	<0.020	1.8	<0.020	<0.020	--	<0.020	<0.020	<0.020	<0.020	<0.020	2.2	
			EHC (Shallow)-3	<0.020	1.7	<0.020	<0.020	--	<0.020	<0.020	<0.020	<0.020	<0.020	1.9	
			Average Concentration (mg/L)	0.75	1.2	ND	ND	--	ND	ND	ND	ND	ND	1.8	
			Standard Deviation (mmoles)	2.1E-03	1.8E-03	0.0E+00	0.0E+00	--	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.8E-02	
			Average Total mmoles	**0.0012**	**0.0027**	**ND**	**ND**	**3.9E-03**	**ND**	**ND**	**ND**	**ND**	**ND**	**0.085**	
	23-May-14	56	EHC (Shallow)-1	<0.020	<0.020	0.60	0.18	--	<0.020	<0.020	<0.020	<0.020	<0.020	2.5	
			EHC (Shallow)-2	<0.020	0.077	<0.020	0.24	--	<0.020	<0.020	<0.020	<0.020	<0.020	5.1	
			EHC (Shallow)-3	<0.020	<0.020	<0.020	0.25	--	<0.020	<0.020	<0.020	<0.020	<0.020	4.5	
			Average Concentration (mg/L)	ND	0.026	0.20	0.22	--	ND	ND	ND	ND	ND	4.0	
			Standard Deviation (mmoles)	0.0E+00	9.4E-05	1.2E-03	4.5E-04	--	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	6.2E-02	
			Average Total mmoles	**ND**	**0.000054**	**0.00070**	**0.0029**	**3.7E-03**	**ND**	**ND**	**ND**	**ND**	**ND**	**0.19**	
	10-Jun-14	74	EHC (Shallow)-1	0.026	<0.020	<0.020	0.24	--	<0.020	<0.020	<0.020	<0.020	<0.020	7.3	
			EHC (Shallow)-2	0.059	<0.020	<0.020	0.23	--	<0.020	<0.020	<0.020	<0.020	<0.020	10	
			EHC (Shallow)-3	0.16	<0.020	<0.020	0.25	--	<0.020	<0.020	<0.020	<0.020	<0.020	9.6	
			Average Concentration (mg/L)	0.082	ND	ND	0.24	--	ND	ND	ND	ND	ND	9.1	
			Standard Deviation (mmoles)	1.1E-04	0.0E+00	0.0E+00	1.6E-04	--	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	7.5E-02	
			Average Total mmoles	**0.00013**	**ND**	**ND**	**0.0032**	**3.3E-03**	**ND**	**ND**	**ND**	**ND**	**ND**	**0.42**	
	25-Jun-14	89	EHC (Shallow)-1	<0.020	<0.020	<0.020	0.22	--	<0.020	<0.020	<0.020	<0.020	<0.020	12	
			EHC (Shallow)-2	<0.020	<0.020	<0.020	0.21	--	<0.020	<0.020	<0.020	<0.020	<0.020	14	
			EHC (Shallow)-3	<0.020	<0.020	<0.020	0.22	--	<0.020	<0.020	<0.020	<0.020	<0.020	14	
			Average Concentration (mg/L)	ND	ND	ND	0.22	--	ND	ND	ND	ND	ND	13	
			Standard Deviation (mmoles)	0.0E+00	0.0E+00	0.0E+00	1.2E-04	--	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	6.7E-02	
			Average Total mmoles	**ND**	**ND**	**ND**	**0.0029**	**2.9E-03**	**ND**	**ND**	**ND**	**ND**	**ND**	**0.62**	
	26-Jun-14	90													Spiked with TCE and CTC to target concentrations of 2 mg/L each.
	10-Jul-14	104	EHC (Shallow)-1	<0.020	<0.020	<0.020	0.44	--	<0.020	<0.020	<0.020	<0.020	<0.020	11	
			EHC (Shallow)-2	<0.020	<0.020	0.021	0.44	--	<0.020	<0.020	<0.020	<0.020	<0.020	13	
			EHC (Shallow)-3	0.029	0.25	0.23	0.43	--	<0.020	<0.020	<0.020	0.060	<0.020	13	
			Average Concentration (mg/L)	0.0097	0.085	0.084	0.43	--	ND	ND	ND	0.020	ND	12	
			Standard Deviation (mmoles)	2.7E-05	3.1E-04	4.5E-04	4.5E-05	--	0.0E+00	0.0E+00	0.0E+00	8.5E-05	0.0E+00	6.9E-02	
			Average Total mmoles	**0.000015**	**0.00018**	**0.00029**	**0.0057**	**6.2E-03**	**ND**	**ND**	**ND**	**0.000049**	**ND**	**0.57**	
	29-Jul-14	123	EHC (Shallow)-1	<0.020	<0.020	<0.020	0.42	--	<0.020	<0.020	<0.020	<0.020	<0.020	23	
			EHC (Shallow)-2	<0.020	<0.020	<0.020	0.43	--	<0.020	<0.020	<0.020	<0.020	<0.020	25	
			EHC (Shallow)-3	<0.020	0.077	<0.020	0.48	--	<0.020	<0.020	<0.020	<0.020	<0.020	17	
			Average Concentration (mg/L)	ND	0.026	ND	0.44	--	ND	ND	ND	ND	ND	22	
			Standard Deviation (mmoles)	0.0E+00	9.5E-05	0.0E+00	4.8E-04	--	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.9E-01	
			Average Total mmoles	**ND**	**0.000055**	**ND**	**0.0058**	**5.9E-03**	**ND**	**ND**	**ND**	**ND**	**ND**	**1.0**	
EHC®-L and ZVI Amended/KB-1® Plus Bioaugmented	27-Mar-14	-1													Spiked with TCE and CTC to target concentrations of 2 mg/L each.
(Shallow)	28-Mar-14	0													Amended with 2 mL of a vitamin/mineral solution.
															Amended with 1 g of ZVI to target a final concentration of 5 g/L.
															Amended with 1.37 mL of EHC®-L to target a final concentration of 1 g/L.
															Amended the first replicate with 100 uL of resazurin.
			EHC/ZVI (Shallow)-1	2.8	<0.020	<0.020	<0.020	--	<0.020	1.3	0.021	<0.020	<0.020	0.046	
			EHC/ZVI (Shallow)-2	2.8	<0.020	<0.020	<0.020	--	<0.020	1.3	<0.020	<0.020	<0.020	0.048	
			EHC/ZVI (Shallow)-3	2.8	<0.020	<0.020	0.024	--	<0.020	1.2	<0.020	<0.020	<0.020	0.057	
			Average Concentration (mg/L)	2.8	ND	ND	0.0079	--	ND	1.3	0.007	ND	ND	0.05	
			Standard Deviation (mmoles)	1.6E-05	0.0E+00	0.0E+00	1.8E-04	--	0.0E+00	6.3E-05	2.0E-05	0.0E+00	0.0E+00	2.8E-04	
			Average Total mmoles	**0.0045**	**ND**	**ND**	**0.0001**	**4.6E-03**	**ND**	**0.0018**	**0.000012**	**ND**	**ND**	**0.0023**	
	04-Apr-14	7	EHC/ZVI (Shallow)-1	2.0	0.027	<0.020	0.030	--	<0.020	<0.020	<0.020	0.083	<0.020	0.064	
			EHC/ZVI (Shallow)-2	2.4	<0.020	<0.020	0.022	--	<0.020	<0.020	<0.020	0.061	<0.020	0.059	
			EHC/ZVI (Shallow)-3	2.1	0.026	<0.020	0.035	--	<0.020	<0.020	<0.020	<0.020	<0.020	0.066	
			Average Concentration (mg/L)	2.2	0.018	ND	0.029	--	ND	ND	ND	0.048	ND	0.063	
			Standard Deviation (mmoles)	3.9E-04	3.3E-05	0.0E+00	8.3E-05	--	0.0E+00	0.0E+00	0.0E+00	1.1E-04	0.0E+00	1.6E-04	
			Average Total mmoles	**0.0035**	**0.000038**	**ND**	**0.00038**	**3.9E-03**	**ND**	**ND**	**ND**	**0.00012**	**ND**	**0.0029**	

Treatment	Date	Day	Replicate	Chlorinated Ethenes					Chlorinated Ethanes						Comment
				TCE	cDCE	VC	Ethene	Total Ethenes	Ethane	CTC	CF	DCM	CM	Methane	
				mg/L	mg/L	mg/L	mg/L	mmol/bottle	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	
EHC®-L and ZVI Amended/KB-1® Plus Bioaugmented	17-Apr-14	20	EHC/ZVI (Shallow)-1	0.39	0.081	<0.020	0.079	--	0.028	<0.020	<0.020	<0.020	<0.020	0.059	
			EHC/ZVI (Shallow)-2	0.41	0.12	<0.020	0.093	--	0.039	<0.020	<0.020	<0.020	<0.020	0.080	
(Shallow)			EHC/ZVI (Shallow)-3	0.53	0.067	<0.020	0.08	--	0.032	<0.020	<0.020	<0.020	<0.020	0.069	
Continued			**Average Concentration (mg/L)**	0.44	0.088	ND	0.084	--	0.033	ND	ND	ND	ND	0.070	
			Standard Deviation (mmoles)	1.3E-04	5.7E-05	0.0E+00	1.0E-04	--	1.1E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	4.8E-04	
			Average Total mmoles	**0.00071**	**0.00019**	**ND**	**0.0011**	**2.0E-03**	**0.00065**	**ND**	**ND**	**ND**	**ND**	**0.0032**	
															Spiked with CTC to target concentrations of 2 mg/L.
	25-Apr-14	28	EHC/ZVI (Shallow)-1	0.074	0.19	<0.020	0.084	--	0.032	<0.020	<0.020	0.22	0.022	0.073	
			EHC/ZVI (Shallow)-2	0.06	0.12	<0.020	0.091	--	0.035	<0.020	<0.020	0.18	0.024	0.071	
			EHC/ZVI (Shallow)-3	0.11	0.072	<0.020	0.082	--	0.034	<0.020	<0.020	0.21	0.034	0.081	
			Average Concentration (mg/L)	0.082	0.13	ND	0.086	--	0.034	ND	ND	0.20	0.027	0.075	
			Standard Deviation (mmoles)	4.2E-05	1.3E-04	0.0E+00	5.9E-05	--	3.6E-05	0.0E+00	0.0E+00	4.3E-05	2.7E-05	2.4E-04	
			Average Total mmoles	**0.00013**	**0.00027**	**ND**	**0.0011**	**1.5E-03**	**0.00067**	**ND**	**ND**	**0.00049**	**0.00011**	**0.0035**	
															Bioaugmented with KB-1® Plus (CF formulation).
	09-May-14	42	EHC/ZVI (Shallow)-1	<0.020	0.055	<0.020	0.088	--	0.034	<0.020	<0.020	0.18	<0.020	0.31	
			EHC/ZVI (Shallow)-2	<0.020	0.075	<0.020	0.096	--	0.041	<0.020	<0.020	0.15	<0.020	0.29	
			EHC/ZVI (Shallow)-3	<0.020	<0.020	0.023	0.099	--	0.057	<0.020	<0.020	0.18	0.032	0.25	
			Average Concentration (mg/L)	ND	0.043	0.0077	0.094	--	0.044	ND	ND	0.17	0.011	0.28	
			Standard Deviation (mmoles)	0.0E+00	8.3E-05	4.7E-05	7.8E-05	--	2.2E-04	0.0E+00	0.0E+00	4.4E-05	7.4E-05	1.4E-03	
			Average Total mmoles	**ND**	**0.000092**	**0.000027**	**0.0012**	**1.3E-03**	**0.00087**	**ND**	**ND**	**0.00042**	**0.000043**	**0.013**	
	23-May-14	56	EHC/ZVI (Shallow)-1	<0.020	0.045	0.022	0.090	--	0.033	<0.020	<0.020	0.14	<0.020	0.29	
			EHC/ZVI (Shallow)-2	<0.020	0.054	0.022	0.098	--	0.039	<0.020	<0.020	0.15	<0.020	0.27	
			EHC/ZVI (Shallow)-3	2.3	<0.020	<0.020	<0.020	--	<0.020	<0.020	<0.020	<0.020	<0.020	0.047	
			Average Concentration (mg/L)	0.75	0.033	0.015	0.063	--	0.024	ND	ND	0.095	ND	0.20	
			Standard Deviation (mmoles)	2.1E-03	6.1E-05	4.5E-05	7.2E-04	--	4.1E-04	0.0E+00	0.0E+00	2.0E-04	0.0E+00	6.4E-03	
			Average Total mmoles	**0.0012**	**0.000070**	**0.000051**	**0.00082**	**2.1E-03**	**0.00047**	**ND**	**ND**	**0.00023**	**ND**	**0.0095**	
	10-Jun-14	74	EHC/ZVI (Shallow)-1	0.072	0.03	0.022	0.094	--	0.035	<0.020	<0.020	0.067	<0.020	0.33	
			EHC/ZVI (Shallow)-2	0.034	<0.020	<0.020	0.10	--	0.05	<0.020	<0.020	0.13	<0.020	0.35	
			EHC/ZVI (Shallow)-3	0.083	0.031	<0.020	0.092	--	0.039	<0.020	<0.020	0.13	<0.020	0.19	
			Average Concentration (mg/L)	0.063	0.021	0.0072	0.095	--	0.041	ND	ND	0.11	ND	0.29	
			Standard Deviation (mmoles)	4.2E-05	3.8E-05	4.4E-05	5.7E-05	--	1.5E-04	0.0E+00	0.0E+00	8.8E-05	0.0E+00	3.9E-03	
			Average Total mmoles	**0.00010**	**0.000044**	**0.000025**	**0.0013**	**1.5E-03**	**0.00082**	**ND**	**ND**	**0.00026**	**ND**	**0.013**	
	25-Jun-14	89	EHC/ZVI (Shallow)-1	<0.020	0.030	<0.020	0.095	--	0.044	<0.020	<0.020	<0.020	<0.020	0.37	
			EHC/ZVI (Shallow)-2	<0.020	0.037	<0.020	0.097	--	0.047	<0.020	<0.020	0.095	<0.020	0.34	
			EHC/ZVI (Shallow)-3	<0.020	0.024	<0.020	0.097	--	0.039	<0.020	<0.020	0.098	<0.020	0.20	
			Average Concentration (mg/L)	ND	0.030	ND	0.096	--	0.043	ND	ND	0.064	ND	0.30	
			Standard Deviation (mmoles)	0.0E+00	1.4E-05	0.0E+00	1.6E-05	--	7.3E-05	0.0E+00	0.0E+00	1.4E-04	0.0E+00	4.2E-03	
			Average Total mmoles	**ND**	**0.000065**	**ND**	**0.0013**	**1.6E-03**	**0.00086**	**ND**	**ND**	**0.00016**	**ND**	**0.014**	
	26-Jun-14	90													Spiked with TCE and CTC to target concentrations of 2 mg/L each.
	10-Jul-14	104	EHC/ZVI (Shallow)-1	0.062	0.067	0.020	0.19	--	0.053	<0.020	<0.020	0.20	0.025	0.36	
			EHC/ZVI (Shallow)-2	0.058	0.068	<0.020	0.19	--	0.048	<0.020	<0.020	0.29	0.047	0.29	
			EHC/ZVI (Shallow)-3	0.062	0.075	<0.020	0.22	--	0.051	<0.020	<0.020	0.29	0.029	0.18	
			Average Concentration (mg/L)	0.060	0.070	0.0067	0.20	--	0.05	ND	ND	0.26	0.033	0.28	
			Standard Deviation (mmoles)	3.6E-06	9.7E-06	4.0E-05	2.6E-04	--	5.0E-05	0.0E+00	0.0E+00	1.3E-04	4.6E-05	4.1E-03	
			Average Total mmoles	**0.000097**	**0.00015**	**0.000023**	**0.0026**	**2.9E-03**	**0.0010**	**ND**	**ND**	**0.00064**	**0.00013**	**0.013**	
	29-Jul-14	123	EHC/ZVI (Shallow)-1	<0.020	0.052	0.021	0.20	--	0.049	<0.020	<0.020	0.021	<0.020	0.37	
			EHC/ZVI (Shallow)-2	<0.020	0.054	<0.020	0.20	--	0.053	<0.020	<0.020	0.21	0.023	0.34	
			EHC/ZVI (Shallow)-3	0.027	0.058	<0.020	0.25	--	0.06	<0.020	<0.020	0.24	0.021	0.22	
			Average Concentration (mg/L)	0.0091	0.055	0.0069	0.21	--	0.054	ND	ND	0.16	0.015	0.31	
			Standard Deviation (mmoles)	2.5E-05	6.0E-06	4.2E-05	3.7E-04	--	1.1E-04	0.0E+00	0.0E+00	2.9E-04	5.2E-05	3.8E-03	
			Average Total mmoles	**0.000015**	**0.00012**	**0.000024**	**0.0028**	**3.0E-03**	**0.0011**	**ND**	**ND**	**0.00038**	**6.0E-05**	**0.014**	
Anaerobic Active Control	27-Mar-14	-1													Spiked with TCE and CTC to target concentrations of 2 mg/L each.
(Intermediate)	28-Mar-14	0													Amended the first replicate with 100 uL of resazurin.
															Amended with 2 mL of a vitamin/mineral solution.
			ANAC (Intermediate)-1	3.2	<0.020	<0.020	<0.020	--	<0.020	1.3	0.039	<0.020	<0.020	0.046	
			ANAC (Intermediate)-2	3.4	<0.020	<0.020	<0.020	--	<0.020	1.6	0.042	<0.020	<0.020	0.041	
			ANAC (Intermediate)-3	3.3	<0.020	<0.020	<0.020	--	<0.020	1.6	0.039	<0.020	<0.020	0.043	
			Average Concentration (mg/L)	3.3	ND	ND	ND	--	ND	1.5	0.040	ND	ND	0.043	
			Standard Deviation (mmoles)	2.1E-04	0.0E+00	0.0E+00	0.0E+00	--	0.0E+00	1.9E-04	3.4E-06	0.0E+00	0.0E+00	1.0E-04	
			Average Total mmoles	**0.0053**	**ND**	**ND**	**ND**	**5.3E-03**	**ND**	**0.0021**	**0.000068**	**ND**	**ND**	**0.0020**	

Treatment	Date	Day	Replicate	TCE	cDCE	VC	Ethene	Total Ethenes	Ethane	CTC	CF	DCM	CM	Methane	Comment
				Chlorinated Ethenes					Chlorinated Ethanes						
				mg/L	mg/L	mg/L	mg/L	mmol/bottle	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	
Anaerobic Active Control	04-Apr-14	7	ANAC (Intermediate)-1	2.7	<0.020	<0.020	<0.020	--	<0.020	<0.020	0.45	<0.020	<0.020	0.042	
(Intermediate)			ANAC (Intermediate)-2	3.1	<0.020	<0.020	<0.020	--	<0.020	0.26	0.17	<0.020	<0.020	0.041	
Continued			ANAC (Intermediate)-3	3.1	<0.020	<0.020	<0.020	--	<0.020	0.067	0.20	<0.020	<0.020	0.043	
			Average Concentration (mg/L)	3.0	ND	ND	ND	--	ND	0.11	0.27	ND	ND	0.042	
			Standard Deviation (mmoles)	3.9E-04	0.0E+00	0.0E+00	0.0E+00	--	0.0E+00	1.9E-04	2.6E-04	0.0E+00	0.0E+00	4.5E-05	
			Average Total mmoles	**0.0047**	**ND**	**ND**	**ND**	**4.7E-03**	**ND**	**0.00015**	**0.00046**	**ND**	**ND**	**0.0020**	
	17-Apr-14	20	ANAC (Intermediate)-1	2.6	<0.020	<0.020	<0.020	--	<0.020	<0.020	0.31	<0.020	<0.020	0.048	
			ANAC (Intermediate)-2	3.0	<0.020	<0.020	<0.020	--	<0.020	<0.020	0.13	<0.020	<0.020	0.045	
			ANAC (Intermediate)-3	3.1	<0.020	<0.020	<0.020	--	<0.020	<0.020	0.20	<0.020	<0.020	0.043	
			Average Concentration (mg/L)	2.9	ND	ND	ND	--	ND	ND	0.22	ND	ND	0.045	
			Standard Deviation (mmoles)	3.9E-04	0.0E+00	0.0E+00	0.0E+00	--	0.0E+00	0.0E+00	1.6E-04	0.0E+00	0.0E+00	1.1E-04	
			Average Total mmoles	**0.0047**	**ND**	**ND**	**ND**	**4.7E-03**	**ND**	**ND**	**0.00037**	**ND**	**ND**	**0.0021**	
															Spiked with CTC to target concentrations of 2 mg/L.
	25-Apr-14	28	ANAC (Intermediate)-1	2.5	<0.020	<0.020	<0.020	--	<0.020	<0.020	0.30	0.081	<0.020	0.045	
			ANAC (Intermediate)-2	3.0	<0.020	<0.020	<0.020	--	<0.020	<0.020	0.13	0.030	<0.020	0.044	
			ANAC (Intermediate)-3	2.9	<0.020	<0.020	<0.020	--	<0.020	<0.020	0.19	0.021	<0.020	0.043	
			Average Concentration (mg/L)	2.8	ND	ND	ND	--	ND	ND	0.21	0.044	ND	0.044	
			Standard Deviation (mmoles)	4.0E-04	0.0E+00	0.0E+00	0.0E+00	--	0.0E+00	0.0E+00	1.4E-04	8.0E-05	0.0E+00	5.8E-05	
			Average Total mmoles	**0.0045**	**ND**	**ND**	**ND**	**4.5E-03**	**ND**	**ND**	**0.00035**	**0.00011**	**ND**	**0.0020**	
															Bioaugmented with KB-1® Plus (CF formulation).
	23-May-14	56	ANAC (Intermediate)-1	2.5	<0.020	<0.020	<0.020	--	<0.020	<0.020	<0.020	<0.020	<0.020	0.046	
			ANAC (Intermediate)-2	2.9	0.22	<0.020	<0.020	--	<0.020	<0.020	<0.020	0.043	<0.020	0.042	
			ANAC (Intermediate)-3	2.7	0.14	<0.020	<0.020	--	<0.020	<0.020	0.14	0.044	<0.020	0.041	
			Average Concentration (mg/L)	2.7	0.12	ND	ND	--	ND	ND	0.047	0.029	ND	0.043	
			Standard Deviation (mmoles)	2.7E-04	2.3E-04	0.0E+00	0.0E+00	--	0.0E+00	0.0E+00	1.4E-04	6.1E-05	0.0E+00	1.2E-04	
			Average Total mmoles	**0.0043**	**0.00025**	**ND**	**ND**	**4.6E-03**	**ND**	**ND**	**0.00008**	**0.000071**	**ND**	**0.0020**	
ZVI Amended/KB-1® Plus Bioaugmented	27-Mar-14	-1													Spiked with TCE and CTC to target concentrations of 2 mg/L each.
(Intermediate)	28-Mar-14	0													Amended the first replicate with 100 uL of resazurin.
															Amended with 1 g of ZVI to target a final concentration of 5 g/L.
															Amended with 2 mL of a vitamin/mineral solution.
			ZVI (Intermediate)-1	3.1	<0.020	<0.020	<0.020	--	<0.020	1.5	0.038	<0.020	<0.020	0.074	
			ZVI (Intermediate)-2	3.3	<0.020	<0.020	<0.020	--	<0.020	1.5	0.04	<0.020	<0.020	0.047	
			ZVI (Intermediate)-3	3.1	<0.020	<0.020	<0.020	--	<0.020	1.4	0.037	<0.020	<0.020	0.049	
			Average Concentration (mg/L)	3.2	ND	ND	ND	--	ND	1.5	0.038	ND	ND	0.056	
			Standard Deviation (mmoles)	1.7E-04	0.0E+00	0.0E+00	0.0E+00	--	0.0E+00	5.3E-05	2.2E-06	0.0E+00	0.0E+00	7.1E-04	
			Average Total mmoles	**0.0051**	**ND**	**ND**	**ND**	**5.1E-03**	**ND**	**0.0021**	**0.000065**	**ND**	**ND**	**0.0026**	
	04-Apr-14	7	ZVI (Intermediate)-1	2.5	<0.020	<0.020	0.032	--	0.022	<0.020	<0.020	<0.020	<0.020	0.074	
			ZVI (Intermediate)-2	1.9	<0.020	<0.020	0.082	--	0.12	<0.020	<0.020	<0.020	<0.020	<0.020	
			ZVI (Intermediate)-3	2.4	<0.020	<0.020	0.032	--	0.041	<0.020	<0.020	<0.020	<0.020	0.092	
			Average Concentration (mg/L)	2.3	ND	ND	0.049	--	0.062	ND	ND	ND	ND	0.056	
			Standard Deviation (mmoles)	4.8E-04	0.0E+00	0.0E+00	3.8E-04	--	1.1E-03	0.0E+00	0.0E+00	0.0E+00	0.0E+00	2.3E-03	
			Average Total mmoles	**0.0036**	**ND**	**ND**	**0.00064**	**4.2E-03**	**0.0012**	**ND**	**ND**	**ND**	**ND**	**0.0026**	
	17-Apr-14	20	ZVI (Intermediate)-1	0.65	0.057	<0.020	0.052	--	0.025	<0.020	<0.020	<0.020	<0.020	0.066	
			ZVI (Intermediate)-2	0.37	0.048	<0.020	0.075	--	0.062	<0.020	<0.020	<0.020	<0.020	0.088	
			ZVI (Intermediate)-3	0.41	0.063	<0.020	0.059	--	0.04	<0.020	<0.020	<0.020	<0.020	0.079	
			Average Concentration (mg/L)	0.48	0.056	ND	0.062	--	0.042	ND	ND	ND	ND	0.078	
			Standard Deviation (mmoles)	2.4E-04	1.6E-05	0.0E+00	1.6E-04	--	3.6E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	5.2E-04	
			Average Total mmoles	**0.00076**	**0.00012**	**ND**	**0.00081**	**1.7E-03**	**0.00083**	**ND**	**ND**	**ND**	**ND**	**0.0036**	
															Spiked with CTC to target concentrations of 2 mg/L.
	25-Apr-14	28	ZVI (Intermediate)-1	0.11	0.064	<0.020	0.049	--	0.024	<0.020	<0.020	0.28	0.037	0.072	
			ZVI (Intermediate)-2	0.042	0.047	<0.020	0.072	--	0.058	<0.020	<0.020	0.33	0.028	0.095	
			ZVI (Intermediate)-3	0.041	0.07	<0.020	0.055	--	0.036	<0.020	<0.020	0.33	0.028	0.082	
			Average Concentration (mg/L)	0.064	0.06	ND	0.059	--	0.039	ND	ND	0.31	0.031	0.083	
			Standard Deviation (mmoles)	6.2E-05	2.6E-05	0.0E+00	1.6E-04	--	3.5E-04	0.0E+00	0.0E+00	8.2E-05	2.1E-05	5.3E-04	
			Average Total mmoles	**0.00010**	**0.00013**	**ND**	**0.00077**	**1.0E-03**	**0.00078**	**ND**	**ND**	**0.00077**	**0.00012**	**0.0038**	
															Bioaugmented with KB-1® Plus (CF formulation).
	09-May-14	42	ZVI (Intermediate)-1	<0.020	<0.020	<0.020	0.06	--	0.038	<0.020	<0.020	0.25	0.031	0.13	
			ZVI (Intermediate)-2	<0.020	0.028	<0.020	0.073	--	0.042	<0.020	<0.020	0.24	<0.020	0.11	
			ZVI (Intermediate)-3	<0.020	0.058	<0.020	0.056	--	0.037	<0.020	<0.020	0.29	0.021	0.081	
			Average Concentration (mg/L)	ND	0.029	ND	0.063	--	0.039	ND	ND	0.26	0.017	0.11	
			Standard Deviation (mmoles)	0.0E+00	6.2E-05	0.0E+00	1.1E-04	--	5.5E-05	0.0E+00	0.0E+00	6.4E-05	6.3E-05	1.0E-03	
			Average Total mmoles	**ND**	**0.000061**	**ND**	**0.00083**	**8.9E-04**	**0.00078**	**ND**	**ND**	**0.00063**	**0.000069**	**0.0049**	

Treatment	Date	Day	Replicate	Chlorinated Ethenes					Chlorinated Ethanes						Comment
				TCE	cDCE	VC	Ethene	Total Ethenes	Ethane	CTC	CF	DCM	CM	Methane	
				mg/L	mg/L	mg/L	mg/L	mmol/bottle	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	
ZVI Amended/KB-1® Plus Bioaugmented	23-May-14	56	ZVI (Intermediate)-1	<0.020	<0.020	<0.020	0.11	--	0.073	<0.020	<0.020	0.18	0.025	0.14	
(Intermediate)			ZVI (Intermediate)-2	<0.020	0.049	<0.020	0.052	--	0.022	<0.020	<0.020	0.23	<0.020	0.072	
Continued			ZVI (Intermediate)-3	<0.020	0.031	<0.020	0.12	--	0.06	<0.020	<0.020	0.27	<0.020	0.11	
			Average Concentration (mg/L)	ND	0.027	ND	0.093	--	0.052	ND	ND	0.22	0.0083	0.11	
			Standard Deviation (mmoles)	0.0E+00	5.3E-05	0.0E+00	4.8E-04	--	5.2E-04	0.0E+00	0.0E+00	1.0E-04	5.7E-05	1.6E-03	
			Average Total mmoles	**ND**	**0.000057**	**ND**	**0.0012**	**1.3E-03**	**0.0010**	**ND**	**ND**	**0.00055**	**0.000033**	**0.0050**	
	10-Jun-14	74	ZVI (Intermediate)-1	<0.020	0.037	<0.020	0.05	--	0.025	<0.020	<0.020	0.21	<0.020	0.089	
			ZVI (Intermediate)-2	<0.020	0.026	<0.020	0.14	--	0.065	<0.020	<0.020	0.23	<0.020	0.14	
			ZVI (Intermediate)-3	<0.020	0.047	<0.020	0.054	--	0.034	<0.020	<0.020	0.25	<0.020	0.092	
			Average Concentration (mg/L)	ND	0.037	ND	0.082	--	0.041	ND	ND	0.23	ND	0.11	
			Standard Deviation (mmoles)	0.0E+00	2.3E-05	0.0E+00	6.9E-04	--	4.1E-04	0.0E+00	0.0E+00	4.7E-05	0.0E+00	1.3E-03	
			Average Total mmoles	**ND**	**0.000078**	**ND**	**0.0011**	**1.2E-03**	**0.00082**	**ND**	**ND**	**0.00056**	**ND**	**0.0049**	
SRS™/ZVI and Ferrous Fumarate Amended/KB-1® Plus	27-Mar-14	-1													Spiked with TCE and CTC to target concentrations of 2 mg/L each.
Bioaugmented	28-Mar-14	0													Amended with 333 uL of SRS™ to target a final concentration of 0.1 % as oil.
(Intermediate)															Amended with 1 g of ZVI to target a final concentration of 5 g/L.
															Amended with 2 mL of a vitamin/mineral solution.
			SRS/ZVI (Intermediate)-1	2.7	<0.020	<0.020	<0.020	--	<0.020	1.3	0.073	<0.020	<0.020	0.051	
			SRS/ZVI (Intermediate)-2	2.9	<0.020	<0.020	<0.020	--	<0.020	1.3	0.06	<0.020	<0.020	0.049	
			SRS/ZVI (Intermediate)-3	2.8	<0.020	<0.020	<0.020	--	<0.020	1.3	0.065	<0.020	<0.020	0.049	
			Average Concentration (mg/L)	2.8	ND	ND	ND	--	ND	1.3	0.066	ND	ND	0.050	
			Standard Deviation (mmoles)	1.1E-04	0.0E+00	0.0E+00	0.0E+00	--	0.0E+00	2.1E-05	1.1E-05	0.0E+00	0.0E+00	6.6E-05	
			Average Total mmoles	**0.0045**	**ND**	**ND**	**ND**	**4.5E-03**	**ND**	**0.0019**	**0.00011**	**ND**	**ND**	**0.0023**	
	04-Apr-14	7	SRS/ZVI (Intermediate)-1	2.3	<0.020	<0.020	0.038	--	0.036	<0.020	<0.020	<0.020	<0.020	0.081	
			SRS/ZVI (Intermediate)-2	2.0	<0.020	<0.020	0.045	--	0.034	<0.020	<0.020	<0.020	<0.020	0.093	
			SRS/ZVI (Intermediate)-3	2.1	<0.020	<0.020	0.044	--	0.036	<0.020	<0.020	0.15	<0.020	<0.020	
			Average Concentration (mg/L)	2.1	ND	ND	0.042	--	0.035	ND	ND	0.049	ND	0.058	
			Standard Deviation (mmoles)	2.1E-04	0.0E+00	0.0E+00	5.3E-05	--	2.4E-05	0.0E+00	0.0E+00	2.1E-04	0.0E+00	2.3E-03	
			Average Total mmoles	**0.0034**	**ND**	**ND**	**0.00056**	**4.0E-03**	**0.00069**	**ND**	**ND**	**0.00012**	**ND**	**0.0027**	
															Amended with 36 mg of fumerous fumarate to target a final concentration of 180 mg/L.
	17-Apr-14	20	SRS/ZVI (Intermediate)-1	0.54	0.076	<0.020	0.098	--	0.063	<0.020	<0.020	<0.020	<0.020	0.088	
			SRS/ZVI (Intermediate)-2	0.53	0.074	<0.020	0.089	--	0.044	<0.020	<0.020	<0.020	<0.020	0.076	
			SRS/ZVI (Intermediate)-3	0.46	0.069	<0.020	0.091	--	0.057	<0.020	<0.020	<0.020	<0.020	0.077	
			Average Concentration (mg/L)	0.51	0.073	ND	0.092	--	0.055	ND	ND	ND	ND	0.080	
			Standard Deviation (mmoles)	6.8E-05	7.1E-06	0.0E+00	6.2E-05	--	1.9E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	3.0E-04	
			Average Total mmoles	**0.00082**	**0.00016**	**ND**	**0.0012**	**2.2E-03**	**0.0011**	**ND**	**ND**	**ND**	**ND**	**0.0037**	
															Spiked with CTC to target concentrations of 2 mg/L.
	25-Apr-14	28	SRS/ZVI (Intermediate)-1	0.13	0.083	<0.020	0.10	--	0.060	<0.020	<0.020	0.23	0.024	0.084	
			SRS/ZVI (Intermediate)-2	0.16	0.086	0.041	0.10	--	0.075	<0.020	<0.020	0.42	0.046	0.18	
			SRS/ZVI (Intermediate)-3	0.063	0.059	<0.020	0.09	--	0.061	<0.020	<0.020	0.30	0.038	0.085	
			Average Concentration (mg/L)	0.12	0.076	0.014	0.098	--	0.065	ND	ND	0.32	0.036	0.12	
			Standard Deviation (mmoles)	7.9E-05	3.1E-05	8.2E-05	1.0E-04	--	1.7E-04	0.0E+00	0.0E+00	2.3E-04	4.4E-05	2.5E-03	
			Average Total mmoles	**0.00019**	**0.00016**	**0.000047**	**0.0013**	**1.7E-03**	**0.0013**	**ND**	**ND**	**0.00078**	**0.00015**	**0.0054**	
															Bioaugmented with KB-1® Plus (CF formulation).
	09-May-14	42	SRS/ZVI (Intermediate)-1	<0.020	0.048	<0.020	0.11	--	0.084	<0.020	<0.020	0.15	<0.020	0.37	
			SRS/ZVI (Intermediate)-2	<0.020	0.023	<0.020	0.088	--	0.066	<0.020	<0.020	0.17	0.03	0.26	
			SRS/ZVI (Intermediate)-3	<0.020	0.052	<0.020	0.085	--	0.037	<0.020	<0.020	0.20	0.023	0.16	
			Average Concentration (mg/L)	ND	0.041	ND	0.095	--	0.063	ND	ND	0.18	0.018	0.26	
			Standard Deviation (mmoles)	0.0E+00	3.3E-05	0.0E+00	2.0E-04	--	4.7E-04	0.0E+00	0.0E+00	6.0E-05	6.2E-05	4.7E-03	
			Average Total mmoles	**ND**	**0.000087**	**ND**	**0.0012**	**1.3E-03**	**0.0012**	**ND**	**ND**	**0.00043**	**0.000070**	**0.012**	
	23-May-14	56	SRS/ZVI (Intermediate)-1	<0.020	0.053	<0.020	0.055	--	0.034	<0.020	<0.020	0.27	<0.020	0.081	
			SRS/ZVI (Intermediate)-2	<0.020	0.049	<0.020	0.12	--	0.072	<0.020	<0.020	0.20	0.021	0.18	
			SRS/ZVI (Intermediate)-3	0.062	0.050	<0.020	0.10	--	0.054	<0.020	<0.020	0.24	0.022	0.16	
			Average Concentration (mg/L)	0.021	0.050	ND	0.093	--	0.053	ND	ND	0.24	0.015	0.14	
			Standard Deviation (mmoles)	5.7E-05	4.1E-06	0.0E+00	4.4E-04	--	3.7E-04	0.0E+00	0.0E+00	9.6E-05	5.0E-05	2.4E-03	
			Average Total mmoles	**0.000033**	**0.00011**	**ND**	**0.0012**	**1.3E-03**	**0.0011**	**ND**	**ND**	**0.00058**	**0.000058**	**0.0065**	
	10-Jun-14	74	SRS/ZVI (Intermediate)-1	<0.020	0.031	<0.020	0.13	--	0.085	<0.020	<0.020	0.15	<0.020	0.21	
			SRS/ZVI (Intermediate)-2	<0.020	0.041	<0.020	0.11	--	0.058	<0.020	<0.020	0.19	<0.020	0.17	
			SRS/ZVI (Intermediate)-3	<0.020	<0.020	<0.020	0.11	--	0.084	<0.020	<0.020	0.13	0.021	0.17	
			Average Concentration (mg/L)	ND	0.024	ND	0.12	--	0.076	ND	ND	0.15	0.0069	0.18	
			Standard Deviation (mmoles)	0.0E+00	4.6E-05	0.0E+00	1.7E-04	--	3.1E-04	0.0E+00	0.0E+00	8.2E-05	4.8E-05	9.7E-04	
			Average Total mmoles	**ND**	**0.000051**	**ND**	**0.0015**	**1.6E-03**	**0.0015**	**ND**	**ND**	**0.00038**	**0.000028**	**0.0084**	

Treatment	Date	Day	Replicate	Chlorinated Ethenes					Chlorinated Ethanes						Comment
				TCE	cDCE	VC	Ethene	Total Ethenes	Ethane	CTC	CF	DCM	CM	Methane	
				mg/L	mg/L	mg/L	mg/L	mmol/bottle	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	
SRS™ and Ferrous Fumarate Amended/KB-1® Plus Bioaugmented (Intermediate)	27-Mar-14	-1													Spiked with TCE and CTC to target concentrations of 2 mg/L each.
	28-Mar-14	0													Amended with 36 mg of fumerous fumarate to target a final concentration of 180 mg/L.
															Amended the first replicate with 100 uL of resazurin.
															Amended with 2 mL of a vitamin/mineral solution.
															Amended with 333 uL of SRS™ to target a final concentration of 0.1 % as oil.
			SRS/solFe (Intermediate)-1	2.8	<0.020	<0.020	<0.020	--	<0.020	1.2	0.085	<0.020	<0.020	0.043	
			SRS/solFe (Intermediate)-2	2.9	<0.020	<0.020	<0.020	--	<0.020	1.3	0.059	<0.020	<0.020	0.042	
			SRS/solFe (Intermediate)-3	2.9	<0.020	<0.020	<0.020	--	<0.020	1.4	0.057	<0.020	<0.020	0.044	
			Average Concentration (mg/L)	2.9	ND	ND	ND	--	ND	1.3	0.067	ND	ND	0.043	
			Standard Deviation (mmoles)	1.5E-04	0.0E+00	0.0E+00	0.0E+00	--	0.0E+00	9.3E-05	2.6E-05	0.0E+00	0.0E+00	3.9E-05	
			Average Total mmoles	**0.0046**	**ND**	**ND**	**ND**	**4.6E-03**	**ND**	**0.0018**	**0.00011**	**ND**	**ND**	**0.0020**	
	04-Apr-14	7	SRS/solFe (Intermediate)-1	2.3	0.022	<0.020	<0.020	--	<0.020	<0.020	0.49	<0.020	<0.020	0.042	
			SRS/solFe (Intermediate)-2	2.4	<0.020	<0.020	<0.020	--	<0.020	<0.020	0.54	<0.020	<0.020	0.043	
			SRS/solFe (Intermediate)-3	2.7	<0.020	<0.020	<0.020	--	<0.020	<0.020	0.63	<0.020	<0.020	0.041	
			Average Concentration (mg/L)	2.5	0.0074	ND	ND	--	ND	ND	0.55	ND	ND	0.042	
			Standard Deviation (mmoles)	3.2E-04	2.7E-05	0.0E+00	0.0E+00	--	0.0E+00	0.0E+00	1.2E-04	0.0E+00	0.0E+00	3.7E-05	
			Average Total mmoles	**0.0039**	**0.000016**	**ND**	**ND**	**3.9E-03**	**ND**	**ND**	**0.00094**	**ND**	**ND**	**0.0020**	
	17-Apr-14	20	SRS/solFe (Intermediate)-1	2.3	<0.020	<0.020	<0.020	--	<0.020	<0.020	0.11	<0.020	<0.020	0.044	
			SRS/solFe (Intermediate)-2	2.4	<0.020	<0.020	<0.020	--	<0.020	<0.020	0.13	<0.020	<0.020	0.044	
			SRS/solFe (Intermediate)-3	2.3	<0.020	<0.020	<0.020	--	<0.020	<0.020	0.097	<0.020	<0.020	0.044	
			Average Concentration (mg/L)	2.3	ND	ND	ND	--	ND	ND	0.11	ND	ND	0.044	
			Standard Deviation (mmoles)	8.5E-05	0.0E+00	0.0E+00	0.0E+00	--	0.0E+00	0.0E+00	2.4E-05	0.0E+00	0.0E+00	1.3E-05	
			Average Total mmoles	**0.0037**	**ND**	**ND**	**ND**	**3.7E-03**	**ND**	**ND**	**0.00019**	**ND**	**ND**	**0.0020**	
															Spiked with CTC to target concentrations of 2 mg/L.
	25-Apr-14	28	SRS/solFe (Intermediate)-1	2.2	<0.020	<0.020	<0.020	--	<0.020	<0.020	0.51	0.16	<0.020	0.042	
			SRS/solFe (Intermediate)-2	2.4	<0.020	<0.020	<0.020	--	<0.020	<0.020	0.67	0.13	<0.020	0.043	
			SRS/solFe (Intermediate)-3	2.3	<0.020	<0.020	<0.020	--	<0.020	<0.020	0.32	0.17	0.031	0.041	
			Average Concentration (mg/L)	2.3	ND	ND	ND	--	ND	ND	0.50	0.15	0.010	0.042	
			Standard Deviation (mmoles)	1.5E-04	0.0E+00	0.0E+00	0.0E+00	--	0.0E+00	0.0E+00	3.0E-04	4.9E-05	7.2E-05	4.4E-05	
			Average Total mmoles	**0.0037**	**ND**	**ND**	**ND**	**3.7E-03**	**ND**	**ND**	**0.00084**	**0.00037**	**0.000041**	**0.0019**	
															Bioaugmented with KB-1® Plus (CF formulation).
	09-May-14	42	SRS/solFe (Intermediate)-1	1.5	0.25	0.028	<0.020	--	<0.020	<0.020	0.031	0.042	<0.020	0.73	
			SRS/solFe (Intermediate)-2	1.5	0.22	0.026	<0.020	--	<0.020	<0.020	0.023	0.055	<0.020	0.83	
			SRS/solFe (Intermediate)-3	1.6	0.16	<0.020	<0.020	--	<0.020	<0.020	0.024	0.18	0.021	0.33	
			Average Concentration (mg/L)	1.5	0.21	0.018	ND	--	ND	ND	0.026	0.091	0.0070	0.63	
			Standard Deviation (mmoles)	7.4E-05	9.0E-05	5.4E-05	0.0E+00	--	0.0E+00	0.0E+00	7.7E-06	1.8E-04	4.9E-05	1.2E-02	
			Average Total mmoles	**0.0025**	**0.00045**	**0.000063**	**ND**	**3.0E-03**	**ND**	**ND**	**0.000045**	**0.00022**	**0.000028**	**0.029**	
	23-May-14	56	SRS/solFe (Intermediate)-1	<0.020	<0.020	<0.020	0.22	--	<0.020	<0.020	<0.020	<0.020	<0.020	2.7	
			SRS/solFe (Intermediate)-2	<0.020	<0.020	<0.020	0.24	--	<0.020	<0.020	<0.020	<0.020	<0.020	1.6	
			SRS/solFe (Intermediate)-3	<0.020	<0.020	0.29	0.21	--	<0.020	<0.020	<0.020	0.096	<0.020	1.7	
			Average Concentration (mg/L)	ND	ND	0.096	0.22	--	ND	ND	ND	0.032	ND	2.0	
			Standard Deviation (mmoles)	0.0E+00	0.0E+00	5.8E-04	2.0E-04	--	0.0E+00	0.0E+00	0.0E+00	1.4E-04	0.0E+00	2.7E-02	
			Average Total mmoles	**ND**	**ND**	**0.00034**	**0.003**	**3.3E-03**	**ND**	**ND**	**ND**	**0.000078**	**ND**	**0.092**	
	10-Jun-14	74	SRS/solFe (Intermediate)-1	<0.020	<0.020	<0.020	0.20	--	<0.020	<0.020	<0.020	<0.020	<0.020	7.8	
			SRS/solFe (Intermediate)-2	<0.020	<0.020	<0.020	0.24	--	<0.020	<0.020	<0.020	<0.020	<0.020	5.9	
			SRS/solFe (Intermediate)-3	<0.020	0.021	<0.020	0.23	--	<0.020	<0.020	<0.020	<0.020	<0.020	7.0	
			Average Concentration (mg/L)	ND	0.0071	ND	0.22	--	ND	ND	ND	ND	ND	6.9	
			Standard Deviation (mmoles)	0.0E+00	2.6E-05	0.0E+00	2.2E-04	--	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	4.4E-02	
			Average Total mmoles	**ND**	**0.000015**	**ND**	**0.0029**	**2.9E-03**	**ND**	**ND**	**ND**	**ND**	**ND**	**0.32**	
SRS™ Amended/KB-1® Plus Bioaugmented (Intermediate)	27-Mar-14	-1													Spiked with TCE and CTC to target concentrations of 2 mg/L each.
	28-Mar-14	0													Amended with 333 uL of SRS™ to target a final concentration of 0.1 % as oil.
															Amended the first replicate with 100 uL of resazurin.
															Amended with 2 mL of a vitamin/mineral solution.
			SRS (Int)-1	3.0	<0.020	<0.020	<0.020	--	<0.020	1.4	0.064	<0.020	<0.020	0.042	
			SRS (Int)-2	2.9	<0.020	<0.020	<0.020	--	<0.020	1.4	0.058	<0.020	<0.020	0.042	
			SRS (Int)-3	3.0	<0.020	<0.020	<0.020	--	<0.020	1.5	0.064	<0.020	<0.020	0.043	
			Average Concentration (mg/L)	2.9	ND	ND	ND	--	ND	1.4	0.062	ND	ND	0.042	
			Standard Deviation (mmoles)	1.2E-04	0.0E+00	0.0E+00	0.0E+00	--	0.0E+00	7.4E-05	6.3E-06	0.0E+00	0.0E+00	2.6E-05	
			Average Total mmoles	**0.0047**	**ND**	**ND**	**ND**	**4.7E-03**	**ND**	**0.0020**	**0.00011**	**ND**	**ND**	**0.0020**	

Treatment	Date	Day	Replicate	Chlorinated Ethenes					Chlorinated Ethanes						Comment
				TCE	cDCE	VC	Ethene	Total Ethenes	Ethane	CTC	CF	DCM	CM	Methane	
				mg/L	mg/L	mg/L	mg/L	mmol/bottle	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	
SRS™ Amended/KB-1® Plus Bioaugmented	04-Apr-14	7	SRS (Intermediate)-1	2.7	<0.020	<0.020	<0.020	--	<0.020	<0.020	0.74	<0.020	<0.020	0.043	
(Intermediate)			SRS (Intermediate)-2	2.8	<0.020	<0.020	<0.020	--	<0.020	<0.020	0.67	<0.020	<0.020	0.042	
Continued			SRS (Intermediate)-3	2.7	<0.020	<0.020	<0.020	--	<0.020	<0.020	0.79	<0.020	<0.020	0.042	
			Average Concentration (mg/L)	2.7	ND	ND	ND	--	ND	ND	0.73	ND	ND	0.042	
			Standard Deviation (mmoles)	1.0E-04	0.0E+00	0.0E+00	0.0E+00	--	0.0E+00	0.0E+00	1.1E-04	0.0E+00	0.0E+00	3.8E-05	
			Average Total mmoles	**0.0044**	**ND**	**ND**	**ND**	**4.4E-03**	**ND**	**ND**	**0.0012**	**ND**	**ND**	**0.0020**	
	17-Apr-14	20	SRS (Intermediate)-1	2.5	0.024	<0.020	<0.020	--	<0.020	<0.020	0.31	<0.020	<0.020	0.043	
			SRS (Intermediate)-2	2.5	<0.020	<0.020	<0.020	--	<0.020	<0.020	0.19	<0.020	<0.020	0.043	
			SRS (Intermediate)-3	2.4	<0.020	<0.020	<0.020	--	<0.020	<0.020	<0.020	<0.020	<0.020	0.043	
			Average Concentration (mg/L)	2.5	0.0079	ND	ND	--	ND	ND	0.17	ND	ND	0.043	
			Standard Deviation (mmoles)	2.2E-05	2.9E-05	0.0E+00	0.0E+00	--	0.0E+00	0.0E+00	2.7E-04	0.0E+00	0.0E+00	1.7E-05	
			Average Total mmoles	**0.0039**	**0.000017**	**ND**	**ND**	**3.9E-03**	**ND**	**ND**	**0.00028**	**ND**	**ND**	**0.0020**	
															Spiked with CTC to target concentrations of 2 mg/L.
	25-Apr-14	28	SRS (Intermediate)-1	1.5	0.98	<0.020	<0.020	--	<0.020	<0.020	0.20	0.3	<0.020	0.041	
			SRS (Intermediate)-2	2.3	<0.020	<0.020	<0.020	--	<0.020	<0.020	0.42	0.22	0.026	0.041	
			SRS (Intermediate)-3	2.3	<0.020	<0.020	<0.020	--	<0.020	<0.020	0.36	0.21	<0.020	0.041	
			Average Concentration (mg/L)	2.0	0.33	ND	ND	--	ND	ND	0.33	0.24	0.0088	0.041	
			Standard Deviation (mmoles)	7.3E-04	1.2E-03	0.0E+00	0.0E+00	--	0.0E+00	0.0E+00	1.9E-04	1.2E-04	6.1E-05	2.2E-05	
			Average Total mmoles	**0.0032**	**0.00070**	**ND**	**ND**	**3.9E-03**	**ND**	**ND**	**0.00055**	**0.00059**	**0.000035**	**0.0019**	
															Bioaugmented with KB-1® Plus (CF formulation).
	09-May-14	42	SRS (Intermediate)-1	<0.020	0.70	0.39	0.075	--	<0.020	<0.020	<0.020	0.24	0.029	0.59	
			SRS (Intermediate)-2	0.42	1.3	0.042	<0.020	--	<0.020	<0.020	<0.020	0.27	0.022	0.91	
			SRS (Intermediate)-3	1.8	0.032	<0.020	<0.020	--	<0.020	<0.020	<0.020	0.16	<0.020	0.20	
			Average Concentration (mg/L)	0.73	0.69	0.14	0.025	--	ND	ND	ND	0.22	0.017	0.57	
			Standard Deviation (mmoles)	1.5E-03	1.4E-03	7.5E-04	5.7E-04	--	0.0E+00	0.0E+00	0.0E+00	1.4E-04	6.0E-05	1.6E-02	
			Average Total mmoles	**0.0012**	**0.0015**	**0.00050**	**0.00033**	**3.5E-03**	**ND**	**ND**	**ND**	**0.00055**	**0.000068**	**0.026**	
	23-May-14	56	SRS (Intermediate)-1	<0.020	<0.020	<0.020	0.25	--	<0.020	<0.020	<0.020	0.31	<0.020	2.4	
			SRS (Intermediate)-2	<0.020	0.031	0.41	0.22	--	<0.020	<0.020	<0.020	0.34	<0.020	5.4	
			SRS (Intermediate)-3	1.3	0.5	0.26	<0.020	--	<0.020	<0.020	<0.020	0.22	0.021	0.39	
			Average Concentration (mg/L)	0.44	0.18	0.22	0.16	--	ND	ND	ND	0.29	0.0070	2.7	
			Standard Deviation (mmoles)	1.2E-03	5.9E-04	7.3E-04	1.8E-03	--	0.0E+00	0.0E+00	0.0E+00	1.5E-04	4.9E-05	1.2E-01	
			Average Total mmoles	**0.00070**	**0.00037**	**0.00079**	**0.0021**	**4.0E-03**	**ND**	**ND**	**ND**	**0.00070**	**0.000028**	**0.13**	
	10-Jun-14	74	SRS (Intermediate)-1	<0.020	0.025	<0.020	0.27	--	<0.020	<0.020	<0.020	<0.020	<0.020	6.9	
			SRS (Intermediate)-2	<0.020	<0.020	<0.020	0.23	--	<0.020	<0.020	<0.020	<0.020	<0.020	11	
			SRS (Intermediate)-3	<0.020	0.11	<0.020	0.28	--	<0.020	<0.020	<0.020	<0.020	<0.020	0.8	
			Average Concentration (mg/L)	ND	0.044	ND	0.26	--	ND	ND	ND	ND	ND	6.1	
			Standard Deviation (mmoles)	0.0E+00	1.2E-04	0.0E+00	2.9E-04	--	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	2.3E-01	
			Average Total mmoles	**ND**	**0.000093**	**ND**	**0.0034**	**3.5E-03**	**ND**	**ND**	**ND**	**ND**	**ND**	**0.28**	
EHC®-L Amended/KB-1® Plus Bioaugmented	27-Mar-14	-1													Spiked with TCE and CTC to target concentrations of 2 mg/L each.
(Intermediate)	28-Mar-14	0													Amended with 1.37 mL of EHC®-L to target a final concentration of 1 g/L.
															Amended the first replicate with 100 uL of resazurin.
															Amended with 2 mL of a vitamin/mineral solution.
			EHC(Intermediate)-1	3.1	<0.020	<0.020	<0.020	--	<0.020	1.4	0.073	<0.020	<0.020	0.042	
			EHC(Intermediate)-2	3.1	<0.020	<0.020	<0.020	--	<0.020	1.4	0.055	<0.020	<0.020	0.042	
			EHC(Intermediate)-3	3.1	<0.020	<0.020	<0.020	--	<0.020	1.5	0.062	<0.020	<0.020	0.044	
			Average Concentration (mg/L)	3.1	ND	ND	ND	--	ND	1.4	0.063	ND	ND	0.043	
			Standard Deviation (mmoles)	7.2E-05	0.0E+00	0.0E+00	0.0E+00	--	0.0E+00	1.3E-05	1.6E-05	0.0E+00	0.0E+00	4.6E-05	
			Average Total mmoles	**0.0049**	**ND**	**ND**	**ND**	**4.9E-03**	**ND**	**0.0020**	**0.00011**	**ND**	**ND**	**0.0020**	
	04-Apr-14	7	EHC(Intermediate)-1	2.7	<0.020	<0.020	<0.020	--	<0.020	<0.020	0.63	<0.020	<0.020	0.036	
			EHC(Intermediate)-2	2.8	<0.020	<0.020	<0.020	--	<0.020	<0.020	0.61	<0.020	<0.020	0.040	
			EHC(Intermediate)-3	2.9	<0.020	<0.020	<0.020	--	<0.020	<0.020	0.63	<0.020	<0.020	0.041	
			Average Concentration (mg/L)	2.8	ND	ND	ND	--	ND	ND	0.62	ND	ND	0.039	
			Standard Deviation (mmoles)	1.0E-04	0.0E+00	0.0E+00	0.0E+00	--	0.0E+00	0.0E+00	2.2E-05	0.0E+00	0.0E+00	1.3E-04	
			Average Total mmoles	**0.0045**	**ND**	**ND**	**ND**	**4.5E-03**	**ND**	**ND**	**0.0011**	**ND**	**ND**	**0.0018**	
	17-Apr-14	20	EHC(Intermediate)-1	2.9	<0.020	<0.020	<0.020	--	<0.020	<0.020	0.25	<0.020	<0.020	0.043	
			EHC(Intermediate)-2	2.7	<0.020	<0.020	<0.020	--	<0.020	<0.020	0.25	<0.020	<0.020	0.041	
			EHC(Intermediate)-3	0.48	2.0	<0.020	<0.020	--	<0.020	<0.020	0.15	<0.020	<0.020	0.043	
			Average Concentration (mg/L)	2.0	0.68	ND	ND	--	ND	ND	0.22	ND	ND	0.042	
			Standard Deviation (mmoles)	2.1E-03	2.5E-03	0.0E+00	0.0E+00	--	0.0E+00	0.0E+00	9.6E-05	0.0E+00	0.0E+00	4.0E-05	
			Average Total mmoles	**0.0032**	**0.0014**	**ND**	**ND**	**4.6E-03**	**ND**	**ND**	**0.00037**	**ND**	**ND**	**0.0020**	
															Spiked with CTC to target concentrations of 2 mg/L.

Treatment	Date	Day	Replicate	Chlorinated Ethenes					Chlorinated Ethanes						Comment
				TCE	cDCE	VC	Ethene	Total Ethenes	Ethane	CTC	CF	DCM	CM	Methane	
				mg/L	mg/L	mg/L	mg/L	mmol/bottle	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	
EHC®-L Amended/KB-1® Plus Bioaugmented	25-Apr-14	28	EHC(Intermediate)-1	2.8	<0.020	<0.020	<0.020	--	<0.020	<0.020	0.23	0.12	0.041	0.042	
(Intermediate)			EHC(Intermediate)-2	2.6	<0.020	<0.020	<0.020	--	<0.020	<0.020	0.26	0.14	<0.020	0.042	
Continued			EHC(Intermediate)-3	0.25	2.4	<0.020	<0.020	--	<0.020	<0.020	0.13	0.16	0.024	0.042	
			Average Concentration (mg/L)	1.9	0.79	ND	ND	--	ND	ND	0.21	0.14	0.022	0.042	
			Standard Deviation (mmoles)	2.3E-03	2.9E-03	0.0E+00	0.0E+00	--	0.0E+00	0.0E+00	1.2E-04	4.6E-05	8.3E-05	1.2E-05	
			Average Total mmoles	**0.0030**	**0.0017**	**ND**	**ND**	**4.7E-03**	**ND**	**ND**	**0.00035**	**0.00033**	**0.000087**	**0.0019**	
															Bioaugmented with KB-1® Plus (CF formulation).
	09-May-14	42	EHC(Intermediate)-1	1.3	0.46	0.099	<0.020	--	<0.020	<0.020	<0.020	0.051	<0.020	1.3	
			EHC(Intermediate)-2	<0.020	<0.020	<0.020	0.24	--	<0.020	<0.020	<0.020	0.084	<0.020	1.4	
			EHC(Intermediate)-3	<0.020	<0.020	<0.020	0.24	--	<0.020	<0.020	<0.020	<0.020	<0.020	1.4	
			Average Concentration (mg/L)	0.45	0.15	0.033	0.16	--	ND	ND	ND	0.045	ND	1.4	
			Standard Deviation (mmoles)	1.2E-03	5.7E-04	2.0E-04	1.8E-03	--	0.0E+00	0.0E+00	0.0E+00	1.0E-04	0.0E+00	1.0E-03	
			Average Total mmoles	**0.00072**	**0.00033**	**0.00012**	**0.0021**	**3.3E-03**	**ND**	**ND**	**ND**	**0.00011**	**ND**	**0.063**	
	23-May-14	56	EHC(Intermediate)-1	0.064	<0.020	<0.020	0.21	--	<0.020	<0.020	<0.020	<0.020	<0.020	2.4	
			EHC(Intermediate)-2	<0.020	<0.020	<0.020	0.23	--	<0.020	<0.020	<0.020	0.12	<0.020	1.5	
			EHC(Intermediate)-3	<0.020	<0.020	<0.020	0.29	--	<0.020	<0.020	<0.020	<0.020	<0.020	1.8	
			Average Concentration (mg/L)	0.021	ND	ND	0.24	--	ND	ND	ND	0.040	ND	1.9	
			Standard Deviation (mmoles)	5.9E-05	0.0E+00	0.0E+00	5.6E-04	--	0.0E+00	0.0E+00	0.0E+00	1.7E-04	0.0E+00	2.1E-02	
			Average Total mmoles	**0.000034**	**ND**	**ND**	**0.0032**	**3.2E-03**	**ND**	**ND**	**ND**	**0.000099**	**ND**	**0.087**	
	10-Jun-14	74	EHC(Intermediate)-1	<0.020	<0.020	<0.020	0.21	--	<0.020	<0.020	<0.020	<0.020	<0.020	5.7	
			EHC(Intermediate)-2	0.024	<0.020	<0.020	0.26	--	<0.020	<0.020	<0.020	<0.020	<0.020	5.5	
			EHC(Intermediate)-3	0.075	<0.020	<0.020	0.28	--	<0.020	<0.020	<0.020	<0.020	<0.020	5.3	
			Average Concentration (mg/L)	0.033	ND	ND	0.25	--	ND	ND	ND	ND	ND	5.5	
			Standard Deviation (mmoles)	6.1E-05	0.0E+00	0.0E+00	4.7E-04	--	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	9.7E-03	
			Average Total mmoles	**0.000053**	**ND**	**ND**	**0.0033**	**3.4E-03**	**ND**	**ND**	**ND**	**ND**	**ND**	**0.25**	
EHC®-L and ZVI Amended/KB-1® Plus Bioaugmented	27-Mar-14	-1													Amended with 1.37 mL of EHC®-L to target a final concentration of 1 g/L.
(Intermediate)	28-Mar-14	0													Spiked with TCE and CTC to target concentrations of 2 mg/L each.
															Amended with 2 mL of a vitamin/mineral solution.
															Amended the first replicate with 100 uL of resazurin.
															Amended with 1 g of ZVI to target a final concentration of 5 g/L.
			EHC/ZVI (Intermediate)-1	2.9	<0.020	<0.020	0.04	--	<0.020	1.3	<0.020	<0.020	<0.020	0.061	
			EHC/ZVI (Intermediate)-2	2.8	<0.020	<0.020	0.059	--	<0.020	1.4	0.056	<0.020	<0.020	0.076	
			EHC/ZVI (Intermediate)-3	2.8	<0.020	<0.020	0.058	--	<0.020	1.1	0.18	<0.020	<0.020	0.070	
			Average Concentration (mg/L)	2.8	ND	ND	0.052	--	ND	1.3	0.08	ND	ND	0.069	
			Standard Deviation (mmoles)	9.5E-05	0.0E+00	0.0E+00	1.4E-04	--	0.0E+00	2.4E-04	1.6E-04	0.0E+00	0.0E+00	3.6E-04	
			Average Total mmoles	**0.0045**	**ND**	**ND**	**0.00069**	**5.2E-03**	**ND**	**0.0018**	**0.00014**	**ND**	**ND**	**0.0032**	
	04-Apr-14	7	EHC/ZVI (Intermediate)-1	2.3	0.031	<0.020	0.021	--	<0.020	<0.020	<0.020	<0.020	<0.020	0.052	
			EHC/ZVI (Intermediate)-2	2.5	0.026	<0.020	0.027	--	<0.020	<0.020	0.020	<0.020	<0.020	0.061	
			EHC/ZVI (Intermediate)-3	2.3	0.025	<0.020	<0.020	--	<0.020	<0.020	<0.020	<0.020	<0.020	0.050	
			Average Concentration (mg/L)	2.3	0.027	ND	0.016	--	ND	ND	0.0067	ND	ND	0.054	
			Standard Deviation (mmoles)	1.9E-04	6.9E-06	0.0E+00	1.9E-04	--	0.0E+00	0.0E+00	2.0E-05	0.0E+00	0.0E+00	2.8E-04	
			Average Total mmoles	**0.0038**	**0.000058**	**ND**	**0.00021**	**4.1E-03**	**ND**	**ND**	**0.000011**	**ND**	**ND**	**0.0025**	
	17-Apr-14	20	EHC/ZVI (Intermediate)-1	0.50	0.087	<0.020	0.079	--	0.031	<0.020	<0.020	<0.020	<0.020	0.067	
			EHC/ZVI (Intermediate)-2	0.72	0.072	<0.020	0.10	--	0.054	<0.020	<0.020	<0.020	<0.020	0.11	
			EHC/ZVI (Intermediate)-3	0.59	0.078	<0.020	0.079	--	0.037	<0.020	<0.020	<0.020	<0.020	0.098	
			Average Concentration (mg/L)	0.60	0.079	ND	0.087	--	0.041	ND	ND	ND	ND	0.091	
			Standard Deviation (mmoles)	1.8E-04	1.5E-05	0.0E+00	1.9E-04	--	2.4E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.0E-03	
			Average Total mmoles	**0.00096**	**0.00017**	**ND**	**0.0011**	**2.2E-03**	**0.0008**	**ND**	**ND**	**ND**	**ND**	**0.0042**	
															Spiked with CTC to target concentrations of 2 mg/L.
	25-Apr-14	28	EHC/ZVI (Intermediate)-1	0.14	0.10	<0.020	0.085	--	0.031	<0.020	<0.020	0.25	<0.020	0.063	
			EHC/ZVI (Intermediate)-2	0.22	0.089	<0.020	0.12	--	0.046	<0.020	<0.020	0.21	0.031	0.068	
			EHC/ZVI (Intermediate)-3	0.14	0.088	<0.020	0.086	--	0.034	<0.020	<0.020	0.23	0.020	0.070	
			Average Concentration (mg/L)	0.17	0.093	ND	0.096	--	0.037	ND	ND	0.23	0.017	0.067	
			Standard Deviation (mmoles)	7.5E-05	1.8E-05	0.0E+00	2.4E-04	--	1.6E-04	0.0E+00	0.0E+00	4.6E-05	6.4E-05	1.8E-04	
			Average Total mmoles	**0.00027**	**0.00020**	**ND**	**0.0013**	**1.8E-03**	**0.00073**	**ND**	**ND**	**0.00057**	**0.000069**	**0.0031**	
															Bioaugmented with KB-1® Plus (CF formulation).
	09-May-14	42	EHC/ZVI (Intermediate)-1	<0.020	0.055	<0.020	0.076	--	0.027	<0.020	<0.020	0.18	<0.020	0.83	
			EHC/ZVI (Intermediate)-2	<0.020	0.056	<0.020	0.11	--	0.036	<0.020	<0.020	0.14	0.021	0.43	
			EHC/ZVI (Intermediate)-3	<0.020	0.047	<0.020	0.077	--	0.026	<0.020	<0.020	0.15	<0.020	0.73	
			Average Concentration (mg/L)	ND	0.052	ND	0.086	--	0.03	ND	ND	0.16	0.0072	0.66	
			Standard Deviation (mmoles)	0.0E+00	1.1E-05	0.0E+00	2.2E-04	--	1.1E-04	0.0E+00	0.0E+00	5.2E-05	5.0E-05	9.6E-03	
			Average Total mmoles	**ND**	**0.00011**	**ND**	**0.0011**	**1.2E-03**	**0.00059**	**ND**	**ND**	**0.00038**	**0.000029**	**0.031**	

TABLE 2: SUMMARY OF MICROCOSM CHLORINATED VOC AND DHG RESULTS
Elkhart, Indiana

Treatment	Date	Day	Replicate	Chlorinated Ethenes					Chlorinated Ethanes						Comment
				TCE	cDCE	VC	Ethene	Total Ethenes	Ethane	CTC	CF	DCM	CM	Methane	
				mg/L	mg/L	mg/L	mg/L	mmol/bottle	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	
EHC®-L and ZVI Amended/KB-1® Plus Bioaugmented	23-May-14	56	EHC/ZVI (Intermediate)-1	<0.020	0.047	0.040	0.089	--	0.035	<0.020	<0.020	0.21	<0.020	0.91	
			EHC/ZVI (Intermediate)-2	<0.020	0.062	0.035	0.13	--	0.051	<0.020	<0.020	0.19	0.023	0.42	
(Intermediate)			EHC/ZVI (Intermediate)-3	<0.020	0.046	0.034	0.094	--	0.034	<0.020	<0.020	0.21	<0.020	0.72	
Continued			**Average Concentration (mg/L)**	ND	0.052	0.036	0.11	--	0.04	ND	ND	0.20	0.0076	0.68	
			Standard Deviation (mmoles)	0.0E+00	2.0E-05	1.3E-05	3.2E-04	--	1.9E-04	0.0E+00	0.0E+00	3.6E-05	5.2E-05	1.1E-02	
			Average Total mmoles	**ND**	**0.00011**	**0.00013**	**0.0014**	**1.6E-03**	**0.00079**	**ND**	**ND**	**0.00049**	**0.00003**	**0.032**	
	10-Jun-14	74	EHC/ZVI (Intermediate)-1	0.049	0.042	0.044	0.094	--	0.039	<0.020	<0.020	0.22	<0.020	1.0	
			EHC/ZVI (Intermediate)-2	0.023	0.080	0.035	0.13	--	0.051	<0.020	<0.020	0.17	<0.020	0.43	
			EHC/ZVI (Intermediate)-3	0.037	0.037	0.031	0.093	--	0.036	<0.020	<0.020	0.20	<0.020	0.77	
			Average Concentration (mg/L)	0.036	0.053	0.037	0.10	--	0.042	ND	ND	0.19	ND	0.75	
			Standard Deviation (mmoles)	2.1E-05	5.0E-05	2.3E-05	2.5E-04	--	1.7E-04	0.0E+00	0.0E+00	6.1E-05	0.0E+00	1.4E-02	
			Average Total mmoles	**0.000058**	**0.00011**	**0.00013**	**0.0014**	**1.7E-03**	**0.00083**	**ND**	**ND**	**0.00048**	**ND**	**0.035**	

Notes:

-- - not analyzed
% - percent
< - compound not detected, the associated value is the detection limit
µL - microliters
ANAC - anaerobic active control
ANSC - anaerobic sterile control
cDCE - cis-1,2-dichloroethene
CM - chloromethane
CTC - carbon tetrachloride
DCM - dichloromethane
mg/L - milligrams per liter
mmoles - millimoles
mmoles/bottle - millimoles per bottle
ND - not detected
SolFe - soluble iron
TCE - trichloroethene
VC - vinyl chloride
ZVI - zero valent iron

TABLE 3: SUMMARY OF MICROCOSM ANION RESULTS

Elkhart, Indiana

Treatment	Date	Day	Treatment Replicate	Total VFAs	Chloride	Nitrite-N	Nitrate-N	Sulfate	Phosphate
				mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Anaerobic Sterile Control (Shallow Depth)	28-Mar-14	0	ANSC-1	2.2	149	<0.09	11	29	20
			ANSC-2	<0.07	126	<0.09	10	25	19
			ANSC-3	0.08	151	<0.09	11	29	26
			Average Concentration	**0.76**	**142**	**ND**	**11**	**28**	**22**
Anaerobic Active Control (Shallow Depth)	28-Mar-14	0	ANAC (Shallow)-1	<0.07	72	<0.09	12	26	16
			ANAC (Shallow)-2	<0.07	75	<0.09	12	27	23
			ANAC (Shallow)-3	<0.07	79	<0.09	12	28	21
			Average Concentration	**ND**	**75**	**ND**	**12**	**27**	**20**
ZVI Amended/KB-1® Plus Bioaugmented (Shallow Depth)	28-Mar-14	0	ZVI (Shallow)-1	0.08	76	<0.09	12	28	21
			ZVI (Shallow)-2	<0.07	68	<0.09	11	25	16
			ZVI (Shallow)-2	<0.07	77	<0.09	12	28	0.65
			Average Concentration	**0.03**	**74**	**ND**	**12**	**27**	**13**
	9-May-14	42	ZVI (Shallow)-1	18	103	<0.09	0.26	29	0.11
			ZVI (Shallow)-2	17	100	<0.09	0.15	29	0.08
			ZVI (Shallow)-2	16	99	<0.09	0.28	28	0.10
			Average Concentration	**17**	**101**	**ND**	**0.23**	**29**	**0.10**
SRS™/ZVI and Ferrous Fumarate Amended/KB-1® Plus Bioaugmented (Shallow Depth)	28-Mar-14	0	SRS/ZVI (Shallow)-1	28	79	<0.09	12	29	7.0
			SRS/ZVI (Shallow)-2	25	73	<0.09	12	27	2.0
			SRS/ZVI (Shallow)-3	29	104	<0.09	12	29	15
			Average Concentration	**28**	**85**	**ND**	**12**	**28**	**8.0**
	9-May-14	42	SRS/ZVI (Shallow)-1	167	98	<0.09	0.13	59	0.16
			SRS/ZVI (Shallow)-2	98	97	<0.09	0.16	31	0.12
			SRS/ZVI (Shallow)-3	170	100	<0.09	0.14	2.7	<0.07
			Average Concentration	**145**	**98**	**ND**	**0.14**	**31**	**0.09**
SRS™ and Ferrous Fumarate Amended/KB-1® Plus Bioaugmented (Shallow Depth)	28-Mar-14	0	SRS/solFe (Shallow)-1	25	76	<0.09	12	28	10
			SRS/solFe (Shallow)-2	25	69	<0.09	11	26	12
			SRS/solFe (Shallow)-3	26	68	<0.09	11	25	20
			Average Concentration	**26**	**71**	**ND**	**11**	**26**	**14**
	9-May-14	42	SRS/solFe (Shallow)-1	120	97	<0.09	0.16	0.45	<0.07
			SRS/solFe (Shallow)-2	89	75	<0.09	0.21	0.95	0.28
			SRS/solFe (Shallow)-3	134	98	<0.09	0.13	0.60	0.07
			Average Concentration	**114**	**90**	**ND**	**0.17**	**0.67**	**0.12**
SRS™ Amended/KB-1® Plus Bioaugmented (Shallow Depth)	28-Mar-14	0	SRS (Shallow)-1	29	77	<0.09	12	29	19
			SRS (Shallow)-2	29	76	<0.09	12	29	16
			SRS (Shallow)-3	29	77	<0.09	12	28	17
			Average Concentration	**29**	**77**	**ND**	**12**	**28**	**17**
	9-May-14	42	SRS (Shallow)-1	56	95	<0.09	0.14	13	<0.07
			SRS (Shallow)-2	71	101	<0.09	0.37	15	0.50
			SRS (Shallow)-3	68	94	<0.09	0.12	16	0.25
			Average Concentration	**65**	**96**	**ND**	**0.21**	**14**	**0.25**
EHC-L® Amended/KB-1® Plus Bioaugmented (Shallow Depth)	28-Mar-14	0	EHC (Shallow)-1	46	72	<0.09	11	27	12
			EHC (Shallow)-2	47	70	<0.09	11	27	10
			EHC (Shallow)-3	53	78	<0.09	12	30	11
			Average Concentration	**49**	**73**	**ND**	**12**	**28**	**11**

TABLE 3: SUMMARY OF MICROCOSM ANION RESULTS
Elkhart, Indiana

Treatment	Date	Day	Treatment Replicate	Total VFAs	Chloride	Nitrite-N	Nitrate-N	Sulfate	Phosphate
				mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
EHC-L® Amended/KB-1® Plus Bioaugmented (Shallow Depth) Continued	9-May-14	42	EHC (Shallow)-1	227	97	<0.09	0.14	0.69	0.27
			EHC (Shallow)-2	258	101	<0.09	0.26	1.5	0.29
			EHC (Shallow)-3	241	96	<0.09	0.23	1.1	<0.07
			Average Concentration	**242**	**98**	**ND**	**0.21**	**1.1**	**0.19**
EHC-L® and ZVI Amended/KB-1® Plus Bioaugmented (Shallow Depth)	28-Mar-14	0	EHC/ZVI (Shallow)-1	45	70	<0.09	11	27	5.4
			EHC/ZVI (Shallow)-2	47	77	<0.09	12	30	6.4
			EHC/ZVI (Shallow)-3	53	82	<0.09	13	31	14
			Average Concentration	**48**	**76**	**ND**	**12**	**29**	**8.4**
	9-May-14	42	EHC/ZVI (Shallow)-1	264	102	<0.09	0.27	0.73	<0.07
			EHC/ZVI (Shallow)-2	253	98	<0.09	0.14	0.69	0.16
			EHC/ZVI (Shallow)-3	266	101	<0.09	0.39	0.94	0.21
			Average Concentration	**261**	**100**	**ND**	**0.27**	**0.79**	**0.12**
Anaerobic Active Control (Intermediate Depth)	28-Mar-14	0	ANAC (Intermediate)-1	12	64	<0.09	3.4	22	11
			ANAC (Intermediate)-2	6.8	71	<0.09	3.5	26	19
			ANAC (Intermediate)-3	10	65	<0.09	3.2	23	8.9
			Average Concentration	**10**	**67**	**ND**	**3.4**	**24**	**13**
ZVI Amended/KB-1® Plus Bioaugmented (Intermediate Depth)	28-Mar-14	0	ZVI (Intermediate)-1	5.5	65	<0.09	3.2	23	15
			ZVI (Intermediate)-2	5.9	61	<0.09	3.0	21	0.89
			ZVI (Intermediate)-3	8.1	67	<0.09	3.4	24	14
			Average Concentration	**6.5**	**64**	**ND**	**3.2**	**23**	**9.7**
	9-May-14	42	ZVI/Nut/Vit (Intermediate)-1	21	89	<0.09	0.11	1.3	0.16
			ZVI/Nut/Vit (Intermediate)-2	38	92	<0.09	0.34	1.7	0.22
			ZVI/Nut/Vit (Intermediate)-3	24	88	<0.09	0.11	0.70	0.14
			Average Concentration	**28**	**90**	**ND**	**0.19**	**1.2**	**0.18**
SRS™/ZVI and Ferrous Fumarate Amended/KB-1® Plus Bioaugmented (Intermediate Depth)	28-Mar-14	0	SRS/ZVI (Intermediate)-1	36	66	<0.09	3.2	24	13
			SRS/ZVI (Intermediate)-2	41	70	<0.09	3.4	25	20
			SRS/ZVI (Intermediate)-3	37	70	<0.09	3.3	24	16
			Average Concentration	**38**	**69**	**ND**	**3.3**	**24**	**16**
	9-May-14	42	SRS/ZVI (Intermediate)-1	219	91	<0.09	0.39	1.2	0.11
			SRS/ZVI (Intermediate)-2	233	88	<0.09	0.39	0.93	0.11
			SRS/ZVI (Intermediate)-3	210	85	<0.09	0.15	0.62	0.25
			Average Concentration	**221**	**88**	**ND**	**0.31**	**0.92**	**0.15**
SRS™ and Ferrous Fumarate Amended/KB-1® Plus Bioaugmented (Intermediate Depth)	28-Mar-14	0	SRS/solFe (Intermediate)-1	45	68	<0.09	3.3	25	19
			SRS/solFe (Intermediate)-2	37	65	<0.09	3.1	24	14
			SRS/solFe (Intermediate)-3	41	69	<0.09	3.3	24	14
			Average Concentration	**41**	**67**	**ND**	**3.3**	**24**	**15**
	9-May-14	42	SRS/solFe (Intermediate)-1	199	86	<0.09	0.10	0.47	0.22
			SRS/solFe (Intermediate)-2	205	85	<0.09	<0.09	0.61	0.36
			SRS/solFe (Intermediate)-3	205	91	<0.09	0.23	1.1	0.33
			Average Concentration	**203**	**87**	**ND**	**0.11**	**0.73**	**0.30**
SRS™ Amended/KB-1® Plus Bioaugmented (Intermediate Depth)	28-Mar-14	0	SRS (Intermediate)-1	50	70	<0.09	3.3	24	12
			SRS (Intermediate)-2	38	67	<0.09	3.2	24	13
			SRS (Intermediate)-3	28	51	<0.09	2.5	18	13
			Average Concentration	**39**	**63**	**ND**	**3.0**	**22**	**13**

TABLE 3: SUMMARY OF MICROCOSM ANION RESULTS
Elkhart, Indiana

Treatment	Date	Day	Treatment Replicate	Total VFAs	Chloride	Nitrite-N	Nitrate-N	Sulfate	Phosphate
				mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
SRS™ Amended/KB-1® Plus Bioaugmented (Intermediate Depth) Continued	9-May-14	42	SRS (Intermediate)-1	210	88	<0.09	0.29	0.76	0.12
			SRS (Intermediate)-2	205	89	<0.09	0.39	0.71	0.27
			SRS (Intermediate)-3	125	88	<0.09	0.16	0.88	0.44
			Average Concentration	**180**	**89**	**ND**	**0.28**	**0.79**	**0.28**
EHC-L® Amended/KB-1® Plus Bioaugmented (Intermediate Depth)	28-Mar-14	0	EHC(Intermediate)-1	61	68	<0.09	3.5	25	9.9
			EHC(Intermediate)-2	56	63	<0.09	3.1	23	5.1
			EHC(Intermediate)-3	59	67	<0.09	3.3	25	6.6
			Average Concentration	**59**	**66**	**ND**	**3.3**	**24**	**7.2**
	9-May-14	42	EHC(Intermediate)-1	255	91	<0.09	0.34	1.1	0.36
			EHC(Intermediate)-2	233	88	<0.09	<0.09	0.65	0.75
			EHC(Intermediate)-3	232	87	<0.09	0.17	0.71	0.33
			Average Concentration	**240**	**88**	**ND**	**0.17**	**0.81**	**0.48**
EHC-L® and ZVI Amended/KB-1® Plus Bioaugmented (Intermediate Depth)	28-Mar-14	0	EHC/ZVI (Intermediate)-1	50	63	<0.09	3.0	23	2.7
			EHC/ZVI (Intermediate)-2	54	73	<0.09	3.5	26	2.1
			EHC/ZVI (Intermediate)-3	44	57	<0.09	2.8	21	2.4
			Average Concentration	**49**	**64**	**ND**	**3.1**	**23**	**2.4**
	9-May-14	42	EHC/ZVI (Intermediate)-1	284	89	<0.09	<0.09	0.35	0.24
			EHC/ZVI (Intermediate)-2	252	89	<0.09	<0.09	0.77	0.22
			EHC/ZVI (Intermediate)-3	296	88	<0.09	0.302	0.60	0.23
			Average Concentration	**277**	**89**	**ND**	**0.10**	**0.57**	**0.23**

Notes:

* All treatments were amended with the vitamin/nutrient mix on Day 0
< - compound not detected, the associated value is the detection limit
ANAC - anaerobic active control
ANSC - anaerobic sterile control
mg/L - milligrams per liter
ND - not detected
sol Fe - soluble iron
VFAs - total volatile fatty acids, calibrated as lactate but may include other VFAs such as formate, acetate, propionate, pyruvate and butyrate
ZVI - zero valent iron

TABLE 4: SUMMARY OF MICROCOSM VFA RESULTS
Elkhart, Indiana

Treatment	Date	Day	Treatment Replicate	Lactate	Acetate	Propionate	Formate	Butyrate	Pyruvate
				mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
ZVI Amended/KB-1® Plus Bioaugmented (Shallow Depth)	28-Mar-14	0	ZVI (Shallow)-1	0.60	1.7	<0.31	1.2	<0.41	<0.69
			ZVI (Shallow)-2	0.56	2.7	<0.31	2.2	<0.41	<0.69
			ZVI (Shallow)-2	0.89	1.7	<0.31	0.97	<0.41	<0.69
			Average Concentration	**0.68**	**2.0**	**ND**	**1.4**	**ND**	**ND**
	9-May-14	42	ZVI (Shallow)-1	<0.39	9.4	1.1	2.0	1.7	<0.69
			ZVI (Shallow)-2	<0.39	9.2	1.0	2.0	1.9	<0.69
			ZVI (Shallow)-2	<0.39	7.8	0.94	2.2	1.7	<0.69
			Average Concentration	**ND**	**8.8**	**1.0**	**2.1**	**1.8**	**ND**
	22-May-14	55	ZVI (Shallow)-1	<0.39	15	1.2	1.0	1.8	<0.69
			ZVI (Shallow)-2	<0.39	50	1.1	0.88	1.9	<0.69
			ZVI (Shallow)-2	<0.39	8.6	1.1	1.2	1.9	<0.69
			Average Concentration	**ND**	**24**	**1.1**	**1.0**	**1.8**	**ND**
SRS®ZVI and Ferrous Fumarate Amended/KB-1® Plus Bioaugmented (Shallow Depth)	28-Mar-14	0	SRS/ZVI (Shallow)-1	33	3.5	5.3	1.2	<0.41	<0.69
			SRS/ZVI (Shallow)-2	26	3.2	4.2	1.0	<0.41	<0.69
			SRS/ZVI (Shallow)-3	31	3.2	4.5	2.1	<0.41	<0.69
			Average Concentration	**30**	**3.3**	**4.7**	**1.4**	**ND**	**ND**
	9-May-14	42	SRS/ZVI (Shallow)-1	<0.39	156	43	2.7	7.2	<0.69
			SRS/ZVI (Shallow)-2	<0.39	76	31	2.2	2.5	<0.69
			SRS/ZVI (Shallow)-3	<0.39	127	99	1.6	4.8	<0.69
			Average Concentration	**ND**	**119**	**57**	**2.2**	**4.8**	**ND**
	22-May-14	55	SRS/ZVI (Shallow)-1	<0.39	181	41	1.2	6.3	<0.69
			SRS/ZVI (Shallow)-2	<0.39	103	105	0.56	2.5	<0.69
			SRS/ZVI (Shallow)-3	<0.39	143	102	0.60	4.8	<0.69
			Average Concentration	**ND**	**142**	**83**	**0.80**	**4.6**	**ND**
SRS® and Ferrous Fumarate Amended/KB-1® Plus Bioaugmented (Shallow Depth)	28-Mar-14	0	SRS/solFe (Shallow)-1	107	2.0	4.4	2.4	<0.41	2.9
			SRS/solFe (Shallow)-2	29	3.4	4.4	1.9	<0.41	<0.69
			SRS/solFe (Shallow)-3	31	3.5	4.7	1.9	<0.41	<0.69
			Average Concentration	**56**	**3.0**	**4.5**	**2.1**	**ND**	**0.96**
	9-May-14	42	SRS/solFe (Shallow)-1	<0.39	138	2.3	1.0	0.43	<0.69
			SRS/solFe (Shallow)-2	<0.39	133	4.3	0.63	0.56	<0.69
			SRS/solFe (Shallow)-3	<0.39	102	0.95	0.36	2.1	<0.69
			Average Concentration	**ND**	**124**	**2.5**	**0.66**	**1.0**	**ND**
	22-May-14	55	SRS/solFe (Shallow)-1	<0.39	171	3.1	0.29	5.2	<0.69
			SRS/solFe (Shallow)-2	<0.39	170	5.3	0.55	3.7	<0.69
			SRS/solFe (Shallow)-3	<0.39	186	1.7	0.30	3.5	<0.69
			Average Concentration	**ND**	**176**	**3.3**	**0.38**	**4.1**	**ND**
SRS® Amended/KB-1® Plus Bioaugmented (Shallow Depth)	28-Mar-14	0	SRS (Shallow)-1	31	3.4	4.5	1.6	<0.41	<0.69
			SRS (Shallow)-2	32	4.5	4.7	1.9	<0.41	<0.69
			SRS (Shallow)-3	32	3.6	4.8	1.6	<0.41	<0.69
			Average Concentration	**31**	**3.8**	**4.7**	**1.7**	**ND**	**ND**
	9-May-14	42	SRS (Shallow)-1	<0.39	59	<0.31	1.1	<0.41	<0.69
			SRS (Shallow)-2	<0.39	72	<0.31	0.77	<0.41	<0.69
			SRS (Shallow)-3	<0.39	70	0.35	0.94	<0.41	<0.69
			Average Concentration	**ND**	**67**	**0.12**	**0.93**	**ND**	**ND**
	22-May-14	55	SRS (Shallow)-1	<0.39	105	0.48	0.73	3.0	<0.69
			SRS (Shallow)-2	<0.39	100	<0.31	0.30	<0.41	<0.69
			SRS (Shallow)-3	<0.39	113	0.60	0.58	5.6	<0.69
			Average Concentration	**ND**	**106**	**0.36**	**0.54**	**2.9**	**ND**
EHC-L® Amended/KB-1® Plus Bioaugmented (Shallow Depth)	28-Mar-14	0	EHC (Shallow)-1	<0.39	2.2	<0.31	2.2	0.65	<0.69
			EHC (Shallow)-2	<0.39	2.2	<0.31	2.6	0.62	<0.69
			EHC (Shallow)-3	<0.39	2.4	<0.31	2.7	0.70	<0.69
			Average Concentration	**ND**	**2.3**	**ND**	**2.5**	**0.65**	**ND**
	9-May-14	42	EHC (Shallow)-1	<0.39	244	15	0.93	32	<0.69
			EHC (Shallow)-2	<0.39	263	61	0.51	11	<0.69
			EHC (Shallow)-3	<0.39	237	65	0.55	24	<0.69
			Average Concentration	**ND**	**248**	**47**	**0.66**	**22**	**ND**
	22-May-14	55	EHC (Shallow)-1	<0.39	293	14	0.63	42	<0.69
			EHC (Shallow)-2	<0.39	370	58	0.27	43	<0.69
			EHC (Shallow)-3	<0.39	315	63	<0.22	38	<0.69
			Average Concentration	**ND**	**326**	**45**	**0.30**	**41**	**ND**

TABLE 4: SUMMARY OF MICROCOSM VFA RESULTS
Elkhart, Indiana

Treatment	Date	Day	Treatment Replicate	Lactate	Acetate	Propionate	Formate	Butyrate	Pyruvate
				mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
EHC-L® and ZVI Amended/KB-1® Plus Bioaugmented (Shallow Depth)	28-Mar-14	0	EHC/ZVI (Shallow)-1	<0.39	2.3	<0.31	2.3	0.87	<0.69
			EHC/ZVI (Shallow)-2	<0.39	2.4	<0.31	2.1	0.75	<0.69
			EHC/ZVI (Shallow)-3	<0.39	2.5	<0.31	2.5	0.74	<0.69
			Average Concentration	**ND**	**2.4**	**ND**	**2.3**	**0.79**	**ND**
	9-May-14	42	EHC/ZVI (Shallow)-1	<0.39	290	43	1.6	7.0	<0.69
			EHC/ZVI (Shallow)-2	<0.39	221	83	1.4	42	<0.69
			EHC/ZVI (Shallow)-3	<0.39	271	73	1.9	20	<0.69
			Average Concentration	**ND**	**260**	**66**	**1.6**	**23**	**ND**
	22-May-14	55	EHC/ZVI (Shallow)-1	<0.39	297	44	0.69	6.7	<0.69
			EHC/ZVI (Shallow)-2	<0.39	239	87	0.61	44	<0.69
			EHC/ZVI (Shallow)-3	<0.39	8.5	1.5	0.51	<0.41	<0.69
			Average Concentration	**ND**	**182**	**44**	**0.60**	**17**	**ND**
ZVI Amended/KB-1® Plus Bioaugmented (Intermediate Depth)	28-Mar-14	0	ZVI (Intermediate)-1	1.3	2.9	<0.31	2.1	<0.41	<0.69
			ZVI (Intermediate)-2	0.41	2.8	<0.31	1.8	<0.41	<0.69
			ZVI (Intermediate)-3	1.2	2.9	<0.31	2.0	<0.41	<0.69
			Average Concentration	**1.0**	**2.9**	**ND**	**2.0**	**ND**	**ND**
	9-May-14	42	ZVI/Nut/Vit (Intermediate)-1	<0.39	17	2.9	1.0	<0.41	<0.69
			ZVI/Nut/Vit (Intermediate)-2	<0.39	21	5.2	4.5	1.0	<0.69
			ZVI/Nut/Vit (Intermediate)-3	<0.39	15	2.2	2.9	0.50	<0.69
			Average Concentration	**ND**	**18**	**3.4**	**2.8**	**0.51**	**ND**
	22-May-14	55	ZVI/Nut/Vit (Intermediate)-1	<0.39	16	2.5	1.4	<0.41	<0.69
			ZVI/Nut/Vit (Intermediate)-2	<0.39	42	5.6	1.3	1.1	<0.69
			ZVI/Nut/Vit (Intermediate)-3	<0.39	25	2.5	2.1	0.61	<0.69
			Average Concentration	**ND**	**28**	**3.5**	**1.6**	**0.58**	**ND**
SRS®ZVI and Ferrous Fumarate Amended/KB-1® Plus Bioaugmented (Intermediate Depth)	28-Mar-14	0	SRS/ZVI (Intermediate)-1	25	3.8	3.8	2.0	<0.41	<0.69
			SRS/ZVI (Intermediate)-2	28	4.1	4.4	2.4	<0.41	<0.69
			SRS/ZVI (Intermediate)-3	25	3.3	3.9	2.1	<0.41	<0.69
			Average Concentration	**26**	**3.7**	**4.0**	**2.2**	**ND**	**ND**
	9-May-14	42	SRS/ZVI (Intermediate)-1	<0.39	183	107	1.6	4.1	<0.69
			SRS/ZVI (Intermediate)-2	<0.39	201	120	1.9	4.7	<0.69
			SRS/ZVI (Intermediate)-3	<0.39	185	105	1.9	6.6	<0.69
			Average Concentration	**ND**	**189**	**111**	**1.8**	**5.1**	**ND**
	22-May-14	55	SRS/ZVI (Intermediate)-1	<0.39	211	111	0.68	4.2	<0.69
			SRS/ZVI (Intermediate)-2	<0.39	233	125	0.69	4.9	<0.69
			SRS/ZVI (Intermediate)-3	<0.39	210	105	1.0	6.7	<0.69
			Average Concentration	**ND**	**218**	**114**	**0.80**	**5.3**	**ND**
SRS® and Ferrous Fumarate Amended/KB-1® Plus Bioaugmented (Intermediate Depth)	28-Mar-14	0	SRS/solFe (Intermediate)-1	31	4.3	4.6	2.5	<0.41	<0.69
			SRS/solFe (Intermediate)-2	24	3.9	4.0	2.3	<0.41	<0.69
			SRS/solFe (Intermediate)-3	27	3.8	4.2	2.4	<0.41	<0.69
			Average Concentration	**27**	**4.0**	**4.3**	**2.4**	**ND**	**ND**
	9-May-14	42	SRS/solFe (Intermediate)-1	<0.39	178	86	0.54	4.7	<0.69
			SRS/solFe (Intermediate)-2	<0.39	100	47	0.57	9.4	<0.69
			SRS/solFe (Intermediate)-3	<0.39	178	78	0.62	10	<0.69
			Average Concentration	**ND**	**152**	**71**	**0.58**	**8.1**	**ND**
	22-May-14	55	SRS/solFe (Intermediate)-1	<0.39	258	84	<0.22	29	<0.69
			SRS/solFe (Intermediate)-2	<0.39	242	89	0.25	23	0.72
			SRS/solFe (Intermediate)-3	<0.39	234	76	<0.22	16	<0.69
			Average Concentration	**ND**	**245**	**83**	**0.08**	**23**	**0.24**
SRS® Amended/KB-1® Plus Bioaugmented (Intermediate Depth)	28-Mar-14	0	SRS (Intermediate)-1	36	5.2	5.3	2.3	<0.41	<0.69
			SRS (Intermediate)-2	28	4.2	4.3	2.3	<0.41	<0.69
			SRS (Intermediate)-3	26	4.3	4.1	2.5	<0.41	<0.69
			Average Concentration	**30**	**4.6**	**4.6**	**2.4**	**ND**	**ND**
	9-May-14	42	SRS (Intermediate)-1	<0.39	221	41	0.41	9.4	<0.69
			SRS (Intermediate)-2	<0.39	111	23	0.49	5.9	<0.69
			SRS (Intermediate)-3	<0.39	151	2.9	0.53	0.65	<0.69
			Average Concentration	**ND**	**161**	**22**	**0.48**	**5.3**	**0.00**
	22-May-14	55	SRS (Intermediate)-1	<0.39	297	43	0.28	26	<0.69
			SRS (Intermediate)-2	<0.39	378	44	<0.22	45	<0.69
			SRS (Intermediate)-3	<0.39	178	2.2	0.36	<0.41	<0.69
			Average Concentration	**ND**	**284**	**30**	**0.21**	**24**	**ND**

TABLE 4: SUMMARY OF MICROCOSM VFA RESULTS

Elkhart, Indiana

Treatment	Date	Day	Treatment Replicate	Lactate	Acetate	Propionate	Formate	Butyrate	Pyruvate
				mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
EHC-L® Amended/KB-1® Plus Bioaugmented (Intermediate Depth)	28-Mar-14	0	EHC(Intermediate)-1	<0.39	3.8	<0.31	3.3	<0.41	<0.69
			EHC(Intermediate)-2	<0.39	3.2	<0.31	2.6	<0.41	<0.69
			EHC(Intermediate)-3	<0.39	3.4	<0.31	2.8	<0.41	<0.69
			Average Concentration	**ND**	**3.5**	**ND**	**2.9**	**ND**	**ND**
	9-May-14	42	EHC(Intermediate)-1	<0.39	236	64	0.26	40	<0.69
			EHC(Intermediate)-2	<0.39	217	67	<0.22	37	<0.69
			EHC(Intermediate)-3	<0.39	235	55	0.25	31	<0.69
			Average Concentration	**ND**	**230**	**62**	**0.17**	**36**	**0.00**
	22-May-14	55	EHC(Intermediate)-1	<0.39	258	56	<0.22	34	<0.69
			EHC(Intermediate)-2	<0.39	240	67	<0.22	31	<0.69
			EHC(Intermediate)-3	<0.39	245	55	<0.22	28	<0.69
			Average Concentration	**ND**	**248**	**59**	**ND**	**31**	**0.00**
EHC-L® and ZVI Amended/KB-1® Plus Bioaugmented (Intermediate Depth)	28-Mar-14	0	EHC/ZVI (Intermediate)-1	2.2	3.8	<0.31	2.9	0.56	<0.69
			EHC/ZVI (Intermediate)-2	<0.39	3.5	<0.31	2.8	0.55	<0.69
			EHC/ZVI (Intermediate)-3	<0.39	3.3	<0.31	2.7	0.54	<0.69
			Average Concentration	**0.74**	**3.6**	**ND**	**2.8**	**0.55**	**ND**
	9-May-14	42	EHC/ZVI (Intermediate)-1	<0.39	284	91	0.72	13	<0.69
			EHC/ZVI (Intermediate)-2	<0.39	234	90	2.2	27	<0.69
			EHC/ZVI (Intermediate)-3	<0.39	312	64	1.1	13	<0.69
			Average Concentration	**ND**	**277**	**82**	**1.3**	**18**	**ND**
	22-May-14	55	EHC/ZVI (Intermediate)-1	<0.39	289	91	0.44	13	<0.69
			EHC/ZVI (Intermediate)-2	<0.39	226	86	0.46	25	<0.69
			EHC/ZVI (Intermediate)-3	<0.39	343	68	0.53	14	<0.69
			Average Concentration	**ND**	**286**	**82**	**0.48**	**17**	**ND**

Notes:

* All treatments were amended with the vitamin/nutrient mix on Day 0
< - compound not detected, the associated value is the detection limit
ND - not detected
sol Fe - soluble iron
ZVI - zero valent iron

TABLE 5: SUMMARY OF MICROCOSM pH AND ORP RESULTS

Elkhart, Indiana

Treatment	Date	Day	Treatment Replicate	pH	ORP
				Standard Units	mV
Anaerobic Sterile Control	28-Mar-14	0	ANSC-1	6.56	--
(Shallow Depth)			ANSC-2	6.59	--
			ANSC-3	6.58	--
			Average Concentration	**6.58**	**--**
	4-Apr-14	7	ANSC-1	6.54	--
			ANSC-2	6.55	--
			ANSC-3	6.58	--
			Average Concentration	**6.56**	**--**
	25-Apr-14	28	ANSC-1	6.47	--
			ANSC-2	6.48	--
			ANSC-3	6.48	--
			Average Concentration	**6.48**	**--**
	9-May-14	42	ANSC-1	--	--
			ANSC-2	--	230
			ANSC-3	--	--
			Average Concentration	**--**	**--**
	23-May-14	56	ANSC-1	6.34	--
			ANSC-2	6.38	--
			ANSC-3	6.31	--
			Average Concentration	**6.34**	**--**
	29-Jul-14	123	ANSC-1	6.44	--
			ANSC-2	6.42	--
			ANSC-3	6.44	--
			Average Concentration	**6.43**	**--**
Anaerobic Active Control	28-Mar-14	0	ANAC (Shallow)-1	6.59	--
(Shallow Depth)			ANAC (Shallow)-2	6.66	--
			ANAC (Shallow)-3	6.62	--
			Average Concentration	**6.62**	**--**
	4-Apr-14	7	ANAC (Shallow)-1	6.67	--
			ANAC (Shallow)-2	6.67	--
			ANAC (Shallow)-3	6.81	--
			Average Concentration	**6.72**	**--**
	17-Apr-14	20	ANAC (Shallow)-1	6.55	--
			ANAC (Shallow)-2	6.62	--
			ANAC (Shallow)-3	6.64	--
			Average Concentration	**6.60**	**--**
	25-Apr-14	28	ANAC (Shallow)-1	6.57	--
			ANAC (Shallow)-2	6.63	--
			ANAC (Shallow)-3	6.67	--
			Average Concentration	**6.62**	**--**
	9-May-14	42	ANAC (Shallow)-1	--	--
			ANAC (Shallow)-2	--	-92
			ANAC (Shallow)-3	--	--
			Average Concentration	**--**	**--**
	23-May-14	56	ANAC (Shallow)-1	6.47	--
			ANAC (Shallow)-2	6.49	--
			ANAC (Shallow)-3	6.56	--
			Average Concentration	**6.51**	**--**
	29-Jul-14	123	ANAC (Shallow)-1	6.61	--
			ANAC (Shallow)-2	6.46	--
			ANAC (Shallow)-3	6.50	--
			Average Concentration	**6.52**	**--**
ZVI Amended/KB-1® Plus Bioaugmented	28-Mar-14	0	ZVI (Shallow)-1	6.69	--
(Shallow Depth)			ZVI (Shallow)-2	6.61	--
			ZVI (Shallow)-2	6.63	--
			Average Concentration	**6.64**	**--**
	4-Apr-14	7	ZVI (Shallow)-1	7.00	--
			ZVI (Shallow)-2	6.66	--
			ZVI (Shallow)-2	6.74	--
			Average Concentration	**6.80**	**--**
	17-Apr-14	20	ZVI (Shallow)-1	6.64	--
			ZVI (Shallow)-2	6.57	--
			ZVI (Shallow)-2	6.61	--
			Average Concentration	**6.61**	**--**
	25-Apr-14	28	ZVI (Shallow)-1	6.60	--
			ZVI (Shallow)-2	6.61	--
			ZVI (Shallow)-2	6.55	--
			Average Concentration	**6.59**	**--**
	9-May-14	42	ZVI (Shallow)-1	6.54	--
			ZVI (Shallow)-2	6.65	-265
			ZVI (Shallow)-2	6.41	--
			Average Concentration	**6.53**	**--**
	23-May-14	56	ZVI (Shallow)-1	6.64	--
			ZVI (Shallow)-2	6.81	--
			ZVI (Shallow)-2	6.58	--
			Average Concentration	**6.68**	**--**
	10-Jun-14	74	ZVI (Shallow)-1	6.55	--
			ZVI (Shallow)-2	6.69	--
			ZVI (Shallow)-2	6.63	--
			Average Concentration	**6.62**	**--**

TABLE 5: SUMMARY OF MICROCOSM pH AND ORP RESULTS
Elkhart, Indiana

Treatment	Date	Day	Treatment Replicate	pH	ORP
				Standard Units	mV
ZVI Amended/KB-1® Plus Bioaugmented (Shallow Depth) Continued	25-Jun-14	89	ZVI (Shallow)-1	6.59	--
			ZVI (Shallow)-2	6.65	--
			ZVI (Shallow)-2	6.52	--
			Average Concentration	**6.59**	**--**
	10-Jul-14	104	ZVI (Shallow)-1	6.42	--
			ZVI (Shallow)-2	6.39	--
			ZVI (Shallow)-2	6.39	--
			Average Concentration	**6.40**	**--**
	29-Jul-14	123	ZVI (Shallow)-1	6.49	--
			ZVI (Shallow)-2	6.41	--
			ZVI (Shallow)-2	6.62	--
			Average Concentration	**6.51**	**--**
SRS™/ZVI and Ferrous Fumarate Amended/KB-1® Plus Bioaugmented (Shallow Depth)	28-Mar-14	0	SRS/ZVI (Shallow)-1	6.59	--
			SRS/ZVI (Shallow)-2	6.62	--
			SRS/ZVI (Shallow)-3	6.60	--
			Average Concentration	**6.60**	**--**
	4-Apr-14	7	SRS/ZVI (Shallow)-1	6.75	--
			SRS/ZVI (Shallow)-2	6.80	--
			SRS/ZVI (Shallow)-3	6.74	--
			Average Concentration	**6.76**	**--**
	17-Apr-14	20	SRS/ZVI (Shallow)-1	6.40	--
			SRS/ZVI (Shallow)-2	6.54	--
			SRS/ZVI (Shallow)-3	6.74	--
			Average Concentration	**6.56**	**--**
	25-Apr-14	28	SRS/ZVI (Shallow)-1	6.48	--
			SRS/ZVI (Shallow)-2	6.62	--
			SRS/ZVI (Shallow)-3	6.82	--
			Average Concentration	**6.64**	**--**
	9-May-14	42	SRS/ZVI (Shallow)-1	6.45	--
			SRS/ZVI (Shallow)-2	6.46	-426
			SRS/ZVI (Shallow)-3	6.48	--
			Average Concentration	**6.46**	**--**
	23-May-14	56	SRS/ZVI (Shallow)-1	6.37	--
			SRS/ZVI (Shallow)-2	6.59	--
			SRS/ZVI (Shallow)-3	6.52	--
			Average Concentration	**6.49**	**--**
	10-Jun-14	74	SRS/ZVI (Shallow)-1	6.30	--
			SRS/ZVI (Shallow)-2	6.57	--
			SRS/ZVI (Shallow)-3	6.59	--
			Average Concentration	**6.49**	**--**
	25-Jun-14	89	SRS/ZVI (Shallow)-1	6.47	--
			SRS/ZVI (Shallow)-2	6.62	--
			SRS/ZVI (Shallow)-3	6.52	--
			Average Concentration	**6.54**	**--**
	10-Jul-14	104	SRS/ZVI (Shallow)-1	6.25	--
			SRS/ZVI (Shallow)-2	6.55	--
			SRS/ZVI (Shallow)-3	6.47	--
			Average Concentration	**6.42**	**--**
	29-Jul-14	123	SRS/ZVI (Shallow)-1	6.24	--
			SRS/ZVI (Shallow)-2	6.37	--
			SRS/ZVI (Shallow)-3	6.33	--
			Average Concentration	**6.31**	**--**
SRS™ and Ferrous Fumarate Amended/KB-1® Plus Bioaugmented (Shallow Depth)	28-Mar-14	0	SRS/solFe (Shallow)-1	6.55	--
			SRS/solFe (Shallow)-2	6.55	--
			SRS/solFe (Shallow)-3	6.56	--
			Average Concentration	**6.55**	**--**
	4-Apr-14	7	SRS/solFe (Shallow)-1	6.57	--
			SRS/solFe (Shallow)-2	6.56	--
			SRS/solFe (Shallow)-3	6.56	--
			Average Concentration	**6.56**	**--**
	17-Apr-14	20	SRS/solFe (Shallow)-1	6.62	--
			SRS/solFe (Shallow)-2	6.61	--
			SRS/solFe (Shallow)-3	6.71	--
			Average Concentration	**6.65**	**--**
	25-Apr-14	28	SRS/solFe (Shallow)-1	6.70	--
			SRS/solFe (Shallow)-2	6.66	--
			SRS/solFe (Shallow)-3	6.67	--
			Average Concentration	**6.68**	**--**
	9-May-14	42	SRS/solFe (Shallow)-1	6.48	--
			SRS/solFe (Shallow)-2	6.49	-304
			SRS/solFe (Shallow)-3	6.51	--
			Average Concentration	**6.49**	**--**
	23-May-14	56	SRS/solFe (Shallow)-1	6.52	--
			SRS/solFe (Shallow)-2	6.50	--
			SRS/solFe (Shallow)-3	6.61	--
			Average Concentration	**6.54**	**--**
	10-Jun-14	74	SRS/solFe (Shallow)-1	6.46	--
			SRS/solFe (Shallow)-2	6.56	--
			SRS/solFe (Shallow)-3	6.50	--
			Average Concentration	**6.51**	**--**

TABLE 5: SUMMARY OF MICROCOSM pH AND ORP RESULTS
Elkhart, Indiana

Treatment	Date	Day	Treatment Replicate	pH	ORP
				Standard Units	mV
SRS™ and Ferrous Fumarate Amended/KB-1® Plus Bioaugmented (Shallow Depth) Continued	25-Jun-14	89	SRS/solFe (Shallow)-1	6.21	--
			SRS/solFe (Shallow)-2	6.25	--
			SRS/solFe (Shallow)-3	6.55	--
			Average Concentration	**6.34**	**--**
	10-Jul-14	104	SRS/solFe (Shallow)-1	6.34	--
			SRS/solFe (Shallow)-2	6.33	--
			SRS/solFe (Shallow)-3	6.65	--
			Average Concentration	**6.44**	**--**
	29-Jul-14	123	SRS/solFe (Shallow)-1	6.09	--
			SRS/solFe (Shallow)-2	6.12	--
			SRS/solFe (Shallow)-3	6.39	--
			Average Concentration	**6.20**	**--**
SRS™ Amended/KB-1® Plus Bioaugmented (Shallow Depth)	28-Mar-14	0	SRS (Shallow)-1	6.59	--
			SRS (Shallow)-2	6.62	--
			SRS (Shallow)-3	6.61	--
			Average Concentration	**6.61**	**--**
	4-Apr-14	7	SRS (Shallow)-1	6.62	--
			SRS (Shallow)-2	6.64	--
			SRS (Shallow)-3	6.66	--
			Average Concentration	**6.64**	**--**
	17-Apr-14	20	SRS (Shallow)-1	6.64	--
			SRS (Shallow)-2	6.61	--
			SRS (Shallow)-3	6.56	--
			Average Concentration	**6.60**	**--**
	25-Apr-14	28	SRS (Shallow)-1	6.71	--
			SRS (Shallow)-2	6.70	--
			SRS (Shallow)-3	6.72	--
			Average Concentration	**6.71**	**--**
	9-May-14	42	SRS (Shallow)-1	6.45	--
			SRS (Shallow)-2	6.47	-226
			SRS (Shallow)-3	6.48	--
			Average Concentration	**6.47**	**--**
	23-May-14	56	SRS (Shallow)-1	6.73	--
			SRS (Shallow)-2	6.56	--
			SRS (Shallow)-3	6.56	--
			Average Concentration	**6.62**	**--**
	10-Jun-14	74	SRS (Shallow)-1	6.54	--
			SRS (Shallow)-2	6.64	--
			SRS (Shallow)-3	6.58	--
			Average Concentration	**6.59**	**--**
	25-Jun-14	89	SRS (Shallow)-1	6.43	--
			SRS (Shallow)-2	6.21	--
			SRS (Shallow)-3	6.38	--
			Average Concentration	**6.34**	**--**
	10-Jul-14	104	SRS (Shallow)-1	6.43	--
			SRS (Shallow)-2	6.33	--
			SRS (Shallow)-3	6.37	--
			Average Concentration	**6.38**	**--**
	29-Jul-14	123	SRS (Shallow)-1	6.15	--
			SRS (Shallow)-2	6.15	--
			SRS (Shallow)-3	6.15	--
			Average Concentration	**6.15**	**--**
EHC-L® Amended/KB-1® Plus Bioaugmented (Shallow Depth)	28-Mar-14	0	EHC (Shallow)-1	6.56	--
			EHC (Shallow)-2	6.53	--
			EHC (Shallow)-3	6.53	--
			Average Concentration	**6.54**	**--**
	4-Apr-14	7	EHC (Shallow)-1	6.40	--
			EHC (Shallow)-2	6.39	--
			EHC (Shallow)-3	6.41	--
			Average Concentration	**6.40**	**--**
	17-Apr-14	20	EHC (Shallow)-1	6.49	--
			EHC (Shallow)-2	6.49	--
			EHC (Shallow)-3	6.49	--
			Average Concentration	**6.49**	**--**
	25-Apr-14	28	EHC (Shallow)-1	6.63	--
			EHC (Shallow)-2	6.66	--
			EHC (Shallow)-3	6.65	--
			Average Concentration	**6.65**	**--**
	9-May-14	42	EHC (Shallow)-1	6.49	--
			EHC (Shallow)-2	6.52	-123
			EHC (Shallow)-3	6.53	--
			Average Concentration	**6.51**	**--**
	23-May-14	56	EHC (Shallow)-1	6.57	--
			EHC (Shallow)-2	6.53	--
			EHC (Shallow)-3	6.58	--
			Average Concentration	**6.56**	**--**
	10-Jun-14	74	EHC (Shallow)-1	6.40	--
			EHC (Shallow)-2	6.35	--
			EHC (Shallow)-3	6.37	--
			Average Concentration	**6.37**	**--**

TABLE 5: SUMMARY OF MICROCOSM pH AND ORP RESULTS
Elkhart, Indiana

Treatment	Date	Day	Treatment Replicate	pH	ORP
				Standard Units	mV
EHC-L® Amended/KB-1® Plus Bioaugmented (Shallow Depth) Continued	25-Jun-14	89	EHC (Shallow)-1	6.24	--
			EHC (Shallow)-2	6.23	--
			EHC (Shallow)-3	6.15	--
			Average Concentration	**6.21**	**--**
	10-Jul-14	104	EHC (Shallow)-1	6.37	--
			EHC (Shallow)-2	6.34	--
			EHC (Shallow)-3	6.32	--
			Average Concentration	**6.34**	**--**
	29-Jul-14	123	EHC (Shallow)-1	6.25	--
			EHC (Shallow)-2	6.24	--
			EHC (Shallow)-3	6.15	--
			Average Concentration	**6.21**	**--**
EHC-L® and ZVI Amended/KB-1® Plus Bioaugmented (Shallow Depth)	28-Mar-14	0	EHC/ZVI (Shallow)-1	6.52	--
			EHC/ZVI (Shallow)-2	6.53	--
			EHC/ZVI (Shallow)-3	6.53	--
			Average Concentration	**6.53**	**--**
	4-Apr-14	7	EHC/ZVI (Shallow)-1	6.45	--
			EHC/ZVI (Shallow)-2	6.50	--
			EHC/ZVI (Shallow)-3	6.46	--
			Average Concentration	**6.47**	**--**
	17-Apr-14	20	EHC/ZVI (Shallow)-1	6.62	--
			EHC/ZVI (Shallow)-2	6.62	--
			EHC/ZVI (Shallow)-3	6.70	--
			Average Concentration	**6.65**	**--**
	25-Apr-14	28	EHC/ZVI (Shallow)-1	6.74	--
			EHC/ZVI (Shallow)-2	6.76	--
			EHC/ZVI (Shallow)-3	6.75	--
			Average Concentration	**6.75**	**--**
	9-May-14	42	EHC/ZVI (Shallow)-1	7.07	--
			EHC/ZVI (Shallow)-2	6.55	-241
			EHC/ZVI (Shallow)-3	6.74	--
			Average Concentration	**6.79**	**--**
	23-May-14	56	EHC/ZVI (Shallow)-1	6.72	--
			EHC/ZVI (Shallow)-2	6.74	--
			EHC/ZVI (Shallow)-3	6.78	--
			Average Concentration	**6.75**	**--**
	10-Jun-14	74	EHC/ZVI (Shallow)-1	6.60	--
			EHC/ZVI (Shallow)-2	6.58	--
			EHC/ZVI (Shallow)-3	6.69	--
			Average Concentration	**6.62**	**--**
	25-Jun-14	89	EHC/ZVI (Shallow)-1	6.95	--
			EHC/ZVI (Shallow)-2	6.90	--
			EHC/ZVI (Shallow)-3	6.80	--
			Average Concentration	**6.88**	**--**
	10-Jul-14	104	EHC/ZVI (Shallow)-1	6.55	--
			EHC/ZVI (Shallow)-2	6.56	--
			EHC/ZVI (Shallow)-3	6.54	--
			Average Concentration	**6.55**	**--**
	29-Jul-14	123	EHC/ZVI (Shallow)-1	6.75	--
			EHC/ZVI (Shallow)-2	6.50	--
			EHC/ZVI (Shallow)-3	6.49	--
			Average Concentration	**6.58**	**--**
Anaerobic Active Control (Intermediate Depth)	28-Mar-14	0	ANAC (Intermediate)-1	6.66	--
			ANAC (Intermediate)-2	6.66	--
			ANAC (Intermediate)-3	6.70	--
			Average Concentration	**6.67**	**--**
	4-Apr-14	7	ANAC (Intermediate)-1	6.60	--
			ANAC (Intermediate)-2	6.66	--
			ANAC (Intermediate)-3	6.64	--
			Average Concentration	**6.63**	**--**
	17-Apr-14	20	ANAC (Intermediate)-1	6.70	--
			ANAC (Intermediate)-2	6.63	--
			ANAC (Intermediate)-3	6.61	--
			Average Concentration	**6.65**	**--**
	25-Apr-14	28	ANAC (Intermediate)-1	6.82	--
			ANAC (Intermediate)-2	6.79	--
			ANAC (Intermediate)-3	6.77	--
			Average Concentration	**6.79**	**--**
	9-May-14	42	ANAC (Intermediate)-1	--	--
			ANAC (Intermediate)-2	--	-69
			ANAC (Intermediate)-3	--	--
			Average Concentration	**--**	**--**
	23-May-14	56	ANAC (Intermediate)-1	6.32	--
			ANAC (Intermediate)-2	6.40	--
			ANAC (Intermediate)-3	6.42	--
			Average Concentration	**6.38**	**--**
ZVI Amended/KB-1® Plus Bioaugmented (Intermediate Depth)	28-Mar-14	0	ZVI (Intermediate)-1	6.63	--
			ZVI (Intermediate)-2	6.75	--
			ZVI (Intermediate)-3	6.65	--
			Average Concentration	**6.68**	**--**

TABLE 5: SUMMARY OF MICROCOSM pH AND ORP RESULTS
Elkhart, Indiana

Treatment	Date	Day	Treatment Replicate	pH	ORP
				Standard Units	mV
ZVI Amended/KB-1® Plus Bioaugmented (Intermediate Depth) Continued	4-Apr-14	7	ZVI (Intermediate)-1	6.67	--
			ZVI (Intermediate)-2	6.64	--
			ZVI (Intermediate)-3	6.64	--
			Average Concentration	**6.65**	**--**
	17-Apr-14	20	ZVI (Intermediate)-1	6.82	--
			ZVI (Intermediate)-2	6.74	--
			ZVI (Intermediate)-3	6.82	--
			Average Concentration	**6.79**	**--**
	25-Apr-14	28	ZVI (Intermediate)-1	6.91	--
			ZVI (Intermediate)-2	6.87	--
			ZVI (Intermediate)-3	6.92	--
			Average Concentration	**6.90**	**--**
	9-May-14	42	ZVI (Intermediate)-1	6.71	--
			ZVI (Intermediate)-2	6.76	-284
			ZVI (Intermediate)-3	6.68	--
			Average Concentration	**6.72**	**--**
	23-May-14	56	ZVI (Intermediate)-1	6.54	--
			ZVI (Intermediate)-2	6.51	--
			ZVI (Intermediate)-3	6.53	--
			Average Concentration	**6.53**	**--**
	10-Jun-14	74	ZVI (Intermediate)-1	6.97	--
			ZVI (Intermediate)-2	7.16	--
			ZVI (Intermediate)-3	6.91	--
			Average Concentration	**7.01**	**--**
SRS™/ZVI and Ferrous Fumarate Amended/KB-1® Plus Bioaugmented (Intermediate Depth)	28-Mar-14	0	SRS/ZVI (Intermediate)-1	6.62	--
			SRS/ZVI (Intermediate)-2	6.67	--
			SRS/ZVI (Intermediate)-3	6.63	--
			Average Concentration	**6.64**	**--**
	4-Apr-14	7	SRS/ZVI (Intermediate)-1	6.53	--
			SRS/ZVI (Intermediate)-2	6.58	--
			SRS/ZVI (Intermediate)-3	6.56	--
			Average Concentration	**6.56**	**--**
	17-Apr-14	20	SRS/ZVI (Intermediate)-1	6.68	--
			SRS/ZVI (Intermediate)-2	6.79	--
			SRS/ZVI (Intermediate)-3	6.64	--
			Average Concentration	**6.70**	**--**
	25-Apr-14	28	SRS/ZVI (Intermediate)-1	6.84	--
			SRS/ZVI (Intermediate)-2	6.75	--
			SRS/ZVI (Intermediate)-3	6.94	--
			Average Concentration	**6.84**	**--**
	9-May-14	42	SRS/ZVI (Intermediate)-1	6.82	--
			SRS/ZVI (Intermediate)-2	6.65	-306
			SRS/ZVI (Intermediate)-3	6.78	--
			Average Concentration	**6.75**	**--**
	23-May-14	56	SRS/ZVI (Intermediate)-1	6.57	--
			SRS/ZVI (Intermediate)-2	6.64	--
			SRS/ZVI (Intermediate)-3	6.52	--
			Average Concentration	**6.58**	**--**
	10-Jun-14	74	SRS/ZVI (Intermediate)-1	6.49	--
			SRS/ZVI (Intermediate)-2	6.86	--
			SRS/ZVI (Intermediate)-3	6.63	--
			Average Concentration	**6.66**	**--**
SRS™ and Ferrous Fumarate Amended/KB-1® Plus Bioaugmented (Intermediate Depth)	28-Mar-14	0	SRS/solFe (Intermediate)-1	6.65	--
			SRS/solFe (Intermediate)-2	6.66	--
			SRS/solFe (Intermediate)-3	6.63	--
			Average Concentration	**6.65**	**--**
	4-Apr-14	7	SRS/solFe (Intermediate)-1	6.56	--
			SRS/solFe (Intermediate)-2	6.54	--
			SRS/solFe (Intermediate)-3	6.51	--
			Average Concentration	**6.54**	**--**
	17-Apr-14	20	SRS/solFe (Intermediate)-1	6.68	--
			SRS/solFe (Intermediate)-2	6.63	--
			SRS/solFe (Intermediate)-3	6.64	--
			Average Concentration	**6.65**	**--**
	25-Apr-14	28	SRS/solFe (Intermediate)-1	6.67	--
			SRS/solFe (Intermediate)-2	6.69	--
			SRS/solFe (Intermediate)-3	6.70	--
			Average Concentration	**6.69**	**--**
	9-May-14	42	SRS/solFe (Intermediate)-1	6.51	--
			SRS/solFe (Intermediate)-2	6.50	-269
			SRS/solFe (Intermediate)-3	6.54	--
			Average Concentration	**6.52**	**--**
	23-May-14	56	SRS/solFe (Intermediate)-1	6.46	--
			SRS/solFe (Intermediate)-2	6.48	--
			SRS/solFe (Intermediate)-3	6.47	--
			Average Concentration	**6.47**	**--**
	10-Jun-14	74	SRS/solFe (Intermediate)-1	6.30	--
			SRS/solFe (Intermediate)-2	6.37	--
			SRS/solFe (Intermediate)-3	6.37	--
			Average Concentration	**6.35**	**--**

TABLE 5: SUMMARY OF MICROCOSM pH AND ORP RESULTS

Elkhart, Indiana

Treatment	Date	Day	Treatment Replicate	pH	ORP
				Standard Units	mV
SRS™ Amended/KB-1® Plus Bioaugmented (Intermediate Depth)	28-Mar-14	0	SRS (Intermediate)-1	6.66	--
			SRS (Intermediate)-2	6.68	--
			SRS (Intermediate)-3	6.65	--
			Average Concentration	**6.66**	**--**
	4-Apr-14	7	SRS (Intermediate)-1	6.47	--
			SRS (Intermediate)-2	6.51	--
			SRS (Intermediate)-3	6.56	--
			Average Concentration	**6.51**	**--**
	17-Apr-14	20	SRS (Intermediate)-1	6.71	--
			SRS (Intermediate)-2	6.65	--
			SRS (Intermediate)-3	6.69	--
			Average Concentration	**6.68**	**--**
	25-Apr-14	28	SRS (Intermediate)-1	6.68	--
			SRS (Intermediate)-2	6.53	--
			SRS (Intermediate)-3	6.74	--
			Average Concentration	**6.65**	**--**
	9-May-14	42	SRS (Intermediate)-1	6.44	--
			SRS (Intermediate)-2	6.49	-89
			SRS (Intermediate)-3	6.52	--
			Average Concentration	**6.48**	**--**
	23-May-14	56	SRS (Intermediate)-1	6.35	--
			SRS (Intermediate)-2	6.29	--
			SRS (Intermediate)-3	6.45	--
			Average Concentration	**6.36**	**--**
	10-Jun-14	74	SRS (Intermediate)-1	6.26	--
			SRS (Intermediate)-2	6.20	--
			SRS (Intermediate)-3	6.57	--
			Average Concentration	**6.34**	**--**
EHC-L® Amended/KB-1® Plus Bioaugmented (Intermediate Depth)	28-Mar-14	0	EHC(Intermediate)-1	6.56	--
			EHC(Intermediate)-2	6.54	--
			EHC(Intermediate)-3	6.58	--
			Average Concentration	**6.56**	**--**
	4-Apr-14	7	EHC(Intermediate)-1	6.36	--
			EHC(Intermediate)-2	6.41	--
			EHC(Intermediate)-3	6.46	--
			Average Concentration	**6.41**	**--**
	17-Apr-14	20	EHC(Intermediate)-1	6.49	--
			EHC(Intermediate)-2	6.49	--
			EHC(Intermediate)-3	6.50	--
			Average Concentration	**6.49**	**--**
	25-Apr-14	28	EHC(Intermediate)-1	6.64	--
			EHC(Intermediate)-2	6.60	--
			EHC(Intermediate)-3	6.61	--
			Average Concentration	**6.62**	**--**
	9-May-14	42	EHC(Intermediate)-1	6.42	--
			EHC(Intermediate)-2	6.42	-140
			EHC(Intermediate)-3	6.44	--
			Average Concentration	**6.43**	**--**
	23-May-14	56	EHC(Intermediate)-1	6.36	--
			EHC(Intermediate)-2	6.40	--
			EHC(Intermediate)-3	6.44	--
			Average Concentration	**6.40**	**--**
	10-Jun-14	74	EHC(Intermediate)-1	6.29	--
			EHC(Intermediate)-2	6.41	--
			EHC(Intermediate)-3	6.45	--
			Average Concentration	**6.38**	**--**
EHC®-L and ZVI Amended/KB-1® Plus Bioaugmented (Intermediate Depth)	28-Mar-14	0	EHC/ZVI (Intermediate)-1	6.56	--
			EHC/ZVI (Intermediate)-2	6.61	--
			EHC/ZVI (Intermediate)-3	6.65	--
			Average Concentration	**6.61**	**--**
	4-Apr-14	7	EHC/ZVI (Intermediate)-1	6.40	--
			EHC/ZVI (Intermediate)-2	6.45	--
			EHC/ZVI (Intermediate)-3	6.46	--
			Average Concentration	**6.44**	**--**
	17-Apr-14	20	EHC/ZVI (Intermediate)-1	6.78	--
			EHC/ZVI (Intermediate)-2	6.94	--
			EHC/ZVI (Intermediate)-3	6.78	--
			Average Concentration	**6.83**	**--**
	25-Apr-14	28	EHC/ZVI (Intermediate)-1	6.91	--
			EHC/ZVI (Intermediate)-2	6.88	--
			EHC/ZVI (Intermediate)-3	6.91	--
			Average Concentration	**6.90**	**--**
	9-May-14	42	EHC/ZVI (Intermediate)-1	6.78	--
			EHC/ZVI (Intermediate)-2	6.78	-190
			EHC/ZVI (Intermediate)-3	6.69	--
			Average Concentration	**6.75**	**--**
	23-May-14	56	EHC/ZVI (Intermediate)-1	6.78	--
			EHC/ZVI (Intermediate)-2	6.65	--
			EHC/ZVI (Intermediate)-3	6.64	--
			Average Concentration	**6.69**	**--**

TABLE 5: SUMMARY OF MICROCOSM pH AND ORP RESULTS

Elkhart, Indiana

Treatment	Date	Day	Treatment Replicate	pH	ORP
				Standard Units	mV
EHC®-L and ZVI Amended/KB-1® Plus Bioaugmented	10-Jun-14	74	EHC/ZVI (Intermediate)-1	6.83	--
(Intermediate Depth)			EHC/ZVI (Intermediate)-2	6.74	--
Continued			EHC/ZVI (Intermediate)-3	6.73	--
			Average Concentration	**6.77**	**--**

Notes:

* All treatments were amended with the vitamin/nutrient mix on Day 0
ANAC - anaerobic active control
ANSC - anaerobic sterile control
ORP - oxidation reduction potential
sol Fe - soluble iron
ZVI - zero valent iron

TABLE 6: HALF-LIVES (DAYS) OF CHLORINATED ETHENES DETECTED IN MICROCOSMS
Elkhart, Indiana

Depth	Treatment/Control	CTC			TCE Pre Bioaugmentation			TCE Post Bioaugmentation		
		Half Life (Days)	T_1 (Day)	T_2 (Days)	**Half Life (Days)**	T_1 (Day)	T_2 (Days)	**Half Life (Days)**	T_1 (Day)	T_2 (Days)
Shallow	Anaerobic Sterile Control	225	0	123	343	0	123	- -	- -	- -
	Anaerobic Active Control (Shallow)	93	0	123	724	0	123	- -	- -	- -
	ZVI Amended/KB-1® Plus Bioaugmented	0.8	0	7	9.0	0	28	5.1	28	56
	SRS™, ZVI and Ferrous Fumarate Amended/KB-1® Plus Bioaugmented	0.9	0	7	8.2	0	28	4.8	28	56
	SRS™ and Ferrous Fumarate Amended/KB-1® Plus Bioaugmented	0.9	0	7	75	0	28	5.2	28	74
	SRS™ Amended/KB-1® Plus Bioaugmented	2.5	0	20	63	0	28	5.2	28	74
	EHC®-L Amended/KB-1® Plus Bioaugmented	0.9	0	7	294	0	28	6.7 *	28	89
	EHC®-L and ZVI Amended/KB-1® Plus Bioaugmented	0.9	0	7	5.5	0	28	3.5	28	42
Intermediate	Anaerobic Active Control (Shallow)	2.4	0	20	82	0	56	- -	- -	- -
	ZVI Amended/KB-1® Plus Bioaugmented	0.9	0	7	4.9	0	28	3.8	28	42
	SRS™, ZVI and Soluble Iron Amended/KB-1® Plus Bioaugmented	0.9	0	7	6.1	0	28	3.1	28	42
	SRS™ and Ferrous Fumarate Amended/KB-1® Plus Bioaugmented	0.9	0	7	89	0	28	3.2	28	56
	SRS™ Amended/KB-1® Plus Bioaugmented	0.9	0	7	50	0	28	5.3	28	74
	EHC®-L Amended/KB-1® Plus Bioaugmented	0.9	0	7	40	0	28	7.9	28	74
	EHC®-L and ZVI Amended/KB-1® Plus Bioaugmented	0.9	0	7	6.9	0	28	2.8	28	42

Notes:

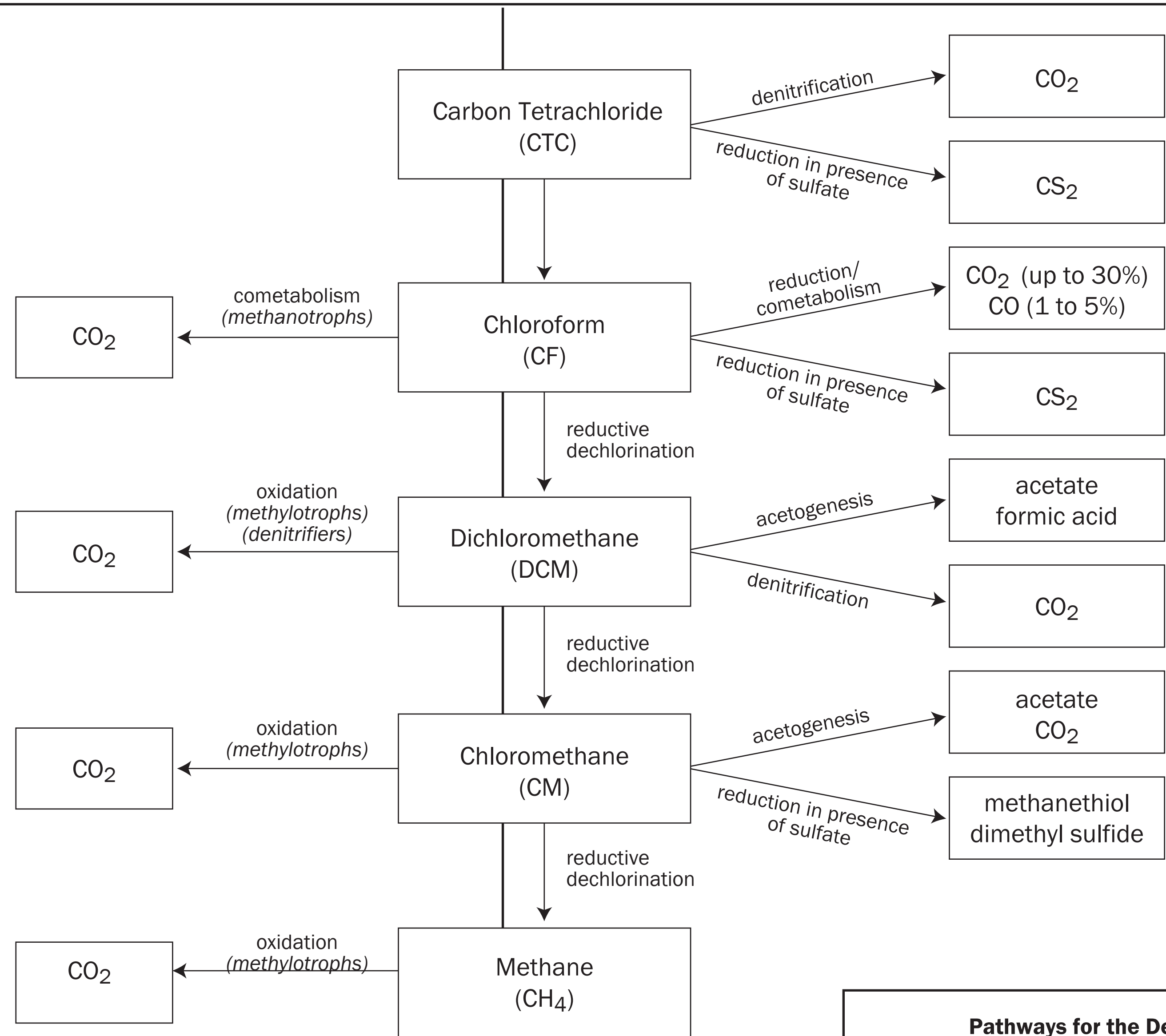
***** TCE was not detected at 56 days in all three replicates. However, TCE was detected at day 74 in all three replicates (with two of three triplicates at concentrations near the detection limit) possibly the result of sorption or related equilibration effects. As a conservative estimate, 89 days is used as the basis for the calculation of the half-life, as all three replicates returned to non detectable concentrations and remained non-detect until the end of the study on Day 123.

CTC - carbon tetrachloride

TCE - trichloroethene

- - not analyzed

FIGURES



Pathways for the Degradation of Chlorinated Methanes

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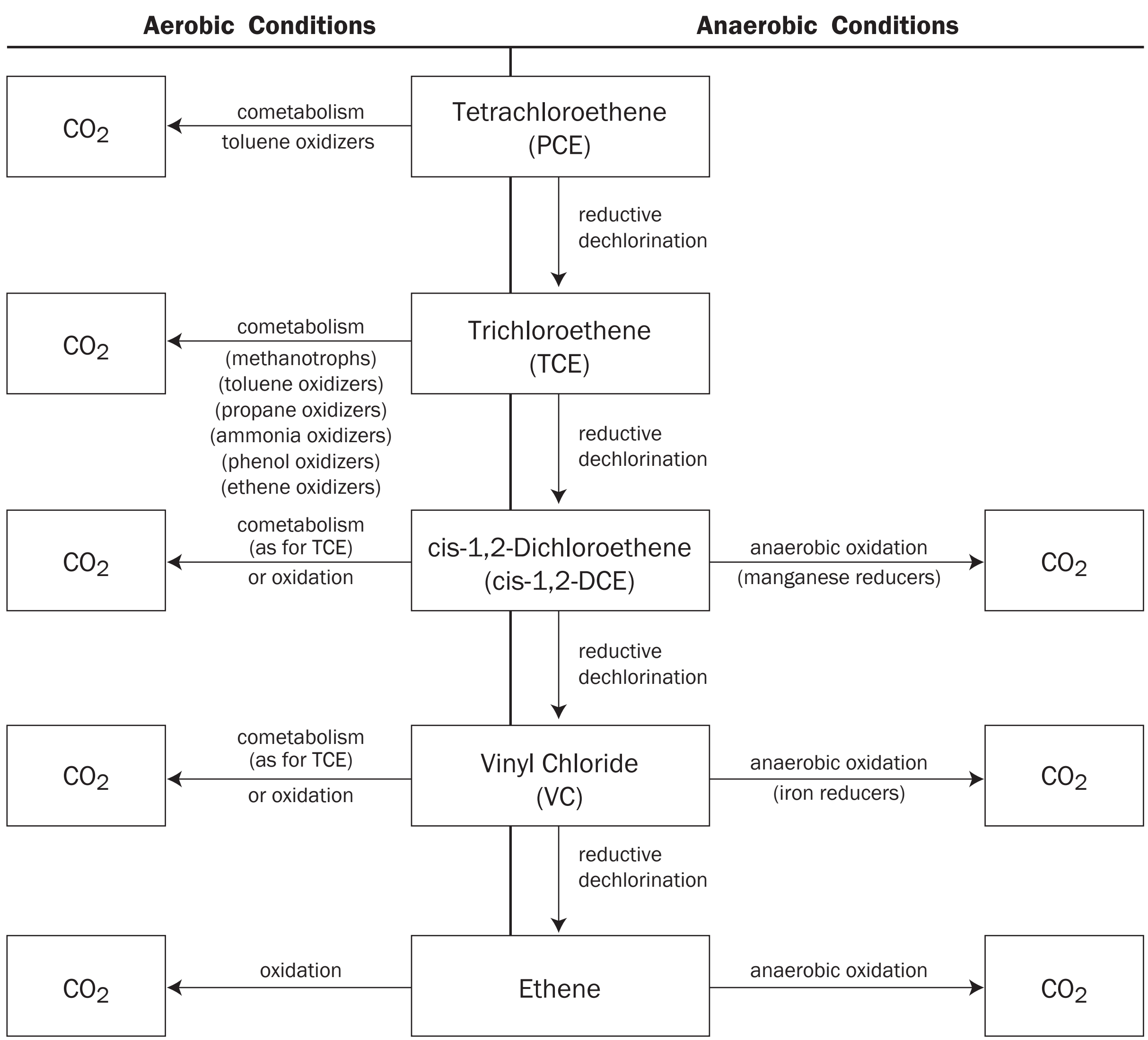
August 2014

Figure: **1**

pathway_methans_2012.ai



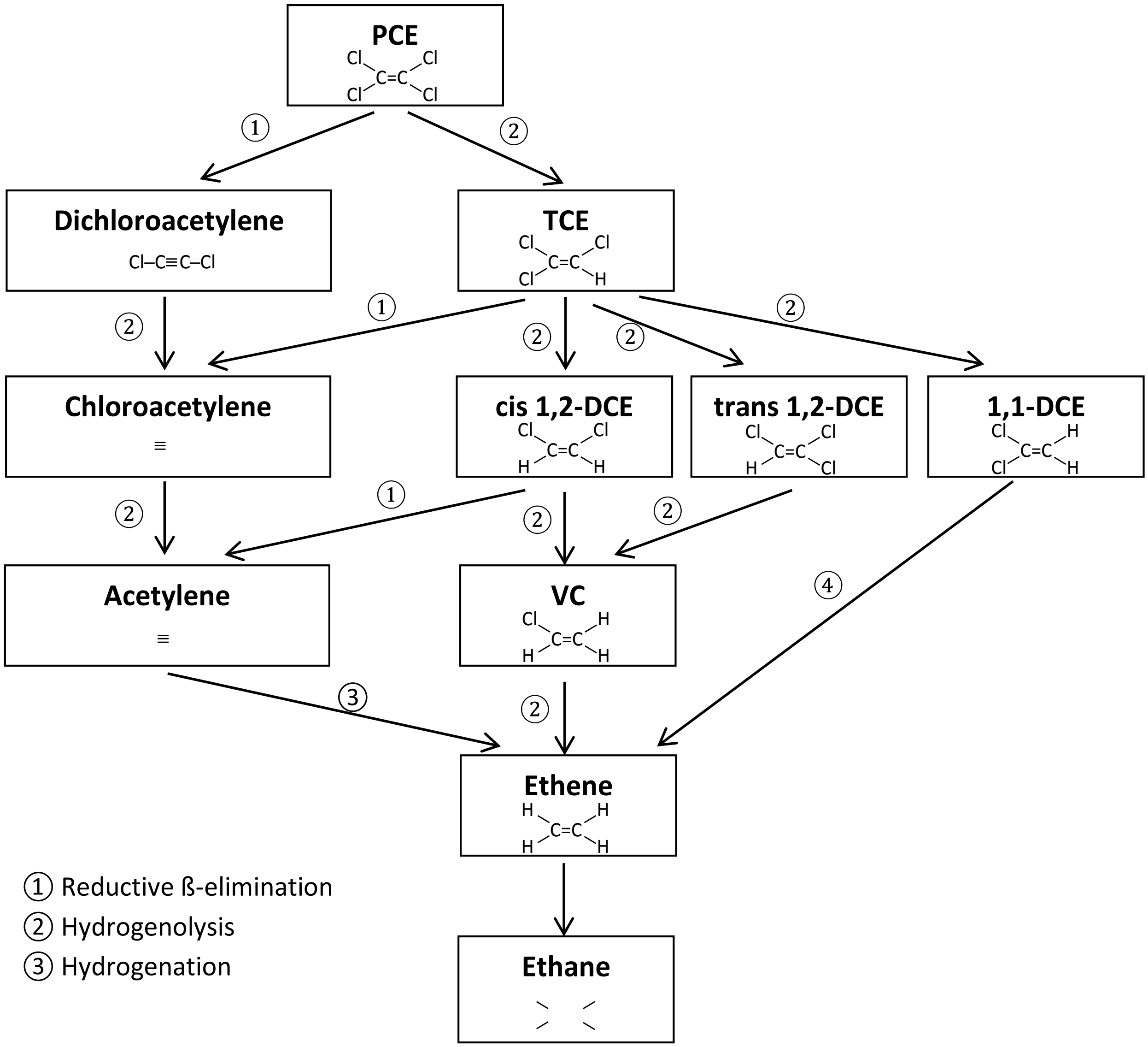
Pathways for the Degradation of Chlorinated Ethenes

SiREM

August 2014

Figure: 2

pathways_chlorinated ethenes.ai

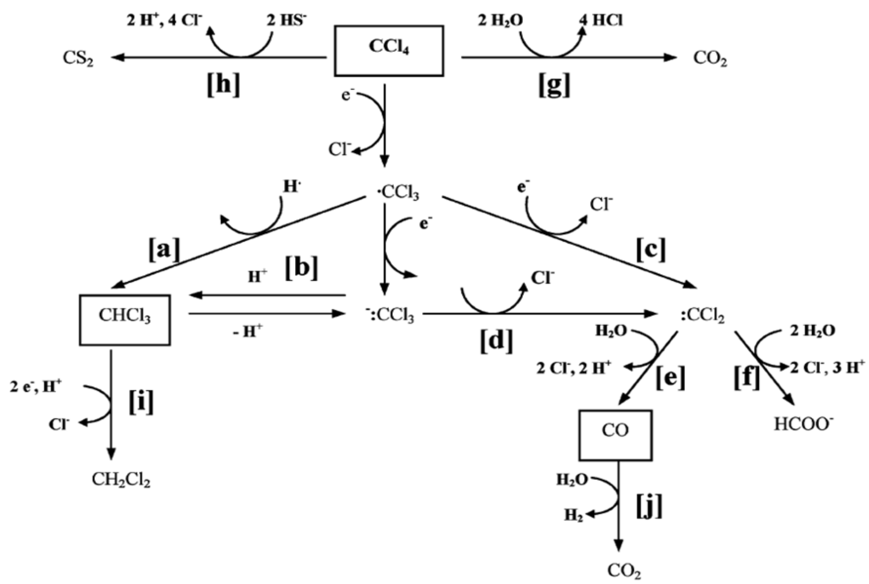


Chlorinated Ethene Degradation Pathways with ZVI

Sep 2014

Figure: **3**

(modified from Arnold and Roberts, 2000)

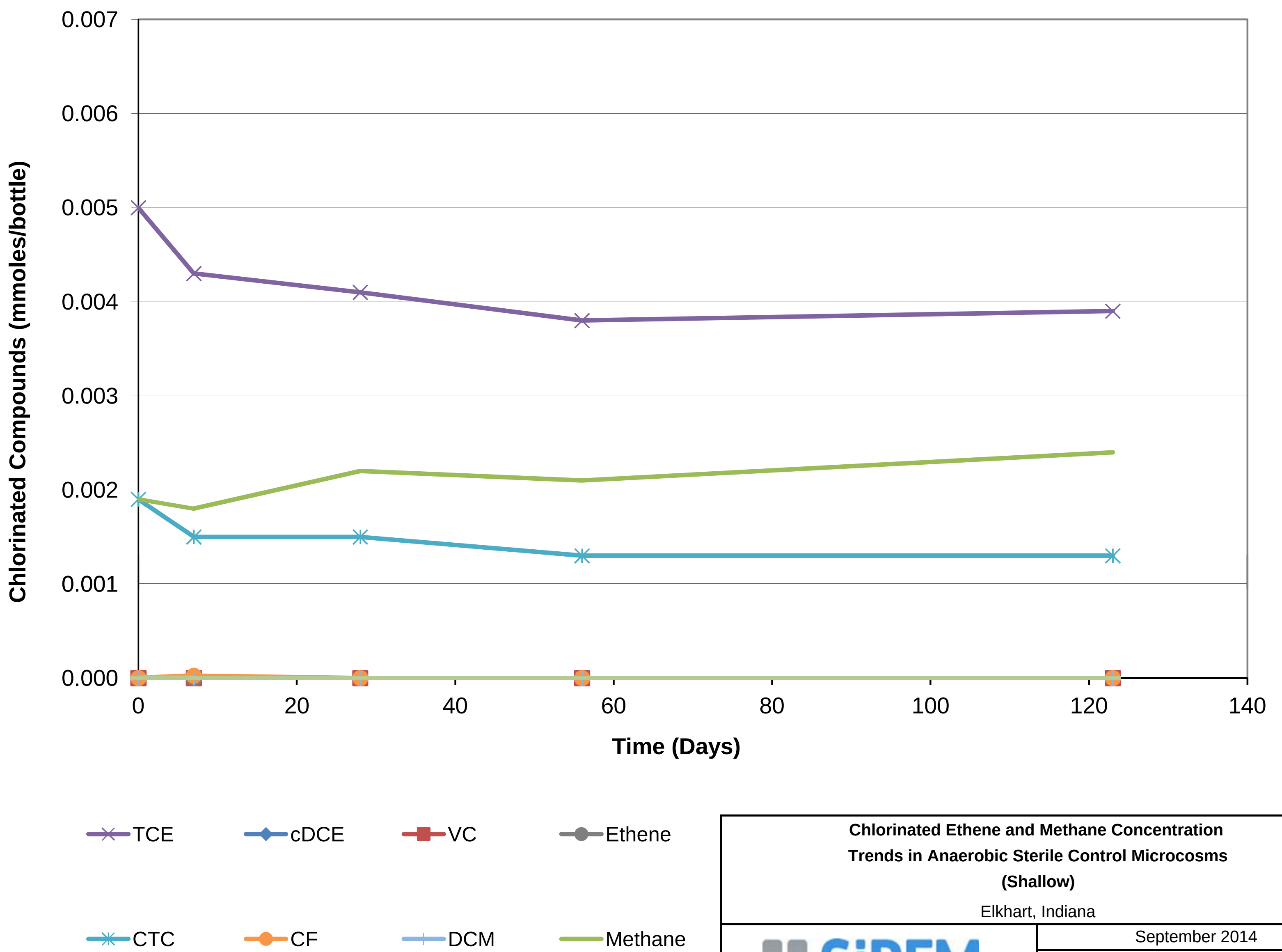


Pathways:

[a] and [i] Reductive dehalogenation
[c], [e], and [f] Dichlorelimination, followed by hydrolysis

(Tamara and Butler, 2004)

Carbon Tetrachloride Degradation Pathways with ZVI	
SiREM	Sep 2014
	Figure: **4**



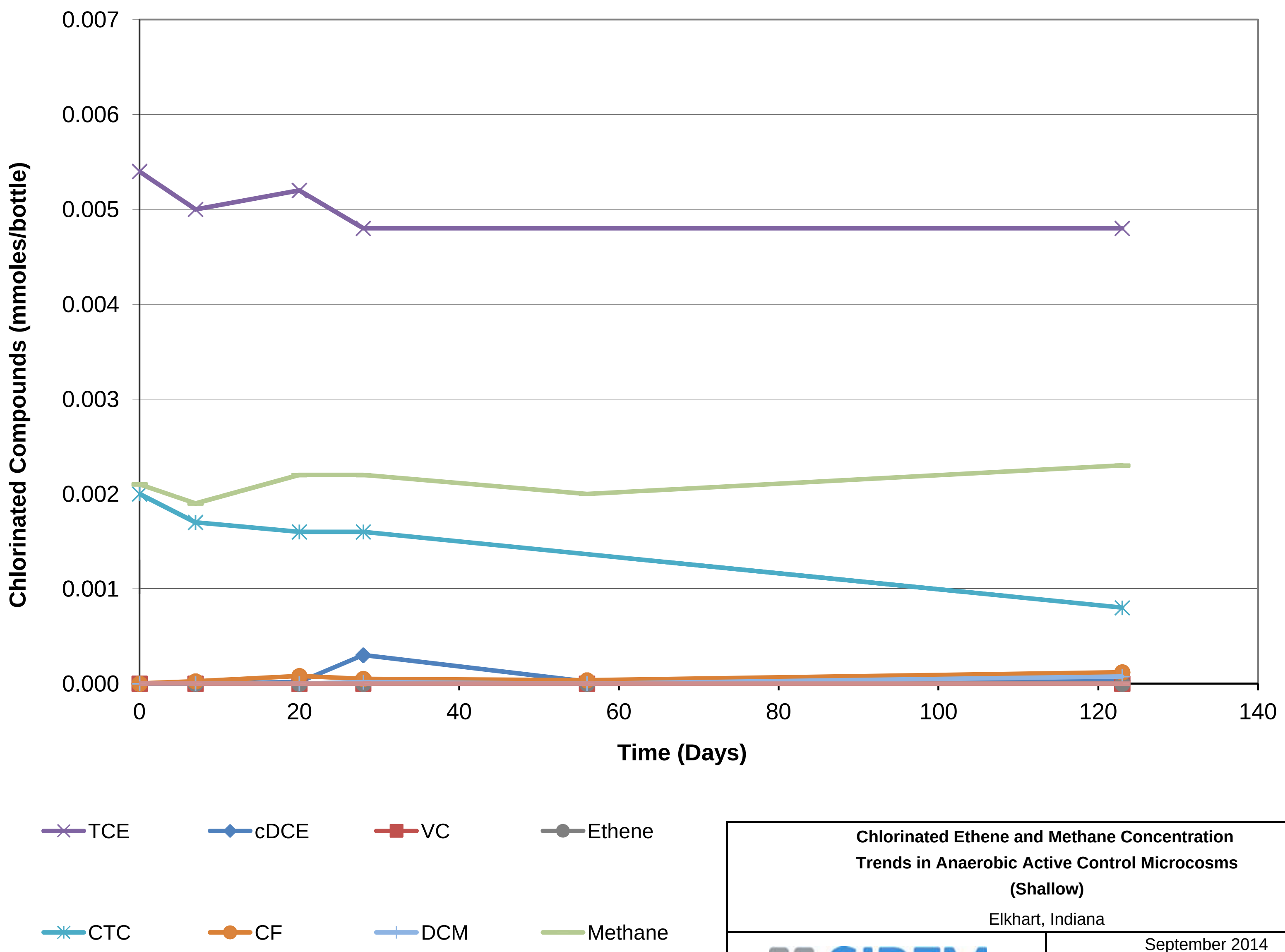
Chlorinated Ethene and Methane Concentration Trends in Anaerobic Sterile Control Microcosms (Shallow)

Elkhart, Indiana

SiREM

September 2014

Figure: **5**



Chlorinated Ethene and Methane Concentration Trends in Anaerobic Active Control Microcosms (Shallow)

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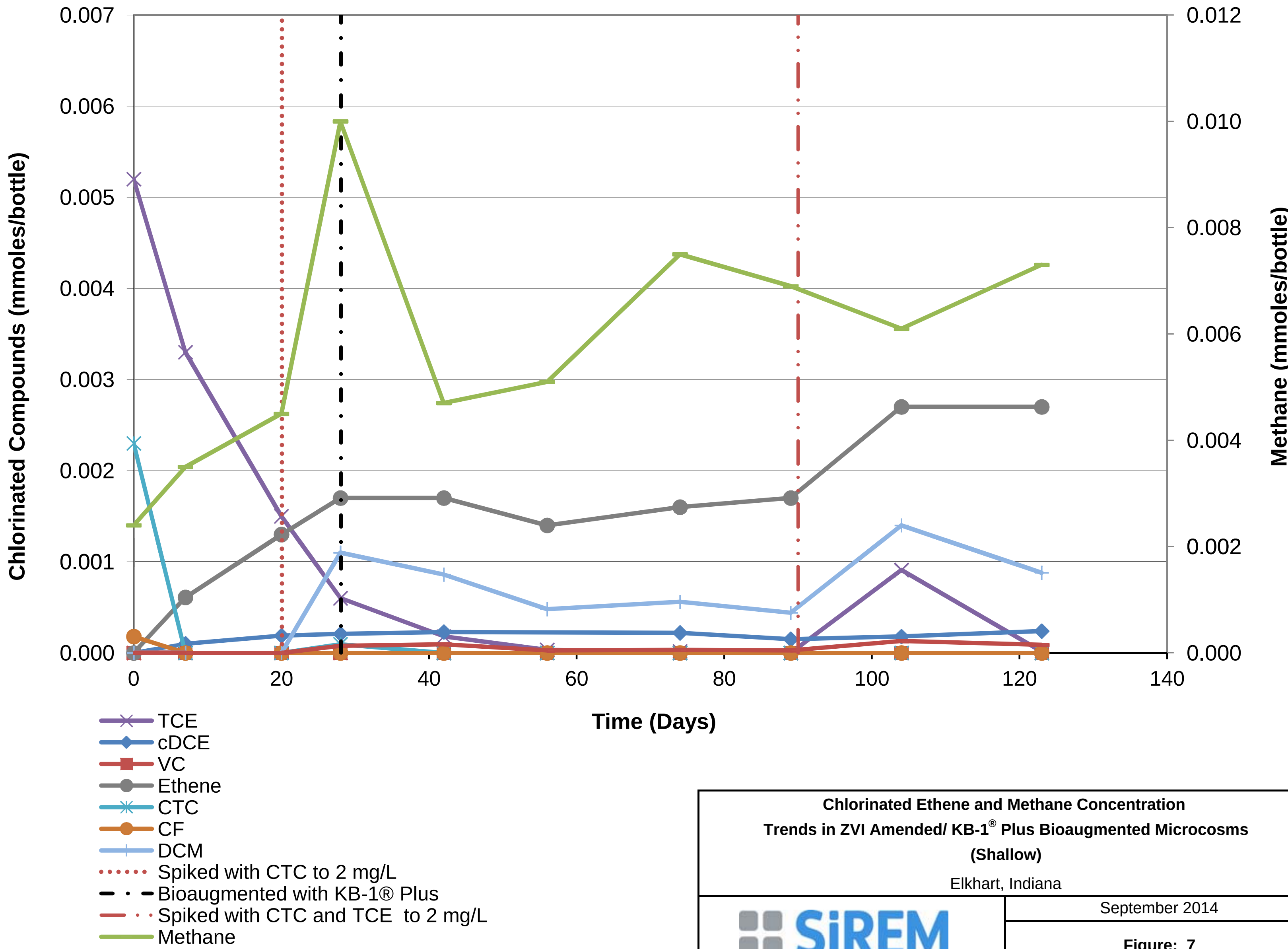
Figure: 6



Chlorinated Ethene and Methane Concentration Trends in ZVI Amended/ KB-1® Plus Bioaugmented Microcosms (Shallow)

Elkhart, Indiana

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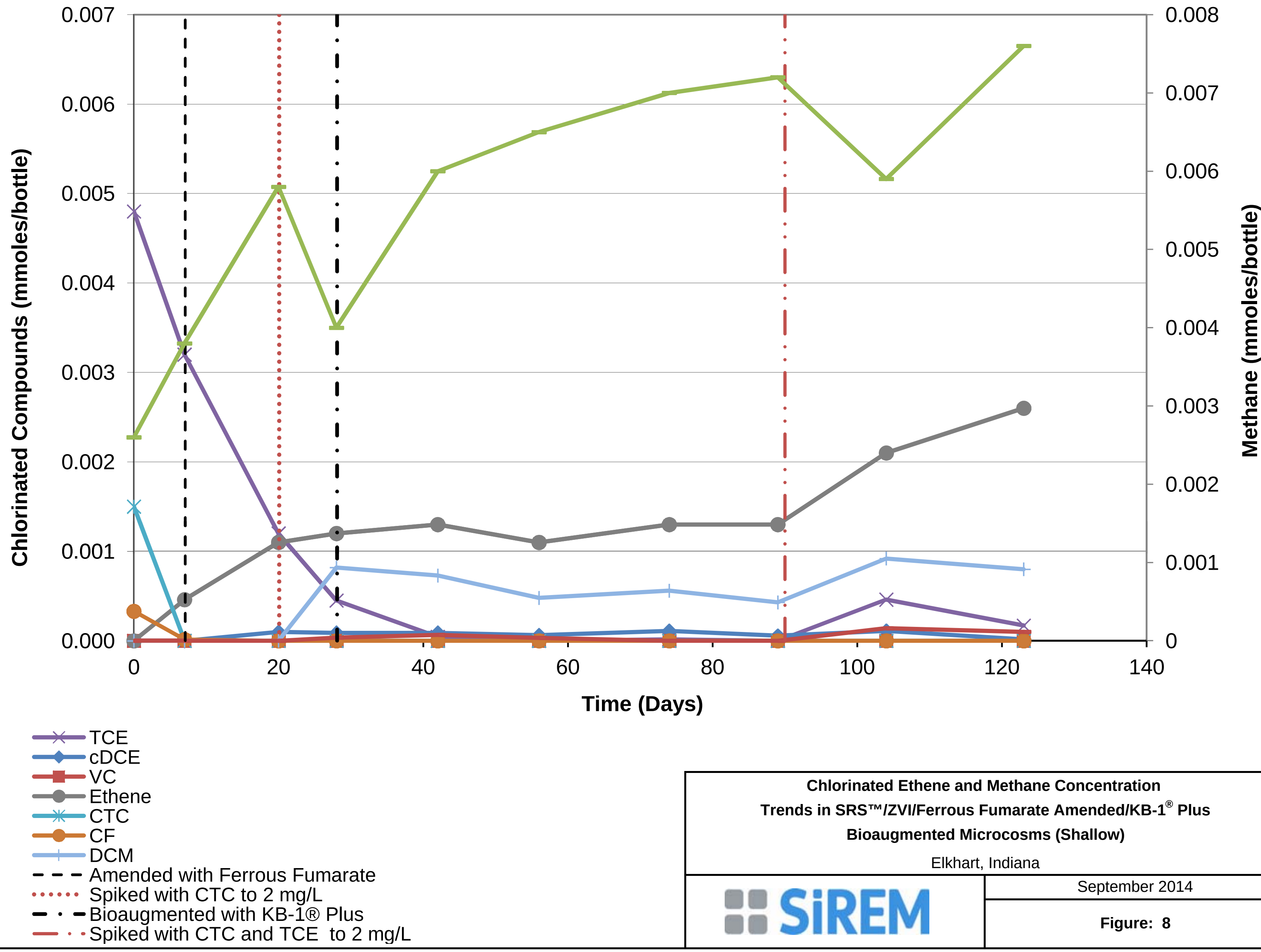
Figure: 7



Chlorinated Ethene and Methane Concentration Trends in SRS™/ZVI/Ferrous Fumarate Amended/KB-1® Plus Bioaugmented Microcosms (Shallow)

Elkhart, Indiana

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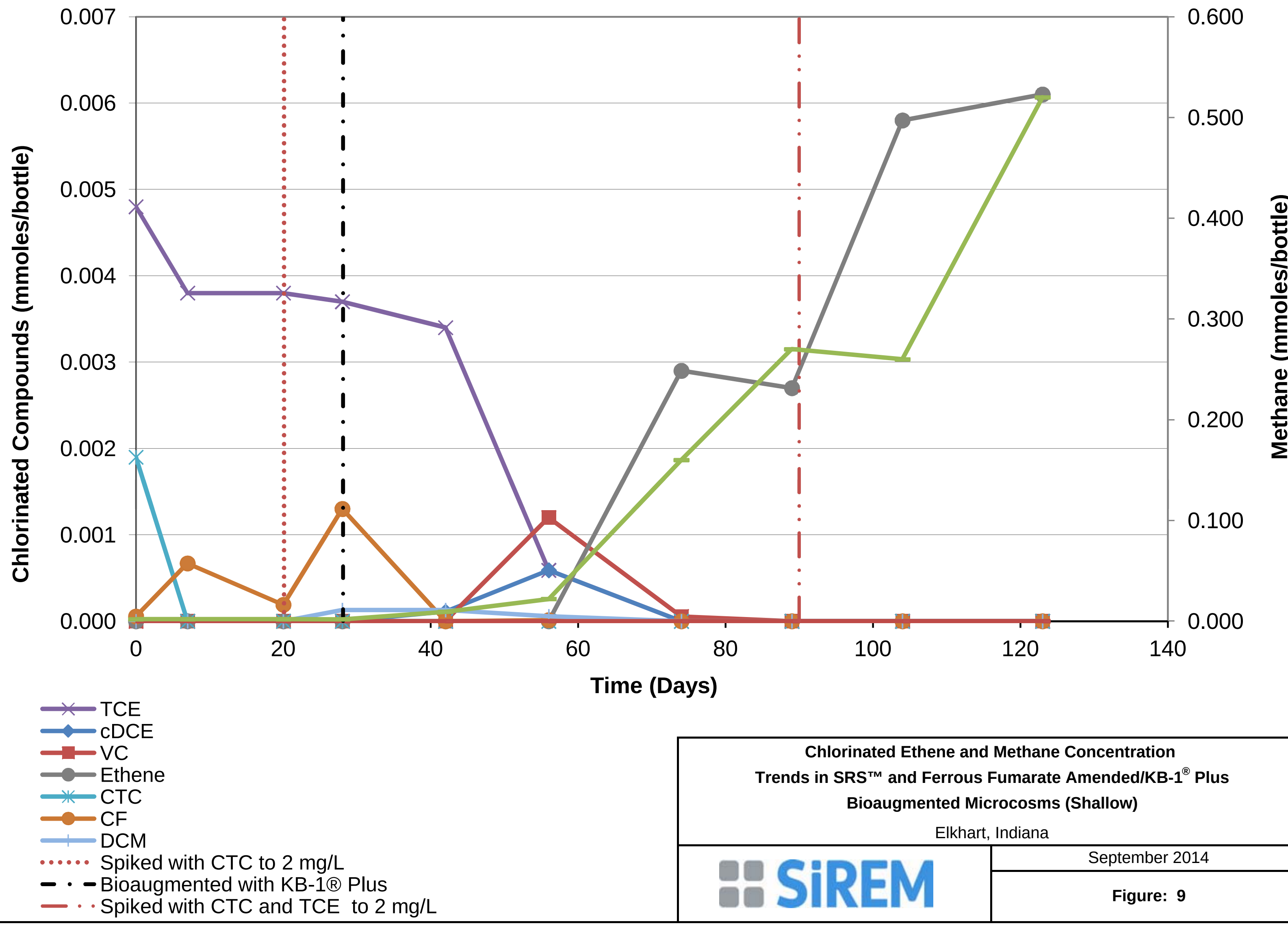
September 2014

Figure: 8



Chlorinated Ethene and Methane Concentration Trends in SRS™ and Ferrous Fumarate Amended/KB-1® Plus Bioaugmented Microcosms (Shallow)

Elkhart, Indiana

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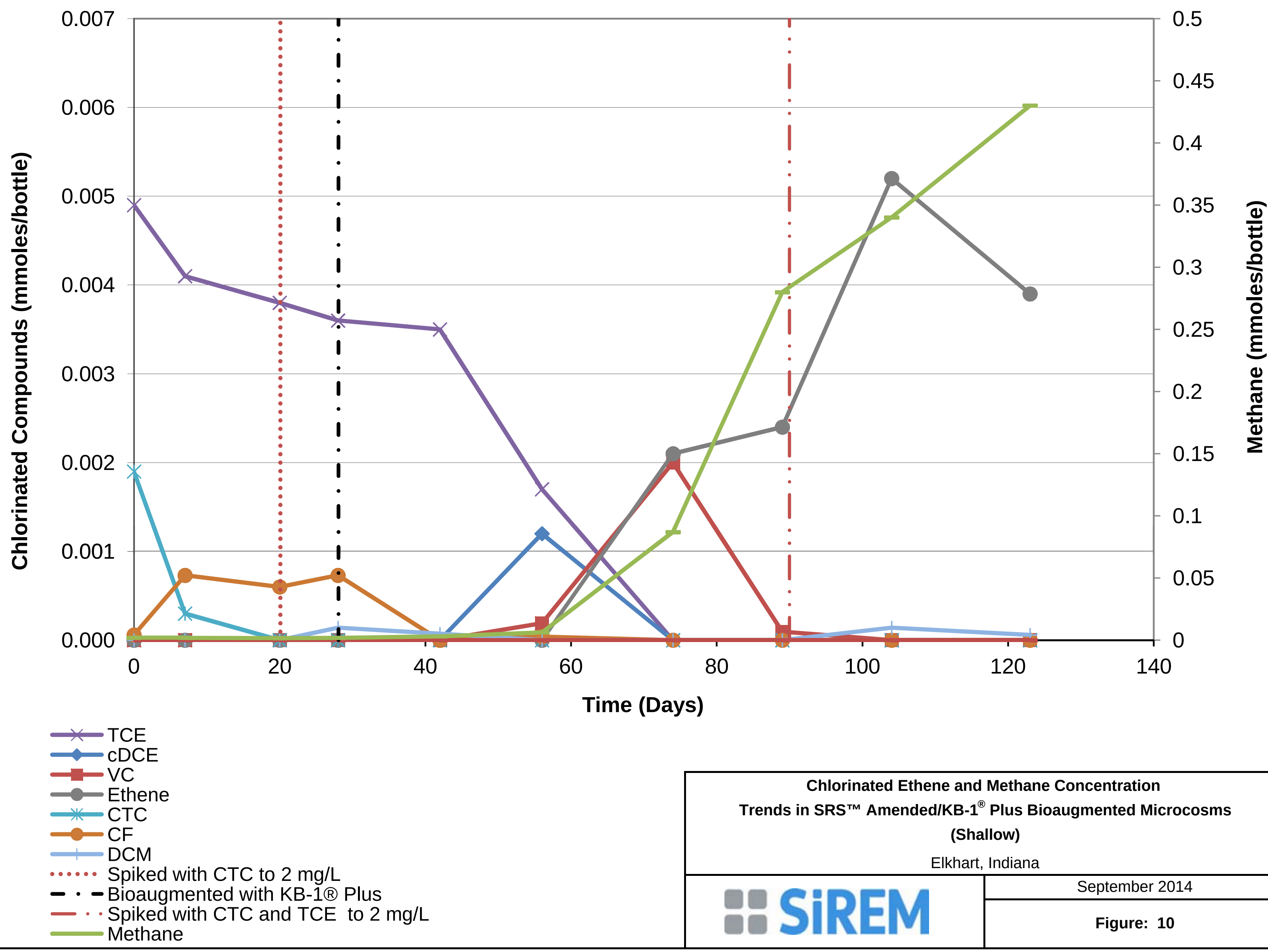
September 2014

Figure: 9



Chlorinated Ethene and Methane Concentration Trends in SRS™ Amended/KB-1® Plus Bioaugmented Microcosms (Shallow)

Elkhart, Indiana

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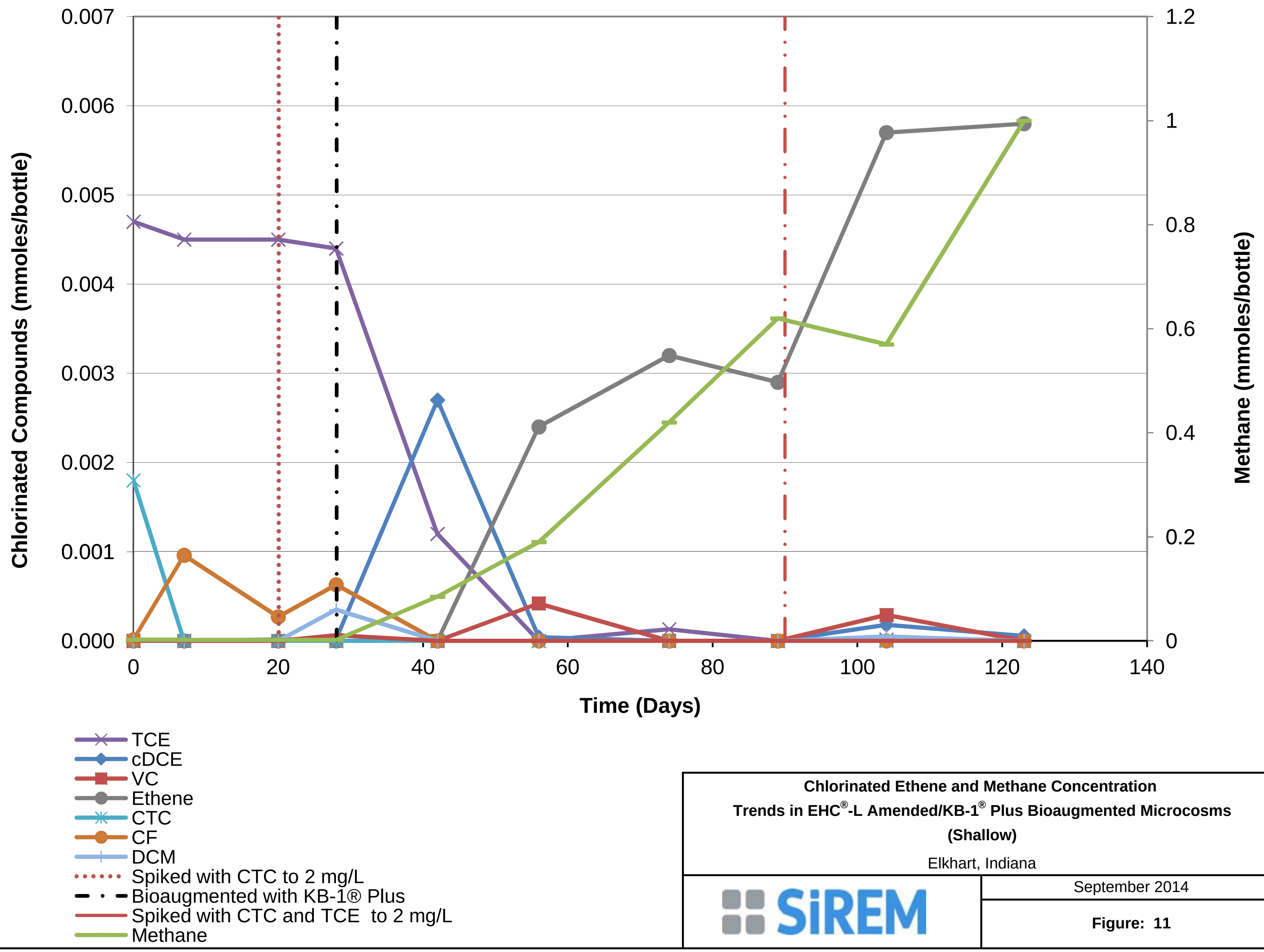
September 2014

Figure: 10



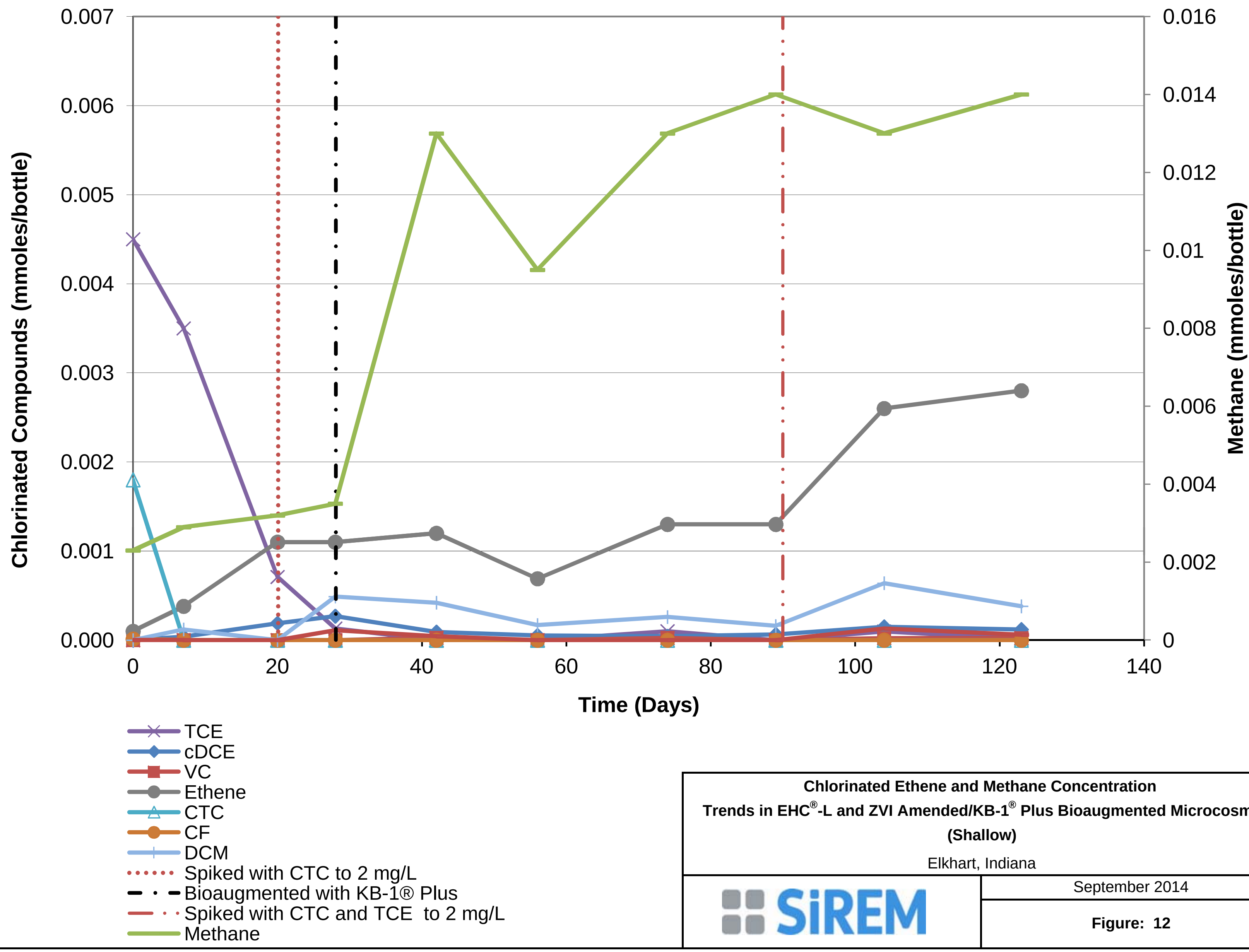
Chlorinated Ethene and Methane Concentration
Trends in EHC®-L Amended/KB-1® Plus Bioaugmented Microcosms
(Shallow)

Elkhart, Indiana

SiREM

September 2014

Figure: 11



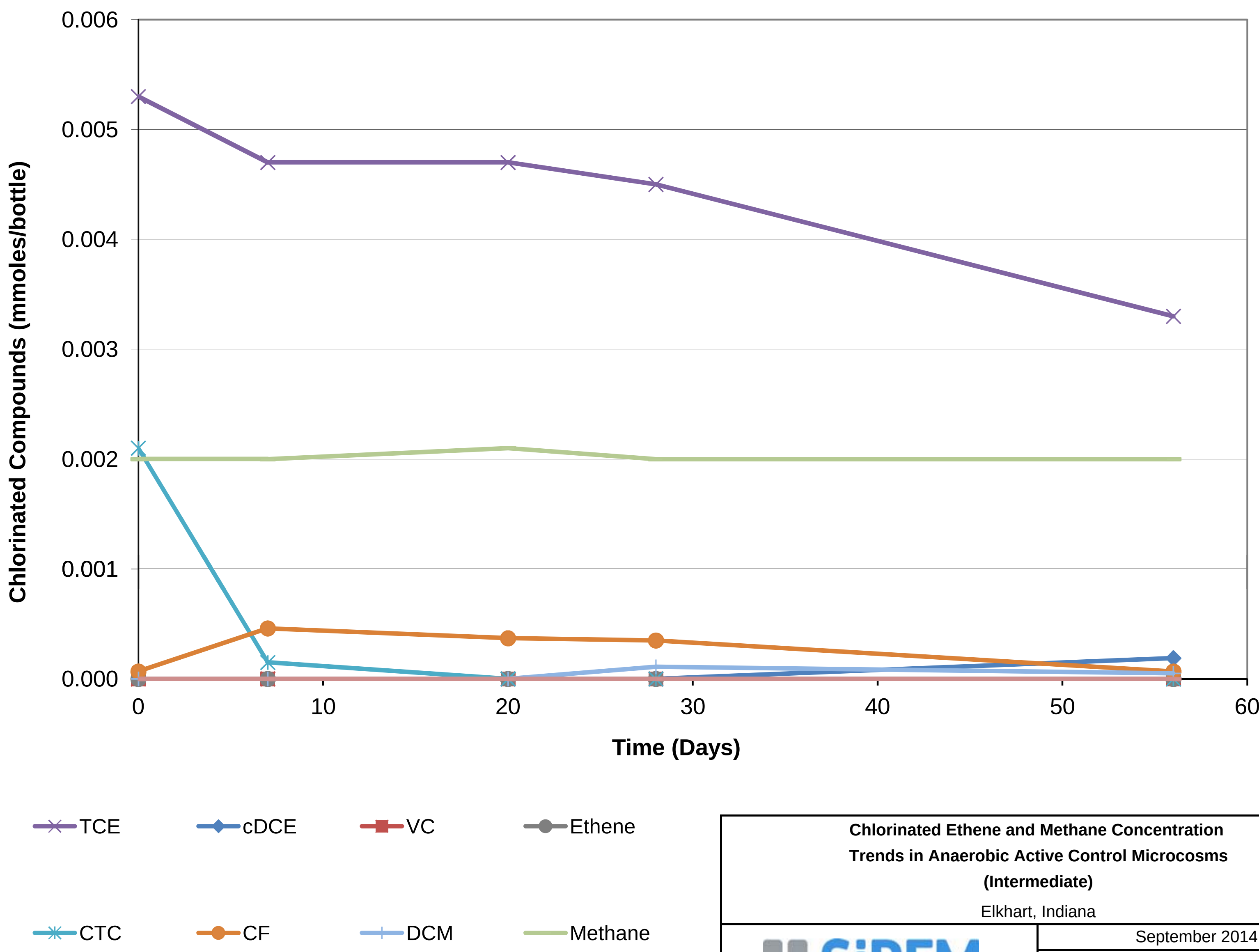
Chlorinated Ethene and Methane Concentration
Trends in EHC®-L and ZVI Amended/KB-1® Plus Bioaugmented Microcosms
(Shallow)

Elkhart, Indiana

SiREM

September 2014

Figure: 12



Chlorinated Ethene and Methane Concentration Trends in Anaerobic Active Control Microcosms (Intermediate)

Elkhart, Indiana

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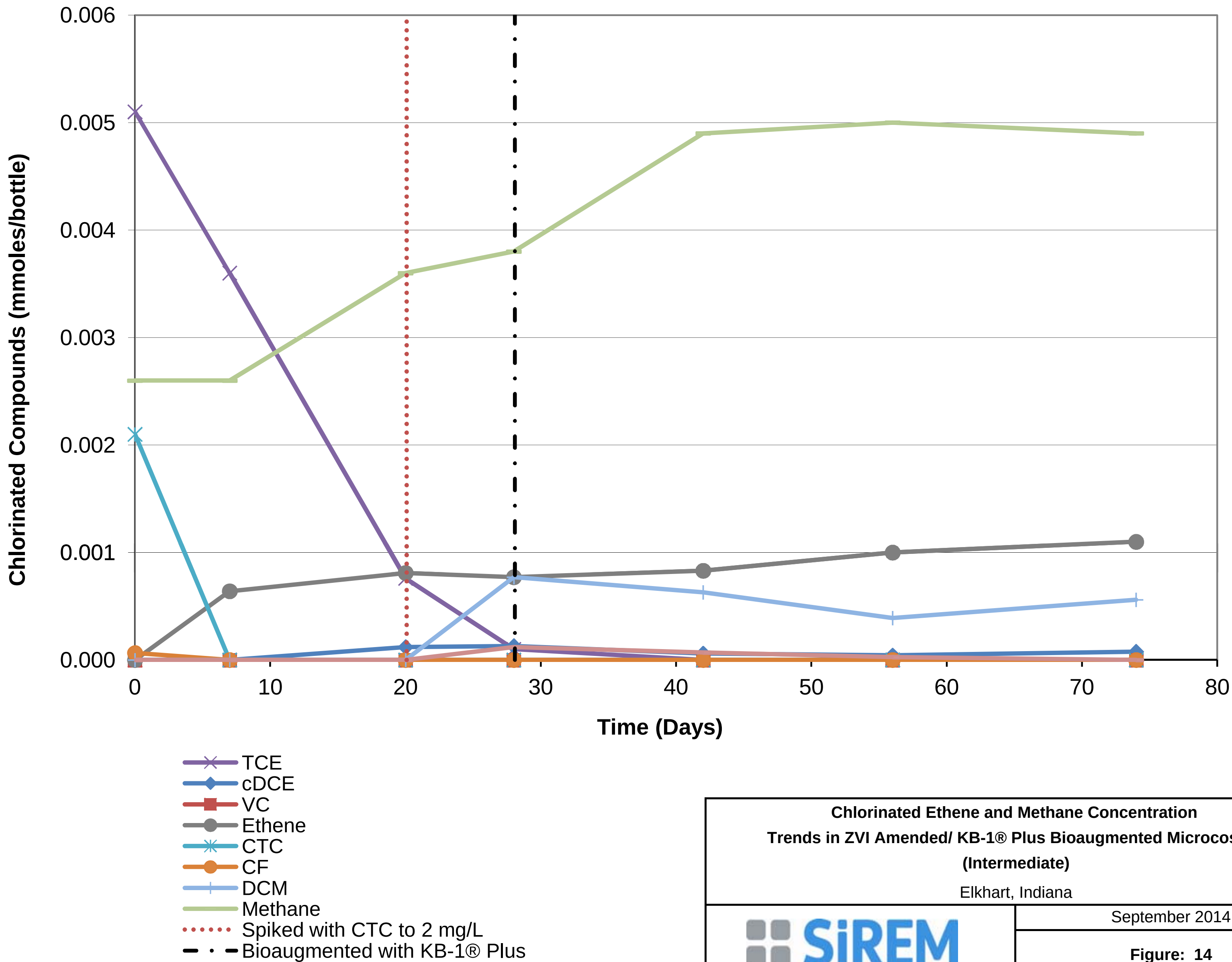
September 2014

Figure: 13



Chlorinated Ethene and Methane Concentration Trends in ZVI Amended/ KB-1® Plus Bioaugmented Microcosms (Intermediate)

Elkhart, Indiana

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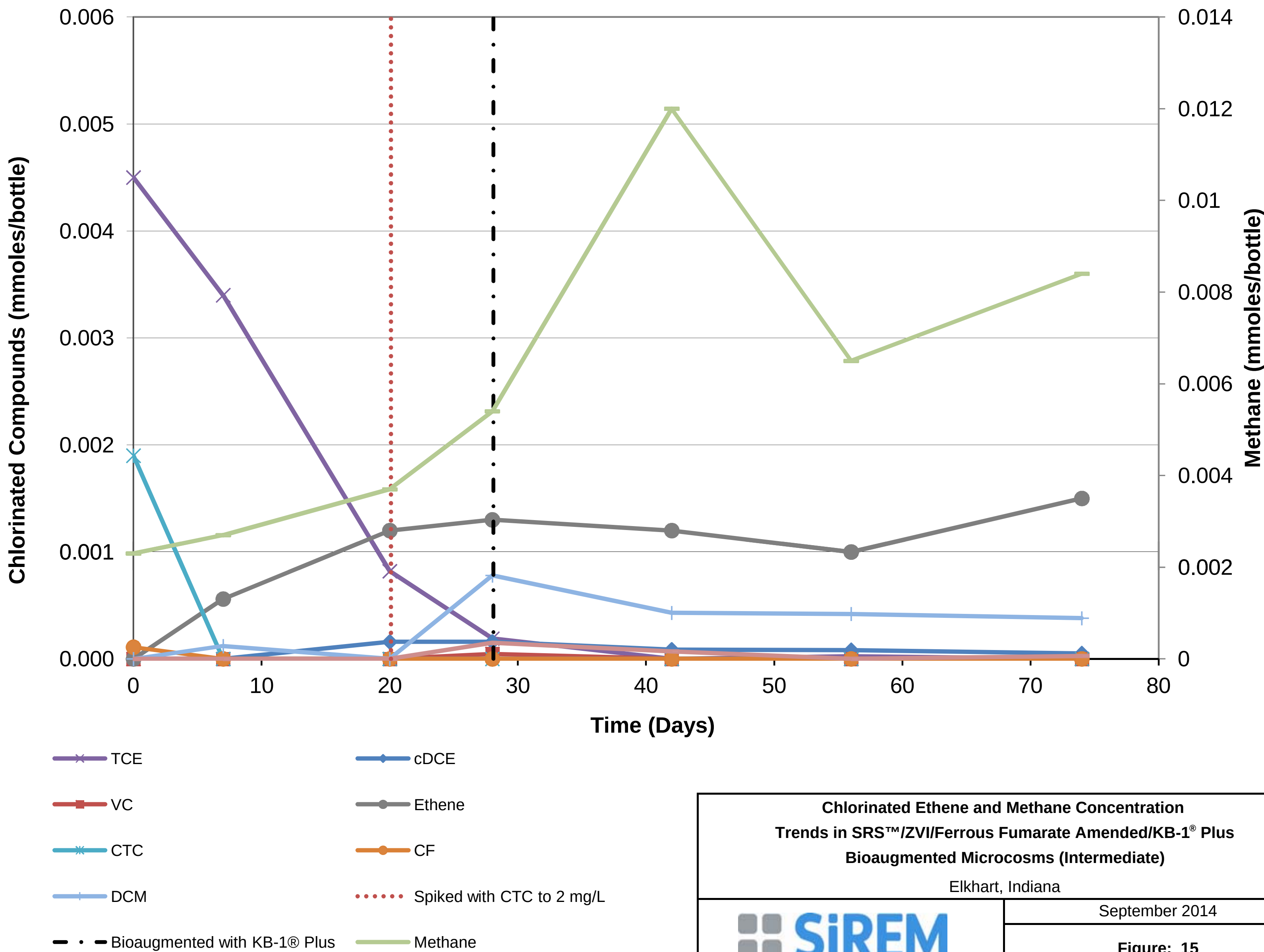
Figure: 14



Chlorinated Ethene and Methane Concentration Trends in SRS™/ZVI/Ferrous Fumarate Amended/KB-1® Plus Bioaugmented Microcosms (Intermediate)

Elkhart, Indiana

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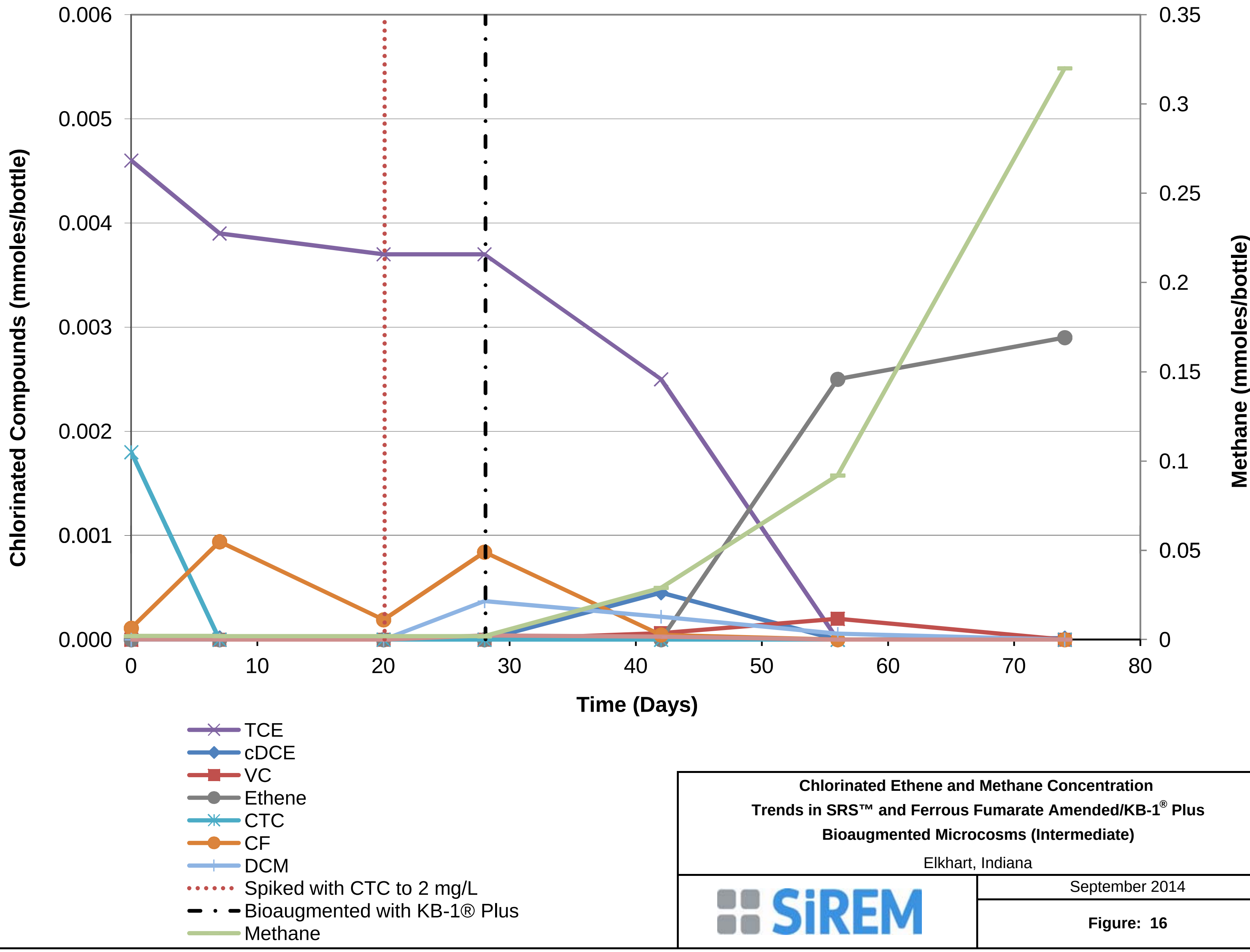
Figure: 15



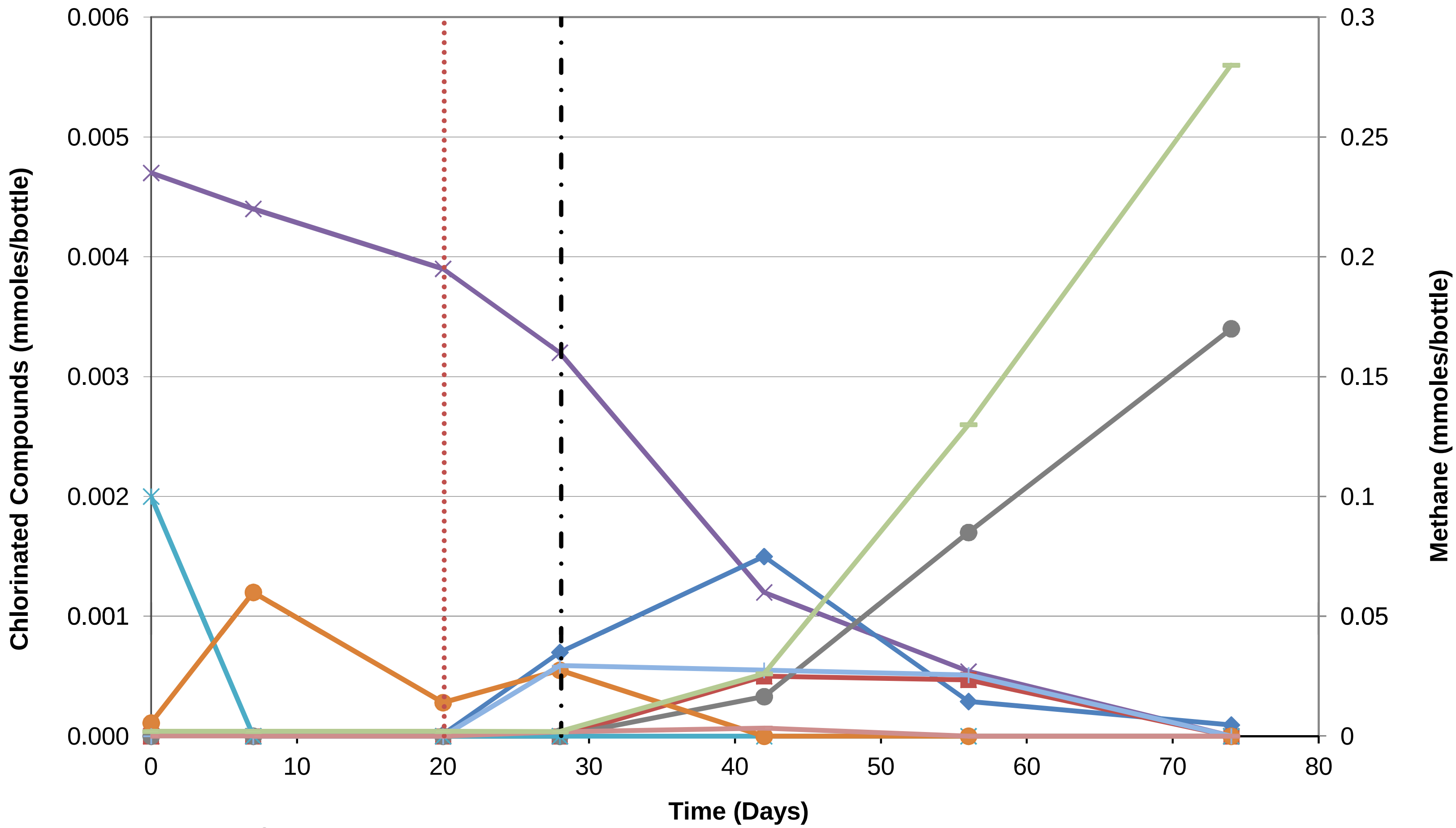
Chlorinated Ethene and Methane Concentration Trends in SRS™ and Ferrous Fumarate Amended/KB-1® Plus Bioaugmented Microcosms (Intermediate)

Elkhart, Indiana

SiREM

September 2014

Figure: 16



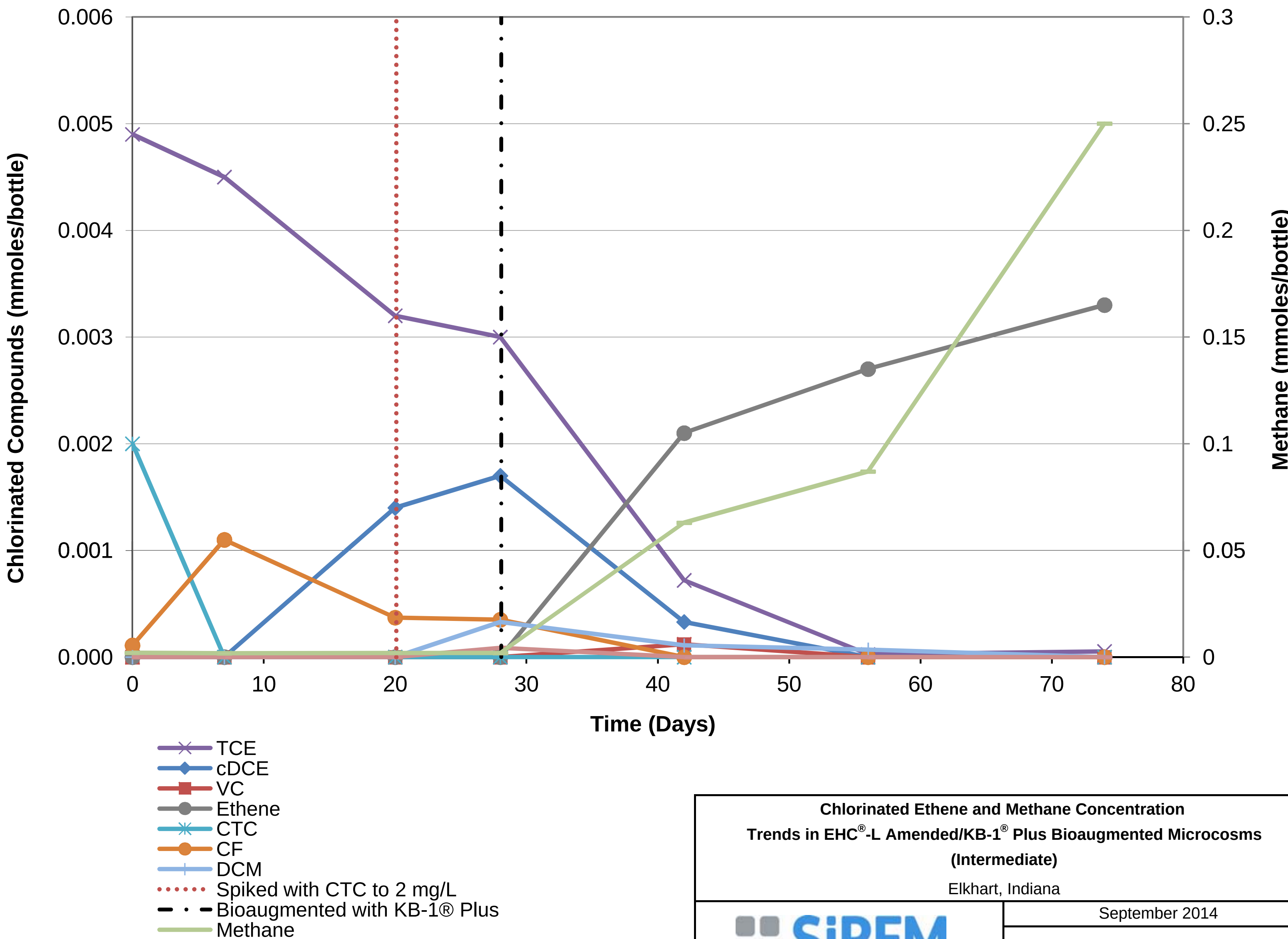
Chlorinated Ethene and Methane Concentration Trends in SRS™ Amended/KB-1® Plus Bioaugmented Microcosms (Intermediate)

Elkhart, Indiana

SiREM

September 2014

Figure: 17



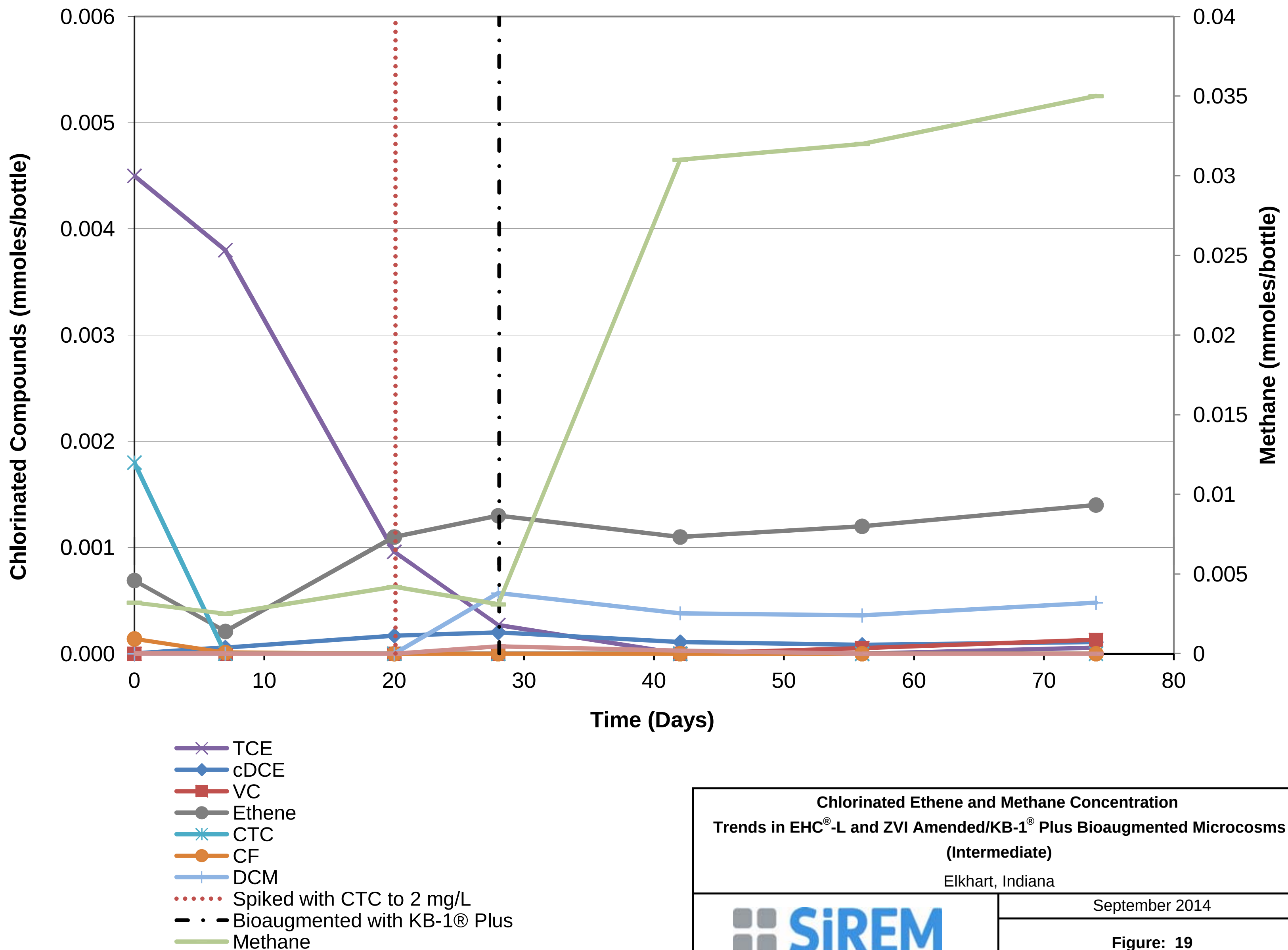
Chlorinated Ethene and Methane Concentration Trends in EHC®-L Amended/KB-1® Plus Bioaugmented Microcosms (Intermediate)

Elkhart, Indiana

SiREM

September 2014

Figure: 18



Chlorinated Ethene and Methane Concentration
Trends in EHC®-L and ZVI Amended/KB-1® Plus Bioaugmented Microcosms
(Intermediate)

Elkhart, Indiana

SiREM

September 2014

Figure: 19

APPENDIX A: Chain of Custody Documentation

SiREM

Chain-of-Custody Form

siremlab.com

130 Research Lane, Ste 2
Guelph ON, Canada N1G 5G3
(519) 822-2265

Lab # S-3114

Project Name	URS-Elkhart Micro. Study	Project #	14951267
Project Manager	Ray Vaské - URS corporation		
Company	URS corporation		
Address	525 Vine Street Suite 1800		
	Cincinnati OH 45202		
Phone #	513-651-3440	Fax #	
Sampler's Signature	[illegible]	Sampler's Printed Name	Katie Pritchard

Analysis

Preservative: 0 — Conrail-Elkhart Study

Preservative Key
0. None
1. HCL
2. Other ______
3. Other ______
4. Other ______
5. Other ______
6. Other ______

Client Sample ID	Lab ID	Sampling Date	Sampling Time	Matrix	# of Containers	Conrail-Elkhart Study											Other Information
~~DSW DSMW-11 (65~~ (KLP)																	Please e-mail copy of COC to R. Vaske upon receipt of samples: RayVaske@urs.com
DSMW-11 (65-70)		2/27/14	1330	Aquifer Material	3	X											

Sample Receipt

Cooler Condition: Good

Cooler Temperature: 4°C

Custody Seals: Yes [✓] No ☐

Invoice Information

P.O. #

Bill To:

For Lab Use Only

	Relinquished By:	Received By:	Relinquished By:	Received By:	Relinquished By:	Received By:
Signature	[illegible]	[illegible]				
Printed Name	Katie Pritchard	Ben Kesick				
Firm	URS Corporation	SiREM				
Date/Time	2/27/14 - 1805	Feb 28/14 14:00				

Distribution: White - Return to Originator: Yellow - Lab Copy: Pink - Retained by Client

SiREM
130 Research Lane, Ste 2
Guelph ON, Canada N1G 5G3
(519) 822-2265
siremlab.com

Chain-of-Custody Form

Lab # S-3127

Project Name	Conrail Superfund
Project #	14951267
Project Manager	Ray Vaske
Company	URS Corp.
Address	525 Vine St. Cinti OH 45202
Phone #	513-651-3440
Fax #	
Sampler's Signature	T. Davis
Sampler's Printed Name	Teresa Davis

Analysis

Preservative	0	0	1
Analysis	well sediment	low-flow groundwater	VOCs

Preservative Key
0. None
1. HCL
2. Other
3. Other
4. Other
5. Other
6. Other

Client Sample ID	Lab ID	Sampling Date	Sampling Time	Matrix	# of Containers	well sediment	low-flow groundwater	VOCs	Other Information
DSMW-08I		3/4/14	1400	water	3		X	X	
DSMW-08S		↓	1530	Sed.	1	X			
DSMW-07S		3/5/14	1340	GW	3		X	X	
DSMW-08S		↓	1530	GW	3		X	X	

Sample Receipt
Cooler Condition: good
Cooler Temperature: 6°C
Custody Seals: Yes ☒ No ☐

Invoice Information
P.O. #
Bill To:

For Lab Use Only

	Relinquished By:	Received By:	Relinquished By:	Received By:	Relinquished By:	Received By:
Signature	T. Davis	Kela Ashworth				
Printed Name	Teresa Davis	Kela Ashworth				
Firm	URS Corp	SiREM				
Date/Time	3/5/14 1830	7 Mar 14 13:55				

Distribution: White - Return to Originator: Yellow - Lab Copy: Pink - Retained by Client

SiREM

130 Research Lane, Ste 2
Guelph ON, Canada N1G 5G3
(519) 822-2265

Chain-of-Custody Form

siremlab.com

Lab # S-3127

Project Name	Corsail Superfund
Project #	14951267
Project Manager	Ray Vaske
Company	URS Corp.
Address	525 Vine St.
Phone #	513-651-3440
Fax #	
Sampler's Signature	(signature)
Sampler's Printed Name	Teresa Davis

Analysis

Preservative Key
0. None
1. HCL
2. Other ____
3. Other ____
4. Other ____
5. Other ____
6. Other ____

Client Sample ID	Lab ID	Sampling Date	Sampling Time	Matrix	# of Containers	well sediment (Preservative 0)	low-flow groundwater (Preservative 0)	VOCs (Preservative 1)								Other Information
DSMW-08I		3/4/14	1115	Sed	1	X										
DSMW-07I		3/5/14	0910	Sed	1	X										
DSMW-07I		↓	1140	GW	3		X	X								
DSMW-07S		3/4/14	1655	Sed	1	X										

Sample Receipt

Cooler Condition: good

Cooler Temperature: 6°C

Custody Seals: Yes ☒ No ☐

Invoice Information

P.O. #

Bill To:

For Lab Use Only

	Relinquished By:	Received By:	Relinquished By:	Received By:	Relinquished By:	Received By:
Signature	(signature)	Kela Ashworth				
Printed Name	Teresa Davis	Kela Ashworth				
Firm	URS Corp.	SiREM				
Date/Time	3/5/14 1815	7 Mar 14 13:55				

Distribution: White - Return to Originator: Yellow - Lab Copy: Pink - Retained by Client

APPENDIX B: Henry's Law Calculation

The following Henry's Law calculation was used to convert aqueous concentrations (Table 2) to total mmoles of each analyte per microcosm bottle (Figures 5 to 19):

$$\text{Total mmoles} = \frac{C_{liq} \times (V_{liq} + H \times V_{gas})}{\text{Molecular Weight (mg/mmol)}}$$

Where

C_{liq} = liquid concentration (mg/L)
V_{liq} = liquid volume (0.230 L) per bottle
V_{gas} = headspace volume (0.020 L) per bottle
H = Henry's Law constant (dimensionless)

The Henry's Law constants used are summarized in the table below.

Analyte	Henry's Law Constant [a] (dimensionless)
Trichloroethene	0.417
cis-1,2-Dichloroethene	0.184
Vinyl chloride	1.08
Carbon Tetrachloride	1.24
Chloroform	0.178
Dichloromethane	0.121
Chloromethane	0.495
Ethene	8.78
Ethane	20.47
Methane	27.27

[a] Source: Montgomery, J.H. 2000. *Groundwater Chemicals Desk Reference, Third Edition.* CRC Press LLC, Boca Raton, FL.

Appendix C: Ferrous Iron Test Method

• Iron, Ferrous, Test Kit

1,10 Phenanthroline Iron Reagent Method

• Trousse d'analyse fer ferreux

Méthode réactif fer 1, 10 Phéanthroline

• Eisen, 2wertig Test Kit

1,10 Phenanthrolin-Eisenreagenz Methode

• Kit de análisis para hierro ferroso

Método reactivo de fenatrolina de hierro 1,10

0.0 – 10.0 mg/L

• Mod. IR-18C

• # 26672-00

- To ensure accurate results, read carefully before proceeding.
- Pour obtenir des résultats exacts, lire attentivement le mode d'emploi avant d'utiliser la trousse.
- Um genaue Ergebnisse zu gewährleisten, lesen Sie das Folgende bitte aufmerksam durch, bevor Sie fortfahren.
- Para obtener resultados precisos, lea detenidamente las instrucciones antes de proceder al análisis.

WARNING

Handling chemical samples, standards, and reagents can be dangerous. Review the Material Safety Data Sheets before handling any chemicals.

ATTENTION

La manipulation des échantillons chimiques, étalons et réactifs peut être dangereuse. Lire les fiches de données de sécurité des produits avant de manipuler tout produit chimique.

WARNUNG

Die Handhabung chemischer Proben, Standards und Reagenzien kann gefährlich sein. Bitte gehen Sie die Materialsicherheitsdatenblätter durch, bevor Sie Chemikalien handhaben.

ADVERTENCIA

El manejo de sustancias químicas, patrones y reactivos, puede resultar peligroso. Lea las fichas de informaciones de seguridad de materiales antes de manipular cualquier producto químico.

HACH®

Introduction

The 1,10 phenanthroline indicator in the Ferrous Iron Reagent reacts with ferrous iron in the sample to form an orange color in proportion to the ferrous iron concentration. Ferric iron does not react. The ferric iron (Fe^{3+}) concentration can be determined by subtracting the ferrous iron concentration from the results of a total iron test.

Introduction

L'indicateur 1,10 phénanthroline dans le réactif fer ferreux réagit avec le fer ferreux présent dans l'échantillon pour former une coloration orange proportionnelle à la concentration de fer ferreux. Le fer ferrique ne réagit pas. La concentration de fer ferrique (Fe^{3+}) peut être déterminée en soustrayant la concentration de fer ferreux des résultats d'une analyse de fer total.

Einleitung

Der 1,10 Phenantrolin Indikator im Eisen(II)-Reagenz reagiert mit Eisen(II) in der Probe durch Bildungen einer orangen Farbe, proprotional zur Konzentration des zweiwertigen Eisens. Eisen(III) reagiert nicht. Die Konzentration des dreiwertigen Eisen (Fe^{3+}) kann bestimmt werden, indem man die Konzentration des zweiwertigen Eisens von den Ergebnissen eines Eisen Gesamt Tests subtrahiert.

Introducción

El indicador de 1,10-fenantrolina en el Reactivo para Hierro Ferroso reacciona con el hierro ferroso de la muestra para formar un color anaranjado en proporción con la concentración de hierro ferroso. El hierro férrico no reacciona. La concentración de hierro férrico (Fe^{3+}) puede ser determinada restando la concentración de hierro ferroso de el resultado de una prueba de hierro total.

Measuring Hints and General Test Information

- Wash all labware between tests. Contamination may alter test results. Clean with a non-abrasive detergent or a solvent such as isopropyl alcohol. Use a soft cloth for wiping or drying. Do not use paper towels or tissue on plastic tubes as this may scratch them. Rinse with clean water (preferably deionized water).
- Rinse all viewing tubes thoroughly with the sample water before testing.
- Use clippers to open plastic powder pillows.
- For critical testing, reagent accuracy should be checked with each new lot of reagents. Prepare a ferrous iron stock solution (100 mg/L Fe) by dissolving 0.702 grams of ferrous ammonium sulfate, hexahydrate, in one liter deionized water. Dilute 5.00 mL of this solution to 100 mL with deionized water to make a 5.0 mg/L standard solution. Prepare this immediately before use. Follow the ferrous iron test instructions using this solution instead of a water sample.

Conseils pour les mesures et informations générales sur l'analyse

- Laver toute la verrerie entre les analyses. La contamination peut fausser les résultats d'analyses. Laver avec un détergent non abrasif ou un solvant tel que l'isopropanol. Utiliser un tissu doux pour essuyer ou sécher. Ne pas utiliser de tissu ou papier d'essuyage sur les tubes en plastique pour ne pas les rayer. Rincer à l'eau propre (de préférence de l'eau désionisée).
- Rincer soigneusement tous les tubes colorimétriques avec l'échantillon d'eau avant l'analyse.
- Utiliser la pince coupante pour ouvrir les gélules en plastique.
- Pour des analyses critiques, l'exactitude du réactif doit être vérifiée pour chaque nouveau lot de réactifs. Préparer une solution-mère de fer ferreux (100 mg/L Fe) en dissolvant 0,702 grammes d'ammonium-fer (II) sulfate, hexahydrate, dans un litre d'eau désionisée. Diluer 3,00 mL de cette solution à 100 mL avec de l'eau désionisée pour obtenir une solution étalon à 3,0 mg/L. Préparer cette solution immédiatement avant emploi. Suivre les instructions d'analyse du fer ferreux en remplaçant l'échantillon par cette solution étalon.

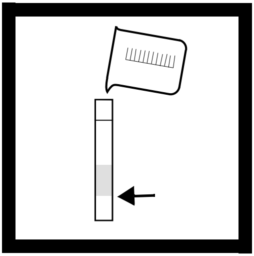
Meßtips und allgemeine Testinformationen

- Waschen Sie alle Laborartikel zwischen den Tests. Verunreinigung kann die Testergebnisse verfälschen. Reinigen Sie sie mit einem nicht scharfen Detergent oder einem Lösungsmittel wie zum Beispiel Isopropylalkohol. Verwenden Sie für das Abwischen oder Abtrocknen ein weiches Tuch. Verwenden Sie bei den Plastikröhrchen keine Papierhandtücher oder Tissue-Papier, da dieses sie zerkratzen kann. Spülen Sie mit sauberem Wasser (vorzugsweise entsalztes Wasser).
- Spülen Sie alle Prüfröhrchen vor dem Test gründlich mit dem Probenwasser.
- Verwenden Sie eine Schere zur Öffnung der Plastik-Pulverkissen.
- Um genaue Bestimungen zu erzielen, sollte die Genauigkeit der Reagenzien für jede neue Charge überprüft werden. Bereiten Sie eine Eisen-II Stammlösung (100mg/L Fe) auf, indem Sie 0,702 Gramm Eisen-II Ammoniumsulfat, hexahydrat, in einem Liter entsalzten Wasser lösen. 3,00 mL dieser Lösung werden mit 100 mL entsalztem Wasser verdünnt, so dass eine 3,0 mg/L Standardlösung entsteht. Diese Lösung wird unmittelbar vor Gebrauch angesetzt. Arbeiten Sie, unter Benutzung dieser Lösung anstelle einer Wasserprobe, gemäß den Anweisungen für den Eisen(II) Test.

Consejos para la medición e información general sobre el análisis

- Lavar todo el material de laboratorio entre los análisis. La contaminación puede alterar los resultados. Limpiar con un detergente no abrasivo o con un solvente como el alcohol isopropílico. Utilizar un paño suave para limpiar o secar. No utilizar ni toallitas ni pañuelos de papel para limpiar los tubos de plastico para no rayarlos. Aclarar con agua limpia (preferentemente agua desionizada).
- Enjuagar todos los tubos para colorimetría abundantemente con la muestra de agua antes de realizar el análisis.
- Utilice las pinzas cortantes para abrir las cápsulas de plástico.
- Para pruebas exigentes o difficiles, la precisión del reactivo debe ser verificada cada vez que se comienza con un nuevo lote. Preparar una solución de reserva de hierro ferroso (100 mg/L Fe), disolviendo 0,702 gs. de sulfato de amonio ferroso, hexahidrato, en un litro de agua desionizada. Diluya 3,00 mL de esta solución en 100 mL de agua desionizada para hacer una solución estándar de 3,00 mg/L. Esta debe ser preparada inmediatamente antes de usarla. Siga las instrucciones de la prueba de hierro ferroso empleando esta solución en vez de una muestra de agua.

• Procedure • Technique • Verfahren • Procedimiento

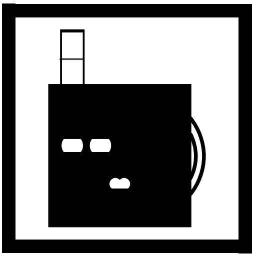


1. Fill a viewing tube to the first (5-mL) line with sample water. This is the blank.

♦ Remplir un tube colorimétrique jusqu'au premier trait (5 mL) avec l'échantillon d'eau. Ceci est le blanc.

♦ Füllen Sie ein Prüfröhrchen bis zur ersten (5 mL) Linie mit Probenwasser. Dieses ist die Blindprobe.

♦ Llene un tubo para colorimetría hasta la primera marca (5 mL) con la muestra de agua. Esto constituye el blanco.

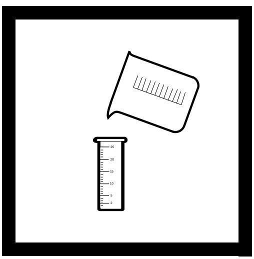


2. Place this tube in the top left opening of the color comparator.

♦ Placer ce tube dans l'ouverture supérieure gauche du comparateur.

♦ Stellen Sie dieses Röhrchen in die obere linke Öffnung des Farbkomparators.

♦ Coloque este tubo en la abertura superior izquierda del comparador.



3. Fill the measuring vial to the 25-mL mark with sample water.

♦ Remplir le tube de mesure jusqu'au trait 25 mL avec l'échantillon d'eau.

♦ Füllen Sie das Messröhrchen bis zur 25 mL Markierung mit dem Probenwasser.

♦ Llene el frasco medidor hasta la marca de 25 mL con el agua de la muestra.

4. Add the contents of one Ferrous Iron Reagent Powder Pillow to the measuring vial.

♦ Ajouter le contenu d'une gélule de réactif du fer ferreux au tube de mesure.

♦ Geben Sie den Inhalt eines Eisen(II)-Reagenz-Pulverkissens in das Messröhrchen.

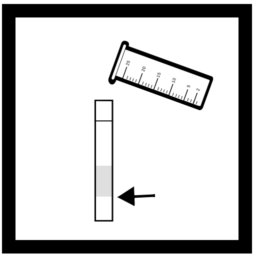
♦ Agregue el contenido de una cápsula del Reactivo para Hierro Ferroso al frasco medidor.

5. Swirl to mix. An orange color will develop if ferrous iron is present. Allow three minutes for full color development.

♦ Agiter pour mélanger. En présence de fer ferreux, une coloration orange se développe. Attendre le développement complet de la coloration.

♦ Schwenken Sie zum Vermischen. Ist Eisen(II) vorhanden, entwickelt sich eine orange Färbung. Warten Sie drei Minuten, bis sich die Farbe vollständig ausgebildet hat.

♦ Agite para mezclar. Se formará un color anaranjado en presencia de hierro ferroso. Deje pasar tres minutos para que el color se desarrolle completamente.

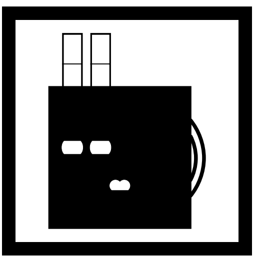


6. Fill another viewing tube to the first (5-mL) mark with the prepared sample.

♦ Remplir un autre tube jusqu’au premier trait (5 mL) avec l’échantillon préparé.

♦ Füllen Sie ein weiteres Prüfröhrchen bis zur ersten (5 mL-) Linie mit der vorbereiteten Probe.

♦ Llene otro tubo para colorimetría hasta la marca de 5mL con la muestra preparada en los puntos 4 y 5.

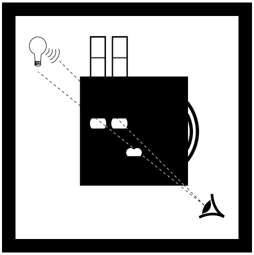


7. Place the second tube in the top right opening of the color comparator.

♦ Placer le second tube dans l’ouverture supérieure droite du comparateur.

♦ Setzen Sie das zweite Röhrchen in die obere rechte Öffnung des Farbkomparators.

♦ Coloque el segundo tubo en la abertura superior derecha del comparador.

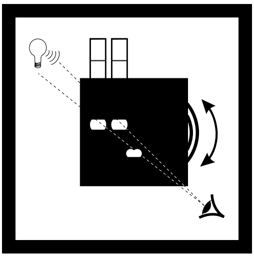


8. Hold comparator up to a light source such as the sky, a window or a lamp. Look through the openings in front.

♦ Tenir le comparateur face à une surface uniformément éclairée (ciel, lampe, fenêtre) et regarder par les ouvertures de la face antérieure du comparateur.

♦ Halten Sie den Komparator gegen eine Lichtquelle wie zum Beispiel den Himmel, ein Fenster oder eine Lampe. Sehen Sie durch die Öffnungen vorn.

♦ Lleve el comparador hasta una fuente de luz, tal como el cielo, una ventana o una lámpara. Mire a través de las aberturas frontales del comparador.

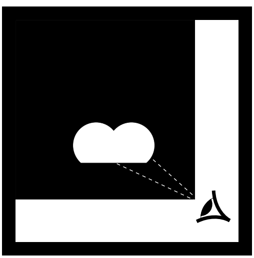


9. Rotate the color disc until the color matches in the two openings.

♦ Tourner le disque jusqu'à égalité des teintes dans les deux ouvertures.

♦ Drehen Sie die Farbscheibe, bis die Farbe in den beiden Öffnungen übereinstimmt.

♦ Haga girar el disco de color hasta que el color coincida en ambas aberturas.



10. Read the mg/L ferrous iron in the scale window.

♦ Lire la concentration du fer ferreux en mg/L dans la fenêtre de l'échelle.

♦ Lesen Sie die mg/L Eisen(II) im Skalenfenster ab.

♦ Lea la concentración de hierro ferroso en mg/L en la ventanilla graduada.

REPLACEMENTS

Description	Unit	Cat. No.
Clippers	each	968-00
Color Comparator	each	1732-00
Color Disc, Iron Phenanthroline	each	1874-00
Ferrous Iron Reagent Powder Pillows, 25 mL	100/pkg	1037-69
Instruction Card, IR-18C Test Kit	each	26672-88
Vial, measuring, with 2, 5, 10, 15, 20 and 25-mL marks	each	2193-00
Viewing Tube, plastic	4/pkg	46600-04
Water, deionized	4 L	272-56

REACTIFS ET PIECES DE RECHANGE

Désignation	Unité	Réf. Nº
Pince coupante pour gélules moyennes	1	968-00
Comparateur	1	1732-00
Disque coloré fer, phénanthroline	1	1874-00
Réactif du fer ferreux en gélules pour 25 mL	100/paq	1037-69
Mode d'emploi de la trousse IR-18C	1	26672-88
Tube de mesure marqué 2, 5, 10, 15, 20 et 25 mL	1	2193-00
Tube colorimétrique en plastique avec bouchon	4/paq	46600-04
Eau désionisée	4 L	272-56

VERBRAUCHSMATERIAL UND ERSATZTEILE

Beschreibung	Einheit	Kat. Nr.
Abschneider	1	968-00
Farbkomparator	1	1732-00
Farbscheibe, Eisenphenanthrolin	1	1874-00
Eisen(II) Reagenz-Pulverkissen, 25 mL	100/Stck	1037-69
Anleitungskarte, IR-18C Test Kit	1	26672-88
Messröhrchen m. 2, 5, 10, 15, 20 und 25 mL Markierungen	1	2193-00
Farbprüfröhrchen, Plastik, mit Kappe	4/Stck	46600-04
Entsalztes Wasser	4 L	272-56

REACTIVOS Y MATERIALES

Descripción	Unidad	Nº Ref.
Pinzas cortantes para cápsulas intermedias	1	968-00
Comparador de Colores	1	1732-00
Disco de colores, fenantrolina de hierro	1	1874-00
Reactivo para Hierro Ferroso, Bolsas de Polvo, 25 mL	100/lote	1037-69
Tarjeta de Instrucciones, Juego de Prueba IR-18C	1	26672-88
Frasco medidor, con marcas a 2, 5, 10, 15, 20 y 25 mL	1	2193-00
Tubo para colorimetría de plástico, con tapa protectora	4/lote	46600-04
Agua desionizada	4 L	272-56

OPTIONAL REAGENTS AND EQUIPMENT

Description	Unit	Cat. No.
Caps, for plastic Color Viewing Tubes 46600-04	4/pkg	46600-14
Ferrous Ammonium Sulfate, Hexahydrate	113 g	11256-14
Flask, volumetric, Class A, 100-mL	each	26366-42
Flask, volumetric, Class A, 1000-mL	each	26366-53
Pipet, volumetric, Class A, 5-mL	each	14515-37
Pipet Filler, safety bulb	each	14651-00

REACTIFS ET EQUIPEMENTS OPTIONNELS

Désignation	Unité	Réf. Nº
Bouchons pour tubes en plastique 46600-04	4/paq	46600-14
Ammonium, fer (II) sulfate, 6 H_2O ACS	113 g	11256-14
Fiole jaugée, classe A, 100ml	1	26366-42
Fiole jaugée, classe A, 1000 ml	1	26366-53
Pipette jaugée, classe A, 5,00ml	1	14515-37
Poire à pipetter	1	14651-00

ZUSÄTZLICHE REAGENZIEN UND ZUBEHÖR

Beschreibung	Einheit	Kat. Nr.
Kappen, für Plastik-Farbprüfröhrchen 46600-04	4/Stck	46600-14
Eisen(II)-Ammoniumsulfat, hexahydrat	113 g	11256-14
Messkolben, Klasse A, 100 mL	1	26366-42
Messkolben, Klasse A, 1000 mL	1	26366-53
Messpipette, Klasse A, 5mL	1	14515-37
Pipettenfüller, Sicherheitsball	1	14651-00

REACTIVOS Y EQUIPAMIENTO OPCIONALES

Descripción	Unidad	Nº Ref.
Tapas protectoras para tubos de plástico 46600-04	4/lote	46600-14
Sulfato de Amonio Ferroso, Hexahidratado	113 g	11256-14
Frasco volumétrico, clase A, 100-mL	1	26366-42
Frasco volumétrico, clase A, 1000-mL	1	26366-53
Pipeta volumétrica, clase A, 5-0 mL	1	14515-37
Bulbo de seguridad para llenador de pipeta.	1	14651-00

- **Pour assistance technique, informations de prix ou informations pour commander, contactez HACH Company ou votre distributeur HACH.**
- **Technische Unterstützung, aktuelle Preisauskünfte und Bestellhilfe erhalten Sie bei Ihrer HACH Vertretung.**
- **Para obtener asistencia técnica asi como información sobre los precios y pedidos, ponerse en contacto con HACH Company o la agencia local de distribución.**

HACH COMPANY
WORLD HEADQUARTERS
P.O. Box 389
Loveland, Colorado 80539-0389
Telephone : (970) 669-3050
FAX : (970) 669-2932
Telex : 160840

HACH EUROPE
Chaussée de Namur, 1
B-5150 Floriffoux (Namur), Belgium
Telephone : (32) (81) 44.71.71
FAX : (32) (81) 44.13.00

FOR TECHNICAL ASSISTANCE, PRICE INFORMATION AND ORDERING:
In the U.S.A. - **Call 800-227-4224 toll-free for more information.**
Outside the U.S.A. - **Contact the HACH office or distributor serving you.**

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Appendix D: External Laboratory Reports

SGS Canada Inc.
P.O. Box 4300 - 185 Concession St.
Lakefield - Ontario - KOL 2HO
Phone: 705-652-2000 FAX: 705-652-6365

16-April-2014

SiREM Laboratory
Attn : Jennifer Webb

130 Research Lane, Suite 2, Guelph
, N1G 5G3
Phone: 519-822-2265, Fax:519-822-3151

Date Rec. : 27 March 2014
LR Report: **CA12685-MAR14**
Reference: Elkhart

Copy: #1

CERTIFICATE OF ANALYSIS

Final Report

Analysis	**3: Analysis Approval Date**	**4: Analysis Approval Time**	**5: Aquifer Soil (Elkhart)**
Sample Date & Time			26-Mar-14 10:0
Total Organic Carbon [	16-Apr-14	08:28	1.03
Iron [µg/g]	07-Apr-14	14:41	5200
Manganese [µg/g]	07-Apr-14	14:41	140

Brian Graham B.Sc.
Project Specialist
Environmental Services, Analytical

OnLine LIMS

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